October 2015

West Sacramento Project
General Reevaluation Report

US Army Corps of Engineers ®
Sacramento District

WSAFCA
West Sacramento Area Flood Control Agency

APPENDIX A

PLAN F0RMULATION

Cover Photo: Sacramento River, West Sacramento, and Yolo Bypass, March 2011

Photo courtesy of Chris Austin.

WEST SACRAMENTO PROJECT, CALIFORNIA
GENERAL REEVALUATION REPORT

Appendix A

Plan Formulation

U.S. Army Corps of Engineers
Sacramento District

October 2015

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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.

Levee Construction Technique Problems

Seepage: 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.

Stability: 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

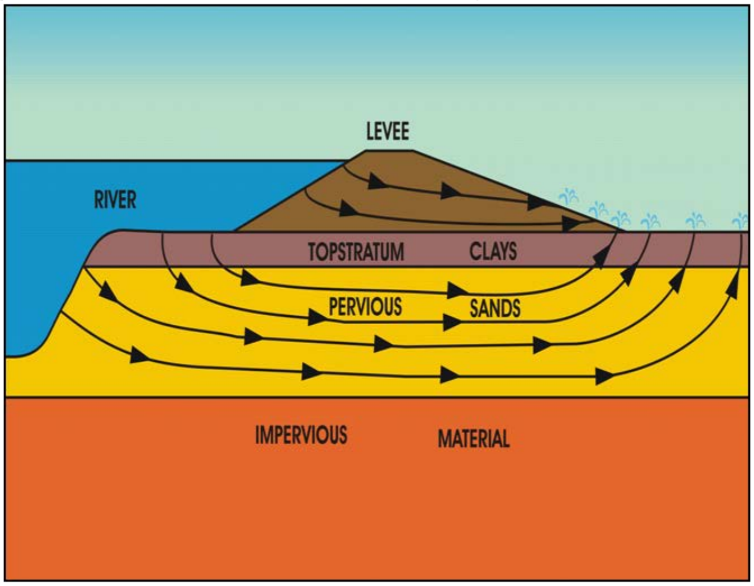


Figure 6. Sloughing of levee slope as a result of stability problem

<u>Erosion:</u> 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.

<u>Levee System Configuration Problem</u>

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.

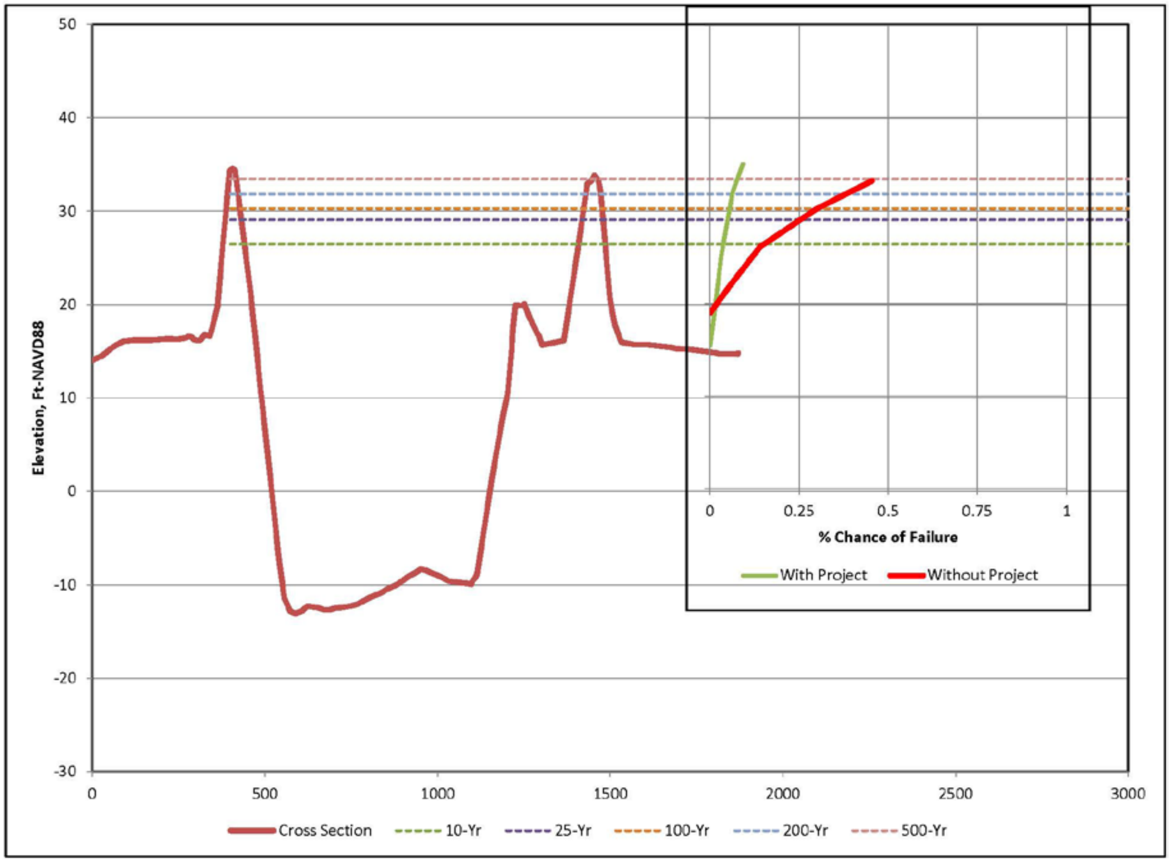
2.5 General Probability of Levee Failures into the Cities of Sacramento and West Sacramento

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.

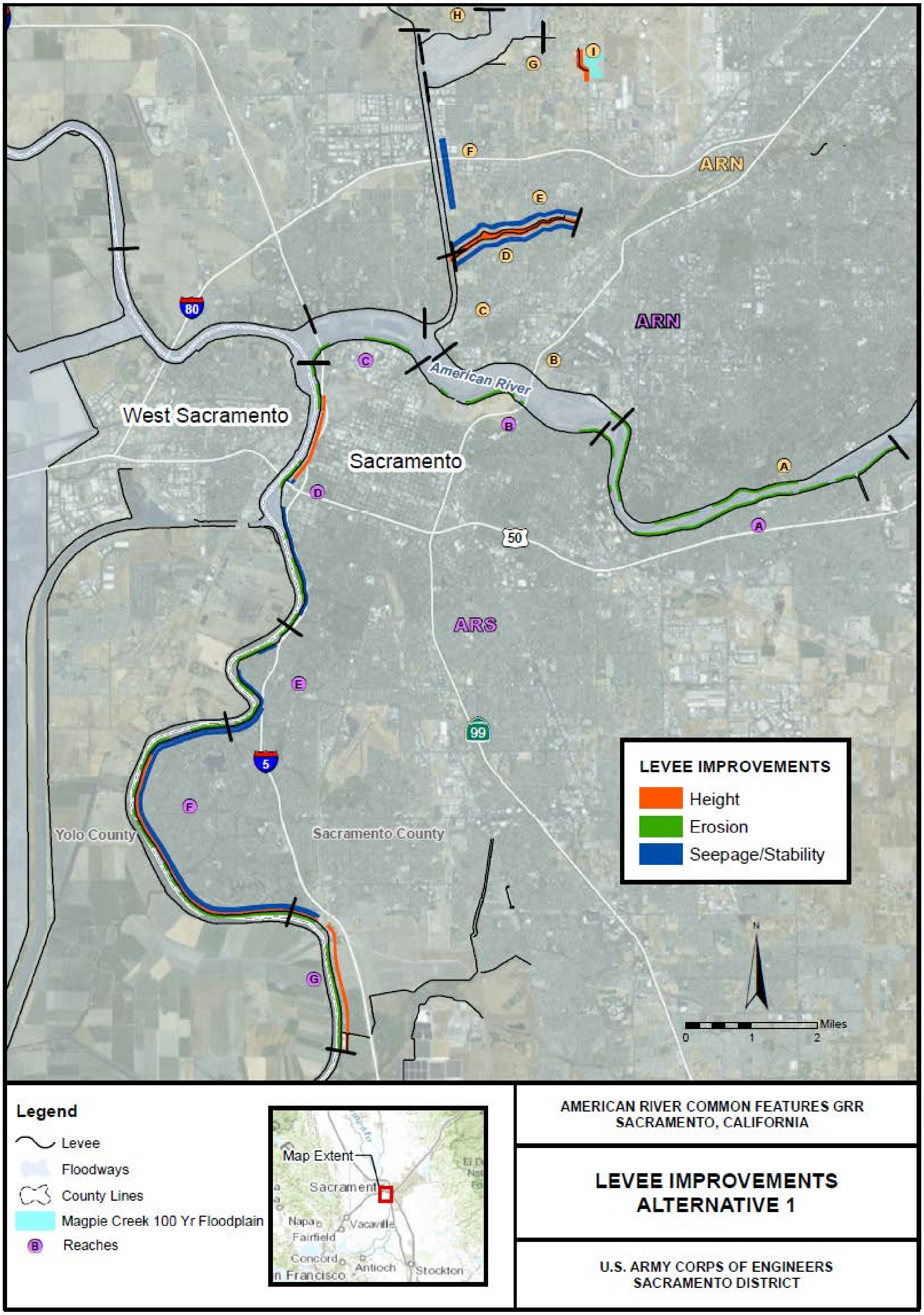


Figure 9. NED Plan Features for the American River Common Features GRR

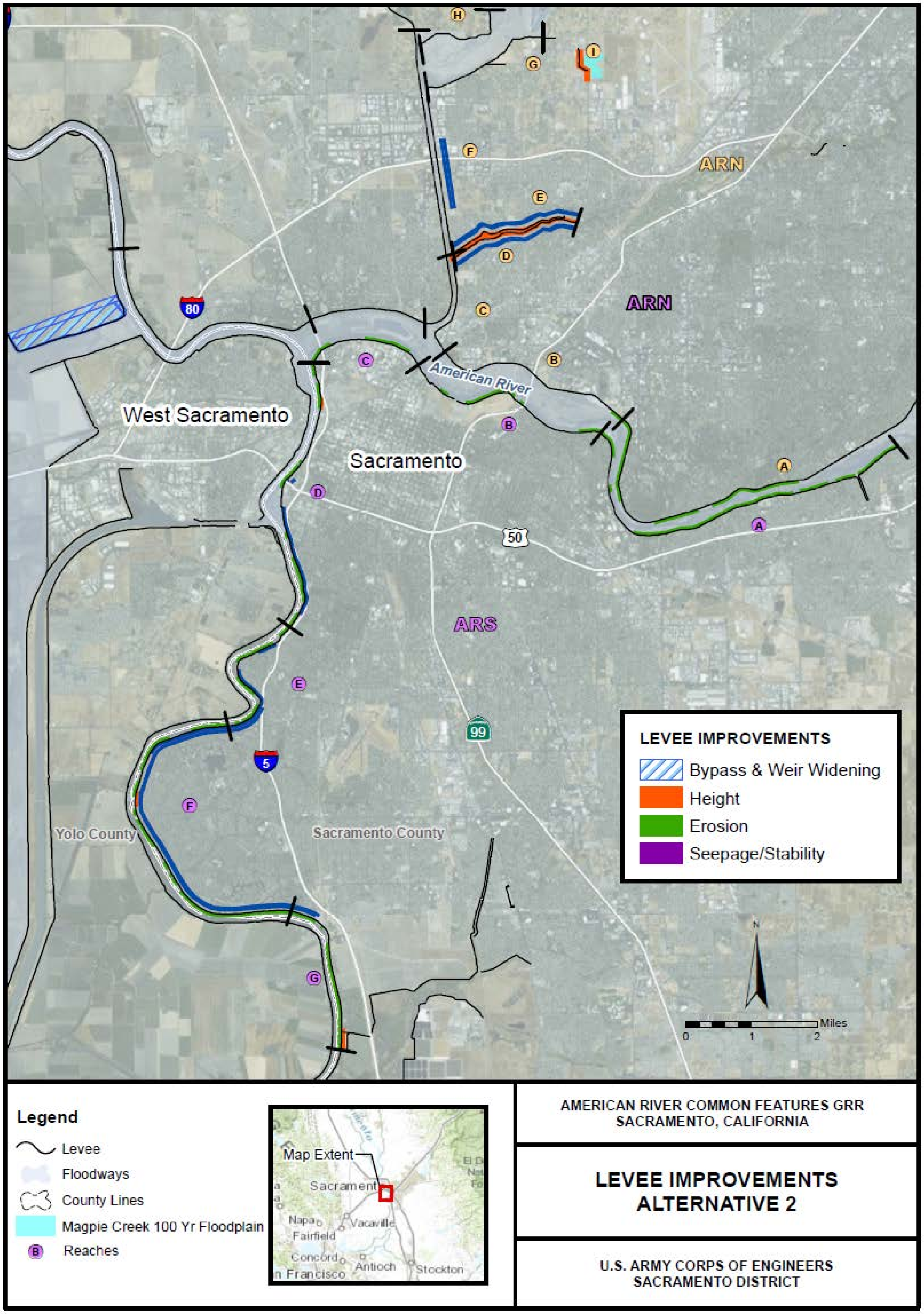


Figure 10. LPP Plan Features for the American River Common Features GRR

<u>5.0</u> 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.

<u>West Sacramento North Basin</u>

- 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.

<u>West Sacramento South Basin</u>

- 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.

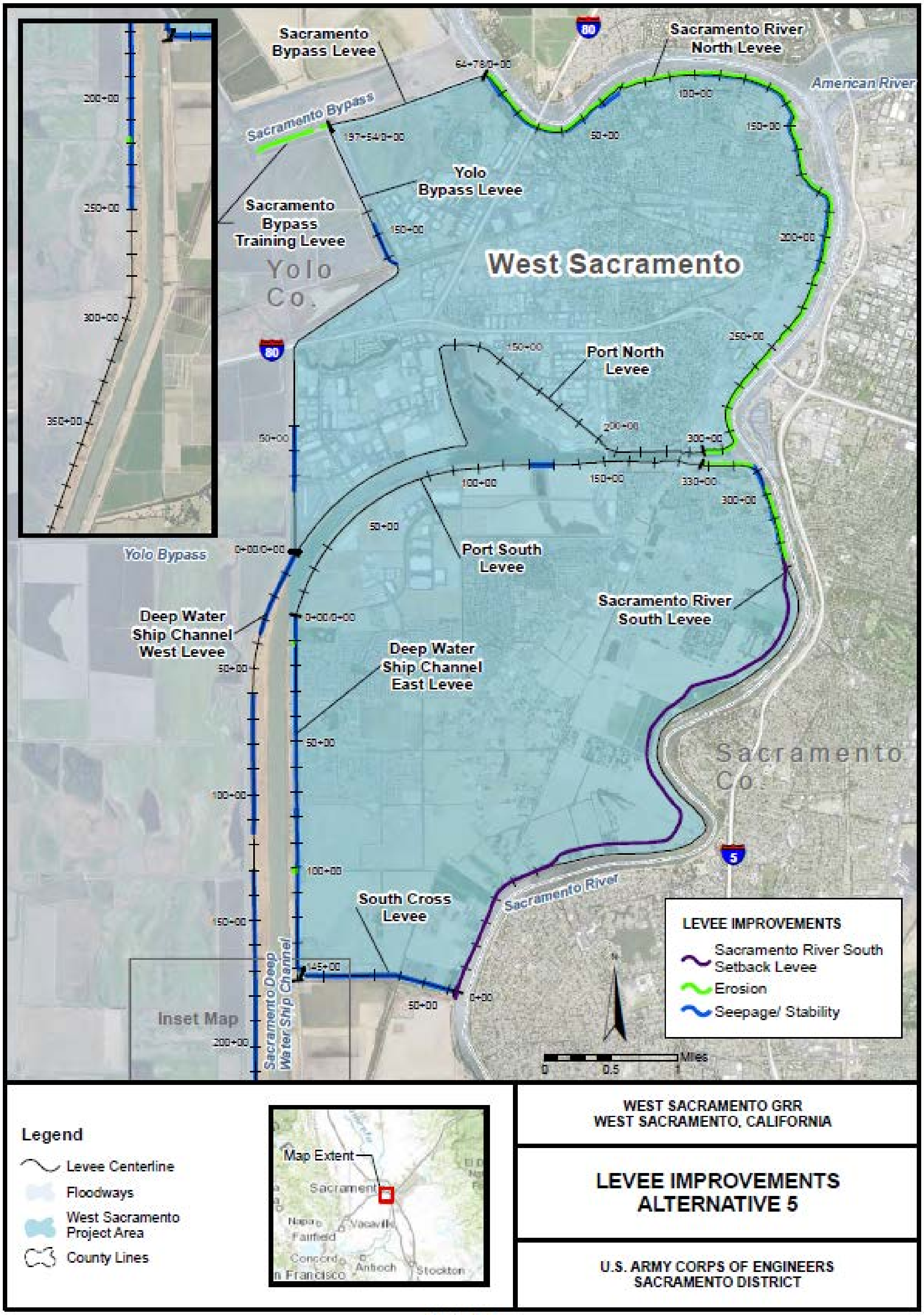


Figure 11. TSP Recommended Features for the West Sacramento GRR

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.

West Sacramento GRR

Appendix B

Review Documentation

District Quality Control

Documentation

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QUALITY CONTROL CERTIFICATE FOR CIVIL DESIGN PRODUCTS

PROJECT NAME: *West Sacramento GRR* **PROJECT MANAGER:** Bryon Lake

ORGANIZATION: Civil Design Section B

TECHNICAL PRODUCTS: Engineering Appendix supporting final report for the West Sacramento General reevaluation Report.

PREPARER – I have prepared the above the products in accordance with the Quality Management Plan. I have incorporated or resolved all review issues in accordance with the Quality Management Plan. (Describe any exceptions and why resolution didn't happen).

Preparer: ______________________ Date: 09/09/2015
Benson Liang, Civil Engineer, PE

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: 09/09/2015
Markus Boedtker, Civil Engineer, PE

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: 09/09/2015
Richard A Torbik, PE
Chief, Civil Design Section B

West Sacramento GRR-Engineering Appendix
DQC review
Comment Submitted by: Markus Boedtker
Evaluated by: Benson Liang
Date: 8/7/2015

Coordinating Discipline(s): Civil,

My comments are listed below:

1. Table of Contents: Correct spelling of "REPORT" for Attachment A.

   The spelling was corrected to "REPORT".

2. Page 5, Paragraph 2.4.1: In the last sentence, it appears part of the sentence is missing, or the first letter should be capitalized.

   The sentence was revised by removing the "." after embankment.

3. Page 12, Paragraph 2.7.2: In the fourth line on this page, change "they" to "the".
   The sentence was revised as you suggested.

4. Page 20, Paragraph 3.3, South Cross Levee: In the first paragraph, add "feet" after "2" in the third sentence. Also, in the second paragraph, add "from" between "feet" and "each" in the second sentence.

   The sentences were revised as you suggested.

5. Figures 1, 2, 4, and 24: These figures are missing.
   These figures were added to the engineering appendix.

6. Figure 5: This figure is missing fill in the center of the raised levee. Adjust the section to include this compacted fill.
   The figure was added arrow to show fill.

7. Figure 8: The reconstructed levee should be shifted waterward to be flush with the existing waterside slope. This will lessen the possibility of erosion at the point of excavation, and require less fill on the landside slope flattening.

   The Figure 8 was revised as suggested.

8. Figure 10. The adjacent raised levee should be shifted waterward to be flush with the existing waterside slope. This will lessen the amount of fill required for constructing the adjacent levee, and reduce the required real estate. The sand and drain rock layer also needs to extend out of the stability berm at the toe.
   The Figure 10 was revised as suggested.

9. Figures 16 through 23: These figures identify Type 1A or Type 1, 2, or 3 fill. Unless you have descriptions of these type of soils, they should be identified as levee fill, or impermeable fill, or clay, etc.

   Attachment G defines the types of fill materials (see Attachment G), a note was added to those figures.

10. Figures 19, 20, and 22: These figures reference Sheets C-200 through C-207 which are not included.

Those figures were created by local sponsor. Those reference sheets will be available upon request.

Liang, Benson Y SPK

From: Boedtker, Markus S SPK
Sent: Monday, August 10, 2015 7:52 AM
To: Liang, Benson Y SPK
Cc: Torbik, Richard A SPK
Subject: RE: Engineering Appendix- West Sac GRR (DQC) (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Benson-

All of my comments have been closed out.

Thanks,
Mark Boedtker
Civil Engineering Section A
Corps of Engineers
(916) 557-6637

-----Original Message-----
From: Liang, Benson Y SPK
Sent: Friday, August 07, 2015 6:19 PM
To: Boedtker, Markus S SPK
Cc: Torbik, Richard A SPK
Subject: RE: Engineering Appendix- West Sac GRR (DQC) (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Mark,
Attached file was my responses to your comments. The Engineering appendix folder is link below. Please close all those comments if it is possible. I will be out of office for a training next week. if you need additional information to close those comments, please contact Rick or contact me after 8/19. Thank you for all those valuable comments.

\\amethyst\civcad\WestSacramento\WestSacramentoGRR\CADD\Civil\Engineering_Appendix\Engineering_Appendix

-----Original Message-----
From: Boedtker, Markus S SPK
Sent: Thursday, August 06, 2015 4:26 PM
To: Liang, Benson Y SPK
Cc: Torbik, Richard A SPK
Subject: RE: Engineering Appendix- West Sac GRR (DQC) (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Benson-

My comments are listed below:

1. Table of Contents: Correct spelling of "REPORT" for Attachment A.
2. Page 5, Paragraph 2.4.1: In the last sentence, it appears part of the sentence is missing, or the first letter should be capitalized.
3. Page 12, Paragraph 2.7.2: In the fourth line on this page, change "they" to "the".
4. Page 20, Paragraph 3.3, South Cross Levee: In the first paragraph, add "feet" after "2" in the third sentence. Also, in the second paragraph, add "from" between "feet" and "each" in the second sentence.
5. Figures 1, 2, 4, and 24: These figures are missing.
6. Figure 5: This figure is missing fill in the center of the raised levee. Adjust the section to include this compacted fill.
7. Figure 8: The reconstructed levee should be shifted waterward to be flush with the existing waterside slope. This will lessen the possibility of erosion at the point of excavation, and require less fill on the landside slope flattening.
8. Figure 10. The adjacent raised levee should be shifted waterward to be flush with the existing waterside slope. This will lessen the amount of fill required for constructing the adjacent levee, and reduce the required real estate. The sand and drain rock layer also needs to extend out of the stability berm at the toe.
9. Figures 16 through 23: These figures identify Type 1A or Type 1, 2, or 3 fill. Unless you have descriptions of these type of soils, they should be identified as levee fill, or impermeable fill, or clay, etc.
10. Figures 19, 20, and 22: These figures reference Sheets C-200 through C-207 which are not included.

Thanks,
Mark Boedtker
Civil Engineering Section A
Corps of Engineers
(916) 557-6637

-----Original Message-----
From: Liang, Benson Y SPK
Sent: Thursday, August 06, 2015 12:18 PM
To: Boedtker, Markus S SPK
Cc: Torbik, Richard A SPK
Subject: Engineering Appendix- West Sac GRR (DQC) (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Mark,
Please click the link below to review the engineering appendix for the west Sacramento GRR.
Thanks,
Benson

\\AMETHYST\civcad\WestSacramento\WestSacramentoGRR\CADD\Civil\Engineering_Appendix

Classification: UNCLASSIFIED
Caveats: NONE

Classification: UNCLASSIFIED
Caveats: NONE

Classification: UNCLASSIFIED
Caveats: NONE

Classification: UNCLASSIFIED
Caveats: NONE

QUALITY CONTROL CERTIFICATE FOR COST ENGINEERING PRODUCTS

Project Name: West Sacramento GRR
Project Manager: Bryon Lake

Technical Products: GRR documents
Actual Completion Date: 9/10/2015

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

Preparer: VRCHOTICKY.ROBERT.DEAN.JR.1231223440 Digitally signed by VRCHOTICKY.ROBERT.DEAN.JR.1231223440 DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=USA, cn=VRCHOTICKY.ROBERT.DEAN.JR.1231223440 Date: 2015.09.10 08:57:50 -07'00' 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: REYNOLDS.JOE.LEROY.1383621085 Digitally signed by REYNOLDS.JOE.LEROY.1383621085 DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=USA, cn=REYNOLDS.JOE.LEROY.1383621085 Date: 2015.09.10 08:53:46 -07'00' date:

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

Preparer: VRCHOTICKY.ROBERT.DEAN.JR.1231223440 Digitally signed by VRCHOTICKY.ROBERT.DEAN.JR.1231223440 DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=USA, cn=VRCHOTICKY.ROBERT.DEAN.JR.1231223440 Date: 2015.09.10 08:58:35 -07'00' 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: SESSIONS.CAMERON.LOUIS.1393765972 Digitally signed by SESSIONS.CAMERON.LOUIS.1393765972 DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=USA, cn=SESSIONS.CAMERON.LOUIS.1393765972 Date: 2015.09.10 09:02:09 -07'00' date:

Branch Chief: SALYERS.ELIZABETH.A.1072738370 Digitally signed by SALYERS.ELIZABETH.A.1072738370 DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=USA, cn=SALYERS.ELIZABETH.A.1072738370 Date: 2015.09.10 09:57:09 -07'00' date:

QUALITY CONTROL CERTIFICATE

Environmental Analysis Section, Planning Division

PROJECT NAME: West Sacramento Flood Risk Management Project GRR
PRODUCT: Final Environmental Impact Statement/Environmental Impact Report
ACTUAL COMPLETION DATE:

PROJECT MANAGER: Bryan Lake

The final environmental impact statement 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 District Quality Control (DQC) effort has verified that the environmental effects 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 environmental effects analysis; that the level and scope of the analysis are appropriate for purposes of an environmental effects analysis; and that the results are reasonable and consistent within the context of an environmental effects analysis.

Specific product reviewed: This DQC review focused on the revisions made to the CWRB read-ahead final EIS/EIR resulting from comments received by SPD and OWPR reviewers and from public comments received on the draft EIS/EIR.

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: Sarah Ross-Arouzzet | Title: Environmental Manager

Print Name | Signature: Sarah Ross Arouzzet | Date: 9/11/15

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: Dan Artho | Date: 9/11/15

RESOURCE PROVIDER

I have reviewed the quality control process and ensured that comments have been adequately addressed, documented, and resolved.

Resource Provider: Josh Garcia | Title: Chief, Environmental Analysis Section

Print Name | Signature | Date: 11 SEP 2015

Final West Sac EIS-EIR 8-7-15_DQC_dfa_17aug2015-backcheck.docx

Main document changes and comments

Page 9: Comment [DFA4]	**L2PDRDFA**	**8/18/2015 10:49:00 AM**

Is this restoration for mitigation or is it restoration as a project purpose?

The area will be used for mitigation and habitat creation- I've reworded the sentence to better reflect this. Restoration is not one of our project purposes.

DFA BACKCHECK: Concur. Comment Closed.

Page 10: Deleted	**L2PDRDFA**	**8/10/2015 2:41:00 PM**

be

Page 12: Comment [DFA6]	**L2PDRDFA**	**8/18/2015 10:50:00 AM**

Per the response to EPA comment, a more explicit discussion of how the preferred altnerative was determined to be the LEDPA needs to be included in the FEIS.

Added language here, but also added tables to show acreage impacts based on alternative in Section 3.6- vegetation and wildlife.

DFA BACKCHECK: Concur. Comment Closed.

Page ii: Deleted	**L2PDRDFA**	**9/4/2015 3:25:00 PM**

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Page vii: Deleted	L2PDRDFA	9/4/2015 3:25:00 PM

458

Page 1: Comment [DFA7]	L2PDRDFA	8/18/2015 10:52:00 AM

The GRR did evaluate Federal interest in addressing levee height concerns, even though it ultimately wasn't justified. Suggest leaving the original text here.

Concur

DFA BACKCHECK: Comment closed.

Page 2: Comment [DFA8]	L2PDRDFA	8/18/2015 10:53:00 AM

What is consistent, the study area? Suggest this statement may be more appropriate in another location that discusses consistency with existing land use plans.

Concur- was trying to say that the Alternative was consistent with the delta plan. Will move to land use and discuss ther

DFA BACKCHECK: Comment closed.

Page 7: Inserted	L2PDRDFA	8/10/2015 3:18:00 PM

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Page 7: Deleted	L2PDRDFA	8/10/2015 3:20:00 PM

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Page 7: Inserted	L2PDRDFA	8/10/2015 3:20:00 PM

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Page 9: Comment [DFA9]	L2PDRDFA	8/18/2015 10:53:00 AM

I think the GRR did address levee height concerns by finding that increasing levee heights for the project were not justified. Suggest leaving the text here as is rather than deleting the identification of height concerns.

Concur- left in height

DFA BACKCHECK: Comment Closed.

Page 11: Deleted	L2PDRDFA	8/13/2015 6:32:00 PM

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Page 11: Inserted	L2PDRDFA	8/13/2015 6:29:00 PM

release

Page 11: Comment [DFA10]	L2PDRDFA	8/18/2015 10:56:00 AM

Is this a 1/200 event on the American River concurrent with a 1/200 event on the Sac River? You should clarify what hydrologic assumptions were used for this.

After talking to Jesse about it, I've taken the 1/200 out and added that additional information can be found in the H&H appendices. The assumptions were based on the comprehensive study and the Natomas PAC, but I don't want to add to many specifics here.

DFA BACKCHECK: Comment closed.

Page 12: Comment [DFA11]	L2PDRDFA	8/18/2015 10:56:00 AM

Is this a project cost of the proposed project or cost that should be assigned to existing O&M? Or is this supposed to be a betterment that will be 100% funded by the sponsor?

This is a project cost since the existing port levees are navigation levees and are maintened by the Corps already. The south cross levee is not in the Federal system and needs to be brought up to Federal standards so it is also a project cost.

DFA BACKCHECK: Comment closed.

Page 12: Comment [DFA12]	**L2PDRDFA**	**8/18/2015 10:57:00 AM**

State standard

Moved sentence to paragraph above so it's not confused with the state information.

DFA BACKCHECK: Comment closed.

Page 14: Inserted	**L2PDRDFA**	**8/10/2015 4:22:00 PM**

The finalized document, and all comments received in the final review, will also be used to prepare the Record of Decision (ROD) for the NEPA lead agency

Page 14: Inserted	**L2PDRDFA**	**8/10/2015 4:24:00 PM**

. In the case of the West Sacramento Project the ROD would be signed by the Assistant Secretary of the Army for Civil Works

Page 14: Inserted	**L2PDRDFA**	**8/10/2015 4:26:00 PM**

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Page 14: Comment [DFA13]	**L2PDRDFA**	**8/18/2015 10:58:00 AM**

Not sure if you want to add anything for CEQA.

Added CEQA information

DFA BACKCHECK: Comment closed.

Page 23: Comment [DFA14]	**L2PDRDFA**	**8/18/2015 10:59:00 AM**

I don't think overtopping is a measure or alternative. Suggest simply calling the measureRaising Levees instead.

Changed to raising levees

DFA BACKCHECK: Comment closed.

Page 23: Comment [DFA15]	**L2PDRDFA**	**8/18/2015 11:00:00 AM**

I don't think you have to mention this if all of the areas that had levee raises identified also required geotech fixes. If that is the case, I would suggest that you can delete this part of the sentence.

Concur, deleted sentence

DFA BACKCHECK: Comment closed.

Page 23: Deleted	**L2PDRDFA**	**8/13/2015 8:04:00 PM**

levee raises to meet

Page 23: Inserted	**L2PDRDFA**	**8/13/2015 8:04:00 PM**

reestablish

Page 23: Inserted	L2PDRDFA	8/13/2015 8:04:00 PM

levee

Page 23: Comment [DFA16]	L2PDRDFA	8/18/2015 11:00:00 AM

Suggest this wording

Concur

DFA BACKCHECK: Comment closed.

Page 32: Comment [DFA17]	L2PDRDFA	9/4/2015 1:51:00 PM

This should be a measure carried forward for further consideration. Suggest you delete this paragraph and make sure this is discussed in the Measures Proposed for Alternatives section.

Moved this paragraph here and reworded slight.y.

DFA BACKCHECK: Comment closed.

Page 33: Inserted	L2PDRDFA	8/11/2015 9:48:00 PM

r

Page 33: Comment [DFA18]	L2PDRDFA	9/4/2015 1:52:00 PM

Why shouldn't it be the responsibility of the DWSC O&M responsible parties to maintain the authorized height from the original project? Why is this additional cost born by the current GRR?

These levees are navigation levees and are maintained by the Corps. They need to be improved to complete the protection for the city.

DFA BACKCHECK: Comment closed.

Page 35: Deleted	L2PDRDFA	8/11/2015 10:05:00 PM

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Page 35: Inserted	L2PDRDFA	8/11/2015 10:06:00 PM

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Page 36: Formatted	L2PMCAEB	

Font: Bold

Page 43: Comment [DFA19]	L2PDRDFA	9/4/2015 1:53:00 PM

Wouldn't the North Port, South Port, and cross levee repairs address overtopping? Suggest leaving this in the general identification of concerns.

Concur

DFA BACKCHECK: Comment closed.

Page 43: Comment [DFA20]	L2PDRDFA	9/4/2015 1:53:00 PM

Suggest keeping this category as Overtopping Measures

Concur

DFA BACKCHECK: Comment Closed.

Page 45: Comment [DFA21]	L2PDRDFA	9/4/2015 1:54:00 PM

Recommend not deleting since work on north port and south port levees are still included in the alternative to address overtopping.

Concur

DFA BACKCHECK: Comment Closed.

Page 48: Comment [DFA22]	**L2PDRDFA**	**9/4/2015 3:22:00 PM**

No longer a measure?

The south cross levee does still need to be raised to be consistent with the system standard.

DFA BACKCHECK Comment closed.

Page 49: Comment [DFA23]	**L2PDRDFA**	**8/13/2015 8:20:00 PM**

Delete

Page 52: Comment [DFA24]	**L2PDRDFA**	**9/4/2015 1:55:00 PM**

Shouldn't this be deleted?

Concur

DFA BACKCHECK: Comment closed.

Page 52: Comment [DFA25]	**L2PDRDFA**	**9/4/2015 1:56:00 PM**

Thought there were no longer any height improvements? Or does this consideration only apply to Alternative 5?

Reworded the improvement, there are height improvements on the port north for every alternative, but for Alt 3 they are taken care of with the closure structure.

DFA BACKCHECK: Comment closed.

Page 53: Comment [DFA26]	**L2PDRDFA**	**9/4/2015 1:56:00 PM**

No longer applies to Alt 3?

It still applies, reworded the measure to be consistent with Alt 1

DFA BACKCHECK: Comment closed.

Page 57: Comment [DFA27]	**L2PDRDFA**	**9/4/2015 1:57:00 PM**

No longer considered for Alt 3?

Deleted

DFA BACKCHECK: Comment closed.

Page 57: Comment [DFA28]	**L2PDRDFA**	**9/4/2015 1:58:00 PM**

No longer considered for Alt 3?

Deleted

DFA BACKCHECK: Comment closed.

Page 58: Comment [DFA29]	**L2PDRDFA**	**9/4/2015 1:58:00 PM**

Does this need to be updated?

Updated the table

DFA BACKCHECK: Comment closed.

Page 59: Comment [DFA30]	**L2PDRDFA**	**9/4/2015 1:59:00 PM**

Delete or change to reestablish authorized levee height? Be consistent with what was described in Section 2.1.3.

DFA BACKCHECK: Comment closed.

Page 60: Comment [DFA31]	**L2PDRDFA**	**9/4/2015 2:00:00 PM**

Update column to reflect current levee height discussion.

Updated

DFA BACKCHECK: Comment closed.

Page 61: Comment [DFA32]	**L2PDRDFA**	**9/4/2015 2:00:00 PM**

Update to reflect current levee height discussion

Updated

DFA BACKCHECK: Comment closed.

Page 61: Comment [DFA33]	**L2PDRDFA**	**9/4/2015 2:01:00 PM**

Update column to reflect current levee height discussion.

Updated

DFA BACKCHECK: Comment closed.

Page 63: Comment [DFA34]	**L2PDRDFA**	**9/4/2015 2:01:00 PM**

Update discussion

Updated

DFA BACKCHECK: Comment closed.

Page 63: Comment [DFA35]	**L2PDRDFA**	**9/4/2015 2:01:00 PM**

Update discussion

DFA BACKCHECK: Comment closed.

Page 63: Comment [DFA36]	**L2PDRDFA**	**9/4/2015 2:02:00 PM**

Update discussion

DFA BACKCHECK: Comment closed.

Page 63: Comment [DFA37]	**L2PDRDFA**	**9/4/2015 2:03:00 PM**

I didn't find the O&M description for alternative 1. Still working on this? Why is a discussion on O&M associated with expanded Sac Weir and Bypass to be included in the West Sac Project?

Updated and added discussion in Section 2.3.3- It was a remnant from ARCF

DFA BACKCHECK: Comment closed.

Page 69: Comment [DFA38]	**L2PDRDFA**	**9/4/2015 2:03:00 PM**

Low relative to what? Is there any way that this can be put into perspective?

I added some language that should help to explain. It's based on the flood protection ability after a 200 yr event.

DFA BACKCHECK: Comment closed.

Page 70: Formatted	**L2PMCAEB**	

Font: 11 pt, Font color: Auto

Page 72: Comment [DFA39]	**L2PDRDFA**	**9/4/2015 2:05:00 PM**

Include a discussion on consistency with or effects to this land use plan as indicated in the comment responses.

DFA BACKCHECK: Comment closed pending addition of discussion on consistency with Delta Plan.

Page 81: Comment [DFA40]	**L2PDRDFA**	**9/4/2015 2:06:00 PM**

What is consistent, the study area? Suggest this statement may be more appropriate in another location that discusses consistency with existing land use plans.

Concur- have added a discussion here

DFA BACKCHECK: Comment closed pending addition of discussion on consistency with Delta Plan.

Page 119: Inserted	**L2PDRDFA**	**8/11/2015 10:38:00 PM**

o

Page 126: Inserted	**L2PDRDFA**	**8/13/2015 8:47:00 PM**

Page 126: Comment [DFA41]	**L2PDRDFA**	**9/4/2015 2:06:00 PM**

Shouldn't this paragraph be in the water quality section?
There is a very similar paragraph in water quality. I took out the specific reference to water quality here. I added this paragraph in response to the EPA comments to highlight the benefits of Alt 5 so I'd like to leave it here as well.

DFA BACKCHECK: Comment closed.

Page 127: Comment [DFA42]	**L2PDRDFA**	**9/4/2015 2:07:00 PM**

Why was this deleted? Suggest keeping it.
At some point there was a comment that we didn't talk about functions and values elsewhere so we deleted it. I added it back in.

DFA BACKCHECK: Comment closed.

Page 130: Inserted	**L2PDRDFA**	**8/13/2015 8:57:00 PM**

project

Page 138: Comment [DFA43]	**L2PDRDFA**	**9/4/2015 2:08:00 PM**

O&M not describe in this section.

Updated Section 2.3.3

DFA BACKCHECK: Comment closed.

Page 188: Comment [DFA44]	**L2PDRDFA**	**9/4/2015 2:09:00 PM**

Include discussion on BO requirements.

Will incluce

DFA BACKCHECK: Comment closed pending discussion of BO requirements here.

Page 219: Comment [DFA45]	L2PDRDFA	9/4/2015 2:10:00 PM

No alternative 2

Corrected this

DFA BACKCHECK: Comment closed.

Page 413: Inserted	L2PDRDFA	8/13/2015 9:18:00 PM

s

Page 413: Inserted	L2PDRDFA	8/13/2015 9:18:00 PM

ve

Page 413: Deleted	L2PDRDFA	8/13/2015 9:18:00 PM

s

Page 420: Comment [DFA46]	L2PDRDFA	9/4/2015 2:11:00 PM

Add a discussion on compliance with the Delta Plan. Is it a State or Federal Law?

Added below

DFA BACKCHECK: Comment closed pending addition of discussion on Delta Plan compliance.

Header and footer changes

Text Box changes

Header and footer text box changes

Footnote changes

Endnote changes

Responses to Public Comments-updated 21Jul15_DQC_dfa_backcheck_11sep2015(2).docx

Main document changes and comments

Page 4: Inserted	**L2PDRDFA**	**8/12/2015 10:46:00 PM**

C

Page 4: Inserted	**Sarah Ross**	**9/10/2015 4:07:00 PM**

by WSAFCA through their Southport 408 project

Page 4: Comment [DFA1]	**L2PDRDFA**	**9/11/2015 8:50:00 AM**

Is ecosystem restoration a project purpose?

No, it's just a flood risk reduction project, hopefully the added language clarifies that.

DFA BACKCHECK: Comment closed.

Page 7: Inserted	**Sarah Ross**	**9/10/2015 4:12:00 PM**

Section 3.6 of

Page 8: Comment [DFA2]	**L2PDRDFA**	**9/11/2015 8:53:00 AM**

Suggest identifying which sections the language was added to.

Added

DFA BACKCHECK: Comment closed.

Page 8: Inserted	**Sarah Ross**	**9/10/2015 4:12:00 PM**

The Corps has also updated the mitigation measures in Section 3.6.7 to include wetland delineations in the pre construction engineering and design phase and to avoid and minimize impacts to wetlands where possible .

Page 8: Deleted	**Sarah Ross**	**9/10/2015 4:12:00 PM**

will

Page 8: Inserted	**Sarah Ross**	**9/10/2015 4:12:00 PM**

has

Page 8: Inserted	**Sarah Ross**	**9/10/2015 4:12:00 PM**

d

Page 8: Comment [DFA3]	**L2PDRDFA**	**9/11/2015 8:54:00 AM**

Suggest you do this as well, if it was developed in-house and can be easily accomplished.

Updated

DFA BACKCHECK: Comment closed.

Page 8: Inserted	**Sarah Ross**	**9/10/2015 4:12:00 PM**

The revised 404(b)(1) analysis is provided in Appendix F to the final EIS/EIR.

Page 8: Inserted	**Sarah Ross**	**9/10/2015 4:13:00 PM**

has

Page 8: Inserted	**Sarah Ross**	**9/10/2015 4:13:00 PM**

Chapter 3, Section 3.6.7 of

Page 8: Inserted	**Sarah Ross**	**9/10/2015 4:13:00 PM**

has

Page 8: Inserted	**Sarah Ross**	**9/10/2015 4:14:00 PM**

in Section 3.6 of the final EIS/EIR

Page 8: Comment [DFA4]	**L2PDRDFA**	**9/11/2015 8:54:00 AM**

Identify sections in EIS/EIR that changes were made.

Added

DFA BACKCHECK: Comment closed.

Page 8: Inserted	**Sarah Ross**	**9/10/2015 4:15:00 PM**

Plates for land type and waters of the US including wetlands have been included in the plates.

Page 9: Deleted	**Sarah Ross**	**9/10/2015 4:15:00 PM**

page XX

Page 9: Inserted	**Sarah Ross**	**9/10/2015 4:15:00 PM**

Chapter 2 and Chapter 3, Sections 3.6, 3,7, and 3.8

Page 9: Comment [DFA5]	**L2PDRDFA**	**9/11/2015 8:55:00 AM**

Identify section in EIS where changes can be found.

Added

DFA BACKCHECK: Comment closed.

Page 9: Comment [DFA6]	**L2PDRDFA**	**9/11/2015 8:57:00 AM**

Is this a significant additional cost that would affect the justification of the selected plan?

No, the selected plan would still have the least impacts to vegetation along levees because of the setback levee.

DFA BACKCHECK: Comment closed.

Page 9: Comment [DFA7]	**L2PDRDFA**	**9/11/2015 12:22:00 PM**

What was this ratio based on? May want to include qualifying language that acknowledges the Corps CE/ICA requirement for deterimining mitigation needs.

Added language

DFA BACKCHECK: Corps policy requires a cost effectiveness/incremental cost analysis be done for any habitat mitigation needs. Isn't one being prepared? Comment Open.

The CE/ICA was conducted for this project and is discussed in Section 3.6 and 3.6.7 of the EIS. The 2:1 mitigation ration did turn out to be a best buy plan.

DFA BACKCHECK(2): Comment closed.

Page 9: Inserted	**Sarah Ross**	**9/10/2015 4:17:00 PM**

as discussed in Chapter 3, Section 3.6.7 of the EIS/EIR

Page 9: Inserted	**Sarah Ross**	**9/10/2015 4:17:00 PM**

The 2:1 ratio was developed in coordination with USFWS as discussed in Section 3.6 to mitigation for temporal loss of habitat.

Page 10: Inserted	**Sarah Ross**	**9/10/2015 4:19:00 PM**

Chapter 2 and Chapter 3, sections 3.6, 3.7, and 3.8

Page 10: Deleted	**Sarah Ross**	**9/10/2015 4:19:00 PM**

page XX

Page 10: Inserted	**Sarah Ross**	**9/10/2015 4:19:00 PM**

1 in Appendix I

Page 10: Deleted	**Sarah Ross**	**9/10/2015 4:19:00 PM**

XX

Page 14: Deleted	**Sarah Ross**	**9/10/2015 4:20:00 PM**

will

Page 14: Inserted	**Sarah Ross**	**9/10/2015 4:20:00 PM**

has

Page 14: Inserted	**Sarah Ross**	**9/10/2015 4:20:00 PM**

d

Page 14: Inserted	**Sarah Ross**	**9/10/2015 4:20:00 PM**

in Appendix C, the Cultural Resources Appendix

Page 14: Comment [DFA8]	L2PDRDFA	9/11/2015 9:04:00 AM

Identify what section in the EIS this information would be added.

DFA BACKCHECK: Comment closed.

Page 16: Inserted	Sarah Ross	9/10/2015 4:23:00 PM

in Chapter 4, Section 4.2.13

Page 16: Deleted	Sarah Ross	9/11/2015 12:10:00 PM

.

Page 16: Comment [DFA9]	L2PDRDFA	9/11/2015 12:24:00 PM

Suggest adding a summary of the findings of the additional evaluation. Also, I think PG&E is wanting you to make an assessment of impacts to all affected resources associated with their construction activities to do the relocation. Do we have enough detail in our designs at this point to make an assessment on impacts associated with utility relocations? If not, would this require supplemental environmental analyses when the detail is known? Might want to check with OC.

See responses to OC comments . We don't have enough information to do that kind of analysis right now.

DFA BACKCHECK: Where are the responses to OC comments? In this instance, since there is a lack of detail you should indicate that supplemental environmental analyses would be completed during PED if final designs indicate that need. Comment Open.

Sent responses to OC comments and included additional language about conducting additional analysis in PED.

DFA BACKCHECK(2): Comment closed.

Page 16: Inserted	Sarah Ross	9/11/2015 12:10:00 PM

and if necessary, supplemental environmental analyses would be completed during PED if final designs indicate that need.

Page 17: Comment [DFA10]	L2PDRDFA	9/11/2015 9:05:00 AM

What attached memo?

Attached to email, will include it with these responses.

DFA BACKCHECK: Comment closed.

Page 17: Comment [DFA11]	L2PDRDFA	9/11/2015 9:06:00 AM

What attached memo?

Attached to email

DFA BACKCHECK: Comment closed.

Page 18: Deleted	**Sarah Ross**	**9/11/2015 12:14:00 PM**

restoration

Page 18: Inserted	**Sarah Ross**	**9/10/2015 4:32:00 PM**

mitigation

Page 18: Deleted	**Sarah Ross**	**9/10/2015 4:33:00 PM**

benefits to

Page 18: Inserted	**Sarah Ross**	**9/11/2015 12:14:00 PM**

to be implemented in the project area.

Page 18: Deleted	**Sarah Ross**	**9/11/2015 12:14:00 PM**

the Sacramento River system.

Page 18: Comment [DFA12]	**L2PDRDFA**	**9/11/2015 12:24:00 PM**

ER is not a project purpose. Suggest deleting this statement unless this is a relevant statement for this commenter.

Per OC's request have sent ICF these comments to get some additional input from them.

DFA BACKCHECK: Still not clear as to why this setback feature is needed for FRM. I like the idea of setback levees, but in this case it seems like it is only included in the plan as an ER feature. Therefore, wouldn't it be considered a betterment in a FRM-only project, which would be 100% non-Fed cost? Need stronger justification for inclusion of this setback as a necessary FRM feature, particularly if there is such opposition from the landowner. Comment open.

Removed restoration and changed the sentence.

DFA BACKCHECK(2): Comment closed.

Header and footer changes

Text Box changes

Header and footer text box changes

Footnote changes

Endnote changes

QUALITY CONTROL CERTIFICATE

Environmental Planning Section, Planning Division

PROJECT NAME: West Sacramento Project GRR
PRODUCT: Habitat Mitigation Monitoring and Adaptive Management Plan
ACTUAL COMPLETION DATE:

PROJECT MANAGER: Bryan Lake

The District has completed review of the habitat mitigation monitoring and adaptive management plan for the West Sacramento 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: Sarah Ross-Arrouzet   Title: Senior Environmental Manager

[signature] 12/1/15

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: Dan Artho   Title: Senior Environmental Manager

[signature] 12/1/15

Signature   Date

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

Ziminsky, Mark T.   [signature] 1/7/16

Signature   Date

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

QUALITY CONTROL CERTIFICATE FOR GEOTECHNICAL ENGINEERING PRODUCTS

Project Name: West Sacramento GRR
Project Manager: Glen Reed
Lead Planner: Andrew Muha
Technical Lead: Benson Liang

Preparing Organization Soil Design Section B

Technical Product Name: West Sacramento General Reevaluation Report Geotechnical Appendix

Actual Completion Date: 10/14, modified 9/9/15 per ATR comments.

CERTIFICATION

I have reviewed and resolved all critical and technical issues that arose during ATR after the previous certificate was signed. 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

Signature – Erik W James, PE, PG

Branch Chief: ______________________ Date: 9/9/15

Signature – April L. Fontaine, PG

West Sacramento Project
DISTRICT QUALITY CONTROL CERTIFICATE
General Reevaluation Report (GRR)

The District Quality Control (DQC) has been completed for the General Reevaluation Report Report (GRR) for the West Sacramento Project specific to the Geotechnical Appendix. The reviewer has thoroughly checked the calculations including assumptions, mandated parameters, references, given values, and formulas. The reviewer has checked for omissions and accuracy of arithmetic; asked questions of the analyst if unsure of any particular element of the calculation; and reviewed the output data of computer calculations for consistency with expected results.

DQC was conducted as defined in the project's Review Plan to comply with the requirements of EC 1165-2-214. During the DQC, 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 design and analyses of the West Sacramento Project study area, the appropriateness of data used and level obtained, and reasonableness of the results, including whether the design meets the Corps' needs consistent with law and existing US Army Corps of Engineers policy.

Product(s) Description: *Geotechnical Appendix – West Sacramento Project – General Reevaluation Report*

Originated by: *Anthony J. Deus*

Print Name: Anthony J. Deus Sign/Date: [signature] 1/8/2014

Reviewed by: *Mary Perlea*

☒ Package of product/calculations have been checked and no outstanding issues identified.

☒ Package of product/calculations have been checked and outstanding issues identified.

☒ Dr. Check's comments, responses, and back-checks have been closed or addressed.

Print Name: Mary Perlea Sign/Date: [signature] 1/8/14

Corrected by: *Anthony J. Deus*

Print Name: Anthony J. Deus Sign/Date: [signature] 1/8/2014

Back-checked by: *Mary Perlea*

Print Name: Mary Perlea Sign/Date: [signature] 1/28/2014

Quality Assurance Verification by: *Derek S. Morley*

Print Name: Derek S. Morley Sign/Date: [signature]

WEST SACRAMENTO GRR
SPK HYDRAULIC ANALYSIS SECTION
DISTRICT QUALITY CONTROL REVIEW

HYDRAULIC APPENDIX
WEST SACRAMENTO TSP SELECTION

Reviewer: Morgan Marlatt
Hydraulic Engineer, Hydraulic Analysis Section
Review Date: September 23, 2013

The following contains SPK District Quality Control (DQC) performed on the report noted above.

No.	Date	Notes
1.	Comment	Table of Contents – Some of the page numbers are missing/incorrectly linked. Please fix.
	Response	Table of contents was fixed. All sections are referenced correctly.
	Back-check	Thank you, Comment closed.
2.	Comment	Section 1.1 mentions a list of memos follows the Table of Contents, but this list does not appear in the document after the Table of Contents. Please either add the list or remove the reference to the location after the table of contents.
	Response	List was added on page 6
	Back-check	Thank you, Comment closed.
3.	Comment	Plates – The plates listed in this document are not listed in traditional order (1, 2, 3 … etc), the first plate mentioned is Plate 4, suggest renumbering plates so they go in order of the references in the report. Also, some plates (1, 3, 23, 24) were not mentioned in the report.
	Response	Plates were re-numbered to match order discussed in document. All plates are now referenced.
	Back-check	Thank you, Comment closed.
4.	Comment	Section 1.2, 3rd paragraph, 3rd sentence – Tells readers to see Plate 2 for the system layout, but plate 3 has the system layout. Please correct or renumber the plates.
	Response	Plates were re-numbered and references the correct plate.

	Back-check	Thank you, Comment closed.
5.	Comment	Please add page numbers to this document.
	Response	Page numbers were added.
	Back-check	Thank you, Comment closed.
6.	Comment	Section 1.3, last paragraph, last sentence – Please define SACOG or develop an acronyms list.
	Response	SACOG is the Sacramento Area Council of Governments. This was added to the document text.
	Back-check	Thank you, Comment closed.
7.	Comment	Section 1.4, 4th paragraph – Since some of the work has been postponed; do we have a risk register for any potential issues for not doing the work before design phase?
	Response	The assumptions made to reduce the level of detail or postponed analyses until the design phase are captured in the Risk Register.
	Back-check	Can you please provide a copy of the risk register?
	Response	Copy of Risk Register was provided
	Back-check	Thank you, Comment closed.
8.	Comment	Table 1.1, Climate Change – Add a reference to the Sutter Feasibility Study in case your reader is unfamiliar with their methodology. Sea Level Rise – Is there a document to reference?
	Response	Added reference to the Climate Change technical memo that further describes methodology (and has reference to Sutter Feasibility Study). For Sea Level Rise, I referenced the Dynamic Solutions report.
	Back-check	Thank you, Comment closed.
9.	Comment	Section 2.1 – This is a great description of the area, can you add the northern and southern sub-basin labels to the project map and reference the map? And, make sure the terms in bold are the same terms used for labeling on the plate map.
	Response	Northern and southern sub-basin labels were added, names in the plate and document match, and map was referenced in text of

		document.
	Back-check	On plate 3 the label is “Sacramento River South Levee” and in the report it is “Sacramento River West South Levee” – please correct.
	Response	The report text was changed to “Sacramento South Levee” to match the label in plate 3.
	Back-check	Thank you, Comment closed.
10.	Comment	Section 2.1 – second paragraph – suggest adding a footnote to “rivermile” identifying if these are Comp Study River miles or USGS river miles.
	Response	Footnote was added. River miles refer to river miles from the Sacramento Basin HEC-RAS model and UNET Comp Study model.
	Back-check	Thank you, Comment closed.
11.	Comment	Section 2.2, 2nd paragraph – Do you need to mention Sac Bank and the Southport 408 project? The SacBank setback at RM 57.2 is near completion – will it be part of the without project conditions?
	Response	These are not included as the without project condition. The Southport 408 has not been approved and we are analyzing it as alternative 5. A discussion of the SacBank setback has been added. Since there is no hydraulic impact with the SacBank setback, it will not affect the West Sac results.
	Back-check	Thank you, Comment closed.
12.	Comment	Section 3.1, 3rd paragraph – The DWSC is dredged regularly, does the topo in the model account for this, was it done before or after the latest dredging and was there any coordination done with that project?
	Response	This section references the DWSC Technical Memorandum. In this memo it describes topography and bathymetry based on Comp Study, DWSC soundings from 2008 & 2009, and 2006 LiDAR. The bathymetry was updated with data from the soundings (that represents depths with dredging). These sources of data are considered to be best available.
	Back-check	Thank you, Comment closed.
13.	Comment	Section 3.3, last paragraph – Is there somewhere the reader can see the comparison of model results and calibration data?
	Response	All that information is in the Calibration Technical Memo (referenced in paragraph 1 of Section 3.3)
	Back-check	Thank you, Comment closed.

14.	Comment	Section 3.4, 1st paragraph, 3rd sentence – This sentence mentions levee raising, this is the first mention of this in this appendix, this should probably have been mentioned before as it is not clear whether you are referring to levee raises in regards to this project or levee raises from other projects previously discussed in this document.
	Response	Since this section is discussing FWOP, I moved the levee raising discussion to Alternative 1.
	Back-check	Thank you, Comment closed.
15.	Comment	Plate 18 is either mislabeled as the 10-yr WSE or it is the wrong figure, please fix as appropriate.
	Response	Plate 18 was updated with the 200-yr WSEL profile.
	Back-check	Thank you, Comment closed.
16.	Comment	Section 4.1, last 2 paragraphs – Mentions that in Plates 11 – 20, alternatives 1 – 4 are shown, but in Plates 11, 12, 13, 14, 16, 17, 18, and 19, only alternatives 1 and 2 are shown.
	Response	For plates 11-19, Alt 1 & Alt 3 are the same (represented by the same line) and Alt 2 & Alt 4 are the same (also represented by the same line). This is shown and labeled in the key.
	Back-check	Thank you, Comment closed.
17.	Comment	Plates 12 and 17 – There is one line for the top of levee and it is labeled "top of levee left right." Which bank does this represent and where is the line representing the opposite bank?
	Response	The line was to represent the right bank. A line for the left bank was also added.
	Back-check	Thank you, Comment closed.
18.	Comment	Plates 11 – 20 – Please add a summary of the graphs in section 4.1. Also add to the report why you are only showing the 10-yr and 200-yr results when you ran the whole slew of n-yr events.
	Response	Summary of graphics was added. Discussion of why 10-yr and 200-yr are the only results being reported was also added.
	Back-check	Thank you, Comment closed.
19.	Comment	Section 4.2, 2nd paragraph – If your fixes for this alternative are primarily landside fixes, how does that address erosion, and lack of veg compliance? Maybe a figure depicting which areas would be fix in place and which areas would be adjacent levees would help to answer this.
	Response	This section was updated. After checking with Planning and team

		members, all fixes proposed are fix in place (no adjacent levees).
	Back-check	Thank you, Comment closed.
20.	Comment	Table 4-1 – The label for this table should be above the table and the font size should not be smaller than the font size in the table.
	Response	The label was moved to above the table and font size increased.
	Back-check	Thank you, Comment closed.
21.	Comment	Table 4-1 – The column with the "No." heading, I assume that is the reach number? If so, please state that, otherwise remove.
	Response	The "No." column was removed.
	Back-check	Thank you, Comment closed.
22.	Comment	Section 4.3, 1st paragraph, 2nd sentence – Please add a word after "more" to indicate what you are redirecting.
	Response	The word "water" was added after "more"
	Back-check	Thank you, Comment closed.
23.	Comment	Section 4.4 – Please reference Plate 23 for the location of the closure structure. Also Plate 24 for Section 4.5
	Response	Plate 23 and 24 were referenced in Section 4.4 and 4.5, respectively.
	Back-check	Thank you, Comment closed.
24.	Comment	Section 4.3 – What model was used to analyze the widening? Can you state it and add some more details about how much water you expect to be diverted into the bypass rather than continuing down the Sacramento River?
	Response	The same HEC-RAS model used to analyze Alternative 1 was used (with adjustments to the Sacramento Weir width). Also added sentence "With this alternative the stages at the downstream portion of West Sacramento (near the Pocket) would be reduced by a foot (compared to the FWOP condition)." Since this alternative has been screened out, I did not spend too much time adding significant detail.
	Back-check	Thank you, Comment closed.
25.	Comment	Section 4.6 – States assumptions about the setback being hydraulically neutral. Does this mean you are assuming it will not affect flow splits? Or are you not concerned since you anticipate less flow in this reach due to the Sacramento Bypass widening?
	Response	Section 4.6 has been revised with input from management.

	Back-check	Thank you, Comment closed.
26.	Comment	Section 5.1, 1st paragraph, last sentence – Please add to this sentence that these are the without project floodplains.
	Response	This was added in.
	Back-check	Thank you, Comment closed.
27.	Comment	Section 5.3 needs a little more information so the reader doesn't wonder what the purpose of the project is if we are not changing the floodplains or residual risk. In the first sentence when stating that the floodplains remain unchanged, add an explanation that while they remain unchanged the chance of breaching is reduced.
	Response	Further explanation was added to the first paragraph in Section 5.3
	Back-check	Thank you, Comment closed.
28.	Comment	Plates 34 – 41 – The index point RMs are provided to four decimal places, I doubt that you have quite that accuracy, perhaps only provide to the tenth place. Also, was the HEC-RAS model accurate enough to provide values to the hundredth place?
	Response	The RMs were changed to only represent the hundredth place. The detail in RM was kept so it can match the HEC-RAS RMs. The water surface elevation data was rounded to represent stages to the tenth place (not hundredths).
	Back-check	Thank you, Comment closed.
29.	Comment	Plate 34 – For Index Point 1 at RM 61.4986, the flows are all listed as N/A, which I understand that you did that for when there is reverse flow in the system, but for the lower flows, can you list the appropriate flow data?
	Response	Flows for the 2year and 10year events were added into the table.
	Back-check	Thank you, Comment closed.
30.	Comment	Section 6.2, last sentence – Suggest that you change "due to backwater effects" to "due to reverse flow and backwater effects, respectively"
	Response	This was changed.
	Back-check	Thank you, Comment closed.
31.	Comment	Table 6-5 needs to be filled out. Also, there is no table 6-2, 6-3, or 6-4, so consider renaming to table 6-2.
	Response	Table was changed to 6-2. Waiting for Economics analysis to be

		complete before filling out the table.
	Back-check	Comment remains open until table is complete.
	Response	Table was filled out by Econ Section and added in.
	Back-check	Thank you, Comment closed.
32.	Comment	Section 7.1, last paragraph – I believe there is only one weir in the West Sac project area that diverts water to the Yolo bypass, please correct. Also, consider adding a map showing the incidental low areas that will likely overtop first.
	Response	This was corrected. Low spots can be seen in Plates 6-10 where the water surface profile for n-year events is compared to the levee profile. Also, in Plate 21 that shows locations of height deficiencies.
	Back-check	Thank you, Comment closed.
33.	Comment	Section 7.3 – This section references EC 1165-2-211 and EC 1165-2-212 – both are documents on Sea Level change, but I believe with just different expiration dates. This report should be consistent on which document was used. Since this references the delta project, then it should probably be whichever EC they used.
	Response	The Dynamic Solutions analysis on the Delta used the EC1165-2-211. This is what is referenced.
	Back-check	Thank you, Comment closed.
34.	Comment	Section 7.3.5, second paragraph – First sentence states "no changes on the Sacramento at Verona" and then the next sentence states "difference in stage of two-tenths of a foot for the 10-yr event on the Sacramento River at Verona" These seem to contradict each other, please clarify.
	Response	It was a typo. There is two-tenths of a foot difference for Sacramento River at Freeport.
	Back-check	Thank you, Comment closed.
35.	Comment	Table 7-6 – Please verify the numbers in this box.
	Response	I double checked the numbers that Levee Safety Section gave me and seem to match. However, as noted in the documentation, these numbers are still draft and subject to change after presented to LSOG.
	Back-check	Thank you, Comment closed.
36.	Comment	Section 8.1, 2nd paragraph – This mentions more analysis is expected, is this going to be done by this project or a different project? When this is done, are you planning on updating this report?
	Response	Further analysis will be done by the West Sacramento GRR project. With SMART planning we do not have time or funding for detailed

		analysis; this will occur in PED.
	Back-check	Thank you, Comment closed.
37.	Comment	Section 8.1, 2nd paragraph – Mentions 3 alternatives, but there are 4 alternatives to this project, which 3 are you referring to or should all 4 alternatives be mentioned?
	Response	That was a typo. Erosion repair is included for all alternatives.
	Back-check	Thank you, Comment closed.
38.	Comment	Table 8.2 – Please move the title to the top of the table. Also, can you add a column as to which site was identified by which firm so that if someone wanted to look at the respective reports they will know which one to look in?
	Response	Table title was moved to the top. Adding more detail of which firm identified what site would make the table a little complicated as there were overlaps that were combined to one site. The intention of this was to be concise (SMART planning) and reference the URS and NHC documents if someone was seeking more detail.
	Back-check	Understood, Comment closed.
39.	Comment	Floodplain Maps – Can you please re-label these as "Inundation Maps" so as to avoid confusion with FEMA floodplain maps and because the flooding is the result of levee breaching.
	Response	The maps were re-labeled as "Inundation Maps"
	Back-check	Thank you, Comment closed.
40.	Comment	Table 8-2 – Can you show the identified erosion locations on a map?
	Response	Locations with erosion sites are shown in Plates 21-25 (Alternatives 1-5 all have the same erosion locations)
	Back-check	Thank you, Comment closed.
41.	Comment	Table 8-2 – Did your project look at the erosion sites identified by DWR's Flood Project Integrity and Inspection Branch's annual inspection? http://cdec.water.ca.gov/fsir.html Did you look at the erosion sites identified by the Sacramento River Bank Protection Project?
	Response	From the sites identified by URS and NHC studies, most of the Sacramento River (within the project area) has erosion problems. There are very few Sac Bank fixes within the project area.
	Back-check	Thank you, Comment closed.
42.	Comment	Section 8.4, second paragraph – Can you please add a map that shows the areas of high, medium, and low risk of failure due to

		wind?
	Response	Plate 42 was added; this shows areas of high, medium and low risk of failure due to wind. The plate was also referenced in the text of the document.
	Back-check	Please add text to this plate indicating that this is risk associated with wind.
	Response	Text indicating risk from wind wave was added.
	Back-check	Thank you, Comment closed.
43.	Comment	Section 8.5 – I think you might want to investigate erosion from boat wake a bit further, there are ocean-going yachts that travel through this reach and barge canals carrying tons of rock come through occasionally. There is also no speed limit or "no wake zone" in the majority of the Sacramento River. Was any analysis done to say it is insignificant?
	Response	An analysis was not done to say boat wave erosion is not significant. It is assumed it is not significant and that any boat wave erosion that may occur would be addressed by Sac Bank or by O&M.
	Back-check	Thank you, Comment closed.
44.	Comment	Section 8.6 – This section mentions the use of a waiver for vegetation. The ETL has the option for a variance, but a request must be made by the local sponsor, is the local sponsor prepared to ask for a variance and likely to get one? If they are not, then can we leave the vegetation in the designs?
	Response	The local sponsor will submit a variance request. The assumption at this point is it will likely be granted.
	Back-check	Thank you, Comment closed.
45.	Comment	Section 8.6 – There is mention of analyzing scour, it mentions the analysis will likely use HEC-18, can you confirm this is what will be used and take "likely" out of the sentence?
	Response	Since this work will be completed in PED we cannot say for certain which model will be used.
	Back-check	Thank you, Comment closed.

QUALITY CONTROL CERTIFICATE

Hydraulic Design/Analysis Section, Engineering Division

PROJECT NAME: WEST SACRAMENTO GENERAL RE-EVALUATION STUDY
PRODUCT: HYDRAULIC APPENDIX TO SUPPORT FINAL ARRAY OF ALTERNATIVES FOR WEST SACRAMENTO STUDY
Actual Completion Date: 17-Oct-13

PROJECT MANAGER: TOM KARVONEN

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

District Quality Control was performed for the West Sacramento General Re-evaluation Study on the Hydraulic appendix to support the final array of alternatives for the feasibility study.

The purpose of this document is to present the summary of hydraulic analyses conducted to support the West Sacramento GRR Study. This is an executive report of what has been traditionally known as a hydraulic appendix. A collection of technical memorandums (developed to support the Common Features GRR project) are referenced to provide detailed information typically found in a full version of the hydraulic appendix. This executive report has been prepared to meet the intention of the new Planning Modernization that USACE has undertaken.

Both Flo2D and HECRAS models were used for this effort.

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.

Hydraulic Lead: Kristy Riley

Kristy Riley	Kristy Riley	10/17/13
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: Morgan Marlatt   Title: Senior Hydraulic Engineer

Morgan Marlatt	M. Marlatt	10/17/13
Print name	Signature	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.

Acting Section Chief: Jesse Schlunegger

Jesse Schlunegger	Jesse Schlunegger	10-24-2013
Print name	Signature	Date

QUALITY CONTROL CERTIFICATE

Hydraulic Design/Analysis Section, Engineering Division

PROJECT NAME: WEST SACRAMENTO GENERAL RE-EVALUATION STUDY
PRODUCT: HYDRAULIC APPENDIX TO SUPPORT FINAL ARRAY OF ALTERNATIVES FOR WEST SACRAMENTO STUDY
Actual Completion Date: 14-Sep-15

PROJECT MANAGER: BRYON LAKE

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

Additional District Quality Control was performed for the West Sacramento 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 hydraulic analyses conducted to support the West Sacramento General Re-evaluation Report (ARCF GRR) Study. This is a summary 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.

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
ARCF-West Sac TSP Comparison
DWSC vs Port Levees

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.

Print name	Signature	Date
Title: Senior Hydraulic Engineer Gene Maak	[signature]	14 Sept 2015

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.

Print name	Signature	Date
DQC Reviewer: Jesse Schlunegger	Title: Hydraulic Analysis Section Chief [signature]	14-Sept-2015

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.

Print name	Signature	Date
Section Chief: Jesse Schlunegger	[signature]	14-Sept-2015

QUALITY CONTROL CERTIFICATE

Hydraulic Design/Analysis Section, Engineering Division

PROJECT NAME: WEST SACRAMENTO GENERAL RE-EVALUATION STUDY
PRODUCT: HYDRAULIC APPENDIX TO SUPPORT FINAL ARRAY OF ALTERNATIVES FOR WEST SACRAMENTO STUDY
Actual Completion Date: 17-Oct-13

PROJECT MANAGER: TOM KARVONEN

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

District Quality Control was performed for the West Sacramento General Re-evaluation Study on the Hydraulic appendix to support the final array of alternatives for the feasibility study.

The purpose of this document is to present the summary of hydraulic analyses conducted to support the West Sacramento GRR Study. This is an executive report of what has been traditionally known as a hydraulic appendix. A collection of technical memorandums (developed to support the Common Features GRR project) are referenced to provide detailed information typically found in a full version of the hydraulic appendix. This executive report has been prepared to meet the intention of the new Planning Modernization that USACE has undertaken.

Both Flo2D and HECRAS models were used for this effort.

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.

Hydraulic Lead: Kristy Riley

Kristy Riley	Kristy Riley	10/17/13
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: Morgan Marlatt   Title: Senior Hydraulic Engineer

Morgan Marlatt	M. Marlatt	10/17/13
Print name	Signature	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.

Acting Section Chief: Jesse Schlunegger

Jesse Schlunegger	[signature]	10-24-2013
Print name	Signature	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

Date 10/19/2010

Gregory A. Kukas, Branch Chief
Hydrology & Hydraulics Branch, SPK

Date 10/19/2010

QUALITY CONTROL CERTIFICATE
Real Estate Division, Acquisition and Management Branch

PROJECT NAME: WEST SACRAMENTO GRR

PRODUCT: REAL ESTATE APPENDIX FOR FRM MILESTONE ACTUAL
COMPLETION DATE: SEPTEMBER 2015

PROJECT MANAGER: BRYON LAKES

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
Laurie Parker
Print Name

Laurie Parker
Signature

Sept 1, 2015
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

Paul Zianno
Print Name

Title: Chief, Civil Works Section

Paul Zianno
Signature

Sept 1, 2015
Date

West Sacramento Real Estate Plan September 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.	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.	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 #. Laurie, Please identify what the letters mean on the map. Need to identify as phases.	Concur – rewriting section as stated above	X
Is this a Road Easement?	Yes it is a Road Easement	X
This is a non-standard estate?	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?	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.	Concur the table will be shown in Section 4. Description of LERRD's.	X
Is this a Road Easement?	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
What does the Letters mean in the Figure please specify. Page 24	I will provide a definition of the letters in the report.	X
We need to expand this paragraph on how we are going to apply Navigational Servitude. The ER 405 talks specific to the requirements.	Will include longer discussion.	X
Briefly describe these relocations	Concur	X

QUALITY CONTROL CERTIFICATE

Economic Risk Analysis Section, Planning Division

PROJECT NAME: WEST SACRAMENTO GRR, CALIFORNIA
PRODUCT: ECONOMIC APPENDIX
Actual Completion Date: 14-Aug-15
PROJECT MANAGER: BRYON LAKE

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 changes incorporating review comments. There was also a cursory review of the entire document. 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: 2015.08.14 08:24:00 -07'00'	14 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 23:27:22 -07'00'	14 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 23:28:24 -07'00'	14 Aug 2015
Print name	Signature	Date

Economic and Risk Analysis Section
District Quality Control Review Comments
West Sacramento 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:** In many cases throughout this document (and in ARCF), we refer to the "SPK Hydraulic Analysis Section" or the "Sacramento District Hydrology Section." We are trying to get away from district specific references in our documentation. Instead, this is a USACE document. Recommend removing district specific references and replacing them with more general USACE references, or not references at all. For example, in Section 2.8.2 it says "The SPK Hydraulic Design Section used the HEC-RAS model to determine stages…" Instead, we can just say "The HEC-RAS model was used to determine stages…"
Response: Concur. All references to specific District sections have been removed.
Backcheck: Verified, comment closed.

2. **Comment:** Pg 3-18. Footnote 2. This footnote bleeds onto the next page. May want to fix that if possible.
Response: Concur. This will be fixed for the Final version of the report.
Backcheck: Comment closed.

Technical Comments:

3. **Comment:** Section 2.7.1, par 2. Text indicates that "There are over 18,000 structures at risk of flooding,' but Table 1 only says 13,838. Please recitify.
Response: Concur. The sentence has been revised to read, "There are close to 14,000 structures…"
Backcheck: Verified, comment closed.

4. **Comment:** Sec 2.7.6, par 2. "An average value of an automobile was determined to be $8,300." This number differs from the $8,549 number described in section 2.7.4. Please rectify or clarify this discrepancy.
Response: Concur. The sentence in Section 2.7.6 has been revised to read "$8,549."
Backcheck: Verified, comment closed.

5. **Comment:** Sec 3.3.2, par 2. "Expected annual damages associated with a levee breach along the Yolo Bypass are estimated to be approximately $288 million." Following this text, Table 7 indicates $297 million in EAD. Please rectify discrepancy.

Response: Concur. The sentence in Section 3.3.2 has been revised to read "$297 million."
Backcheck: Verified, comment closed.

6. **Comment:** Table 17 and Table 20. Why do there appear to be no benefits to doing a levee raise for IP3 and IP6?
Response: Either there are no levee raises being proposed (IP 3) or levee raises do not provide any additional benefit (IP 3 and IP 6) in these reaches.
Backcheck: Comment closed.

7. **Comment:** Table 31. Gets back to my previous comment. Why is there no benefit to the levee raises for IP 3? We should better explain somewhere in the document why this is (or maybe I just missed it).
Response: There are no levee raises being proposed at IP 3; however, a sensitivity analysis was performed by raising the top of levee at this index point location – levee raises do not provide any additional benefit. A statement noting this has been added to Section 4.3 (last paragraph).
Backcheck: Verified, comment closed.

8. **Comment:** Table 32-34 footnote. "additional hydraulic modeling of Alternative 5 will occur in the future." The future is now! Since this is the final report, we either need to make the change or remove this footnote.
Response: Concur. No additional hydraulic modeling has been completed. Therefore, the statement in these footnotes referring to additional modeling has been removed.
Backcheck: Verified, comment closed.

9. **Comment:** Section 4.10. Change net benefit text from $160 million to $161 million.
Response: Concur. This revision has been made.
Backcheck: Verified, comment closed.

10. **Comment:** Section 4.10. Change title to "*TENTATIVE* IDENTIFICATION OF NATIONAL ECONOMIC DEVELOPMENT (NED) PLAN
Response: Concur. "Tentative" has been added to the section title.
Backcheck: Verified, comment closed.

11. **Comment:** Section 4.11.4. Change title to "*FINAL* Updated Net Benefit/BCR Analyses for the Recommended Plan (Alternative 5)
Response: Concur. "Final" has been added to the section title.
Backcheck: Verifed, comment closed.

12. **Comment:** Attachment Title Page. The current title page only lists RED/OSE as an attachment, but there appear to also be Floodplains and geotech curves. Please edit the title page as appropriate.
Response: There are two attachment title pages – one for RED/OSE and another one for the Engineering Supporting Data.
Backcheck: Comment closed.

13. **Comment:** There were no TPCS cost tables included in the attachments, so I could not verify costs were used correctly (i.e. cultural resources costs removed from the economic analysis per USACE policy). Please add TPCS tables if they exist. This can be done when the FINAL certified costs are made available and price levels/rates are updated to Oct. 15.
Response: Concur. The cost estimate for the Recommended Plan will be included as an attachment to the Economic Appendix when the final certified costs are available and during the next update (around October 2015) of the Economic Appendix. (Cultural preservation resource costs have been excluded from the analysis.)
Backcheck: Thanks, 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.

DISTRICT QUALITY CONTROL CERTIFICATION
WEST SACRAMENTO GENERAL REEVALUATION REPORT, YOLO COUNTY, CALIFORNIA

COMPLETION OF QUALITY CONTROL ACTIVITIES

The District has completed review of the West Sacramento 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 American River Common Features 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 Date 9/4/15
Quality Control Reviewer

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.

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   9/14/15

(for) Mark E. Cowan   Date
Chief, Water Resources Branch

West Sacramento Draft Final Report 24 August 2015
DQC Comments
Reviewer: Jerry Fuentes, RTS

Comment	Response	Backcheck
Page 1-2, section 2.0 - Citation format is incorrect. Revise per OC guidelines.	Concur – Citation Format Revised	Response accepted. Comment Closed.
Page 1-3, Figure 1 - use of rectangle for depicting Study Area doesn't match narrative description.	Concur – Rectangle depicting study area removed from map.	Response accepted. Comment Closed.
Page 2-6, section 2.4 - next to last sentence: replace "study" with "project."	Concur – change made	Response accepted. Comment Closed.
Page 2-6, section 2.4 - last sentence: Add "benefits" to "all potential effects."	Concur – benefits added to sentence.	Response accepted. Comment Closed.
Page 4-7, section 4.2, first paragraph: Be specific about "minimal warning or evacuation times."	Concur – text was revised to be more specific.	Response accepted. Comment Closed.
Page 4-7, section 4.2, first paragraph: Would the railroad be impassable from any flood or a specific one?	Concur – pending response from hydraulics reference to railroad was removed from sentence.	Response accepted. Comment Closed.
Page 4-8, section 4.4, bullet 4: Suggest you state specifically whether the improvements are either in-place or not in place rather than say "part of the without project condition."	Concur – text revised to indicate the improvements are in place.	Response accepted. Comment Closed.
Page 4-8, section 4.4, bullet 5: Is the assumption that development would be constrained until 100-year protection is achieved consistent with SB-5?	Concur – included language regarding requirements of SB-5	Response accepted. Comment Closed.
Page 3-17, after Alternative 8: Suggest at least a brief discussion in the text about methodology for preliminary costs and benefits. Although footnote in Table 7 addresses costs, it really should be in text.	Concur – Included information from footnote in text above Table.	Response accepted. Comment Closed.
Page 4-39, Table 4-10: Costs for levees is roughly $10 K more per mile than Common Features.	Concur – Cost differences are due to various factors including: the use of different contingencies, differences in existing conditions, and design criteria, such as slurry wall depth. The latest revised cost is approximately $90 million less in the MCACES Account 11 than was presented in the table.	Response accepted. Comment Response accepted. Comment Closed. Closed.
Page 4-39, Table 4-10: Costs for bank protection is half the cost per mile of Common Features.	Concur – The extent of bank protection for West Sac was revised based on feasibility level design and environmental agency comments.	Response accepted. Comment Closed.
Page 4-39, Table 4-10: Total Cost is different than in Table 4-8.	Concur - Costs will be revised and made consistent once Cost ATR and Certification are completed.	Response accepted. Comment Closed.
Page 4-40, Table 4-11: Lands & Damages	Concur – The Federal Admin costs	Response accepted.

account should include Federal admin costs.	will be included once RE costs are resolved.	Comment Closed.
Page 4-41: Should include a discussion of Environmental Operating Principles and USACE Campaign Plan.	Concur – discussion of EOP and the Campaign Plan has been added to Chapter 4.	Response accepted. Comment Closed.
Page 5-2, Section 5.3: Update interest rate to 3.375%	Concur. Updated.	Response accepted. Comment closed.
Page 5-4, Table 5-3: Suggest deleting this table since it does not show any crediting and is already part of Table 5-4.	Concur. Table has been deleted.	Response accepted. Comment Closed.
Page 5-5, Section 5.5: Should include that the total is included for reference.	Concur. Text added.	Response accepted. Comment closed.
Page 5-5, Table 5-4, GRR costs are inconsistent with Table 4-5.	Concur - Costs will be revised and made consistent once Cost ATR and Certification are completed.	Response accepted. Comment Closed.
Page 6-4, Section 6.8: Second sentence should start with "Coordination with…"	Concur. Text added.	Response accepted. Comment closed.
Page 7-1: Recommendations should include specifics.	Concur. Updated.	Response accepted. Comment closed.
Page 7-2, Third sentence is repetitive and should be deleted.	Concur. Deleted.	Response accepted. Comment closed.
PACR - Cost tables are inconsistent with GRR.	Concur - Costs will be revised and made consistent once Cost ATR and Certification are completed.	Response accepted. Comment Closed.
PACR -16 Section 6: Include a brief summary of areas of concern in review comments	Concur. Text added.	Response accepted. Comment closed.
PACR-17, Section 17 - change to Section 7.	Concur. Change made.	Response accepted. Comment closed.

West Sacramento GRR

Appendix B

Review Documentation

Agency Technical Review (ATR)

Documentation

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FLOOD RISK MANAGEMENT PLANNING CENTER OF EXPERTISE REVIEW MANAGEMENT ORGANIZATION'S

AGENCY TECHNICAL REVIEW REPORT, SEPTEMBER 2015

Of the:

WEST SACRAMENTO PROJECT FINAL GENERAL REEVALUATION REPORT, AND FINAL ENVIRONMENTAL IMPACT STATEMENT /ENVIRONMENTAL IMPACT REPORT SEPTEMBER 2015

Sacramento District

US Army Corps of Engineers ®

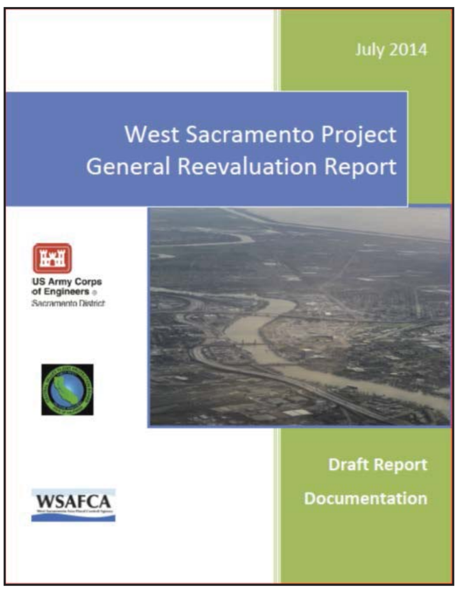
TABLE OF CONTENTS

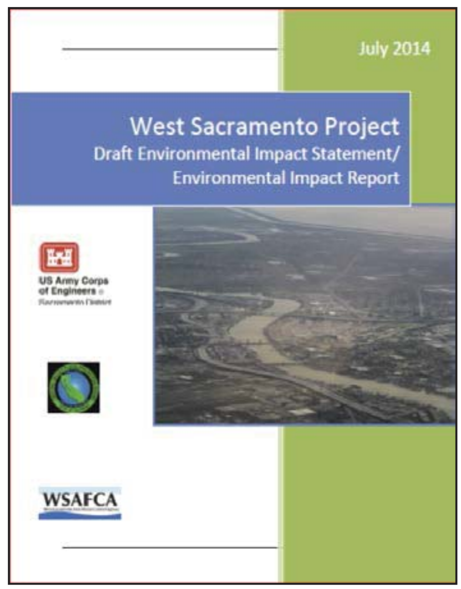
AGENCY TECHNICAL REVIEW REPORT

ENCLOSURES

Agency Technical Review Report

Subject: Review report for the **WEST SACRAMENTO PROJECT, FINAL GENERAL REEVALUATION REPORT, AND FINAL ENVIRONMENTAL IMPACT STATEMENT / ENVIRONMENTAL IMPACT REPORT, SEPTEMBER 2015**, Sacramento District. Document covers below show the draft general reevaluation report and National Environmental Policy Act document covers 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 changes made to the report between the draft (July 2014) and final (August 2015) versions. Final report cover versions were not necessary.





1. Scope and Purpose of Review. The purpose of this review report was to document agency technical review (ATR) for the subject products. The review was conducted for the Sacramento District. The point of contact for the District was Andrew T. Muha, CESPK-PPMD. The ATR team (ATRT) was lead by Marc L. Masnor, CESWF-PEC-PF (Tulsa, OK). The Flood Risk Management Planning Center of Expertise (FRM-PCX) was the Review Management Organization responsible for managing the ATR. The review documents will be referred to as the final GRR and the draft EIS/EIR.

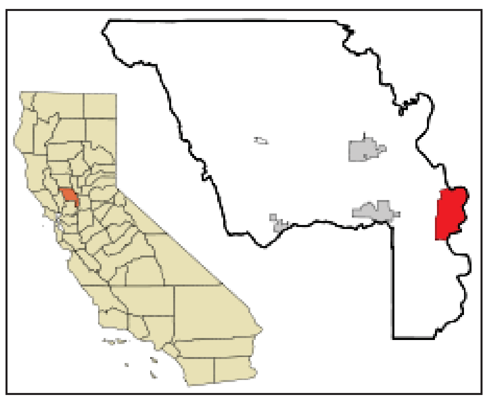
Six targeted ATR work product reviews were conducted as part of the review of the draft GRR and draft EIS/EIR between January 2014 and February 2015. The work products consisted of GRR appendices for geotechnical engineering, economics, hydrology and hydraulic engineering, and civil engineering; the real estate plan, and detailed cost engineering estimates and supporting documentation. Some work product comments were backchecked subsequent to review of the draft GRR and the draft EIS/EIR.

The draft GRR and draft EIS/EIR were reviewed between July 2014 and January 2015.

Review of the final GRR was conducted in August and September 2015. This review report documents the ATR of the final GRR and the NEPA document and all supporting documents.

2. References.
a. This review report was prepared in response to EC 1165-2-214, 15 December 2012, Water Resources Policies and Authorities, CIVIL WORKS REVIEW.
b. The review documents reside online at ProjNet™ (www.projnet.org). The Projnet™ DrChecks Project and Review titles are: Project: (320653) West Sacramento General Reevaluation Report (GRR) (incl ATR & DQC Reviews)(P2# 320653) and Review: ATR Final GRR (7-28 Aug 2015).

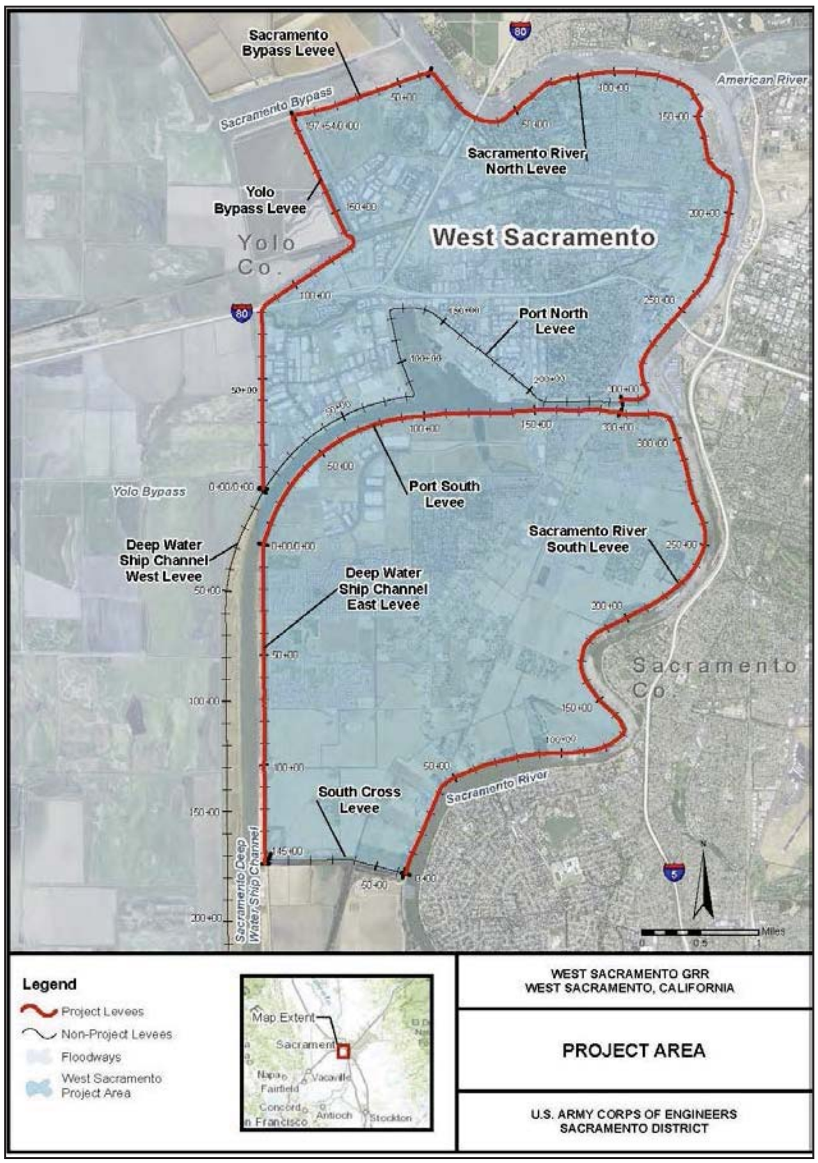
3. Project Description. The purpose of the West Sacramento Project is to reduce the flood risk for the City of West Sacramento (below right, right insert), California (below left), Yolo County (below right, left insert). The general reevaluation report (GRR) documented evaluation of proposed system improvements and additional levee improvements and other measures to provide flood risk management for the City of West Sacramento.



The study area approximately corresponds with the city limit for the City of West Sacramento comprising 13,000 acres of mixed-use land and an estimated population of 48,000 residents. The City of West Sacramento is located directly across the Sacramento River from the City of Sacramento, the State's Capitol.

The project area is almost completely bound by floodways and levees [graphic next page]. The study area is bound by the Yolo Bypass to the west, the Sacramento Bypass to the north, and the Sacramento River to the east. Further, the City is bifurcated by the Sacramento River Deep Water Ship Channel (DWSC) and Barge Canal. The associated levee system currently protecting the study area includes nearly 50 miles of levees in Reclamation District (RD) 900, RD 537, Maintenance Area 4, and along the DWSC and Barge Canal.

Northern Sub-basin – The northern sub-basin, representing approximately 6,100 acres, is bounded by the Port North area and the DWSC to the south, the Sacramento River North Levee to the north and east, the Sacramento Bypass Levee to the north, and the Yolo Bypass Levee to the west. The right bank of the Sacramento River extends for approximately 5.5 miles of the northern and eastern sides of the basin.



Southern Sub-Basin – The Southern Sub-Basin encompasses approximately 6,900 acres and varies from El. 18.0 feet to El. 8.0 feet. The area is bounded by the Port South Levee and the DWSC to the north, the Sacramento River South Levee to the east, the South Cross Levee to the south, and the DWSC East Levee to the west. The right bank of the Sacramento River extends for approximately 6.2 miles on the east side of the basin.

A majority of the levees within the study area are part of the Sacramento River Flood Control Project. The few exceptions are the Port North area and Port South levees, the DWSC West levee and the South Cross levee. The Port South and DWSC West levees were constructed as part of the Port of Sacramento.

The Port North area includes high ground along the northern portion of the Port of West Sacramento. The South Cross levee is a private levee. Although the DWSC West levee was constructed as part of the navigation project supporting the Port of West Sacramento, this levee provides significant flood benefits to portions of both the northern and southern sub-basins. The Corps currently maintains this navigation levee.

4. Review Team. The following team members met the requirements of the District and RMO.

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 and Policy – Douglas E. Lilly, CESWF-PEC-PF (Tulsa, OK), 918-693-7196, Douglas.E.Lilly@usace.army.mil. Mr. Lilly is a lead water resources planner for the U.S. Army Corps of Engineers, Tulsa District. Mr. Lilly also serves as Project Manager for assigned projects. His professional experience includes planning and management of watershed studies and projects for flood control, stream bank erosion, and ecosystem restoration in southern Kansas, Oklahoma, northern Texas, and the western United States. Mr. Lilly began his Corps career as a study manager in February 1987 in the Planning and Environmental Division. Prior to his Corps career, he worked as a structural engineer at a consulting engineering firm in Tulsa, Oklahoma. Mr. Lilly is a native Oklahoman. He graduated from Oklahoma State University with a Bachelor's Degree in Architecture and a Master's Degree in Architectural Engineering.

Biologist - Michael Scuderi, CENWS-PM-ER - 206-764-7205 michael.r.scuderi@usace.army.mil. Mr. Scuderi has been with the Corps of Engineers since 1983 serving initially in Los Angeles District (1 ½ years) and then Seattle District (27 years). He received a B.A. (Double major Geography and Economics) from UCLA in 1978. He also completed his M.A. in Geography (emphasis on Resource Management) from the University of Washington in 1981. Mr. Scuderi has worked on a variety of large and small Flood Control, Restoration and Military projects, being responsible for environmental compliance and design for those projects. He is currently a Senior Biologist in the Seattle District Environmental and Cultural Resource Branch focusing on directing restoration projects and is the Lead Environmental Coordinator for the Green-Duwamish Ecosystem Restoration Project covering the construction of 45 restoration projects in the Green-Duwamish Watershed. Mr. Scuderi is also the ECO-PCX Account Manager for LRD, and is a member of the Corps of Engineers Research Directorate Environmental Research Area Review Group, and the environmental representative for the Corps National Levee Vegetation Variance ATR team.

Environmental Compliance/Cultural – Ron W. Deiss, CEMVP-PD-P - 309-794-5185 ronald.w.deiss@usace.army.mil. Mr. Deiss is a graduate from Illinois State University, Normal, Illinois with a B.S. Comprehensive Anthropology, Minor in Historic Geography and a Master's of Science in Historic Archeology. His field work since 1975 in archeology, architecture, underwater, and historic research includes the states of Florida, Illinois, Indiana, Iowa, Kentucky, Louisiana, North Dakota, Maryland, Minnesota, Montana, and Tennessee. He has been employed by the Rock Island District since 1988 conducting environmental studies, archeological and architectural contracts, and planning documents. He has participated in ITR, ATR, and IEPR, and has served as a resource and mentor for his colleagues and proficient on the National Environmental Policy Act and National Historic Preservation Act. Of the most complex and sensitive projects in which he was a Team member include the Great Lakes and Mississippi River Interbasin Study, Lockport Pool Rehabilitations on the Chicago Sanitary and Ship Canal, Illinois River Basin Comprehensive Management Plan, Upper Mississippi River System Navigation Feasibility Study, and the Major Rehabilitation for the Upper Mississippi River and Illinois Waterway. Presently, Mr. Deiss is the St. Paul District Corps of Engineers District Archeologist, the Rock Island District Military Construction Coordinator, and the Rock Island District Native American Tribal Liaison. He is a certified member of the Register of Professional Archaeologists.

Hydrology and Hydraulic Engineer, CESWT – 918-669-7107, Russell.Wyckoff@usace.army.mil. Mr. Wyckoff graduated from Oklahoma State University in 1986 with a Bachelor of Science degree in Agricultural Engineering. He is a Registered Professional Engineer in the state of Oklahoma. He has worked for the U.S. Army Corps of Engineers for 23 years in the Tulsa District office. He currently serves as the Lead Hydraulic Design Engineer for Tulsa District in the areas of flood modeling and flood control structure design as well as Dam and Levee Safety. He has also integrated detailed terrain analysis and GIS (Geographic Information System) applications as part of the modeling process. Mr. Wyckoff serves on a National Dam Safety Evaluation Team and has conducted several Risk Based Analyses in the field of Hydrology and Hydraulics. Current work includes modeling of dam break scenarios on multiple structures nationwide as well as levee certification modeling, all based on risk analysis framework.

Real Estate – Karen Vance, Real Estate Specialist, CEMVK-RE-E - 504-862-1349, Karen.E.Vance@usace.army.mil. Ms. Vance has been with the Corps of Engineers since 1999, serving initially at the Tulsa District (11 years) and then the New Orleans District (5 years). During her service with the Corps of Engineers, she has served in New Orleans following Hurricane Katrina in demolition and debris removal, and in Bagram, Afghanistan in real estate acquisition. She is currently a member of the Appraisal and Planning Branch in New Orleans, and serves as a planning team member for multiple projects. Ms. Vance has worked on a variety of large and small projects, including flood risk management, navigation, ecosystem restoration and military projects. She has specialized in working with a vertical team for planning real estate activities for large scale ecosystem restoration projects. She has been appointed a member of the Planning Centers of Expertise for Agency Technical Reviews, and has conducted reviews for a variety of complex projects. She currently serves as an instructor for Real Estate Planning Management and Control PROSPECT training, and provides training and advice on Real Estate issues for civil works project planning.

Economics - Brian Harper, IWR – 409-766-3886, Brian.K.Harper@usace.army.mil. Brian Harper has 20 years of experience as an economist and planner with the Corps of Engineers. Brian is presently a regional economist with the Galveston District. He previously worked as a senior economist/planner at the Institute for Water Resources and was chief of the economics section in the Alaska District from 2002-2006.Prior to those assignments, Brian was a regional economist with the Little Rock District. While at IWR, he worked with a team to develop and implement risk-informed planning processes, with a particular focus on flood risk management and coastal storm damage reduction. In Alaska his work included extensive involvement in small boat harbor and flood & coastal storm damage evaluations. In the Little Rock District he conducted planning studies and economic evaluations across multiple Corps missions. He introduced risk analysis techniques into the District's evaluations of three hydropower projects in the mid-90's and served on the SWD regional technical team for hydropower rehab studies. Brian also incorporated risk & uncertainty analyses into flood damage reduction studies and completed many water supply reallocation, inland navigation, agricultural flood damage, and stream-bank erosion studies. He started his Corps career as a Dept of the Army intern with the Los Angeles District from 1989-1991. He works remotely from the Galveston District Office, Galveston, Texas.

Civil Design Engineer - Norman Gartner, CESWL - 501-324-5274, Norman.P.Gartner@usace.army.mil. Mr. Gartner serves as a Senior Civil Engineer and Design Coordinator in the Engineering and Construction Division. With 34 years of civil engineering experience, he has planned, designed and managed the construction on a wide range of civil works projects including site design; street improvements; water and sanitary sewer improvements; wastewater treatment facilities; water storage reservoirs; commercial and residential subdivisions; pumping systems; mass grading projects; erosion control projects; and drainage improvements including detention facilities, water quality facilities, wetland mitigation, wetland restoration, river diversion and lake pumping projects. Since joining the US Army Corps of Engineers in 2009, his responsibilities have included: preparation of plans and specifications, cost estimates, contract modification packages, technical reviews of studies and designs, and field office support. He is currently leading a multi-discipline design team for the $25,000,000 May Branch flood reduction project in Fort Smith, Arkansas. He is coordinating with the projects stakeholders to deliver a quality product to meet established scope, cost, and time requirements.

Cost Engineer - 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 Engineer - 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.

Geotechnical Engineer – Brad J. Arcement, CEMVK-EC-GA - 601-631-5899 Brad.J.Arcement@usace.army.mil. Mr. Arcement is a licensed Professional Engineer in the state of Mississippi and has been a practicing geotechnical engineer since 1998. He has a bachelor of science degree in civil engineering from Louisiana Tech University and a masters degree from the University of Texas at Austin. Mr. Arcement joined the Corps of Engineers in June 2009 and serves as the Section Chief of the Analytical Section of the Geotechnical Branch of the Vicksburg District. He was selected as a Geotechnical Regional Technical Specialist for MVD in 2010. Prior to serving with the Corps Mr. Arcement spent 10 years as a consulting geotechnical engineer.

Hydraulic Engineer – Michael K. Deering P.E., Civil Engineer, CEIWR-HEC-WR - 530-756-1104, Michael.K.Deering@usace.army.mil. Mr. Deering is a senior hydraulic engineer with the Water Resource Systems Division, Institute for Water Resources and is the lead for the development of HEC-FRM and member of the GUMP team for updating various policy and technical guidance. His expertise includes 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 has a BS, 1977 Civil Engineering, University California at Davis, and an MS, 1986 Civil Engineering, University California at Davis. He is a Registered Professional Civil Engineer, California, 1982. His experience includes 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; and 13 years – Hydraulic Engineer, SPK – Hydraulic modeling technical expert particularly with multi-dimensional applications.

5. Charge to Reviewers. A charge to project delivery team and reviewers was developed for this ATR. The charge statements were all generic statements and therefore are not included in this documentation. The ATRT Lead discussed the roles and responsibilities with ATRT members, identified the PDT, and the District POC. All of the team members had participated in similar reviews with the same ATRT Lead and all had participated in the ATR of the draft GRR and NEPA documents. The reviewers fully understood the roles and responsibilities. The ATRT Lead's electronic meeting notice to the ATRT provided the location and description of review documents, review schedule, labor codes, and labor amounts. The notice also identified the PDT and provided contact information, identified the ProjnetTM DrChecks project and reviews, and stated the requirement for four part comments. The notice provided numerous schedule and status updates during the ATR.

6. Summary. The project documentation was extensive, including over 2,000 pages of documentation between the main report (about 810 pages) and the EIS/EIR (about 1,210 pages). Six targeted ATR work product reviews were conducted. The draft GRR and draft EIS/EIR were reviewed between July 2014 and January 2015. The Final ATR had 86 comments received that were all closed, and ATR completed without issues or controversy.

The following paragraphs summarize the status of comments.

a. Critical. None. There were 6 Very High or High Significant comments that were discussed and resolved:

> 6230324 Cost Engineering
> VERY HIGH
> CONCERN: The 2015 PDT members attending the risk register update exclude Contracting, Construction and Geotechnical. Just 5 PDT members were included on a $1B project
> RESOLVED: Additional meetings were held with additional PDT members present.
>
> 6230325 Cost Engineering
> HIGH

CONCERN: Risk CO1 Differing Site Conditions - The risk register refers to the risk as Mods and Claims. The model and the sensitivity chart refers to the same risk as Differing Site Conditions.
RESOLVED: Risk register titles were revised.

6230327 Cost Engineering
VERY HIGH
CONCERN: Risk ET 1 Estimate Assumptions and Quantities - This risk appears to be the 2nd most variable risk and is a composition of estimate assumptions and quantities. Looking at the supporting documentation, the risk was actually modeled as quantity impacts only. Further, the variance values are the same as risk TL12 Design Development, suggesting a possible duplication or correlation. The actual estimate assumptions were not apparently modeled but could be assumptions related to contractor markups and assignments, construction methodology, crews and productivity, borrow sources and haul distances.
RESOLVED: Risk documents and categories have been revised.

6230342 Cost Engineering
VERY HIGH
CONCERN: Risk TL8 Vegetation Variance - When considering variance values, this should be the highest risk variable presented. Yet, since the probability assigns a 10%, the risk does not show up as a high risk on the sensitivity chart. Also I note that is modeled as a uniform distribution, suggesting the cost impacts are REALLY unknown.
RESOLVED: PDT reviewed issue and cost impacts and provided additional information from an existing project.

6230343 Cost Engineering
HIGH
CONCERN: Some low modeled risks actually show a higher variance and impact than certain moderate risks. Some moderate risks in the model suggest that they are actually low due to the small value.
RESOLVED: PDT provided clarification.

6230344 Cost Engineering
HIGH
CONCERN: Risk Model –The latest risk model is based on $942M and excludes real estate. But then the TPCS includes the same contingency % for Real Estate. I do not find a Real Estate report supporting the TPCS.
RESOLVED: PDT provided additional RE information and is reviewing RE contingency.

b. Unresolved. None.

c. Lessons Learned. None.

7. ProjnetTM DrChecks Report. The Projnet™ DrChecks report for the Final ATR is attached as Enclosure 1.

8. ATR Completion Statement. Enclosure 2 contains the completion statement of agency technical review.

____

Marc L. Masnor, P.E.
CESWF-PEC-PF (Tulsa, OK)

Enclosure 1

PROJNET^{TM} DRCHECKS REPORT OF ALL COMMENTS

Comment Report: All Comments
Project: West Sacramento General Reevaluation Report (GRR) (incl ATR & DQC Reviews)(P2# 320653)
Review: ATR Final GRR (7-28 Aug 2015)
Displaying 86 comments for the criteria specified in this report.

Id	Discipline	Section/Figure	Page Number	Line Number
6197423	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**
Evaluation added by the ATRT Lead to allow closing of the "no comment" comment.

Submitted By: Marc Masnor (918-669-7349) Submitted On: Sep 09 2015

1-1 Backcheck Recommendation **Close Comment**
Backcheck closed by the ATRT Lead for the "no comment" comment to allow closing of the backcheck.

Submitted By: Marc Masnor (918-669-7349) Submitted On: Sep 09 2015

Current Comment Status: **Comment Closed**

Id	Discipline	Section/Figure	Page Number	Line Number
6211169	Hydraulics	Study Approach	1-3	2nd Paragraph

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**
(Document Reference: West Sac Hyd Appendix Reformatted 11Aug2015Maak)

REVIEW CONCERN: The firs sentence notes that the flood inundations are based on a single levee breach within a reach. At first reading this suggest that there is only one breach location evaluated.

BASIS FOR THE CONCERN: In a system this large there will be multiple breach locations that should be evaluated.

SIGNIFICANCE OF THE CONCERN: Low since I believe that the evaluation is correct and multiple locations were included to make sure that every interior area with potential life loss and damage potential was analyzed.

ACTION NEEDED TO RESOLVE THE CONCERN: Note if this has been described in other areas of the project documentation or expand on the discussion to validate that the flood inundations were developed to incorporate all the potential impacted areas.

Submitted By: Russell Wyckoff (918-669-7107). Submitted On: Aug 25 2015

1-0 Evaluation **Concurred**

There were 8 reaches within the system. The text has been updated to include the following statement: "The West Sacramento Levee System was divided up into 8 reaches for this analysis." Additional information is also in Chapters 5 and 6.

Submitted By: Jesse Schlunegger (916-557-6777) Submitted On: Sep 05 2015

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Russell Wyckoff (918-669-7107) Submitted On: Sep 08 2015

Current Comment Status: **Comment Closed**

6211178 Hydraulics Model Calibration 3-1 1st paragraph

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**
(Document Reference: West Sac Hyd Appendix Reformatted 11Aug2015Maak)

REVIEW CONCERN: The calibration results are noted as being "reasonably" reproduced". I'm not sure that this tells the reader that there is a high confidence in the modeling.

BASIS FOR THE CONCERN: Calibration of modeling is paramount to instill a level of confidence in the analysis results. Showing calibration results is a positive aspect and shows that a significant level of efffort has been expended to come up with a reasonable answer

SIGNIFICANCE OF THE CONCERN: Moderate. Level of effort conducted by H&H should be shown or noted.

ACTION NEEDED TO RESOLVE THE CONCERN: Recommend additional discussion be provided that will help to define the level of calibration. What is the actual differences in WS and Flow.

Submitted By: Russell Wyckoff (918-669-7107). Submitted On: Aug 25 2015

1-0 Evaluation **Concurred**

The Technical Memorandum referenced in the paragraph contains much of this information. This hydraulic appendix was intended to be a streamlined to meet SMART Planning Principles. Additional information from the Tech Memo has been added to the hydraulic appendix.
The Calibration Technical Memorandum can be made available as well.

Submitted By: Jesse Schlunegger (916-557-6777) Submitted On: Sep 05 2015

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

Submitted By: Russell Wyckoff (918-669-7107) Submitted On: Sep 08 2015
Current Comment Status: **Comment Closed**

6211222	Hydraulics	Section 3.4 Water Surface Profiles	3-2	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**
(Document Reference: West Sac Hyd Appendix Reformatted 11Aug2015Maak)

REVIEW CONCERN: It was stated that all modeling was conducted with HEC-RAS.

BASIS FOR THE CONCERN: The results suggest that the modeling was conducted in unsteady mode, but unsteady runs are necessary to conduct the interior flooding component

SIGNIFICANCE OF THE CONCERN: Low - confirmation of work

ACTION NEEDED TO RESOLVE THE CONCERN: Verify that the HEC-RAS was conducted using the unsteady module.

Submitted By: Russell Wyckoff (918-669-7107). Submitted On: Aug 25 2015

1-0 Evaluation **Concurred**
Yes, the hydraulic modeling conducted to develop the water surface profiles were based on HECRAS unsteady model runs with hydrographs.

Submitted By: Jesse Schlunegger (916-557-6777) Submitted On: Sep 05 2015

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

Submitted By: Russell Wyckoff (918-669-7107) Submitted On: Sep 08 2015
Current Comment Status: **Comment Closed**

6211233	Hydraulics	Section 3.5 Levee Breach Assumptions	3-3	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**
(Document Reference: West Sac Hyd Appendix Reformatted 11Aug2015Maak)

REVIEW CONCERN: The first bullett notes 500 feet breach widths were used and suggested that 1,000 feet was referenced in other studies. These referenced values are good to know but were any sensitivity analyses conducted to deterimine if varied breach widths were highly sensitive to consequences?

BASIS FOR THE CONCERN: Using a 500 or 1,000 feet width just seems arbitrary unless there is some type of analysis noted to give confidence in the value

SIGNIFICANCE OF THE CONCERN: Moderate

ACTION NEEDED TO RESOLVE THE CONCERN: Note in the text if any analyses were conducted to help determine a reasonable breach width or if analyses were conducted to determine a range of widths that are sensitive to consequences.

Submitted By: Russell Wyckoff (918-669-7107). Submitted On: Aug 25 2015

1-0 Evaluation **Concurred**

The last paragraph includes a reference to a Levee Breach Sensitivity Technical Memorandum where several sensitivity analyses were conducted to show that 500' was a reasonable estimate for breaks on the Sacramento River, Yolo Bypass and other major rivers in the system. This Technical Memo can also be provided to the reviewer. This hydraulic appendix was intended to be a streamlined to meet SMART Planning Principles.

Submitted By: Jesse Schlunegger (916-557-6777) Submitted On: Sep 05 2015

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Russell Wyckoff (918-669-7107) Submitted On: Sep 08 2015

Current Comment Status: **Comment Closed**

6211253	Hydraulics	Section 3.5 Levee Breach Assumptions	3-3	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**
(Document Reference: West Sac Hyd Appendix Reformatted 11Aug2015Maak)

REVIEW CONCERN: The second bullet notes that the trigger for breach of the levees was set at 0.5 feet below the max water surface at the failure location. It was noted in the Section 6.10 text that all levees were assumed to hold and the only failure mode analyzed was overtopping. if this is the case, was using a depth of flooding over the top of the levee an option? Also, does the 0.5 ft below peak stage only work if the water surface is more than 0.5 feet over the top of the levee?

BASIS FOR THE CONCERN: Since sensitivity of the flood inundation was noted as volume then for a large flood the failure could occur earlier for depth over the levee than 0.5 ft before the max stage. timing could affect the inundation outcome and consequences.

SIGNIFICANCE OF THE CONCERN: Moderate

ACTION NEEDED TO RESOLVE THE CONCERN: REcommend additional discussion on development of the trigger elevation assumption and include why this assumption fits this project.

Submitted By: Russell Wyckoff (918-669-7107). Submitted On: Aug 25 2015

Revised Aug 25 2015.

1-0 Evaluation **Concurred**

More discussion of levee breach sensitivity is included in section 5.2 of the hydraulic appendix. The use of the 0.5' target below the max water surface elevation was to ensure a levee break occurred during that flood event so that a floodplain could be generated for use in HECFDA. This ensures a 100% of failure and the combination of probabilities for H&H and Geotech was left to be evaluated in HECFDA. It was not intended to reflect what might actually happen in terms of a timing of a levee break. In terms of timing, if the break occurs well after the peak then the volume of water reaching the basin is significantly reduced. While this may happen, the study was trying to have a consistent set of floodplains through suite of n-year events and at each index point.

Submitted By: Jesse Schlunegger (916-557-6777) Submitted On: Sep 05 2015

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Russell Wyckoff (918-669-7107) Submitted On: Sep 08 2015

Current Comment Status: **Comment Closed**

6211269	Hydraulics	4.2 Alternative 1: Improve Levees in Place	4-2	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

(Document Reference: West Sac Hyd Appendix Reformatted 11Aug2015Maak)

REVIEW CONCERN: The alternative 1 description does not specifically address raising levees.

BASIS FOR THE CONCERN: Protection from overtopping is noted but I think it should be more pronounced that this includes a levee raise

SIGNIFICANCE OF THE CONCERN: Low

ACTION NEEDED TO RESOLVE THE CONCERN: Recommend additional discussion in the paragraph to show that the intent is to raise the level various levels with an expected maximum of about 2 feet.

Submitted By: Russell Wyckoff (918-669-7107). Submitted On: Aug 25 2015

1-0 Evaluation **Concurred**

There has been significant concern about levee raising on this project due to policy concerns. Also, with such a limited height raise, it was not clear if this limited raise is a separate increment or part of overall levee repair. Text edits have been made to help clarify.

Submitted By: Jesse Schlunegger (916-557-6777) Submitted On: Sep 05 2015

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

Submitted By: Russell Wyckoff (918-669-7107) Submitted On: Sep 08 2015

Current Comment Status: **Comment Closed**

6211279	Hydraulics	4.3 Alternative 2: Improve Levees in Place and Widen Sacramento ByPass	4-3	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**
(Document Reference: West Sac Hyd Appendix Reformatted 11Aug2015Maak)

REVIEW CONCERN: The description of the alternative includes impacts to the Sacramento River but there is no discussion about impacts to the Yolo Bypass due to the added volume, peak flow and duration of flow.

BASIS FOR THE CONCERN: ARe there detrimental effects downstream due to the diversion of flow along the Yolo Bypass

SIGNIFICANCE OF THE CONCERN: Low

ACTION NEEDED TO RESOLVE THE CONCERN: Recommend additional discussion on the impact, if any, to the Yolo Bypass. Include model results.

Submitted By: Russell Wyckoff (918-669-7107). Submitted On: Aug 25 2015

1-0 Evaluation **Concurred**
Additional Information has been added to Section 4.3 with a new section 4.3.1 on Yolo Bypass Impacts. This information was taken from the American River Common Features GRR as the Sac Bypass Widening is part of the Recommended Plan for the American River Common Features GRR.

Submitted By: Jesse Schlunegger (916-557-6777) Submitted On: Sep 05 2015

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

Submitted By: Russell Wyckoff (918-669-7107) Submitted On: Sep 08 2015

Current Comment Status: **Comment Closed**

6211307	Hydraulics	5.1 FLO-2D Model Development	5-1	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**
(Document Reference: West Sac Hyd Appendix Reformatted 11Aug2015Maak)

REVIEW CONCERN: The 5th bullet states that no rainfall on the interior was modeled. Generally, excessive rainfall causing high water in the river could also cause local flooding. Can the existing pumping system keep up with local rainfall prior to levee failure from the river side?

BASIS FOR THE CONCERN: The added volume from interior rain could increase flood levels.

SIGNIFICANCE OF THE CONCERN: Moderate

ACTION NEEDED TO RESOLVE THE CONCERN: Provide additional discussion on the residual flooding component. Include how this component can be eliminated

Submitted By: Russell Wyckoff (918-669-7107). Submitted On: Aug 25 2015

1-0 Evaluation **Concurred**

An interior drainage analysis was also conducted and is summarized in Section 7.4. From the analysis, the interior drainage had little residual risk and adequately kept up with rainfall events up to the 200-yr event. The pumps are already built to pump water over the levee system.

Submitted By: Jesse Schlunegger (916-557-6777) Submitted On: Sep 05 2015

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Russell Wyckoff (918-669-7107) Submitted On: Sep 08 2015

Current Comment Status: **Comment Closed**

6211789 Hydraulics 5.1 FLO-2D Model Development 5-2 n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**
(Document Reference: West Sac Hyd Appendix Reformatted 11Aug2015Maak)

REVIEW CONCERN: I'm not clear on the assumption of failure of the soundwalls. I understand that the structural integrity may not be adequate and that is a legitimate concern. I am not sure I understand how the road embankment eliminates the need for the soundwall. Is the roadway the actual barrier?

BASIS FOR THE CONCERN: Generally, soundwalls can redirect flood waters and provide some level of protection so it would be good to have these in the model. if the roadway is the more prominate barrier then that would probably be fine.

SIGNIFICANCE OF THE CONCERN: Low

ACTION NEEDED TO RESOLVE THE CONCERN: I think that after looking at this in more detail I see that the intent is to use the roadway as the barrier and then there is no need to special model the soundwall. This isn't necessarily clear at first read so I suggest a little more detail to make sure this is understood clearly and easily as i think this is any important part of the interior modeling.

Submitted By: Russell Wyckoff (918-669-7107). Submitted On: Aug 26 2015

1-0 Evaluation **Concurred**
Text was added to the assumption to clarify that the raised roadway embankment is acting as the barrier.

Submitted By: Jesse Schlunegger (916-557-6777) Submitted On: Sep 05 2015

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

Submitted By: Russell Wyckoff (918-669-7107) Submitted On: Sep 08 2015
Current Comment Status: **Comment Closed**

6211808	Hydraulics	6 Risk Analysis	6-1	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**
(Document Reference: West Sac Hyd Appendix Reformatted 11Aug2015Maak)

REVIEW CONCERN: The last paragraph in section 6 discusses several pertinent studies in the Sacramento area. These studies were conducted by contractors and relate to development of process and parameters to support development of Risk values for this complicated system. These are good references but its not clear as to what was actually taken from these studies and how it impacts this part of the study.

BASIS FOR THE CONCERN: There is little doubt that the information obtained is likely pertinent but there is no reference to exactly what data was taken from the studies or how it was used.

SIGNIFICANCE OF THE CONCERN: Moderate

ACTION NEEDED TO RESOLVE THE CONCERN: Recommend more detail about the studies and what specific information was used from these to enhance this study phase.

Submitted By: Russell Wyckoff (918-669-7107). Submitted On: Aug 26 2015

1-0 Evaluation **Concurred**
Text was added to clarify what information was used from the studies. HEC developed HECFDA models for the Sacramento River System along with uncertainty values and this information was update slightly by the local sponsor (SAFCA) and their consultants.

Submitted By: Jesse Schlunegger (916-557-6777) Submitted On: Sep 05 2015

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

Submitted By: Russell Wyckoff (918-669-7107) Submitted On: Sep 08 2015
Current Comment Status: **Comment Closed**

6211825	Hydraulics	7.1 Superiority	7-1	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**
(Document Reference: West Sac Hyd Appendix Reformatted 11Aug2015Maak)

REVIEW CONCERN: Utilizing the Sacramento Weir as flood relief along the Sacramento River is good up to the design level storm. Levee Superiority applies to events greater than the design storm. I don't feel that there has been enough information presented to show what will happen if the design event is exceeded.

BASIS FOR THE CONCERN: Larger events should be analyzed to show at what levels the Sacramento Weir can provide relief and what conditions exist that may still cause levee overtopping.

SIGNIFICANCE OF THE CONCERN: Moderate

ACTION NEEDED TO RESOLVE THE CONCERN: Recommend analyses to analyze the operation of the Sacramento Weir for a larger than design storm and describe how this protects the levee system from greater events. Also, consider what conditions could exist that would cause first overtopping.

Submitted By: Russell Wyckoff (918-669-7107). Submitted On: Aug 26 2015

1-0 Evaluation **Concurred**

This text of this section has been significantly updated to include much more discussion on superiority and residual risk. The 0.2% (1/500) ACE event was modeled. The overtopping during events greater than a 0.5% (1/200) are limited because much of the extra water in the American River goes out of the channel upstream of the American River Levees and into the American River North and South Basins. The other threat is from the Sacramento River System where the Bypasses serve as a buffer and many of the upstream levees are not built to contain a 0.2% (1/500) ACE event and will likely overtop the levees upstream also limiting the amount of water that can get to the West Sac Levees. Inside the basin, the levee that is likely to be overtopped first is backfilled to the top of levee and even a bit higher. The overopping flows here would not cascade down but gently flow into an industrial area and then likely into the Sacramento Deep Water Ship Channel which also serves as a natural drain.

Submitted By: Jesse Schlunegger (916-557-6777) Submitted On: Sep 05 2015

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Russell Wyckoff (918-669-7107) Submitted On: Sep 08 2015

Current Comment Status: **Comment Closed**

6211992	Hydraulics	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

No Comment. All Hydraulic comments were based on review of the H&H Appendix entitled:

"WestSac_HYD_APPENDIX_Reformatted_11Aug2015Maak.docx"

Submitted By: Russell Wyckoff (918-669-7107). Submitted On: Aug 26 2015

1-0 Evaluation **Concurred**
Thanks for the clarification.

Submitted By: Jesse Schlunegger (916-557-6777) Submitted On: Sep 05 2015

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

Submitted By: Russell Wyckoff (918-669-7107) Submitted On: Sep 08 2015
Current Comment Status: **Comment Closed**

6213695 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. Please agree or disagree.

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 27 2015

1-0 Evaluation **Concurred**
concur

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 02 2015

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

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 07 2015
Current Comment Status: **Comment Closed**

6213696 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

2. CONCERN: 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 27 2015

1-0 Evaluation **Concurred**

concur

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 02 2015

1-1 Backcheck Recommendation **Close Comment**

Observation Comment Closed.

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 07 2015

Current Comment Status: **Comment Closed**

6213697 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

3. CONCERN: I am concerned about the estimate capturing all the project scope since the cost has changed significantly since the last set of documents was provided.

Direct Cost Sub CMU Cost To Prime Prime CMU Contract Cost

2015 02 02 798,672,922 210,635,910 947,537,158 291,506,964 1,300,815,796

2015 08 12 688,662,868 129,497,585 556,915,490 171,333,380 989,493,832

The direct cost has changed (110,010,055) or -13.77%.

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 a short description in the evaluation to document the apparent scope change.

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 27 2015

1-0 Evaluation **Concurred**

The apparent scope is one of actually many. At the time of prior submission, the major folder levee for the Sacramento River South – FIP was still being carried in the estimate due to the ADM not being completed. The ADM has been performed and those items not selected have been removed from the estimate. The MII file also has been cleaned up of all folders that were previously struck-thru, at least the appropriate ones have, as well as other clean up so that only the most current scope assumptions remain. At the previous submittal, only the top level folders were designated as Prime, and all subordinate folders where SUBCONTRACT. This has now been changed to what would reasonably be assumed would be the Prime/Subcontract relationships for the entire estimate by reach. Real estate had some big swings in cost as well as environmental. Both are still in motion and will be updated again prior to submission of TPCS. As a note, these costs generally are not carried in the MII estimate, however, they are now included in the MII and carried forward to the TPCS. Labor and equipment has been repriced to current levels.

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 04 2015

1-1 Backcheck Recommendation **Close Comment**

Understood. Comment Closed.

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 07 2015

Current Comment Status: **Comment Closed**

6213698 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

4. CONCERN: I am concerned about the estimate capturing all the project scope since The following features of work have been deleted from the estimate. Their direct costs are indicated here.

4.1. 11 --- DWSC East Station 115+00 to171+71 Length = 4,825 = 0.91mi 15,859,513
4.1.1. 11.1 01 Real Estate 4,952,000
4.1.2. 11.2 02 Relocation 2,755,441
4.1.3. 11.3 06 Fish & Wildlife Facilities 2,730,000
4.1.4. 11.4 11 Levee & Floodwalls 5,422,073

4.2. 14 Sac River - South Levee - FIP 189,109,521
4.2.1. 14.2 Relocations 28,374,853

4.2.2. 14.3 Environmental 4,305,000
4.2.3. 14.4 Levees and Floodwalls 156,429,668

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 a short description in the evaluation to document the apparent scope change.

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 27 2015

1-0 Evaluation **Concurred**

The MII file previously submitted was created in such a manner as to be able to price all alternatives in one MII file as apposed to several files.

DWSC East 115+00 to 171+71 is now combined with DWSC East 0+00 to 115+00 to create the new DWSC East 0+00 to 171+71.

Since the Sac River-South Levee - FIP was not carried forward and the Sac River-South set back Levee was, this reach has been removed from the MII estimate file.

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 02 2015

1-1 Backcheck Recommendation **Close Comment**

Understood. Comment Closed.

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 07 2015

Current Comment Status: **Comment Closed**

6213699 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

5. CONCERN: I am concerned about the estimate capturing all the project scope since The following features of work have been added to the estimate. Their direct costs are indicated here.

5.1. 2 Yolo Bypass
5.1.1. 2.1 Yolo Bypass Levee (North) Sta. 136+00 to 155+00 = 1,900 lf = .36 mi 6,428,996
5.2. 2.2 Yolo Bypass Levee (South) Sta 0+00 to 64+60 = 6460 lf = 1.22 mi
5.2.1. 2.2.1 01 Real Estate 175,500
5.3. 3 Lock Closure Levee
5.3.1. 3.1 01 Real Estate 1,300,000
5.3.2. 3.3 11 Levees and Floodwalls 13,095,524
5.4. 4 DWSC West Station 0+00 to123+00 Length = 12,300' = 2.33 mi

5.4.1. 4.1 01 Real Estate 1,409,365

5.5. 5 DWSC West Levee (Navigation Levee) 123+00 - 1002+60 = 87,960 lf = 16.7 mi
5.5.1. 5.1 01 Real Estate 3,509,375
5.6. 6 South Cross Levee Station 0+00 to 62+73 Length = 6,273' = 1.19mi
5.6.1. 6.1 01 Real Estate 8,990,000
5.7. 7 Port North Levee
5.7.1. 7.1 01 Relocation Inventory & Costs from RE 6,400,000
5.8. 8 Port South Levee
5.8.1. 8.1 01 Relocation Inventory & Costs from RE 5,100,000
5.9. 9 DWSC East Station 0+00 to171+71 Length = 17,171' = 3.25mi
5.9.1. 9.1 01 Real Estate 13,000,000
5.10. 10 Sac River - North Levee
5.10.1. 10.1 01 Real Estate Relocation Assistance 52,552,500

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 a short description in the evaluation to document the cost change.

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 27 2015

1-0 Evaluation **Concurred**

5.1. 2 Yolo Bypass
5.1.1. 2.1 Yolo Bypass Levee (North) Sta. 136+00 to 155+00 = 1,900 lf = .36 mi 6,428,996 This reach was not included in the alternative selection process. Being left out did NOT affect the selection process because it would have been in ALL of the alternatives.
5.2. 2.2 Yolo Bypass Levee (South) Sta 0+00 to 64+60 = 6460 lf = 1.22 mi
5.2.1. 2.2.1 01 Real Estate 175,500 MII not normally include Real Estate (RE) and account for these costs in the TPCS. Real Estate updated their numbers. 3 Lock Closure Levee
5.2.2. 3.1 01 Real Estate 1,300,000 Updated RE costs.
5.2.3. 3.3 11 Levees and Floodwalls 13,095,524 This is not a new item or reach. The name has changed slightly from that time.
5.3. 4 DWSC West Station 0+00 to123+00 Length = 12,300' = 2.33 mi
5.3.1. 4.1 01 Real Estate 1,409,365 Real Estate updated their numbers.
5.4. 5 DWSC West Levee (Navigation Levee) 123+00 - 1002+60 = 87,960 lf = 16.7 mi
5.4.1. 5.1 01 Real Estate 3,509,375 MII not normally include Real Estate (RE) and account for these costs in the TPCS. Real Estate updated their numbers.
5.5. 6 South Cross Levee Station 0+00 to 62+73 Length = 6,273' = 1.19mi
5.5.1. 6.1 01 Real Estate 8,990,000 MII not normally include Real Estate (RE) and account for these costs in the TPCS. Real Estate updated their numbers.
5.5.2.
5.6. 7 Port North Levee
5.6.1. 7.1 01 Relocation Inventory & Costs from RE 6,400,000 MII not normally include

Real Estate (RE) and account for these costs in the TPCS. Real Estate updated their numbers.
5.7. 8 Port South Levee
5.7.1. 8.1 01 Relocation Inventory & Costs from RE 5,100,000 MII not normally include Real Estate (RE) and account for these costs in the TPCS. Real Estate updated their numbers.
5.8. 9 DWSC East Station 0+00 to171+71 Length = 17,171' = 3.25mi
9.1 01 Real Estate 13,000,000 MII not normally include Real Estate (RE) and account for these costs in the TPCS. Real Estate updated their numbers. . This reach was previously estimated as two separate folder reaches and has since been combined into one when the selected plan was determined.
5.9. 10 Sac River - North Levee
10.1 01 Real Estate Relocation Assistance 52,552,500 MII not normally include Real Estate (RE) and account for these costs in the TPCS. Real Estate updated their numbers.

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 04 2015

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

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 07 2015
Current Comment Status: **Comment Closed**

6213700 Cost Engineering n/a n/a n/a
Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

6. CONCERN: At the detail level, some costs have decreased and some have increased. Cost changes are due to quantity changes because of added or deleted features noted above, and due to unit price changes. The following detail items have unit price that changed significantly. The actual list is much longer. The unit cost change is significant but in most cases the impact to the total estimated amount is not significant.

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: Low

RESOLUTION: Please provide a short description in the evaluation to document the unit cost change. General statements are sufficient.

Date 01/29/16 08/12/16

title only from 2015 01 29 DUC DUC Units DUC Change %

Haul of Material to Waste 64.51 2,132 TON 3205.4%

Wood Power Pole Relocation 30,000 94,651 EA 215.5%

10.5'-14' Wide Footing Compaction (160+00 - 1 0.11 0.26 SF 140.1%

Remove Silt Fence by hand and repair area 1.06 0.11 LF 89.8%

Grade setter / checker 40.67 76.70 HR 88.6%

20K Gallon Baker Tank 8.21 1.02 HR 87.6%

Storm Drain Inlet Protection 58.60 8.08 EA 86.2%

Laborers, (Semi-Skilled) 50.86 9.57 HR 81.2%

Saw Cutting Existing AC Paving (to 4" deep) 4.06 0.92 LF 77.3%

Place Traffic Signs (eg Stop Sign) 280.48 75.75 EA 73.0%

ABC, placement 22.10 6.35 TON 71.3%

Electrical Utility Poles, wood poles material handli 438.91 127.12 EA 71.0%

ABC, purchase and placement 24.05 6.99 TON 70.9%

DUC = Direct Unit Cost

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 27 2015

1-0 Evaluation **Concurred**

Haul of Material to Waste 64.51 2,132 TON 3205.4% Three of the instances occurred in the Sac River South FIP and this "reach" is not being built and is now an omitted folder. The remaining instance is reasonable.

Wood Power Pole Relocation 30,000 94,651 EA 215.5%
Changed to 30k so that consistent with other projects of similar scope
10.5'-14' Wide Footing Compaction (160+00 - 1 0.11 0.26 SF 140.1%
Working conditions are limit access/movement area, so production was changed to a one day minimum

Remove Silt Fence by hand and repair area 1.06 0.11 LF 89.8% Crew has been updated.

Grade setter / checker 40.67 76.70 HR 88.6%
Adjusted to current labor rates.

20K Gallon Baker Tank 8.21 1.02 HR 87.6% Items changed from Stand By to Average

Storm Drain Inlet Protection 58.60 8.08 EA 86.2% Crew makeup changed

Laborers, (Semi-Skilled) 50.86 9.57 HR 81.2%

% Reviewed crews and adjusted as required.
Saw Cutting Existing AC Paving (to 4" deep) 4.06 0.92 LF 77.3% Reviewed crews and adjusted as required.

Place Traffic Signs (eg Stop Sign) 280.48 75.75 EA 73.0% Reviewed crews and adjusted as required.

ABC, placement 22.10 6.35 TON 71.3% Reviewed estimate to make sure that all elements are in current estimate. Some items did not have the material in them for some reason, the most consistent common between items was the fact that the the description included "Purchase" but did not actually include it. Estimate confirmed to include all needed tasks.

Electrical Utility Poles, wood poles material handli 438.91 127.12 EA 71.0% Could not find this item in estimate.

ABC, purchase and placement 24.05 6.99 TON 70.9% Reviewed estimate to make sure that all elements are in current estimate. Some items did not have the material in them for some reason, the most consistent common between items was the fact that the the description included "Purchase" but did not actually include it. Estimate confirmed to include all needed tasks.

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 04 2015

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

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 07 2015
Current Comment Status: **Comment Closed**

6213701 Cost Engineering n/a n/a n/a
Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

7. OBSERVATION: Estimate Structure

1610 Notes

606 Unique Notes

2355 detail

491 upper folder

937 lower folder

5393 Lines of Data

RESOLUTION: Observation Comment. No Resolution Required. Please agree or disagree.

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 27 2015

1-0 Evaluation **Concurred**
concur

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 02 2015

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

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 07 2015

Current Comment Status: **Comment Closed**

6213702 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

8. OBSERVATION: Direct Construction Cost Summary

97,614,136 22.4% Direct Construction Labor $97,614,136, 22.41% of Direct Construction Cost

130,971,135 30.1% Direct Construction Equipment $130,971,135, 30.07% of Direct Construction Cost

228,585,272 52.5% Direct Construction Labor + Equipment $228,585,272, 52.48% of Direct Construction Cost

127,001,900 29.2% Direct Construction Matl $127,001,900, 29.16% of Direct Construction Cost

28,993,216 6.7% Direct Construction Sub Bid $28,993,216, 6.66% of Direct Construction Cost

50,967,270 11.7% Direct Construction User $50,967,270, 11.7% of Direct Construction Cost

435,547,658 100% Direct Construction Cost

RESOLUTION: Observation Comment. No Resolution Required. Please agree or disagree.

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 27 2015

1-0 Evaluation **Concurred**
concur

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 02 2015

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

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 07 2015

Current Comment Status: **Comment Closed**

6213703 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

9. OBSERVATION: Direct Cost Overrides

$ % of Labor, Equip, Material % of Total Direct Construction

M 34 19,014,613 14.97% 4% 34 MATERIAL Overrides, $19,014,613, 14.97% of Direct Construction Matl, 4.37% of Direct Construction Cost

N 2118 313,048,380 72% 2118 NO Overrides, $313,048,380, 71.87% of Direct Construction Cost

E 25 526,167 0.40% 0.12% 25 EQUIPMENT Overrides, $526,167, 0.4% of Direct Construction Equipment, 0.12% of Direct Construction Cost

O 101 88,115,052 20.23% 101 OUTPUT Overrides, $88,115,052, 20.23% of Direct Construction Cost

L 12 274,592 0.28% 0.06% 12 LABOR Overrides, $274,592, 0.28% of Direct Construction Labor, 0.06% of Direct Construction Cost

Sb 55 11,093,050 2.55% 55 SUB BID Overrides, $11,093,050, 2.55% of Direct Construction Cost

Total 227 119,023,475 27.33% 227 TOTAL Overrides, $119,023,475, 27.33% of Direct Construction Cost

RESOLUTION: Observation Comment. No Resolution Required. Please agree or disagree.

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 27 2015

1-0 Evaluation **Concurred**
concur

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 02 2015

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

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 07 2015

Current Comment Status: **Comment Closed**

6213704 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

10. CONCERN: The following item reference 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 referenced file "ProdQuant WORKSHEETS.xls"

10.1. detail Random Levee Material Placement, Shaping, and Compaction, Sheepsfoot , 1,417,647 ECY @ $8.61 per ECY = $12,206,936, 5% of the estimated direct Labor and Equipment Construction Cost, 3% of the estimated total direct construction cost, used 2 times in the estimate, overrides = 0

Cost supported by the following note: (Note: for Production Rate (Crew Output), see ProdQuant WORKSHEETS.xls - Task considers placement, shaping, and compaction of levee material. Crew output based on average material placed at ~300 LCY/HR. Material when compacted, ECY, is estimated to

10.2. detail Delivery of Levee Material from Borrow Site , 1,850,829 LCY @ $14.97 per LCY = $27,709,727, 12% of the estimated direct Labor and Equipment Construction Cost, 6% of the estimated total direct construction cost, used 3 times in the estimate, overrides = 0

Crew and Production Rate development supported by the following note "for Haul Rate (Crew Output), see ProdQuant WORKSHEETS.xls - **Quantity to be calculated by taking volume takeoff, ECY, multiplied by swell factor for ECY to LCY, 1.4,. **Using trucks with a capacity of 24CY, considering a 90% average loading factor, accounting for loading, 20 mi haul, dump, and return trucks should cycle at 1.7 HRS/Load. This equates to ~300 LCY/HR. Material loaded and hauled is determined to be LCY, use appropriate material swell and shrink factors when calculating volume. Change material cost to specific material."

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 27 2015

1-0 Evaluation **Concurred**

10.1: Spreadsheet notes added to notes in estimate.

10.2: Spreadsheet notes added to notes in estimate.

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 04 2015

1-1 Backcheck Recommendation **Close Comment**

Understood. Comment Closed.

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 07 2015

Current Comment Status: **Comment Closed**

6213705 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

11. CONCERN: Crew and Production Rate development are not supported by notes that I could find.

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 notes to document the crew and production rate development. If crew and production rate development are documented in "ProdQuant WORKSHEETS.xls", Please provide file "ProdQuant WORKSHEETS.xls".

11.1. detail Barge Travel Time, 4 Barge Group, Round Trip , 2,908 HR @ $2,656.44 per HR = $7,725,576, 3% of the estimated direct Labor and Equipment Construction Cost, 2% of the estimated total direct construction cost, used 2 times in the estimate, overrides = 0

11.2. detail Articulated Haul Truck (36 tn load) , 109,751 HR @ $204.68 per HR = $22,464,358, 10% of the estimated direct Labor and Equipment Construction Cost, 5% of the estimated total direct construction cost, used 1 times in the estimate, overrides = 0

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 27 2015

1-0 Evaluation **Concurred**

11.1: Spreadsheet notes added MII notes.

11.2: Haul assumption notes adde dto haul folder level.

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 04 2015

1-1 Backcheck Recommendation **Close Comment**

Understood. Comment Closed.

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 07 2015

Current Comment Status: **Comment Closed**

6213706 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

12. OBSERVATION: detail Double Bottom Dump , 131,956 HR @ $125.24 per HR = $16,526,447, 7% of the estimated direct Labor and Equipment Construction Cost, 4% of the estimated total direct construction cost, used 35 times in the estimate, overrides = 0

Crew and Production Rate development supported by the following note: Load: 6 minutes

Fill site to Job site: 3.2 miles x hr / 15 miles
+ 35 miles x hr / 55 miles
+ 4.9 miles x hr / 35 miles = 59 minutes
Scales 5 minutes
Dump: 6 minutes
Return 59 minutes
135 minutes / round = 2.25 hrs/rnd = 2.25 hrs/load
RESOLUTION: Observation Comment. No Resolution Required. Please agree or disagree.

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 27 2015

1-0 Evaluation **Concurred**
concur

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 02 2015

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

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 07 2015

Current Comment Status: **Comment Closed**

6213707 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

13. OBSERVATIION: detail Slurry Wall Placement, DSM Method , 4,900 HR @ $2,475.73 per HR = $12,131,081, 5% of the estimated direct Labor and Equipment Construction Cost, 3% of the estimated total direct construction cost, used 4 times in the estimate, overrides = 0

RESOLUTION: Observation Comment. No Resolution Required. Please agree or disagree.

Costs are supported by the following note:

DeepSoilMixing (DSM) STA 155+00 to 194+50
assumes 4 shaft auger rig with shafts at 2 ft OC
DeepSoilMixing (DSM) (NOTE: effective width of panel is expected to be 7 ft)
Cutoff Wall Production, SCB Wall, DSM, more than 80 ft deep
DeepSoilMixing (DSM)
Production Hour (Need a Separate Data Calc. for every change in Wall Depth and Overhead Power Site)
Length of Wall 3,950 LF Total Area 452,275 SF

Depth of Wall 114.5 FT Total Working Panel Wall Area 581,202 SF
Width of Wall 3 FT %Soil 100 %
Number of Wall Panals 564 EA %Rock 0 %
Setup time per Wall Panal 0.5 HRS Soil Down Cycle 1.00 Ft/min
Number of Pipes 0 EA Rock Down Cycle 1.00 Inch/min
Setup time per Pipes 8 HRS Up Cycle 1.25 Ft/min

Increase Hour Factor 1 FCTR Production Rate 300 SF/HR
Normal work 1, Under Powerlines 1.55 Subtotal Hours 1937.34 HRS
Total Width of each Panel 9.00 LF Wall Panels and Pipe Set Up Time (+) 282 HRS
Overlap between Panel 2.00 LF Subtotal Hours (=) 2219.34 HRS
Daily Setup Time 0.17 HRS/DAY Total Daily Setup Time 32.98 HRS
Hours Work 10 HRS Subtotal Hours 2252.32 HRS
Roundup to the nears 1,2,4,8 hrs 10 HRS Total hours Req'd 2,260 HRS
End
Slurrywall Mixture Quantities
Width of Wall 3 FT
Waste Factor 1.05 FCTR
Soil Weight 3500 lb/cy
Soil Weight for Mix 3286 lb/cy
3.5 % Bentonite Mix
Bentonite 122.5 #/CY Bentonite Req'd 3,900 TONS
80 #/BAG
3 % Cement Mix
Cement 105 #/CY Cement Req'd 3,343 TONS
94 #/BAG
Water 25 GAL/CY Gal of Water Req'd 1,695,173 GAL
End

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.

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 27 2015

1-0 Evaluation **Concurred**
concur

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 02 2015

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

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 07 2015
Current Comment Status: **Comment Closed**

6213708 Cost Engineering n/a n/a n/a
Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

14. OBSERVATION: The following detail items include notes to document crew and production rate development.

RESOLUTION: Observation Comment. No Resolution Required. Please agree or disagree.

14.1. detail Push boat / Tug Crew , 18,348 HR @ $550.85 per HR = $10,106,968, 4% of the estimated direct Labor and Equipment Construction Cost, 2% of the estimated total direct construction cost, used 1 times in the estimate, overrides = 0

14.2. detail Borrow Site Site Loading , 1,877,236 LCY @ $4.39 per LCY = $8,237,610, 4% of the estimated direct Labor and Equipment Construction Cost, 2% of the estimated total direct

14.3. detail Base Drill Rig , 9,864 HR @ $608. per HR = $5,997,312, 3% of the estimated direct Labor and Equipment Construction Cost, 1% of the estimated total direct construction cost, used 7 times in the estimate, overrides = 0

14.4. detail Scraper, Open Bowl, 32-44 cy, Cat 657E w/ Operator , 10,472 HR @ $586.59 per HR = $6,142,822, 3% of the estimated direct Labor and Equipment Construction Cost, 1% of the estimated total direct construction cost, used 6 times in the estimate, overrides = 0

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 27 2015

1-0 Evaluation **Concurred**
concur

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 02 2015

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

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 07 2015

Current Comment Status: **Comment Closed**

6213709 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

15. CONCERN: Significant Material Cost. Riprap costs. 71,629,007 16% of the total direct cost. Note documenting material cost are lacking or incomplete (source contact information, date, amount, conditions (delivery included, tax included, loading or unloading included). One note provides a date : " (Note: per Teichert Aggregate & Asphalt Pricing (FY 04/01/12-03/31/13) (Cool Cave Quarry))" indicating that the cost is over 2 years old.

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 get recent quotes and document in the notes with source contact information, date, amount, conditions (delivery included, tax included, loading or unloading included).

15.1. detail Riprap , 2,179,314 TON @ $26.25 per TON = $57,208,352, 45% of the estimated direct Material Construction Cost, 13% of the estimated total Direct Construction Cost, used 6 times in the estimate, overrides = 0

15.2. detail Rip Rap , 463,718 TON @ $21.65 per TON = $10,039,495, 8% of the estimated direct Material Construction Cost, 2% of the estimated total Direct Construction Cost, used 2 times in the estimate, overrides = 0

15.3. detail 10"-23" Rip Rap , 85,574 TON @ $21.33 per TON = $1,824,887, 1% of the estimated direct Material Construction Cost, 0% of the estimated total Direct Construction Cost, used 2 times in the estimate, overrides = 0

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 27 2015

1-0 Evaluation **Concurred**

15.1: Unit price has been adjusted to current quote

15.2: Unit price has been adjusted to current quote

15.3: Item no longer used in estimate. Replaced with landside placement rock

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 04 2015

1-1 Backcheck Recommendation **Close Comment**

Understood. Comment Closed.

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 07 2015

Current Comment Status: **Comment Closed**

6213710 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

16. CONCERN: Significant Material Cost. detail Borrow Site Site Loading , 1,877,236 LCY @ $8.59 per LCY = $16,124,473, 13% of the estimated direct Material Construction Cost, 4% of the estimated total Direct Construction Cost, used 11 times in the estimate, overrides = 0

There are 11 instances of this item but only one includes any cost for material. 11.4.9.1 Borrow Site Site Loading 1,489,559 LCY $16,124,473

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 verify it is intended that only one instance have material costs and obtain a quote or other documentation to support the material price. Quote to include source contact information, date, amount, conditions (delivery included, tax included, loading or unloading included).

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 27 2015

1-0 Evaluation **Concurred**

The one instance mentioned is a value created by the AE for the City of Sacramento for a borrow area indentified very close to the SRSouth reach and is located within a couple miles of project. The price for this is reasonable. Instances where material costs were added to the estimate as these items were missing the cost of the material. The remaining instances relate to the same excavation crew being used for mixing the cement/bentonite/soil mixture for placement back into the slurry ditch. It is reasonable that no purchase costs are included

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 04 2015

1-1 Backcheck Recommendation **Close Comment**

Understood. Comment Closed.

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 07 2015

Current Comment Status: **Comment Closed**

6213711 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

17. CONCERN: Significant Material Cost. detail Cement , 45,722 TON @ $195.66 per TON = $8,946,034, 7% of the estimated direct Material Construction Cost, 2% of the estimated total Direct Construction Cost, used 15 times in the estimate, overrides = 0

Some of the instances include the following note: "(Note: take from Contractor pricelist 10/2012) ". This pricing may not be current.

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: For this significant cost I suggest that a material quote be obtained. Quote to include source contact information, date, amount, conditions (delivery included, tax included, loading or unloading included).

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 27 2015

1-0 Evaluation **Concurred**

Material costs in estimate have been changed to be consistent with other current projects. Trucking costs have also been added to reflect reasonable haul costs. Material cost updated, haul cost updated. Subbid used for haul from WY to project site Offload is with onsite fork lift.

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 04 2015

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

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 07 2015
Current Comment Status: **Comment Closed**

6213712 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

18. CONCERN: Significant Material Cost. detail Bentonite, 1ton bag , 43,527 TON @ $190.29 per TON = $8,282,834, 7% of the estimated direct Material Construction Cost, 2% of the estimated total Direct Construction Cost, used 16 times in the estimate, overrides = 0

Some of the instances include the following note: "(Note: taken from Contractor pricelist 10/2012). This pricing may not be current.

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: For this significant cost I suggest that a material quote be obtained. Quote to include source contact information, date, amount, conditions (delivery included, tax included, loading or unloading included).

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 27 2015

1-0 Evaluation **Concurred**
Material cost updated, haul cost updated. Subbid used for haul from WY to project site Offload is with onsite fork lift.

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 04 2015

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

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 07 2015
Current Comment Status: **Comment Closed**

6213713 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

19. OBSERVATION: Less significant detail material direct costs: The following is a list of the moat expensive but less significant material cost. They appear to be reasonable.

RESOLUTION: Observation Comment. No Resolution Required. Please agree or disagree.

19.1. detail Fill Materiall - Embankment , 562,295 TON @ $7.59 per TON = $4,266,380, 3% of the estimated direct Material Construction Cost, 1% of the estimated total Direct Construction Cost, used 10 times in the estimate, overrides = 0

19.2. detail 3/4" Cl 2 AB , 204,228 TON @ $13.67 per TON = $2,791,212, 2% of the estimated direct Material Construction Cost, 1% of the estimated total Direct Construction Cost, used 11 times in the estimate, overrides = 0

19.3. detail 3/4" OGM - Asphalt , 42,723 TON @ $57.37 per TON = $2,451,125, 2% of the estimated direct Material Construction Cost, 1% of the estimated total Direct Construction Cost, used 3 times in the estimate, overrides = 0

19.4. detail Bentonite , 13,771 TON @ $177.53 per TON = $2,444,766, 2% of the estimated direct Material Construction Cost, 1% of the estimated total Direct Construction Cost, used 3 times in the estimate, overrides = 0

19.5. detail Seeding, mechanical seeding hydro or air seeding for large areas, includes lime, fertilizer and seed , 4,675,440 SY @ $.43 per SY = $2,024,466, 2% of the estimated direct Material Construction Cost, 0% of the estimated total Direct Construction Cost, used 2 times in the estimate, overrides = 0

19.6. detail AZ-26 Sheet Pile - Matl. Cost - Temp. Sheet Pile Assume Using New/Salvage - , 2,389,019 LB @ $.81 per LB = $1,939,584, 2% of the estimated direct Material Construction Cost, 0% of the estimated total Direct Construction Cost, used 1 times in the estimate, overrides = 0

19.7. detail 48" Concrete Pipe - Class 3 , 12,700 LF @ $121.24 per LF = $1,539,748, 1% of the estimated direct Material Construction Cost, 0% of the estimated total Direct Construction Cost, used 1 times in the estimate, overrides = 0

19.8. detail Buy fill material , 299,036 CY @ $3.52 per CY = $1,052,046, 1% of the estimated direct Material Construction Cost, 0% of the estimated total Direct Construction Cost, used 3 times in the estimate, overrides = 1

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 27 2015

1-0 Evaluation **Concurred**
concur

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 04 2015

1-1 Backcheck Recommendation **Close Comment**
Observation comment closed.

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 07 2015

Current Comment Status: **Comment Closed**

6213714	Cost Engineering	n/a	n/a	n/a	

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

20. OBSERVATION: Direct Construction Sub Bid $28,993,216, 6.66% of Direct Construction Cost. The following Direct Construction Sub Bid are less significant each on their own and appear to be reasonable.

RESOLUTION: Observation Comment. No Resolution Required. Please agree or disagree.

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 27 2015

1-0 Evaluation **Concurred**
concur

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 02 2015

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

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 07 2015
Current Comment Status: **Comment Closed**

6213717 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

21. OBSERVATION: Significant Direct User Costs: detail Mobilization and Demobilization , 5 LS @ $3,469,005.6 per LS = $17,345,028, 34% of the estimated direct User Construction Cost, 4% of the estimated total Direct Construction Cost, used 5 times in the estimate, overrides = 0

Costs are supported by the following notes:
(Note: = 5% of Direct cost of this contract)
(Note: = 7% of Direct cost of this contract)
(Note: = 10% of Direct cost of this contract)

RESOLUTION: Observation Comment. No Resolution Required. Please agree or disagree.

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 27 2015

1-0 Evaluation **Concurred**
concur

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 02 2015

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

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 07 2015
Current Comment Status: **Comment Closed**

6213718 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

22. CONCERN: Significant Direct User Costs: detail Real Estate Relocations , 1 EA @ $6,382,116. per EA = $6,382,116, 13% of the estimated direct User Construction Cost, 1% of the estimated total Direct Construction Cost, used 1 times in the estimate, overrides = 0

Parent folder title reads "Relocation Inventory & Costs from RE". This may be only 1% of the direct construction cost but I can't tell what it is for

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 add a not indicating this is for.

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 27 2015

1-0 Evaluation **Concurred**
This item consists of the following items based on Real Estate information: 30" storm drain siphon, Main pump station lines (2-30", 1-42"), 48" steel line, 8" pipe line, 8" pipeline, 20" pipeline.

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 04 2015

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

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 07 2015
Current Comment Status: **Comment Closed**

6213719 Cost Engineering n/a n/a n/a
Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

23. CONCERN Wage Rates: There is a significant wage difference for truck drivers that could be understating the costs as much as $4 million.

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 consider the items discussed below and revise the lower rate drivers to match the upper rate drivers.

23.1. There are 6 different truck drivers at Base + Fringe = about 53.54/hr totaling 561,451 hours,

$36,416,384

Journeyman - 1.3.2.1 Truck Drivers, Heavy , max = $53.54 per hour, min = $53.54 per hour, % difference = 0%, occurs 63 times in the estimate, accounting for 1.35% of the total labor cost

Journeyman - 1.3.1.1 Outside Truck Drivers, Heavy , max = $53.54 per hour, min = $53.54 per hour, % difference = 0%, occurs 90 times in the estimate, accounting for 25.6% of the total labor cost

Journeyman - 1.3.2.3 Truck Drivers, Medium , max = $52.84 per hour, min = $52.84 per hour, % difference = 0%, occurs 17 times in the estimate, accounting for 0.26% of the total labor cost

Journeyman - 1.3.1.3 Outside Truck Drivers, Medium , max = $52.84 per hour, min = $52.84 per hour, % difference = 0%, occurs 120 times in the estimate, accounting for 9.55% of the total labor cost

Journeyman - 1.3.1.2 Outside Truck Drivers, Light , max = $52.54 per hour, min = $52.54 per hour, % difference = 0%, occurs 3 times in the estimate, accounting for 0.02% of the total labor cost

Journeyman - 1.3.2.2 Truck Drivers, Light , max = $52.54 per hour, min = $52.54 per hour, % difference = 0%, occurs 6 times in the estimate, accounting for 0.41% of the total labor cost

23.2. There are 5 different truck drivers at Base + Fringe = about $36 to $25 per hour totaling 66,783 hrs, $2,219,930.

Journeyman - 4.2 Private Truck Driver 1 (Bttm's) , max = $38.27 per hour, min = $38.27 per hour, % difference = 0%, occurs 7 times in the estimate, accounting for 0.47% of the total labor cost

Journeyman - 4.3 Private Truck Driver 4 (Transfer) , max = $37.01 per hour, min = $37.01 per hour, % difference = 0%, occurs 1 times in the estimate, accounting for 0.01% of the total labor cost

Journeyman - 4.1 Private Truck Driver 2 (Semi end) , max = $36.44 per hour, min = $36.44 per hour, % difference = 0%, occurs 5 times in the estimate, accounting for 0.01% of the total labor cost

Journeyman - 3.1.2 Outside Truck Driver, Transfer Truck (Trucking Service) , max = $29.83 per hour, min = $29.83 per hour, % difference = 0%, occurs 7 times in the estimate, accounting for 0.13% of the total labor cost

Journeyman - 3.1.1 Outside Truck Driver, Semi End Dump (Trucking Service) ,

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 27 2015

1-0 Evaluation **Concurred**

There should actually only be two different wage rates, and MII has been changed so that this is the case. The reason for this is because of the Prevailing Wage rules. Material from a commercial plant delivered to the project, the driver does not get paid PW rates, rather they are paid a private wage. A driver who's sole job is to deliver material does not get PW. A driver that only works on the site, a water truck driver for instance would get PW because he is working on site. A driver moving soils from a government supplied borrow site would also get PW, but if the source is procured by a business, they would not. I spoke to a truck broker, and obtained their hourly rates for different types of trucks, they are basically $98/hr. Crews are created using the equipment cost book so that equipment costs an fuel can be easily adjusted. The hourly labor rate is the difference between the truck broker rate and the equipment rate. Because of this, there is a very good reason that there are two different rates. Most contractors do not own their own trucks, they usually go thru truck brokers for all their transportation needs. Water trucks on the other hand are a different story and they get paid PW.

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 04 2015

1-1 Backcheck Recommendation **Close Comment**

Understood. Comment Closed.

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 07 2015

Current Comment Status: **Comment Closed**

6213721 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

24. CONCERN: Equipment Rates. There are 125 different equipment items used in the estimate. 12% of the equipment costs are included in the 13 different most expensive equipment items below. Adjusting the equipment selection could have a significant impact to the total cost.

For example, consider the first item in the list below. From the region 7 equipment manual, a very similar equipment selection is EP T55JD004 TRUCK, OFF-HIGHWAY, ARTICULATED FRAME, 29.7 CY, 41 TON, 6X6, REAR DUMP $142.84/hr. $15/hr more expensive x 111,187 hrs = 15,881,941, an increase of $1,750,448

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 consider the most significant equipment items listed below and verify that the equipment selected is reasonable for the job. .

Description EQHours Total $/hr

TRUCK, OFF-HIGHWAY, ARTICULATED FRAME, 21.6-29.2 CY, 40.3 TON, 6 X 6 X 2, REAR DUMP 111,187 14,131,492 127

TRUCK, HIGHWAY, 50,000 LBS GVW, 3 AXLE, 6X4 (CHASSIS ONLY-ADD OPTIONS) 184,808 9,810,411 53

WORK TUG, 1000 HP 18,348 5,946,403 324

CRANE, MECHANICAL, LATTICE BOOM, CRAWLER, LIFTING, 100 TON (91 MT), 200' (61.0 M) BOOM 12,202 1,210,512 99

LOADER, FRONT END, WHEEL, ARTICULATED, 10 CY (7.6 M3) BUCKET, 4X4 12,202 2,207,912 181

Base Drill Rig 5,060 3,076,480 608

HYDRAULIC EXCAVATOR, CRAWLER, 227,100 LBS, 8.50 CY BUCKET, 34.25' MAX DIGGING DEPTH 3,688 1,037,303 281

TRUCK, OFF-HIGHWAY, ARTICULATED FRAME, 21.6-29.2 CY, 40.3 TON, 6 X 6 X 2, REAR DUMP 111,187 14,131,492 127

SCRAPER, TANDEM POWERED, STANDARD LOADING, 32-44 CY (24-34 M3), 52 TON (47.2 MT), 4X4, D-11 ASSISTED LOADING 11,324 5,520,905 488

ROLLER, STATIC, SELF-PROPELLED, LANDFILL/SOIL COMPACTOR, SHEEPSFOOT, 4X4, 35 TON, 51" DIA, 16.00' WIDTH PER 2-PASS, W/BLADE 8,210 1,323,757 161

TRACTOR, CRAWLER (DOZER), 310 HP, POWERSHIFT, W/15.3 CY SEMI-U BLADE (ADD ATTACHMENTS) 14,403 2,316,529 161

TRUCK, HIGHWAY, 55,000 LB (24,948 KG) GVW, 6X4, 3 AXLE (ADD ACCESSORIES) 26,271 1,703,031 65

HYDRAULIC EXCAVATOR, CRAWLER 90,000 LB (40,823 KG), 2.50 CY (1.9 M3) BUCKET, 30.4' (9.3 M) MAX DIGGING DEPTH 10,146 1,016,127 100

TRUCK TRAILER, BOTTOM DUMP, 18 CY (13.8 M3), 27 TON (24.5 MT) (ADD TOWING TRUCK) 114,916 1,060,393 9

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 27 2015

1-0 Evaluation **Concurred**

a) Both trucks are just as reasonable as the other. This is more of an optimization issue that will be determined later

b) This equipment item is basically the equipment portion of the on road haul trucks and water trucks

c) Required to push rip rap ~74 miles from Assumed San Francisco to about DWSC mile 37

d) Used for offloading rip rap. This size needed so that can reach out over barges and place onland

e) Used to load rip rap. Smaller size would hamper production.

f) Equipment used for Deep Soil Mixing and is the normal equipment used for this type of construction. Equipment rate is from CalTrans Rental book.

g) Normal piece of equipment used for excavator method of excavation for slurry walls to 85' deep.

h) Reasonable compactor to meet compaction requirements for soils being placed in new levee and levee backfill after installation of slurry walls.

i) Reasonable size dozer for most work on project. Stripping, ripping, general grading all very reasonable due to soils conditions on this project.

j) Reasonable sized machine for use in clearing, underground, loading of trucks type operations.

k) Used in crews for hauling soils and baserock. Reasonable to be used in estimate for equipment trailer. Capacity is over what can legally be hauled in CA. Unit rate reasonable.

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 04 2015

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

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 07 2015
Current Comment Status: **Comment Closed**

6215823	Cost Engineering	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

CONCERN: A risk analysis has not been provided

BASIS: Cost Engineering Criteria

RESOLUTION: Provide risk analysis when available.

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 28 2015

1-0 Evaluation **Concurred**
CSRA electronic file has been sent for review.

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 04 2015

1-1 Backcheck Recommendation **Open Comment**
As of 9/7/2015, I cannot find that I have received the csra

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 07 2015

2-0 Evaluation **Concurred**
CSRA sent. CSRA & TPCS to be updated when notified that all comments will be closed upon final submission of final MII/CSRA/TPCS

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 10 2015

2-1 Backcheck Recommendation **Close Comment**
Risk analysis received 9/92015. Comment Closed

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 10 2015

Current Comment Status: **Comment Closed**

6218152	Environmental	n/a	GENERAL	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**
(Document Reference: EIS/EIR)

CONCERN: For Information Only. EIS/EIR is well written containing a systematic/consistent review of impacts according to Corps and CEQ Regulations. The PDT had a good understanding of Corps Levee Vegetation requirements which is important for this analysis. No major concerns with document. Nice job!
BASIS FOR CONCERN: ER200-2-2 and CEQ Guidelines
SIGNIFICANCE OF CONCERN: NA
ACTION NEEDED TO RESOLVE CONCERN:NONE

Submitted By: Michael Scuderi (206-764-7205). Submitted On: Aug 31 2015

1-0 Evaluation **Concurred**
concur

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 02 2015

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

Submitted By: Michael Scuderi (206-764-7205) Submitted On: Sep 04 2015

Current Comment Status: **Comment Closed**

6218165	Environmental	n/a	Table 3.6	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**
(Document Reference: EIS/EIR)

CONCERN: Table Title appears inconsistent with information provided
BASIS FOR CONCERN: Compensation is indicated on the title but there is no row listing proposed compensation
SIGNIFICANCE OF CONCERN: Medium
ACTION NEEDED TO RESOLVE CONCERN: Either eliminate compensation from title or add information from CE/ICA analysis

Submitted By: Michael Scuderi (206-764-7205). Submitted On: Aug 31 2015

1-0 Evaluation **Concurred**
Added a column with the proposed mitigation/compensation for each alternative and also updated the acreages based on USFWS BO and CAR. Updated Tables 3.6-1, 3.6-2, and 3.6-3.

Submitted By: Sarah Ross Arrouzet (916-557-5256) Submitted On: Sep 03 2015

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

Submitted By: Michael Scuderi (206-764-7205) Submitted On: Sep 04 2015
Current Comment Status: **Comment Closed**

6218166 Environmental n/a Pg 144; pg 195 n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**
(Document Reference: EIS/EIR)

CONCERN: Different work windows
BASIS FOR CONCERN: There are two work windows listed here that are different. Difficult to determine which takes precedent or impact on construction schedule. Also GGS window is different. How does that fit in to the construction plan? This discrepancy appears several times in the EIS
SIGNIFICANCE OF CONCERN: Medium
ACTION NEEDED TO RESOLVE CONCERN: At minimum in mitigation measures section describe how these different work windows interact

Submitted By: Michael Scuderi (206-764-7205). Submitted On: Aug 31 2015

1-0 Evaluation **Concurred**
Updated the in water work windows to be consistent with the BO from NMFS (August 1-November 30). GGS work windows are April through October, but once measures are in place to keep GGS out of the construction area and with a monitor on site, work may continue past October. Work windows for GGS also refer to out of water work during the active season (April-October), in water work would not be a problem after October since GGS are then hibernating in the upland areas. Will update mitigation measures sections to address discrepancy.

Submitted By: Sarah Ross Arrouzet (916-557-5256) Submitted On: Sep 03 2015

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

Submitted By: Michael Scuderi (206-764-7205) Submitted On: Sep 04 2015
Current Comment Status: **Comment Closed**

6218168 Environmental n/a pg. 178 n/a
Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**
(Document Reference: EIS/EIR)

CONCERN: Use of SAM Methodology
BASIS FOR CONCERN: SAM is introduced here but there is no explanation of how the values produced here fit into the CE/ICA analysis
SIGNIFICANCE OF CONCERN: Medium
ACTION NEEDED TO RESOLVE CONCERN: Enhance explanation of use of SAM and HEP in the impacts analysis.

Submitted By: Michael Scuderi (206-764-7205). Submitted On: Aug 31 2015

1-0 Evaluation **Concurred**
Updated language to say SAM was used to negotiate appropriate mitigation with Resource Agencies in order to identify long term impacts to fish species. SAM was not used in connection with the CE/ICA. The mitigation cost for SRA (salmon habitat) is directly related to the loss of SRA which was calculated by measuring habitat loss in the project area. Will add additional language in the impact analysis to better explain use of HEP relating to mitigation and CE/ICA.

Submitted By: Sarah Ross Arrouzet (916-557-5256) Submitted On: Sep 03 2015

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

Submitted By: Michael Scuderi (206-764-7205) Submitted On: Sep 04 2015
Current Comment Status: **Comment Closed**

6218170 Environmental n/a pg. 196 n/a
Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**
(Document Reference: EIS/EIR)

CONCERN: No sure how mitigation will be formulated for the setback area given the wording presented in the hydrology section
BASIS FOR CONCERN: Hydrology section indicates potential flood level rise with setback. This could impact the effectiveness of the setback area for mitigation.
SIGNIFICANCE OF CONCERN: Medium
ACTION NEEDED TO RESOLVE CONCERN: Provide enhanced description of what types of mitigation are possible or clearly define what other analysis needs to be accomplished. Page 398

should also reflect this.

Submitted By: Michael Scuderi (206-764-7205). Submitted On: Aug 31 2015

1-0 Evaluation **Concurred**

Mitigation/restoration of the setback area will be designed further in PED depending on mitigation needs and best fit for habitat construction based on elevation and inundation of the site. Changed language in the Hydrology Section to indicate that the change in water surface elevation with the setback levee was determined not to be significant. Changed both sections.

Submitted By: Sarah Ross Arrouzet (916-557-5256) Submitted On: Sep 03 2015

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Michael Scuderi (206-764-7205) Submitted On: Sep 04 2015

Current Comment Status: **Comment Closed**

6218867	Geotechnical	Section 11.4.12 - S. Basin - Yolo Bypass E. L - St. 10+00	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**
(Document Reference: Geotechnical Appendix)

Previous review comment 5570098 stated: "Based on review of the analyses provided at this station, there is no engineering reason to construct a seepage cutoff wall for the "with project" condition at Sta. 10+00. Recommend that recommendation be revised." Comment was originally closed based on conversation with the District that clarification has been added that detail level design will further re-evaluate these alternatives.

Reviewer noted this language has been added in later sections of this report; however, it is recommended that similar language be added directly to Section 11.4.14. The gradients and slope stability factors of safety still do not support the recommended alternative of a cutoff wall to EL-60.

Submitted By: Brad Arcement (601-631-5899). Submitted On: Sep 01 2015

1-0 Evaluation **Concurred**

The feasibility analysis at the Sacramento River north levee does not demonstrate the need for seepage or stability mitigation. Several other reports prepared for WSAFCA by others indicated the need for seepage or stability mitigation modifications. Based on the information available at the feasibility level, and the conflict between recommendations from the sponsor and the Corps, the geotechnical recommendation was to recommend work in this area, with the final determination of need to be made during PED. We will add a clarification to 11.4.14 per the reviewer's comment.

Submitted By: Erik James (916-557-5259) Submitted On: Sep 09 2015

1-1 Backcheck Recommendation **Close Comment**
Reviewer discussed the comment with the district and understands that clarification will be added to the report to satisfy the comment.

Submitted By: Brad Arcement (601-631-5899) Submitted On: Sep 09 2015
Current Comment Status: **Comment Closed**

6218925	Geotechnical	Table 13-10	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**
(Document Reference: Geotechnical Appendix)

Table 13-10 provides the geotechnical recommendations for the Sacramento Bypass North Levee. The recommendation is for construction of a "New Levee" for the Sacramento Bypass North Levee. This recommendation is not match the analyses completed at Sta. 8+30 that was used as the representative crosss section for this reach. The analyses completed for Sta. 8+30 is for a modification of the levee "in-place", not construction of a new levee. The "in-place" modifications analysed and presented in Section 11.5.1 include a levee raise and construction of a 80-ft wide berm. The recommendations in Table 13-10 include a "New Levee" with a 300-ft wide seepage berm or a "New Levee" with a 80-ft wide berm AND 20-ft deep cutoff wall.

The analyses that support the "New Levee" alternatives should be included in the report and Section 11.5.1 should be revised, or Table 13-10 should be revised to reflect the recommendations developed for the geotechnical analyses that include only a raise and berm.

Submitted By: Brad Arcement (601-631-5899). Submitted On: Sep 01 2015

1-0 Evaluation **Concurred**
Analyses was performed on the existing Sacramento Bypass north levee to determine the performance of that levee as well as the general material composition of the levee. However, the project alternative recommendation was for a relocated north levee. There are no existing borings or other geotechnical data available for the location of the new north Sacramento bypass levee. Therefore, a conservative assumption was made regarding potential seepage or stability improvements required for the new north levee. These assumptions were intended to reasonably maximize real estate and environmental impacts for the planning study, with final determination of need to be determined in PED.

Submitted By: Erik James (916-557-5259) Submitted On: Sep 09 2015

1-1 Backcheck Recommendation **Close Comment**
Reviewer discussed the comment with the District and understands that clarification will be added to the report to satisfy the response.

Submitted By: Brad Arcement (601-631-5899) Submitted On: Sep 09 2015
Current Comment Status: **Comment Closed**

6218977	Geotechnical	Levee Problems at Specific Locations	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**
(Document Reference: Chapter 2 - Problem Identification)

The discussion for the North Basin and South Basin in Chapter 2 there are references to "probability of failure....". The use of the phrase "probability of failure" is incorrect and should be re-written to state "probability of poor performance" for each segment of the North and South Basin as discussed.

The probabilistic analyses presented in the Geotechnical Appendix does not provide a "probability of failure", but rather a "probability of poor performance" and has been corrected as such based on previous reviews. The use of the term "failure" implies breach of the levee prior to overtopping. The probabilistic analyses in the Geotechnical Appendix only provides a probability of initiation of seepage and stability failure modes. The actual probability of "failure" (breach) is lower than presented in the Geotechnical Appendix - which is why that section was re-written.

Submitted By: Brad Arcement (601-631-5899). Submitted On: Sep 01 2015

1-0 Evaluation **Concurred**
Text has been changed as suggested.

Submitted By: Andrew Muha ((916) 557-6756) Submitted On: Sep 02 2015

1-1 Backcheck Recommendation **Close Comment**
Understood that text has been changed as recommended.

Submitted By: Brad Arcement (601-631-5899) Submitted On: Sep 03 2015
Current Comment Status: **Comment Closed**

6219365 Real Estate n/a n/a n/a
Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

REVIEW CONCERN: REP Section 4 (page 10) discusses 15 foot permanent easements for providing maintenance access and flood fighting purposes. Would this be a (non-standard) perpetual access easement? There is no description of what type of easement would be acquired. In addition, this section does not mention the bank protection easements to be acquired and the purpose of those estates.
BASIS FOR THE CONCERN: ER 405-1-12
SIGNIFICANCE OF THE CONCERN: Low
RECOMMENDED ACTION: Recommend adding more description of the type of estate to be acquired for access/flood fight purposes, and discussion of the bank protection easement.

Submitted By: Karen Vance (5048621349). Submitted On: Sep 01 2015

1-0 Evaluation **Concurred**
Page 24 discussed bank protection easements but I will add a discussion of bank protection on Page 10 as well. Thes easemetns required are levee easements and O&M corridors. They are standard estates. I can add a clarification senctence.

Submitted By: Laurie Parker (557-6741) Submitted On: Sep 03 2015

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

Submitted By: Karen Vance (5048621349) Submitted On: Sep 08 2015
Current Comment Status: **Comment Closed**

6219366 Real Estate n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

REVIEW CONCERN: ER 405-1-12 specifies that in the REP, there should be discussion of any previous Real Estate Plans that were prepared for the project. The REP mentions a feasibility report was completed in 1992 and project costs presented to Congress in 2009 and 2011. Was there an REDM/REP for the originally authorized project? The GRR is a result of a Post Authorization Change – was a REP prepared for the PAC as well?
BASIS FOR THE CONCERN: ER 405-1-12
SIGNIFICANCE OF THE CONCERN: Low
RECOMMENDED ACTION: Recommend including some discussion of previous Real Estate Plans prepared for the project and any changes that may have occurred since that time.

Submitted By: Karen Vance (5048621349). Submitted On: Sep 01 2015

1-0 Evaluation **Concurred**
Yes there is a real estate appendix from the previous feasibility report. The existing levees have levee easements already except the South Cross Levee which is a private levee to be converted to a federal levee. They executed flowage easements in Yolo Bypass and Sacramento Bypass were executed in the 1940's and 1950's. There were tempoary construction easements executed, borrow easments and fee title for mitigation.

Submitted By: Laurie Parker (557-6741) Submitted On: Sep 03 2015

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

Submitted By: Karen Vance (5048621349) Submitted On: Sep 08 2015
Current Comment Status: **Comment Closed**

6219367 Real Estate n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

REVIEW CONCERN: Table 4 on Page 16 is inconsistent with the same table shown as Table 4-4 in Chapter 4 of the GRR. The acreages/costs in the main report differ from what is shown in the REP.
BASIS FOR THE CONCERN: ER 405-1-12
SIGNIFICANCE OF THE CONCERN: Low
RECOMMENDED ACTION: Revise Table 4 in the REP to be consistent with the main report.

Submitted By: Karen Vance (5048621349). Submitted On: Sep 01 2015

1-0 Evaluation **Concurred**

My table 4 should be consistant with Table 4-4, Chapter 4 of the GRR. I will reinsert new table.

Submitted By: Laurie Parker (557-6741) Submitted On: Sep 03 2015

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Karen Vance (5048621349) Submitted On: Sep 08 2015

Current Comment Status: **Comment Closed**

6219368	Real Estate	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

REVIEW CONCERN: There is a discussion in the REP of several railroad parcels to be acquired as part of the lands required for the project. Will acquisition of these parcels present any significant issues relating to project schedule or the overall project plan?
BASIS FOR THE CONCERN: ER 405-1-12
SIGNIFICANCE OF THE CONCERN: Low
RECOMMENDED ACTION: Recommend further discussion of any issues that could arise as a result of this acquisition plan including railroad parcels.
REVIEW CONCERN: There is a discussion in the REP of several railroad parcels to be acquired as part of the lands required for the project. Will acquisition of these parcels present any significant issues relating to project schedule or the overall project plan?
BASIS FOR THE CONCERN: ER 405-1-12
SIGNIFICANCE OF THE CONCERN: Low
RECOMMENDED ACTION: Recommend further discussion of any issues that could arise as a result of this acquisition plan including railroad parcels.

Submitted By: Karen Vance (5048621349). Submitted On: Sep 01 2015

1-0 Evaluation **Concurred**

The railroad parcels occur in Port North reach. A flood wall is the construction feature that crosses the railroad track. A new location for the floodwall may avoid disrupting the railroad parcels. In PED suggest a new alighment to avoid delay to cost and schedule. Definetly a risk register item.

Submitted By: Laurie Parker (557-6741) Submitted On: Sep 03 2015

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Karen Vance (5048621349) Submitted On: Sep 08 2015

Current Comment Status: **Comment Closed**

6219370	Real Estate	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

REVIEW CONCERN: Section 5, page 23 – Although it is apparent that the City and the State are Non Federal Sponsors for the project, there is no statement to that effect. Additionally, there is a Capability Assessment for both, so it is assumed that both will be responsible for LERRDs acquisition.
BASIS FOR THE CONCERN: ER 405-1-12
SIGNIFICANCE OF THE CONCERN: Low
RECOMMENDED ACTION: Recommend mentioning at the beginning of Section 5 who the NFS is and who is responsible for LERRDs acquisition.

Submitted By: Karen Vance (5048621349). Submitted On: Sep 01 2015

1-0 Evaluation **Concurred**
Will provide a clarifying sentence on who the NFS is.

Submitted By: Laurie Parker (557-6741) Submitted On: Sep 03 2015

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

Submitted By: Karen Vance (5048621349) Submitted On: Sep 08 2015
Current Comment Status: **Comment Closed**

6219623	Planning - Plan Formulation	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

Based on my review of Chapter 3 of the West Sacramento Project GRR, I have no technical comments on the plan formulation strategy assuming there are no major issues from other ATR SME's. The attached graphs and following discussion provides the rationale for my response.

The step-wise plan formulation process used is a logical approach. The plan formulation strategy is based on the existing condition defined in Section 3.11: "There are some reaches of levees where the seepage and stability issues are worse than other reaches. However, improving those reaches moves the point(s) of greatest concern to the next location. West Sacramento is surrounded by a system of levees, the performance of each segment of the system is essential of functioning of the entire levee system."

The PDT initially identified an array of structural and non-structural management measures. Measures were screened using a combination of preliminary cost estimates for some measures and professional judgment. Remaining measures were then combined to formulate 12 structural and 1 non-structural Alternatives. These Alternatives were evaluated and screened using Completeness; Efficiency, based on parametric cost estimates; Effectiveness; and Acceptability criteria. The evaluation metrics used are shown in Table 3-18 (the initial assessment of the preliminary array of alternatives indicated that Alternative 5 would potentially be the NED plan). A final array of the 3 top candidate Alternatives (Alternatives 1, 3, and 5) were retained for more detailed evaluation. The more detailed evaluation resulted in the verification and selection of Alternative 5 as the NED

Plan.

Editorial comments on Chapter 3 and other Chapters will be provided by separate correspondence.

(Attachment: West_Sacramento_NED_Plan_Review.pdf)

Submitted By: Gene Lilly (918-669-7196). Submitted On: Sep 01 2015

1-0 Evaluation **Concurred**
Thanks for the positive feedback

Submitted By: Andrew Muha ((916) 557-6756) Submitted On: Sep 02 2015

1-1 Backcheck Recommendation **Close Comment**
The response is to my satisfaction. Thank you.

Submitted By: Gene Lilly (918-669-7196) Submitted On: Sep 09 2015
Current Comment Status: **Comment Closed**

6220224 Civil Table 3 17 n/a
Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

1. REVIEW CONCERN: Unsure if the proposed features in Table 3 match those listed in Attachment E - Civil Design Engineering Appendix? (Note: Attachment E was not provided as part of the review documents.)

2. BASIS FOR THE CONCERN: The proposed features in Table 3 do not match those in Table 4 of the Draft Civil Engineering Appendix dated December 2014. As such, I feel that the information in "Attachment E - Civil Design Engineering Appendix" may be in conflict with Table 3.

3. SIGNIFICANCE OF THE CONCERN: Possible conflict between Table 3 and those listed in Attachment E - Civil Design Engineering Appendix.

4. ACTION NEEDED TO RESOLVE THE CONCERN: Compare Table 3 to the comparable table in the referenced "Attachment E - Civil Design Engineering Appendix" and verify that they cite the same information. If they do not revise either Table 3 or the Engineering Appendix so that they provide the same information.

Submitted By: Norman Gartner (501-324-5274). Submitted On: Sep 02 2015

1-0 Evaluation **Concurred**
Civil Design Engineering Appendix and other appendixes will be provided for review and backcheck. The table 4 of the draft civil engineering appendix was revised to match table 3 in the engineering appendix.

Submitted By: Benson Liang (916-557-6768) Submitted On: Sep 04 2015

1-1 Backcheck Recommendation **Open Comment**
Revised appendices were not provided.

Submitted By: Norman Gartner (501-324-5274) Submitted On: Sep 08 2015

1-2 Backcheck Recommendation **Close Comment**
Revised engineering appendix was received and rev iewed. Table 4 in Attachment E has been revised to match Table 3.

Submitted By: Norman Gartner (501-324-5274) Submitted On: Sep 09 2015

Current Comment Status: **Comment Closed**

6220232 Civil 1.2.3 3 n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

1. REVIEW CONCERN: The wrong Figure number is cited in the first sentence.

2. BASIS FOR THE CONCERN: Figure 3 is the Early Implementation Project map.

3. SIGNIFICANCE OF THE CONCERN: Minor clarification.

4. ACTION NEEDED TO RESOLVE THE CONCERN: Change "Figure 2" to "Figure 3".

Submitted By: Norman Gartner (501-324-5274). Submitted On: Sep 02 2015

Revised Sep 02 2015.

1-0 Evaluation **Concurred**
The figure number in the first sentence was revised to Figure 3.

Submitted By: Benson Liang (916-557-6768) Submitted On: Sep 04 2015

1-1 Backcheck Recommendation **Close Comment**
Comment resolved.

Submitted By: Norman Gartner (501-324-5274) Submitted On: Sep 08 2015

Current Comment Status: **Comment Closed**

6220239 Civil Table 2 and Table 3 15 & 17 n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

1. REVIEW CONCERN: The reach length for the Sacramento River South Levee does not match between Tables 2 and 3.

2. BASIS FOR THE CONCERN: Table 2 lists the reach length as 33,100 and Table 3 lists it as 30,000.

3. SIGNIFICANCE OF THE CONCERN: Minor clarification.

4. ACTION NEEDED TO RESOLVE THE CONCERN: Determine which reach length is corrrect

and revise the appropriate Table accordingly.

Submitted By: Norman Gartner (501-324-5274). Submitted On: Sep 02 2015

Revised Sep 02 2015.

1-0 Evaluation **Concurred**
The reach length in the table 3 was revised to 33,100.

Submitted By: Benson Liang (916-557-6768) Submitted On: Sep 04 2015

1-1 Backcheck Recommendation **Close Comment**
Comment resolved.

Submitted By: Norman Gartner (501-324-5274) Submitted On: Sep 08 2015
Current Comment Status: **Comment Closed**

6220244 Civil South Cross Levee 20 n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

1. REVIEW CONCERN: The reach length for South Cross Levee does not match Table 3.

2. BASIS FOR THE CONCERN: Table 3 lists the reach length as 6400 feet and this section lists it as 6300 feet.

3. SIGNIFICANCE OF THE CONCERN: Minor clarification.

4. ACTION NEEDED TO RESOLVE THE CONCERN: Determine which reach length is corrrect and revise the appropriate Table or section accordingly.

Submitted By: Norman Gartner (501-324-5274). Submitted On: Sep 02 2015

Revised Sep 02 2015.

1-0 Evaluation **Concurred**
The number 6300 in the section was revised to 6400 feet.

Submitted By: Benson Liang (916-557-6768) Submitted On: Sep 04 2015

1-1 Backcheck Recommendation **Close Comment**
Comment resolved.

Submitted By: Norman Gartner (501-324-5274) Submitted On: Sep 08 2015
Current Comment Status: **Comment Closed**

6220249 Civil DWSC West Levee 20 n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

1. REVIEW CONCERN: The reach length for the DWSC West Levee does not match Table 3.

2. BASIS FOR THE CONCERN: Table 3 lists the reach length as 99,010 feet and this section lists it as 99,000 feet.

3. SIGNIFICANCE OF THE CONCERN: Minor clarification.

4. ACTION NEEDED TO RESOLVE THE CONCERN: Determine which reach length is corrrect and revise the appropriate Table or section accordingly.

Submitted By: Norman Gartner (501-324-5274). Submitted On: Sep 02 2015

1-0 Evaluation **Concurred**

The number in the section was revised to 99,010 feet.

Submitted By: Benson Liang (916-557-6768) Submitted On: Sep 04 2015

1-1 Backcheck Recommendation **Close Comment**

Comment resolved.

Submitted By: Norman Gartner (501-324-5274) Submitted On: Sep 08 2015

Current Comment Status: **Comment Closed**

6221931 Cultural Resources Section 3.9 pages 195 to 205 n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

The report 1) lacks documentation and text that cultural resources were integrated entirely into project development as part of the Planning Process and 2) the report text concerning cultural resources does not specifically define the Area of Potential Effect (APE). A recommendation and suggestion would be to focus on a description and discussion of the proposed alternative recommended by the report relative to the identification and delineation of the APE, and the steps taken to reduce affects to historic properties in the context of project development and planning.

Submitted By: Ronald Deiss (309-794-5185). Submitted On: Sep 03 2015

1-0 Evaluation **Concurred**

The location of cultural resources are not know for the entire project footprint. There has not been a systematic cultural resources survey for the Project Area. A records search of the APE does provide information for some know sites. There have been no actual project plans engineered for this project because it is being completed in phases. The avoidance of Cultural resources during later project specific development will have this information and considered during design.

Submitted By: Dawn Sullo (916-557-7628) Submitted On: Sep 03 2015

1-1 Backcheck Recommendation **Close Comment**
It seems that although the project is being engineered in phases an attempt for the protection of historic properties has been attempted.

Submitted By: Ronald Deiss (309-794-5185) Submitted On: Sep 09 2015
Current Comment Status: **Comment Closed**

6221936	Cultural Resources	Section 3.9	pages 195 to 205	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

This section would be dramatically improved by the removal of text that contain a general overview of the cultural resources and the context of historic properties relative to the National Historic Preservation Act, rather than a focused approach toward a description of project specific and existing conditions relative to historic properties that would be potentially affected by the project, and the documentation of, and the definition of the APE. Recommendations would be removal of those sections of the report and begin the Section 3.90 with the "Results of the Record Search" section on page 204.

Submitted By: Ronald Deiss (309-794-5185). Submitted On: Sep 03 2015

1-0 Evaluation **For Information Only**
This information is standard for SPK to include in its NEPA docuements.

Submitted By: Dawn Sullo (916-557-7628) Submitted On: Sep 09 2015

1-1 Backcheck Recommendation **Close Comment**
Although requirements of NEPA documents are often dictated by the Corps standardized and traditional processes, and also, often directed by reviewers' comments, non-project specific overviews are not a legal requirement and unnecessarily add to the length of the NEPA document. The reviewer found the evaluator's comment acceptable.

Submitted By: Ronald Deiss (309-794-5185) Submitted On: Sep 09 2015
Current Comment Status: **Comment Closed**

6221987	Cultural Resources	Section 3.9	page 205 and page 208	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

The referenced Figure 3.9-3 is missing from the report. The lack of a justifiable APE induces risks throughout the planning process phases, which increase exponentially, through and during construction. The recommendation is to include appropriate figures and text.

Submitted By: Ronald Deiss (309-794-5185). Submitted On: Sep 03 2015

1-0 Evaluation **Concurred**
I will let our lead planner know that this figure is missing and it will be added.

Submitted By: Dawn Sullo (916-557-7628) Submitted On: Sep 03 2015

1-1 Backcheck Recommendation **Close Comment**
The evaluation is acceptable.

Submitted By: Ronald Deiss (309-794-5185) Submitted On: Sep 09 2015

Current Comment Status: **Comment Closed**

6221995 Cultural Resources Section 3.9 pages 195 to 211 n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

A major deficiency of this section is the lack of focus on coordination of the APE, eventually leading to the Programmatic Agreement for the protection of historic properties. It is paramount that the report documents the coordination process, effort, and responses. The coordination and consultation effort should reference to an appendix containing evidence of those, meetings, letters, correspondence, and responses. The recommendation for section 3.9 is to: 1) describe and document the coordination and consultation of the APE, as promulgated under Section 106 of the National Historic Preservation Act, as amended, and its implementing regulation 36 CFR Part 800, and consultation with Tribes and other interested and consultation parties, 2) full disclosure of coordination and consultation of the APE and how the Corps took measure of reduce effect to historic properties, and to 3) document and delineate the coordination and consultation leading to the proposal and development of a draft programmatic agreement, placing all permanent correspondence in an appendix.

Submitted By: Ronald Deiss (309-794-5185). Submitted On: Sep 03 2015

1-0 Evaluation **Concurred**
The APE was coordinated with the SHPO. Documentation of coordination will be appended to the EIS.

Submitted By: Dawn Sullo (916-557-7628) Submitted On: Sep 09 2015

1-1 Backcheck Recommendation **Close Comment**
The evaluation and corrective measures are acceptable.

Submitted By: Ronald Deiss (309-794-5185) Submitted On: Sep 09 2015

Current Comment Status: **Comment Closed**

6222002 Cultural Resources Section 3.9 Page 208 n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

The last sentence "The APE was described and consulted with the State Historic Preservation Officer." This correspond should referenced a dated letter, which should be reference to the appropriate report appendix with all correspondence and responses, and mention of lack of responses. A recommendation would be to reference the appropriate consultation and coordination relative to National Historic Preservation Act that: 1) contributed to the identification and protection of historic properties, sacred sites, traditional historic properties and 2) resulted in the identification and delineation of the APE.

Submitted By: Ronald Deiss (309-794-5185). Submitted On: Sep 03 2015

1-0 Evaluation **Concurred**
The correspondance will be referenced in the document and the appropriate attachments will be appended to the document.

Submitted By: Dawn Sullo (916-557-7628) Submitted On: Sep 09 2015

1-1 Backcheck Recommendation **Close Comment**
The evaluation and corrective measures are acceptable.

Submitted By: Ronald Deiss (309-794-5185) Submitted On: Sep 09 2015

Current Comment Status: **Comment Closed**

6222005 Cultural Resources Section 3.9.2 pages 212 to 213 n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

Portions of the "Methodology and Basis of Significance" section seem out of place. A suggestion would be to place the "Past NHPA/CEQA Compliance for the West Sac GRR Study" effort in the existing conditions and past coordination cultural resource sections of the report, keeping the "Methodology" and "Basis of Significance".

Submitted By: Ronald Deiss (309-794-5185). Submitted On: Sep 03 2015

1-0 Evaluation **Concurred**
I will discuss this with our lead planner.

Submitted By: Dawn Sullo (916-557-7628) Submitted On: Sep 03 2015

1-1 Backcheck Recommendation **Close Comment**
Consideration of the suggestion has been made.

Submitted By: Ronald Deiss (309-794-5185) Submitted On: Sep 09 2015

Current Comment Status: **Comment Closed**

6222008 Transportation Section 3.10 page 219 n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

Transportation and Navigation (There is nothing in this section and it should be removed or completed). A recommendation would be to provide introductory text for this section.

Submitted By: Ronald Deiss (309-794-5185). Submitted On: Sep 03 2015

1-0 Evaluation **Concurred**
I will discuss this with our lead planner.

Submitted By: Dawn Sullo (916-557-7628) Submitted On: Sep 03 2015

1-1 Backcheck Recommendation **Close Comment**
Consideration of the suggestion has been made.

Submitted By: Ronald Deiss (309-794-5185) Submitted On: Sep 09 2015

Current Comment Status: **Comment Closed**

6222012 Cultural Resources Section 5.1 Pages 417-419 n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

This Section can be significantly reduced. A recommendation would be to state as to whether compliance has process met, how compliance is being met, and that the protection of historic properties will occur through the execution of a Programmatic Memorandum of Agreement, prior to a signed Record of Decision.

Submitted By: Ronald Deiss (309-794-5185). Submitted On: Sep 03 2015

1-0 Evaluation **Concurred**
I will discuss this with our lead planner.

Submitted By: Dawn Sullo (916-557-7628) Submitted On: Sep 03 2015

1-1 Backcheck Recommendation **Close Comment**
Consideration of the recommendation has been made.

Submitted By: Ronald Deiss (309-794-5185) Submitted On: Sep 09 2015

Current Comment Status: **Comment Closed**

6222015 Cultural Resources N/A N/A N/A

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**
(Document Reference: Appendix C: Draft Programmatic Agreement)

Appendix C: Draft Programmatic Agreement (PA) It is recommended to change the title of the cover page be "Appendix C: Draft Programmatic Agreement"

Submitted By: Ronald Deiss (309-794-5185). Submitted On: Sep 03 2015

1-0 Evaluation **Concurred**
I will discuss this with our lead planner.

Submitted By: Dawn Sullo (916-557-7628) Submitted On: Sep 03 2015

1-1 Backcheck Recommendation **Close Comment**
Consideration of the recommendation has been made.

Submitted By: Ronald Deiss (309-794-5185) Submitted On: Sep 09 2015
Current Comment Status: **Comment Closed**

6222018 Cultural Resources N/A N/A N/A
Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**
(Document Reference: Appendix C: Draft Programmatic Agreement)

Appendix C: Draft Programmatic Agreement (PA) ATTACHMENTS (the last section of the PA). It is recommended that this section of the PA should have its own heading (i.e., XXIII. ATTACHMENTS) or (XXIII. ATTACHMENT).

Submitted By: Ronald Deiss (309-794-5185). Submitted On: Sep 03 2015
1-0 Evaluation **Concurred**
I will discuss this with our lead planner

Submitted By: Dawn Sullo (916-557-7628) Submitted On: Sep 03 2015
1-1 Backcheck Recommendation **Close Comment**
Consideration of the recommendation has been made.

Submitted By: Ronald Deiss (309-794-5185) Submitted On: Sep 09 2015
Current Comment Status: **Comment Closed**

6222019 Cultural Resources N/A N/A N/A
Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**
(Document Reference: Appendix C: Draft Programmatic Agreement)

Appendix C: Draft Programmatic Agreement (PA). It is recommended that the pages of the ATTACHMENT(S) should be numbered

Submitted By: Ronald Deiss (309-794-5185). Submitted On: Sep 03 2015
1-0 Evaluation **Concurred**
This has been updated and there are not numbers on the bottom of the page

Submitted By: Dawn Sullo (916-557-7628) Submitted On: Sep 03 2015
1-1 Backcheck Recommendation **Close Comment**
Consideration of the recommendation has been made.

Submitted By: Ronald Deiss (309-794-5185) Submitted On: Sep 09 2015

2-0 Evaluation **Concurred**
THe PA has been rewritten and the numbers are on the new document.

Submitted By: Dawn Sullo (916-557-7628) Submitted On: Sep 09 2015

Backcheck not conducted

Current Comment Status: **Comment Closed**

6222020 Cultural Resources N/A N/A N/A

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**
(Document Reference: Appendix C: Draft Programmatic Agreement)

ATTACHMENT A: A project "Description of Project and Alternatives" is typically not attached to a PA. It is recommended that the PA should reference the West Sacramento General Revaluation Report, Final Environmental Impact Statement/Environmental Impact Report for the "Description of Project and Alternatives" as the FINAL and BEST source for the description of the alternative and tentatively selected plan (or preferred "final" alternative).

Submitted By: Ronald Deiss (309-794-5185). Submitted On: Sep 03 2015

1-0 Evaluation **Non-concurred**
The CA SHPO requested an attachment noting the the "Descripton and Project Alternatives" Our SHPO does not want to see the NEPA/CEQA documents during their review and have to search for the sections.

Submitted By: Dawn Sullo (916-557-7628) Submitted On: Sep 03 2015

1-1 Backcheck Recommendation **Close Comment**
New amendments to the National Historic Preservation Act in 2000 indicated the integration of the Section 106 process with the National Environmental Policy Act is acceptable under appropriate circumstances. Since the Corps is the lead federal agency of this action, it is the Corps decision to integrate both Acts for compliance. Also, if the process is being engineering in phase the reviewer questions how can the Area of Potential Effect be fully and accurately described. Since this is a request from the CA SHPO and the "Description of Project and Alternatives" is an acceptable appendix to the Programmatic Agreement, the reviewer acquiesces.

Submitted By: Ronald Deiss (309-794-5185) Submitted On: Sep 09 2015

Current Comment Status: **Comment Closed**

6222021 Cultural Resources N/A N/A N/A

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**
(Document Reference: Appendix C: Draft Programmatic Agreement)

ATTACHMENT B: Area of Potential Effects and Alternatives. It is recommended that this attachment should be the most updated map of the tentative selective plan or final alternative with the APE identified (state that that figure/map(s) would be updated, modified, added to, and/or replaced in the PA, as necessary during the life of the PA).

Submitted By: Ronald Deiss (309-794-5185). Submitted On: Sep 03 2015

1-0 Evaluation **Concurred**

The updated APE will be added to the package that goes to SPD and Headquarters

Submitted By: Dawn Sullo (916-557-7628) Submitted On: Sep 09 2015

1-1 Backcheck Recommendation **Close Comment**

Consideration of the recommendation has been made and corrective measures taken.

Submitted By: Ronald Deiss (309-794-5185) Submitted On: Sep 09 2015

Current Comment Status: **Comment Closed**

6222022 Cultural Resources N/A N/A N/A

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

(Document Reference: Appendix C: Draft Programmatic Agreement)

ATTACHMENT C: This attachment Historic Properties Management Plan should have been coordinated separately from the PA and approved by the SHPO, TRIBES, and interested and consulting parties and therefore, need not be a permanent attachment to the PA. It can have a correspondence section with a cover sheet SUMMERIZING ALL of the correspondence by date and subject, and a dated summery of the each and all responses or any lack of any response. Documentation of a lack of response should be mentioned. All Corps correspondence and responses can be appended to this sheet, if necessary. If this is too bulky and not required, reference in the correspondence and consultation summary sheet that all correspondence is on permanent file at the Sacramento District. It is recommended that the HPMP be coordinated separately from the PA, and not be attached to the PA, and that execution of the PA be predicated upon the acceptance of the final HPMP.

Submitted By: Ronald Deiss (309-794-5185). Submitted On: Sep 03 2015

1-0 Evaluation **Concurred**

It was requested by the SHPO that an HPMP be developed in conjunction with the PA. It was attached an appendix to the EIS with the PA as part of the Cultural Resource appendices and not neccesarly as an attachment to the PA.

Submitted By: Dawn Sullo (916-557-7628) Submitted On: Sep 03 2015

1-1 Backcheck Recommendation **Close Comment**

Consideration of the recommendation has been made, but signatories may be confused to the status of the HPMP relative to the execution of the PA.

Submitted By: Ronald Deiss (309-794-5185) Submitted On: Sep 09 2015

Current Comment Status: **Comment Closed**

6222025 Cultural Resources N/A N/A N/A

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**
(Document Reference: Appendix C: Draft Programmatic Agreement)

Attachment C: Historic Properties Management Plan (HPMP) in the ATTACHEMENTS section co-authored by the West Sacramento Area Flood Control Agency. The HPMP can be coordinated separately from the PA and approved by the SHPO, TRIBES, and interested and consulting parties and therefore, need not be a permanent attachment to the PA. It is recommended that the HPMP state as to whether the HPMP is to be implemented by both parties or just by the Corps. If it is implemented by both parties, discuss why the West Sacramento Area Flood Control Agency isn't a signatory/concurring party to the PA.

Submitted By: Ronald Deiss (309-794-5185). Submitted On: Sep 03 2015

1-0 Evaluation **Concurred**
The HPMP is in draft form and will be coordinated and finalized after the PA has been signed. " coordinated separately" The HPMP is to be implemented by the Corps. Therefore the WSAFCA is not a signatory to the PA.

Submitted By: Dawn Sullo (916-557-7628) Submitted On: Sep 09 2015

1-1 Backcheck Recommendation **Close Comment**
the reviewer concurs with the process described by in the comment evaluation.

Submitted By: Ronald Deiss (309-794-5185) Submitted On: Sep 09 2015
Current Comment Status: **Comment Closed**

6222028	Cultural Resources	N/A	N/A	N/A

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**
(Document Reference: Appendix C: Draft Programmatic Agreement)

Attachment C: Relative to the "Curation of Recovered Material," the HPMP states, "Archaeological materials collected during the project activities will remain property of the WSAFCA." This implies that all materials will be obtained from land owned by the WSAFCA or those investigations and material collections will occur after real estate ownership is procured. This may result in eventual ownership problems. This could state generally that, "All materials collected will be identified by each designated land owner(s) and curated as property of the designated land owner(s)."

Submitted By: Ronald Deiss (309-794-5185). Submitted On: Sep 03 2015

1-0 Evaluation **Concurred**
The HPMP is in draft form and this text will be changed to reflect that state law will be followed regarding property ownership and collections/burials

Submitted By: Dawn Sullo (916-557-7628) Submitted On: Sep 09 2015

1-1 Backcheck Recommendation **Close Comment**
The reviewer concurs with the evaluation.

Submitted By: Ronald Deiss (309-794-5185) Submitted On: Sep 09 2015
Current Comment Status: **Comment Closed**

6222039 Cultural Resources N/A N/A N/A
Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**
(Document Reference: Record of Descision (to be written))

Project Record of Decision (ROD): It is recommended that the ROD should have a reference to the executed PA for the protection of historic properties. It is suggested that the executed PA, as well as all agreement documentation included in the ROD package.

Submitted By: Ronald Deiss (309-794-5185). Submitted On: Sep 03 2015

1-0 Evaluation **Concurred**
This comment will be provided to the Planner for this project and it will be included in the FInal ROD

Submitted By: Dawn Sullo (916-557-7628) Submitted On: Sep 03 2015

1-1 Backcheck Recommendation **Close Comment**
The reviewer concurs with the evaluation.

Submitted By: Ronald Deiss (309-794-5185) Submitted On: Sep 09 2015
Current Comment Status: **Comment Closed**

6229987 Cost Engineering n/a n/a n/a
Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

Filename SPK - West Sacramento - CSRA - 2015-09-09 - DRAFT.xlsm. I am concerned that there may not be enough risk to cost from estimate assumptions on crew members and production rates. Best = -$36,066,750 most likely = $0 high = $72,133,500 total estimated construction cost = 850,019,780.30. This could be a 5% contribution to cost contingency and I would expect 10%.

Resolution: Please consider increasing the risk for the high value.

Submitted By: Gary Smith (651 260 1819). Submitted On: Sep 10 2015

1-0 Evaluation **Concurred**
Per recommendation, ET1-Estimate Assumptions has been changed to a -5%, 0, +10% cost distribution

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 11 2015

1-1 Backcheck Recommendation **Close Comment**
Change observed. Comment Closed.

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 15 2015

Current Comment Status: **Comment Closed**

6230004 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

Filename SPK - West Sacramento - CSRA - 2015-09-09 - DRAFT.xlsm.

Please consider adding risk items to cover cost increase from changes to design based on changes to criteria, or development of better solutions. This could be a significant risk considering the duration of this project.

Submitted By: Gary Smith (651 260 1819). Submitted On: Sep 10 2015

1-0 Evaluation **Concurred**
Risk TL6 – Design Criteria had been discussed with the PDT. PDT felt that while criteria changes were likely, impacts would be negligible. It can also be argued risk is also captured in TL13 Quantity Variations and TL12 Design Development.

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 11 2015

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

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 15 2015

Current Comment Status: **Comment Closed**

6230007 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

Filename SPK - West Sacramento - CSRA - 2015-09-09 - DRAFT.xlsm.

Please consider adding risk items to cover cost increase from changes to the project scope.

Submitted By: Gary Smith (651 260 1819). Submitted On: Sep 10 2015

1-0 Evaluation **Concurred**
TL-13 has been added to the risk register and modeled.

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 15 2015

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

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 15 2015

Current Comment Status: **Comment Closed**

6230323 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**
(Document Reference: Risk Analysis)

1. OBSERVATION: The CSRA made available to start ATR on 9 Sep 2015.

Submitted By: Jim Neubauer (509-527-7332). Submitted On: Sep 10 2015

1-0 Evaluation **Concurred**
Concur

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 10 2015

1-1 Backcheck Recommendation **Close Comment**
Final contingencies running about 32%.

Submitted By: Jim Neubauer (509-527-7332) Submitted On: Sep 15 2015

Current Comment Status: **Comment Closed**

6230324 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**
(Document Reference: Risk Analysis)

2. CONCERN: The 2015 PDT members attending the risk register update exclude Contracting, Construction and Geotechnical. Just 5 PDT members were included on a $1B project.
SIGNIFICANCE: VERY HIGH. Inclusion of PDT members for risk analyses has been stressed many times from the HQ level. That list will be included in the risk analysis report.
RESOLUTION: Confer with the PDT members cited and include on the membership attendance.

Submitted By: Jim Neubauer (509-527-7332). Submitted On: Sep 10 2015

1-0 Evaluation **Concurred**
Meetings are being scheduled and comment addressed. Will submit revised meeting attendence register documenting dates met.

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 11 2015

1-1 Backcheck Recommendation **Close Comment**
Contracting and geotech aded. The cost engineer also served as the construction rep.

Submitted By: Jim Neubauer (509-527-7332) Submitted On: Sep 15 2015

Current Comment Status: **Comment Closed**

6230325 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**
(Document Reference: Risk Analysis)

3. Risk CO1 Differing Site Conditions – CONCERN: The risk register refers to the risk as Mods and Claims. The model and the sensitivity chart refers to the same risk as Differing Site Conditions. SIGNIFICANCE: HIGH. RESOLUTION: Rename the model and charts to Construction Mods and Claims.

Submitted By: Jim Neubauer (509-527-7332). Submitted On: Sep 10 2015

1-0 Evaluation **Concurred**
All titles now state Modifications and Claims.

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 11 2015

1-1 Backcheck Recommendation **Close Comment**
Confirmed.

Submitted By: Jim Neubauer (509-527-7332) Submitted On: Sep 15 2015
Current Comment Status: **Comment Closed**

6230327 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**
(Document Reference: Risk Analysis)

4. Risk ET 1 Estimate Assumptions and Quantities - CONCERN: This risk appears to be the 2nd most variable risk and is a composition of estimate assumptions and quantities. Looking at the supporting documentation, the risk was actually modeled as quantity impacts only. Further, the variance values are the same as risk TL12 Design Development, suggesting a possible duplication or correlation. The actual estimate assumptions were not apparently modeled but could be assumptions related to contractor markups and assignments, construction methodology, crews and productivity, borrow sources and haul distances. SIGNIFICANCE: VERY HIGH because estimate assumption were not included yet show us as a high risk by virtue of title. RESOLUTION:

•Separate the various estimate risks into separate categories as described.

•Address whether risks TL12 and ET1 are duplicated or correlated risks.

•Move quantity confidence into Technical Risks.

•Address the quantity confidence for each of the major construction elements separately.

Submitted By: Jim Neubauer (509-527-7332). Submitted On: Sep 10 2015

1-0 Evaluation **Concurred**
ET1 has been revised to reflect only Estimate Assumptions. Risk TL13 – Quantity Variations has been added and modeled separately for quantity variations for Relocations, Fish and Wildlife Facilities, Levees and Floodwalls and Bank Stabilization. Quantity Variations are correlated with TL12 - Design Development.

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 11 2015

1-1 Backcheck Recommendation **Close Comment**
Confirmed.

Submitted By: Jim Neubauer (509-527-7332) Submitted On: Sep 15 2015

Current Comment Status: **Comment Closed**

6230342 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**
(Document Reference: Risk Analysis)

5. Risk TL8 Vegetation Variance – CONCERN: When considering variance values, this should be the highest risk variable presented. Yet, since the probability assigns a 10%, the risk does not show up as a high risk on the sensitivity chart. Also I note that is modeled as a uniform distribution, suggesting the cost impacts are REALLY unknown. SIGNIFICANCE: VERY HIGH. RESOLUTION: Study further with supporting data. Provide a basis for the cost variance. Model as a triangular distribution if reasonable. Reconsider the 10% probability. Ensure it is clearly covered w/in the final CSRA report.

Submitted By: Jim Neubauer (509-527-7332). Submitted On: Sep 10 2015

1-0 Evaluation **Concurred**
Issue was discussed again with SPK PDT and potential cost impacts reassessed. Potential cost impacts have been decreased dramatically with potentially costs impacts ranging from $7M to $11.5M. 10% probability of occurrence remains as district has received a vegetation variance for Natomas project and it's entirely likely (assumed 90% likely) they will also receive a variance for West Sac.

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 11 2015

1-1 Backcheck Recommendation **Close Comment**
Noted.

Submitted By: Jim Neubauer (509-527-7332) Submitted On: Sep 15 2015

Current Comment Status: **Comment Closed**

6230343 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**
(Document Reference: Risk Analysis)

6. Risk Level – CONCERN: Some low modeled risks actually show a higher variance and impact than certain moderate risks. Some moderate risks in the model suggest that they are actually low due to the small value. SIGNIFICANCE; HIGH since it leaves a false impression in the risk register, part of the CSRA report. RESOLUTION: Re-lable those risks as moderate risks.

Submitted By: Jim Neubauer (509-527-7332). Submitted On: Sep 10 2015

1-0 Evaluation **Concurred**
Some items labeled LOW Cost Risk were still modeled because moderate or higher schedule risks had associated cost impacts. The schedule risk were moderate to high risk event that would need to be addressed.

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 11 2015

1-1 Backcheck Recommendation **Close Comment**
Explanation accepted.

Submitted By: Jim Neubauer (509-527-7332) Submitted On: Sep 15 2015
Current Comment Status: **Comment Closed**

6230344 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**
(Document Reference: Risk Analysis)

7. Risk Model – CONCER: The latest risk model is based on $942M and excludes real estate. But then the TPCS includes the same contingency % for Real Estate. I do not find a Real Estate report supporting the TPCS. SIGNIFICANCE: HIGH since the base cost is estimated at $163M. RESOLUTION: Provide the Real Estate report. Confer w/ the RE office regarding contingencies.

Submitted By: Jim Neubauer (509-527-7332). Submitted On: Sep 10 2015

1-0 Evaluation **Concurred**
Please review the file named "West Sac RE contingencies" which is from the RE report. It may be necessary to remove the contingency shown in the TPCS for the RE items.

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 10 2015

1-1 Backcheck Recommendation **Close Comment**
PDT is currently sorting out the RE contingency, excluded from the CSRA.

Submitted By: Jim Neubauer (509-527-7332) Submitted On: Sep 15 2015
Current Comment Status: **Comment Closed**

6230345 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**
(Document Reference: Risk Analysis)

8. CSRA Report: Upon ATR resolution, provide the final CSRA report for the Vertical Team.

Submitted By: Jim Neubauer (509-527-7332). Submitted On: Sep 10 2015

1-0 Evaluation **Concurred**
Concur

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 10 2015

1-1 Backcheck Recommendation **Close Comment**
CSRA report will not delay the TPCS for Cost Certification.

Submitted By: Jim Neubauer (509-527-7332) Submitted On: Sep 15 2015

Current Comment Status: **Comment Closed**

6231647	Economics	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

I have no comments on the revisions to the economic appendix.

Submitted By: Brian Harper (571-239-0726). Submitted On: Sep 11 2015

1-0 Evaluation **Concurred**
No Comments noted by the ATR Lead for this review

Submitted By: Miki Fujitsubo ((916) 557-7440) Submitted On: Sep 15 2015

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

Submitted By: Miki Fujitsubo ((916) 557-7440) Submitted On: Sep 15 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 **WEST SACRAMENTO PROJECT, FINAL GENERAL REEVALUATION REPORT, 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 ATR did assess the District Quality Control (DQC) documentation and found it 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: 2015.09.16 08:54:46 -07'00'

Miki Fujitsubo, NTS for
Marc L. Masnor, P.E.
ATR Team Leader
CESWF-PEC-PF (Tulsa, OK)

Date

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THAUT.ERIC.WILLIAM.1231631824
Date: 2015.09.16 09:00:11 -07'00'

Eric W. Thaut
FRM–PCX Deputy Director
Review Management Organization
CESPD-PDS

Date

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Date: 2015.09.16 09:11:36 -07'00'

Bryon L. Lake
Project Manager
CESPK-PM-C

Date

DISTRICT'S STATEMENT

CERTIFICATION OF AGENCY TECHNICAL REVIEW
SEPTEMBER 2015

Of the:

WEST SACRAMENTO PROJECT
FINAL GENERAL REEVALUATION REPORT, 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 **WEST SACRAMENTO PROJECT, FINAL GENERAL REEVALUATION REPORT, 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: (320653) West Sacramento General Reevaluation Report (GRR) (incl ATR & DQC Reviews)(P2# 320653) and Review: ATR Final GRR (7-28 Aug 2015)
d. The ATR review report is titled: FLOOD RISK MANAGEMENT, PLANNING CENTER OF EXPERTISE,RESOURCE MANAGEMENT ORGANIZATION'S, AGENCY TECHNICAL REVIEW REPORT, SEPTEMBER 2015, Of the: WEST SACRAMENTO PROJECT, FINAL GENERAL REEVALUATION REPORT, AND FIANL 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.

Rick L. Poeppelman

Rick L. Poeppelman, P.E.
Chief, Engineering Division
CESPK-ED

17 Sept 2015
Date

Mark T. Z

for Alicia E. Kirchner
Chief, Planning Division
CESPK-PD

9/18/15
Date

ProjNet Report

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

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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Marc L. Masnor
ATR Team Lead

West Sacramento GRR

Appendix B

Review Documentation

Independent External Peer Review

(IEPR) Documentation

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Final Comment Response Record for the Independent External Peer Review (IEPR) of the West Sacramento Project, California, General Reevaluation Report (GRR) Flood Risk Management (FRM) Project

Prepared by

Battelle
505 King Avenue
Columbus, Ohio 43201

February 3, 2015

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Final Panel Comment 1

The project benefits are overestimated because the probability of geotechnical failure used in the HEC-FDA analyses is unreasonably high.

Basis for Comment

The computed probabilities reported in Section 14.2 of Appendix C (Geotechnical Appendix) to the GRR, which often exceed 90%, are for “poor performance” of levee reaches. While the Panel agrees that the probability of poor performance in a design flood is indeed very high, this value is not the probability of failure. The GRR describes the probabilities incorrectly (p. 2-12), representing them as the probability of failure. As a result, the failure probabilities described in the GRR are unreasonably high. These probabilities are then incorporated into the HEC-FDA analyses, resulting in an overestimate of project benefits.

One reason that the probability of poor performance significantly exceeds the probability of failure is that the risks associated with seepage constitute a large portion of the total risk of poor performance. As stated in Section 26 (p.26-1) of the recent joint work on Best Practices by USACE and the U.S. Bureau of Reclamation (USBR, 2012), internal erosion is “a potential failure mode that cannot be completely analyzed using numerical formulae or models.” Thus, although seepage gradients that exceed standard criteria are a reasonable indication of potential poor performance, they are not an accurate or reasonable measure of the probability of failure.

The probability of a levee breach due to slope instability is also not the same as the probability of poor performance. Not every slope failure inevitably leads to a levee breach. Some failures are only maintenance issues; in other cases active intervention can prevent a downstream failure from developing into a levee breach.

In addition to the analytical challenges of estimating failure probability, the computed probabilities reported in Appendix C (Section 14.2) do not appear to consider the potential risk reduction through intervention by active flood fighting measures. While significant risks of failure remain even with intervention, completely ignoring the benefit overstates risk. The Best Practices work (USBR, 2012) states (pp. 35-37) that “the USACE approach is to evaluate and communicate the potential risk reduction that can be achieved with intervention while at the same time to not mask the seriousness of a potential dam safety issue by relying on intervention to reduce the risk.” The analysis conducted for the GRR is inconsistent with this approach because it ignores intervention.

The GRR also does not address the degree of uncertainty associated with estimated probabilities. Best Practices (USBR, 2012) states (p.26-1) that “…risk estimating procedures, although quantitative, do not provide precise or accurate numerical results. The nature of the risk evaluation should be advisory and not prescriptive.” In assessing the uncertainty associated with probability estimates, consideration should be given to a general calibration provided by Christian and Baecher (2011) when they indicate that one of the 10 major questions regarding geotechnical risk and reliability is “why failures are less frequent than reliability studies predict.” They state that predicted failure frequencies are an order of magnitude larger than observed, and two orders of magnitude larger than the frequency of modes of failure for earth dams. An understanding of the relatively imprecise nature of probabilities estimated for geotechnical events is required so that decisions to fund projects can be made with an appropriate “knowledge of the degree of reliability of the estimated benefits and costs and of the effectiveness of alternative plans,” specifically required by ER 1105-2-100 (USACE, 2000).

Significance – High

Inaccurate geotechnical probabilities in the HEC-FDA analyses result in an overstatement of without-project costs that could be significant and affect the benefit-cost-ratio. Providing calculations of failure probabilities without a description of the degree of reliability of those calculations is inconsistent with policy described by ER-1105-2-100 (USACE, 2000).

Recommendation for Resolution

1. Estimate geotechnical failure probabilities using a semi-quantitative risk analysis conducted in accordance with USBR (2012). It may be necessary to use expert elicitation to establish a conditional probability relationship between poor performance and levee breach. Case history data may also be informative.
2. Revised failure probabilities should include an assessment of the uncertainty in those probabilities to comply with USACE (2000), Section 10. For example, perform sensitivity studies (such as the example provided in USBR [2012], Section 12) to assist in estimating the uncertainty in calculated failure probability that results from uncertainty in input distributions.

PDT Final Evaluator Response (FPC#1):

__X_**Concur** ___ **Non-Concur**
The estimate of geotechnical failure probabilities were established according to state of practice for the USACE at the time of the analysis by following Corps guidance (ETL 1110-2-556). ETL 1110-2-556 has not been replaced; even though it has been "expired" for several years. Conditional probabilities were established by conducting an Expert Elicitation which is included as Enclosure 5 of the Geotechnical Appendix.

While developed following USACE guidance it is acknowledged that the geotechnical probability of poor performance is conservative in their estimation of a levee failure where the protected area is now inundated. While there is not updated guidance to resolve this, there are emerging ideas from the Risk Management Center and agency wide coordination efforts with the Bureau of Reclamation."

In the risk register, SPK has documented the use of Corps Guidance (ETL 1110-2-556) to develop the levee performance curves as likely overstating the risk of inundation.

Recommendation #1: __Adopt _X_Not adopt
The estimate of geotechnical failure probabilities were established according to state of practice for the USACE at the time of the analysis by following Corps guidance (ETL 1110-2-556). ETL 1110-2-556 has never been replaced, so even though it has been "expired" for several years, Corps Districts still use it for Feasibility Studies because new Feasibility Study fragility curve guidance has not been issued. Conditional probabilities were established by conducting an Expert Elicitation which is included as Enclosure 5 of the Geotechnical Appendix.

Recommendation #2: __Adopt _X_Not adopt
The failure probabilities were developed following the current USACE state of practice as defined in ER 11105-2-101 and ETL 1110-2-556 and did not incorporate a direct uncertainty within the probabilities. During the Expert elicitation process for judgment bases probabilities a range was assigned for each category. For probabilities associated with underseepage, through seepage, and stability analyses, a coefficient of variation is prescribed to each parameter. Those parameters were then varied independently resulting in a probability of poor performance for each of the aforementioned categories.

Further evaluation of the uncertainty in the geotechnical performance uncertainty is beyond the requirements of a feasibility study level of analysis.

Panel Final BackCheck Response (FPC#1):

Concur.

Literature Cited:

USACE (2000). Planning – Planning Guidance Notebook. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. Engineer Regulation (ER) 1105-2-100. April 22. Available online at http://planning.usace.army.mil/toolbox/library/ERs/entire.pdf

USBR (2012). Best Practices in Dam and Levee Safety Risk Analysis. A Joint Publication by U.S Department of Interior, Bureau of Reclamation and U.S. Army Corps of Engineers; 3 December. Available online at: http://www.usbr.gov/ssle/damsafety/Risk/methodology.html

Christian, J.T. and Baecher, G.B. (2011). Unresolved problems in geotechnical risk and reliability. Geo-Risk 2011:50-63.

Final Panel Comment 2

Potential FRM benefits have not been evaluated and project benefits are likely to be significantly greater than presented in the GRR.

Basis for Comment

The GRR does not address potential FRM benefits the project could reasonably be expected to provide. Reductions in the following costs/damages are likely to result from the project, but are not accounted for in the economic analysis.

- Emergency costs
- Agricultural flood damages associated with crops
- Damages associated with future intensification of land uses in West Sacramento.

Emergency costs would include Federal, state, and local government emergency measures, evacuation and subsistence costs, reoccupation costs, and commercial cleanup and restoration costs. Such costs can represent a significant portion of total damages. For example, reductions in emergency costs accounted for 10 to 15% of the total FRM benefits estimated for the Louisiana Comprehensive Master Plan for a Sustainable Coast (USACE, 2007). It is reasonable to believe that reductions in emergency costs in West Sacramento would be on a similar scale. Although less significant, another benefit category that was not addressed is agricultural crop damage. The land use map (Economics Appendix, Figure 6, p. 2-8) indicates that there is significant agriculture in West Sacramento, particularly in the South Basin.

A third benefit category that is not addressed focuses on land use. The Economics Appendix states (Section 3.3.2, p. 4-3) that the study area is considered to be fully built out and, therefore, expected annual damages are equal to equivalent annual damages. However, the following factors indicate that future growth is probable:

- The land use map (Economics Appendix, Figure 6, p. 2-8) shows large areas of agriculture and open space that could be converted to higher intensity land uses.
- The GRR states that there are plans for infill development in the North Basin.
- The City of West Sacramento plans additional development in the South Basin.
- The GRR states that a 64% increase in population is projected to occur between 2007 and 2030.
- The EIS/EIR describes new development projects that are under way now and into the next 20 years.

Based on the growth that has occurred in the last 10 years in West Sacramento, it is reasonable to believe that growth will continue into the foreseeable future. This would increase future benefits of alternative plans.

Currently, the USACE budgetary guidance (USACE, 2013a) requires that a flood damage reduction project have at least a 2.5 benefit-to-cost ratio at a 7% discount rate to be included in the Administration's budget (which includes Construction General Appropriations). The benefit-to-cost ratio presented in the GRR is calculated with only a 3.5% discount rate. Therefore, based on the existing economic analysis, it is possible that even if the West Sacramento Project gets authorized, the benefit-to-cost ratio may not be adequate to qualify for Construction General Appropriations.

Significance – Medium/High

Including the additional sources of project benefits (reductions in emergency costs and agricultural flood damages and greater reductions in flood damages resulting from future development) would provide a more accurate representation of the benefits of the project.

Recommendations for Resolution

1. Calculate FRM benefits that would be expected in West Sacramento due to reduced emergency costs and include them in the benefit-to-cost ratio.
2. Calculate FRM benefits that would result from reduced agricultural flood damages and include them in the benefit-to-cost ratio.
3. Assess future development that is likely to occur in West Sacramento and recalculate FRM benefits based on equivalent annual damages.

PDT Final Evaluator Response (FPC#2):

_X_**Concur** __**Non-Concur**

Benefits associated with the prevention of emergency cost losses, agricultural crop damages, and potential land-use intensification (future development) have not been evaluated at this stage. The benefits associated with these categories may add to project benefits, but most likely not significantly.

Recommendation #1: _X_Adopt __Not adopt

Reduced emergency cost losses will be evaluated and factored into the net benefit and benefit-to-cost analyses for the without project conditions and the Tentatively Selected Plan (TSP). The HEC-FDA software will be used to estimate emergency cost losses and benefits. The methods and assumptions used in the Sutter Basin Feasibility Study, a study which has gone through the Civil Works Review Board (CWRB) and which also has been authorized by Congress, will be used. The prevention of emergency cost losses were not assessed during this stage of the planning process but will be assessed for the Final Report; the current project schedule and budget includes resources (time and funding) to complete an emergency cost loss evaluation for the Tentatively Selected Plan (TSP). Emergency costs were evaluated qualitatively during the plan formulation process and were determined to not impact plan selection. Depending on the method used to calculate losses, and based on information from other studies in the District, it is believed that damages/benefits associated with emergency cost loss categories could comprise anywhere between 2% to 15% of total damages/benefits.

Recommendation #2: _X_Adopt __Not adopt

A brief qualitative discussion on agricultural crop damages will be added to the economic appendix. A quantitative agricultural crop damage analysis was not completed for this study due to the relatively small amount of agricultural acreage in the study area (Figure 6). Additionally, when factoring in the chance of flooding by month (flooding is more likely to occur during the November to April time frame) in conjunction with the planting season for the various crops grown in the study area (mostly April to October), crop damages are expected to be minimal and an extremely small percentage (<1%) of the total damages.

Recommendation #3: _X_Adopt __Not adopt

A discussion regarding future population growth and floodplain management (EO 11988) will be added to the Final Economics Appendix. The reviewer is correct in noting that the land-use map (Figure 6) provided in the Economic Appendix indicates the potential for future development in the study area; it is estimated that there are approximately 3,900 acres of developable land. Future without project population growth and development were considered in terms of residual risk and EO 11988, but were not included in the economic damage analysis, as it would have little impact on project benefits and would not change NED identification, the recommended plan or economic feasibility.

Factors that led to the future without-project condition assumptions used for this study from a planning and economic standpoint were:

a) Sec 308 of WRDA 1990 (33 USC 2318) precludes USACE from justifying projects based on future development. Residual risk associated with a potential full growth scenario will be presented in the final Economic Appendix.

b) CA Senate Bill 5 will limit future development (or intensification) in the study area under future without-project conditions given that the study area would not have 0.5% ACE ("200yr") level of flood protection. According to current USACE floodplain modeling, this area would be within the 0.5% ACE ("200yr") without-project floodplain.

c) Given #2 above, any development (or intensification) that did take place would likely occur outside or with foundation heights above the mean 0.5% ACE "200yr" WSEL, meaning very infrequent damaging flooding which would be discounted to present values. The result is low equivalent annual damages which would not significantly impact plan selection or project benefits. For purposes of the economic analysis, however, the area was assumed to be "built out" so that damages/benefits associated with any future development would not be overstated.

Panel Final BackCheck Response (FPC#2):

Concur.

Literature Cited:

USACE (2013a). Army Programs: Corps of Engineers Civil Works Direct Program, Budget Development Guidance, Fiscal Year 2015. Engineer Circular (EC) 11-2-204. Department of the Army, U.S. Corps of Engineers, Washington, D.C. March 31.

USACE (2007). Economic Analysis and Consequences, Integrated Ecosystem Restoration and Hurricane Protection: Louisiana's Comprehensive Master Plan for a Sustainable Coast. New Orleans District, U.S. Army Corps of Engineers. April.

Final Panel Comment 3

Economic residual risks associated with seismic damage are not assessed.

Basis for Comment

The seismic vulnerability of levees has been assessed based on their ability to provide post-seismic flood protection, in accordance with the USACE Draft ETL 1110-2-580, Guidelines for Seismic Evaluation of Levees (not yet published). The analyses and classification in accordance with this ETL (as summarized in the Geotechnical Appendix, p. 12-3), indicates that seismic damage to cutoff walls is possible for the Bypass Levee and very likely for the West South Levee. The Panel understands that these levees do not retain water in the non-flood season, and thus the threat of loss of life only exists when a flood occurs either simultaneously or soon after a major earthquake, a relatively improbable occurrence. However, it appears that neither potential economic benefits nor residual economic risks associated with seismic damage have been fully assessed for the project.

The Geotechnical Appendix does not indicate whether the proposed project will improve seismic resistance of the levees. This would be a potential benefit to the project.

It appears that costs associated with repairing seismic damage to cutoff walls have not been estimated. Thus, the residual economic risks associated with repairing seismic damage to cutoff walls have not been assessed. In addition, no consideration appears to have been given to evaluating whether it would be cost-effective to improve the seismic resistance for the Bypass Levee and the West South Levee to reduce the risk of cutoff wall damage in a seismic event.

Significance – Medium/High

Without an estimate of the cost of repairing cutoff wall damage in a seismic event, the net benefit of the project may be overstated because the cost associated with the residual risk of seismic damage to cutoff walls has not been included in evaluating residual risk.

Recommendations for Resolution

1. Estimate the probability of levee damage due to seismic shaking, and estimate the cost of subsequent repair.
2. Based on the results of the above recommendation, consider whether it would be warranted to develop a conceptual design and cost estimates for improvements to resist seismic damage.

PDT Final Evaluator Response (FPC#3):

__Concur X Non-Concur

Further discussion as to the extent of detail within the O&M contingency costs to address seismic damage was discussed during the Cost Schedule Risk Analysis (CSRA) occurring the week of 17 November. It was determined through review and discussions with the technical disciplines and Emergency Operations that the same actions and activities employed after the 6.0 Magnitude Earthquake in Napa CA on August 24, 2014 would be applicable. Agencies performed the necessary inspections of the infrastructure for visible signs of damage. If there was a change in the structure's ability to perform 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 U.S. Army Corps of Engineers Policy does not require consideration of PL 84-99 in the project economics. The CSRA Lead (Bill Bolte) from Walla Walla indicated that this would not be included in the O&M contingency costs.*

It has been determined through additional discussions with the Subject Matter Expert in Seismic Research that the appropriate State of the Practice was applied in the development of the seismic appendix of the Draft Report in assigning the probability of a seismic event and the probability of a damaging event or one that would result in liquefaction. This being the case the Sacramento District feels any further discussion on this would fall into the realm of the PDT following current Policy and Engineering Regulations and the Panel desiring something that is beyond the sphere of the District or Divisions ability to alter.

One of the more common construction methodologies utilized involves the use of Bentonite in the construction which is self-sealing.

Recommendation #1: __Adopt _X_Not adopt
The West Sacramento GRR has evaluated the probability of levee damage due to seismic shaking as detailed in Enclosure No. 6. Development of a conceptual design and cost estimate for seismic mitigation is commonly not completed as the probability of a concurrent flood event and an earthquake occurring is considered to be quite low.

Recommendation #2: __Adopt _X_Not adopt
See above.

Panel Final BackCheck Response (FPC#3):

Concur.

The Panel concurs based on the understanding that:

1. Any seismic damage to the levee cut-off wall would be repaired to re-establish the level of operational effectiveness existing prior to the seismic event, 2. the repair would be funded under PL 84-99 regardless of the magnitude of the cost, and 3. USACE policy is that PL 84-99 costs are not included in feasibility economics.

Literature Cited:

USACE Draft ETL 1110-2-580, Guidelines for Seismic Evaluation of Levees (not yet published).

Final Panel Comment 4

The conclusions regarding seismic hazards in relation to the California Seismic Hazards Mapping Act in the Draft EIS/EIR are contradicted by the results of analyses presented in the Geotechnical Appendix to the GRR.

Basis for Comment

The Draft EIS/EIR (p. 408) indicates that “the California Seismic Hazards Mapping Act of 1990 (California Public Resources Code [PRC] Sections 2690–2699.6) addresses seismic hazards other than surface rupture, such as liquefaction and induced landslides. The Seismic Hazards Mapping Act specifies that the lead agency for a project may withhold development permits until geologic or soils investigations are conducted for specific sites and mitigation measures are incorporated into plans to reduce hazards associated with seismicity and unstable soils.” The Draft EIS/EIR then concludes that because the closest active fault is 35 miles to the northwest, there are no significant issues due to seismicity. However, the seismic assessment presented in Geotechnical Appendix (p. 12-3) indicates that some sections of the levee have medium to high vulnerability, placing the Sacramento River West South Levee in a classification associated with seismically induced flow slides. This is consistent with the Panel’s belief that a distance of 35 miles from an active fault is insufficient to conclude that no significant issues exist due to seismicity. Thus, the project as currently proposed appears out of compliance with the Seismic Hazards Act because seismic hazards exist, and no mitigation measures are incorporated to reduce them. If the lead agency withholds development permits until mitigation measures are incorporated, these additional measures could incur significant additional costs, possibly reducing the net project benefit.

The seismic risk is also described inconsistently elsewhere in project documents. The Draft EIS/EIR states (p. 67, second paragraph) that a 200-year seismic event could very likely compromise the levee at several locations due to lateral spreading. However, in the next paragraph, the report states that “because the expected magnitude of ground shaking from large regional earthquakes is relatively low in the project area, the potential for failure or significant damage of project structures is low.” The analyses in the Geotechnical Appendix indicate that the expected magnitude of ground shaking is likely to result in significant damage to some levee reaches. The statements are contradictory and the analyses described do not support the latter statement.

Significance – Medium

The conclusions regarding seismic hazards in relation to the California Seismic Hazards Mapping Act are inaccurate. If mitigation measures were deemed necessary to obtain a development permit in accordance with the Act, the costs incurred would reduce net project benefit. Furthermore, inconsistent descriptions of the potential for cutoff wall damage due to seismic events could affect the understanding and accuracy of the project.

Recommendations for Resolution

1. Clarify the discussion of seismic hazards presented in the Draft EIS/EIR (p. 67).
2. Review the conclusions related to the California Seismic Hazards Mapping Act in light of other descriptions of seismic risks (i.e., p. 67 of the EIS/EIR and the GRR, Appendix C, Section 12) and resolve any inconsistency. (The Panel does not have expertise to recommend action required for

compliance with the Act.)

PDT Final Evaluator Response (FPC#4):

__X__**Concur** ___**Non-Concur**
The Corps will ensure that the Seismicity section in the EIS/EIR and the Geotechnical Appendix are consistent.

Recommendation #1: __X__Adopt __Not adopt
The Corps will update the discussion of seismic hazards in the EIS/EIR to be consistent with the Geotechnical Appendix.

Recommendation #2: __X__Adopt __Not adopt
The Corps will resolve the inconsistency in the seismic risk discussion, review conclusions related to the Act and update the EIS/EIR to ensure compliance with the Act.

Panel Final BackCheck Response (FPC#4):

Concur.

Final Panel Comment 5

Decisions to upgrade the levee are sometimes based on qualitative criteria that are not clearly defined, potentially resulting in non-essential levee upgrades.

Basis for Comment

Recommendations regarding whether to upgrade a levee do not consistently rely on analyses and stated design criteria (e.g., exit gradient). Sometimes they are based either on qualitative criteria such as reported seepage and stability problems in a reach or engineering judgment. Because the criteria are unclear, it is not possible to evaluate whether resulting recommendations for levee improvement are essential.

Specific examples from the Geotechnical Appendix where design criteria do not support recommended actions are:

- A shallow cutoff wall is recommended for the North Basin -- Sacramento South Bypass Levee on p. 11-8, apparently to address low calculated stability. However, no analyses were performed for the with-project results.
- Although analyses indicate seepage gradients meet design criteria, a cutoff wall is recommended for the North Basin – Sacramento West Levee on p. 11-10 to “provide continuity to adjoining project reaches as well as mitigate against potential defects in the blanket layer.”
- A cutoff wall is recommended for the South Basin – Port South Levee on p. 11-14, even though without-project conditions meet design criteria. The justification is related to soil conditions and historic seepage concerns.
- No analyses are reported to support the recommendation on p. 11-13 that no mitigation measures should be constructed for the southern 75% of the South Basin – Deep Water Ship Channel West Levee.
- A cutoff wall is recommended for the South Basin – Yolo Bypass East Levee on p.11-19, even though seepage criteria are met for without-project conditions.

While the Panel values engineering judgment, it is unclear whether the qualitative criteria used to justify the recommendations are appropriate, cost effective, and consistently applied. Recommended repairs using this justification may not be necessary or cost effective. Including them in the project may add cost without adding corresponding benefits, thus reducing the net benefits from the project.

Significance – Medium

Upgrades that have been recommended based on unclear criteria may be non-essential to the levee, and thus would decrease the net project benefit.

Recommendation for Resolution

1. Evaluate whether qualitative design criteria could be established and described to supplement the quantitative criteria.
2. Perform additional investigations and analyses in future design stages to resolve inconsistencies between observed performance and results of analyses.

PDT Final Evaluator Response (FPC#5):

__X_**Concur** ___**Non-Concur**

Evaluate whether qualitative design criteria could be established and described to supplement the quantitative criteria, the recommendation had transposed "qualitative" and "quantitative".

Additional analyses will be completed in future design stages as to resolve potential discrepancies within the analyses results completed during the feasibility level design process. Design criteria established for use during the study is of a quantitative nature. Increased levels of analysis to included finite element modeling with information obtained from further, more extensive exploration and laboratory testing programs, will serve to provide an improved level of concurrence between design considerations and past performance history.

Recommendation #1: ___Adopt _X_Not adopt

Establishment of a qualitative design criteria was considered in response to the recommendation and would potentially be evaluated during the design phase of the project. At the current status, the level of analyses performed and methodology employed follows USACE state of practice for feasibility level studies. The Corps Planning Modernization initiative states in part:, the approach to level of detail, data collection, and models throughout the process must be based on what is necessary to conduct and deliver that feasibility study. The expense and time of collecting more data, developing a new model, or analyzing multiple alternatives to a high level of detail must be justified, rather than assumed.

Recommendation #2: _X_Adopt __Not adopt

Additional analyses will be completed in future design stages as to resolve potential discrepancies within the analyses results completed during the feasibility level design process.

Panel Final BackCheck Response (FPC#5):

Concur.

Final Panel Comment 6

The adequacy of the internal water management system and the incremental costs and benefits of improving the system have not been evaluated.

Basis for Comment

In order to provide flood protection to West Sacramento, it is necessary to operate and maintain a system of canals, control structures, and pump stations. Even if the Federal levee system withstands high river and bypass flows, there could be flooding in West Sacramento if the internal water management system does not function properly during a large storm event. If the internal water management system fails under such conditions, the benefits of the recommended plan would be reduced. In other words, the Federal expenditures on making improvements to the levee system will not produce the desired benefits without proper functioning of the local system. No analyses of the adequacy of the internal water management system or its operation and maintenance were performed.

The internal water management system is designed for the 1% ACE (annual chance exceedance) event. No analysis was performed to evaluate the incremental costs and benefits of improving the system to provide a greater level of protection, similar to the Federal project (i.e., maximize the net benefits). Therefore, it is possible the full extent of potential net benefits will not be realized without evaluating the incremental costs and benefits of improvements to the internal system.

Significance – Medium

Without an analysis of the design and operation and maintenance practices of the West Sacramento internal water management system, it is not possible to assess whether the system could fail during a major flood event on the Sacramento River.

Recommendations for Resolution

1. Evaluate the design, existing condition, and operations and maintenance practices of the West Sacramento internal water management system to verify that the system is designed appropriately and will continue to function properly in the future.
2. Evaluate the incremental costs and benefits of improvements to the internal water management system to determine whether such improvements are justified and could increase the total net FRM benefits of the recommended plan.

PDT Final Evaluator Response (FPC#6):

__X_**Concur** __**Non-Concur**

An analysis of the existing condition internal water management system was conducted earlier in the study by the local sponsor's consultant to help establish the future without project conditions.

Features or improvements to existing interior features are unlikely to be economically justified based on the enclosed basin without inflow, capacity of the existing storm drainage system, and minimal residual damages with the existing interior drainage facilities in place. There is no flooding for events up to the 200-yr and there is only shallow 1-2' ponding in a few areas. It is unlikely that annualized damages for minor flooding with events greater than 200-yr would support project features.

The selected plan does not impact the interior drainage of the basin, as we are recommending levee repairs only. The interior drainage system in West Sac Basin is an enclosed system and receives runoff only from precipitation on the basin itself. The probability of the timing of a large high water event in the Sacramento River and a large rain event in the enclosed West Sacramento Basin is very low. The rainfall event in the enclosed West Sacramento Basin would occur much earlier than the high water in the Sacramento River. The two events are also likely to occur at different times in the season as they are different hydrologic events. The large rain events in the West Sacramento basin are often the result of a smaller but more concentrated thunderstorm in late summer and early fall. The storm event causing high water in the Sacramento River is from a larger winter storm.

Per the Planning Guidance Notebook, ER 1105-2-100, App E, pg E-88 section g. "In urban and urbanizing areas provision of a basic drainage system to collect and convey local runoff is a non-Federal responsibility." The only part that would be a federal responsibility would be the pump stations that take the water over the federal flood control works and gravity drains or ponding areas, if any. For the purposes of this study, the pumps were found to be adequate for current hydrologic conditions and would only be upgraded if the levee repairs interfere with the pump operation.

Recommendation #1: _X_Adopt __Not adopt
An analysis of the existing condition internal water management system was conducted earlier in the study by the local sponsor's consultant to help establish the future without project conditions.

Recommendation #2: _X_Adopt __Not adopt
The analysis mentioned in Recommendation 1 demonstrated that the interior drainage is already adequate. A qualitative assessment was conducted and it was determined that for the purposes of this study, improvements to the existing interior drainage system is not economically justified.

Panel Final BackCheck Response (FPC#6):

Concur.

Final Panel Comment 7

The basis for the assumption that the project will receive funding for construction at a rate of $100 million per year 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

The cost of interest during construction is based on the estimated construction period and has a significant impact on the Total Project Cost. Table 38 (Economics Appendix, p. 4-14) shows the Project Costs of the recommended plan at $1,613,768,000. The interest during construction is $646,916,000 for a Total Project Cost of $2,259,684. The interest during construction is about 28% of the Total Project Cost.

The Economics Appendix (Section 4.7, p. 4-13) states that the construction period used to calculate interest during construction was based on an assumption that funding would be provided at a rate of $100 million per year. From the HQ-USACE web site, an examination of the FY 2014 budget justification sheets (USACE, 2013b) shows that a total of just under $120 million was included in the Construction General budget for the Sacramento District. The Economics Appendix (Section 4.7, p. 4-14) states that the construction period for the recommended plan is 17 years. Hence, the assumption that funding for the West Sacramento Project would be provided at an average rate of $100 million per year for 17 consecutive years for a single project appears to be unlikely. Assuming that the FY 2014 appropriations are typical for the Sacramento District, this would require that over 80% of the District's total Construction General budget would be devoted to a single project for 17 years.

Significance – Medium

If the assumption that an average of $100 million will be available annually for 17 consecutive years is overly optimistic, the construction period could be significantly lengthened and the cost of interest during construction would be increased.

Recommendations for Resolution

1. Add a description of the basis for the assumption that the project will receive $100 million per year during the construction period.

PDT Final Evaluator Response (FPC#7):

__X_ **Concur** ___**Non-Concur**
The project team made the assumption regarding receiving $100 million per year and thought it was reasonable. Note that the $100 million per year would be split up 65% fed/35% non-fed so that the district would be receiving $65 million per year in federal funding. This simplified assumption was applied to all of the alternatives in the final array (consistentcy). This assumption would not affect plan selection. The availability of some construction equipment, such as deep soil mixing and jet grouting equipment, could impact the construction schedule.

Recommendation #1: _X_Adopt __Not adopt
The basis for the assumption will be added to the document text. A construction schedule, based on optimal funding, will be developed for the Cost Schedule Risk Analysis and the final report. In addition, the construction schedule developed for the CSRA will be used to re-calculate IDC, which will be incorporated into the net benefit and benefit-to-cost analyses.

Panel Final BackCheck Response (FPC#7):

Concur.

Literature Cited:

USACE (2013b). Fiscal Year 2014 -- Civil Works Budget Details for the U.S. Army Corps of Engineers, Volume II. Department of the Army, Office of the Assistant Secretary of the Army (Civil Works). 1 May. Available online at:
http://www.usace.army.mil/Portals/2/docs/civilworks/budget_just/just_2014_vol2.pdf

Final Panel Comment 8

The mitigation requirements for the alternatives and the recommended plan are not described in the GRR and it is not clear whether the cost estimates include the cost of implementing and monitoring mitigation measures.

Basis for Comment

Table PAC-7 (p. 11) in the GRR identifies a significant number of mitigation measures that would be required for the recommended plan, but does not describe them. The Draft EIS/EIR gives general descriptions of the mitigation measures, but the level of detail on mitigation requirements is limited. Providing a more detailed description of the proposed mitigation measures for the recommended plan would allow an assessment of their reasonableness and potential obstacles that might be encountered during implementation. More details on the mitigation measures would give confidence that the costs are reasonable, but there is no indication in the GRR whether the cost of the mitigation measures and monitoring are included in the total project cost estimate.

Significance – Medium

Providing descriptions of the mitigation measures and describing the basis for the cost estimates would strengthen the understanding of the project costs and any uncertainty that might exist in the cost estimate.

Recommendation for Resolution

1. Provide more detailed descriptions of the mitigation measures, how they will be implemented, and uncertainties related to implementation.
2. Add a discussion of how the cost estimates for mitigation measures and monitoring were developed, include a line item for mitigation measures and monitoring in the total project cost estimate, and discuss uncertainty.

PDT Final Evaluator Response (FPC#8):

__X_**Concur** ___**Non-Concur**
The final report will contain descriptions of the mitigation measures and the basis for calculation of the mitigation cost estimates.

Recommendation #1: _X_Adopt __Not adopt
The final report will provide more detailed descriptions of the mitigation measures, the manner in which they will be implemented, and any uncertainties that would be related to their implementation.

Recommendation #2: _X_Adopt __Not adopt
The final report will include a discussion of how the cost estimates for mitigation measures and monitoring were developed and the uncertainties associated with the cost estimate. The total project cost estimate will include a line item with information regarding the cost of mitigation and monitoring.

Panel Final BackCheck Response (FPC#8):

Concur.

Final Panel Comment 9

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 No. 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.

Recommendation for Resolution

1. Discuss existing conditions for invasive plants/noxious weeds in the project area. If recent field or other site-specific data to characterize invasive plant conditions in the project 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#9):

__X_**Concur** __**Non-Concur**
The Corps will update the EIS/EIR to ensure that invasive plants are properly addressed in the vegetation and wildlife section.

Recommendation #1: _X_Adopt __Not adopt
The Corps will update the vegetation and wildlife section to include a discussion of existing conditions for invasive plants. This will likely consist of a summary of the expected or likely conditions, due to lack of site-specific survey data.

Recommendation #2: _X_Adopt __Not adopt
The Corps will update the vegetation and wildlife section to include the effects analysis for invasive plants. The Corps will consider what mitigation or BMPs might be implemented in order

to reduce the potential for spread of invasive plants.

Panel Final BackCheck Response (FPC#9):

Concur.

Literature Cited:

Executive Order No. 13112 (1999). Invasive Species, 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 10

Some biological resources in the study area potentially affected by project implementation have not been presented in sufficient detail to describe the existing conditions and support the EIS/EIR analysis.

Basis for Comment

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. Section 3.6 of the Draft EIS/EIR (pp. 106-107, 120-121) references Figures 3.6-1 through 3.6-5, but they are not in the document. These figures reportedly show the distribution and types of land cover and other biological resources in the study area potentially affected by project implementation. USACE confirmed during the August 21, 2014 mid-review teleconference with the Panel (facilitated by Battelle) that these figures did not exist yet. Additionally, 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 is not included in the biological resources analysis but would improve the clarity of the analysis and conclusions.

The conclusions of the biological resources analysis may be accurate; however, some of the biological resources information needed to evaluate the magnitude of effects and support the conclusions are not clearly presented in the Draft EIS/EIR.

Significance – Medium

The lack of figures that are referenced in the Draft EIS/EIR and the lack of clear quantitative comparisons of impacts among the alternatives limit the completeness and quality of the report.

Recommendation for Resolution

1. Prepare and add Figures 3.6-1, 3.6-2, 3.6-3, 3.6-4, and 3.6-5 to the Draft EIS/EIR.
2. Add 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.

PDT Final Evaluator Response (FPC#10):

__X__**Concur** ___**Non-Concur**
The Corps will update the EIS/EIR to include the recommendations discussed below.

Recommendation #1: __X__Adopt __Not adopt
The Corps will ensure that the vegetation and wildlife section includes habitat maps of the study area. These figures did not exist for the draft but will be prepared and included in the final report.

Recommendation #2: __X__Adopt __Not adopt
The Corps has prepared tables identifying habitat acreages impacted by the project. These tables will be included in the final report.

Panel Final BackCheck Response (FPC#10):

Concur.

Final Panel Comment 11

Issues that are important to the integrity of the levee that may affect its future performance (such as poor soil composition, presence of any large trees at or near the levee, and the likelihood of animals burrowing the soil) have not been fully addressed.

Basis for Comment

As the nation's levee system continues to grow older and the risk to public health and safety grows along with it, levee owners and operators can greatly mitigate these risks by implementing a basic protection/maintenance plan of levees. Issues that concern levee stability include poor soil settlement and erosion over time, presence of trees larger than 2 inches in diameter at or near the levee, and the continuous, natural activity of animal burrowing within the levee. Burrows that are created by animals can cause great damage to the integrity of levees and can often lead to rapid levee failures during times of flood. Therefore, some consideration must given to these conditions that occur at or near the levee.

The GRR acknowledges that poor soil composition is an issue (p. 1-19, Section 1.5.1.4) and the soil does not meet today's engineering standards. The GRR (Sections 2-10 to 2-12 and 4-3) does not fully address the size of the trees on or near the levee, riprapped areas, or drainage channels that would pose a problem. In addition, the GRR does not fully address an animal abatement program or control techniques that should be put in place. The presence of burrowing animals may not be readily detected without conducting a thorough inspection or putting in place control techniques such as bait stations, trapping, or removal of animals (in the case of beavers).

Since these issues could be a problem for future levee owners and operators, the diameter of the trees posing a problem should be specified and specific control techniques should be stated to address the issue of burrowing animals. Treatment of the soil (if possible), removal of oversized trees (larger than 2 inches in diameter) that pose a problem to the levee, and detection of the activities of burrowing animals is crucial to the integrity of the levee. If these issues are addressed and actively monitored, the levee is expected to perform well. By understanding that no single plan can guarantee that a levee system will not fail under all circumstances, levee owners and operators are encouraged to work with local public safety officials in assisting them to develop effective protection/maintenance plans. One of the most important links in the "safety chain" of flood risk management is, indeed, the protection of levees.

Significance – Medium

Without addressing issues that play a factor in levee stability (e.g., poor soil composition of the levee, presence of large trees at or near the levees, and the likelihood of animals burrowing the soil), it is not possible to assess the future performance of the levee.

Recommendation for Resolution

1. Implement an active abatement or control program to remove any animals or large trees that are located at or near the levees.

PDT Final Evaluator Response (FPC#11):

__X_**Concur** ___**Non-Concur**

The levees will be brought into compliance with USACE levee safety policy during design and construction of the Tentatively Selected Plan. The local maintaining agency is responsible for maintenance of the *levees following construction. The Operations and Maintenance manual developed for the project will include an active abatement and control program to remove any animals or large trees that are located near the levee and present a risk to the functionality of the levee.*

Recommendation #1: _X_Adopt __Not adopt
The O&M manual will include an abatement and control program for borrowing animals and removal of vegetation.

Panel Final BackCheck Response (FPC#11):

Concur.

Literature Cited:

USACE (2006). Levee Owner's Manual for Non-Federal Flood Control Works. The Rehabilitation and Inspection Program, Public Law 84-99. U.S. Army Corps of Engineers. March. Available online at: http://media.swf.usace.army.mil/pubdata/ppmd/emermgt/pdf/leveeownersmanual.pdf

Final Panel Comment 12

A strategy has not been presented for allocating costs and benefits for West Sacramento alternatives that might be integrated with the Locally Preferred Option being considered in the American River Common Features Project.

Basis for Comment

The GRR states (Section 3.12.2, p. 3-26) that widening the Sacramento Weir and Bypass is being carried forward as part of the Locally Preferred Option (i.e., the alternative that is preferred by the non-Federal sponsor) in the American River Common Features Project. Implementation of these measures would preclude the need to raise portions of the West Sacramento levees along the Sacramento River. The West Sacramento GRR also indicates (Section 3.12.4, p.3-28) that the costs of widening the Sacramento Weir and Bypass could be "cost shared" between the two projects. However, the West Sacramento GRR does not present a strategy for how to allocate the total costs between the projects. If the costs of widening the Sacramento Weir and Bypass are shared between the two projects, it would be reasonable for the benefits that result from the costs to also be shared. Care must be taken to account for and allocate all benefits and costs, but avoid double-counting costs or benefits. Additionally, with two different non-Federal sponsors, a cost sharing strategy is needed.

Significance – Medium/Low

Without presenting a strategy for allocating the costs and benefits between the American River Common Features and the West Sacramento Projects, it will not be possible to determine the full benefits and costs of alternative plans for both projects, which may impact the benefit-to-cost ratios of alternatives for both projects.

Recommendations for Resolution

1. Develop and apply a strategy for allocating costs and benefits to the American River Common Features Locally Preferred Option and the West Sacramento Project alternatives, assuming both projects are authorized.
2. Assess and document the non-Federal sponsors' willingness to participate in plans that integrate the American River Common Features Locally Preferred Alternative with the West Sacramento recommended plan.
3. Develop strategies for the West Sacramento Project based on future scenarios with and without authorization and construction of the American River Common Features Project.

PDT Final Evaluator Response (FPC#12):

_X_**Concur** ___**Non-Concur**

Please note - The text on page 3-28 will be revised to remove the mention of "cost sharing."

Neither the costs nor the benefits of the West Sacramento GRR and the American River Common Features GRR are shared. There are not any features of the two projects that have shared costs. Each project is a stand-alone project.

West Sacramento GRR Alternatives 2 and 4, which included the Sacramento Bypass widening, were not carried into the final array of alternatives, because they were not as cost effective as other alternatives.

The District determined that because there is a limited amount of levee raising (approximately 5,000 ft. of levee) needed along the Sacramento River for the West Sacramento project, the more efficient option was to raise the levees in place to address that concern.

Recommendation #1: __Adopt _X_Not adopt
See explanation above

Recommendation #2: __Adopt _X_Not adopt
Not applicable based on reasons presented above

Recommendation #3: _X_Adopt __Not adopt
The West Sacramento and ARCF projects are stand alone projects. A hydraulic analysis including the future with project conditions for both projects has been conducted to verify that the projects can be implemented on their own.

Panel Final BackCheck Response (FPC#12):

Concur.

Final Panel Comment 13

It is not clear how evaluation metrics were used in screening preliminary alternatives or evaluating the final alternatives.

Basis for Comment

Table 3-18 of the GRR (p. 3-35) provides a set of evaluation metrics that could be used to assess how well alternatives meet the planning objectives. However, there is no description in the GRR of how the evaluation metrics were applied and how they were used to screen or compare alternatives. Nor does the GRR describe how the alternatives were uniformly evaluated using a common set of evaluation metrics.

Significance – Medium/Low

A clear description of how the alternatives were evaluated is necessary to determine how well they met the planning objectives.

Recommendations for Resolution

1. Provide a description of how the evaluation metrics in Table 3-18 were applied to the alternatives and how the alternatives compared. A table could be added to compare how well each alternative met the planning objectives based on the evaluation matrix.

PDT Final Evaluator Response (FPC#13):

_X_**Concur** __**Non-Concur**
A table will be created and included in the final report that compares the preliminary array of alternatives to the evaluation metrics. Narrative will be added for further description.

Note that Table 3-20 – Screening of Preliminary Array of Alternatives - includes a column Effectiveness (Meets Objectives) that presents information regarding screening. With the exception of alternatives 0.5A, 0.5B, and 0.5C the preliminary alternatives meet the objectives for the most part. An explanation of the major reason the alternative did not meet the objective is included in the table.

Recommendation #1: _X_Adopt __Not adopt
A table will be created and included in the final report that compares the preliminary array of alternatives to the evaluation metrics. Narrative will be added for further description.

Panel Final BackCheck Response (FPC#13):

Concur.

Final Panel Comment 14

It is not clear how the magnitude of impacts and level of significance were determined for effects of sedimentation and turbidity on fisheries resources.

Basis for Comment

The Draft EIS/EIR (Section 3.7, pp. 131-135) concludes that an increase in sedimentation and turbidity could be considered significant for fisheries in general; however, the specific types and 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.129), it is not clear how the level of significance was determined. For example, it is not clear 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 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 is not clear.

Recommendation 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.

2. Discuss the assumptions made about the amount of project-related increased sedimentation and turbidity (relative to baseline conditions) 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#14):

__X_**Concur** ___**Non-Concur**
The Corps will update the EIS/EIR to include the recommendations discussed below.

Recommendation #1: _X_Adopt __Not 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: _X_Adopt __Not adopt
The Corps will ensure that the fisheries section includes a discussion regarding the assumptions that were made about project-related increased sedimentation and turbidity (relative to baseline conditions). The significance criteria will be clarified.

Panel Final BackCheck Response (FPC#14):

Concur.

Final Panel Comment 15

Details about dates, locations, and objectives of reconnaissance-level surveys for some biological resources are not presented.

Basis for Comment

Sections 3.6 and 3.8 of the Draft EIS/EIR (pp. 107, 137, 150, 151, 167) mention that reconnaissance-level surveys to characterize existing biological resource conditions and analyze project-related impacts were conducted. The Panel believes they are likely appropriate to support the analysis. However, no information is provided about the methodology and timing of the surveys, or the types of information collected (e.g., vegetation mapping, evaluating habitat suitability for special-status species, etc.). Section 3.7 of the Draft EIS/EIR does not mention whether reconnaissance-level or other surveys for fisheries resources were conducted.

Significance – Medium/Low

The overall quality and adequacy of the reconnaissance-level surveys cannot be evaluated without some additional detail about the timing, objectives, and methods of the surveys.

Recommendation for Resolution

1. Provide a discussion of the survey methods, including survey areas, dates, and types of information collected in Sections 3.6, 3.7, and 3.8 of the Draft EIS/EIR.

PDT Final Evaluator Response (FPC#15):

_X_**Concur** __**Non-Concur**
The Corps will update the EIS/EIR to include details on what surveys have been conducted at this time. Surveys have not been completed for the full project area. The Corps will clarify where the surveys occurred and where the Corps used GIS data and aerials in order to estimate potential impacts to habitat types.

Recommendation #1: _X_Adopt __Not adopt
The Corps will update the listed sections to include details on what surveys have been conducted at this time. Surveys have not been completed for the full project area. The Corps will clarify where the surveys occurred and where the Corps used GIS data and aerials in order to estimate potential impacts to habitat types.

Panel Final BackCheck Response (FPC#15):

Concur.

Final Panel Comment 16

No analyses have been reported that confirm that the seepage model extent is sufficient so that boundary effects do not result in inaccurate results.

Basis for Comment

As described in the Geotechnical Appendix, Section 11.1, no-flow boundary conditions were applied at the downstream extent of the seepage model used to determine exit gradients and evaluate whether seepage control measures are required. The boundary conditions are unlikely to represent actual conditions because some landward flow probably exists. The Panel infers that it was assumed that the numerical seepage model extent of 2000 ft described in Section 11.1 is large enough that boundary conditions will not affect the results near the levee. No information is provided whether any analyses have been conducted to confirm this assumption. Instead of no-flow boundary conditions, an option would be to use a constant head boundary based on assumed groundwater conditions on the landside boundary of the seepage model.

Significance – Low

Confirming that boundary conditions used for seepage analyses do not result in inaccurate results will improve the understanding and accuracy of the project.

Recommendation for Resolution

1. The inferred assumption should be confirmed in future design phases either by analyzing a few cases with larger model extents and comparing results to confirm that exit gradients are the same, or by applying constant head boundary conditions on vertical surfaces with reasonably assumed piezometric levels.

PDT Final Evaluator Response (FPC#16):

__X_**Concur** ___**Non-Concur**
The inferred assumption regarding boundary conditions will be confirmed in future design phases.

Recommendation #1: _X_Adopt __Not adopt
During future design phases analyses incorporation of more robust model extents (i.e. extension of the landside extent of the model past 2000ft from the landside levee toe, or by assigning applicable vertical head boundary conditions) will allow for a comparison of results to confirm consistency in exit gradients.

Panel Final BackCheck Response (FPC#16):

Concur.

Final Panel Comment 17

The use of effective peak shear strength parameters may not be appropriate for all materials.

Basis for Comment

The strength parameters used for concept level analyses are appropriate for the vast majority of the project; however, it is possible that in a few cases the risk of slope instability is somewhat higher than present calculations indicate. Stability analyses used effective shear strength parameters for all materials and were determined using the 33% percentile value from either in situ tests or triaxial tests. While the method is appropriate for the majority of the soils encountered for the proposed project, special cases exist where performing analyses using undrained or fully softened parameters might reduce calculated stability for both with- and without-project conditions. Using effective stress parameters is not appropriate for soft to medium stiff foundation clays and silty clays that generate positive pore pressure during shear, unless sophisticated and unusual methods are used to determine these pore pressures. Stability analyses of such materials are appropriately performed using undrained strength, as described by Ladd (1986).

Using strength determined from in situ and triaxial tests may be unconservative for fat clays, even using the 33% percentile value. This is especially true when subjecting the materials to alternating cycles of wetting and drying. For these materials, Duncan and Wright (2005) summarize research demonstrating that the fully softened strength is more appropriate for these materials. In situ tests and standard triaxial testing provide peak strength, not fully softened strength. Duncan and Wright discuss appropriate lab testing methods, and provide correlations for estimating appropriate strengths.

The Panel believes that in a few cases the use of undrained or fully softened strength parameters may overestimate both with- and without-project condition level slope stability. Reanalyzing the slopes with more appropriate parameters could increase both the cost of levee repair, but also the likelihood of failure for without-project conditions, thus increasing the benefit of the project. As a result, any changes in the benefit-to-cost ratio are almost certainly within the margin of uncertainty for the project.

Significance – Low

Using undrained or fully softened strength parameters will improve the accuracy and technical quality of the project, notably in the future design phase.

Recommendation for Resolution

1. During future design phases, evaluate whether conditions exist where using undrained or fully softened strength parameters might affect details of recommended repairs. If necessary, perform lab tests or use applicable correlations to determine appropriate strength parameters for use in detailed design.

PDT Final Evaluator Response (FPC#17):

__X_**Concur** __**Non-Concur**
The use of effective peak shear strength parameters may not be appropriate for all materials. The parameters will be evaluated during future design phases.

Recommendation #1: _X_Adopt __Not adopt
During future design phases, evaluation of whether conditions exist that may warrant an undrained of fully

softened shear strength case will be considered. This evaluation will be done in conjunction with future design level laboratory testing program to allow for a more defined definition of the shear strength parameters.

Panel Final BackCheck Response (FPC#17):

Concur.

Literature Cited:

Duncan, J. Michael and Wright, Stephen G. (2005). Soil Strength and Stability. John Wiley and Sons Inc., 312 pp.

Ladd, C.C. (1986). Stability evaluation during staged construction. ASCE Journal of Geotechnical Engineering, 1986:117(4)

Final Panel Comment 18

The level of significance of impacts on biological resources after mitigation is not clearly presented.

Basis for Comment

The Panel believes the overall conclusions of the analysis of the impacts on biological resources may be accurate, and the biological effects of implementing and operating the project with mitigation incorporated could be relatively minor. However, the biological rationale and evidence to support the conclusions are not always consistent or clearly presented. Clear presentation of this information is important for supporting the analysis, conclusions, and whether proposed mitigation is adequate.

Table ES-1 of the Draft EIS/EIR (pp. ES-13 to 20) summarizes the environmental effects, mitigation, and levels of significance for each alternative. In the "Vegetation and Wildlife" category, all the effects are listed as "significant" (with mitigation incorporated); however, the analysis in Section 3.6 (pp. 114-121) describes the effects as being reduced to a less-than-significant level with mitigation incorporated. The same issue applies to Table 4-2 (p. 392).

The cumulative effects analyses for vegetation and wildlife, fisheries resources, and special-status species (Draft EIS/EIR, pp. 384-387) do not describe or provide a rationale for whether the project's contribution to a cumulative effect is considered significant.

The mitigation proposed for impacts on special-status bat species states (Draft EIS/EIR, p. 182): "The same measures described above for migratory bird species would also be used to minimize the effects to bats." However, because survey techniques and timing for detecting migratory birds are different than those for detecting bat species, the measures proposed for migratory birds would not likely be appropriate for detecting and minimizing/avoiding impacts on bats.

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.

Recommendation for Resolution

1. For the biological resources impact discussions presented in Sections 3.6, 3.7, and 3.8 of the Draft EIS/EIR (pp. 114-124, 131-135, 168-185), include a conclusion about whether all potentially significant effects have been reduced to a less-than-significant level, 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 Tables ES-1 and 4-2 to make them consistent with the analysis conclusions for biological resources.
3. Provide details of the proposed mitigation for impacts on special-status bat species (e.g., survey methods, limited operating periods, minimization/avoidance measures, etc.).
4. Expand the cumulative effects discussion (pp. 384-387) to include a discussion of the project's contribution to a cumulative effect and its level of significance. (For consistency, this revision could be made to all of the resource sections.)

PDT Final Evaluator Response (FPC#18):

_X__Concur __Non-Concur

The Corps will update the EIS/EIR to include the recommendations discussed below.

Recommendation #1: _X_Adopt __Not adopt

A conclusion will be added to the biologic resource impact discussions in Section 3.6, 3.7, and 3.8 of the EIS/EIR regarding whether all of the potentially significant impacts have been reduced to a less than significant level.

Recommendation #2: _X_Adopt __Not adopt

Special status species section in the tables will be updated to be consistent with one another. The other resources are all consistent between the tables.

Recommendation #3: _X_Adopt __Not adopt

The Corps will update and provide additional details to the proposed mitigation measures for special-status bat species.

Recommendation #4: _X_Adopt __Not adopt

A significance determination was not made for Special Status Species or Cultural Resources. The Corps will update the cumulative effects section to ensure that an appropriate determination is made for these two resources.

Panel Final BackCheck Response (FPC#18):

Concur.

West Sacramento, 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 February 2015.

Overall, 18 comments were identified and documented; one was identified as having high significance, two were identified as having medium/high significance, eight had medium significance, four had medium/low significance, and three were identified as having low significance. The following discussions present the Final Response to the 18 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*. The project benefits are overestimated because the probability of geotechnical failure used in the HEC-FDA analyses is unreasonably high.

The comment included two recommendations for resolution which were not adopted as discussed below.

USACE Response (#1): Not Adopted

1. **Action Taken:** The IEPR Panel recommended **e**stimating geotechnical failure probabilities using a semi-quantitative risk analysis conducted in accordance with USBR (2012). It may be necessary to use expert elicitation to establish a conditional probability relationship between poor performance and levee breach. Case history data may also be informative. N

   Not adopted - The estimate of geotechnical failure probabilities were established according to state of practice for the USACE at the time of the analysis by following Corps guidance (ETL 1110-2-556). ETL 1110-2-556 has never been replaced, so even though it has been "expired" for several years, Corps Districts still use it for Feasibility Studies because new Feasibility Study fragility curve guidance has not been issued. Conditional probabilities were established by conducting an Expert Elicitation which is included as Enclosure 5 of the Geotechnical Appendix.

2. **Action Taken –** The IEPR Panel suggested that the revised failure probabilities should include an assessment of the uncertainty in those probabilities to comply with USACE (2000), Section 10. For example, perform sensitivity studies (such as the example provided in USBR [2012], Section 12) to assist in estimating the uncertainty in calculated failure probability that results from uncertainty in input distributions.

   Not Adopted - The failure probabilities were developed following the current USACE state of practice as defined in ER 11105-2-101 and ETL 1110-2-556 and did not incorporate a direct uncertainty within the probabilities. During the Expert elicitation process for judgment bases probabilities a range was assigned for each category. For probabilities associated with underseepage, through seepage, and stability analyses, a coefficient of variation is prescribed to each parameter. Those parameters were then varied independently resulting in a probability of poor performance for each of the aforementioned categories. Further evaluation of the uncertainty in the geotechnical performance uncertainty is beyond the requirements of a feasibility study level of analysis.

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2. IEPR Comment – *Medium/ High Significance*. Potential FRM benefits have not been evaluated and project benefits are likely to be significantly greater than presented in the GRR.

The comment includes three recommendations for resolution which were adopted as discussed below.

<u>USACE Response (#1): Adopted</u>

> **Action Taken:** The IEPR panel recommended to **c**alculate FRM benefits that would be expected in West Sacramento due to reduced emergency costs and include them in the benefit-to-cost ratio.

<u>USACE Response (#2): Adopted</u>

> **Action Taken:** The IEPR Panel recommended calculation of FRM benefits that would result from reduced agricultural flood damages and include them in the benefit-to-cost ratio.

<u>USACE Response (#3): Adopted</u>

Action Taken: The IEPR panel recommended an assess of future development that is likely to occur in West Sacramento and recalculate FRM benefits based on equivalent annual damages

3. IEPR Comment – *Medium/High Significance*. Economic residual risks associated with seismic damage are not assessed.

The comment includes two recommendations for resolution which were both adopted as discussed below.

<u>USACE Response (#1): Not Adopted</u>

Action Taken: The IEPR panel recommended estimation of the probability of levee damage due to seismic shaking, and estimate the cost of subsequent repair. We did not adopt this recommendation based on the following: *The West Sacramento GRR has evaluated the probability of levee damage due to seismic shaking as detailed in Enclosure No. 6. Development of a conceptual design and cost estimate for seismic mitigation is commonly not completed as the probability of a concurrent flood event and an earthquake occurring is considered to be quite low.*

USACE Response (#2): Not Adopted

Action Taken: The IEPR Panel recommended that based on the results of the above recommendation, consider whether it would be warranted to develop a conceptual design and cost estimates for improvements to resist seismic damage. *We did not adopt this recommendation for the reasons stated above.*

4. IEPR Comment – ***Medium Significance.*** **The conclusions regarding seismic hazards in relation to the California Seismic Hazards Mapping Act in the Draft EIS/EIR are contradicted by the results of analyses presented in the Geotechnical Appendix to the GRR.**

The comment includes two recommendations for resolution which were all adopted as discussed below.

USACE Response (#1): Adopted

Action Taken: The IEPR panel recommended clarifying the discussion of seismic hazards presented in the Draft EIS/EIR (p. 67)The IEPR panel recommended adding figures that depict biological resources within the study area, including vegetation/habitat types in relation to proposed project features.

USACE Response (#2): Adopted

Action Taken: The IEPR panel recommended review of the conclusions related to the California Seismic Hazards Mapping Act in light of other descriptions of seismic risks (i.e., p. 67 of the EIS/EIR and the GRR, Appendix C, Section 12) and resolve any inconsistency.

5. IEPR Comment – ***Medium Significance.*** **Decisions to upgrade the levee are sometimes based on qualitative criteria that are not clearly defined, potentially resulting in non-essential levee upgrades.**

The comment includes two recommendations for resolution which were all adopted as discussed below.

USACE Response (#1): Adopted

1. **Action Taken:** The IEPR panel recommended evaluating whether qualitative design criteria could be established and described to supplement the quantitative criteria.

USACE Response: (#2) Adopted

2. **Action Taken:** The IEPR panel recommended performing additional investigations and analyses in future design stages to resolve inconsistencies between observed performance and results of analyses.

6. IEPR Comment – *Medium Significance.* The adequacy of the internal water management system and the incremental costs and benefits of improving the system have not been evaluated.

The comment includes two recommendations for resolution which were all adopted as discussed below.

<u>USACE Response (#1): Adopted</u>

1. **Action Taken:** The IEPR panel recommended evaluating the design, existing condition, and operations and maintenance practices of the West Sacramento internal water management system to verify that the system is designed appropriately and will continue to function properly in the future.

<u>USACE Response (#2): Adopted</u>

2. **Action Taken:** The IEPR panel recommended evaluating the incremental costs and benefits of improvements to the internal water management system to determine whether such improvements are justified and could increase the total net FRM benefits of the recommended plan.

7. IEPR Comment – *Medium Significance.* The basis for the assumption that the project will receive funding for construction at a rate of $100 million per year 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 one recommendation for resolution which was adopted as discussed below.

<u>USACE Response (#1): Adopted</u>

1. **Action Taken: The IEPR panel recommended adding** a description of the basis for the assumption that the project will receive $100 million per year during the construction period.

8. IEPR Comment – *Medium Significance.* The mitigation requirements for the alternatives and the recommended plan are not described in the GRR and it is not clear whether the cost estimates include the cost of implementing and monitoring mitigation measures.

The comment includes two recommendations for resolution which were all adopted as discussed below.

USACE Response (#1): Adopted

Action Taken: The IEPR panel recommended providing more detailed descriptions of the mitigation measures, how they will be implemented, and uncertainties related to implementation.

USACE Response(#2) Adopted

Action Taken: The IEPR panel recommended adding a discussion of how the cost estimates for mitigation measures and monitoring were developed, and include a line item for mitigation measures and monitoring in the total project cost estimate, and discuss uncertainty.

9. 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 all adopted as discussed below.

USACE Response (#1): Adopted

Action Taken: The IEPR panel recommended discussing existing conditions for invasive plants/noxious weeds in the project area. If recent field or other site-specific data to characterize invasive plant conditions in the project 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.

USACE Response (#2): Adopted

Action Taken: The IEPR panel recommended adding a discussion of construction-related impacts in the effects analysis and considering whether mitigation to prevent invasive plant spread during construction is needed.

10. IEPR Comment – *Medium Significance.* Some biological resources in the study area potentially affected by project implementation have not been presented in sufficient detail to describe the existing conditions and support the EIS/EIR analysis.

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 preparing and adding Figures 3.6-1, 3.6-2, 3.6-3, 3.6-4, and 3.6-5 to the Draft EIS/EIR. These figures were added to the EIS

<u>USACE Response (#2): Adopted</u>

Action Taken: The IEPR panel recommended adding a table that quantifies (in acres) and compare the amount of each land cover type, including waters of the U.S., assumed to be affected under each alternative.

11. IEPR Comment – *Medium Significance.* Issues that are important to the integrity of the levee that may affect its future performance (such as poor soil composition, presence of any large trees at or near the levee, and the likelihood of animals burrowing the soil) have not been fully addressed.

The comment includes two recommendations for resolution which were adopted as discussed below.

<u>USACE Response (#1): Adopted</u>

Action Taken: The IEPR panel recommended implementation of an active abatement or control program to remove any animals or large trees that are located at or near the levees.

<u>USACE Response (#2): Adopted</u>

2. **Action Taken:** The IEPR panel recommended adding a discussion of construction-related impacts in the effects analysis and considering whether mitigation to prevent invasive plant spread during construction is needed.

12. IEPR Comment – *Medium/Low Significance.* A strategy has not been presented for allocating costs and benefits for West Sacramento alternatives that might be integrated with the Locally Preferred Option being considered in the American River Common Features Project.

The comment includes three recommendations for resolution; two were not adopted and one was adopted as discussed below.

<u>USACE Response (#1): Not Adopted</u>

Action Taken: The IEPR panel recommended development and application of a strategy for allocating costs and benefits to the American River Common Features Locally Preferred Option and the West Sacramento Project alternatives, assuming both projects are authorized.

USACE did not adopt this recommendation because neither the costs nor the benefits of the West Sacramento GRR and the American River Common Features GRR are shared. There are not any features of the two projects that have shared costs. Each project is a stand-alone project.

West Sacramento GRR Alternatives 2 and 4, which included the Sacramento Bypass widening, were not carried into the final array of alternatives, because they were not as cost effective as other alternatives. The District determined that because there is a limited amount of levee raising (approximately 5,000 ft. of levee) needed along the Sacramento River for the West Sacramento project, the more efficient option was to raise the levees in place to address that concern.

<u>USACE Response (#2): Not Adopted</u>

Action Taken: The IEPR panel recommended and assessment and documentation the non-Federal sponsors' willingness to participate in plans that integrate the American River Common Features Locally Preferred Alternative with the West Sacramento recommended plan.

Reason to not adopt – see above.

<u>USACE Response (#3): Adopted</u>

Action Taken: The IEPR panel recommended development of strategies for the West Sacramento Project based on future scenarios with and without authorization and construction of the American River Common Features Project.

13. IEPR Comment – *Medium/Low Significance.* It is not clear how evaluation metrics were used in screening preliminary alternatives or evaluating the final alternatives.

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 a description of how the evaluation metrics in Table 3-18 were applied to the alternatives and how the alternatives compared. A table could be added to compare how well each alternative met the planning objectives based on the evaluation matrix.

14. IEPR Comment – *Medium/Low Significance.* It is not clear how the magnitude of impacts and level of significance were determined for effects of sedimentation and turbidity on fisheries resources.

The comment includes two recommendations recommendation for resolution which were adopted as discussed below.

<u>USACE Response (#1): Adopted</u>

Action Taken: The IEPR panel recommended a description of how the evaluation metrics in Table 3-18 were applied to the alternatives and how the alternatives compared. A table could be added to compare how well each alternative met the planning objectives based on the evaluation matrix.

A table was added as suggested.

15. IEPR Comment – *Medium/Low Significance.* Details about dates, locations, and objectives of reconnaissance-level surveys for some biological resources are not presented.

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 a discussion of the survey methods, including survey areas, dates, and types of information collected in Sections 3.6, 3.7, and 3.8 of the Draft EIS/EIR. A discussion was added to the EIS as suggested.

16. IEPR Comment – *Low Significance.* No analyses have been reported that confirm that the seepage model extent is sufficient so that boundary effects do not result in inaccurate results.

The comment included one recommendation for resolution which was adopted as discussed below.

<u>USACE Response (#1): Adopted</u>

Action Taken: The IEPR panel requested that the inferred assumption should be confirmed in future design phases either by analyzing a few cases with larger model extents and comparing results to confirm that exit gradients are the same, or by applying constant head boundary conditions on vertical surfaces with reasonably assumed piezometric levels.

17. IEPR Comment – *Low Significance.* The use of effective peak shear strength parameters may not be appropriate for all materials.

The comment included one recommendation for resolution which was adopted as discussed below.

USACE Response (#1): Adopted

Action Taken: The IEPR panel requested that during future design phases, evaluate whether conditions exist where using undrained or fully softened strength parameters might affect details of recommended repairs. If necessary, perform lab tests or use applicable correlations to determine appropriate strength parameters for use in detailed design.

18. IEPR Comment – *Low Significance.* The level of significance of impacts on biological resources after mitigation is not clearly presented.

The comment included 4 recommendations for resolution which were adopted as discussed below.

USACE Response (#1): Adopted

Action Taken: For the biological resources impact discussions presented in Sections 3.6, 3.7, and 3.8 of the Draft EIS/EIR (pp. 114-124, 131-135, 168-185), include a conclusion about whether all potentially significant effects have been reduced to a less-than-significant level, 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 requested the review of and, if needed, revision to Tables ES-1 and 4-2 to make them consistent with the analysis conclusions for biological resources.

USACE Response (#3): Adopted

Action Taken: The IEPR panel requested that details of the proposed mitigation for impacts on special-status bat species (e.g., survey methods, limited operating periods, minimization/avoidance measures, etc.) are provided.

USACE Response: (#4) Adopted

Action Taken: The IEPR panel requested that the cumulative effects discussion (pp. 384-387) be expanded to include a discussion of the projects contribution to a cumulative effect and its levee of significance. (For consistency, this revision could be made to all of the resource sections):

DEPARTMENT OF THE ARMY
SOUTH PACIFIC DIVISION, U.S. ARMY CORPS OF ENGINEERS
1455 MARKET STREET
SAN FRANCISCO, CALIFORNIA 94103-1398

REPLY TO
ATTENTION OF

CESPD-PDP (FRM-PCX) 5 February 2015

MEMORANDUM FOR Commander, Sacramento District, U.S. Army Corps of Engineers (CESPK-PM-C/Bryon Lake)

SUBJECT: Final Comment Response Record for the Independent External Peer Review (IEPR) of the West Sacramento Project, California, General Reevaluation Report (GRR) Flood Risk Management (FRM) Project

1. References:

a. EC 1165-2-214, Civil Works Review, 15 December 2012.

b. Memorandum, CESPD-PDP (FRM-PCX), 14 October 2014, subject: FRM-PCX Transmittal of Final Independent External Peer Review (IEPR) Report for West Sacramento Project, California, General Reevaluation Report (GRR) Flood Risk Management (FRM) Project.

2. Enclosed is the Final Comment Response Record for the Independent External Peer Review (IEPR) of the West Sacramento Project, California, General Reevaluation Report (GRR) Flood Risk Management (FRM) Project.

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 were documented in the Final Independent External Peer Review (IEPR) Report for West Sacramento Project, California, General Reevaluation Report (GRR) Flood Risk Management (FRM) Project, dated 6 October 2014.

4. Eighteen 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 18 responses; however, the panel provided a clarifying statement as part of its concurrence with the District response to the final panel comment #3.

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 1.a. 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.

6. For further information, please contact the undersigned at (415) 503-6852, or Ms. Anastasiya Kononova, PCX IEPR lead at (410) 962-2558.

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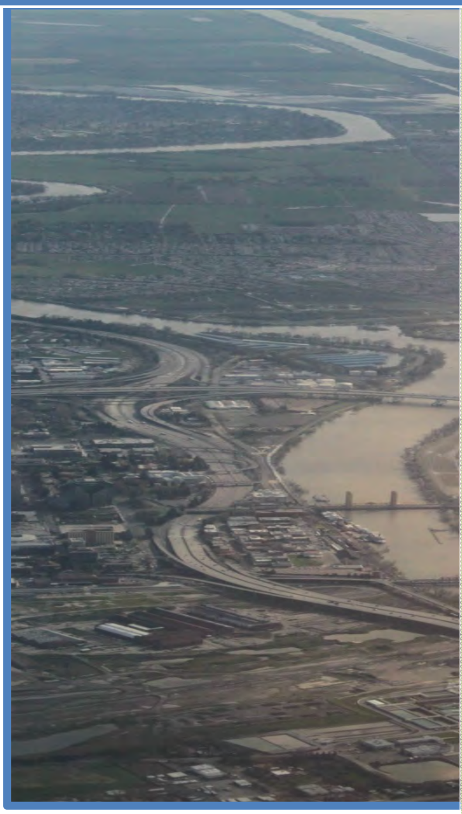
Date: 2015.02.05 09:56:42 -08'00'

Encl

Eric Thaut
Deputy Director, Flood Risk Management
Planning Center of Expertise

CF:
CENAB-PL-P (Anastasiya Kononova)
CESPK-PM-C (Bryon Lake)
CESPK-PPMD (Andrew Muha)
CESPK-PD (Alicia Kirchner)
CESPD-PDP (Kurt Keilman)
CEIWR-RMC (John Clarkson)
CECW-CP (Stuart McLean)

General Reevaluation Report



US Army Corps of Engineers ®
Sacramento District

WSAFCA
West Sacramento Area Flood Control Agency

Final Report Documentation

Engineering Appendix

Cover Photo: Sacramento River, West Sacramento, and Yolo Bypass, March 2011

Photo courtesy of Chris Austin.

WEST SACRAMENTO PROJECT, CALIFORNIA
GENERAL REEVALUATION REPORT

Draft Report Documentation

Engineering Appendix

U.S. Army Corps of Engineers
Sacramento District

December 2015

WEST SACRAMENTO PROJECT, CALIFORNIA

GENERAL REEVALUATION REPORT

Engineering Appendix

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CHAPTER 1 INTRODUCTION

1.1 Purpose and Scope

This engineering appendix documents the design for the West Sacramento General Reevaluation Report (GRR). The purpose of the West Sacramento GRR is to evaluate the additional levee improvements and measures needed to reduce the flood risk to the City of West Sacramento which is located between the Sacramento River and Yolo Bypass at the confluence of the Sacramento and American Rivers. This appendix provides narrative description of the final alternative, Alternative 5, which is the Recommended Plan. The objective of this appendix (along with referenced subject matter appendices) is to summarize, the existing conditions, the final alternative, design considerations, costs, and schedule for the Recommended Plan.

1.2 Project Location and Background

1.2.1 Project Background

The West Sacramento area has a high probability of flooding due to its location at the confluence of the American and Sacramento Rivers, adjacent to the Yolo Bypass and within the floodplain of the Sacramento River. Both of these rivers have large watersheds with very high potential runoff which has overwhelmed the existing flood management system in the past. The city of West Sacramento is essentially surrounded by a system of levees that provide flood risk management for the city. The existing levee system was designed and built many years ago, before modern construction methods were employed. These levees were constructed close to the river to increase velocities which would flush out hydraulic mining debris. This debris is essentially gone now but the high velocities associated with flood flows are eroding the levees which comprise the flood risk management for the study area.

Newspaper accounts and anecdotal evidence mention at least nine major floods in the Sacramento River valley prior to 1900, which prompted the construction of spoil bank levees across the flood plain. The modern flood control system originated with the Sacramento River Flood Control Project (SRFCP) levees authorized in 1917, the Central Valley Project (including Shasta Dam), the construction of Folsom Dam completed in 1956, and the completion of Oroville Dam in 1967. Since the operation of Folsom Dam on the American River became effective, large floods have occurred in 1955, 1964, 1969, 1970, 1982, 1986, 1997, and 2006. The 1986 flood is the flood of record.

February 1986 Flood

In February 1986, a series of storms led to severe flooding in central and northern California. In many areas, precipitation from this 10-day storm delivered more than half of the normal annual precipitation for the area. The Sacramento River flood control system was overloaded and reservoirs in the system were filled beyond their design capacity. Record flow releases from the reservoirs produced river flows that exceeded the design capacity of downstream levees: water came within inches of overtopping levees protecting Sacramento. The timely cessation of the storm event prevented overtopping of the American River levees. At the runoff peak, an estimated 650,000 cfs flowed past the Sacramento metropolitan area in either the Sacramento River or Yolo Bypass and out to the Sacramento Delta.

Emergency levee work and flood fighting prevented catastrophic flooding. However, the extended high water caused boils, slips, sloughing, seepage, flood flow erosion and wave erosion that required emergency work to minimize or prevent further damage during the flood. Several levees upstream from West Sacramento failed during this flood. At the conclusion of the storm, the Governor declared emergencies in 39 counties, with damages totaling more than $500 million.

January 1997 Flood

In mid- to late-December 1996, heavy snow fell in the Sierra Nevada Mountains. This was followed by heavy precipitation on the western slope of the mountains. The rain began to fall on December 26, and from December 31 to January 3, an atmospheric river (locally known as a "Pineapple Express") brought approximately 30 inches of rain on the western slopes of the Sierra Nevada Mountains, dumping more than half a year's worth of rain on Northern California in 10 days. In addition to the local rainfall, 50°F temperatures and rain in the Sierra Nevada Mountains melted the snowpack below 6,000 feet. The combination of record snowfall and record rain resulted in high stream flows around Sacramento. The Sacramento River peaked within half a foot of the 1986 record level. Folsom Dam was barely able to keep releases within the objective release of 115,000 cfs. Upstream from West Sacramento, levees on the Feather River at Olivehurst and on the Sutter Bypass failed during the flood event.

1.2.2 Project Location

The West Sacramento GRR project area includes approximately 50 miles of levee and approximately corresponds with the city limits for the City of West Sacramento. The project area is bound by the Yolo Bypass to the west, the Sacramento Bypass to the north, and the Sacramento River to the east, See Figure 1:

Additionally, the Deep Water Ship Channel (DWSC) divides the project area into the North and South Basin. The project area has been split into nine reaches for technical evaluation (see Figure 2). A description of the levee reaches is below:

- **Sacramento River North Levee** extends for approximately 5.5 miles along the Sacramento River right bank levee from the Sacramento Bypass south to the confluence of the Barge Canal and the Sacramento River.
- **Sacramento Bypass Levee** extends for approximately 1.1 miles along the Sacramento Bypass left bank levee from the Sacramento Weir west to the Yolo Bypass Levee.
- **Yolo Bypass Levee** extends for approximately 3.7 miles along the Yolo Bypass levee left bank from the confluence of the Sacramento Bypass and the Yolo Bypass south to the Navigation Levee (DWSC West).
- **Port North Levee** extends for approximately 4.9 miles along the DWSC right bank from the Barge Canal west to the bend in the Navigation Levee.
- **Port South Levee** extends for approximately 4 miles along the DWSC left bank levee from the Barge Canal west past the bend in the DWSC.
- **DWSC West Levee** extends for approximately 21.4 miles along the DWSC right bank levee from the bend in the DWSC at the intersection of Port North Levee and Yolo Bypass Levee south to Miners Slough.
- **DWSC East Levee** extends for approximately 2.8 miles along the DWSC left bank levee from the end of Port South Levee south to South Cross Levee.
- **Sacramento River South Levee** extends approximately 5.9 miles along the Sacramento River right bank levee from the confluence of the Barge Canal and the Sacramento River south to the South Cross Levee.
- **South Cross Levee** extends along the South Cross levee for approximately 1.2 miles from Jefferson Boulevard to the Sacramento River where it intersects the southern end of Sacramento River South Levee.

1.2.3 Early Implementation Projects (EIPs)

Some locations have been improved by WSAFCA as Early Implementation Projects (EIPs) in advance of the Federal project, see Figure 3. The I-Street Bridge EIP project was completed in 2008, and construction was recently completed at the CHP Academy and Rivers EIP sites. Both of these projects included construction of cutoff walls to address underseepage. EIP reaches were excluded for this GRR with the exception of the Sacramento River South Port EIP, which is currently under design, and is included in this GRR. In addition to the EIP Projects, the Corps of Engineers completed Contract C and D on the Yolo Bypass levee in 2009 and 2011.

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 Array of Alternatives for which quantitative analysis was conducted. The Recommended Plan, which is the Alternative 5, will be considered in this appendix.

2.2 Hydrology

The hydrologic information used in support of this project is presented in Synthetic Hydrology Technical Documentation (USACE 2009) which completed ATR certification in January 2009. See Attachment A – Hydrology Executive Report information regarding use of the hydrologic information.

2.3 Hydraulic Design

The water surface elevations were developed using hydraulic modeling by the Sacramento District Hydraulic Design Section (CESPK-ED-HA). 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). For details about the boundary conditions, calibration, data verification, and other issues related to the hydraulic modeling see Attachment B– Hydraulic Executive Report.

For most reaches, the median 0.5% (1/200) annual chance exceedance (ACE) event plus 3 feet was chosen as the minimum levee top profile. In areas where the existing ground was higher than the criteria, the existing ground elevation was used for the design profile. The top elevations for height improvements (levees and floodwalls) were determined using the median 0.5% (1/200) ACE event plus 3 feet. The south cross levee used a water surface elevation of 30.5 ft as described in the authorized 1957 profile, and the levee height for both port north levee and port south used the currently authorized project elevation 20.5 ft.

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. There have been many studies on erosion, sediment transport, and channel stability in the study area. The plan for erosion is ongoing; more analysis (likely in PED) is expected to provide greater insight.

See Attachment A – Hydraulic Executive Report for information regarding hydraulic design.

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 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 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 the American River Common Features Project's borrow sites established for the Natomas Basin (See ARCFP Engineering Appendix Chapter 2, 6 December 2014). Additionally, the Sacramento District has studied the Deep Water Ship Channel spoil areas as a borrow source several times 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.

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.

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

This section describes the civil design and site considerations required for construction of project features, access roads, staging areas, real estate requirements, relocations, and quantities developed for the Recommended Plan 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.

2.5.1 Alignment and Stationing

Levee stationing in feet was developed for each feature reach for design and quantity take-off purposes of this report. Alignments for existing levee improvements were determined by the existing features such as existing levee crown, landside or riverside toe, etc. The landside toe was determined using the LiDAR data and recent aerial photos and was visually located by USACE Sacramento District Civil Design Section. Most of the access-related improvements were developed using offsets of this approximation.

2.5.2 Topographic Data

The topographic data used for civil design alternative quantity estimates were based on Light Detection and Ranging (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 River was also used in conjunction with the LiDAR surveys for Sacramento River North and Stone Lock. Bathymetric data was collected using post processed kinematic GPS for vertical and horizontal positioning of soundings.

2.5.3 Datum

All horizontal and vertical coordinates of position from survey are presented in Universal Transverse Mercator (UTM), measured in feet, using the North American Datum of 1983 (NAD83). Horizontal coordinates were converted to the California State Plane Zone II coordinate system by Corpscon. All GPS derived elevations are referenced to North American Vertical Datum of 1988 (NAVD88). All elevations provided herein are relative to the NAVD88 vertical datum and NAD83 horizontal datum.

2.5.4 Civil Estimates

Earthwork quantities were arrived at by producing templates corresponding to the recommendations from the Sacramento District Soils Design Section. InRoads, a product of Bentley, was used to develop earthwork material quantities that were summarized by reach and displayed within Excel spreadsheets. Information on existing utilities came from a variety of sources, including a Levee Encroachment and Utility Summary Report for West Sacramento (2011) developed by HDR Inc., City of West Sacramento (water, storm sewer, and sanitary sewer maps), GIS data from Sacramento District Levee Safety Section, Google Earth (obstructions, trees, utilities poles, and homes), and California Department of Water Resources (DWR) Levee Logs. Utilities were summarized by reach on a single Excel Spreadsheet. The Setback Levee, Alternative 5, is currently under final design by WSAFCA as the Sacramento River Southport EIP and the quantities were received from WSAFCA.

2.5.5 Relocations and Utilities

Utilities

Relocations were based upon the work previously done by HDR Inc. for WSAFCA, the Sacramento District Levee Safety Section periodic inspection reports, and existing levee logs maintained by the Department of Water Resources. Existing GIS and existing mapping provided location information for the existing pump stations and many existing power poles. If the levee height was increased, pumps and pipes were assumed to be replaced. If the levee height remained as existing and the pump stations were outside of levee footprint, it was assumed the pipes would be modified to include positive closure devices.

In addition, the City of West Sacramento provided utility mapping that detailed the pipe sizes and locations for water, sewer and gas. All pipelines and conduits crossing the levee alignment will be modified to include positive closure devices and meet the USACE design criteria for levee penetrations in accordance with EM 1110-2-1913. Abandoned pipelines and conduits within levee footprint will be removed, and relocation of power poles within each of the alternatives was determined by inspection of the footprints. The utility summary for each reach was made available to the estimator and can be reviewed upon request. It shows the type of fix required whether jet grouting or replacement occurs.

Building structures

Building structures located inside the proposed levee footprint or rights of way would be bought out and removed or relocated.

However, note that this is not the case for the Sac River North reach. For this reach commercial buildings will not be removed, but instead there will be temporary access available during construction. For residential homes in this reach, residents will need to temporarily vacate to hotels since utilities will be disconnected during construction. Once construction of the cutoff wall is complete utilities will be restored and residents will then be able to return to their homes.

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 some scour bank protection sites along the Sacramento River, riprap stone protection could be constructed using barges. For other areas, additional riverside access roads will be constructed.

For other site features, the permanent access easements associated with this project are expected to be adequate for construction of the features. 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.

There are available sites such as farm land, parks, levee ramps, and vacant land available along the levees that may serve as staging areas. The exact need for staging areas and identification of areas will be completed during the PED phase.

2.6 Real Estate Requirements

Real estate requirements for the project area consisted of Permanent Flowage Easements (PFE), Flood Protection Levee Easements (FPLE) and Bank Protection Easement (BPE). These easements were needed to provide adequate construction room to build proposed flood mitigation features, secure lands needed for Operations and Maintenance (O&M), and acquire lands needed to comply with Corps of Engineers vegetation on levees policies. The easements are described in Sacramento District Standard Operating Procedures (SOP), and summarized below as they apply to the project.

- Bank Protection – 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 FPLE.
- Riverside 15 ft – Easement needed for O&M from the riverside toe and to restrict woody vegetation growth per Engineering Technical Letter (ETL) 1110-2-571. This easement includes the entire area from the riverside toe to an offset line 15 feet towards the river.
- The levees will have a permanent FPLE, which will provide space for the levee, landside seepage remediation, and a 20-foot operation and maintenance right-of-way on the landside of the seepage remediation feature and riverside toe. Easements are necessary for maintenance, inspection, and flood fight access.
- Flood Protection Levee Easement – 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 riverside toe of the existing and/or proposed levee. Refinement of these footprints will be provided in final design prior to levee construction.

More information on the types of easements, relocations, and estimates can be found in the Real Estate Appendix.

2.7 Environmental Impact Assessment

The riverside and landside of the levees in the project area provide a large amount of habitat for the West Sacramento Area. These woodland, grassland, and wetland areas are important as nesting, roosting, and resting habitats for a variety of wildlife, some of which are special-status species. The riverside wooded areas along the Sacramento River 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/Environmental Impact Report along with any options that may reduce or mitigate the affects of the proposed project features.

2.7.1 Hazardous, Toxic, and Radioactive Wastes (HTRW)

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 West Sacramento 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 land side of the levees 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 1 below. These sites will also need further investigation.

Table 1: Environmental Site Assessments

Site Name	Closest Levee Reach	Issue
DWR Maintenance Yard	Sacramento River north levee	Chemical plume with elevated levels of total petroleum hydrocarbons as gas and diesel, benzene, toluene, ethylbenzene, and xylene (BTEX) compounds, and methyl tert-butyl ether (MTBE).
Capitol Plating	Sacramento River north levee	Presence of chromium, nickel, lead, copper, and cadmium in soil and presence of Dichloroethane (DCA) plume.
Tesoro-ARCO Remediation Project (TARP)	Sacramento River north levee	The contaminant plume on this site includes total petroleum hydrocarbons as gasoline (TPH-g), total petroleum hydrocarbons as diesel (TPH-d), benzene, and MTBE currently appears to be stable to decreasing in size.
Shell Oil, Ramos Environmental, KMEP	Sacramento River north levee	Contaminant plumes consisting of TPH-g, TPH-d, benzene, MTBE, and tertiary butyl alcohol (TBA) are currently under monitored natural attenuation.
Port of Sacramento	Port North Area	Nitrogen associated contaminant plume
Agrium U.S. Inc.	Port North Area	A nitrate and ammonia plume

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 West Sacramento 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.

A 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 pose a threat to planned construction.

2.7.2 Environmental Commitments

During the Preconstruction Engineering and Design (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; a reduced footprint on the landside of the levee or reduced bank protection on the riverside of the levee. In addition, 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 riverside trees on the lower 1/3 of the slope to remain in place. This allows approximately 10 miles of trees along the Sacramento River from the Sacramento Weir to the South Cross levee to continue to provide habitat for fish and wildlife species. Trees on the lower 1/3 of the slope would be protected in place 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 minimize impacts to fish and wildlife species; however, the impact to riparian habitat would still be significant. Species of plants will be coordinated with the National Marine Fisheries Service, Fish and Wildlife Service, and State and local partners.

To compensate for the removal of 65 acres of riparian habitat along the Sacramento River, approximately 130 acres of replacement habitat will be created in the setback area and or at a mitigation bank. 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 Sacramento River. 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 or the flood conveyance capacity of the River. Some of the 130 acres of riparian habitat would be planted in the setback area. 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 starting at 30 feet from the toe of the levee. The exact location of the compensation lands will be coordinated in the PED phase of the project with the city of West Sacramento and will comply with City ordinances. It is assumed that sufficient lands will be available within the setback area, however, if there is not sufficient land, other locations within the City of West Sacramento will be identified and pubic coordination will occur. If appropriate lands cannot be located, a FWS approved mitigation bank may be used to offset the impacts. There are parcels of land within a short distance of the project area that could be planted, however, further evaluation on availability of these lands and coordination with the resource agency will be needed. Because it would take many years for the compensation sites to provide the value of those removed, this alternative would cause a significant impact on vegetation and wildlife.

On the landside, where the footprint cannot be reduced, trees will be removed to construct the levee 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 riverside 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. Compensation for the removal of oak trees in the project footprint will be done in compliance with the City of West Sacramento tree ordinance. There are multiple locations that are suitable for planting the compensation trees within the setback area and or on City of West Sacramento Parks land.

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 provides a general description of additional features proposed as part of the West Sacramento project (GRR) and describes the Corps understanding of increases/decreases in OMRR&R effort as a result.

The Corps 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 along the Sacramento River levees, the Yolo Bypass levees, the South Cross levee and the Deep Water Ship Channel levees. During construction of the cutoff walls, vegetation will be removed from some areas of the levees. The removal of trees will reduce the existing OMRR&R requirement which will result in a reduction in future OMRR&R costs. No additional maintenance cost is needed for the cutoff wall feature.

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 fifteen-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 percent to account for the additional area.

Erosion Protection
There is new erosion protection proposed for most areas along the Sacramento River 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.

There will also be vegetation (mainly trees) planted in designated areas. The vegetation will be outside the 15’ riverside of the levee toe boundary. The proposed plantings are native plants and should regenerate and require no maintenance. No additional costs were calculated for additional plantings.

2.9 Cost Engineering

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 and B, Environmental Planning, and Real Estate sections. Summary of estimates for the preliminary alternatives for the Plan are provided in Attachment D – Cost Estimates.

Real estate estimates were based on footprint requirements for project construction, operation and maintenance provided by Civil Design Section. 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. The cost estimates for the preliminary alternatives, were prepared by the Cost Engineering Section of the Sacramento District. 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 American River Watershed Common Features GRR 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.

2.10 Levee Problems

Within the study area, the geotechnical and hydraulic deficiencies of the levees were identified and grouped in the following categories:

- Seepage – Through seepage and underseepage
- Stability – Oversteepened slopes, typically less than 2H:1V
- Height – Levee overtopping
- Erosion – Highly erodible soils, significant scour and velocity issues

Table 2 describes levee problems for each reach.

Table 2: Reach Problems

REACH	REACH LENGTH FEET	FEATURE LENGTH FEET	IMPROVEMENT
Sacramento Bypass	6,478	-	None
Yolo Bypass	19,750	3,860	Stability
		2,500	Seepage, Stability
		1,900	Seepage
DWSC West Levee	100,260	9,000	Seepage, Levee Geometry
		7,000	Seepage, Levee Geometry
		9,000	Seepage, Levee Geometry
		5,560	Levee Geometry
		99,010	Erosion
DWSC East Levee	17,171	1,500	Seepage
		7,055	Seepage
		5,574	Seepage
		1,800	Levee Geometry
Port North	241,140	3352	Levee Geometry
		2090	height
Port South	17,720	2950	Levee Geometry
		1,000	Seepage
South Cross Levee	6400	1340	Stability, Height
		5,000	Seepage, Height
Sacramento River North Levee	30,700	14,300	Erosion
		11,045	Seepage
		1,475	Seepage
		500	Seepage
		5,520	Seepage
		7,600	Levee Geometry
Sacramento River South Levee	33,100	33,100	Seepage, Erosion
Sacramento Bypass Training Dike	3,000	3,000	Erosion Protection

CHAPTER 3 Recommended Plan

3.1 Alternatives

A wide range of features were evaluated to reduce flood risk in the project area. For the purposes of this study, the alternatives were developed by combining measures. Below is the preliminary array of alternatives that were considered:

- Alternative 1 – Improve levees
- Alternative 2 – Improve levees and Sacramento Bypass widening
- Alternative 3 – Improve levees and DWSC Closure Structure
- Alternative 4 – Improve levees, Sacramento Bypass widening and DWSC closure structure
- Alternative 5 – Improve levees and Sacramento River South Setback Levee

The project development team further refined the array of alternatives by screening out the Sacramento Bypass widening measure. The alternatives 1, 3 and 5 were described in the Civil engineering Appendix, see Attachment E.

The final design revisions are only for the Recommended Plan, which is alternative 5. The Appendix provides feasibility level design details for features used during plan formulation and development of the Recommended Plan.

3.2 Recommended Plan– Improve Levees and Sacramento River South Setback Levee

Recommended Plan applies many of the levee remediation measures proposed in Alternative 1 (Improve Levees) except along the Sacramento River South levee reach. The Sacramento River South levee alignment includes fix-in-place, adjacent and a setback levee. This alignment is the same alignment that is being considered in the Non-Federal Sponsors EIP. The improvements for each reach for Recommended Plan are shown on the Figure 3, and a summary of the proposed improvements is in Table 3.

Table 3: Recommended Plan – Proposed Features

RECOMMENDED PLAN – Improve Levees and Sacramento River South Setback					
Reach	**Reach Length Feet**	**Feature Length Feet**	**Improvement**	**Figure Number**	**Features**
Sacramento Bypass	6,478	-	None	-	None
Yolo Bypass	19,750	3,860	Landside Slope	8	Flatten Landside Slope
		2,500	Seepage, Stability	7	Flatten Landside Slope/ 40' Cutoff wall
		1,900	Seepage	6	100' Cutoff Wall
DWSC West Levee	100,260	9,000	Seepage, LGI	6	85' Cutoff Wall
		7,000	Seepage, LGI	6	50' Cutoff Wall
		9,000	Seepage, LGI	6	75' Cutoff Wall
		5,560	LGI	5	Embankment Fill
		99,010	Erosion	-	Bank Protection (120' x3' Depth)
DWSC East Levee	17,171	1,500	Seepage	6	120' Cutoff Wall, DSM
		7,055	Seepage	6	130' Cutoff Wall, DSM
		5,574	Seepage	6	50' Cutoff Wall
		1,800	LGI	5	Embankment Fill
Port North	24,140	-	-	-	No improvements in this Recommended Plan.
Port South	17,720	1,000	Seepage	6	70' Cutoff Wall
South Cross Levee	6,400	1,340	Stability	9	Stability Berm and Embankment Fill
		5,000	Seepage, LGI	10	Relief Wells and Embankment Fill
Sacramento River North Levee	30,700	14,300	Erosion	13	Bank Protection
		11,045	Seepage	6	30' Cutoff Wall
		1,470	Seepage	6	80' Cutoff Wall
		500	Seepage	6	45' Cutoff Wall
		5,520	Seepage	6	110' Cutoff Wall
		7,600	LGI	5	Embankment Fill
Sacramento River South Levee (Setback Levee)	33,100	9,060	Erosion	14-17	Bank Protection
		29,320	Seepage	14-22	Embankment Fill and Cutoff Wall/Berm
Stone Lock	570	540	Flow Direction	11	Embankment Fill, Sheet Pile Wall and Stone Protection
Sacramento Bypass Training Dike	3,000	3,000	Erosion	12	Bank Protection

Note: Where "DSM" is not shown indicate that open trench construction method may be applied. "LGI" stands for Levee Geometry Improvement.

3.3 ***Recommended Plan Reaches***

For the individual levee segments that make up recommended plan, most of them required geometric fixes, seepage repairs, height improvement and stone protection to meet Corps standards.

In terms of the setting the top of levee the initial plan was to find areas where there was not 3 feet of levee between the top of levee and the 1/200 ACE water surface profile. Significant concerns about economic justification cause this option to be dropped. During feasibility level design, the idea of re-establishing a line of defense at the authorized minimum height was created as a middle ground between fixing up to the 1/200 ACE and doing nothing at all. Similar concerns about economic justification in addition to a new concern about the proposed levee heights being an O&M concern led to their removal from the recommended plan. All the recommended features in the reaches described below are generally set to the existing top of levee.

All features along the Port North Levee/Area have been removed from the recommend plan. The height raising along the Port South Levee and the South Cross Levee have also been removed from the recommended plan.

Sacramento Bypass

It is along the Sacramento Bypass left bank levee from Sacramento Weir west to Yolo Bypass levee, and the length of the levee is approximately 6,478 feet. The reach was completed in 2011. It provides flood risk management benefits to the people and property of West Sacramento in advance of the Federal project.

Sacramento Bypass Training Dike

This training dike extends approximately 3,000 feet southwest of the Sacramento Bypass levee into the Yolo Bypass. Erosion protection improvements will be required. Bank protection would be placed on the training dike to address the erosion concerns, see attachment F1 for details.

Yolo Bypass Levee

It is approximately 19,750 feet along the Yolo Bypass levee left bank from the confluence of the Sacramento Bypass and the Yolo Bypass south to the Navigation Levee (DWSC West). The improvements for this reach require 3,860 feet landside slope improvement and cutoff wall installation ranging from 40 feet to 100 feet in depth on 4,400 feet of the reach, see attachment F2 for details.

Port North Levee

It extends for approximately 24,140 feet along the DWSC right bank from the plug lock approach to the bend in the Navigation Levee. This reach encompasses the combination of levees and high ground that exists along the north side bank of Deep Water Ship Channel, and its highest elevations are around 19ft to 23 ft. Some area may need flood wall or embankment fill to rise to meet the minimum height criteria as found in the O&M manual. However, during the feasibility level design and the review process, all features including height improvement and levee geometry improvements were removed from the recommended plan. It is assumed that the local O&M agency would maintained the levee geometry and the levee minimum height 20.5ft as described in the O&M manual.

The Plug Lock Approach (Stone Lock)

This reach extends approximately 570 feet directly east of the inactivated Stone Locks. This levee will stop the flood water go to the Deep Water Ship Canal (DWSC) from the Sacramento River. The improvements for this reach is to construct a new levee with embankment fill sheet pile walls and provide stone protection, see attachment F3 for details.

Sacramento River North Levee

It is approximately 30,700 feet along the Sacramento River right bank levee from the Sacramento Bypass south to the confluence of the Barge Canal and the Sacramento River. The improvements for this reach require 14,300 feet in length erosion protection, 18,535 feet in length seepage improvements with cutoff wall installation ranging from 30 feet to 110 feet in depth, and levee geometry improvements of 7,600 feet in length embankment fill, see attachment F4 for details.

Port South Levee

It is approximately 17,720 feet along the DWSC left bank levee from the Plug Lock Approach west past the bend in the DWSC. However, during the feasibility level design and the review process, the levee height improvement was removed from the recommended plan. We assumed the local O&M agency would maintained the levee geometry and the levee minimum height 20.5ft as described in the O&M manual. The fixes for this reach will be 1,000 feet of seepage improvements with cutoff wall, see attachment F5 for details.

DWSC East Levee

It is approximately 17,171 feet along the DWSC left bank levee from the end of Port South levee south to South Cross levee. The fixes for this reach include 1,800 feet of levee geometry improvements with embankment fill and 14,129 feet of seepage improvements with Cutoff wall, see attachment F6 for details.

South Cross Levee

It is approximately 6,400 feet from the south end of the DWSC East to the Sacramento River where it intersects the southern end of the Sacramento River South levee. The existing levee may not have enough space for O&M from the riverside toe. Our design for this reach will provide 15 ft access corridor at the riverside toe, twenty feet levee crown, and 3:1 slope on both sides of levee. The existing levee was originally set to the minimum system levee height known as the 1957 design profiles (currently set as 30.5 ft NAVD88 in the adjacent Sacramento River. However during the feasibility level design and the review process, the levee heights were removed from the recommended plan. This levee will be strengthened to its existing height.

The improvements for this reach also require 1,340 feet in length of stability berm and relief wells along 5,000 feet of the levee. The relief wells are spaced 50 feet from each other. A ditch will be constructed along the relief wells to collect drains from the relief wells, see attachment F7 for details.

The Setback Levee

It is approximately 30,000 feet along the Sacramento River right bank levee from the confluence of the Barge Canal and the Sacramento River south to the South Cross levee. The setback levee will be constructed offset from the existing levee as shown on Figure 3. It requires approximately 29,320 ft cutoff wall and berm to address seepage concerns. It also requires stone protection on the riverside slope of the levee to prevent significant erosions.

DWSC West Levee

It is approximately 100,260 feet along the DWSC right bank levee from the bend in the DWSC at the intersection of the Port North levee and Yolo Bypass levee south to Miners Slough. The improvements for this reach require approximately 25,000 feet of cutoff wall ranging from 50 feet to 85 feet in depth, approximately 5,560 feet of levee geometry improvements with embankment fill, and 99,010 feet of stone protection for erosion improvements.

3.4 ***Levee Geometry***

Where the existing levee cross section does not meet the levee design requirements, as discussed in Section 2.8 above, slope flattening, crown widening, and/or a levee raise is required. This improvement measure addresses problems with slope stability, geometry, overtopping, and levee toe and crest access and maintenance. The levee crown would be widened to 20 feet and a minimum 3:1 landside and riverside slopes would be established. To begin levee embankment grading, the area would be cleared, grubbed, stripped, and, where necessary, portions of the existing embankment would be excavated to allow for bench cuts and keyways to tie in additional embankment fill. Excavated and borrow material (from nearby borrow sites) would be stockpiled at staging areas. Haul trucks or scrapers would bring borrow materials to the site, which would then be spread evenly and compacted according to levee design plans.

The existing levee centerline would be shifted landward, where necessary in order to meet the Corps' standard levee footprint requirements. In some locations, a retaining wall may be constructed at the existing landside levee toe location to maintain the existing levee footprint. Retaining walls would range from 2 to 4 feet in height (full stem height) and would require landside slope benching to establish the additional fill into the levee section. The levee crown patrol road would be re-established and a new toe access corridor would be added to landward of the levee toe.

3.5 ***Cutoff Walls***

To address seepage concerns, a cutoff wall will be constructed through the levee crown. The cutoff wall would be installed by one of two methods: (1) conventional open trench cutoff walls, or (2) deep soil mixing (DSM) cutoff walls. The method of cutoff wall selected for each reach would depend on the depth of the cutoff wall needed to address the seepage. The open trench method can be used to install a cutoff wall to a depth of approximately 85 feet. For cutoff walls of greater depth, the DSM method would be utilized.

Prior to construction of either cutoff wall method, the construction site and any staging areas would be cleared, grubbed, and stripped. The levee crown would be degraded to approximately half the levee height to create a large enough working platform (approximately 30 feet) and to reduce the risk of hydraulically fracturing the levee embankment from the insertion of slurry fluids.

Conventional Open Trench Cutoff Wall

Under the open trench method, a trench approximately 3 feet wide would be excavated at the top of levee centerline and into the subsurface materials up to 85 feet deep with a long boom excavator. As the trench is excavated, it is filled with a low density temporary bentonite water slurry to prevent cave in. The soil from the excavated trench is mixed nearby with hydrated bentonite, and in some applications cement. The soil bentonite mixture is backfilled into the trench, displacing the temporary slurry. Once the slurry has hardened, it would be capped and the levee embankment would be reconstructed with impervious or semi-impervious soil.

DSM Cutoff Wall

The DSM method involves a crane supported set of two to four mixing augers used to drill through the levee crown and subsurface to a maximum depth of approximately 140 feet. As the augers are inserted and withdrawn, a cement bentonite grout would be injected through the augers and mixed with the native soils. An overlapping series of mixed columns would be drilled to create a continuous seepage cutoff barrier. Once the slurry has hardened, it would be capped and the levee embankment would be reconstructed with impervious or semi-impervious soil.

3.6 *Seepage Berm*

Construction of the seepage berm would consist of clearing, grubbing, and stripping the ground surface. Depending on the action alternative, soil used to construct a berm would be stockpiled from levee degradation, excavated from nearby borrow pits, or trucked on site from off-site locations (if on-site material is not adequately available). During the degrading, soil would be stockpiled at the proposed berm site. If constructing the alternative does not require levee degradation, all soil material used to construct a berm would come from nearby borrow sites. At the borrow sites, bulldozers would excavate and stockpile borrow material. Front-end loaders would load haul trucks, and the haul trucks would transport the borrow material to the site. The haul trucks would then dump the material, and motor graders would spread it evenly, placing approximately 3 to 5 feet of embankment fill material. Material used for berm construction would have greater permeability than the native blanket material. However, depending on material availability, a lower permeability material may be used. Adjustments to berm width would be made in such cases, as appropriate. During the embankment placement, material would be placed in a maximum of 1- to 2-foot loose lifts, thereby allowing the compactors to achieve the specified compaction requirements. Sheep foot rollers would compact the material, and water trucks would distribute water over the material to ensure proper moisture for compaction and reduction of fugitive dust emissions. The new seepage berm would be hydroseeded following construction.

Seepage berms may have an optional feature of a drainage relief trench under the toe of the berm. Drained seepage berms would include the installation of a drainage layer (gravel or clean sand) beneath the seepage berm backfill and above the native material at the levee landside toe. A drained seepage berm may decrease the overall footprint of the berm.

3.7 *Bank Protection*

Bank protection on the Sacramento River would be addressed by standard bank protection. The standard bank protection measure for the Sacramento River consists of placing rock protection on the bank to prevent erosion. This measure entails filling the eroded portion of the bank, when necessary, and installing revetment along the riverside levee slope and streambank from streambed to a height determined by site-specific analysis. The sites would be prepared by removing vegetation along the levee slopes at either end of the site for construction of a temporary access ramp, if needed. The ramp would then be constructed using imported borrow material that would be trucked on site.

The placement of rock onto the levee slope would occur from atop the levee and/or from the riverside by means of barges. Rock required within the channel, both below and slightly above the water line at the time of placement, would be placed by an excavator located on a barge. Construction would require two barges: one barge would carry the excavator, while the other barge would hold the stockpile of rock to be placed on the channel slopes. Rock required on the upper portions of the slopes would be placed by an excavator located on top of the levee. Rock placement from atop the levee would require one excavator and one loader for each potential placement site. The loader brings the rock from a permitted source and stockpiles it near the levee in the construction area. The excavator then moves the rock from the stockpile to the riverside of the levee.

The revetment would be placed via the methods discussed above on existing bank at a slope varying from 2V:1H to 3V:1H depending on site specific conditions. After revetment placement has been completed, a small planting berm would be constructed in the rock when feasible to allow for some revegetation of the site.

CHAPTER 4 SCHEDULE FOR DESIGN AND CONSTRUCTION

4.1 Construction Priorities

When the construction schedule is developing, the construction priority will be used as one of the important considerations. A construction priority analysis was performed using levee fragility curves, hydraulic stage-frequency data, and economic data. The construction activities subsequently were prioritized based on the risk impacts as shown on Table 4. The Yolo Bypass levee has the most risk impacts; it will be considered to be fixed as the first priority. The priorities for other reaches were shown in the last column of table 4.

Table 4: Construction Priority Based On Risk Drivers

BASIN	RISK DRIVER	INDEX POINT	HYDRAULIC STAGE (NAVD 88)		PR (FAILURE)		CONSEQUENCE ACE Event Damages (0.5%) in $millions	RISK RANKING	CONSTRUCTION PRIORITY
			100-YR	200-YR	100-YR	200-YR			
North	Seepage and Stability	(3) Yolo Bypass	31.21	32.58	0.78	0.9	3,800	3420	1
North/South	Seepage, Stability and height	(7) DWSC West	30.69	31.85	0.87	0.91	3,400	3094	2
North	Seepage, Stability, Erosion and Height	(1) Sac River North	36.18	37.47	0.36	0.48	3,500	1680	3
North	Seepage, Stability, Erosion and Height	(2) Sac River North	34.32	36.47	0.09	0.24	3,600	864	4
South	Seepage, Stability, and erosion	(5) Sac River South	32.35	34.46	0.12	0.21	3,600	756	5
South	Seepage, Stability, and erosion	(6) Sac River South	30.59	32.62	0.1	0.13	3,400	442	6
South	Seepage and Height	(8) Port South	16.2	16.93	0.5	0.7	254	178	7

4.2 Construction Schedule

Preconstruction Engineering and Design (PED) Real Estate acquisition will occur over 1 to 2 years prior to commencement of construction for each area of construction. The minimum years to construct each reach was developed based on many factors, such as the construction quantities, the production rates for the construction crews, minimizing costs and environmental effects and the assumption that the yearly federal monetary allotment for the project will be approximately $100 million. To minimize costs and environmental impacts, the following construction schedule (Figure 24) was developed.

Acronym & Abbreviation

ACE- Annual Chance Exceedance

BPE- Bank Protection Easement

DSM-Deep Soil Mixing

DWR- California Department of Water Resources

DWSC -Deep Water Ship Channel

EIP- Early Implementation Project

ETL-Engineering Technical Letter

FPLE- Flood Protection Levee Easements

GRR- General Reevaluation Report

LMA- Local Maintaining Agency

LiDAR- Light Detection and Ranging

NAD83- North American Datum of 1983

NAVD88- North American Vertical Datum of 1988

NCSS- National Cooperative Soil Survey

NFS- Non-Federal Sponsor

NLIP- Natomas Levee Improvement Program

NRCS- National Resources Conservation Service

O&M- Operation & Maintenance

OMRR&R -Operation, Maintenance repair, Replacement and Rehabilitation

PED- Preconstruction, Engineering and Design

PFE-Permanent Flowage Easements

SOP-Standard Operating Procedures

SRA- Shaded Riverine Aquatic

SRFCP- Sacramento River Flood Control Project

ULE- Urban Levee Evaluation

UTM- Universal Transverse Mercator

WSAFCA - West Sacramento Area Flood Control Agency

REFERENCES

ATTACHMENTS

ATTACHMENT A- HYDROLOGY EXECUTIVE REPORT

ATTACHMENT B- HYDRAULIC APPENDIX REPORT

ATTACHMENT C- GEOTECHNICAL REPORT

ATTACHMENT D- COST ENGINEERING

ATTACHMENT E- CIVIL DESIGN APPENDIX REPORT

ATTACHMENT F1- SACRAMENTO BYPASS TRAINING DIKE

ATTACHMENT F2- YOLO BYPASS LEVEE

ATTACHMENT F3- THE PLUG LOCK APPROACH

ATTACHMENT F4- SACRAMENTO RIVER NORTH LEVEE

ATTACHMENT F5- PORT SOUTH LEVEE

ATTACHMENT F6- DWSC EAST LEVEE

ATTACHMENT F7- SOUTH CROSS LEVEE

ATTACHMENT G- TYPES OF FILL MATERIALS

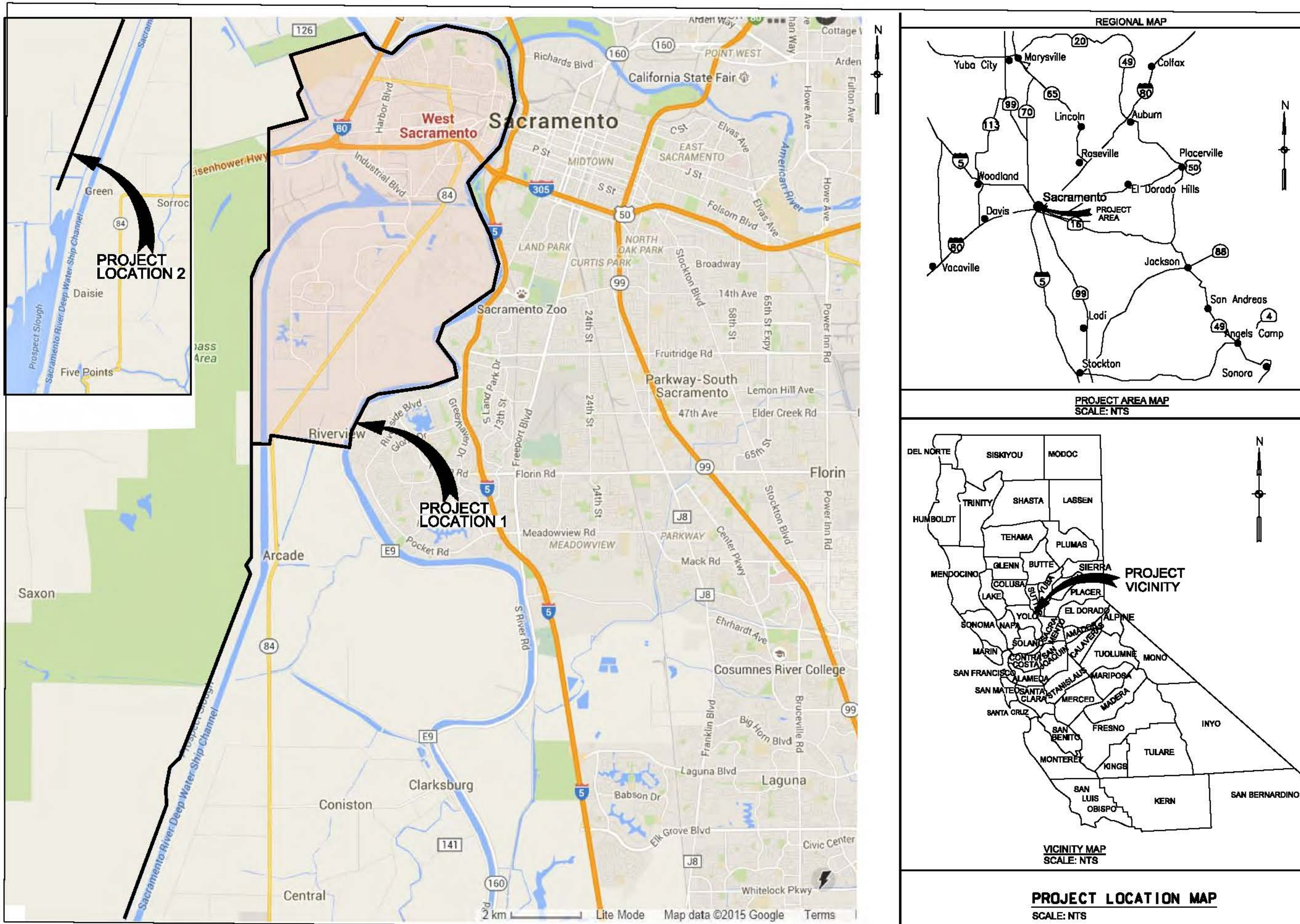
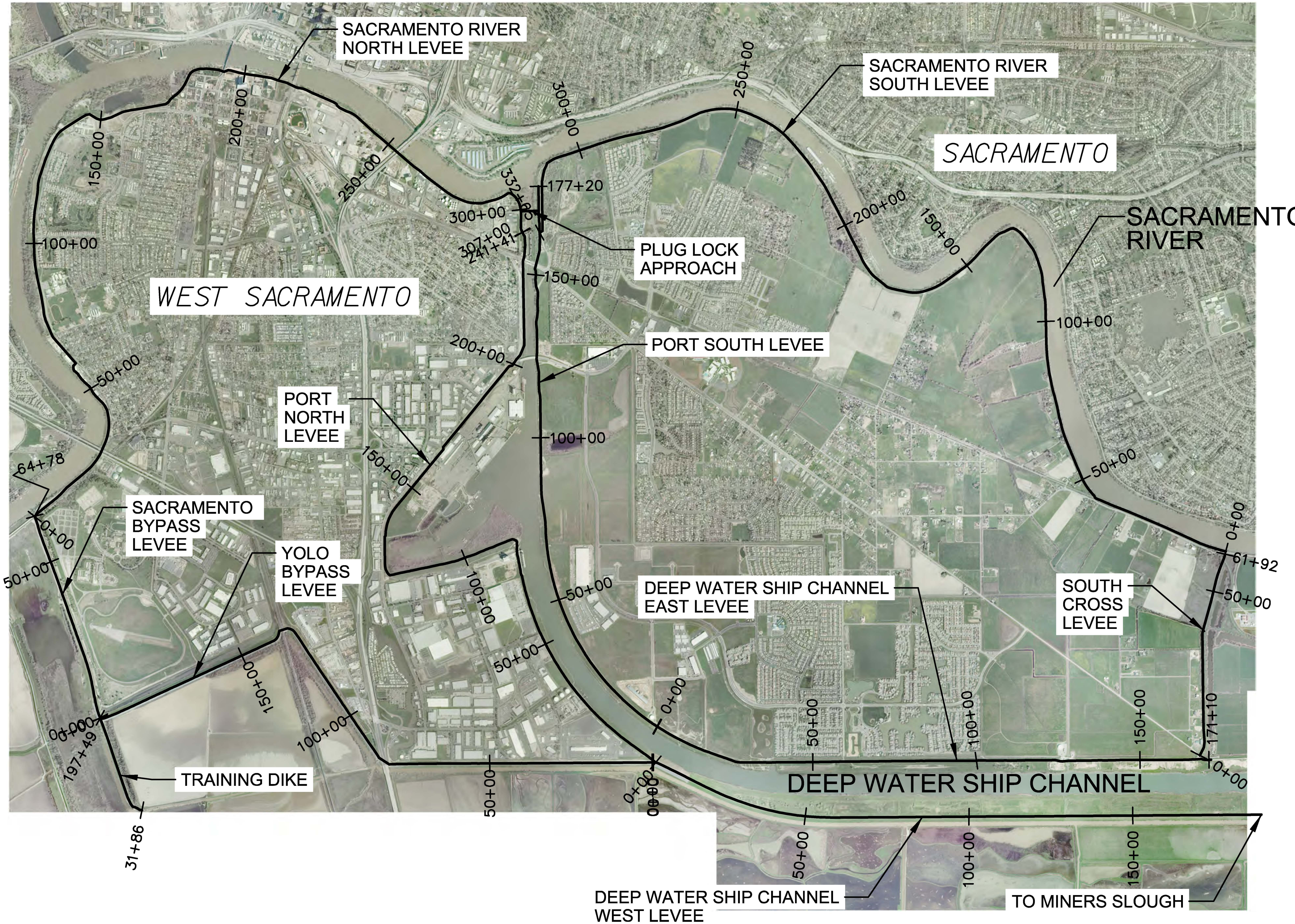


Figure 1: Project Location



YOLO COUNTY, CALIFORNIA
WEST SACRAMENTO PROJECT
GENERAL REEVALUATION REPORT
FLOOD RISK MANAGEMENT PROJECT

PROJECT LEVEE ALIGNMENTS

FIGURE 2 THE EXISTING LEVEES

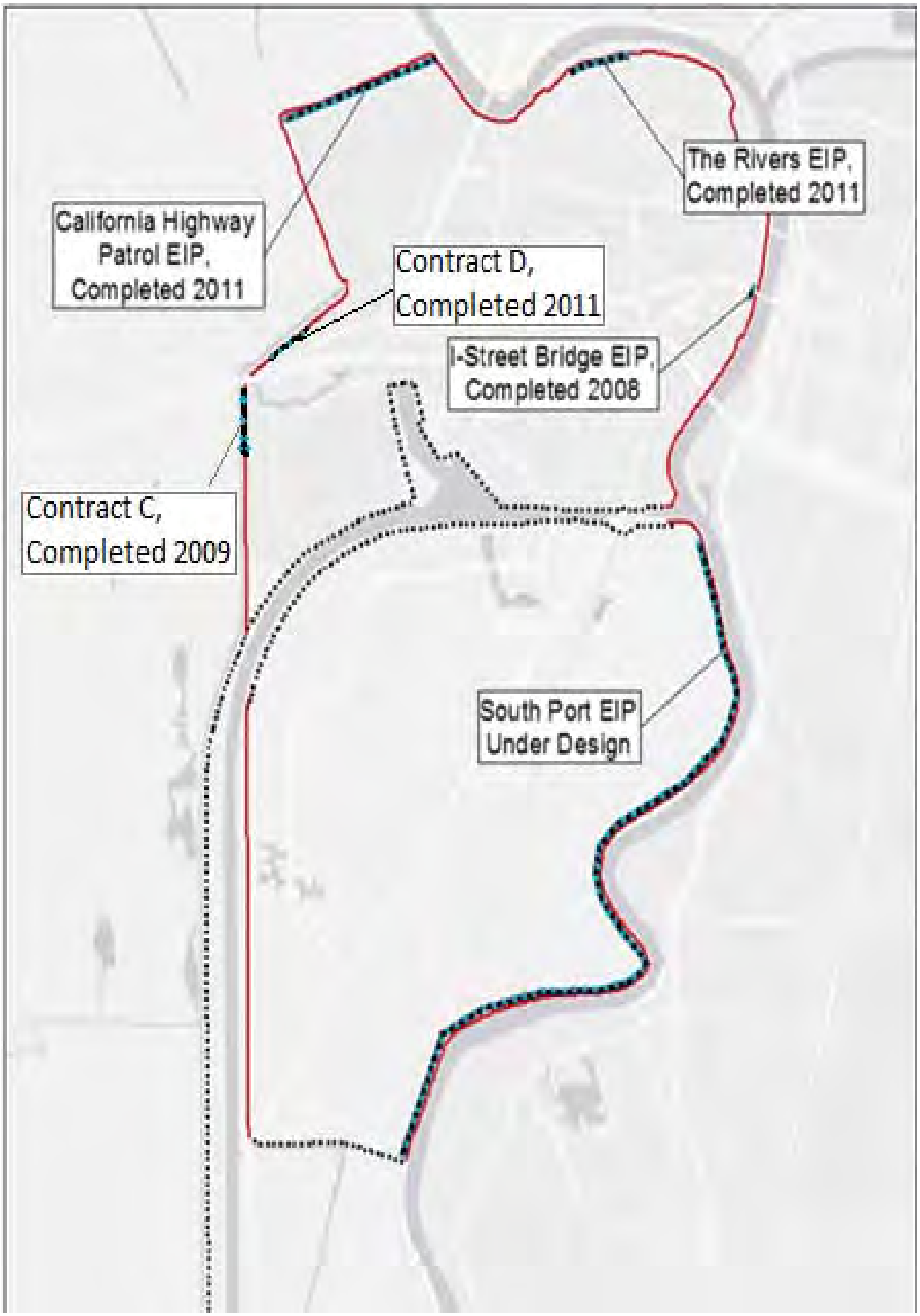
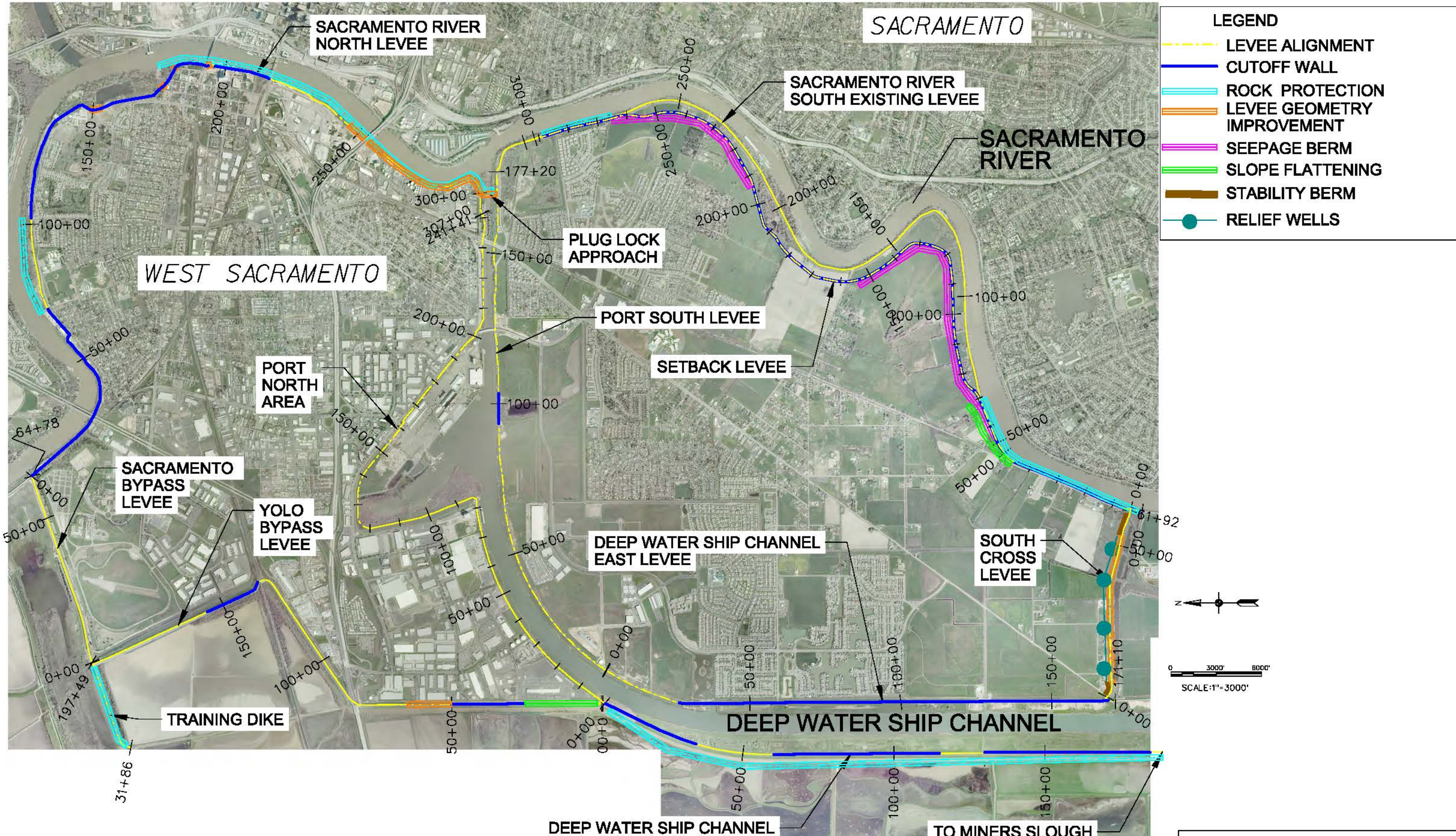


Figure 3: Early Implementation Project Locations



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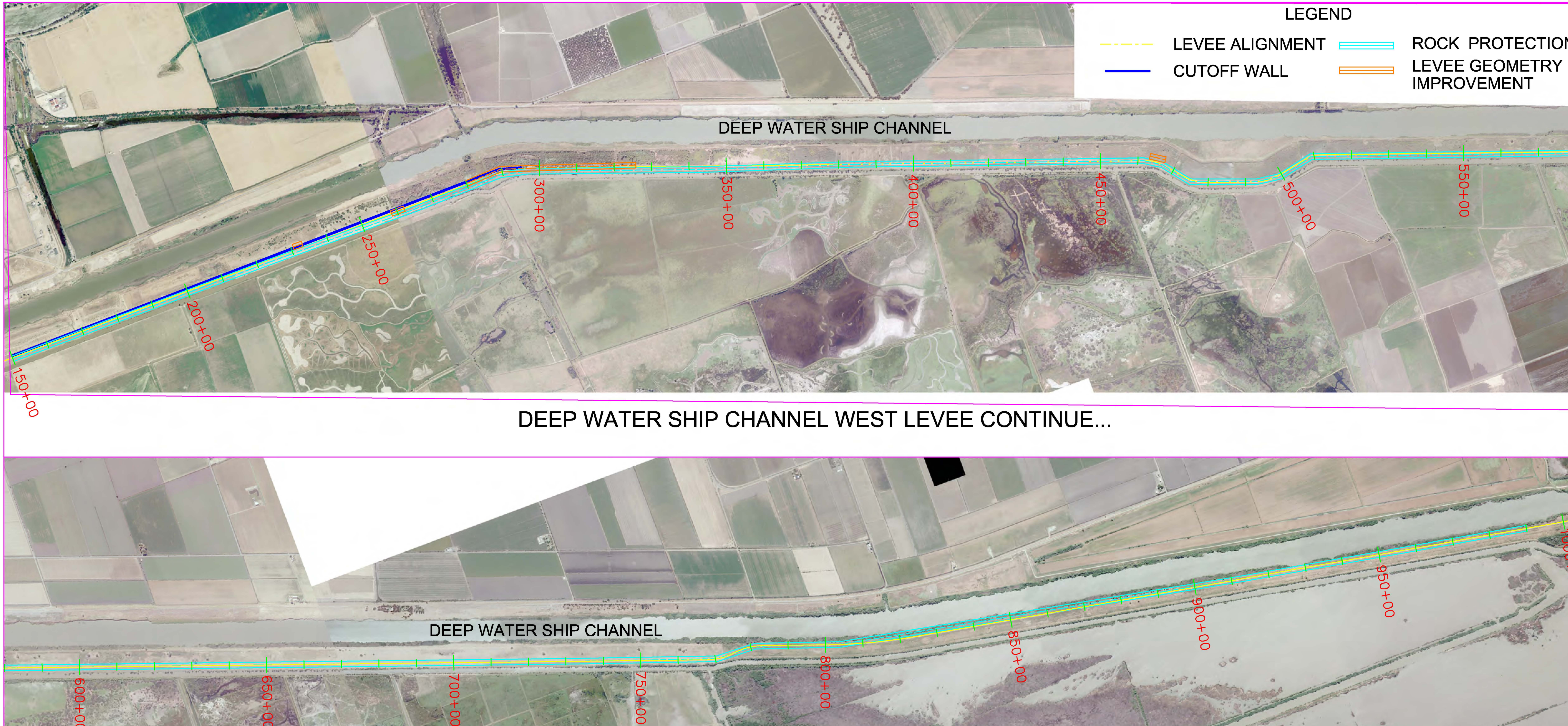
ALTERNATIVE 5

FIGURE 4 - Recommended Plan



DEEP WATER SHIP CHANNEL WEST LEVEE CONTINUE...

N

0 2500' 5000'

SCALE:1''=2500'

YOLO COUNTY, CALIFORNIA
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FLOOD RISK MANAGEMENT PROJECT
ALTERNATIVE 5

FIGURE 4A - Recommended Plan

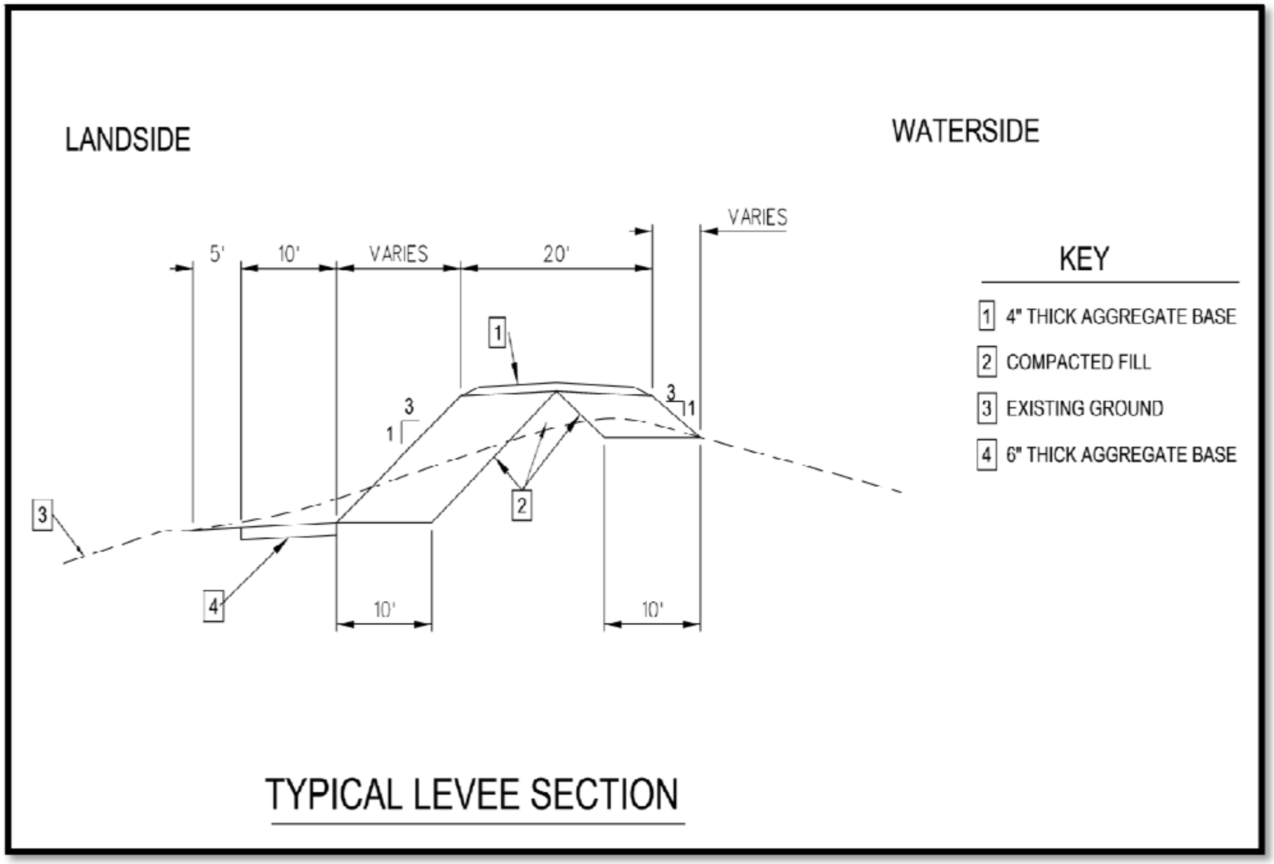


Figure 5: Typical Embankment Fill

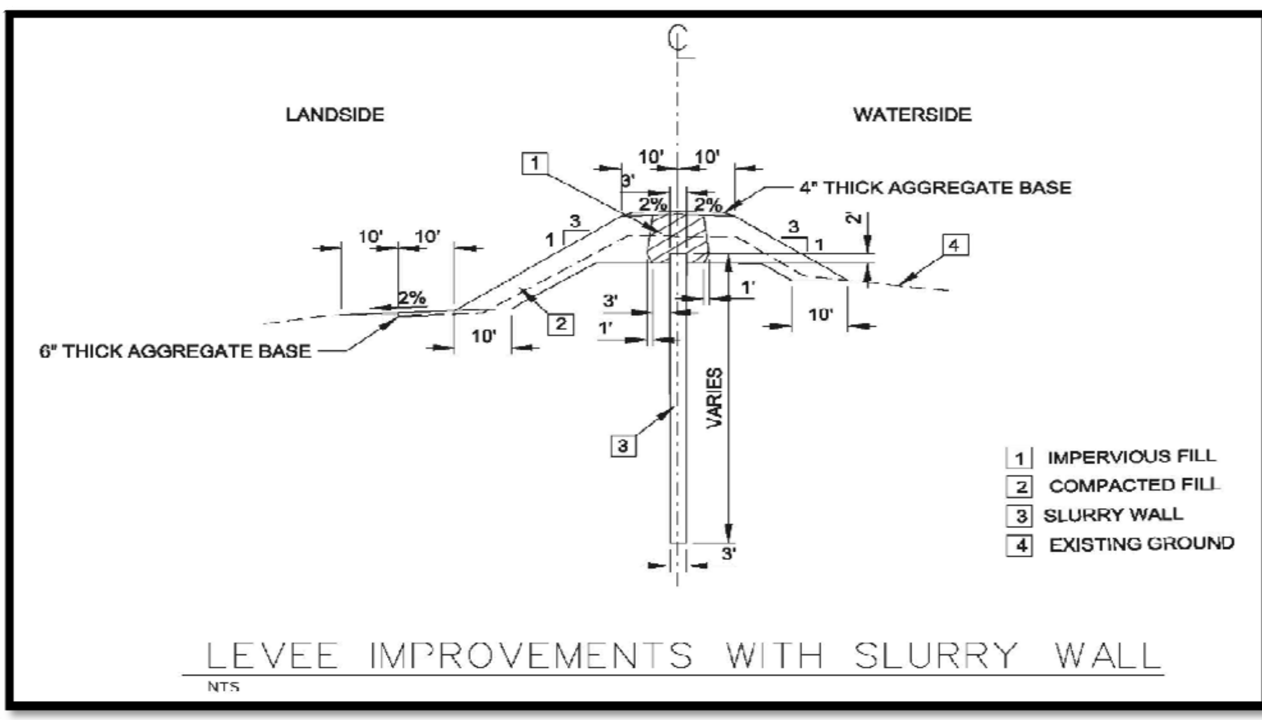


Figure 6: Levee Improvements with Cutoff Wall

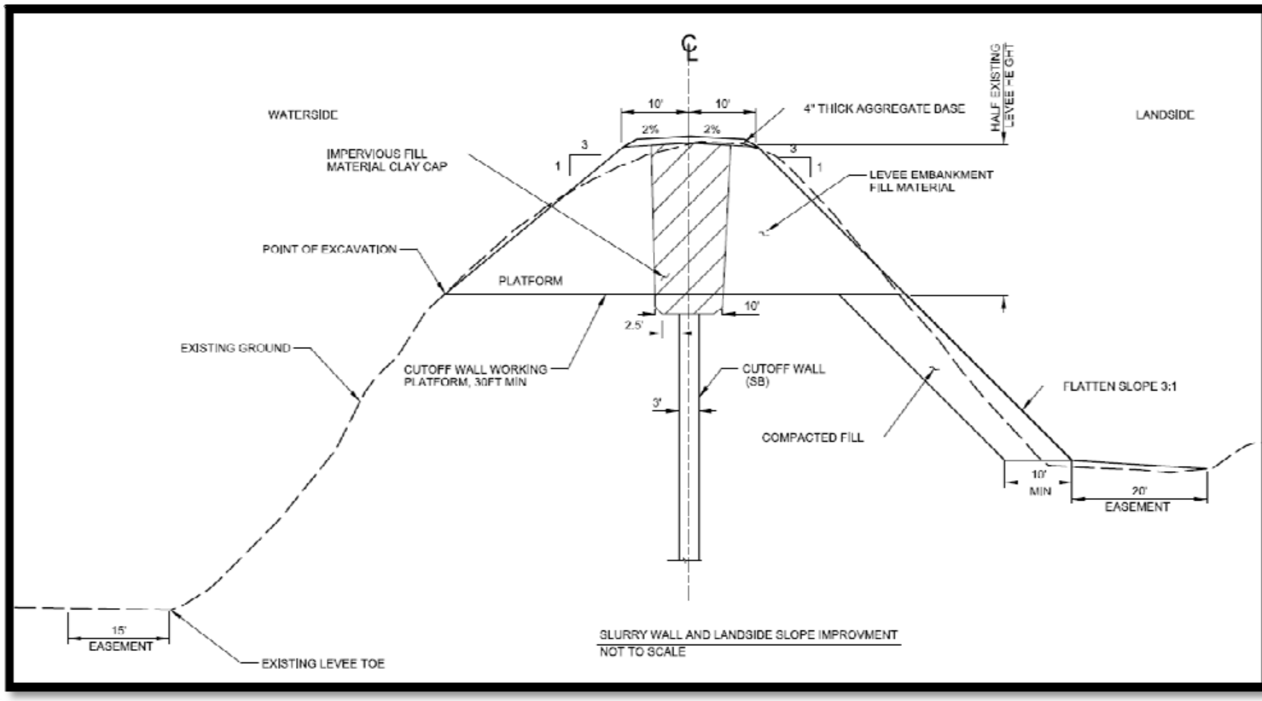


Figure 7: Cutoff Wall and Landside Slope Improvement

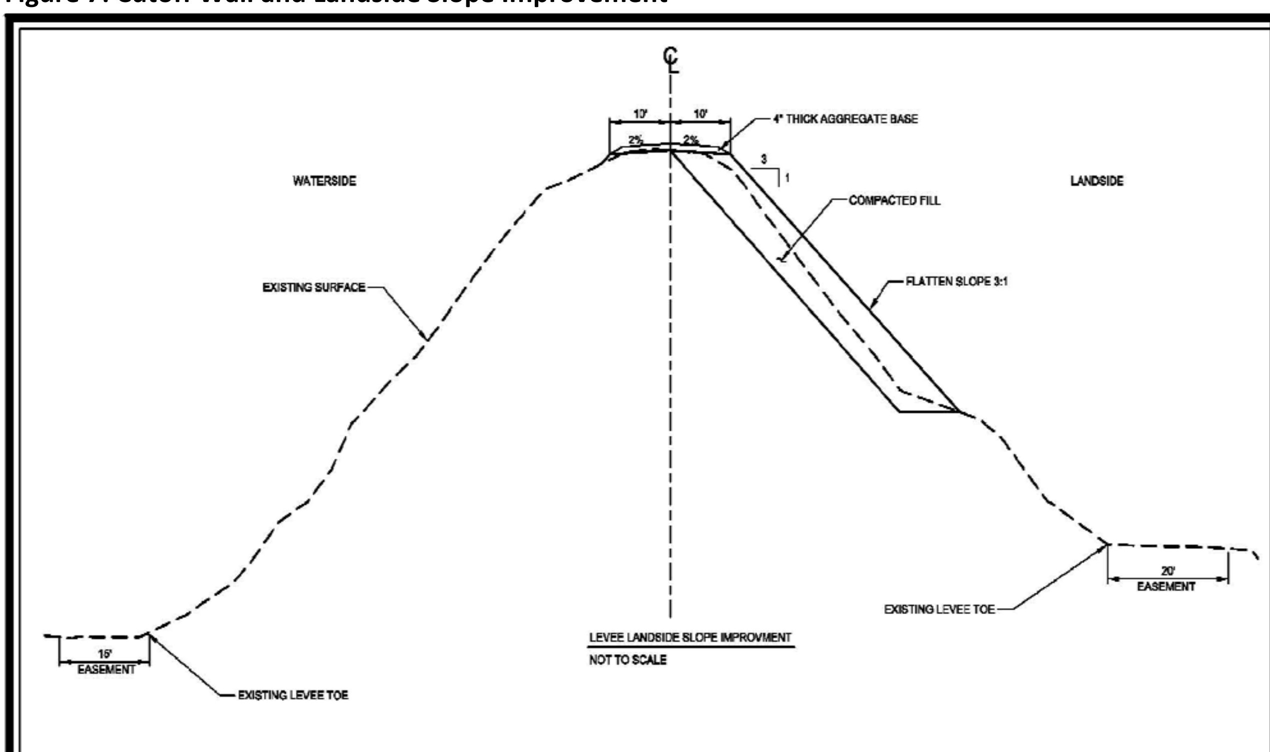


Figure 8: Levee Landside Slope Improvement

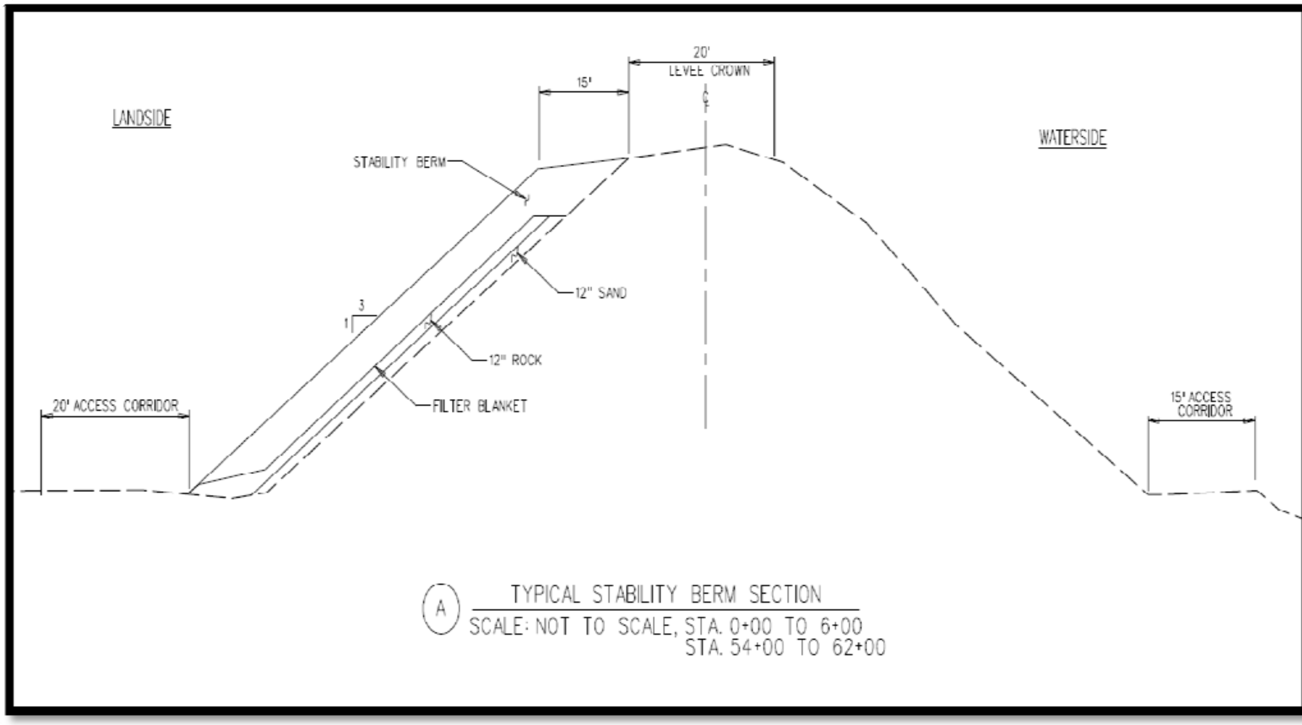


Figure 9: Embankment Fill and Stability Berm

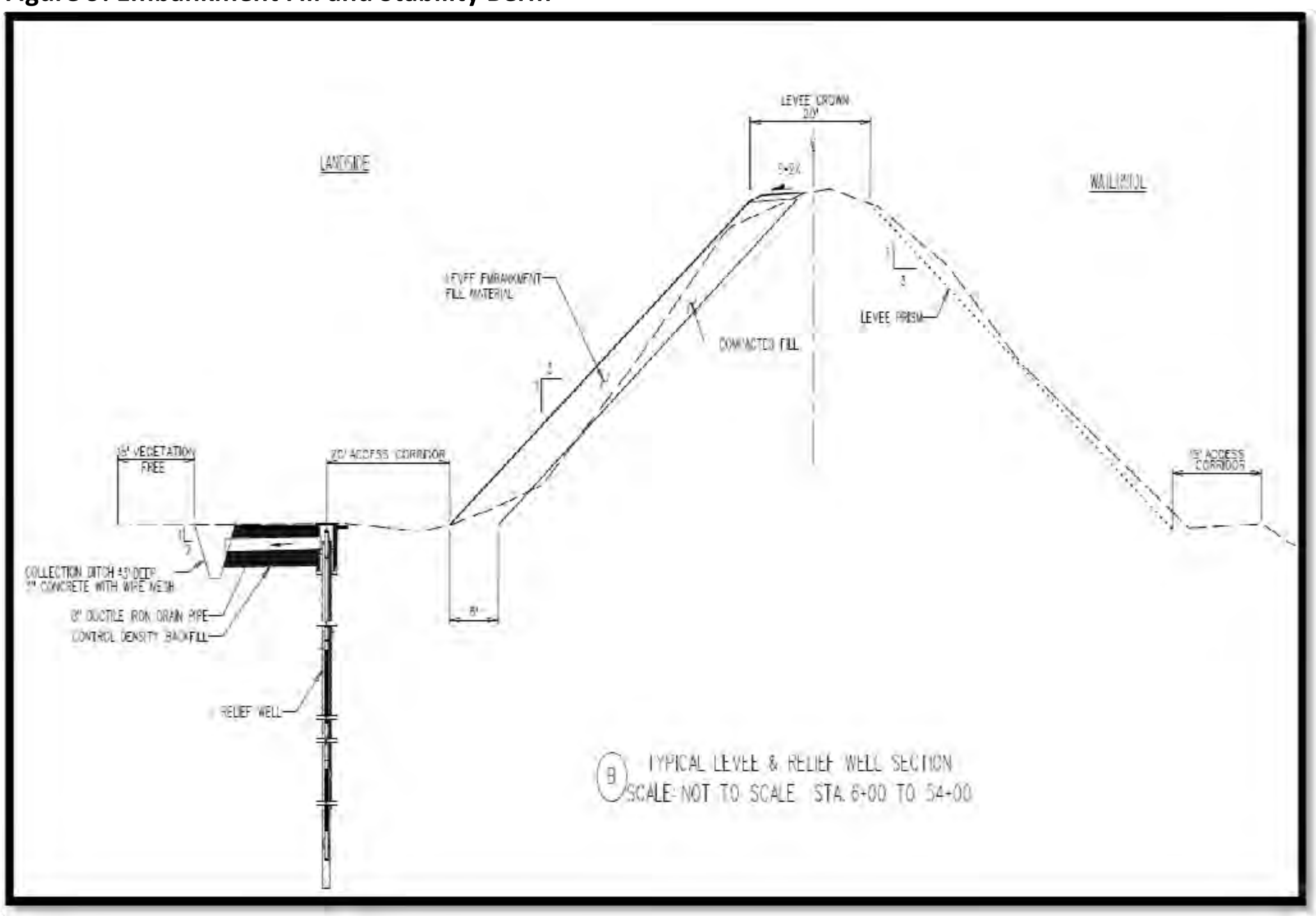


Figure 10: Embankment Fill & Relief Well

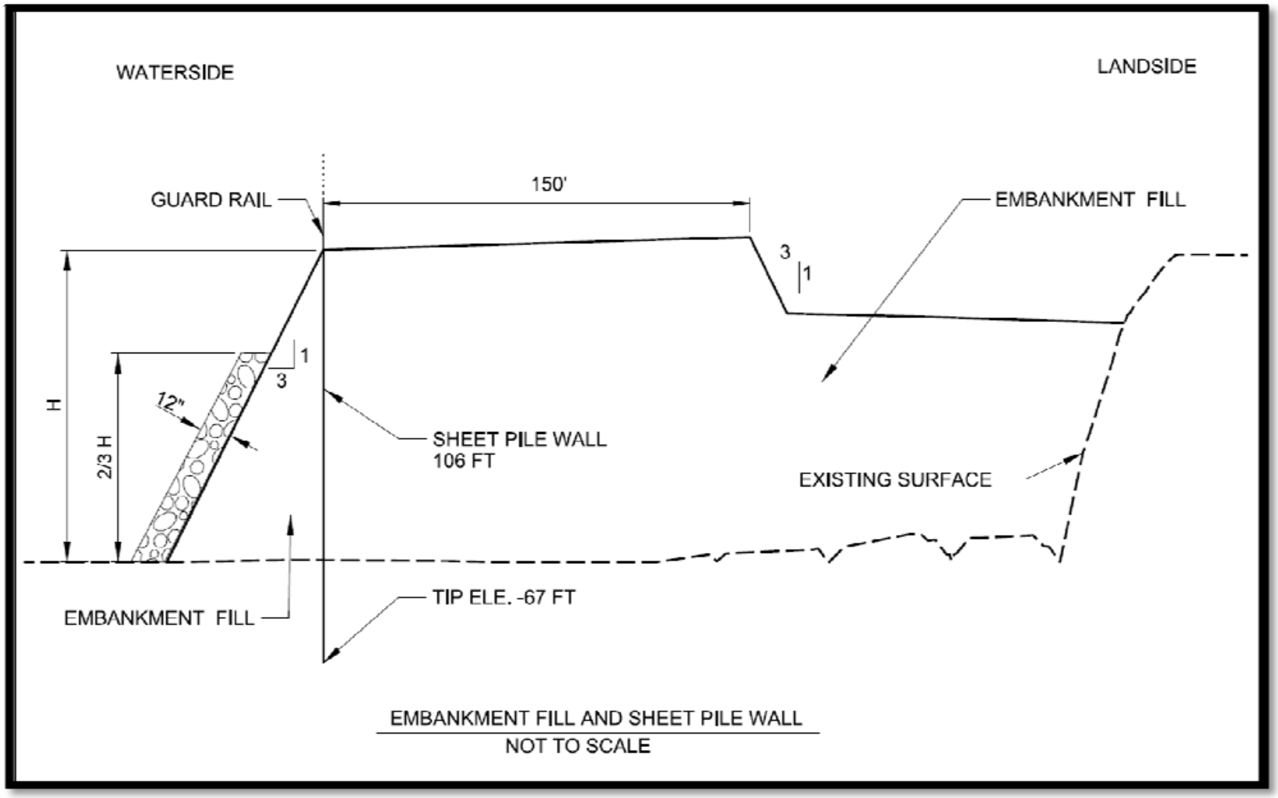


Figure 11: Embankment Fill and Sheet Pile Wall

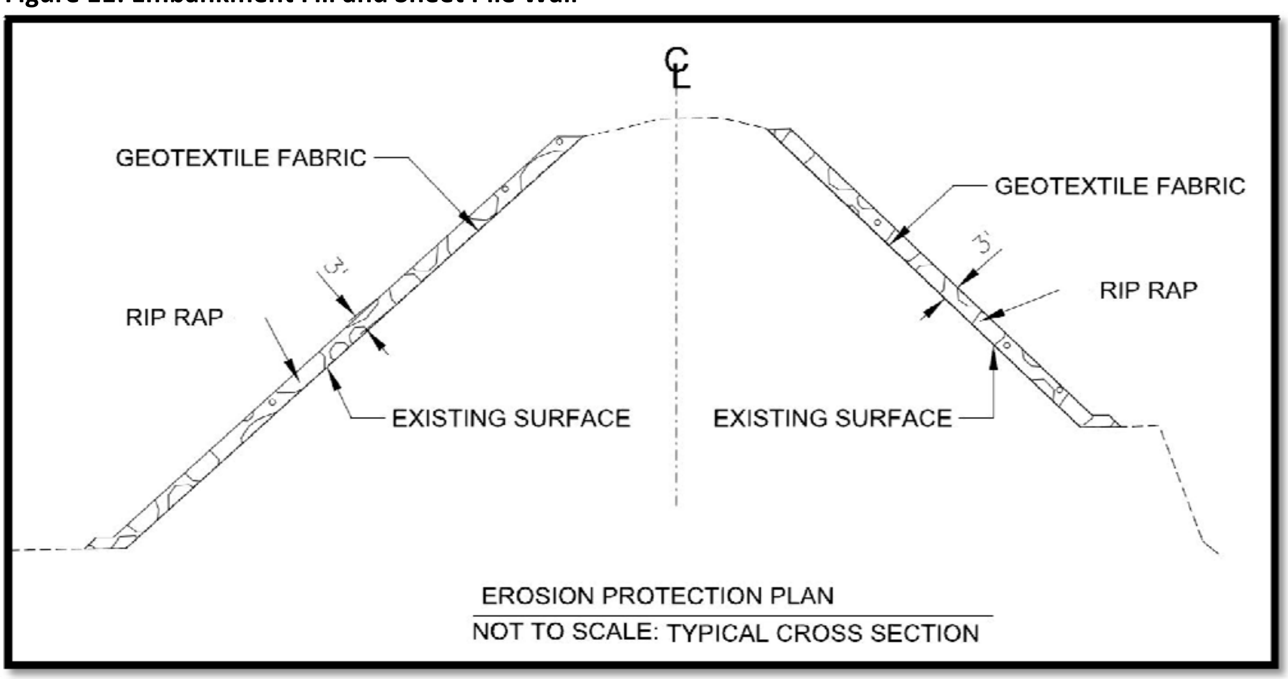


Figure 12: Erosion Protection Plan

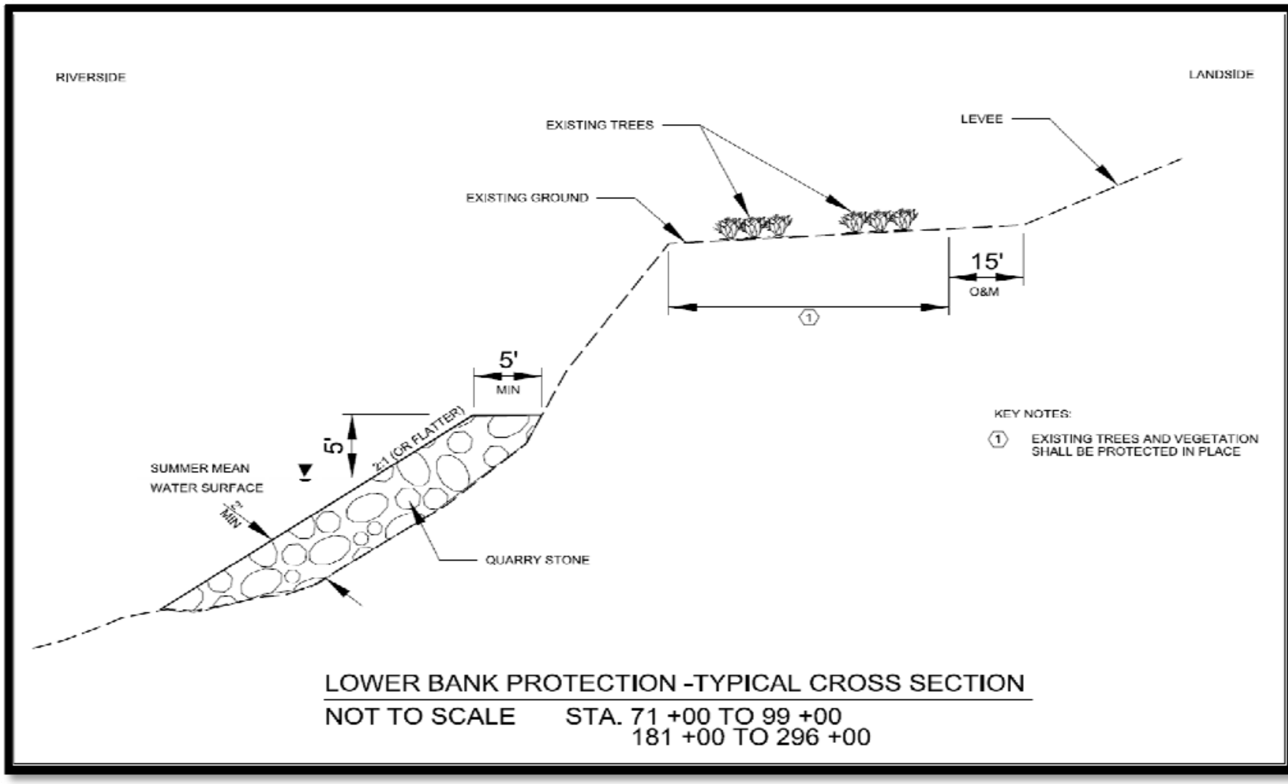


Figure 13: Bank Erosion Protection

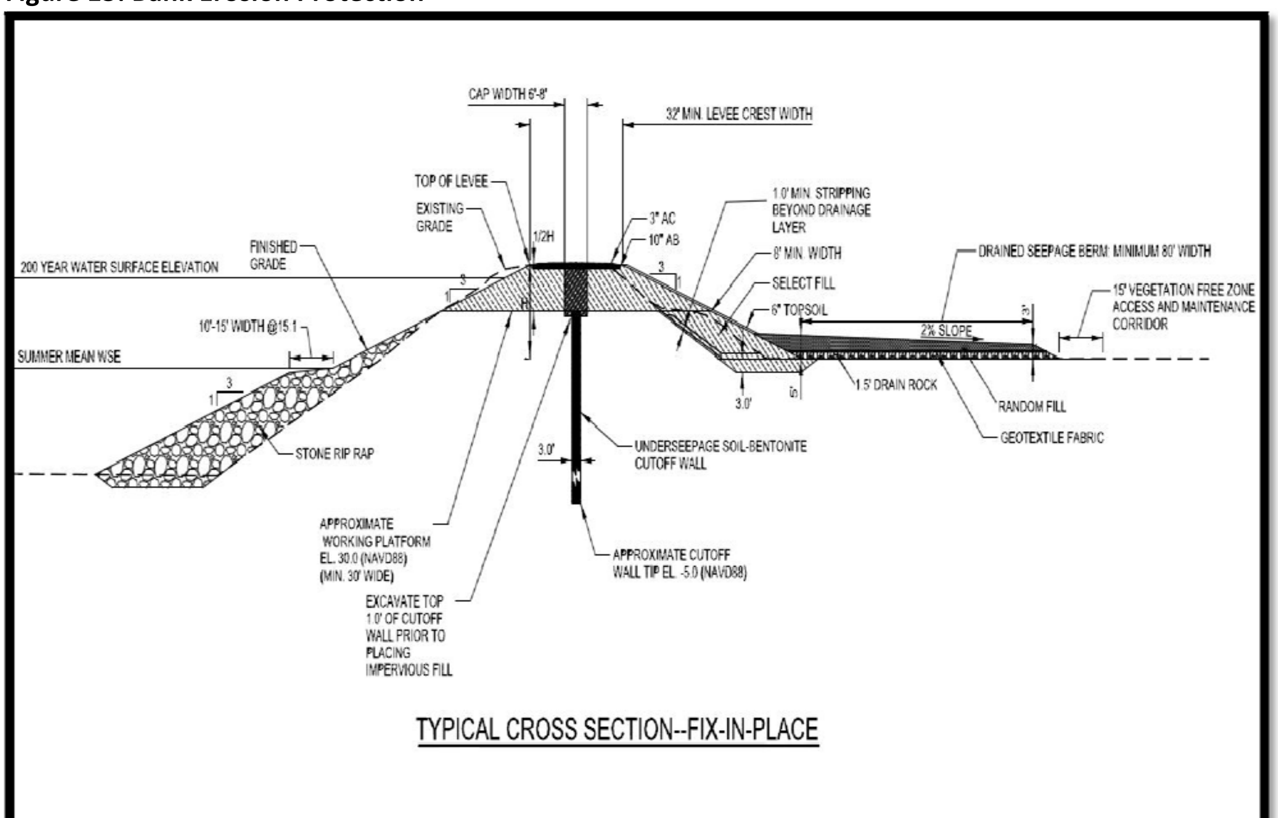


Figure 14: Typical Cross Section Fix-in-Place

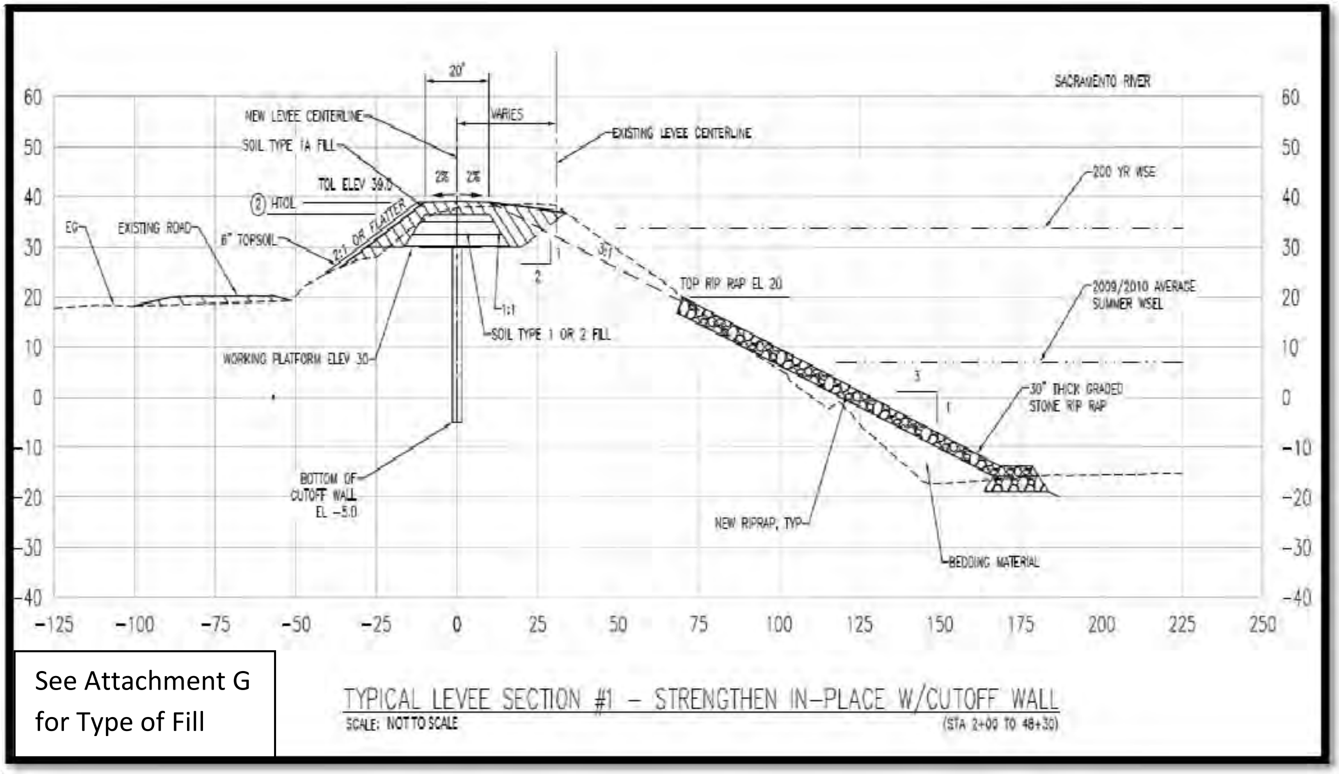


Figure 15: Typical Cross Section Strengthen In-Place with Cutoff wall

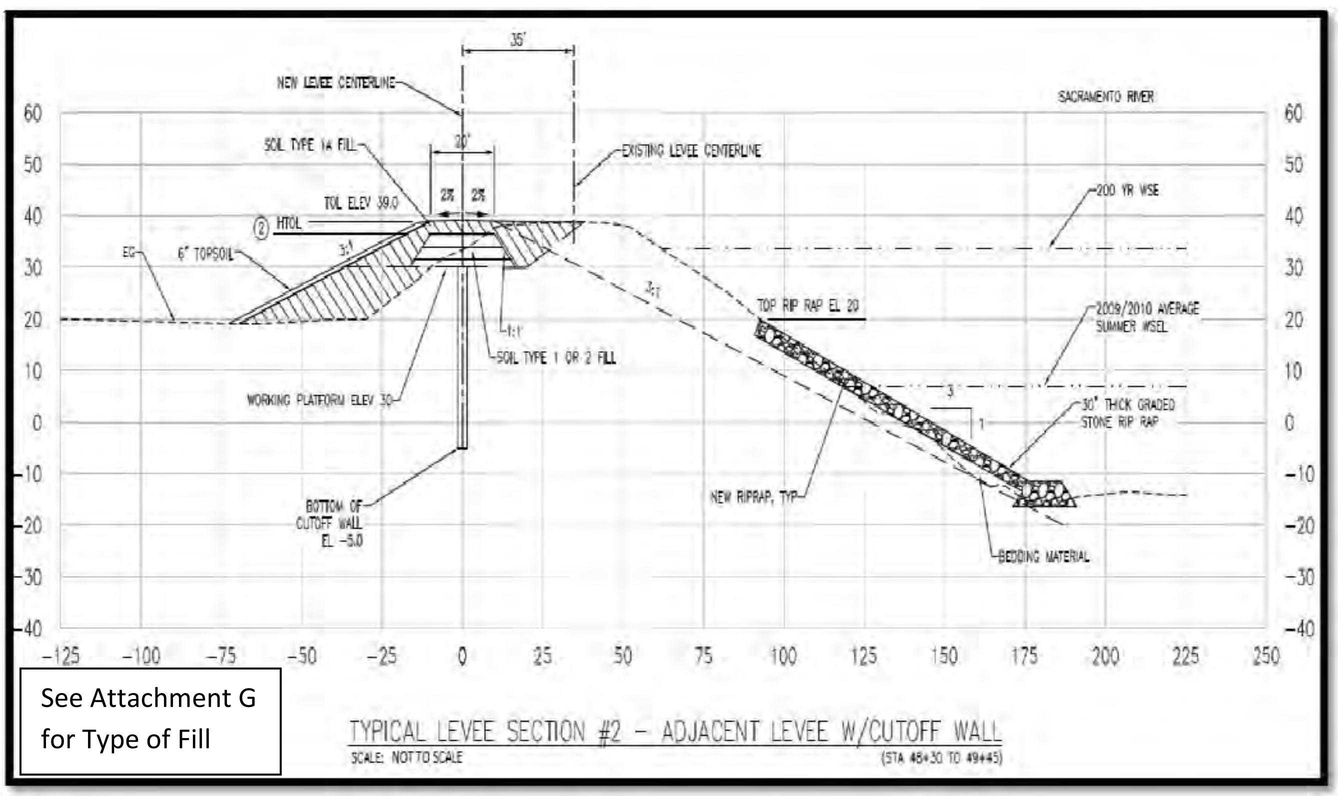


Figure 16: Typical Cross Section – Adjacent Levee with Cutoff Wall

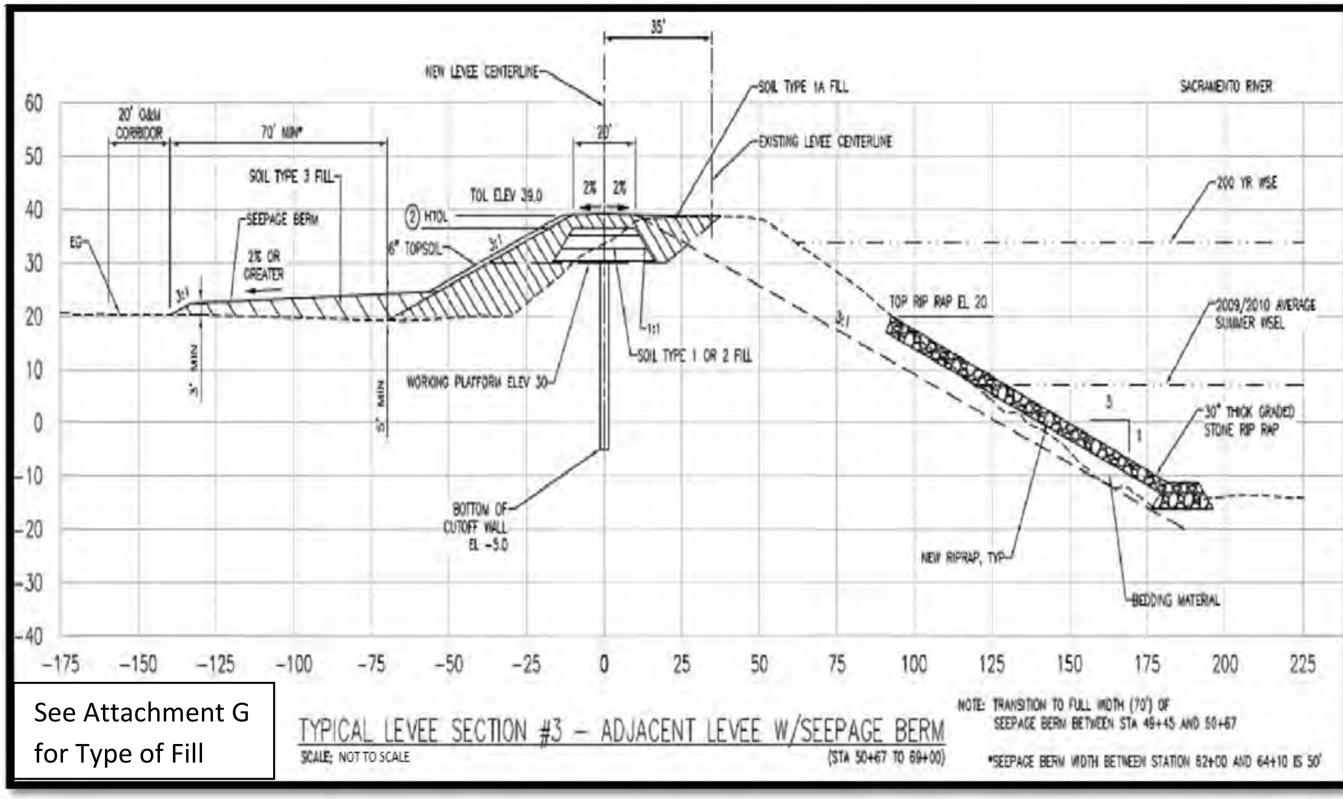


Figure 17: Adjacent Levee with Seepage Berm

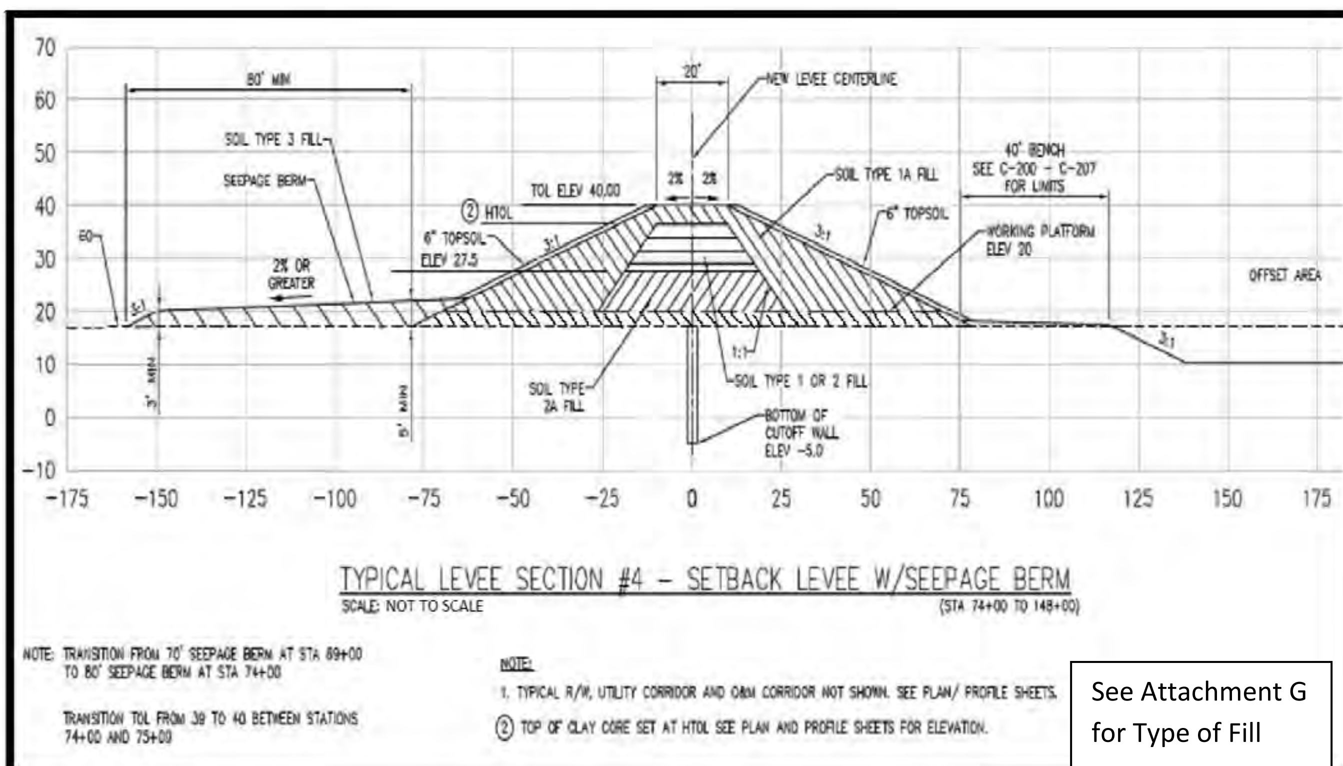


Figure 18: Setback Levee with Seepage Berm

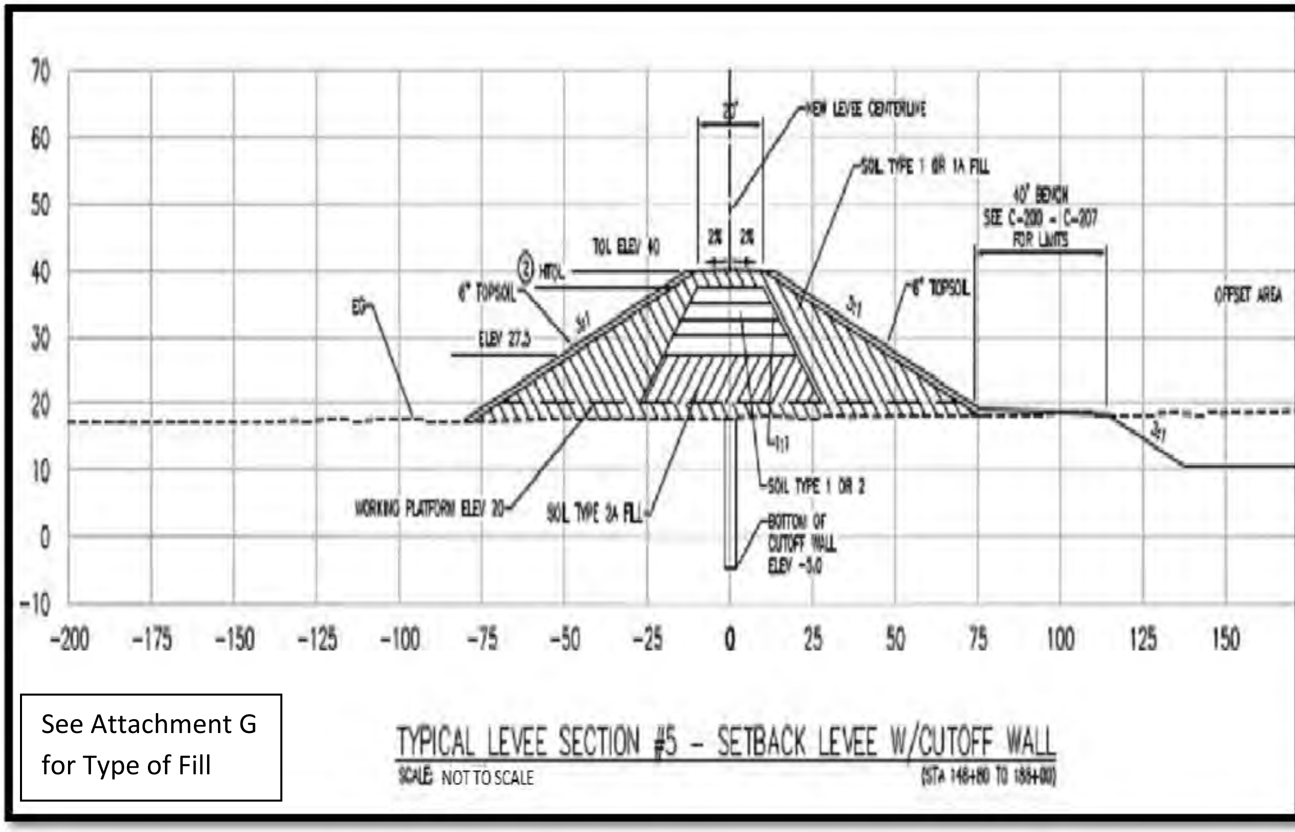


Figure 19: Setback Levee with Cutoff Wall

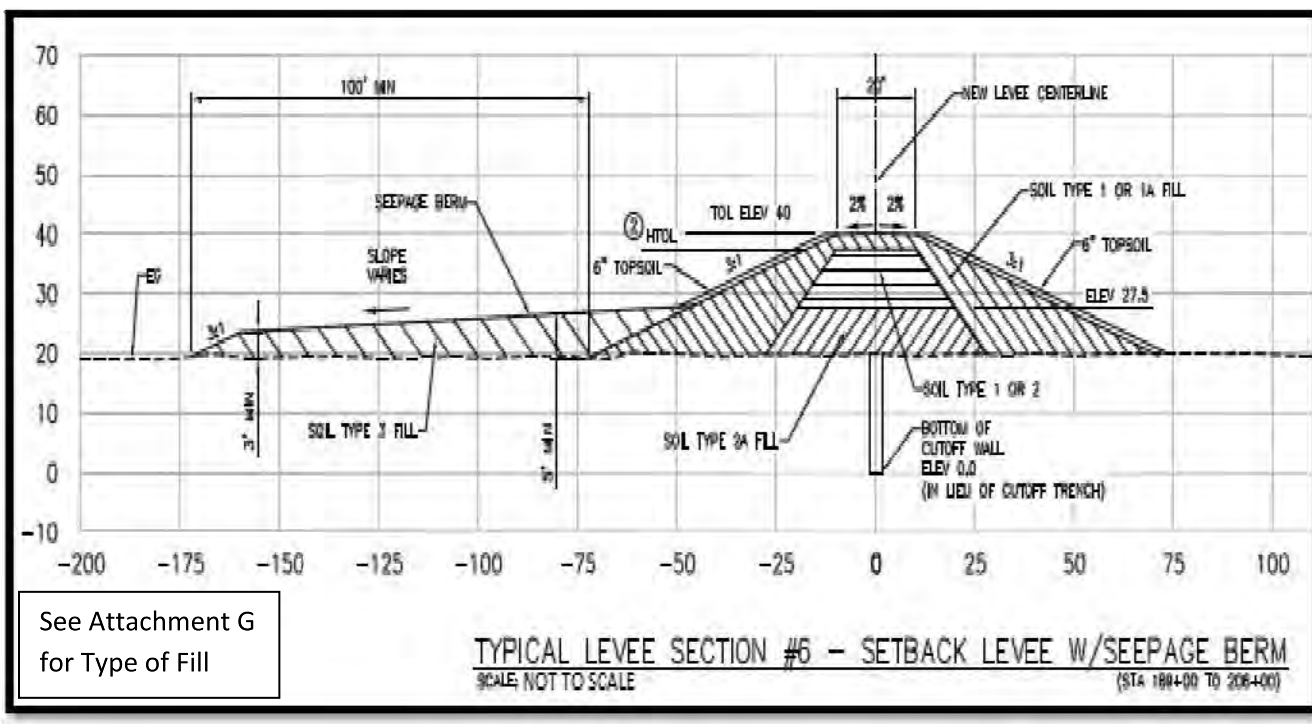


Figure 20: Setback Levee with Seepage Berm

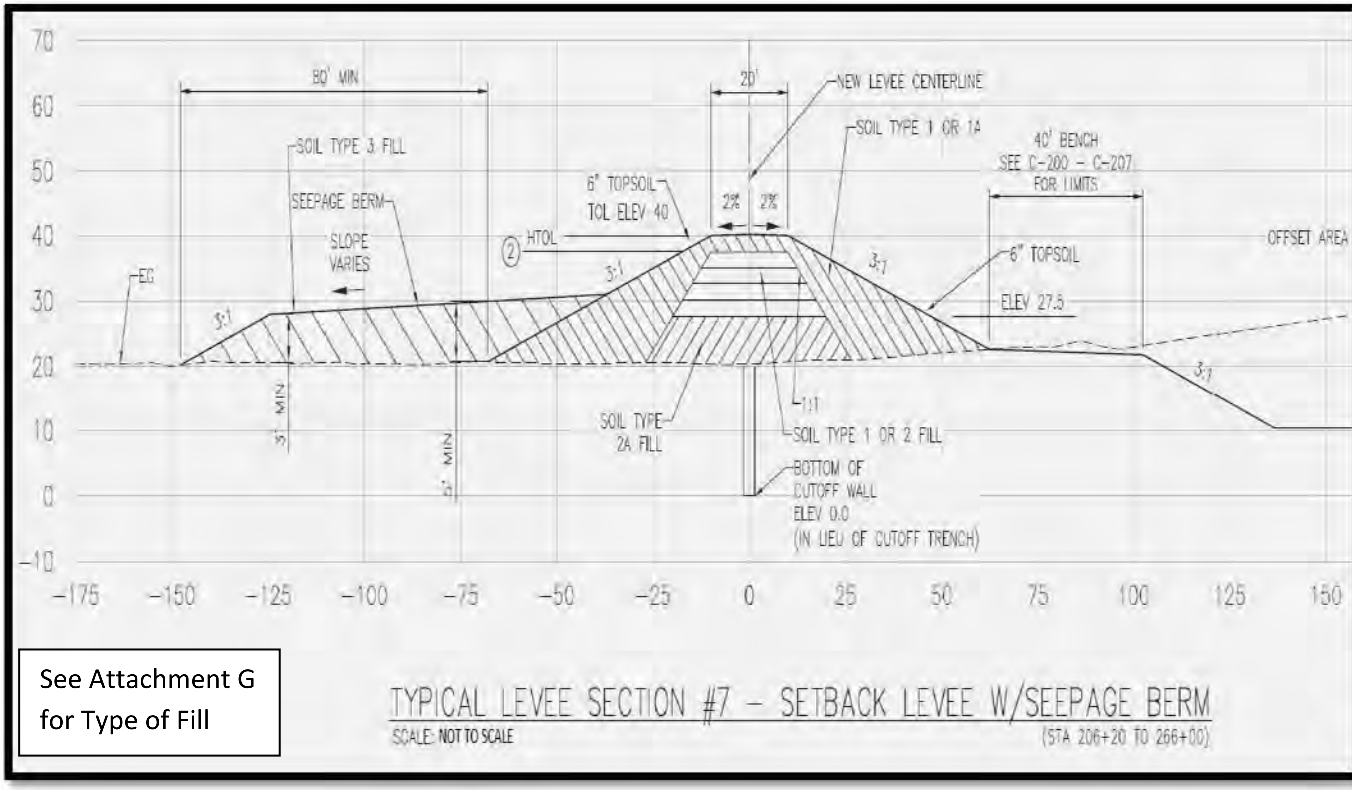


Figure 21: Setback Levee with Seepage Berm

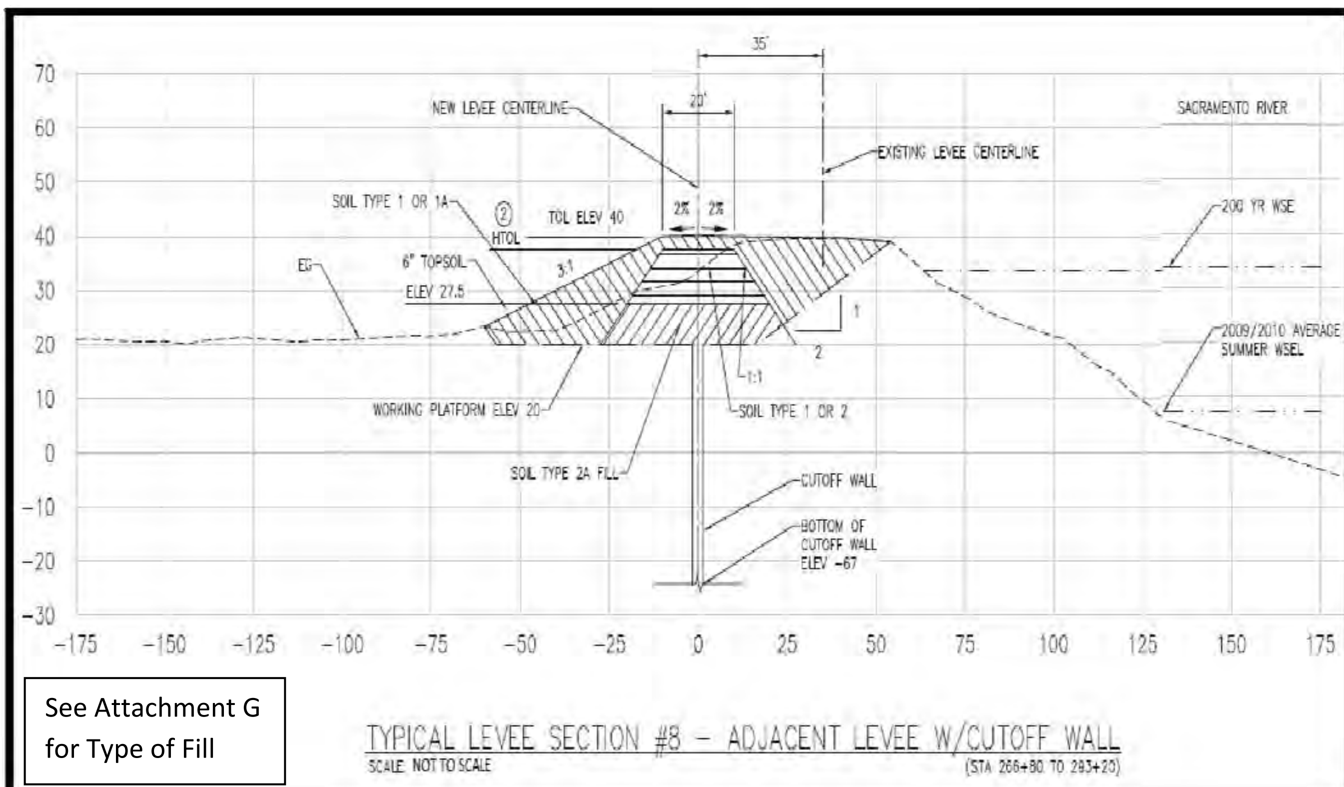
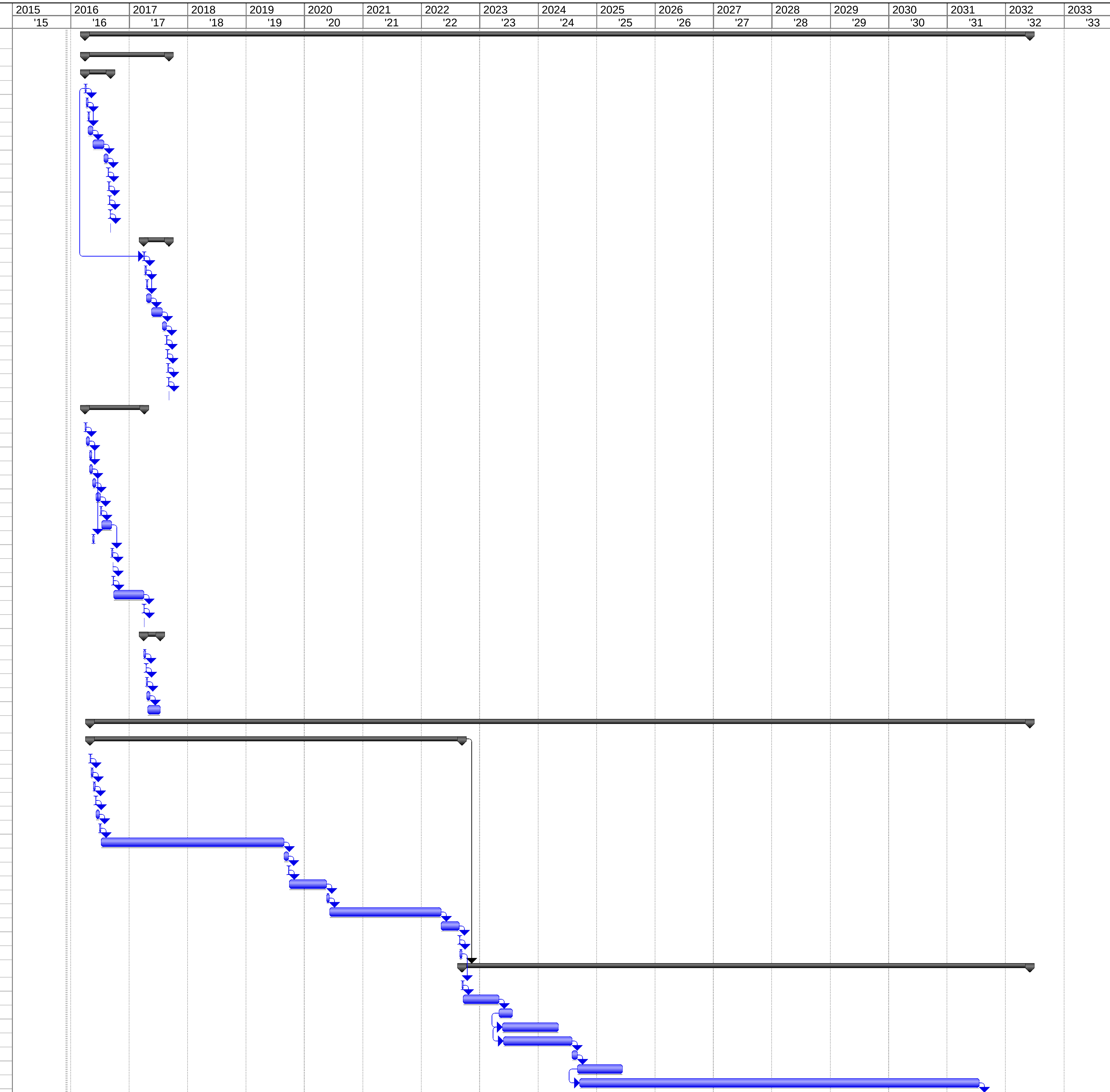


Figure 22: Adjacent Levee with Cutoff Wall

ID	Task Name	Duration	Start	Finish	Predecessors
1	**West Sacramento GRR**	**1813 days?**	**Fri 4/1/16**	**Wed 6/2/32**	
2	**Yolo Bypass - North**	**245 days**	**Fri 4/1/16**	**Thu 9/7/17**	
3	**Year 1**	**114 days**	**Fri 4/1/16**	**Wed 9/7/16**	
4	Staging area	5 days	Fri 4/1/16	Thu 4/7/16	
5	Mobilization	8 days	Fri 4/8/16	Tue 4/19/16	4
6	Set up Batch Plant	6 days	Wed 4/20/16	Wed 4/27/16	5
7	Degrade Levee	22 days	Wed 4/20/16	Thu 5/19/16	5
8	Deep Soil Mix installation	49 days	Fri 5/20/16	Wed 7/27/16	7
9	Import/replace levee to final grad	18 days	Thu 7/28/16	Mon 8/22/16	8
10	Final grade slopes	3 days	Tue 8/23/16	Thu 8/25/16	9
11	Restore Rip Rap	3 days	Fri 8/26/16	Tue 8/30/16	10
12	Place Aggregate Base @ Levee crown	3 days	Wed 8/31/16	Fri 9/2/16	11
13	Restore staging area	2 days	Mon 9/5/16	Tue 9/6/16	12
14	Hydroseed project	1 day	Wed 9/7/16	Wed 9/7/16	13
15	**Year 2**	**114 days**	**Mon 4/3/17**	**Thu 9/7/17**	
16	Staging area	5 days	Mon 4/3/17	Fri 4/7/17	4SS+365 edays
17	Mobilization	8 days	Mon 4/10/17	Wed 4/19/17	16
18	Set up Batch Plant	6 days	Thu 4/20/17	Thu 4/27/17	17
19	Degrade Levee	22 days	Thu 4/20/17	Fri 5/19/17	17
20	Deep Soil Mix installation	49 days	Mon 5/22/17	Thu 7/27/17	19
21	Import/replace levee to final grad	18 days	Fri 7/28/17	Tue 8/22/17	20
22	Final grade slopes	3 days	Wed 8/23/17	Fri 8/25/17	21
23	Restore Rip Rap	3 days	Mon 8/28/17	Wed 8/30/17	22
24	Place Aggregate Base @ Levee crown	3 days	Thu 8/31/17	Mon 9/4/17	23
25	Restore staging area	2 days	Tue 9/5/17	Wed 9/6/17	24
26	Hydroseed project	1 day	Thu 9/7/17	Thu 9/7/17	25
27	**Yolo Bypass - South**	**135 days?**	**Fri 4/1/16**	**Thu 4/6/17**	
28	Staging area	5 days	Fri 4/1/16	Thu 4/7/16	
29	Mobilization	15 days	Fri 4/8/16	Thu 4/28/16	28
30	Set up Batch Plant	10 days	Fri 4/29/16	Thu 5/12/16	29
31	Strip Grass	13 days	Fri 4/29/16	Tue 5/17/16	29
32	Degrade Levee	15 days	Wed 5/18/16	Tue 6/7/16	31
33	Slurry Wall	20 days	Wed 6/8/16	Tue 7/5/16	32
34	Import clay material	6 days	Wed 7/6/16	Wed 7/13/16	33
35	Import/replace levee to final grad	44 days	Thu 7/14/16	Tue 9/13/16	34
36	Relocate waterline	7 days	Thu 5/19/16	Fri 5/27/16	31FS+1 day
37	Final grade slopes	6 days	Wed 9/14/16	Wed 9/21/16	35
38	Restore Rip Rap	1 day?	Thu 9/22/16	Thu 9/22/16	37
39	Place Aggregate Base @ Levee crown	2 days	Fri 9/23/16	Mon 9/26/16	38
40	Remove batch plant	5 days	Tue 9/27/16	Mon 4/3/17	39
41	Restore staging area	2 days	Tue 4/4/17	Wed 4/5/17	40
42	Hydroseed project	1 day	Thu 4/6/17	Thu 4/6/17	41
43	**Training Dike**	**75 days**	**Mon 4/3/17**	**Fri 7/14/17**	
44	Mobilization	10 days	Mon 4/3/17	Fri 4/14/17	
45	Staging area	2 days	Mon 4/17/17	Tue 4/18/17	44
46	Tree Removal	6 days	Wed 4/19/17	Wed 4/26/17	45
47	Clearing / Export	15 days	Fri 4/21/17	Thu 5/11/17	46FS-4 days
48	Rip Rap	56 days	Fri 4/28/17	Fri 7/14/17	47FS-10 days
49	**DWSC - West**	**1792 days**	**Mon 5/2/16**	**Wed 6/2/32**	
50	**DWSC - West Sta 0+00 to 123+00**	**773 days**	**Mon 5/2/16**	**Tue 9/13/22**	
51	Staging area	5 days	Mon 5/2/16	Fri 5/6/16	
52	Mobilization	10 days	Mon 5/9/16	Fri 5/20/16	51
53	Set up Batch Plant	10 days	Mon 5/23/16	Fri 6/3/16	52
54	Clearing	3 days	Mon 6/6/16	Wed 6/8/16	53
55	Strip Grass / Load / Export	15 days	Thu 6/9/16	Wed 6/29/16	54
56	Levee Degrade	7 days	Thu 6/30/16	Fri 7/8/16	55
57	DSM Slurry Wall	384 days	Mon 7/11/16	Tue 8/27/19	56
58	Embankment Fill	20 days	Wed 8/28/19	Tue 9/24/19	57
59	Empervious Fill	3 days	Wed 9/25/19	Fri 9/27/19	58
60	Finish Slopes	14 days	Mon 9/30/19	Tue 5/19/20	59
61	Replace striping on banks	13 days	Wed 5/20/20	Fri 6/5/20	60
62	Rip Rap	196 days	Mon 6/8/20	Thu 5/5/22	61
63	Place Aggregate base	81 days	Fri 5/6/22	Fri 8/26/22	62
64	Restore staging area	2 days	Mon 8/29/22	Tue 8/30/22	63
65	Hydroseed project	10 days	Wed 8/31/22	Tue 9/13/22	64
66	**DWSC - West Sta 123+00 to 1002+60**	**1019 days**	**Wed 9/14/22**	**Wed 6/2/32**	50
67	Staging area	5 days	Wed 9/14/22	Tue 9/20/22	65
68	Mobilization	10 days	Wed 9/21/22	Tue 5/2/23	67
69	Strip Grass	60 days	Wed 5/3/23	Tue 7/25/23	68
70	Export Strip	98 days	Wed 5/24/23	Tue 5/7/24	69SS+15 days
71	Embankment Fill	154 days	Wed 5/31/23	Wed 7/31/24	70SS+5 days
72	Impervioius Fill	24 days	Thu 8/1/24	Tue 9/3/24	71
73	Finish Slopes	50 days	Wed 9/4/24	Thu 6/12/25	72
74	Rip Rap	722 days	Wed 9/18/24	Mon 7/21/31	73SS+10 days
75	Place Aggregate base	42 days	Tue 7/22/31	Wed 9/17/31	74

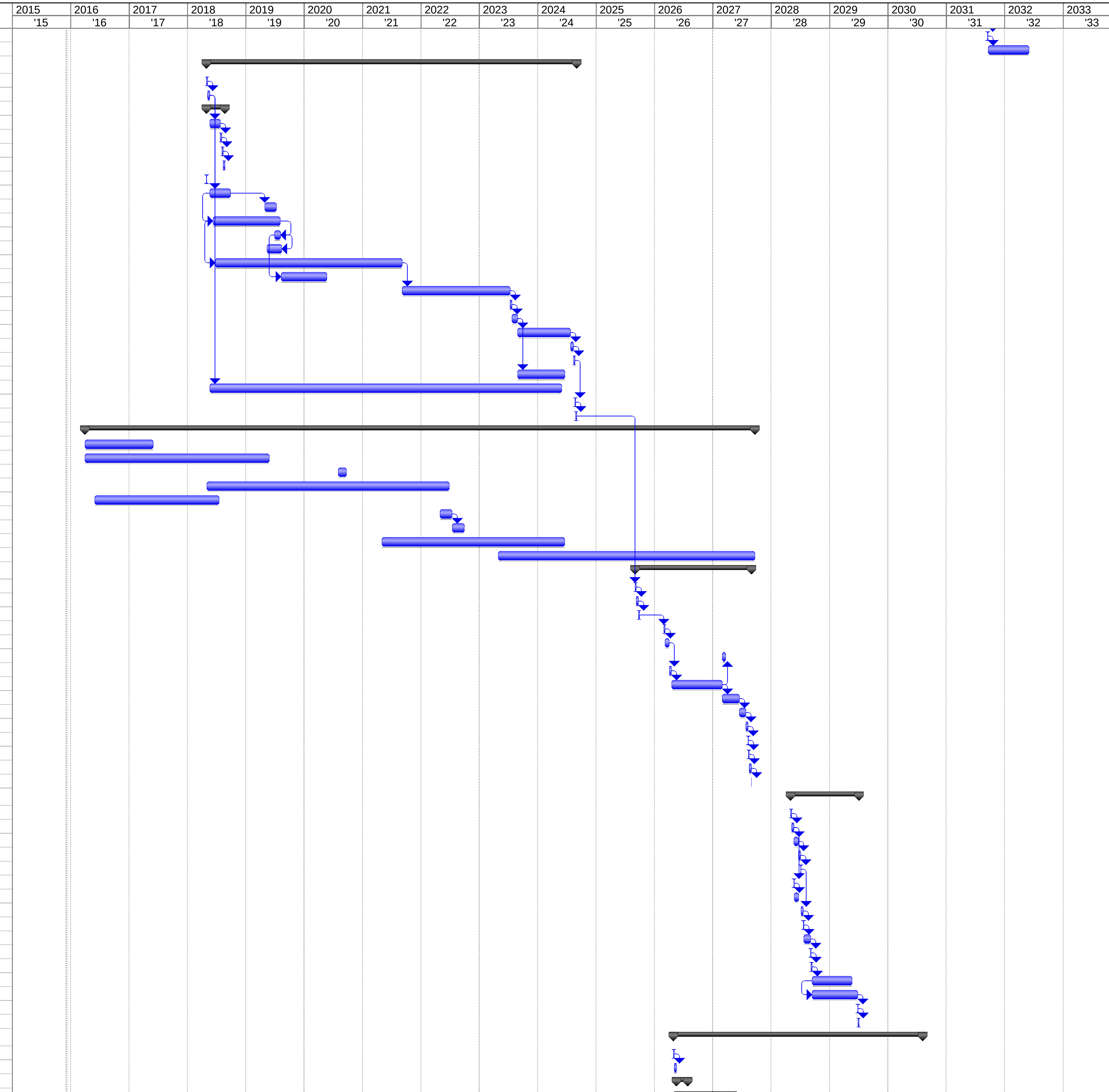


Project: W Sac GRR Const Sched - Al
Date: Thu 12/3/15

Task		Progress		Summary		External Tasks	
Split		Milestone		Project Summary		External Milestone	

Deadline

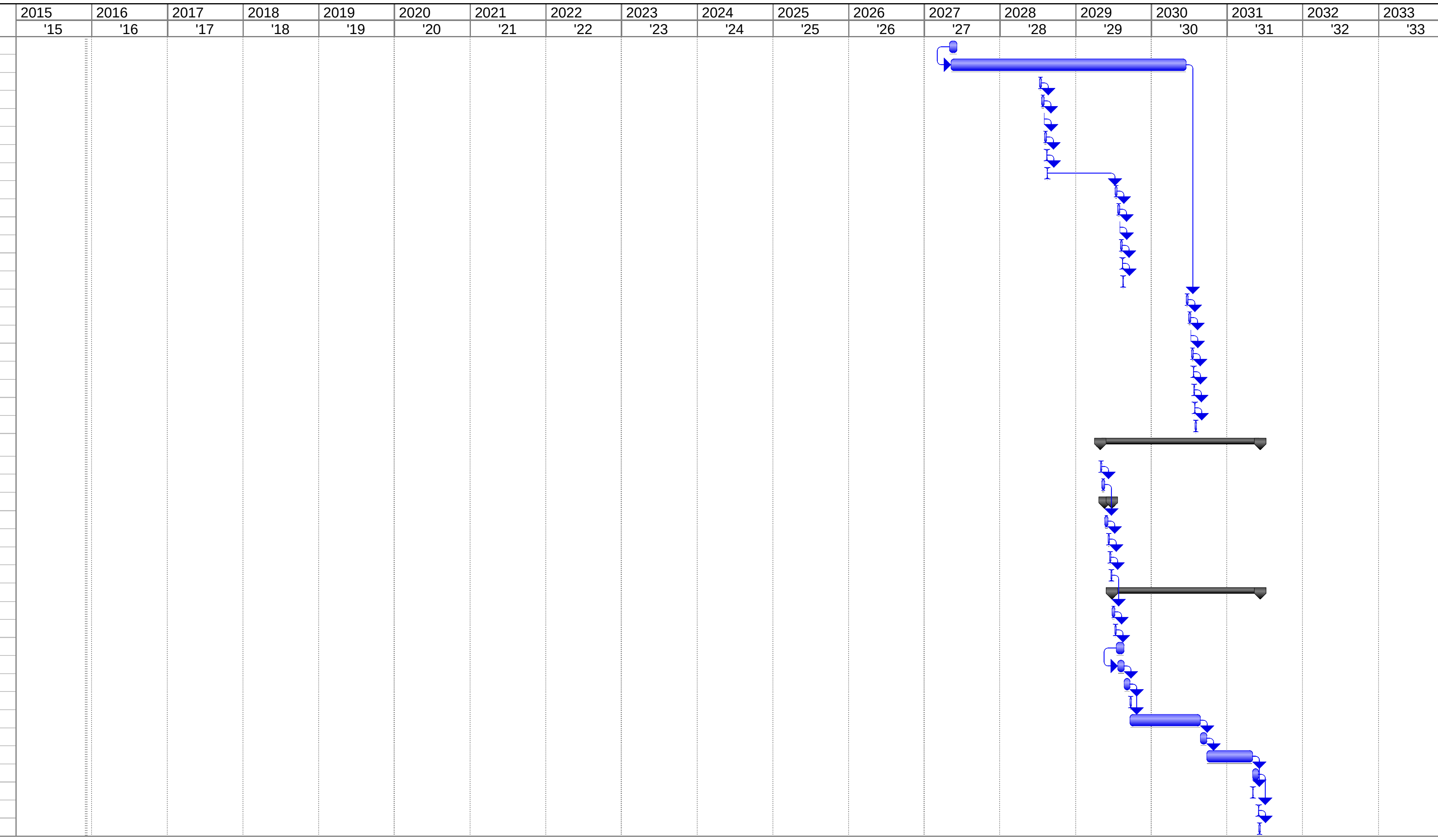
ID	Task Name	Duration	Start	Finish	Predecessors
76	Restore staging area	2 days	Thu 9/18/31	Fri 9/19/31	75
77	Hydroseed project	30 days	Mon 9/22/31	Wed 6/2/32	76
78	**Sac River - North**	**745 days**	**Tue 5/1/18**	**Mon 9/2/24**	
79	Staging area	5 days	Tue 5/1/18	Mon 5/7/18	
80	Mobilization	10 days	Tue 5/8/18	Mon 5/21/18	79
81	**Relocations**	**84 days**	**Tue 5/1/18**	**Fri 8/24/18**	
82	R & R Electrical poles a& conductors	48 days	Tue 5/22/18	Thu 7/26/18	80
83	R & R light poles	6 days	Fri 7/27/18	Fri 8/3/18	82
84	Pulverize AC	6 days	Mon 8/6/18	Mon 8/13/18	83
85	Move AB/AC to stockpile	9 days	Tue 8/14/18	Fri 8/24/18	84
86	Remove tiles	2 days	Tue 5/1/18	Wed 5/2/18	
87	Clear & Grub	94 days	Tue 5/22/18	Fri 9/28/18	80
88	Striping to stockpile	53 days	Wed 5/1/19	Fri 7/12/19	87
89	Degrade levee	148 days	Tue 6/12/18	Mon 8/5/19	87SS+15 days
90	Excavation, Inspection Trench	28 days	Mon 7/1/19	Wed 8/7/19	89FF+2 days
91	SCB Slurry Wall - Excavator	66 days	Wed 5/15/19	Wed 8/14/19	90FF+5 days
92	SCB Slurry Wall - DSM	378 days	Tue 6/26/18	Mon 9/6/21	89SS+10 days
93	Clay Cap	52 days	Mon 8/12/19	Fri 5/22/20	90SS+30 days
94	Import from stockpile	182 days	Tue 9/7/21	Thu 7/13/23	92
95	Random Fill from borrow pit	8 days	Fri 7/14/23	Tue 7/25/23	94
96	ABC - 4 t	25 days	Wed 7/26/23	Tue 8/29/23	95
97	Place reclaimed AB/AC back on levee road	85 days	Wed 8/30/23	Thu 7/25/24	96
98	Place new AB	13 days	Fri 7/26/24	Tue 8/13/24	97
99	Place new AC	7 days	Wed 8/14/24	Thu 8/22/24	98
100	Install new tiles	60 days	Wed 8/30/23	Thu 6/20/24	96
101	Place Rip Rap	664 days	Tue 5/22/18	Fri 5/31/24	80
102	Restore staging area	2 days	Fri 8/23/24	Mon 8/26/24	99
103	Hydroseed project	5 days	Tue 8/27/24	Mon 9/2/24	102
104	**Sac River - South**	**1347 days**	**Fri 4/1/16**	**Wed 9/22/27**	
105	Clearing	175 days	Fri 4/1/16	Thu 6/1/17	
106	Utility demo, relocation	390 days	Fri 4/1/16	Tue 5/28/19	
107	AC Demo	37 days	Mon 8/3/20	Tue 9/22/20	
108	Install slurry wall	474 days	Fri 5/4/18	Mon 6/27/22	
109	Road Relocation	275 days	Wed 6/1/16	Wed 7/18/18	
110	Erosion Repair Site C	55 days	Mon 5/2/22	Fri 7/15/22	
111	Erosion Repair Site G	55 days	Mon 7/18/22	Fri 9/30/22	110
112	Levee work	365 days	Mon 5/3/21	Wed 6/19/24	
113	Rip Rap (Waterside Placement)	540 days	Mon 5/1/23	Wed 9/22/27	
114	**Lock Closure Levee**	**306 days?**	**Wed 9/3/25**	**Wed 9/1/27**	
115	Staging area	5 days	Wed 9/3/25	Tue 9/9/25	103
116	Mobilization	10 days	Wed 9/10/25	Tue 9/23/25	115
117	Clearing	5 days	Wed 9/24/25	Tue 9/30/25	116
118	Tree Removal	6 days	Mon 3/2/26	Mon 3/9/26	117
119	Install Temporary Coffer Dam	19 days	Tue 3/10/26	Fri 4/3/26	118
120	Concrete Demo	15 days	Wed 3/3/27	Tue 3/23/27	122
121	Temporary Sheet Piles	10 days	Mon 4/6/26	Fri 4/17/26	119
122	Dewater work area	120 days	Mon 4/20/26	Tue 3/2/27	121
123	Import Fill material	77 days	Wed 3/3/27	Thu 6/17/27	122
124	Permanent Sheet piles	28 days	Fri 6/18/27	Tue 7/27/27	123
125	Remove Temp Sheet Piles	10 days	Wed 7/28/27	Tue 8/10/27	124
126	Place Aggregate base	2 days	Wed 8/11/27	Thu 8/12/27	125
127	Guard Rail	3 days	Fri 8/13/27	Tue 8/17/27	126
128	Restore staging area	10 days	Wed 8/18/27	Tue 8/31/27	127
129	Hydroseed project	1 day?	Wed 9/1/27	Wed 9/1/27	128
130	**Port South**	**156 days**	**Wed 5/3/28**	**Thu 7/5/29**	
131	Staging area	5 days	Wed 5/3/28	Tue 5/9/28	
132	Mobilization	10 days	Wed 5/10/28	Tue 5/23/28	131
133	Utility Relocations	20 days	Wed 5/24/28	Tue 6/20/28	132
134	Strip grass & export	10 days	Wed 6/21/28	Tue 7/4/28	133
135	Demo trees	2 days	Wed 7/5/28	Thu 7/6/28	134
136	Degrade for slurry wall	2 days	Wed 5/24/28	Thu 5/25/28	132
137	Slurry wall - Excavator	20 days	Fri 5/26/28	Thu 6/22/28	136
138	Compact Orginal Grade (levee footprint)	10 days	Fri 7/7/28	Thu 7/20/28	135
139	Levee cut & rebuild per detail	2 days	Fri 7/21/28	Mon 7/24/28	138
140	Fill Material - Embankment	30 days	Tue 7/25/28	Mon 9/4/28	139
141	Finish grade levee slopes	3 days	Tue 9/5/28	Thu 9/7/28	140
142	Scarify, moisture condition, finish grade soils prior to pla	5 days	Fri 9/8/28	Thu 9/14/28	141
143	Place Aggregate Base	27 days	Fri 9/15/28	Tue 5/22/29	142
144	Finish Aggregate Base	52 days	Fri 9/15/28	Tue 6/26/29	143SS
145	Restore staging area	2 days	Wed 6/27/29	Thu 6/28/29	144
146	Hydroseed project	5 days	Fri 6/29/29	Thu 7/5/29	145
147	**DWSC East - Sta 0+00 to 171+71**	**508 days**	**Fri 5/1/26**	**Wed 8/7/30**	
148	Staging area	3 days	Fri 5/1/26	Tue 5/5/26	
149	Mobilization	10 days	Wed 5/6/26	Tue 5/19/26	148
150	**Clear & Grub**	**51 days**	**Wed 5/20/26**	**Wed 7/29/26**	
155	**Relocate ditch**	**85 days**	**Fri 6/5/26**	**Mon 5/3/27**	



Project: W Sac GRR Const Sched - Al
Date: Thu 12/3/15

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

ID	Task Name	Duration	Start	Finish	Predecessors
159	Levee Degrade to temp stockpile	26 days	Tue 5/4/27	Tue 6/8/27	158
160	SB Slurry wall - Excavator	357 days	Tue 5/11/27	Tue 6/18/30	159SS+5 days
161	Embankment Fill	8 days	Tue 7/11/28	Thu 7/20/28	
162	Impervious Fill	9 days	Fri 7/21/28	Wed 8/2/28	161
163	Finish Slopes	1 day	Thu 8/3/28	Thu 8/3/28	162
164	SOG prior to placement of AB	7 days	Fri 8/4/28	Mon 8/14/28	163
165	Place Aggregate Base	2 days	Tue 8/15/28	Wed 8/16/28	164
166	Finish Aggregate Base	2 days	Thu 8/17/28	Fri 8/18/28	165
167	Embankment Fill	8 days	Wed 7/11/29	Fri 7/20/29	166
168	Impervious Fill	9 days	Mon 7/23/29	Thu 8/2/29	167
169	Finish Slopes	1 day	Fri 8/3/29	Fri 8/3/29	168
170	SOG prior to placement of AB	7 days	Mon 8/6/29	Tue 8/14/29	169
171	Place Aggregate Base	2 days	Wed 8/15/29	Thu 8/16/29	170
172	Finish Aggregate Base	2 days	Fri 8/17/29	Mon 8/20/29	171
173	Embankment Fill	8 days	Wed 6/19/30	Fri 6/28/30	160
174	Impervious Fill	9 days	Mon 7/1/30	Thu 7/11/30	173
175	Finish Slopes	1 day	Fri 7/12/30	Fri 7/12/30	174
176	SOG prior to placement of AB	7 days	Mon 7/15/30	Tue 7/23/30	175
177	Place Aggregate Base	2 days	Wed 7/24/30	Thu 7/25/30	176
178	Finish Aggregate Base	2 days	Fri 7/26/30	Mon 7/29/30	177
179	Restore staging area	2 days	Tue 7/30/30	Wed 7/31/30	178
180	Hydroseed project	5 days	Thu 8/1/30	Wed 8/7/30	179
181	**South Cross Levee Sta 0+00 to 62+73**	**248 days**	**Tue 5/1/29**	**Wed 6/11/31**	
182	Staging area	5 days	Tue 5/1/29	Mon 5/7/29	
183	Mobilization	10 days	Tue 5/8/29	Mon 5/21/29	182
184	**Relocated Utilities & structues**	**25 days**	**Tue 5/22/29**	**Mon 6/25/29**	
185	Ditch	12 days	Tue 5/22/29	Wed 6/6/29	183
186	Power Poles	5 days	Thu 6/7/29	Wed 6/13/29	185
187	Shed Structures	5 days	Thu 6/14/29	Wed 6/20/29	186
188	Relocate fence	3 days	Thu 6/21/29	Mon 6/25/29	187
189	**Clearing & Grubbing**	**208 days**	**Tue 6/26/29**	**Wed 6/11/31**	
190	Trees	10 days	Tue 6/26/29	Mon 7/9/29	188
191	Misc	5 days	Tue 7/10/29	Mon 7/16/29	190
192	Strip Grass	27 days	Tue 7/17/29	Wed 8/22/29	191
193	Load out Grass	23 days	Tue 7/24/29	Thu 8/23/29	192SS+5 days
194	Jet Gout Sewer	20 days	Fri 8/24/29	Thu 9/20/29	193
195	Stability Berm aggregates	5 days	Fri 9/21/29	Thu 9/27/29	194
196	Embankment Fill	90 days	Fri 9/21/29	Mon 8/26/30	194
197	Replace stripings at completion of prject	23 days	Tue 8/27/30	Thu 9/26/30	196
198	Finish Slopes	5 days	Fri 9/27/30	Mon 5/5/31	197
199	Relief Wells	20 days	Tue 5/6/31	Mon 6/2/31	198
200	Place Aggregate base	3 days	Tue 5/6/31	Thu 5/8/31	198
201	Restore staging area	2 days	Tue 6/3/31	Wed 6/4/31	199
202	Hydroseed project	5 days	Thu 6/5/31	Wed 6/11/31	201

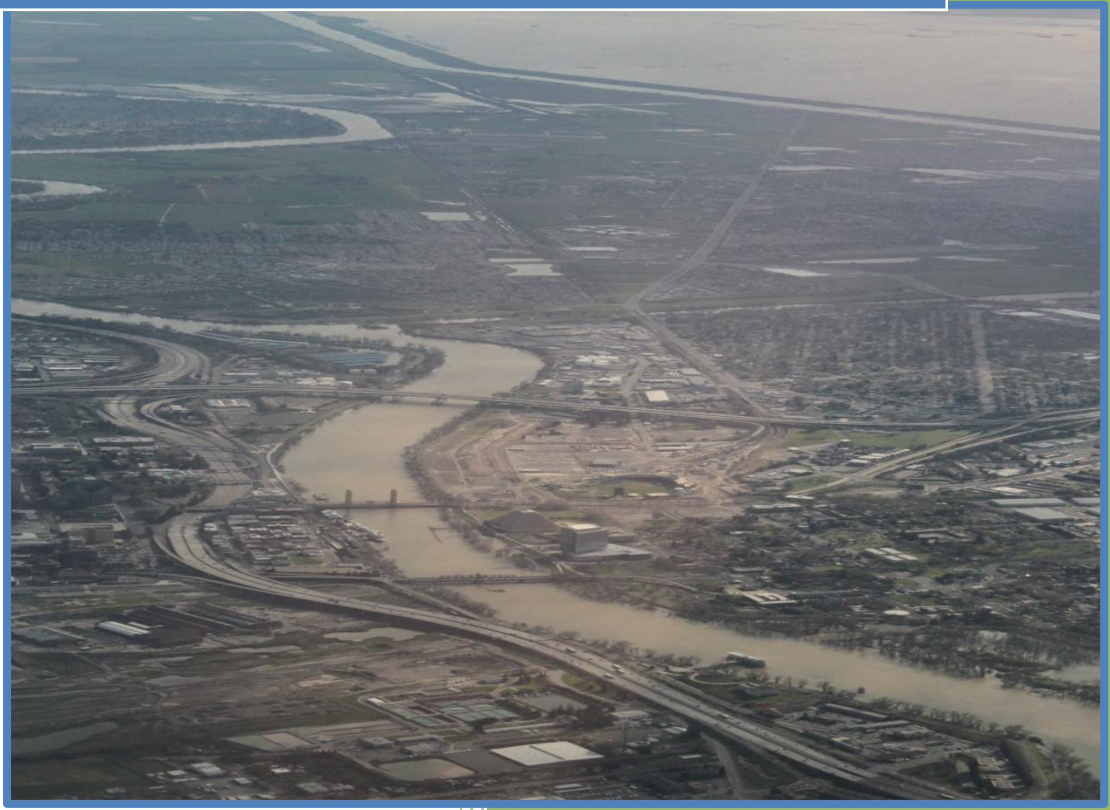


Project: W Sac GRR Const Sched - Al
Date: Thu 12/3/15

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

December 2015

West Sacramento Project
General Reevaluation Report



US Army Corps of Engineers®
Sacramento District

West Sacramento Area Flood Control Agency

Final Report

Hydrology Report

Cover Photo: Sacramento River, West Sacramento, and Yolo Bypass, March 2011

Photo courtesy of Chris Austin.

WEST SACRAMENTO PROJECT, CALIFORNIA
GENERAL REEVALUATION REPORT

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

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
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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

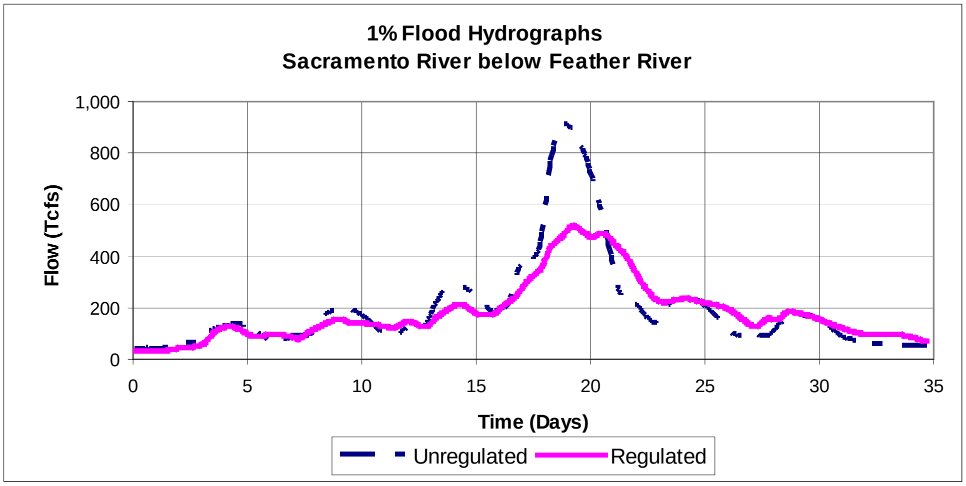
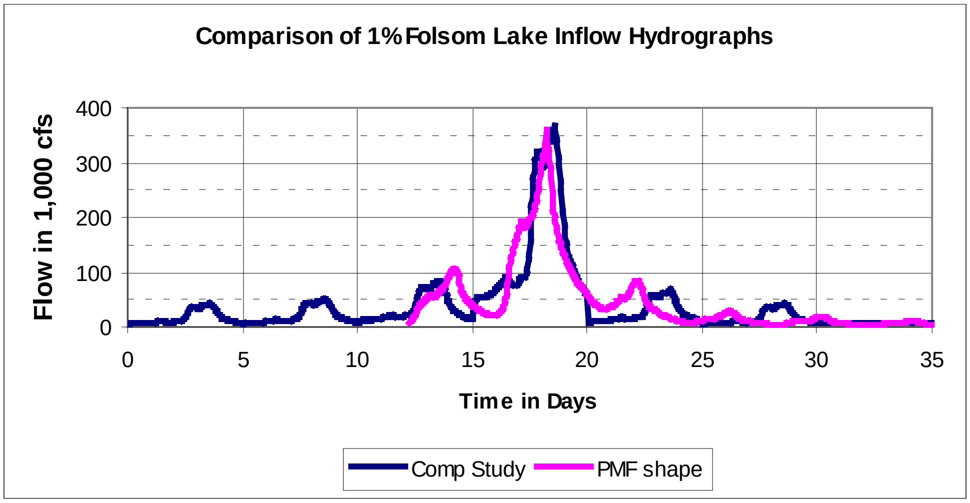


Figure 2



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

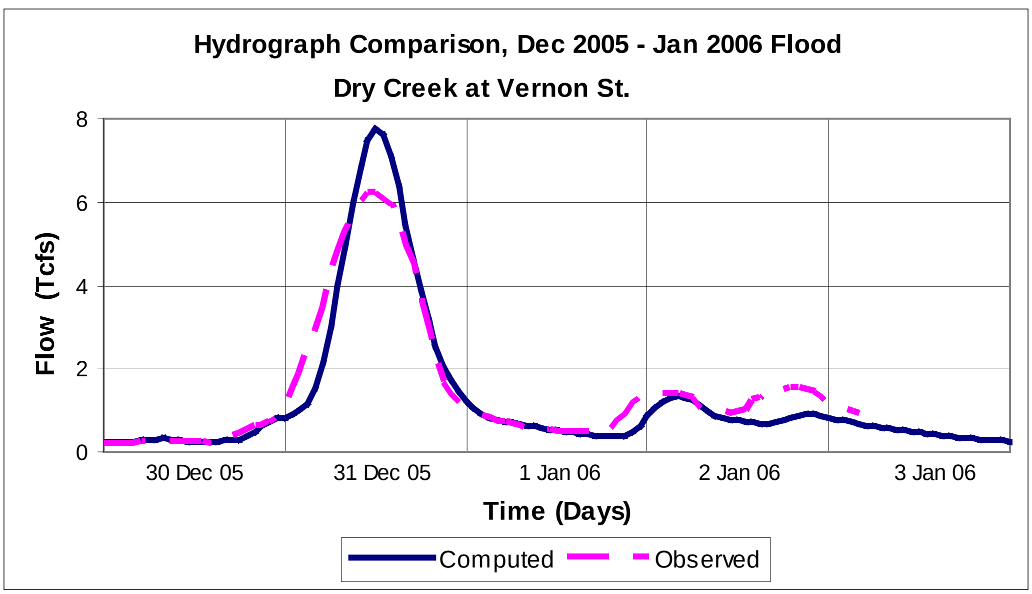


Table 7
30 December 2005 - 3 January 2006 Flood Volume Comparison
For Three Steelhead Creek Tributary Streamflow Gaging Stations

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

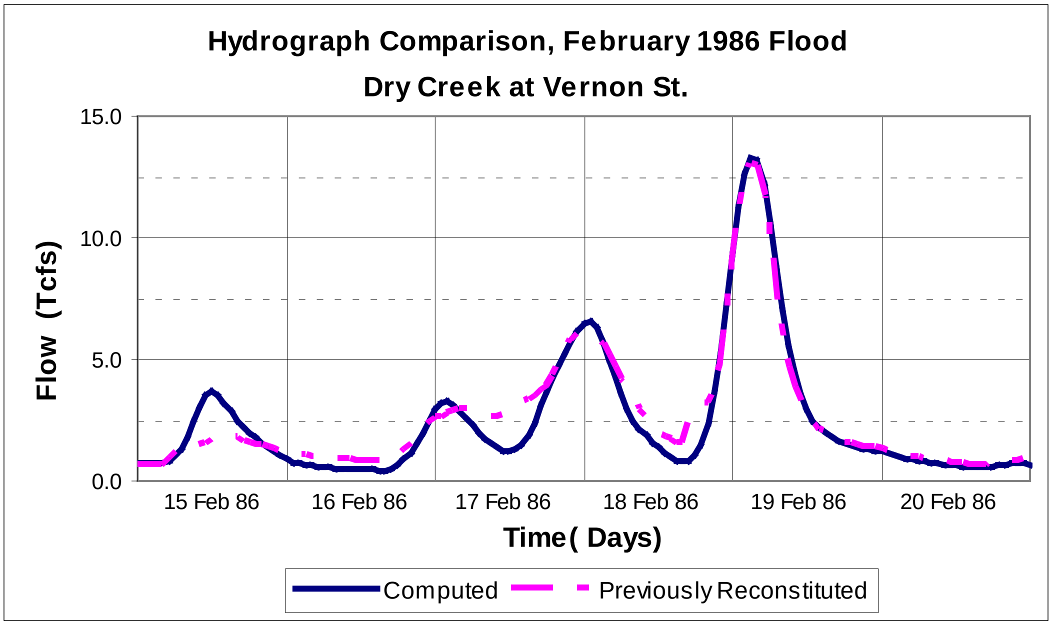


Table 8

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

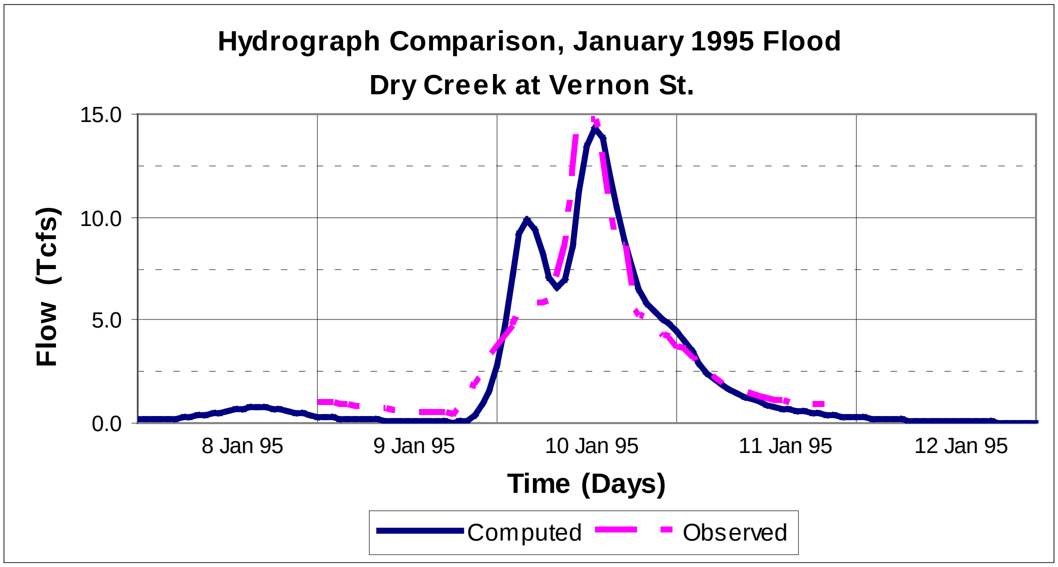


Table 9
8 – 12 January 1995 Flood Hydrograph Comparison
Dry Creek at Roseville Gage

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

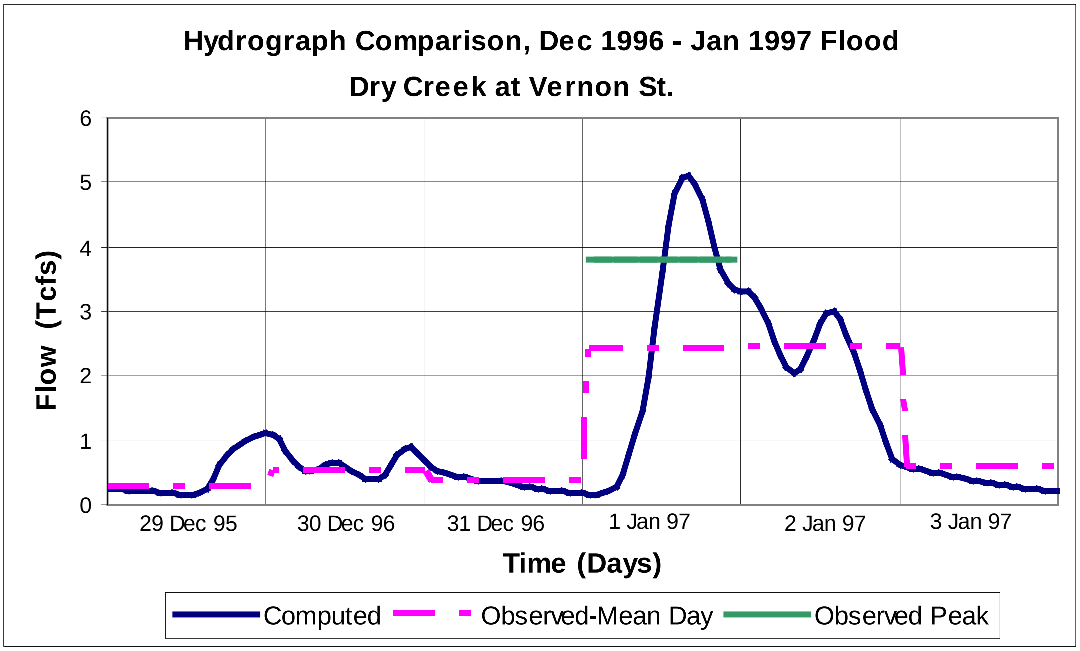


Figure 7

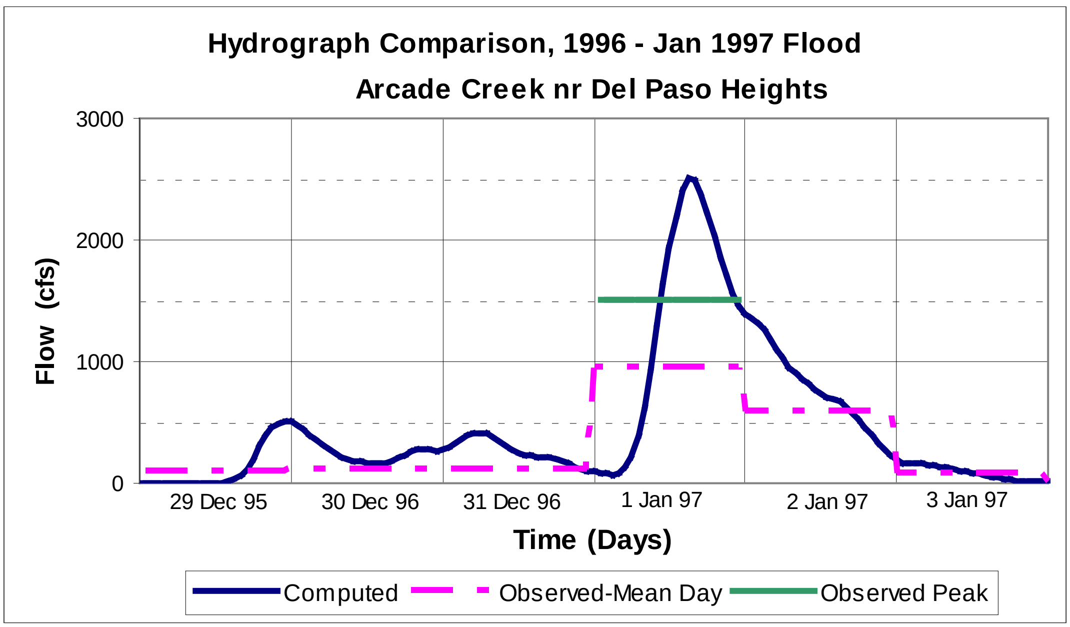


Table 10
29 December 1996 – 3 January 1997 Flood Volume Comparison
For Three Steelhead Creek Tributary Streamflow Gaging Stations

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

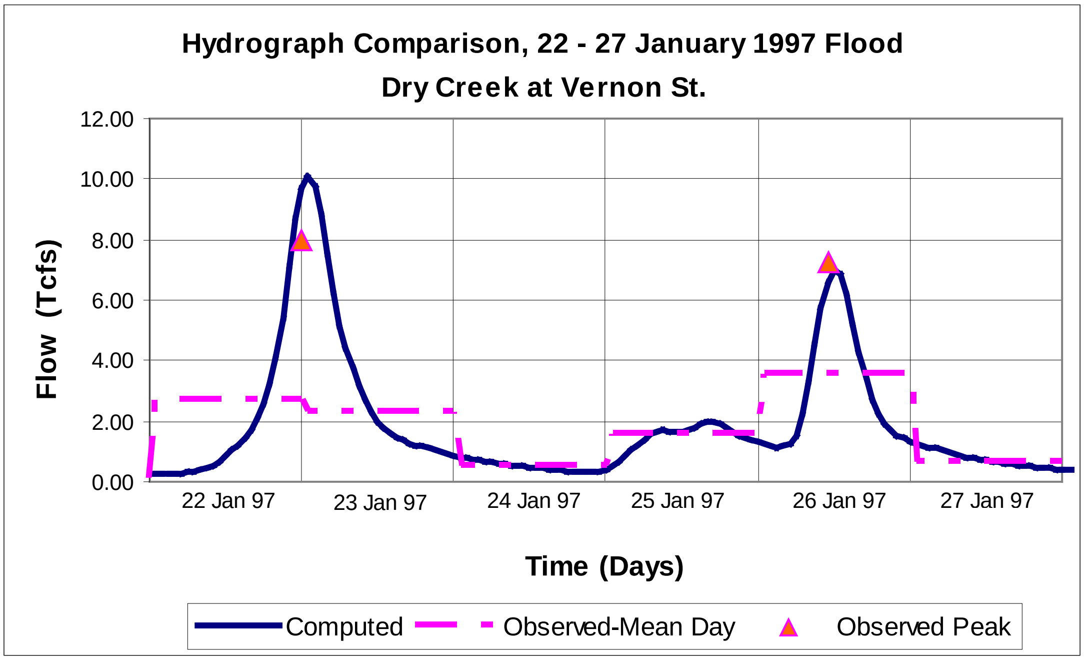


Table 11
22 - 26 January 1997 Flood Volume Comparison
For Three NEMDC Tributary Streamflow Gaging Stations

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

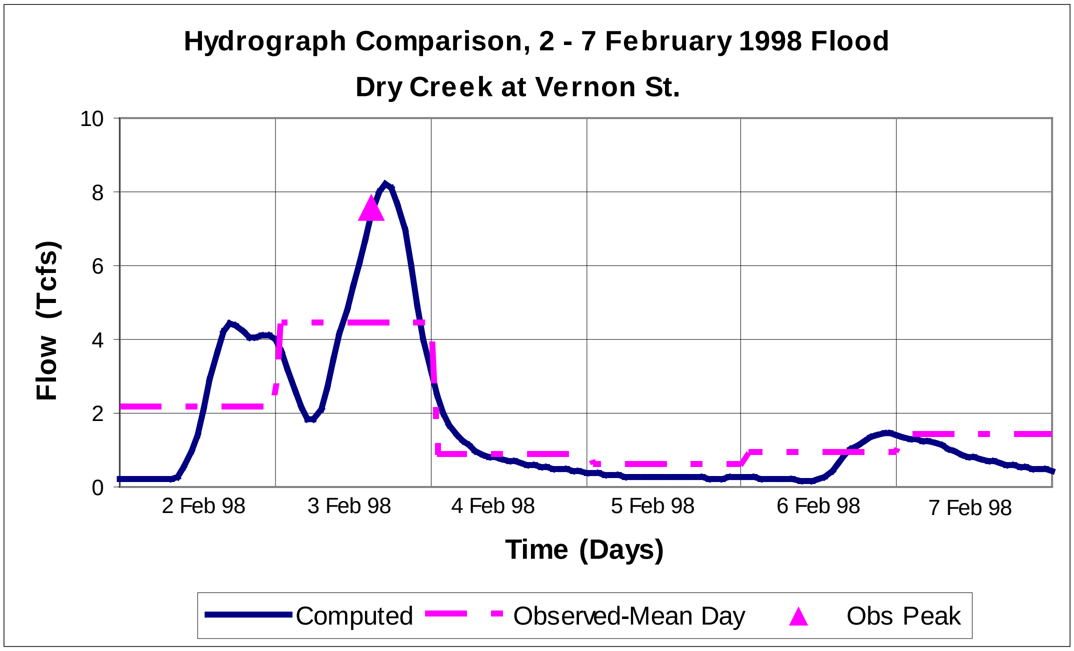


Table 12
2 - 6 February 1998 Flood Volume Comparison
For Two Steelhead Creek Tributary Streamflow Gaging Stations

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	D.A.	8-Flood Series Five-Day Volumes (in Acre-Feet)							
at Mouth	(sq.mi.)	50%	20%	10%	4%	2%	1%	0.50%	0.20%
Steelhead Cr									
Dry Cr. at NEMDC	116.48	9,250	15,450	19,800	26,600	31,000	35,600	39,800	47,200
Upper NEMDC	27.13	2,010	3,230	4,110	5,300	6,190	7,120	7,980	9,360
OldMag at NEMDC (5-DAY)	4.57	380	594	747	952	1,103	1,260	1,410	1,640
Arcade Cr. At NEMDC	40.14	3,400	5,310	6,650	8,430	9,710	11,050	12,300	14,260
NEMDC Sum	188.32	14,970	24,600	31,340	41,320	48,020	54,980	61,360	71,750
Cross Canal									
Coon Creek at WPRR	112.61	8,760	15,640	20,360	29,430	34,360	39,410	44,040	51,430
Markham Rav. at WPRR	32.36	1,840	3,310	4,370	5,660	6,700	7,760	8,810	10,480
Auburn Rav. at WPRR	79.97	6,770	11,250	14,290	19,460	22,500	25,660	28,600	33,250
Pl.Grove Cr. at WPRR	46.69	4,140	6,500	8,110	10,360	11,880	13,390	15,080	17,420
Curry Creek at WPRR	16.59	1,190	2,000	2,560	3,300	3,850	4,420	4,950	5,810
Cross Canal Sum	288.22	22,690	38,710	49,680	68,160	79,230	90,580	101,420	118,320

The 5-day volumes in **Table 13** and the volume frequency curves on **Plate 11** were used to estimate the percent exceedence of the 5-day volumes for Steelhead Creek for the six historical flood events described above. **Table 14** lists the 5-day volumes for the Steelhead Creek tributaries computed using the HEC-1 program and the storm isohyetal maps for the 6 historical floods, along with the estimated percent exceedence of the 5-day volume for Steelhead Creek hydrographs.

Table 14

5-Day Volume Frequency Relationships for Six Historical Storms

Steelhead Creek Tributaries

Steelhead Cr Index Pt	5-Day Volume (ac-ft)	5-Day Volume % Chance Event (%)	Steelhead Cr Index Pt	5-Day Volume (ac-ft)	5-Day Volume % Chance Event (%)
Feb 1986 Storm			Mid-Jan 1997 Storm		
Dry Cr. At Mouth	38,400	0.6%	Dry Cr. At Mouth	28,500	2.6%
Arcade Cr.-Del Paso Hghts	10,700	0.6%	Arcade Cr.-Del Paso Hghts	7,420	4.6%
Arcade Cr. at Mouth	12,200	0.6%	Arcade Cr. At Mouth	8,300	4.4%
Upper NEMDC abv. Pump	7,090	1.0%	Upper NEMDC abv. Pump	4,230	9.3%
Old Magpie Cr. abv. Pump	1,420	0.6%	Old Magpie Cr. Abv. Pump	810	8.0%
Steelhead Sum	58,300	0.7%	Steelhead Sum	41,600	3.6%
Jan 1995 Storm			Feb 1998 Storm		
Dry Cr. At Mouth	29,800	2.2%	Dry Cr. At Mouth	24,100	5.1%
Arcade Cr.-Del Paso Hghts	8,300	2.7%	Arcade Cr.-Del Paso Hghts	7,380	5.7%
Arcade Cr. at Mouth	9,540	2.3%	Arcade Cr. At Mouth	8,100	4.9%
Upper NEMDC abv. Pump	5,430	3.6%	Upper NEMDC abv. Pump	4,540	7.3%
Old Magpie Cr. abv. Pump	930	4.6%	Old Magpie Cr. Abv. Pump	780	9.0%
Steelhead Sum	45,700	2.4%	Steelhead Sum	37,500	5.4%
New Year 1997 Storm			New Year 2006 Storm		
Dry Cr. At Mouth	17,400	14.5%	Dry Cr. At Mouth	17,700	13.8%
Arcade Cr.-Del Paso Hghts	5,300	15.6%	Arcade Cr.-Del Paso Hghts	5,430	14.6%
Arcade Cr. at Mouth	6,100	13.5%	Arcade Cr. At Mouth	6,370	11.8%
Upper NEMDC abv. Pump	3,370	18.4%	Upper NEMDC abv. Pump	2,820	28.0%
Old Magpie Cr. abv. Pump	600	19.5%	Old Magpie Cr. Abv. Pump	700	13.0%
Steelhead Sum	27,500	14.6%	Steelhead Sum	27,600	14.4%

A sensitivity analysis of storm centerings and runoff discussed in the Natomas GRR Hydrology Appendix showed there was less than a 5 percent difference in runoff on Steelhead Creek for a 1 percent storm centering on the Steelhead drainage and a concurrent storm on Steelhead Creek with the specific centering on Cross Canal drainage. The difference in runoff was also less than 5 percent for the Natomas Cross Canal. To simplify Natomas flood centerings for the Coincident Frequency Analysis, an n-percent chance flood is assumed to be centered on the combined drainages of Steelhead Creek and Natomas Cross Canal. So, if the 5-day flood hydrograph for Steelhead Creek for the New Year 1997 flood is a 15 percent exceedence event, it is assumed to be a 15 percent exceedence event for the Natomas Cross Canal 5-day runoff volume as well. Based on the flood volumes listed in **Table 13**, the 5-day volume of the New Year 1997 flood for the Natomas Cross Canal should be about 43,300 acre-feet. Based on this combined 5-day flood volume for the Cross Canal, 5-day flood hydrographs needed to be computed for the five Cross Canal tributaries for the New Year 1997 flood, to be used in the Coincident Frequency Analysis. Computation of the Natomas Cross Canal tributary hydrographs for the New Year 1997 flood and other five historic floods is discussed in **Section 2.2**.

2.2 Natomas Cross-Canal Historical Flood Hydrographs.

a. Computing 5-Day Volumes for 6 Historical Floods on Natomas Cross Canal. There are several problems with developing historical flood hydrographs for the Natomas Cross Canal tributaries. One is the lack of precipitation stations in the Cross Canal watershed. See **Plate 2**, the watershed map showing the precipitation station locations. Also, there are no flow gages – only a few stage gages on Pleasant Grove Creek at and upstream of Fiddyment Road, and in the upper watersheds of Coon Creek and Auburn Ravine. Coon Creek and Auburn Ravine stage gage locations can be found at **Reference 9,** on the map of Sacramento County ALERT gages. The Pleasant Grove Creek stage gage locations can be found at **Reference 10**, the map of City of Roseville Flood Alert gages. The isohyetal lines on the isohyetal maps for the six historic storms (**Plates 5 through 10**) were extended from Steelhead Creek drainage north through the Cross Canal drainage.

The Civil Engineering Solutions HEC-1 models and the isohyetal maps (**Plates 5 through 10**) were used to compute preliminary runoff hydrographs for the Cross Canal tributaries for the six historical floods. The storm isohyetal maps and subbasins storm amounts for the Cross Canal tributaries were adjusted until the 5-day runoff volumes for the Cross Canal tributaries matched the percent exceedence of the 5-day Steelhead Creek tributary volumes for the same event. (See **Table 14**.) The Pleasant Grove Creek and Markham Ravine drainages are similar to Arcade Creek in east-to-west alignment, drainage area, and elevation range (below 300 feet), so that the percent exceedence event for the Arcade Creek 5-day flood volumes were used as guidance to estimate the flood volumes for those two Cross Canal tributaries. For the larger tributaries, Coon Creek and Auburn Ravine, with large contributing drainage above 300 feet (extending up to 2,000 feet for Coon Creek), the percent exceedence 5-day volumes for the six historical floods were based on the percent exceedence flood volumes for Dry Creek at Steelhead Creek. Curry Creek is adjacent to Upper NEMDC, which was used as a model in case the 5-day volumes on Curry Creek needed adjustment.

Table 15 lists the computed 5-day flood volumes from the above adjusted modeling runs for the Natomas Cross Canal tributaries, as well as the ratios of peak-to-5-day-volume for the computed hydrographs on the Steelhead Creek and Cross Canal tributaries. The HEC-1 models developed by Civil Engineering Solutions, Inc., for the Natomas Cross canal tributaries, discussed in the Natomas GRR Hydrology Appendix (**Reference 6**), assumed that future housing and urbanization projects were in place. At the present time, they have yet to be constructed. One review comment on the Hydrology Appendix was that the Cross Canal tributary peak flows computed for the Hydrology Appendix had much higher peak flows in proportion to their flood volumes and contributing drainage areas. The relationship for Cross Canal peak flows should be more in line with the ratios of peak flow to flood volume and to drainage area for the Steelhead Creek tributaries.

Table 15
Ratio of Peaks to 5-Day Volumes
for 6 Historical Floods on Natomas Tributaries

Stream at Mouth	D.A. (sq.mi.)	8-Flood Series - Peaks, Volumes and Ratios: Peak to Volume						Average Peak to Volume
		Feb-86	Jan-95	NY 1997	MidJan 97	Feb-98	NY 2006	
Steelhead Cr								
Dry Cr. At Steelhead Cr.	Peak (cfs)	10,040	12,080	5,110	7,830	7,350	6,900	
5-day Vol. (ac-ft)		38,400	29,800	17,400	28,500	24,100	17,700	
Drainage Area 116.48 sq.mi.	PK/Vol.	0.26	0.41	0.29	0.27	0.30	0.39	0.32
Upper NEMDC	Peak (cfs)	3,830	3,840	2,610	2,610	1,610	2,110	
5-day Vol. (ac-ft)		7,090	5,430	3,370	4,230	4,540	2,820	
Drainage Area 27.13 sq.mi.	PK/Vol.	0.54	0.71	0.77	0.62	0.35	0.75	0.62
Old Magpie Cr. above Pump	Peak (cfs)	831	918	603	673	389	573	
5-day Vol. (ac-ft)		1,420	930	600	810	780	700	
Drainage Area 4.57 sq.mi.	PK/Vol.	0.59	0.99	1.01	0.83	0.50	0.82	0.79
Arcade Cr. At Steelhead Cr.	Peak (cfs)	3,720	4,950	2,640	3,470	3,200	3,360	
5-day Vol. (ac-ft)		12,200	9,540	6,100	8,300	8,100	6,370	
Drainage Area 40.14 sq.mi.	PK/Vol.	0.30	0.52	0.43	0.42	0.40	0.53	0.43
Steelhead Cr. Sum	Peak (cfs)	14,060	17,840	8,470	11,300	11,050	10,860	
5-day Vol. (ac-ft)		58,300	45,700	27,500	41,600	37,500	27,600	
Drainage Area 188.32 sq.mi.	PK/Vol.	0.24	0.39	0.31	0.27	0.29	0.39	0.32
Cross Canal		Feb-86	Jan-95	NY 1997	MidJan 97	Feb-98	NY 2006	Average
Coon Creek at WPRR	Peak (cfs)	11,700	26,500	8,250	13,700	10,150	9,970	
5-day Vol. (ac-ft)		35,500	29,100	17,600	20,700	18,050	13,460	
Drainage area 112.61 sq.mi.	PK/Vol.	0.33	0.91	0.47	0.66	0.56	0.74	0.61
Markham Rav. At WPRR	Peak	6,510	4,830	2,520	4,810	2,550	4,120	
5-day Vol. (ac-ft)		8,620	4,850	3,700	5,280	5,130	3,440	
Drainage Area 32.36 sq.mi.	PK/Vol.	0.76	1.00	0.68	0.91	0.50	1.20	0.84
Auburn Rav. At WPRR	Peak (cfs)	11,700	10,200	4,290	6,840	5,490	5,700	
5-day Vol. (ac-ft)		26,450	21,000	12,500	16,360	14,100	10,200	
Drainage Area 79.97 sq.mi.	PK/Vol.	0.44	0.49	0.34	0.42	0.39	0.56	0.44
Pl.Grove Cr. At WPRR	Peak (cfs)	7,870	9,100	4,550	7,360	4,610	5,470	
5-day Vol. (ac-ft)		14,900	11,400	6,560	9,090	9,330	6,160	
Drainage Area 46.69 sq.mi.	PK/Vol.	0.53	0.80	0.69	0.81	0.49	0.89	0.70
Curry Creek at WPRR	Peak (cfs)	2,520	2,500	1,570	1,680	1,020	1,290	
5-day Vol. (ac-ft)		4,650	3,330	2,130	2,890	3,000	1,730	
Drainage Area 16.59 sq.mi.	PK/Vol.	0.54	0.75	0.74	0.58	0.34	0.75	0.62
Cross Canal Sum	Peak (cfs)	30,700	43,600	16,100	23,200	20,800	21,300	
5-day Vol. (ac-ft)		89,800	72,900	42,500	54,300	49,500	35,000	
Drainage Area 288.22 sq.mi.	PK/Vol.	0.34	0.60	0.38	0.43	0.42	0.61	0.46

Upper NEMDC (Steelhead tributary) and Curry Creek (Cross Canal tributary) are adjacent basins on the valley floor and have similar ratios of computed peak to 5-day volume for each of the six flood events. The 6-event averaged ratio of peak/5-day volume (**Table 15**, right-hand column) is the same, 0.62, for Upper NEMDC and Curry Creek.

Arcade Creek (Steelhead tributary) and Pleasant Grove Creek and Markham Ravine (Cross Canal tributaries) are similar in orientation and elevation. However, because of the highly urbanized HEC-1 models used for Pleasant Grove Creek and Markham Ravine, the 6-event averaged ratio of peak/5-day volume for Pleasant Grove Creek is 60 percent higher than for Arcade Creek and for Markham Ravine is nearly two times that of Arcade Creek.

Dry Creek (Steelhead tributary) and Coon Creek and Auburn Ravine (Cross Canal tributaries) have larger drainage areas as well as headwaters at much higher elevations than the other Natomas tributaries. Because of the highly urbanized HEC-1 models used for Auburn Ravine and Coon Creek, the 6-event averaged ratio of peak/5-day volume for Auburn Ravine is 38 percent higher than for Dry Creek and is 91 percent higher for Coon Creek than for Dry Creek.

Table 16 shows the ratios of peak-to-drainage-area for the computed hydrographs on the Steelhead Creek and Cross Canal tributaries.

Table 16
Ratio of Peaks to Drainage Areas
for 6 Historical Floods on Natomas Tributaries

Stream	D.A.	8-Flood Series - Ratios of Peaks to Drainage Areas						Average
at Mouth	(sq.mi.)	Feb-86	Jan-95	NY 1997	MidJan 97	Feb-98	NY 2006	Peak to
Steelhead Cr								D.A.
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. <u>Re-shaping the Natomas Cross Canal Historical Hydrographs</u>. 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

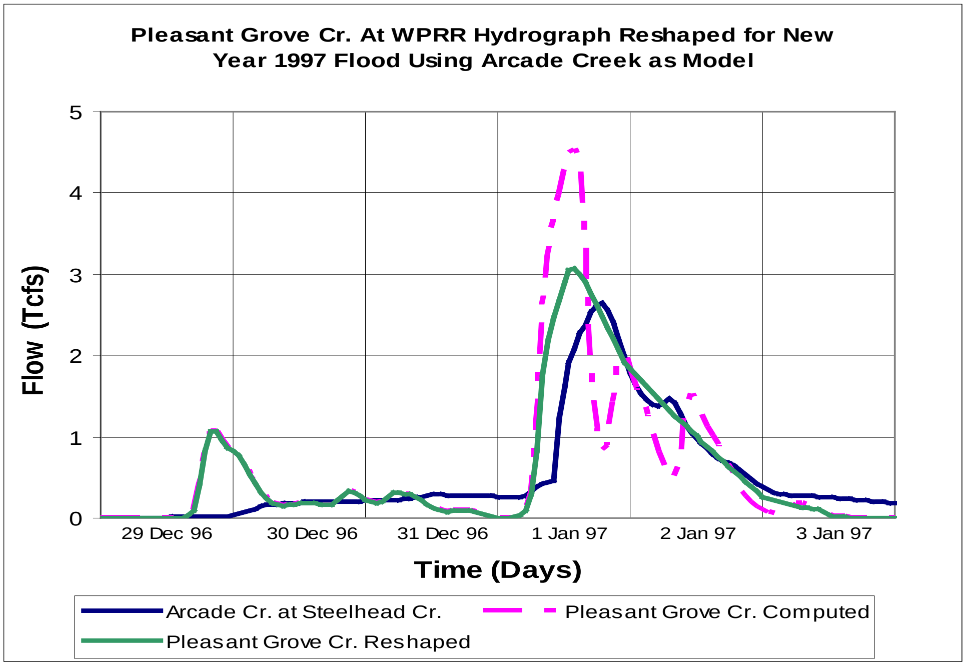
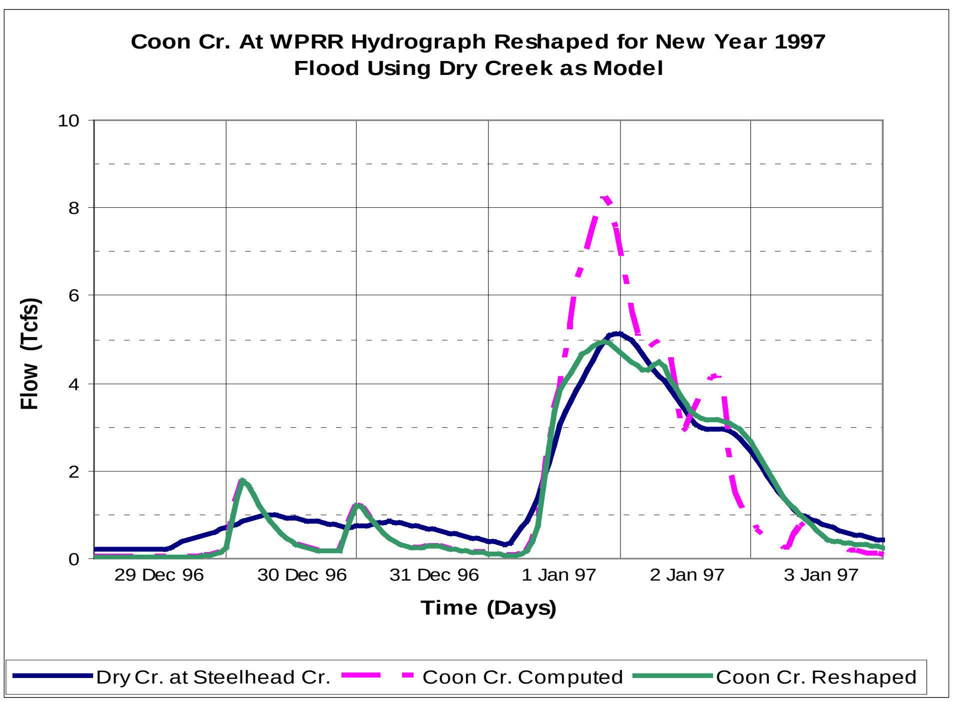
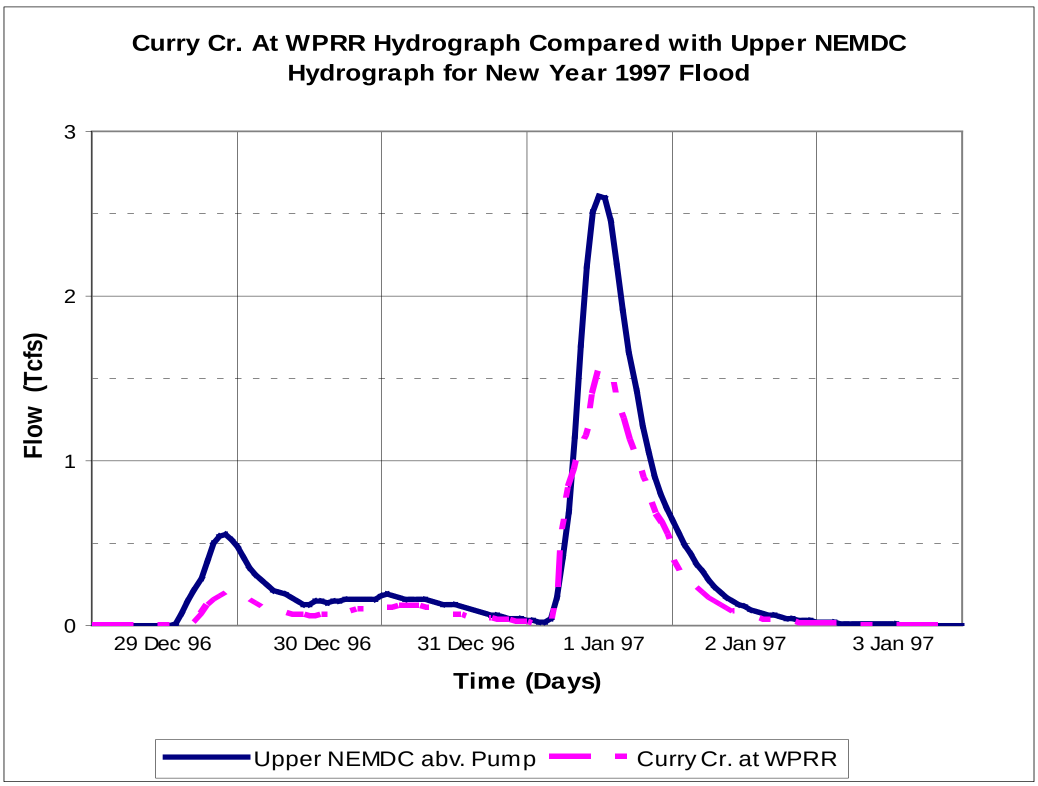


Figure 11



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

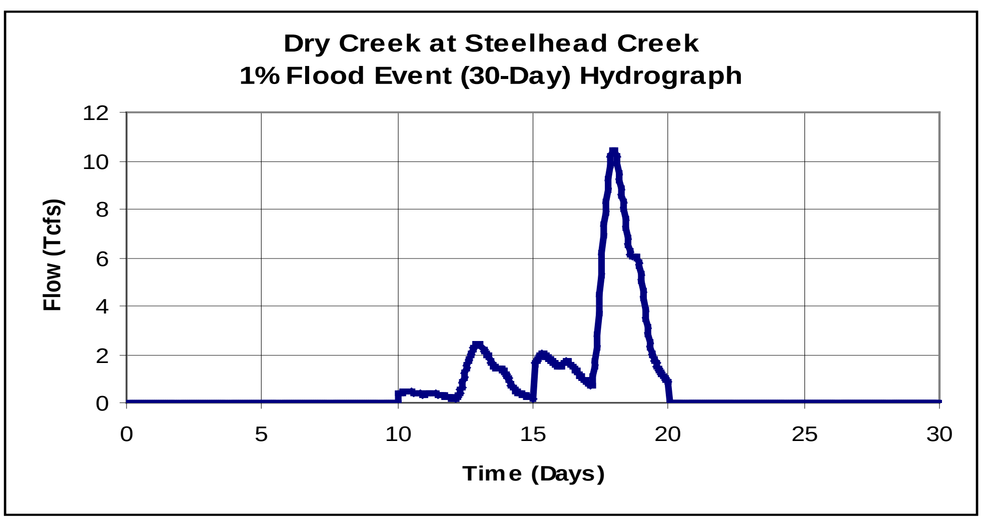
Summary Table - 8-Flood Series - Ten-Day Duration Volumes

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 <u>Total Probability Theorem</u>. Instead of the Comprehensive Study concurrent flood centering methodology, a total probability approach was used to evaluate coincident flood stages on the Natomas Cross Canal and Steelhead Creek. The procedure used was an extension of the Total Probability method documented in **Reference 11**, Procedures for Developing Stage-Probability Functions for Tributary Streams, prepared by David Ford Consulting Engineers (Ford) in February 2007.

Tangible benefit of a flood management project is computed, in part, as the expected value of inundation damage reduced. This computation requires a stage-frequency function at the location of interest. If that location is on a tributary stream, development of the function must account properly for the influence of the mainstem stream into which the tributary flows. A systematic, uniform approach is required for development of the stage-frequency functions for the locations of interest. The procedure begins with an assessment of the degree to which the tributary is dependent on the mainstem. An overview flowchart for the tributary analysis procedure is shown on **Plate 16**.

If the tributary is not dependent on mainstem conditions (Case 1), then the necessary information can be developed using typical riverine analyses: estimate the discharge for a specified probability, use that as the upstream boundary condition, and use a rating curve or similar control as the downstream boundary condition for the hydraulics model.

If tributary conditions are hydraulically dependent on mainstem conditions, can the frequency of the stage at the tributary location be predicted, given the mainstem conditions? If so (Case 3), then the Comprehensive Study methodology is used to develop the tributary flow-frequency function and the mainstem stage-frequency function. A channel model is developed for the reach of interest, and a resulting stage-frequency function is derived for the tributary index location.

If tributary conditions cannot be predicted reliably from mainstem conditions (Case 2), then combinations of boundary conditions are applied to the standard watershed and channel models. Using the results from analysis of tributary stages computed with varying downstream boundary conditions, the total probability equation is used to compute the desired stage-frequency function at the tributary location. The equation is:

$$F(stage_{tributary}) = \sum_{\substack{mainstem \\ conditions}} (F(stage_{tributary} | stage_{mainstem}) \times F(stage_{mainstem}))$$

If a correlation exists between the tributary and mainstem, but is not definitive (Case 4), then a conditional probability analysis needs to be done. Practical methods to accomplish this have yet to be developed and field-tested.

4.2 Application to Natomas Tributaries. The coincident-frequency procedures that Ford used to develop stage-frequency curves for the Natomas Cross Canal and Steelhead Creek channels are described in the memorandum, "NCC/SHC Coincident Frequency Study: Exposition of Analytical Procedures," dated September 10, 2008, prepared by David Ford Consulting Engineers (**Reference 12**). Primary technical tasks include assessing hydrologic dependence between tributary and mainstem channels and identifying flow regimes where hydrologic independence may be presumed. A secondary task is identifying timing differences between tributary and mainstem peak stages. Total probability methodology relies on historical rainfall and streamflow data. Stage records from the California Data Exchange Center (CDEC, **Reference 13**) were used for the analysis. Due to the lack of stage data on the Natomas Cross Canal, CDEC stage records for the Dry Creek gage at Vernon Street (VRS) were substituted to develop a cross-correlation with the Sacramento River at Verona (VON) records. Records for the Sacramento River at I Street (IST) and at Ord Ferry (ORD) gages were used to supplement/correct the VON stage records. Similarly, due to the unavailability of long-term records for Steelhead Creek, Arcade Creek (AMC) records were cross-correlated with American River at H-Street gage (HST) records. American River at Fair Oaks (AFO) records were used to fill in missing values in the HST record. **Table 18** summarizes the primary stream gages used for this study. Gaging station locations (except for ORD) are shown on **Plate 1**.

Table 18
CDEC Gage Records Used for Hydrologic Dependence Analysis

Gage Name	CDEC gage ID	Period of Record
Sacramento River at Verona	VON	01Jan1984 – Present
Sacramento River at I Street	IST	01Jan1984 – Present
Sacramento River at Ord Ferry	ORD	01Jan1984 – Present
American River at H Street	HST	01Jan1984 – Present
American River at Fair Oaks	AFO	02Nov1998 – Present
Dry Creek at Vernon Street	VRS	19Oct1996 – Present
Arcade Creek at Winding Way	AMC	29Oct1996 – Present

The memorandum, "Cross-Correlation Analysis Results for NCC/SHC Coincident-Frequency Study," dated April 17, 2008, prepared by David Ford Consulting Engineers (**Reference 14**), describes the methods Ford used to assess conditions of hydrologic dependence between (1) Steelhead Creek and the American River, (2) Natomas Cross Canal and the

Sacramento River, and (3) the American River and the Sacramento River. It also identifies peak-stage timing differences between each tributary and the downstream mainstem channel.

Table 19 shows the tributary/mainstem confluence water surface elevations used as input in the Hydraulic Design Section's hydraulic models for the Natomas Cross Canal (NCC) and Steelhead Creek (SHC) tributaries as a function of mainstem annual exceedence probability (AEP) stages. Water surface elevation (WSEL) values are referenced to the National Geodetic Vertical Datum of 1929 (NGVD29). Water surface elevations on SHC and NCC in **Table 19** correspond to stages on the American River and on the Sacramento River, respectively. For the more frequent mainsteam AEP between 0.50 and 0.04, Steelhead Creek stages are affected more by stages on the Sacramento River than by flows down the American River.

An analytical approach based on historical storm event data was used to characterize tributary/mainstem dependencies. Local event Annual Exceedence Probabilities (AEPs) were assigned to individual storm events, based on precipitation records from rainfall gages close to the SHC and NCC drainages. Rainfall frequency data was provided by Rainfall Depth-Duration Frequency Analysis for California Rain Gages (**Reference 15**), assembled by retired California State Climatologist Jim Goodridge. Historical mainstem peak flows were matched to concurrent local rainfall events on an event-by-event basis. Based on local storm magnitudes, the set of historic events was partitioned into return-frequency classes. Distributions for rarer AEP events were based on projected regional meteorologic patterns. Only rainfall and flow/stage records collected after 1980 were used for the analysis. It was assumed that n-year local flow event corresponded to the n-year local rainfall event, and that mainstem/tributary conditional distribution patterns can be extrapolated for rarer events using general knowledge of regional storm patterns and local channel hydraulics.

Table 19

Applied Stage-Frequency Functions for Mainstem AEP Events

Mainstem-event AEP	Steelhead Creek (SHC) Downstream WSEL (ft. NGVD29)	Natomas Cross Canal (NCC) Downstream WSEL (ft. NGVD29)
0.500	24.09	33.08
0.200	24.80	35.10
0.010	25.70	36.34
0.040	30.71	39.34
0.020	32.65*	40.10
0.010	35.43*	41.62
0.005	37.18*	43.00
0.002	42.62*	44.35

Notes:

AEP = Annual Exceedence Probability

WSEL = Water Surface Elevation

* WSEL is stage for American River conditions. All other WSELs are stages on the Sacramento River Mainstem.

The Hydraulic Design models were used to generate peak water surface elevations for the SHC and NCC index points for various combinations of tributary discharge and fixed mainstem stage (per **Table 19**). The tributary discharge rates were characterized by local-event AEP; similarly, the downstream confluence stages were characterized by mainstem AEP. The computed NCC and SHC index point stage values corresponded to regulated mainstem conditions.

4.3 Computational Results. Ford developed stage-frequency functions for the Natomas Cross Canal and Steelhead Creek index points. **Table 20** presents the stage-frequency functions for the NCC and SHC index points based on Ford's coincident-frequency evaluation. The stage values were computed under regulated mainstem conditions. Water surface elevation (WSEL) values are referenced to the National Geodetic Vertical Datum of 1929 (NGVD29).

Table 20

Computed Stage-Frequency Functions for Local AEP Events

Local-event AEP	Steelhead Creek (SHC) Index Point WSEL (ft. NGVD29)	Natomas Cross Canal (NCC) Index Point WSEL (ft. NGVD29)
0.500	26.3	33.9
0.200	28.6	34.5
0.010	29.9	34.8
0.040	31.4	36.6
0.020	33.4	37.8
0.010	35.5	38.6
0.005	37.4	40.1
0.002	40.1	42.4

Notes:
AEP = Annual Exceedence Probability
WSEL = Water Surface Elevation
SHC index point is located at RM 3.713
NCC index point is located at RM 4.323

Stages listed in **Table 20** are based on UNET modeling, not on the latest HEC-RAS model. The above stages may change when the HEC-RAS model is used for the analyses. The memorandum, "NCC/SHC Coincident Frequency Study: Computational Results," dated September 10, 2008 prepared by Ford (**Reference 16**), provides additional details regarding the results in **Table 20** from the analyses - the special factors considered, the hydraulic profiles and probabilistic relations used in the computations, and the coincident stage-frequency functions.

Table 21 shows the combination of which mainstem flood hydrographs are being used in combination with which Natomas tributary flood hydrographs in the HEC- RAS hydraulic model. These flood hydrograph combinations are being used in preparation for the F3 Conference Milestone. Different combinations of floods may be tested for later analysis.

Preliminary analysis determined that, for the mouth of the Natomas Cross Canal, the flood stages for the Sacramento Mainstem and Shanghai-Yuba centerings were similar. So the Shanghai-Yuba flood series hydrographs are not being used in the current phase (pre-F3 Milestone) of the analysis, but will be tested later.

Table 21
Flood Hydrograph Combinations used in HEC-RAS Hydraulic Model
for Current Phase of Analysis

Sacramento Mainstem Flood-event AEP	Steelhead Creek Flood-event AEP	Natomas Cross Canal Flood-event AEP
0.500	0.500	0.500
0.200	0.500	0.500
0.010	0.200	0.200
0.040	0.010	0.010
0.020	0.040	0.040
0.010	0.020	0.020
0.005	0.010	0.010
0.002	0.005	0.005
American River Flood-event AEP	Steelhead Creek Flood-event AEP	Natomas Cross Canal Flood-event AEP
0.500	0.500	0.500
0.200	0.500	0.500
0.010	0.200	0.200
0.040	0.010	0.010
0.020	0.040	0.040
0.010	0.020	0.020
0.005	0.010	0.010
0.002	0.005	0.005

Notes: AEP = Annual Exceedence Probability

5.0 List of References

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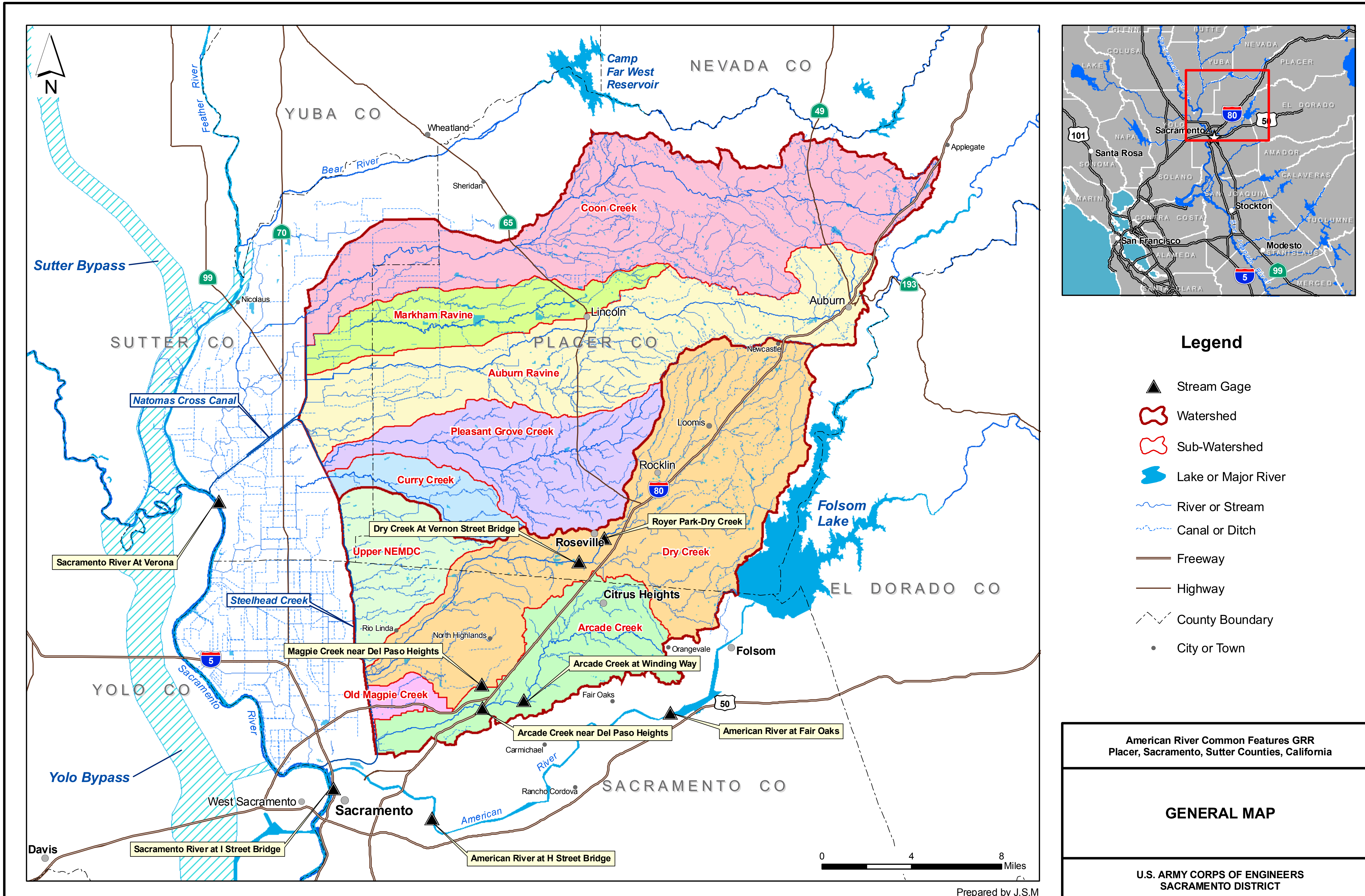

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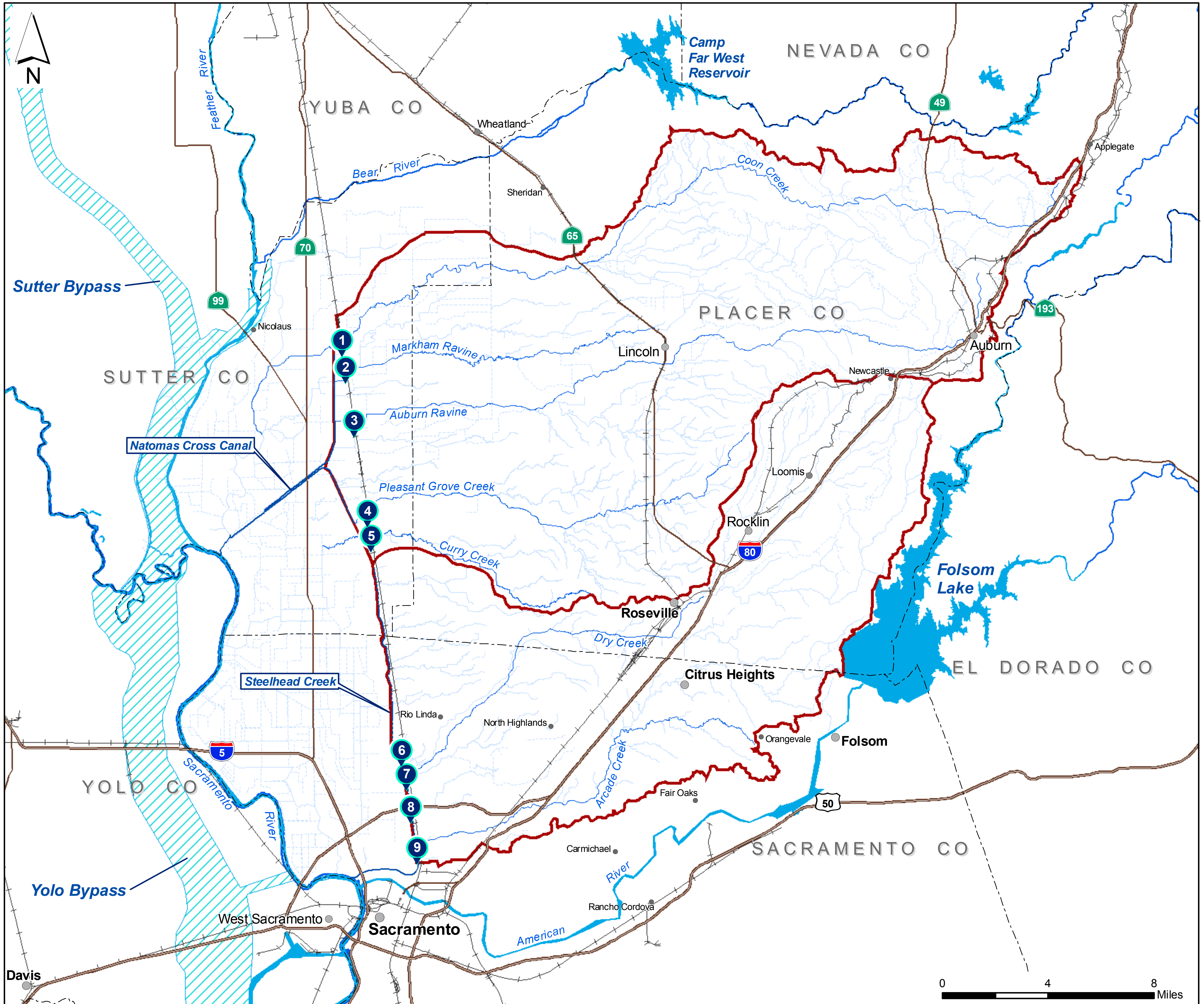
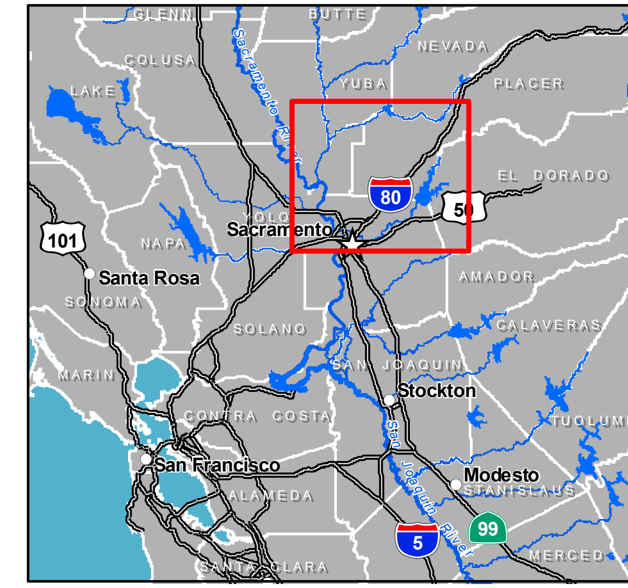
PLATE 1





Legend

Watershed	Freeway
Lake or Major River	Highway
River or Stream	Railroad
Canal or Ditch	County Boundary
City or Town	

Input Sites

1 Coon Creek	6 Upper NEMDC Tribs
2 Markham Ravine	7 Dry Creek
3 Auburn Ravine	8 Old Magpie Creek
4 Pleasant Grove Creek	9 Arcade Creek
5 Curry Creek	

American River Common Features GRR
Placer, Sacramento, Sutter Counties, California

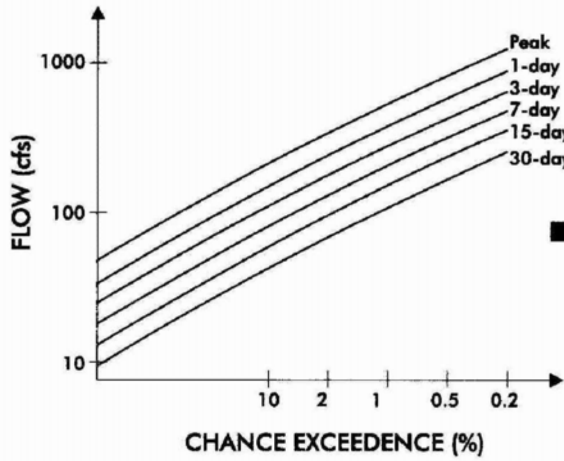
NATOMAS TRIBUTARY INPUT LOCATIONS FOR HYDRAULIC MODEL

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by J.S.M

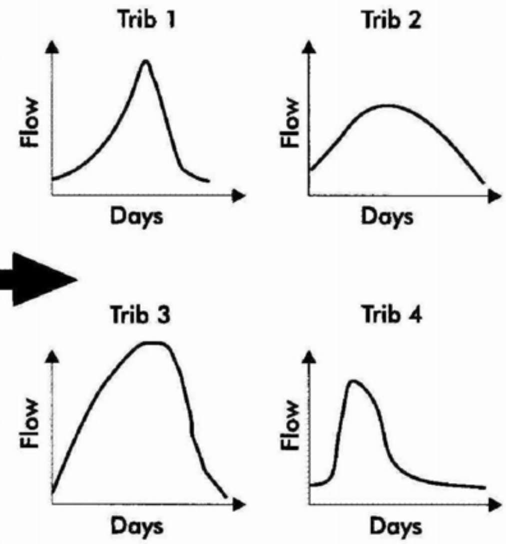
SEP 2008

Full Natural Flow



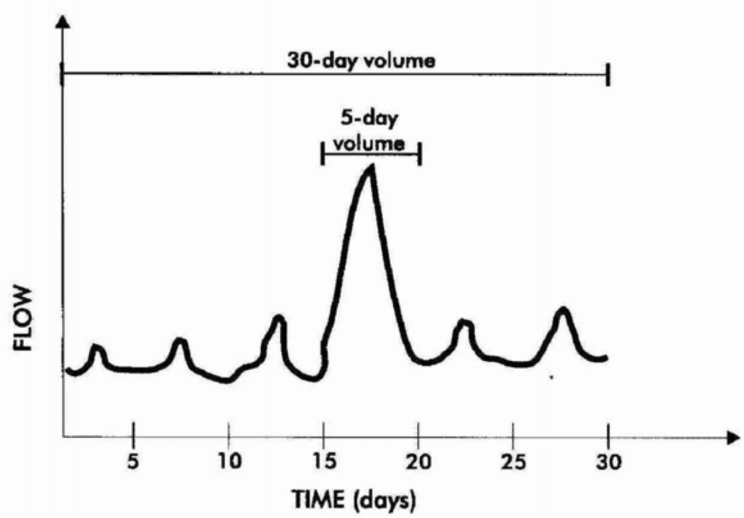
Full natural flow volumes were developed for each of 7 synthetic exceedence events on each tributary

Tributary-Specific Patterns



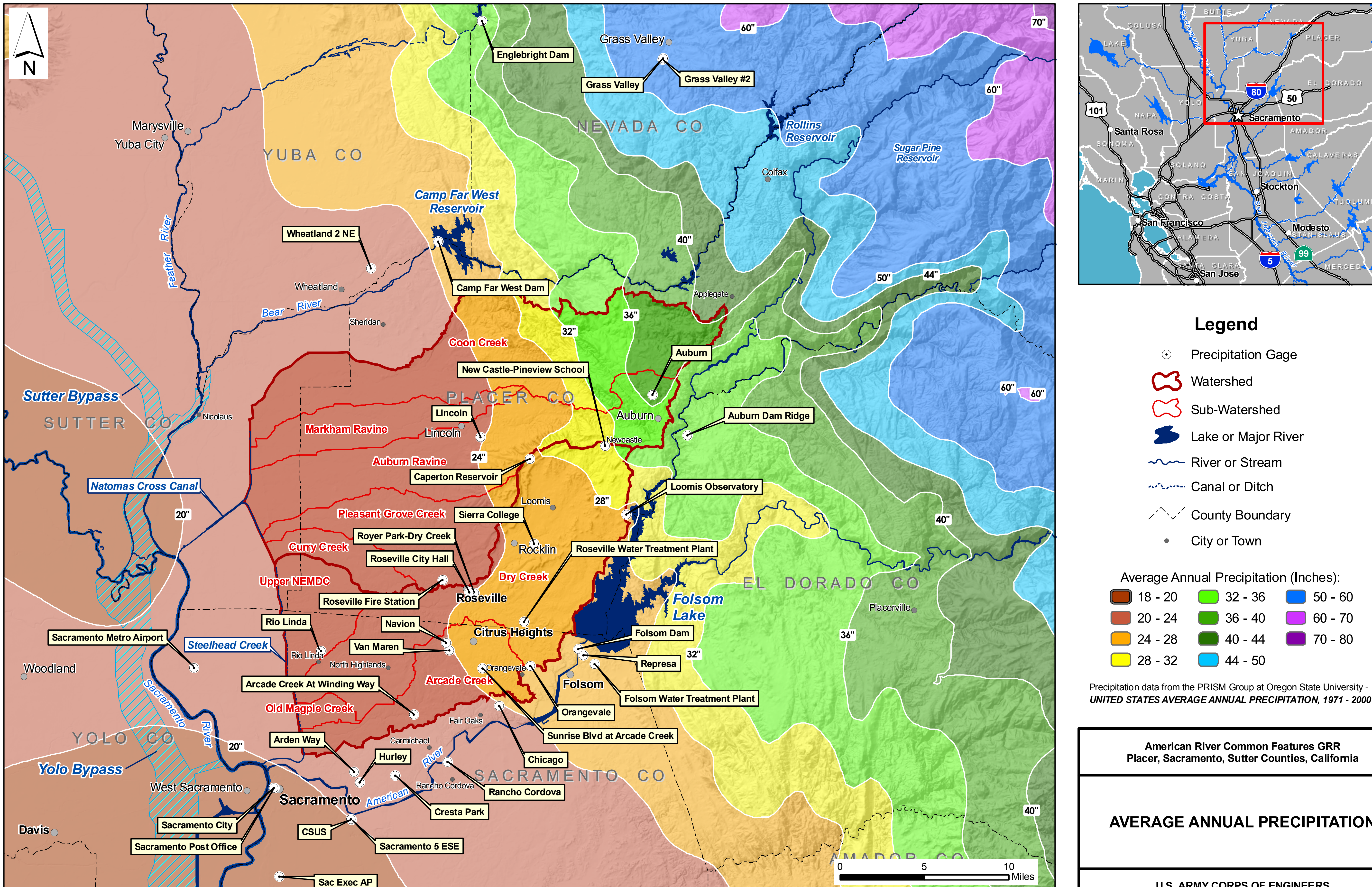
Tributary-specific hydrograph patterns were used to translate 5-day incremental volumes to flow patterns

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

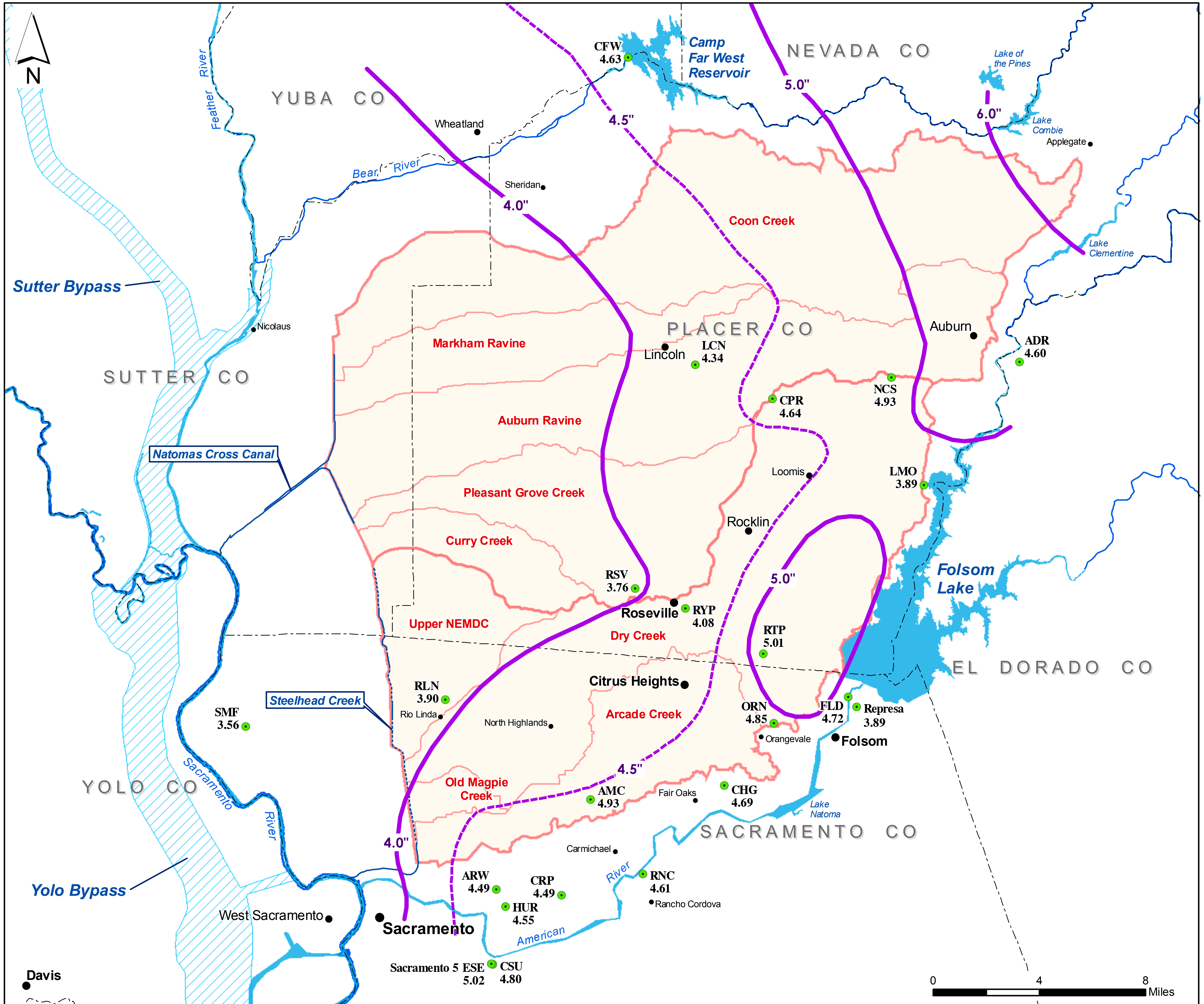


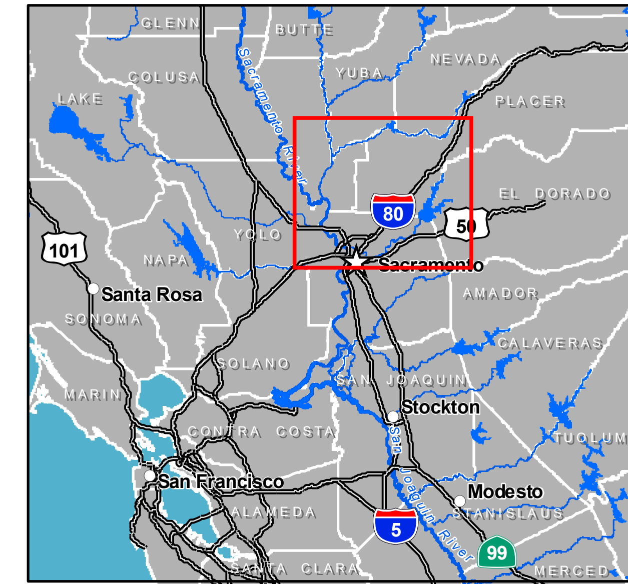
American River Common Features GRR
Placer, Sacramento, Sutter Counties, California

AVERAGE ANNUAL PRECIPITATION

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

SEP 2008 PLATE 4



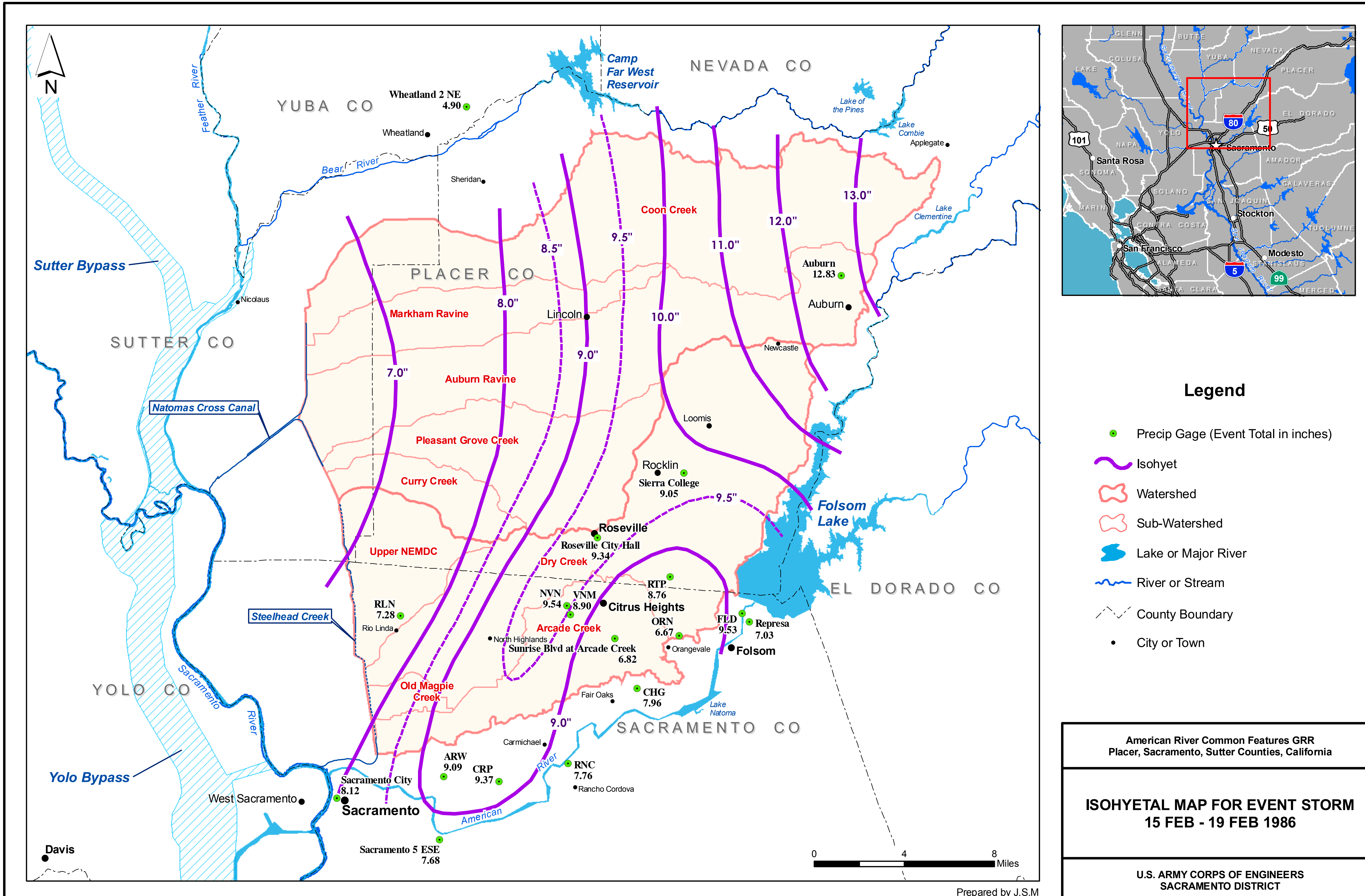


American River Common Features GRR
Placer, Sacramento, Sutter Counties, California

ISOHYETAL MAP FOR EVENT STORM
30 DEC 2005 - 2 JAN 2006

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

SEP 2008 PLATE 5



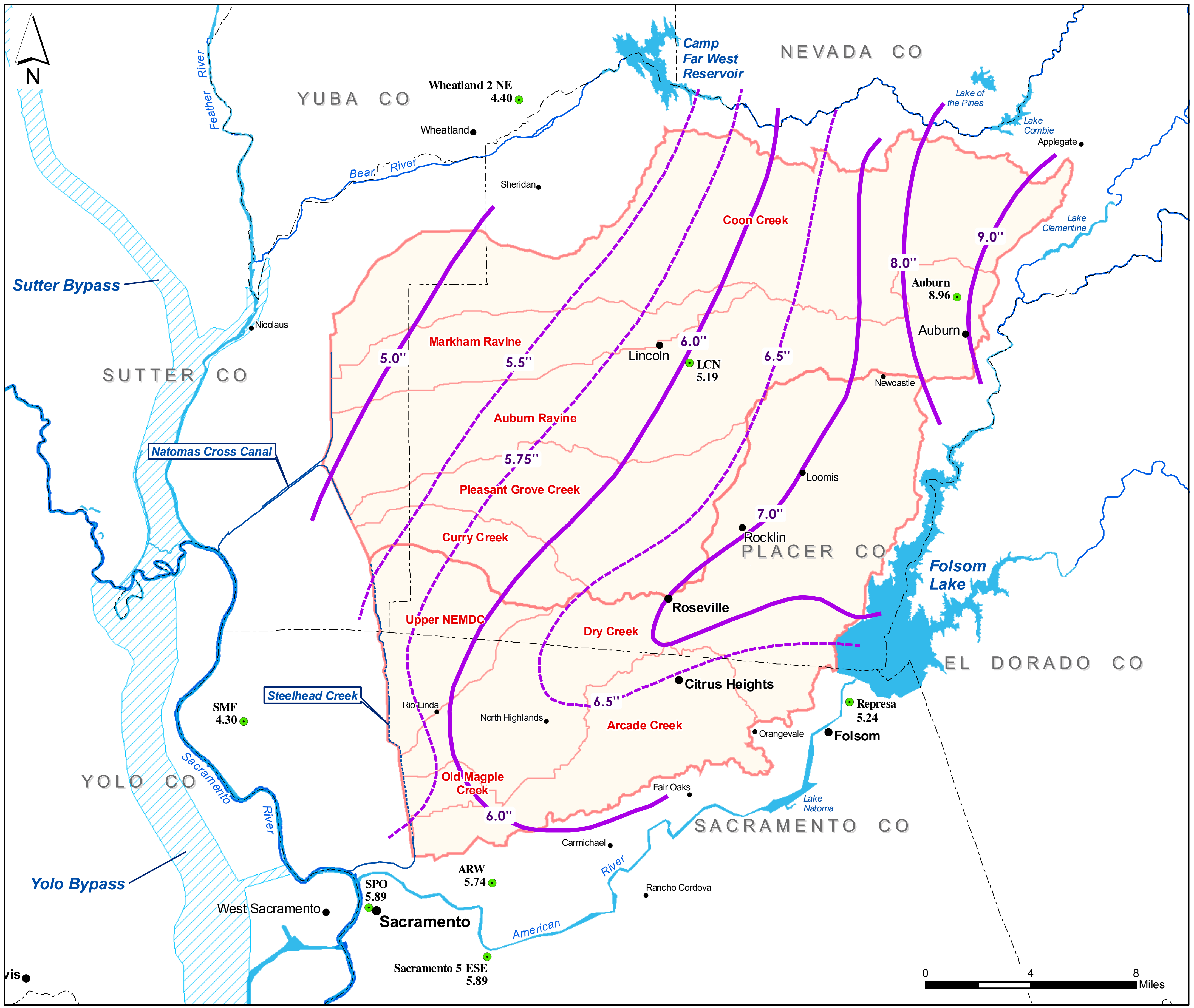
American River Common Features GRR
Placer, Sacramento, Sutter Counties, California

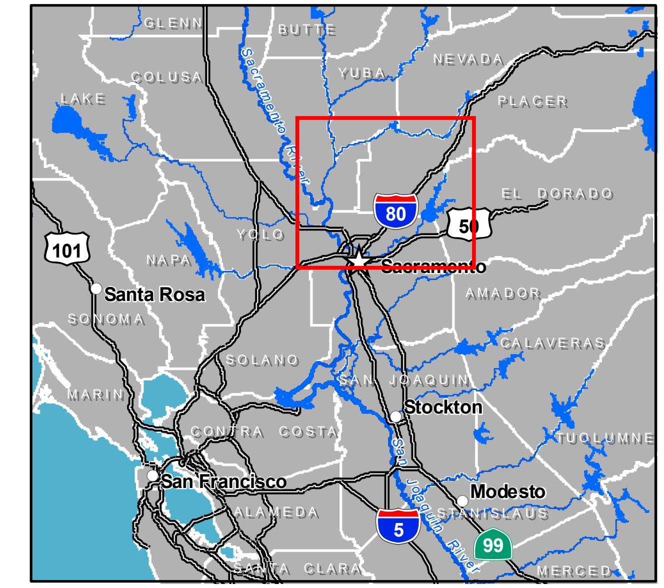
ISOHYETAL MAP FOR EVENT STORM 15 FEB - 19 FEB 1986

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

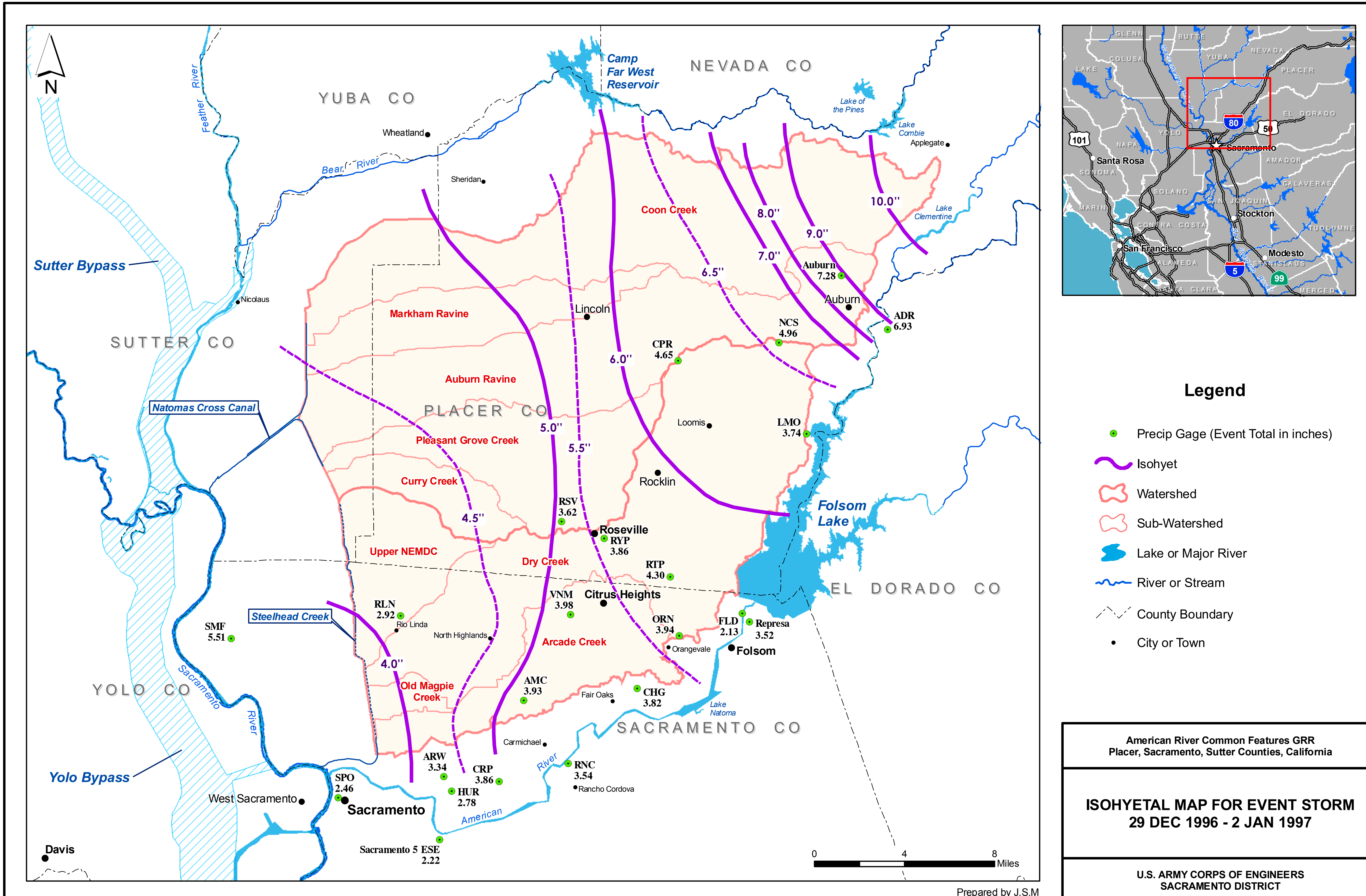
American River Common Features GRR
Placer, Sacramento, Sutter Counties, California

ISOHYETAL MAP FOR EVENT STORM 8 JAN - 12 JAN 1995

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

SEP 2008

PLATE 7

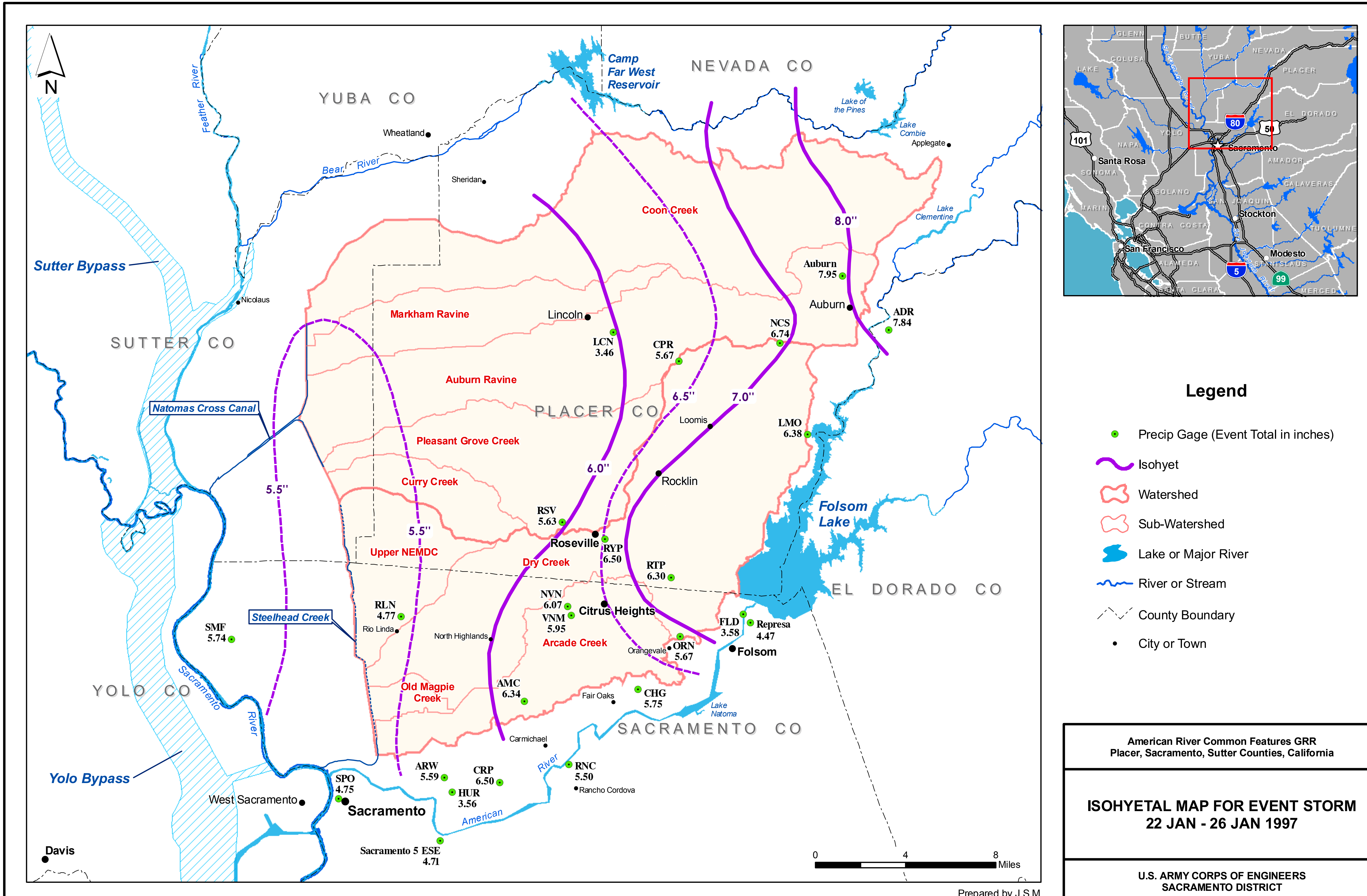


American River Common Features GRR
Placer, Sacramento, Sutter Counties, California

ISOHYETAL MAP FOR EVENT STORM 29 DEC 1996 - 2 JAN 1997

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

SEP 2008

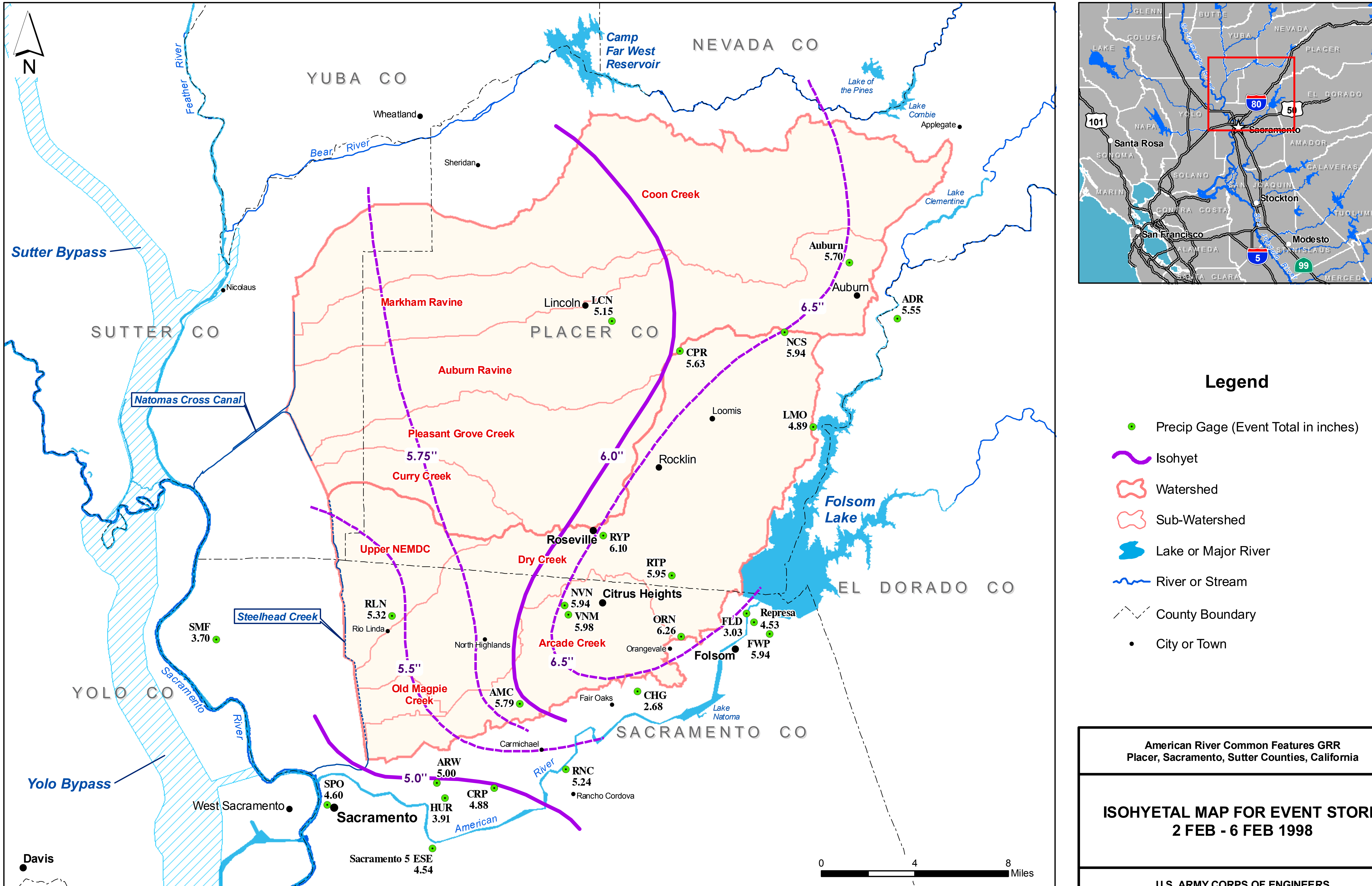


American River Common Features GRR
Placer, Sacramento, Sutter Counties, California

ISOHYETAL MAP FOR EVENT STORM 22 JAN - 26 JAN 1997

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

SEP 2008



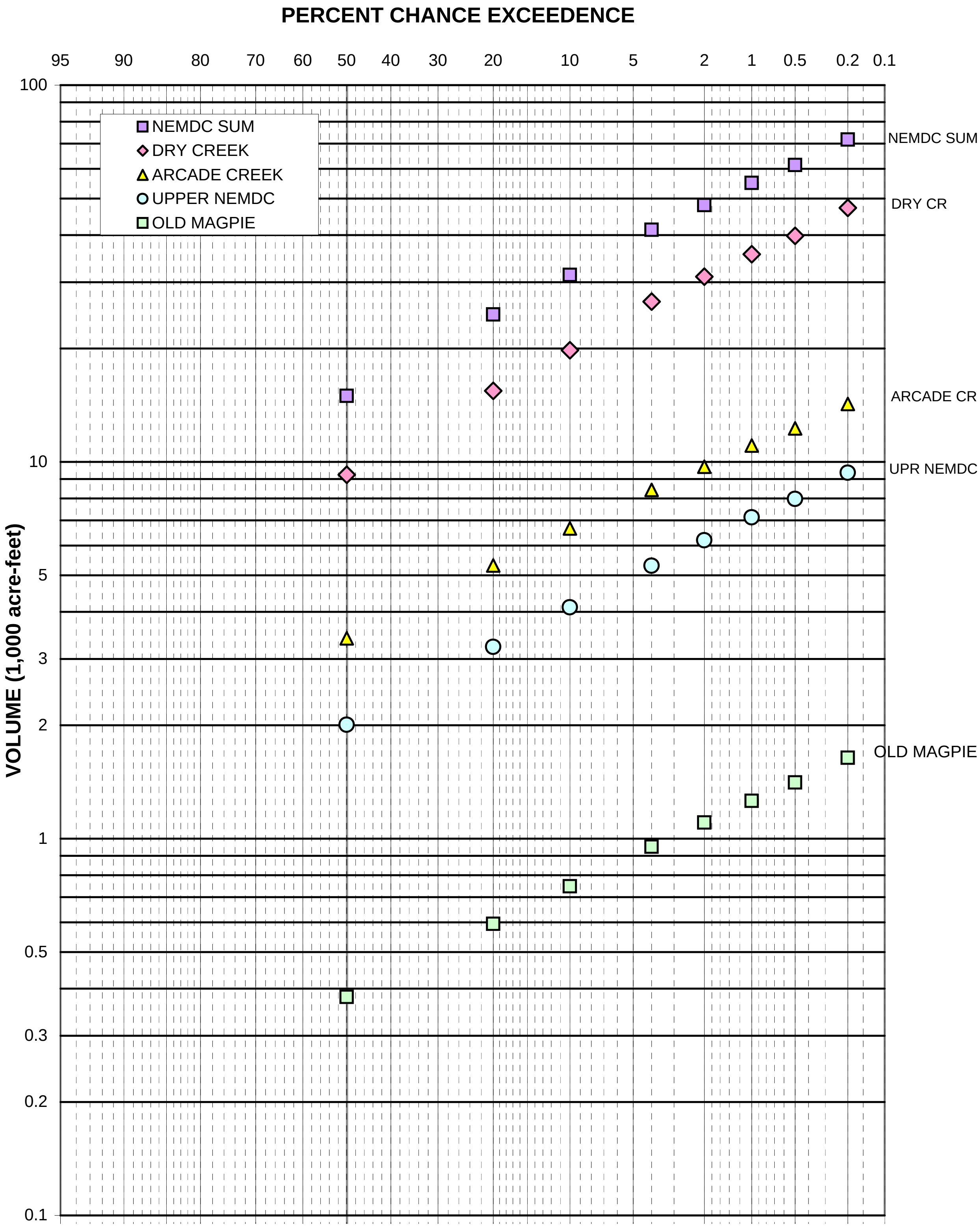
Prepared by J.S.M

American River Common Features GRR
Placer, Sacramento, Sutter Counties, California

ISOHYETAL MAP FOR EVENT STORM
2 FEB - 6 FEB 1998

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

SEP 2008



NOTES:

Dry Creek 116.48 sq. mi.

Arcade Creek 40.14 sq. mi.

Upper NEMDC 27.13 sq. mi.

Old Magpie Sum 4.57 sq. mi.

NEMDC Sum 188.32 sq. mi.

Developed by LLW and prepared by JLB

AMERICAN RIVER COMMON FEATURES GRR

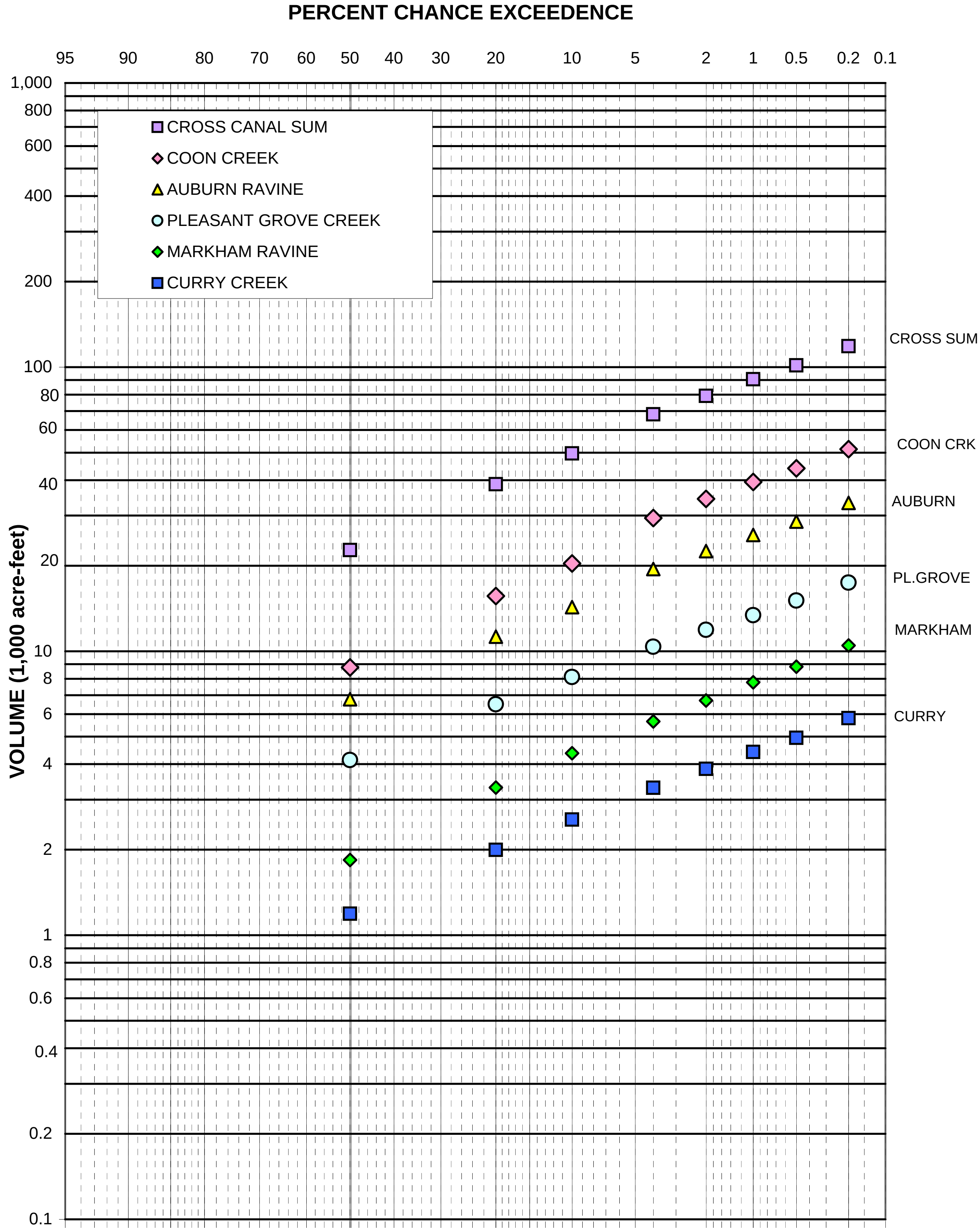
PLACER, SACRAMENTO, SUTTER COUNTIES, CALIFORNIA

5-DAY VOLUME FREQUENCY CURVES
STEELHEAD CREEK DRAINAGE

U.S. ARMY CORPS OF ENGINEERS

SACRAMENTO DISTRICT

SEP 2008



NOTES:

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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.

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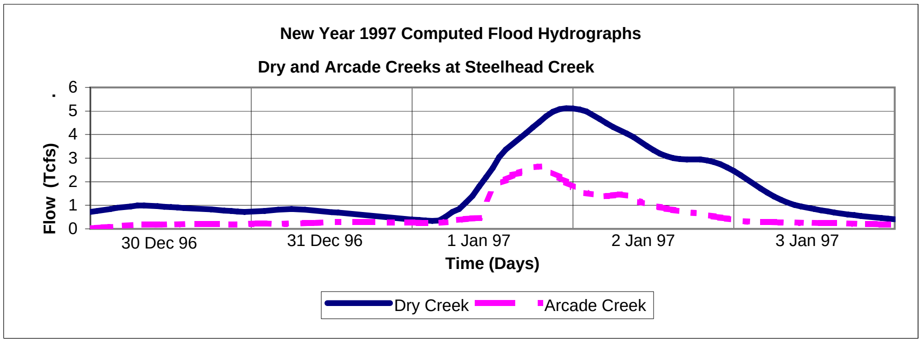
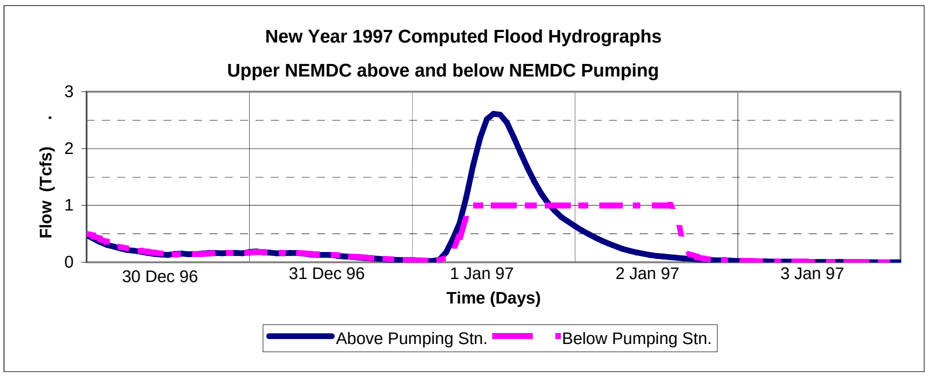
AMERICAN RIVER COMMON FEATURES GRR
PLACER, SACRAMENTO, SUTTER COUNTIES, CALIFORNIA

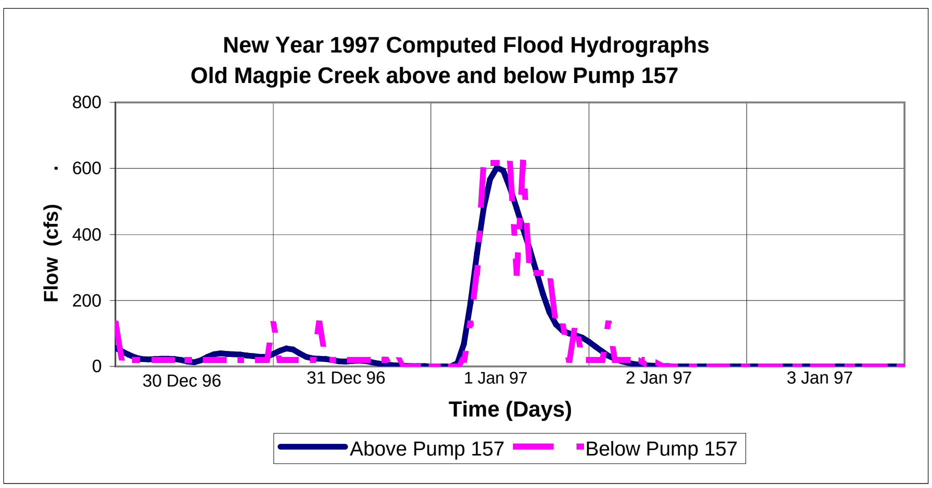
5-DAY VOLUME FREQUENCY CURVES
CROSS CANAL TRIBUTARIES

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

SEP 2008



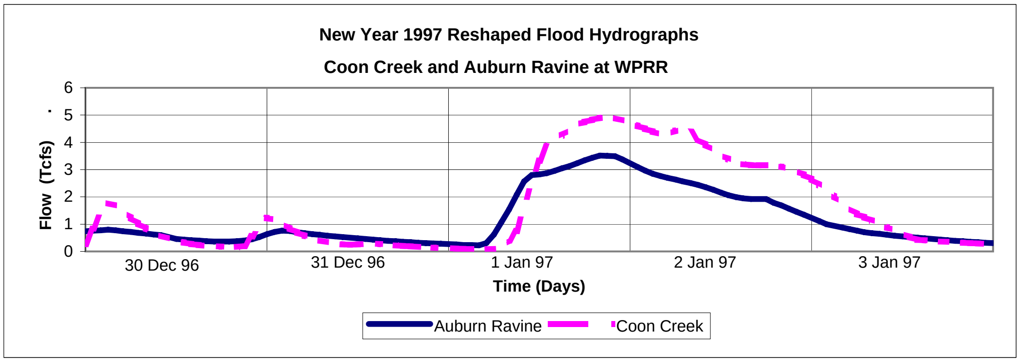


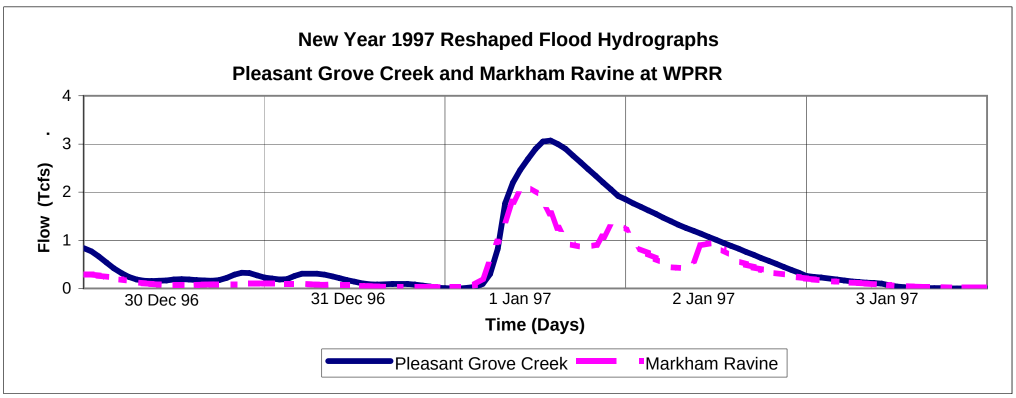


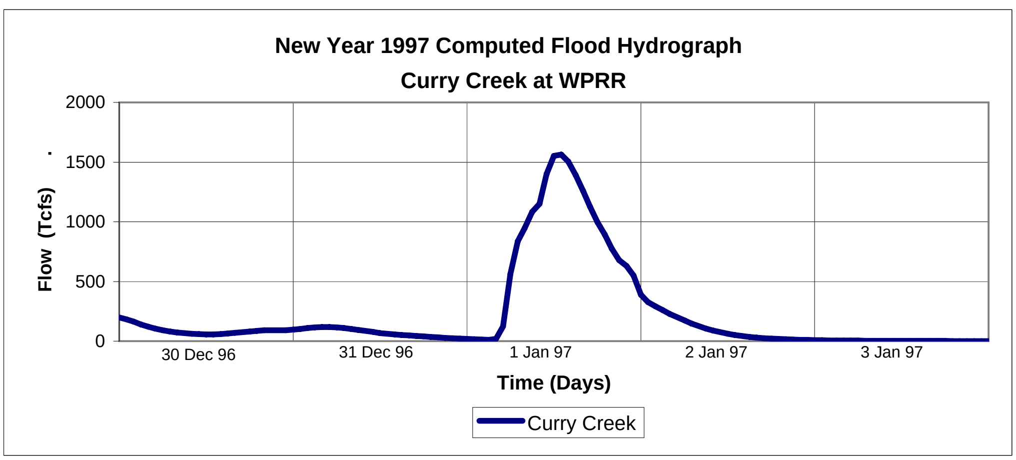
AMERICAN RIVER COMMON FEATURES GRR
PLACER, SACRAMENTO, SUTTER COUNTIES, CALIFORNIA

COMPUTED AND RESHAPED HYDROGRAPHS FOR FOR NEW YEAR 1997 FLOOD EVENT STEELHEAD CREEK TRIBUTARIES

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



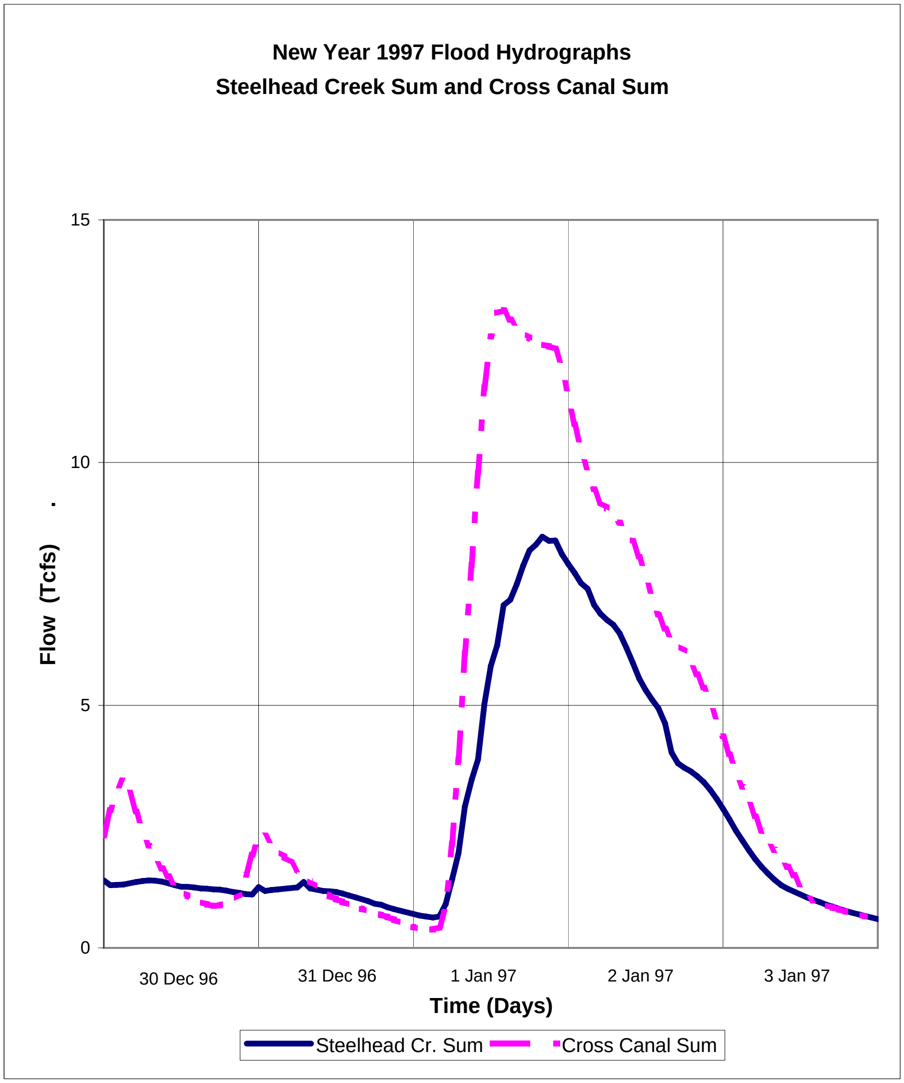




AMERICAN RIVER COMMON FEATURES GRR
PLACER, SACRAMENTO, SUTTER COUNTIES, CALIFORNIA

COMPUTED AND RESHAPED HYDROGRAPHS FOR FOR NEW YEAR 1997 FLOOD EVENT NATOMAS CROSS CANAL TRIBUTARIES

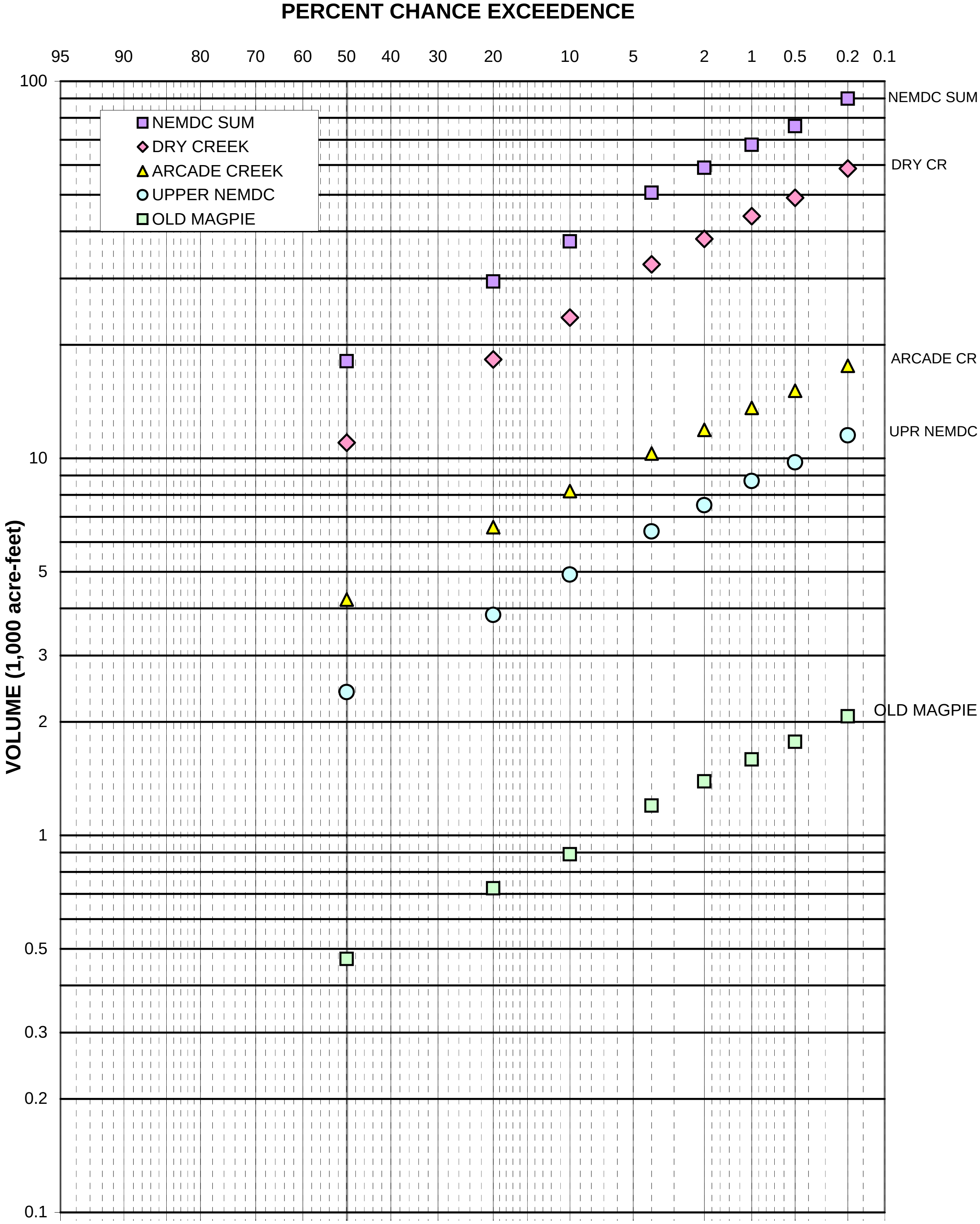
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



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



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Old Magpie Sum 4.57 sq. mi.

NEMDC Sum 188.32 sq. mi.

Developed by LLW and prepared by JLB

AMERICAN RIVER COMMON FEATURES GRR

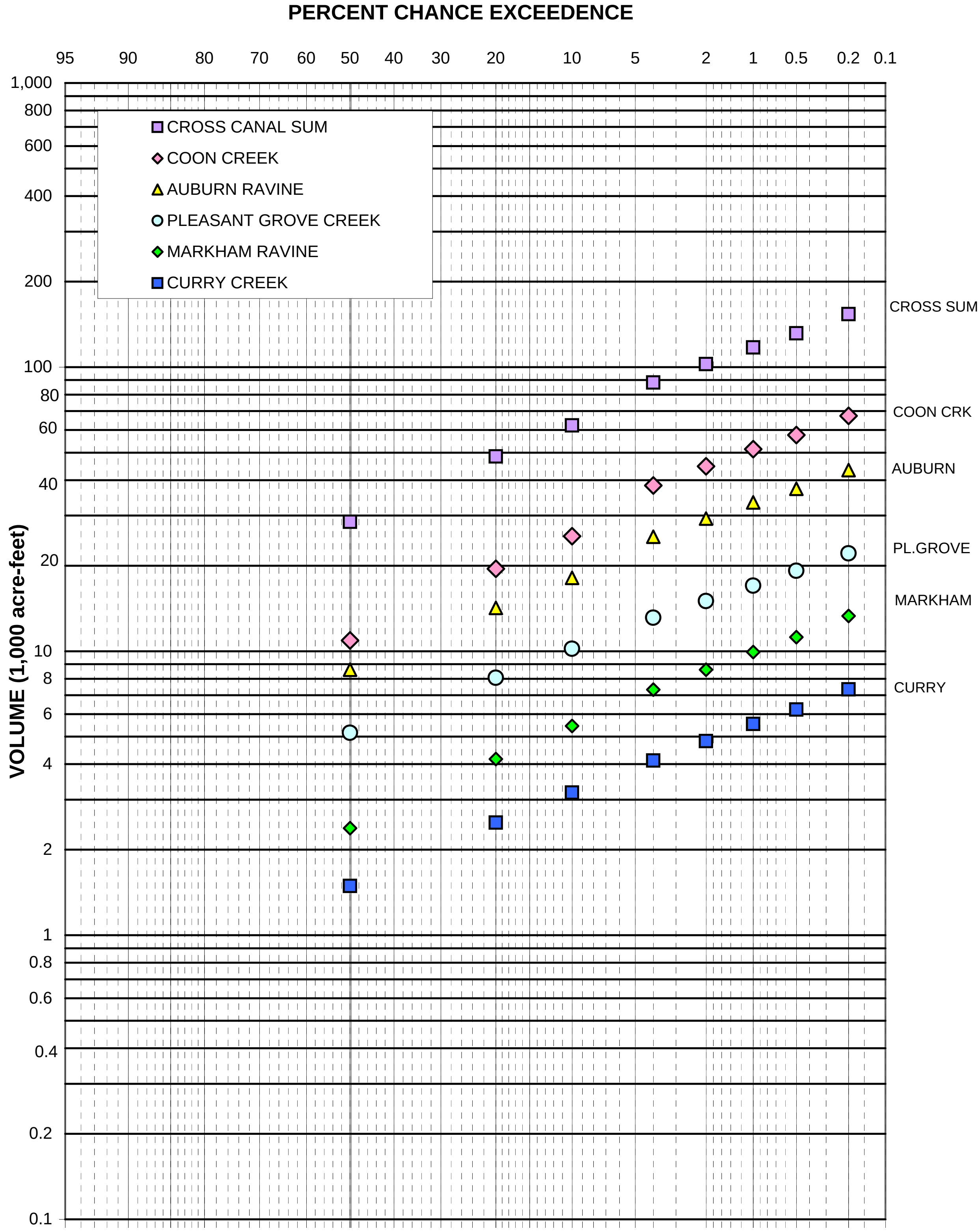
PLACER, SACRAMENTO, SUTTER COUNTIES, CALIFORNIA

10-DAY VOLUME FREQUENCY CURVES
STEELHEAD CREEK DRAINAGE

U.S. ARMY CORPS OF ENGINEERS

SACRAMENTO DISTRICT

SEP 2008



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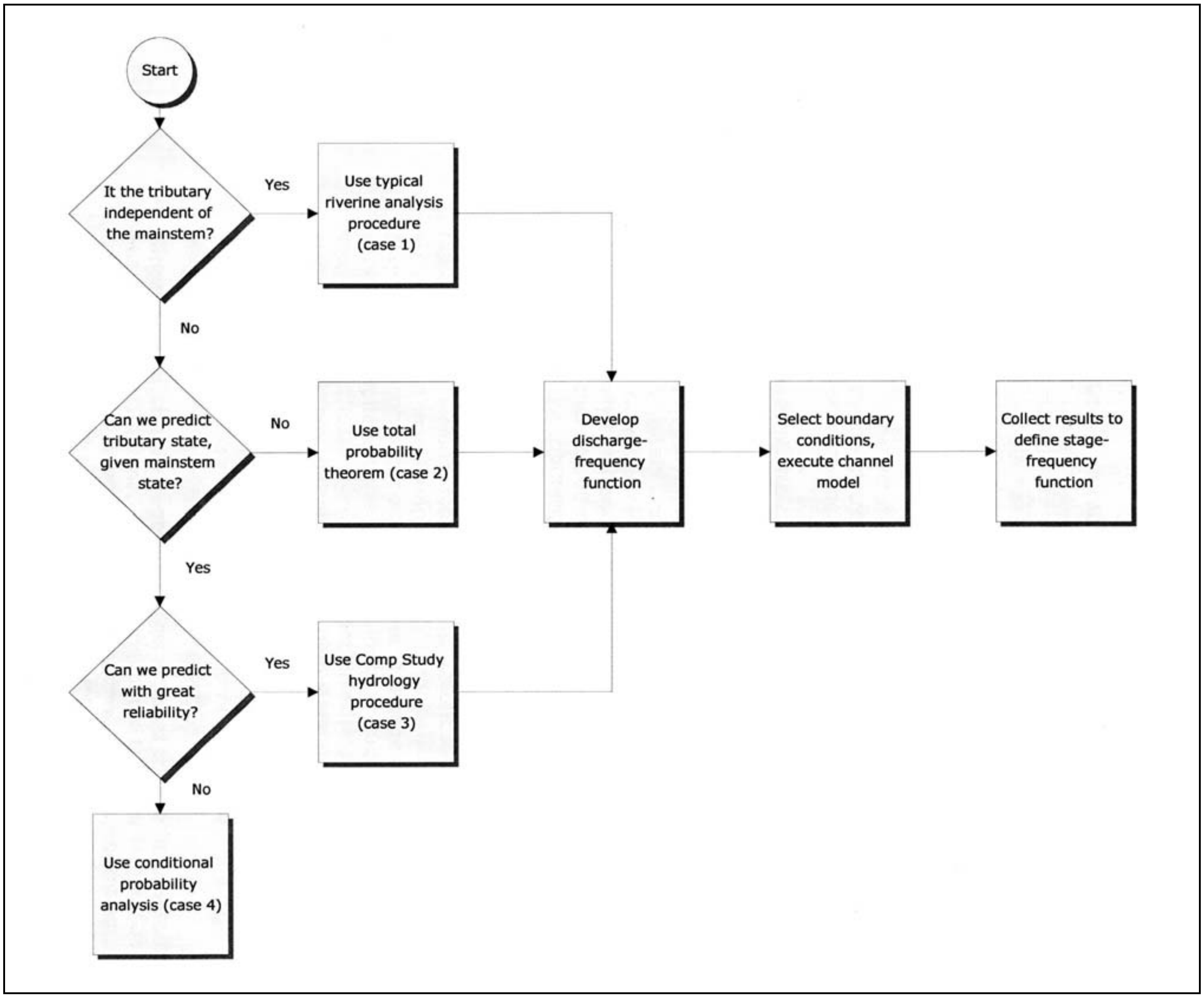
AMERICAN RIVER COMMON FEATURES GRR
PLACER, SACRAMENTO, SUTTER COUNTIES, CALIFORNIA

10-DAY VOLUME FREQUENCY CURVES
CROSS CANAL TRIBUTARIES

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

SEP 2008



Overview Flowchart for Tributary Analysis Procedure

American River Watershed
Common Features Project
Natomas Post-Authorization Change Report

American River Hydrology
&
Folsom Dam Reservoir Operations

APPENDIX B2

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FIGURES

TABLES

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.

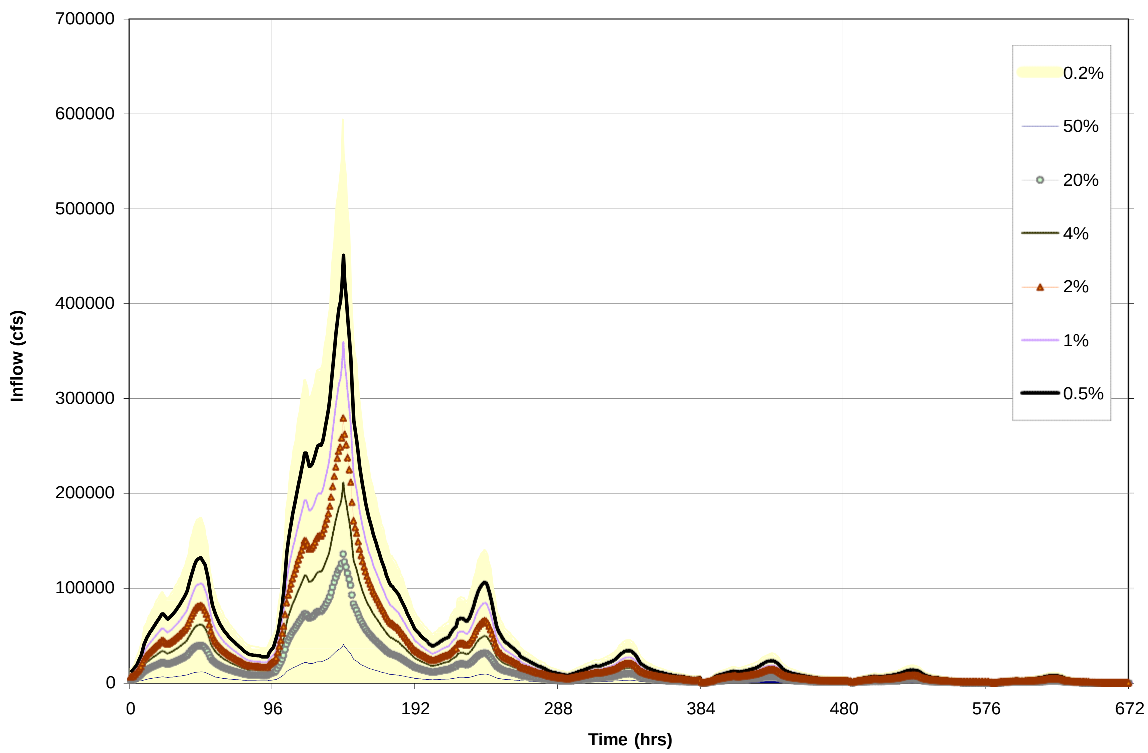

FIGURE A-1
FLOOD HYDROGRAPHS

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 [ŧ]

1-in-N chance per year event	WO1 (Flood Pool 470.0 ft)		WO2 (Flood Pool 470.0 ft)		WO3 (Flood Pool 470.0 ft)		NA1-145 (Flood Pool 470.0 ft)		NA2-145 (Flood Pool 466.0 ft)		NA3-145 (Flood Pool 471.5 ft)		W1-160 (Flood Pool 470.0 ft)		W2-160 (Flood Pool 466.0 ft)		W3-160 (Flood Pool 471.5 ft)	
	Max WS (El, ft)	Peak Outflow (cfs)	Max WS (El, ft)	Peak Outflow (cfs)	Max WS (El, ft)	Peak Outflow (cfs)	Max WS (El, ft)	Peak Outflow (cfs)	Max WS (El, ft)	Peak Outflow (cfs)	Max WS (El, ft)	Peak Outflow (cfs)	Max WS (El, ft)	Peak Outflow (cfs)	Max WS (El, ft)	Peak Outflow (cfs)	Max WS (El, ft)	Peak Outflow (cfs)
2	403.93	30295	403.53	37708	403.53	37708	402.43	30183	403.18	25215	403.18	25215	403.08	25891	401.91	37708	403.18	25215
10	429.80	43692	408.97	90000	408.97	90000	429.13	43127	421.65	71655	421.65	71655	431.09	43519	421.65	71655	421.65	71655
25	442.53	98760	427.80	90000	427.80	90000	442.69	99738	431.43	115000	431.43	115000	444.54	104311	432.02	115000	432.02	115000
50	457.34	115000	443.02	115000	443.02	115000	457.01	115000	442.97	115000	442.97	115000	459.13	115000	444.04	115000	444.04	115000
100	476.35	123107	461.00	115000	461.00	115000	470.81	145000	460.46	115000	460.46	115000	472.32	145000	461.31	115000	461.31	115000
200	476.33	444310	476.65	169173	478.67	138359	476.40	320142	470.02	210332	474.92	145000	476.37	321017	470.02	196633	472.47	160000
250	476.65	476319	475.23	331691	477.27	232803	476.67	412114	470.65	309673	477.90	197562	476.64	408551	470.44	296022	477.15	193667
500	479.62	554268	480.97	627077	481.31	510279	479.01	512982	472.08	594159	478.32	558062	479.04	513195	471.57	594159	478.03	534386

Notes:

ŧ *The gray shaded area depicts encroachment into the remaining surcharge storage space above the "Flood Pool" mark; Dam Safety operation takes the highest priority above the "Flood Pool" mark.*

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A-7 Risk Analysis (HEC- FDA Inputs)

Corps engineering guidance (EM 1110-2-1619, “Risk-Based Analysis for Flood Damage Reduction Studies”) and planning guidance (ER 1105-2-100, “Periodic Inspection and Continuing Evaluation of Completed Civil Works Structures” and ER 1105-2-101, “Risk Analysis for Flood Damage Reduction Studies”) require that risk analyses be used to quantify the project performance of the various scenarios. The hydrologic data provided to Economics as input for the HEC-FDA program includes the unregulated inflow exceedance probability function and the curves defining the relationship between unregulated inflow and reservoir discharge. The uncertainty in the hydrology is defined by the confidence limits, derived via statistics. The uncertainty in reservoir discharge is derived by changing the parameters used in the reservoir routings. The risk analysis scenarios reflect the operating conditions ranging from the most likely to occur (BASE) to the most extreme operating conditions likely to produce the largest (MAXIMUM) or smallest (MINIMUM) expected release. The BASE condition assumptions and results are previously described for the W01, W02, W03, NA1, NA2, and NA3 scenarios. Generally, the operational criteria are developed based on actual flood operations, the analysis of historical data, and discussion between representatives of the Corps, SAFCA, and Reclamation. **Table A-4** presents selected assumptions used to create the different scenarios.

TABLE A-4: RISK ANALYSIS OPERATIONAL ASSUMPTIONS [1, 2]

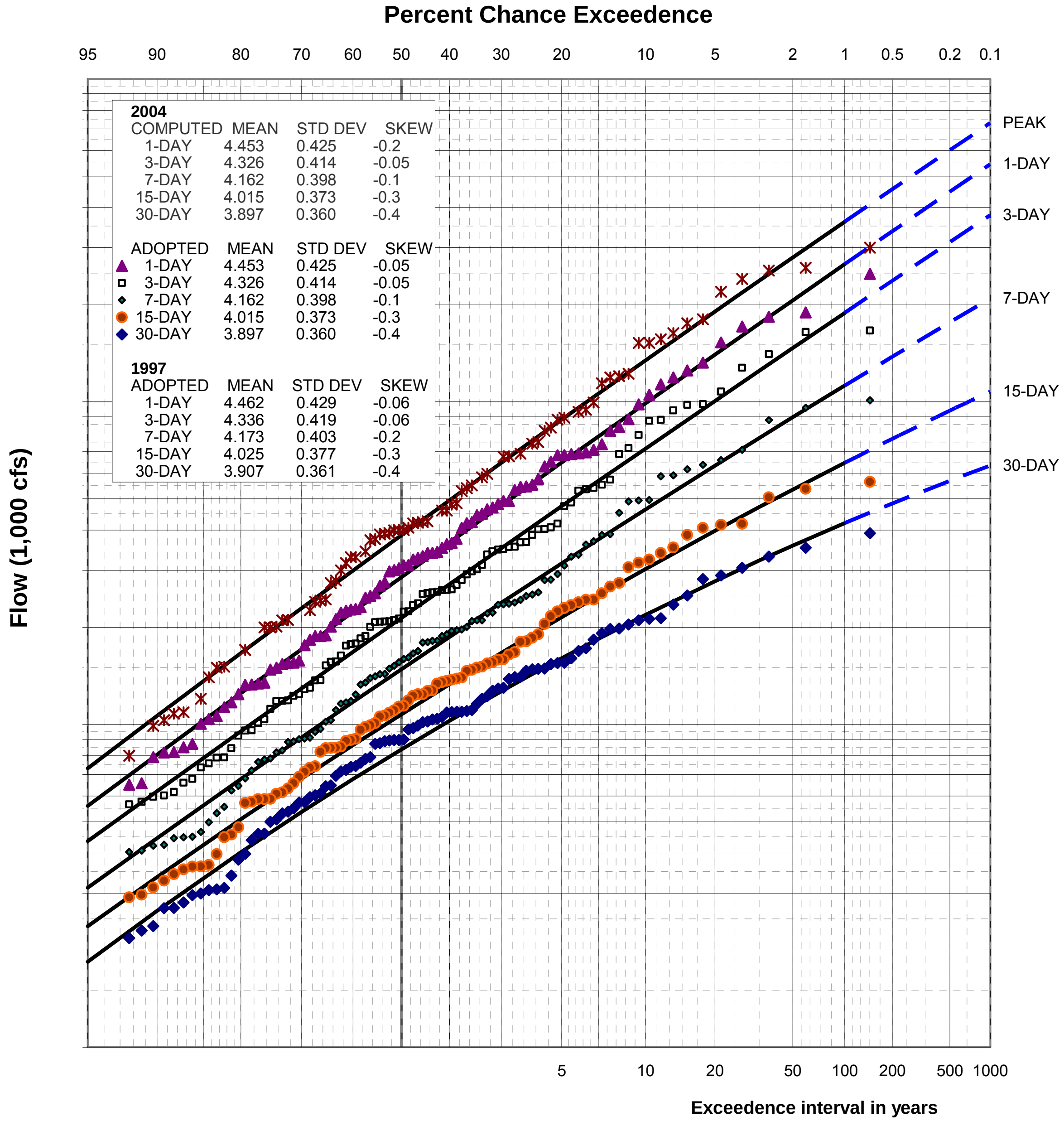
Uncertainty Parameters	Alternative	Discharge Scenario		
		BASE (Normal)	MAXIMUM (Upper Limit)	MINIMUM (Lower Limit)
Initial Encroachment [3] (acre-feet)	WO & NA	0	50,000	0
Extra Space in Folsom Lake (acre-feet)	WO & NA	0	0	100,000
Available Upstream Reservoir Space (acre-feet)	WO & NA	0	0	150,000
Starting Storage (acre-feet)	WO & NA	367,000	417,000	429,000
Response Time Delay [4] (hours)	WO	8	8	8
	NA	4	8	0
Main Dam River Outlets Operation During Concurrent Spillway Operation (percent gate opening)	WO & NA	60	0	60
KEY Cfs – cubic feet per second				

Notes:
1. *Discharge is presumed through only one power penstock due to maintenance work during the flood season (per Reclamation).*
2. *Application of the uncertainty parameters may sometimes result in anomalies for the smaller or more frequent events. The settings meant to induce the largest or smallest discharge may actually result in the reverse. This issue appears intermittently.*
3. *Encroachment is relative to the allowable storage as determined from the water control diagram (dependent on upstream storage space).*
4. *Lag in matching Release to previous hour Inflow – while discharge is less than the normal objective release target.*

A-8 Conclusion

Water Management produced routings for two different scenarios. The without-project (WO) condition reflects the American River levee system prior to any improvements or repair work. The no-action (NA) condition reflects the existing state of the American River levees with the improvements made as authorized by WRDA 1996 and 1999. The NA condition will result in the ability of the downstream channel to sustain 145,000 cfs (or 160,000 cfs as reported in the 2007 PAC Report). The 50%-, 20%-, 4%-, 2%-, 1%-, 0.5%, 0.2%-annual chance flood events were routed through Folsom Dam for the various WO and NA scenarios. The routing results were given to Hydraulic Design for the floodplains development and to Economics for the economic benefit analyses. The hydrographs provided to Hydraulic Design are shown in **Figures A-4 through A-6**.

Figure A-10 through A-23 provides a snapshot of the data provided to Economics in a variety of ways. **Figure A-10 through A-13** presents the set of WO, NA, and W results (BASE condition only) as regulated frequency curves. This allows one to view the increase in project performance as improvements are made to Folsom Dam. **Figure A-14** consolidates the results of all the routings (BASE condition only) as “inflow versus outflow curves” to allow comparisons across the different set of routings. **Figure A-15 through A-23** presents the uncertainty band around the discharge for any given event. Note that the uncertainty range required some adjustment around the more frequent event where the points crossed. Generally, the anomalies (MAX < BASE < MIN) where the points cross occur for events with less than 1-in-5 yr chance exceedance. In these instances, the MAX discharge is lower than BASE due to the inability to match inflow quickly (8 hour lag). This handicap is a benefit or plus for the smaller flood events. The MIN discharge is large than BASE due to the ability to match inflow quickly (1 hour lag). This advantage (rapid response) is a detriment or negative for the smaller, more frequent events. The initial starting storage also is a factor in this aspect. A full summary of the routings can be found in **Tables A-5** through **A-31**. The reservoir routings covered herein were developed for planning purposes only. These scenarios are hypothetical and would not be built or implemented as stand-alone projects. All reservoir elevations provided herein use the NGVD29 vertical datum.



NOTES:

1. Adjusted USGS gage 11446500 to account for daily change in storage at upstream reservoirs (potential channel, out-of-channel, or storage losses neglected).
2. Median plotting positions.
3. Computed Probability
4. No adjustments for outliers.
4. Drainage area: 1,888 sq. mi.
5. Period of record: 1905-2004.

AMERICAN RIVER WATERSHED PROJECT

COMMON FEATURES

GENERAL REEVALUATION REPORT

RAIN FLOOD FREQUENCY CURVES
AMERICAN RIVER AT FAIR OAKS
UNREGULATED CONDITIONS

FIGURE A-2

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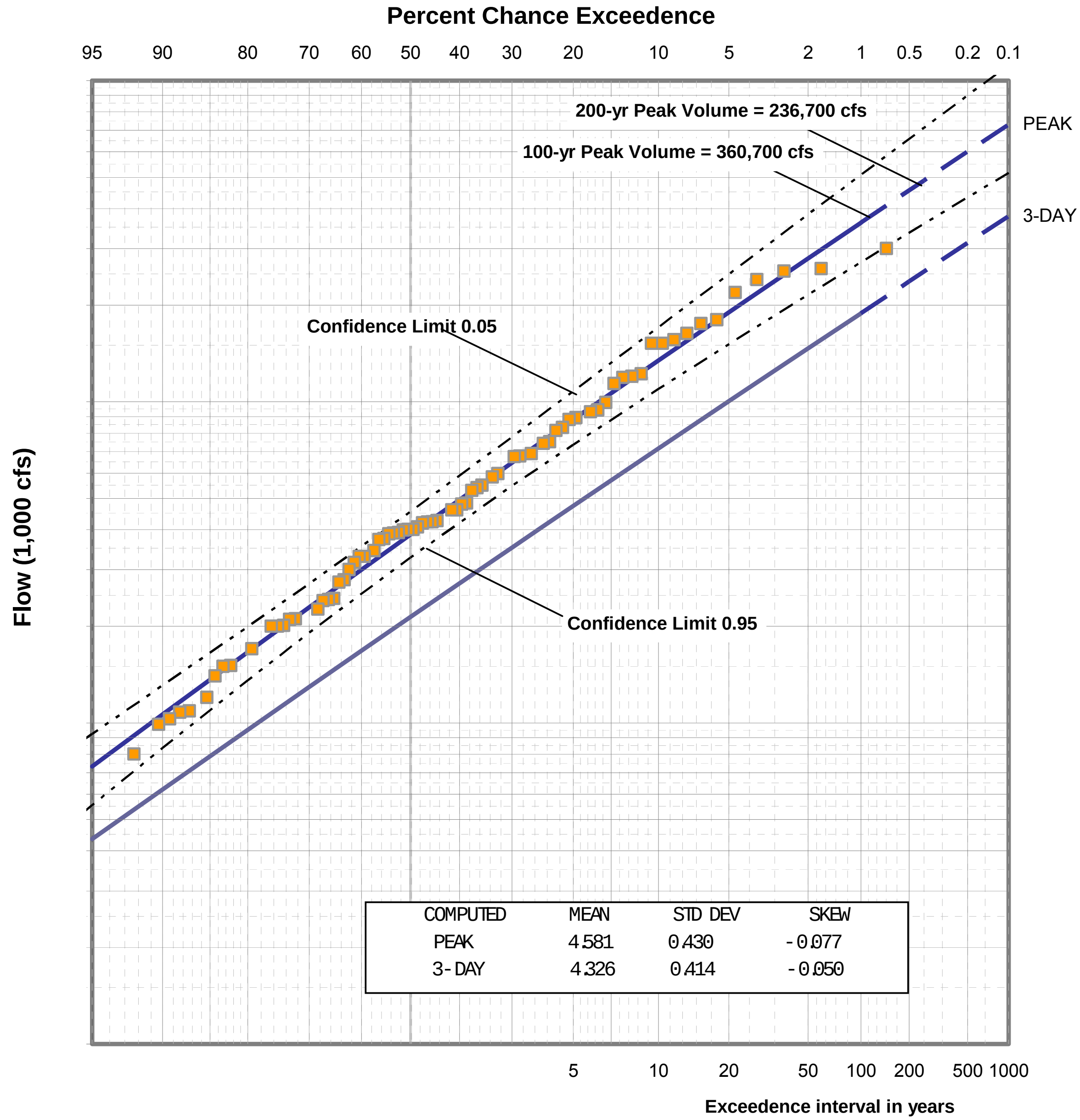

NOTES:

1. Adjusted USGS gage 11446500 to account for daily change in storage at upstream reservoirs (potential channel, out-of-channel, or storage losses neglected).
2. Median plotting positions.
3. Computed Probability
4. No adjustments for outliers.
5. Confidence limits based on station statistics
6. Drainage area: 1,888 sq. mi.
7 Period of record: 1905-2004.

AMERICAN RIVER WATERSHED PROJECT
COMMON FEATURES

UNREGULATED PEAK AND MEAN 3-DAY RAIN FLOOD FREQUENCY CURVES AMERICAN RIVER AT FAIR OAKS

FIGURE A-3

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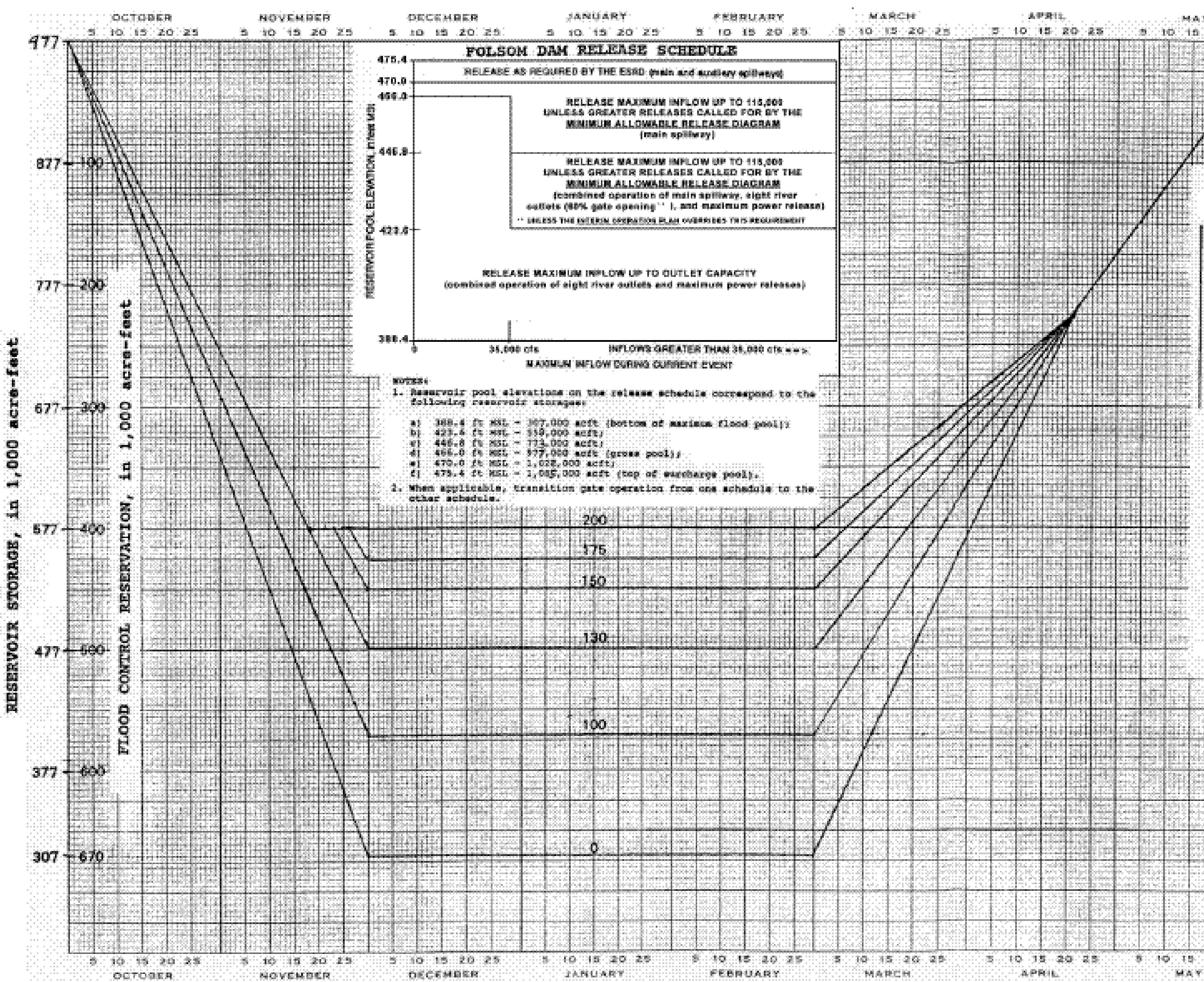

FLOOD CONTROL DIAGRAM FOR FOLSOM DAM AND LAKE

USE OF DIAGRAM

1. Folsom Dam and Lake shall be operated for flood control in accordance with the Flood Control Diagram. When water is stored within the Flood Control Reservation, reservoir releases must be in accordance with requirements of this diagram.
2. The parameters on the flood control diagram define the required Flood Control Reservation, on any given day, based on available space in the upstream reservoirs. Once the required Flood Control Reservation is computed, the Required Reservoir Storage for flood control can be determined. Water stored in excess of the Required Reservoir Storage must be evacuated. Computation of the parameter is discussed below:

FOLSOM DAM AND LAKE
COMPUTATION OF REQUIRED RESERVOIR STORAGE

1. Compute space available below spillway crest, in acre-feet, for the following reservoirs: French Meadows, Hell Hole and Union Valley.
2. The amount of creditable flood control transfer space in each reservoir is then computed by taking the smaller of the space available or the maximum creditable space for that reservoir.
   a. The maximum creditable space by reservoir is as follows:
      French Meadows - 45,000 acre-feet
      Hell Hole - 80,000 acre-feet
      Union Valley - 75,000 acre-feet
   b. Combine the creditable flood control transfer space for each reservoir to compute the total creditable space.
3. Determine the Flood Control Reservation at Folsom Lake by applying the creditable flood control transfer space (parameter on the Flood Control Diagram in 1,000 acre-feet).

SAMPLE COMPUTATION OF REQUIRED RESERVOIR STORAGE

RESERVOIR	STORAGE ON JAN 1 (TAF)	STORAGE AT SPILLWAY CREST (TAF)	SPACE AVAILABLE (TAF)	MAXIMUM CREDITABLE SPACE (TAF)	CREDITABLE FLOOD CONTROL TRANSFER SPACE (TAF)
French Meadows	75.7	110.7	35	45	35
Hell Hole	87.6	207.6	120	80	80
Union Valley	170.1	235.1	65	75	65
TOTAL CREDITABLE FLOOD CONTROL TRANSFER SPACE (TAF)					180
FLOOD CONTROL RESERVATION AT FOLSOM LAKE (TAF)					420
REQUIRED RESERVOIR STORAGE AT FOLSOM LAKE (TAF)					557

3. During a potential flood situation, water stored within the Flood Control Reservation, defined hereon, shall be released as rapidly as possible subject to the following schedule:
   a. Required Flood Control Release - Promptly release inflow up to 115,000 cfs, while inflows are increasing, as discussed in the FOLSOM DAM RELEASE SCHEDULE. Control flows in the American River below the dam to not more than 115,000 cfs, except when larger releases are required by the accompanying INTERIM OPERATION PLAN.
   b. Releases will not be increased more than 15,000 cfs or decreased more than 10,000 cfs during any 2 hour period.

4. Maintenance or repair of any one power generating unit at Folsom Dam which results in loss of the power penstock for more than one day may require additional Flood Control Reservation. The amount of additional reservation is defined by the Adjusted Required Reservoir Storage, as identified on the graph at right, depending on the following conditions:
   a. The Required Reservoir Storage in Folsom Lake, as computed in paragraph 2 above;
   b. The existing and forecasted meteorological conditions in the basin; and,
   c. The duration the generating unit is expected to be off-line.

Required Reservoir Storage greater than or equal to 525,000 acre-feet requires no additional Flood Control Reservation.

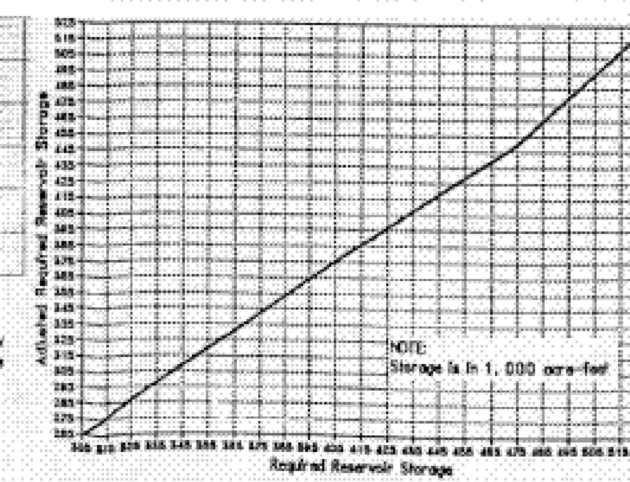

FIGURE A-4
WATER CONTROL DIAGRAM -- HISTORICAL
EXISTING CONDITION 400/670

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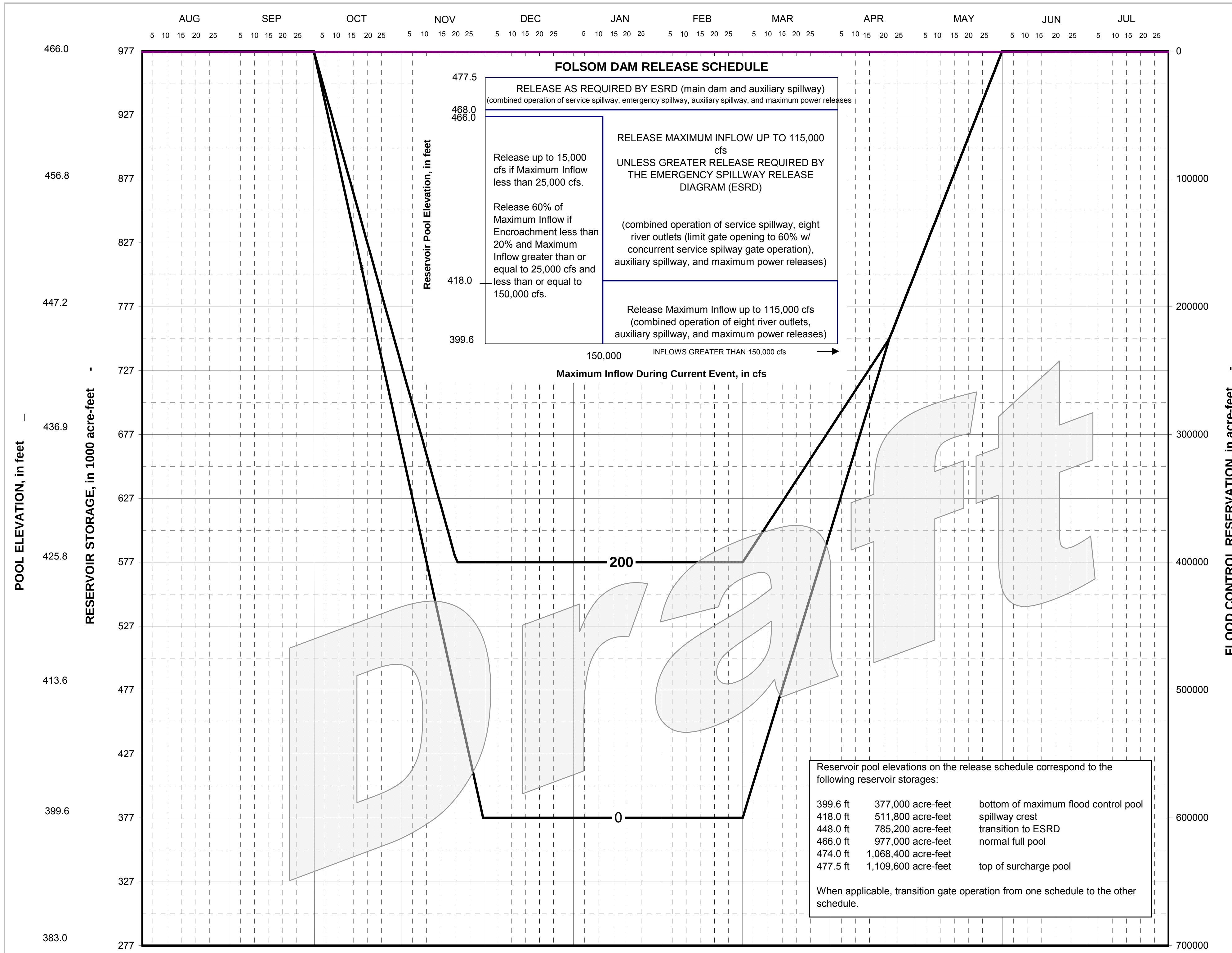

FLOOD CONTROL DIAGRAM

USE OF DIAGRAM

1. Folsom Dam and Lake shall be operated for flood control in accordance with the Flood Control Diagram. When water is stored within the Flood Control Reservation, reservoir releases must be in accordance with the requirements of this diagram.

2. The parameters on the flood control diagram define the required Flood Control Reservation, on any given day, based on available space in the upstream reservoirs. Once the required Flood Control Reservation is computed, the Required Reservoir Storage for flood control can be determined. Water stored in excess of the Required Reservoir Storage must be evacuated. Computation of the parameter is discussed below:

COMPUTATION OF REQUIRED FLOOD RESERVATION STORAGE

1. Compute space available below spillway crest, in acre-feet, for the following reservoirs: French Meadows, Hell Hole and Union Valley.

2. The amount of creditable flood control transfer space in each reservoir is then computed by taking the smaller of the space available or the maximum creditable space for that reservoir.

   a. The maximum creditable space by reservoir is as follows:
      French Meadows 45,000 acre-feet
      Hell Hole 80,000 acre-feet
      Union Valley 75,000 acre-feet

   b. Combine the creditable flood control transfer space for each reservoir to compute the total creditable space.

   c. Determine the Flood Control Reservation at Folsom Lake by applying the creditable flood control transfer space (parameter on the Flood Control Diagram in 1,000 acre-feet).

SAMPLE COMPUTATION OF REQUIRED RESERVOIR STORAGE

RESERVOIR	STORAGE ON JAN 1 (TAF)	STORAGE @ SPILLWAY CREST (TAF)	SPACE AVAILABLE (TAF)	MAXIMUM CREDITABLE SPACE (TAF)	CREDITABLE FLOOD CONTROL TRANSFER SPACE (TAF)
FRENCH MEADOWS	65.7	110.7	45	45	45
HELL HOLE	87.6	207.6	120	80	80
UNION VALLEY	160.1	235.1	75	75	75
TOTAL CREDITABLE FLOOD CONTROL TRANSFER SPACE (TAF)					200
FLOOD CONTROL RESERVATION AT FOLSOM LAKE (TAF)					577
REQUIRED RESERVOIR STORAGE AT FOLSOM LAKE (TAF)					577

RELEASE SCHEDULE

3. During a potential flood situation, water stored within the Flood Control Reservation, defined herein, shall be released as rapidly as possible subject to the following schedule:

   a. Required flood Control Release - Promptly release inflow up to 115,000 cfs while inflows are increasing, as discussed in the FOLSOM DAM RELEASE SCHEDULE. Control flows in the American River below the dam to not more than 115,000 cfs, except when larger releases are required by the accompanying EMERGENCY SPILLWAY RELEASE DIAGRAM (ESRD). Once the reservoir pool begins falling, maintain releases in excess of inflow until water stored in the Flood Control Reservation is evacuated.

   b. Releases will not be increased more than 30,000 cfs or decreased more than 10,000 cfs during any 2-hour period.

FIGURE A-5
WATER CONTROL DIAGRAM -- HYPOTHETICAL
FUTURE CONDITION 400/600

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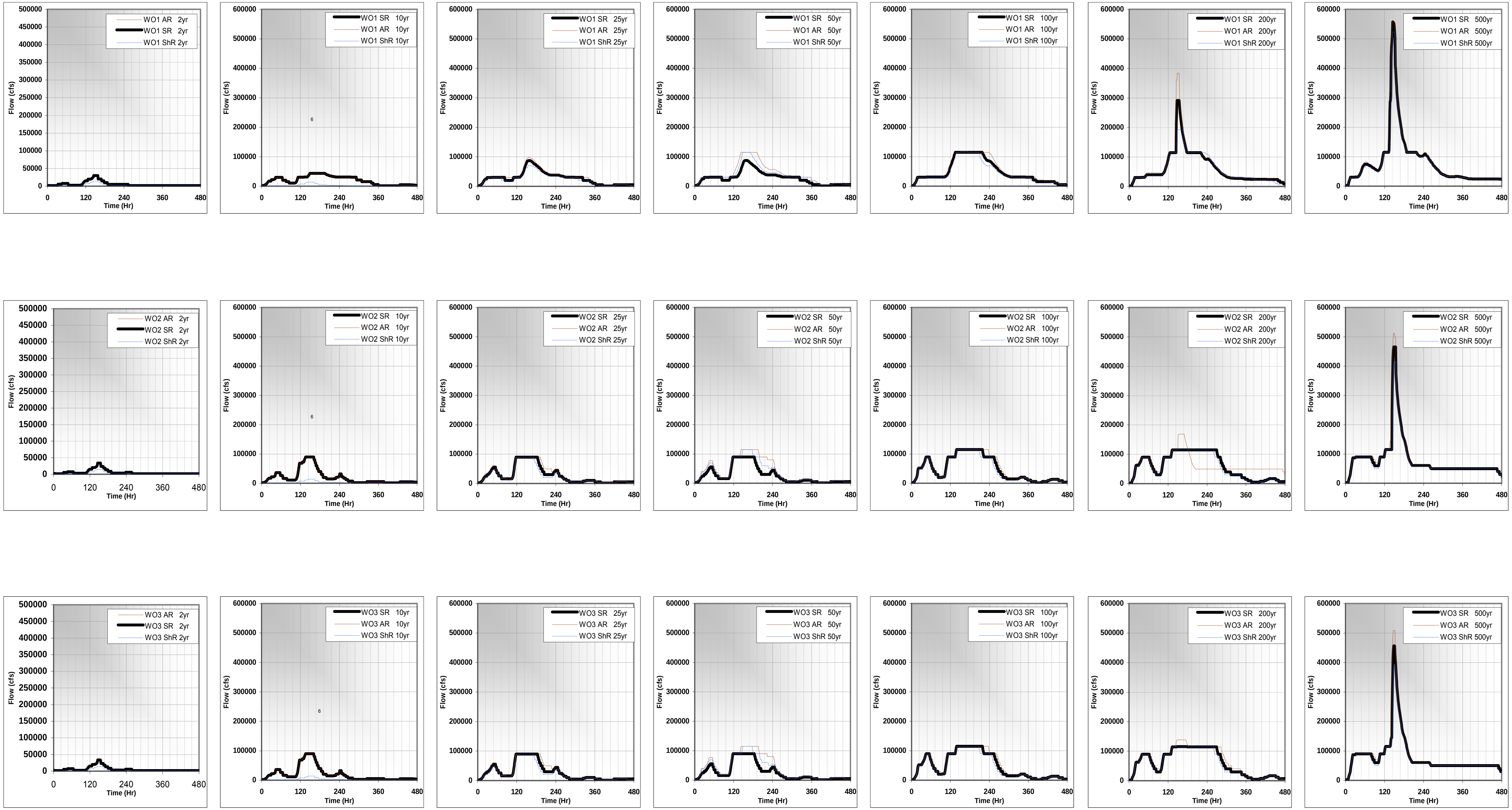

Key

SR Sacramento River
AR American River
ShR Shanghai River

FIGURE A-8: DISCHARGE HYDROGRAPHS – BASE – EXISTING CONDITION

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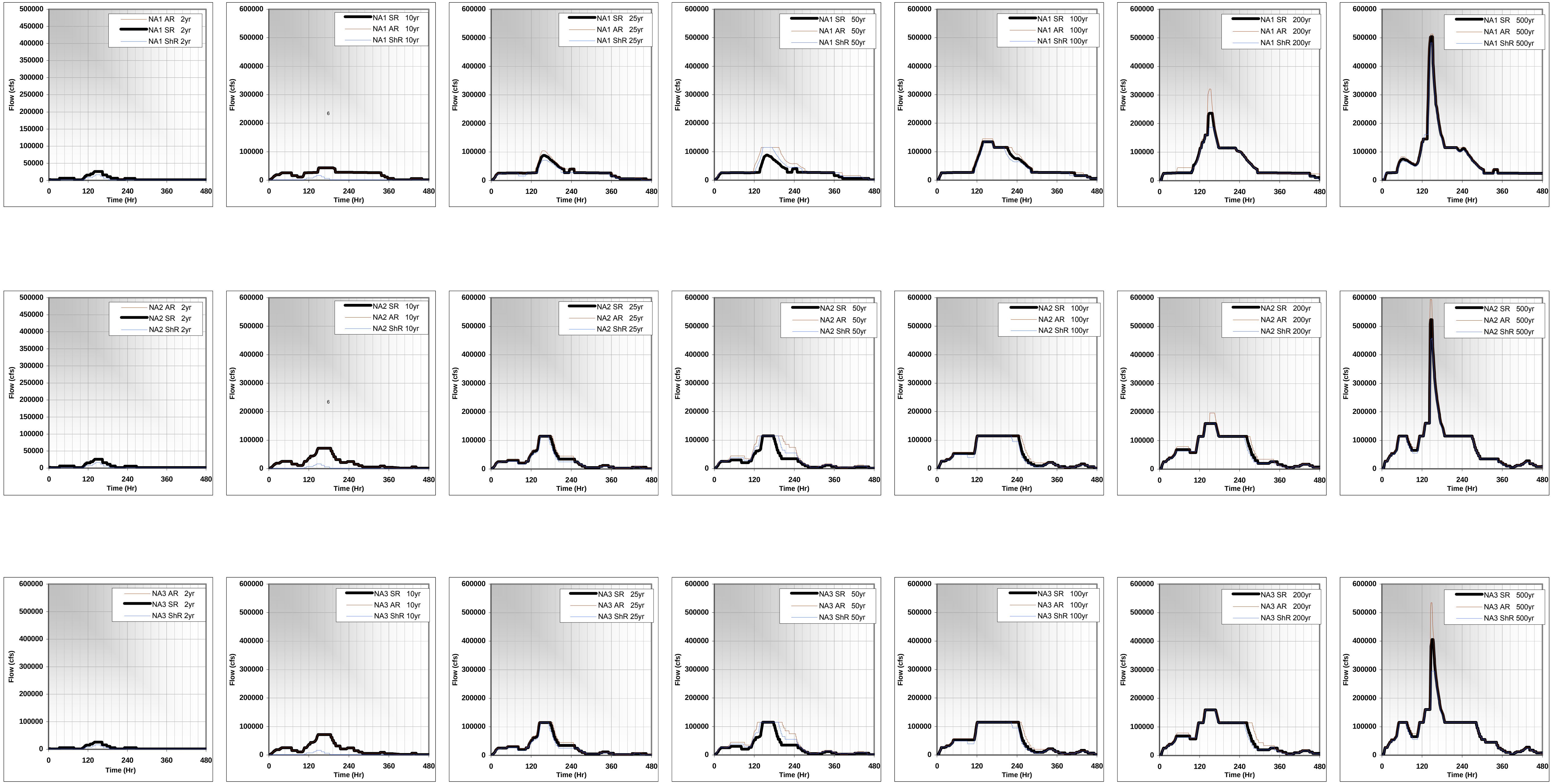

Key

SR Sacramento River
AR American River
ShR Shanghai River

FIGURE A-9: DISCHARGE HYDROGRAPHS – BASE – FUTURE WITHOUT-PROJECT (NO ACTION)

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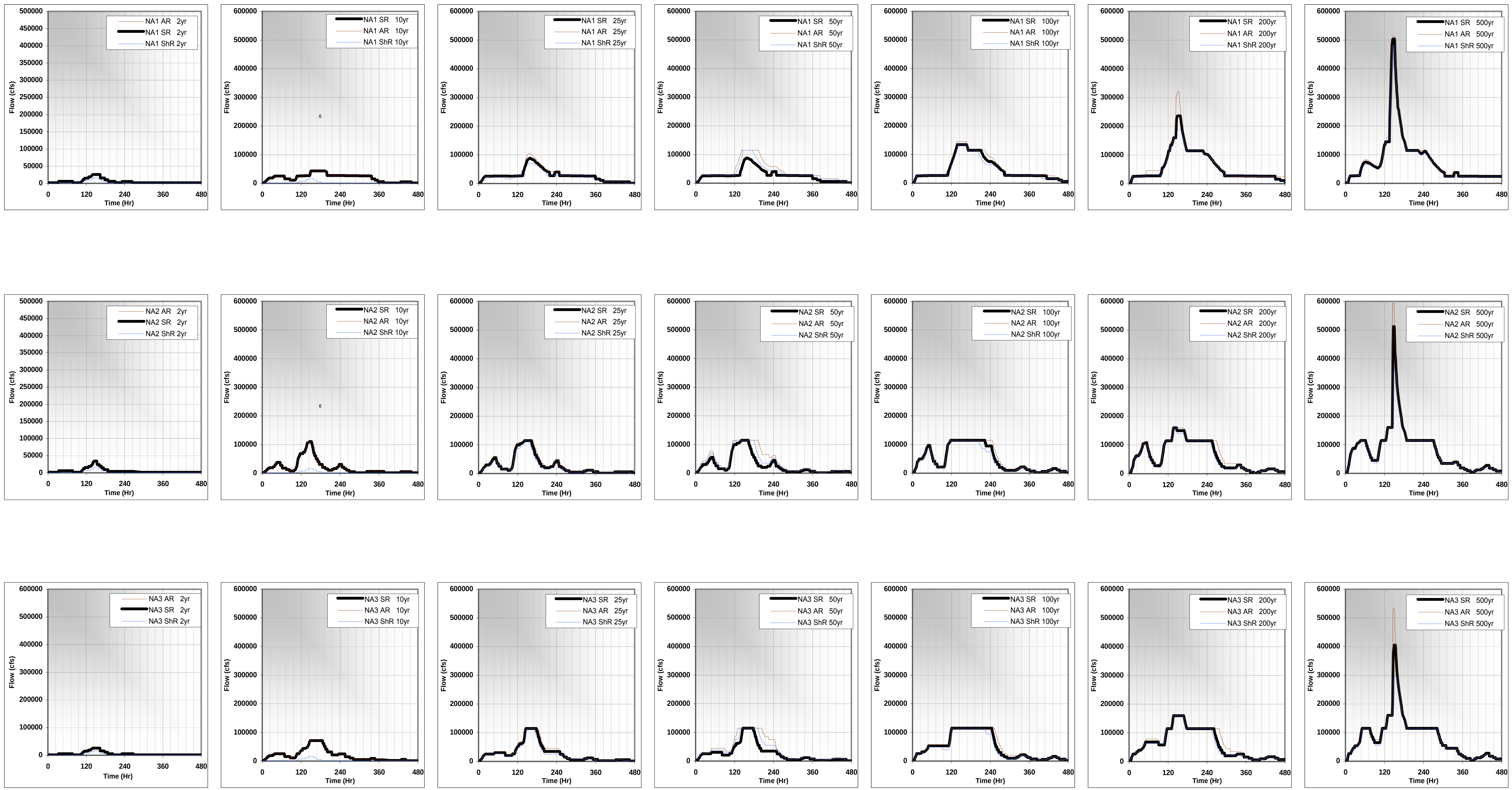

Key

SR Sacramento River
AR American River
ShR Shanghai River

FIGURE A-10: DISCHARGE HYDROGRAPHS – BASE – WITH-PROJECT

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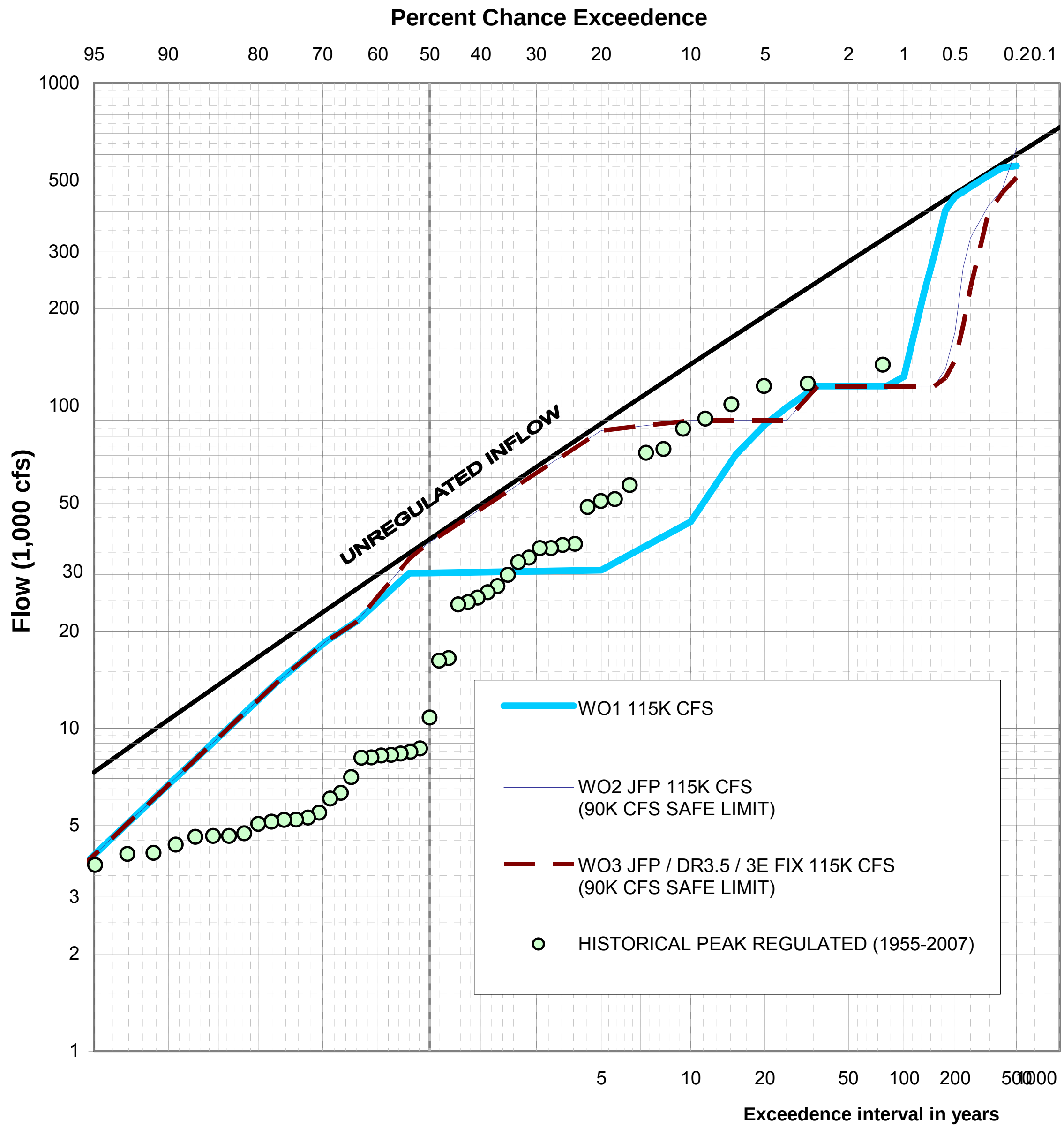

NOTES:

1. Adjusted USGS gage 11446500 to accoiunt for daily change in storage at upstream reservoirs (potential channel, out-of-channel, or storage losses neglected).
2. Median plotting positions
3. No adjustments for outliers.
4. Drainage area: 1,888 sq. mi.
5. Period of record: 1905-2004 (Unregulated).

AMERICAN RIVER WATERSHED PROJECT
COMMON FEATURES GRR

REGULATED FREQUENCY CURVES
FOLSOM DAM
EXISTING CONDITION
(WITHOUT-PROJECT)

FIGURE A-11

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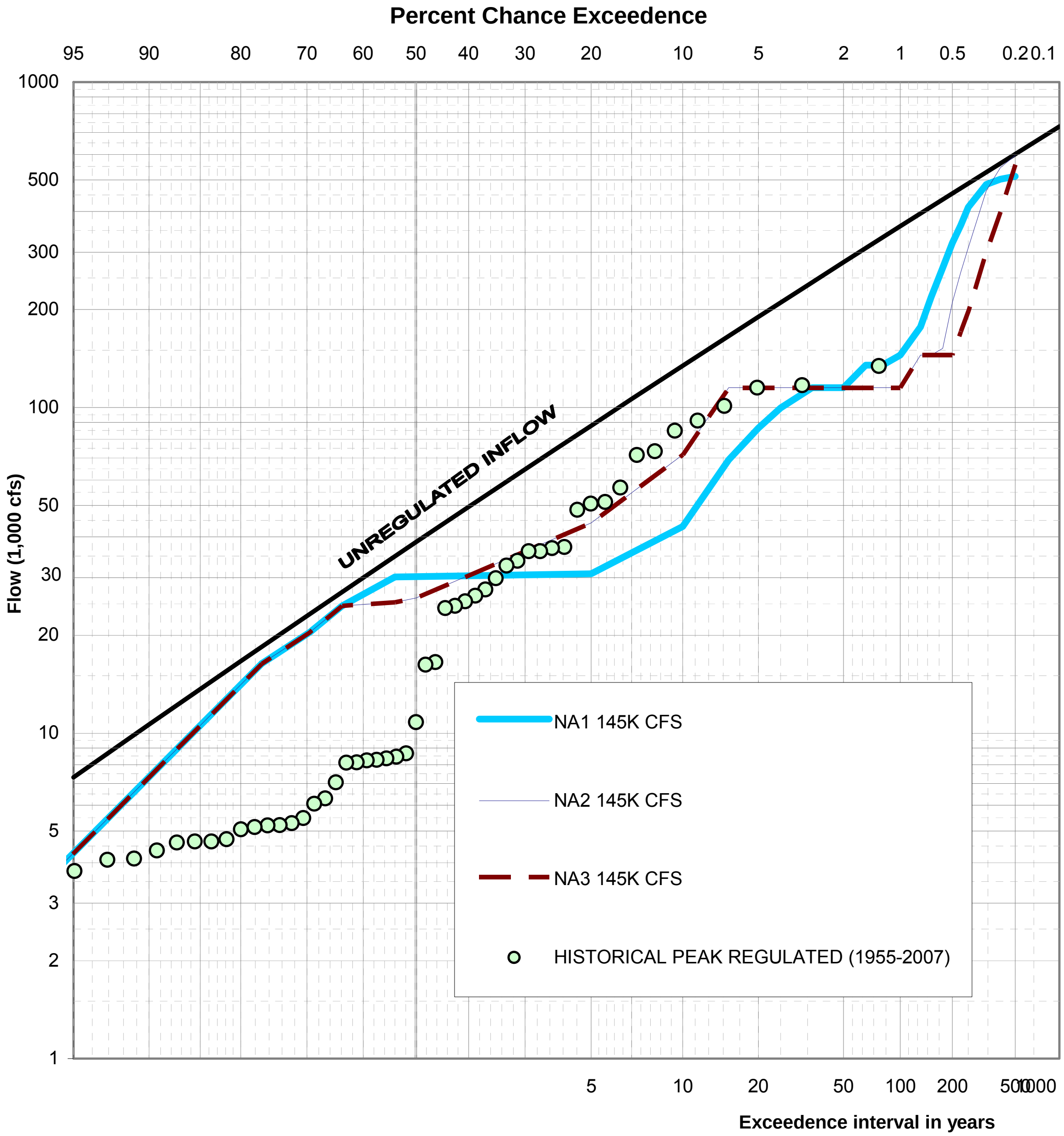

NOTES:

1. Adjusted USGS gage 11446500 to accoiunt for daily change in storage at upstream reservoirs (potential channel, out-of-channel, or storage losses neglected).
2. Median plotting positions
3. No adjustments for outliers.
4. Drainage area: 1,888 sq. mi.
5. Period of record: 1905-2004 (Unregulated).

AMERICAN RIVER WATERSHED PROJECT
COMMON FEATURES GRR

REGULATED FREQUENCY CURVES
FOLSOM DAM
FUTURE WITHOUT-PROJECT
(NO ACTION)

FIGURE A-12

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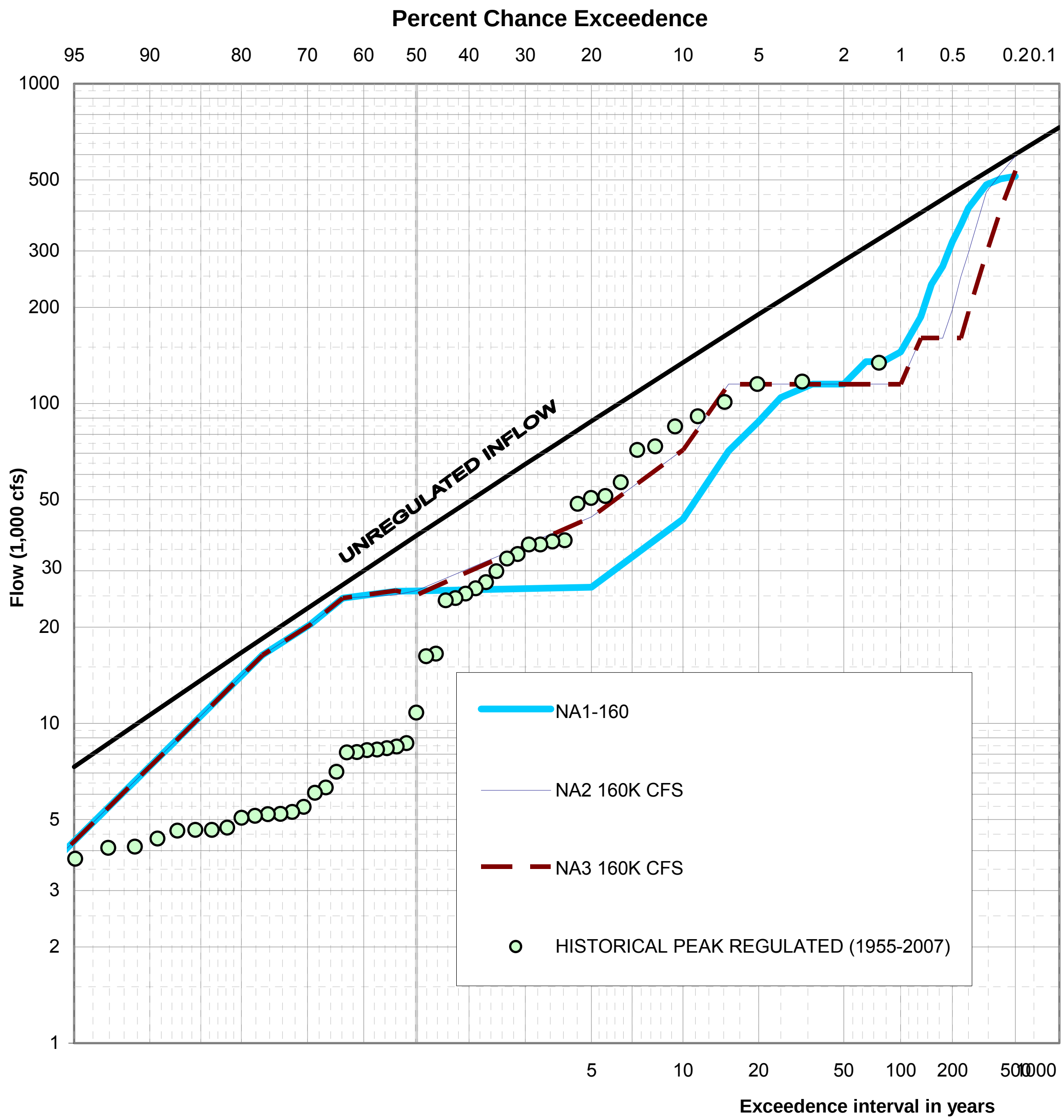

NOTES:

1. Adjusted USGS gage 11446500 to accoiunt for daily change in storage at upstream reservoirs (potential channel, out-of-channel, or storage losses neglected).
2. Median plotting positions
3. No adjustments for outliers.
4. Drainage area: 1,888 sq. mi.
5. Period of record: 1905-2004 (Unregulated).

AMERICAN RIVER WATERSHED PROJECT
COMMON FEATURES GRR

REGULATED FREQUENCY CURVES
FOLSOM DAM
FUTURE PROJECT

FIGURE A-13

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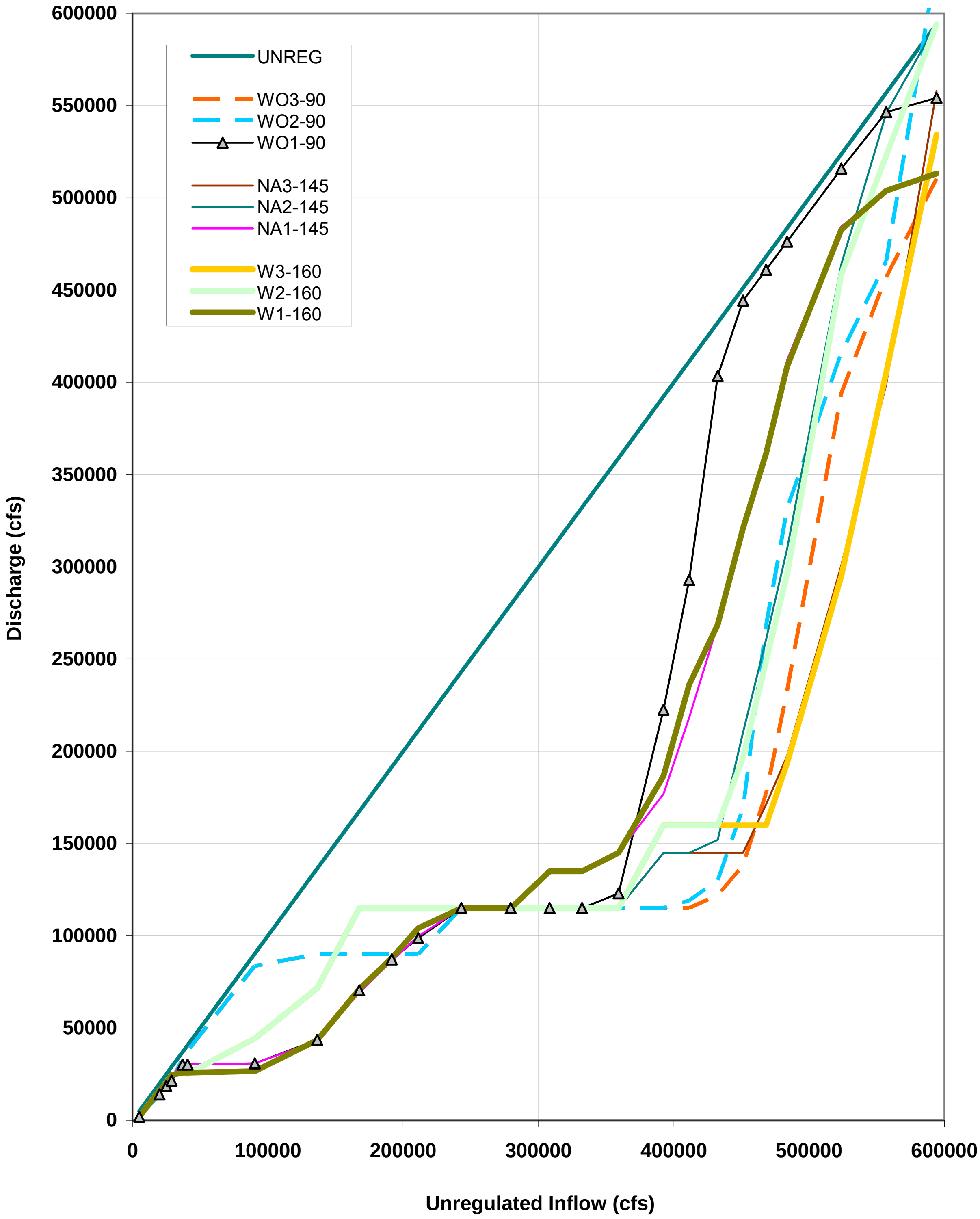

FIGURE A-14: INFLOW-OUTFLOW TRANSFORM – BASE – COMPARISON

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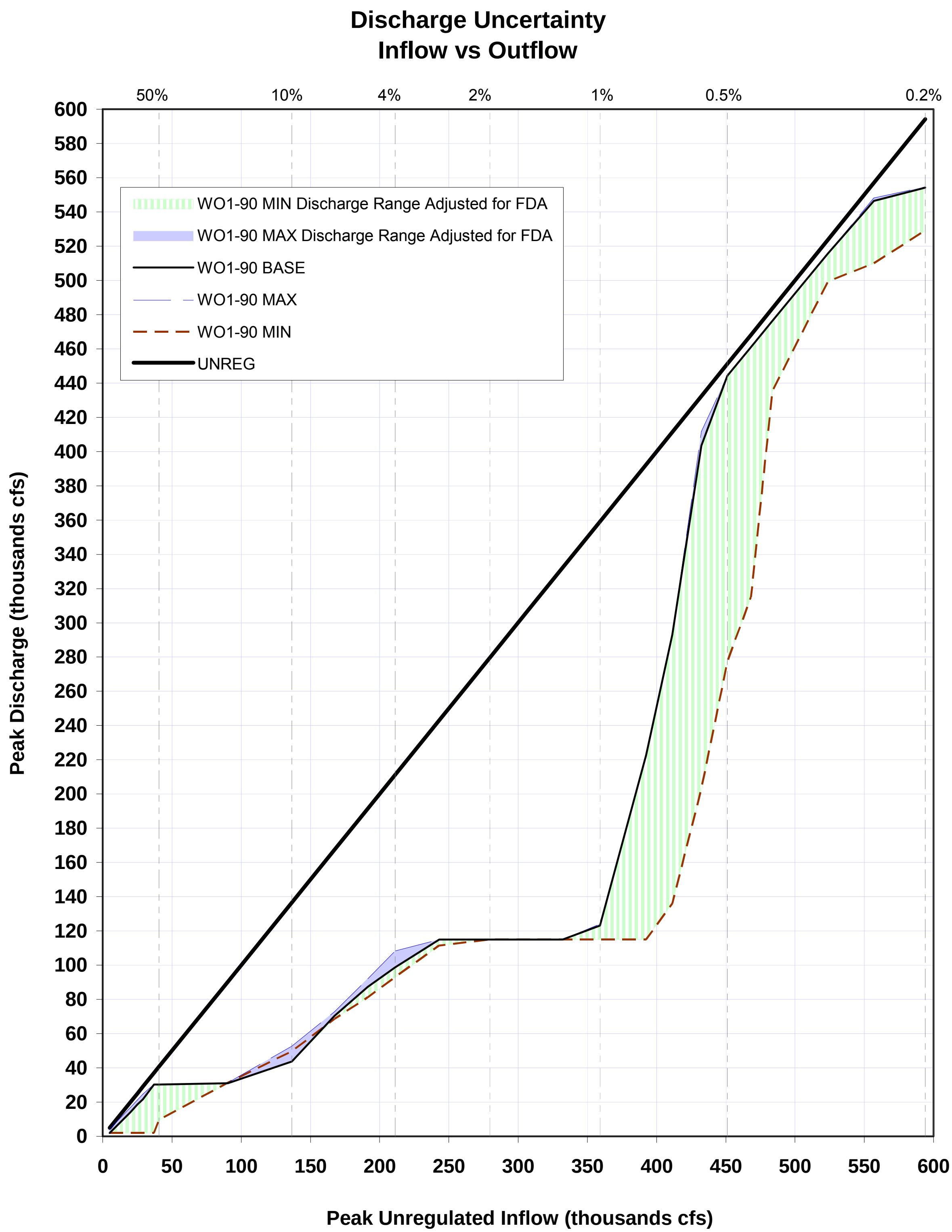

FIGURE A-15: DISCHARGE UNCERTAINTY – WO1 WITHOUT-PROJECT – 115,000 CFS

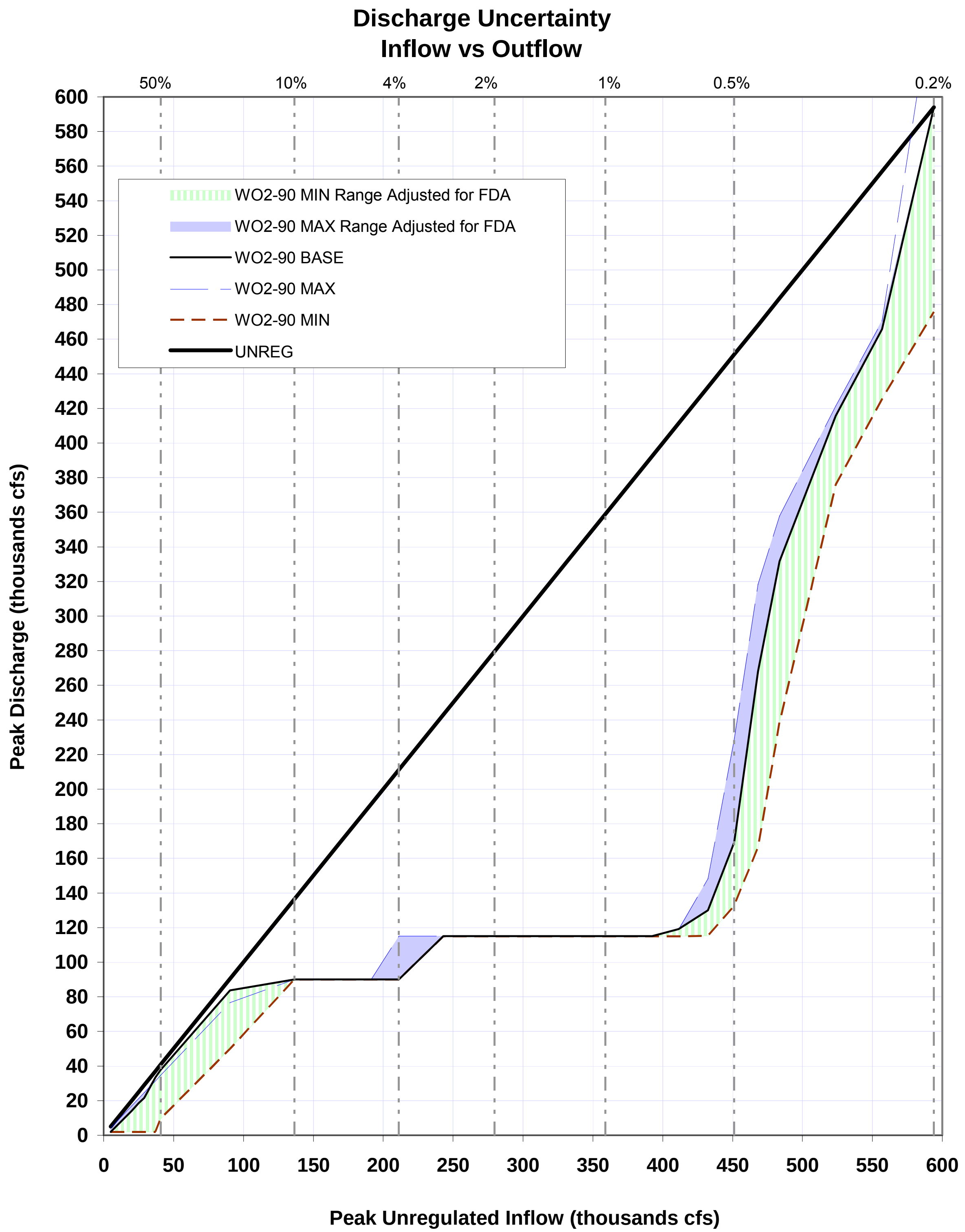

FIGURE A-16: DISCHARGE UNCERTAINTY – WO2 WITHOUT-PROJECT – 115,000 CFS

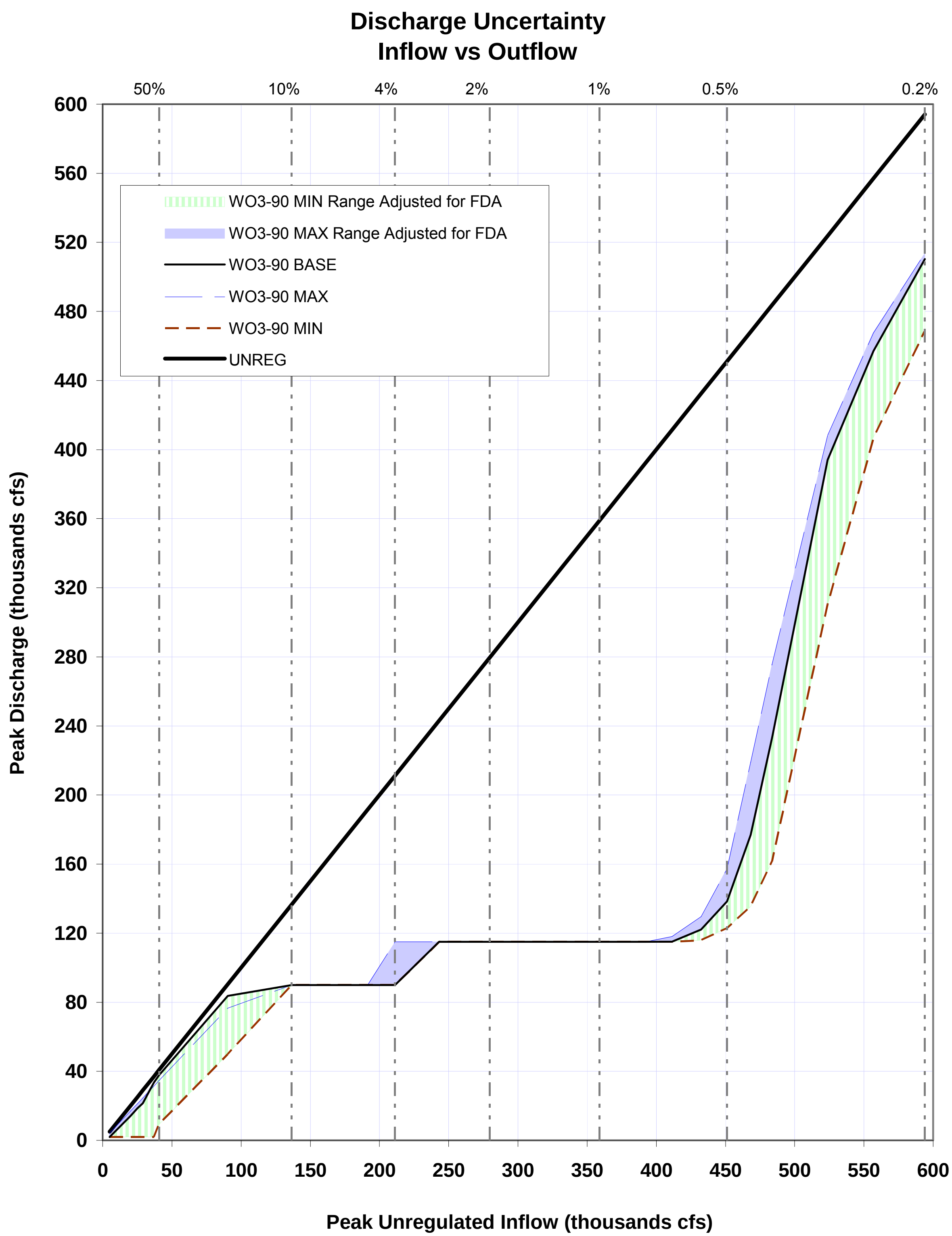

FIGURE A-17: DISCHARGE UNCERTAINTY – WO3 WITHOUT-PROJECT – 115,000 CFS

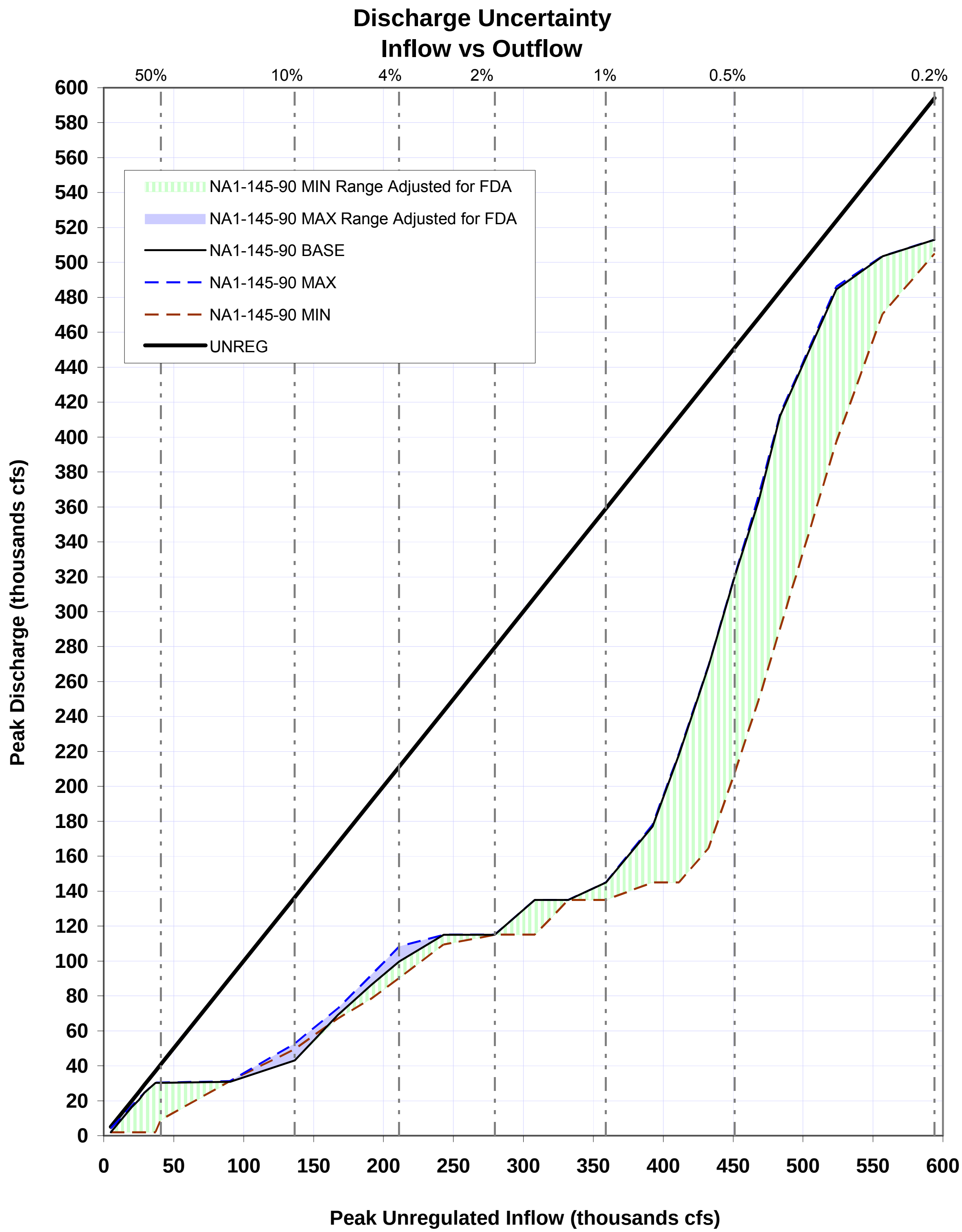

FIGURE A-18: DISCHARGE UNCERTAINTY – NA1 NO ACTION (FUTURE WITHOUT-PROJECT) – 145,000 CFS

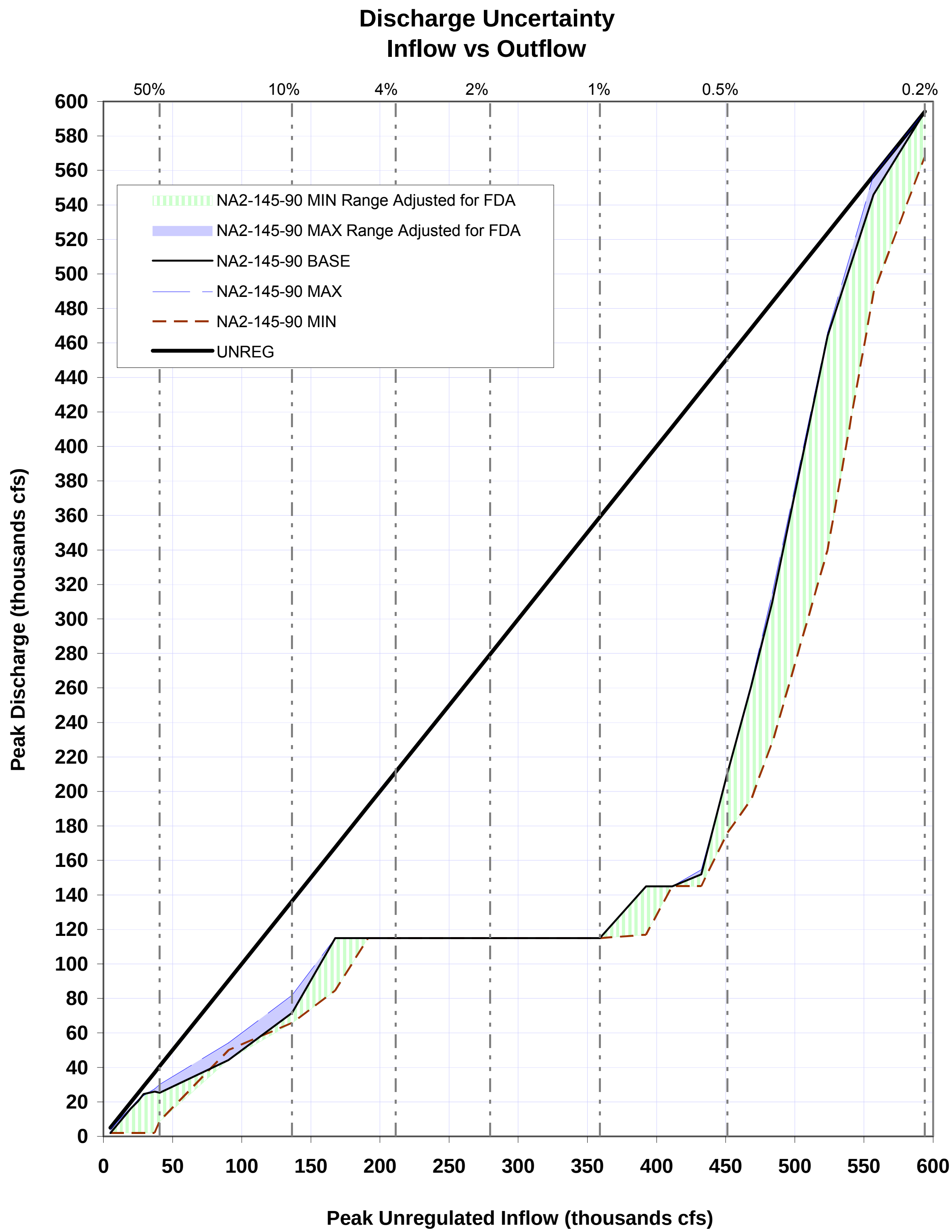

FIGURE A-19: DISCHARGE UNCERTAINTY – NA2 NO ACTION (FUTURE WITHOUT-PROJECT) – 145,000 CFS

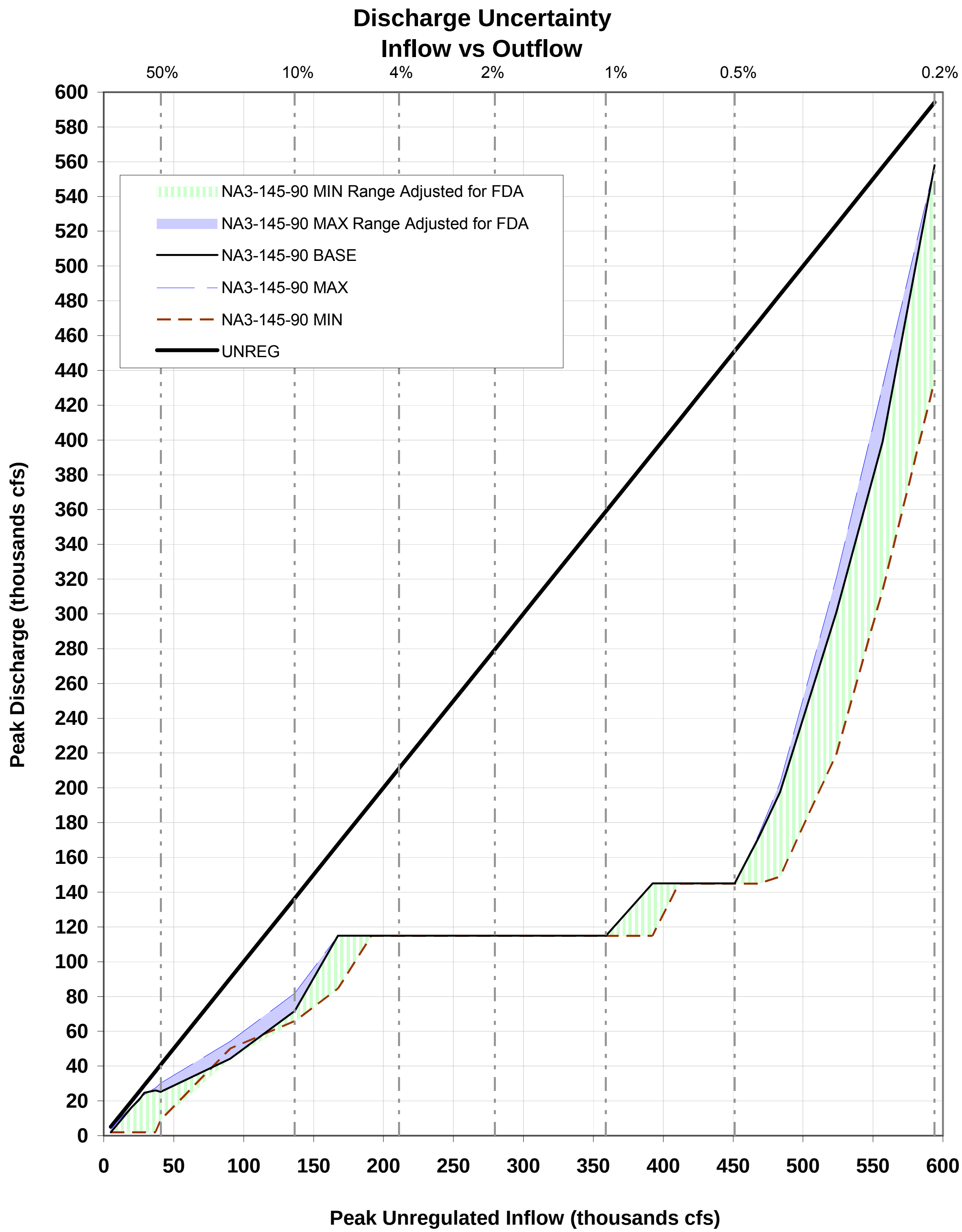

FIGURE A-20: DISCHARGE UNCERTAINTY – NA3 NO ACTION (FUTURE WITHOUT-PROJECT) – 145,000 CFS

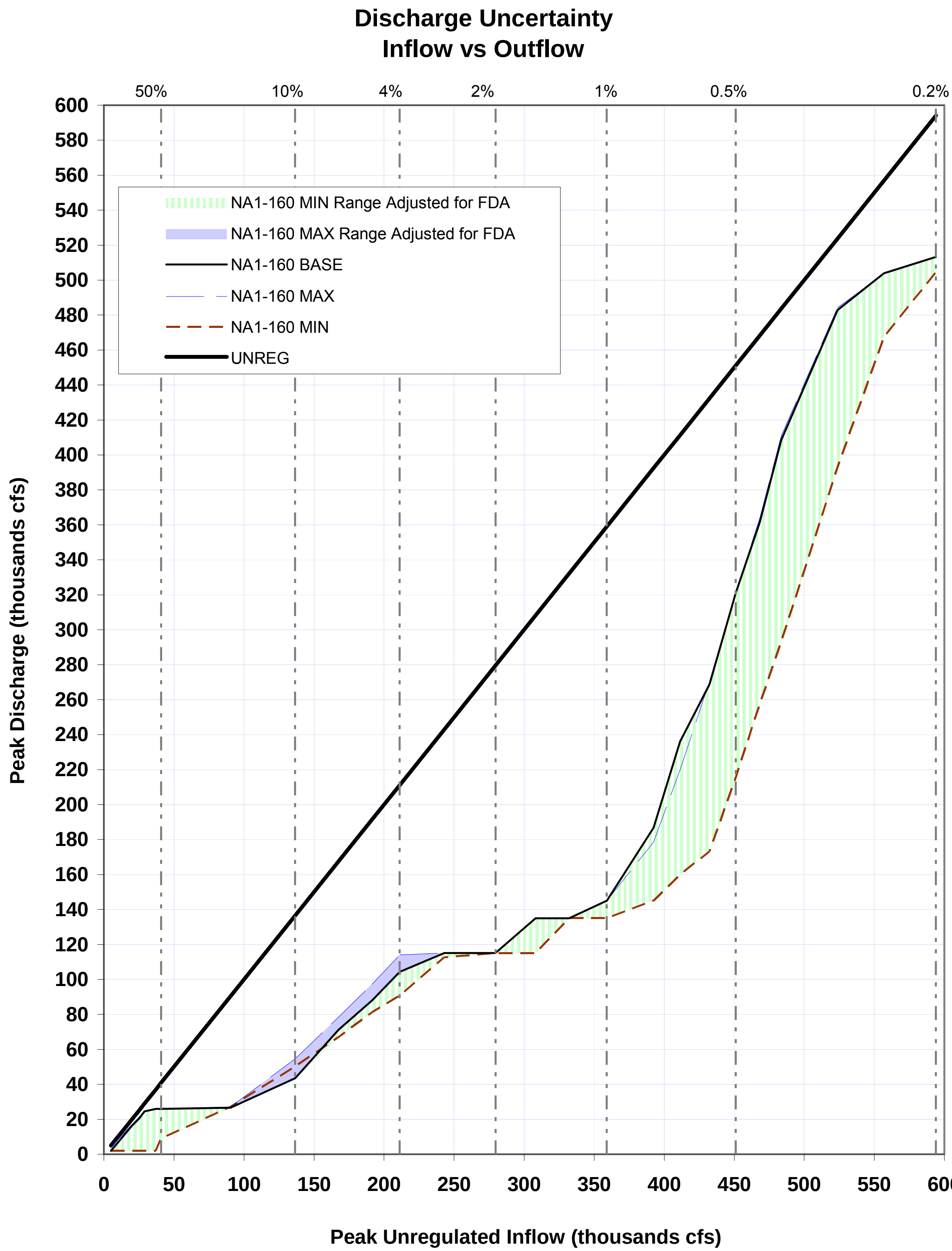

FIGURE A-21: DISCHARGE UNCERTAINTY – W1 WITH-PROJECT – 160,000 CFS

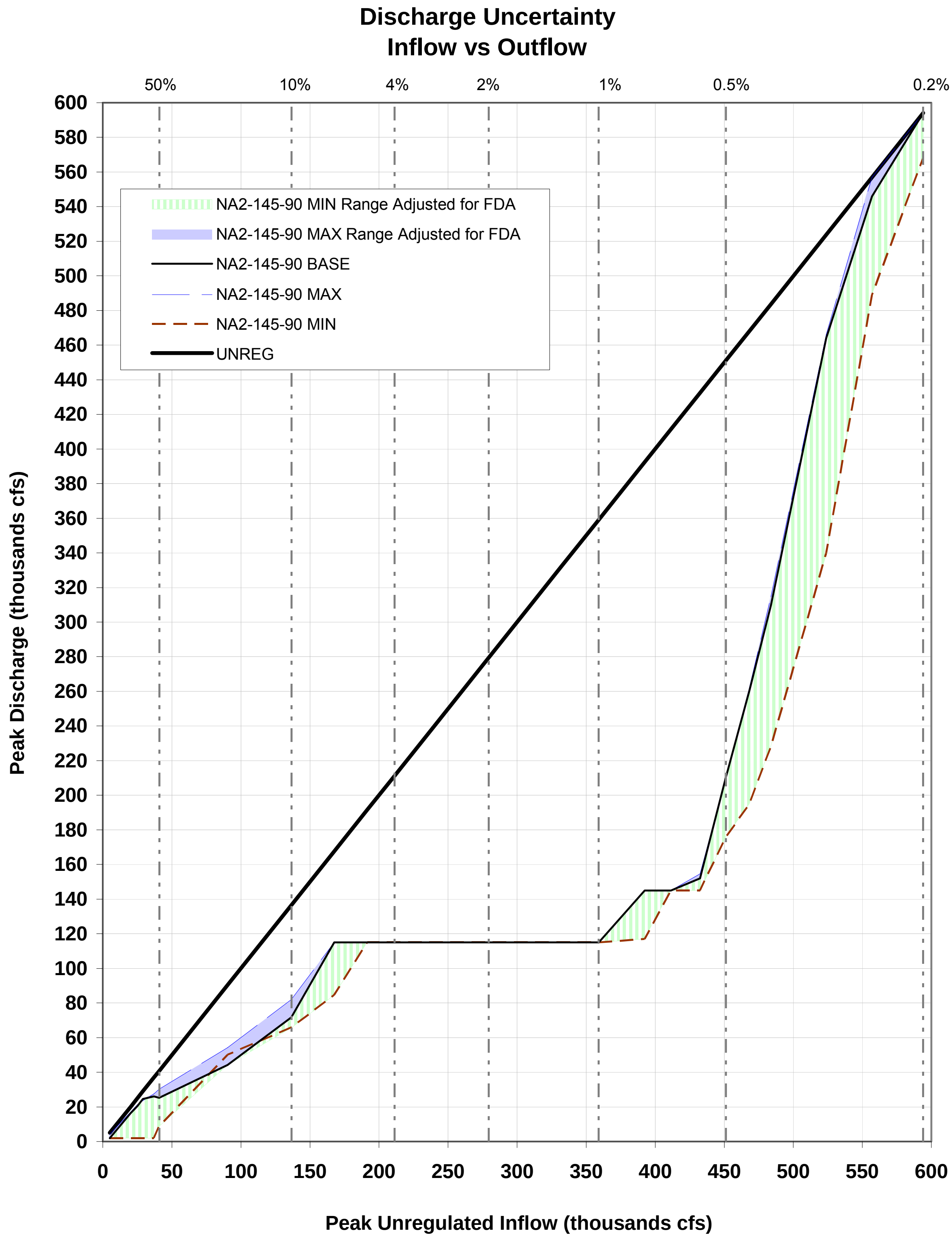

FIGURE A-22: DISCHARGE UNCERTAINTY – W2 WITH-PROJECT – 160,000 CFS

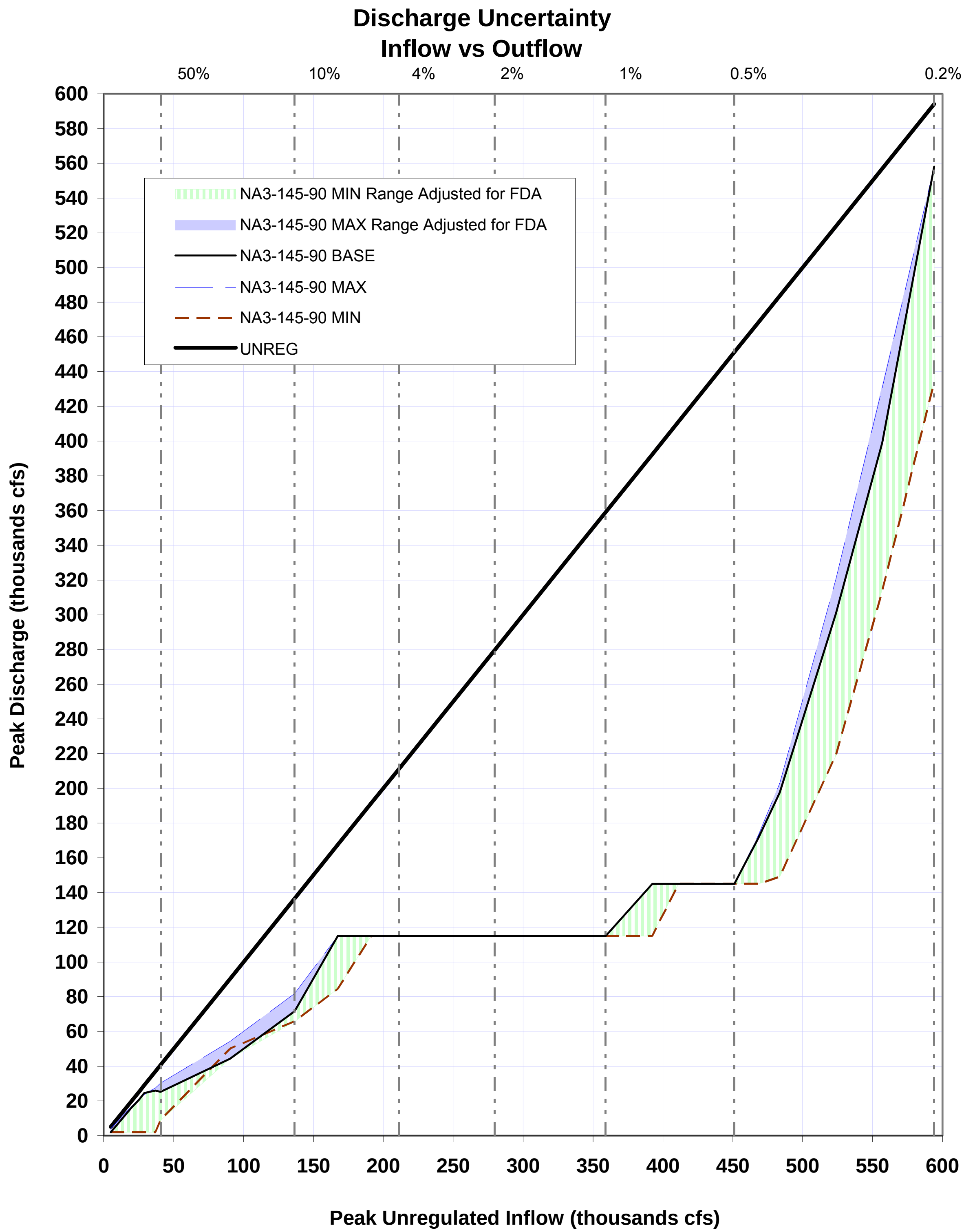

FIGURE A-23: DISCHARGE UNCERTAINTY – W3 WITH-PROJECT – 160,000 CFS

TABLE A-5: W01 BASE (R000_800CF_No Fix_115_FP470_P1_20080914)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	399.42	369.20	5000	5000	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	402.83	391.87	20002	20002	14057	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	402.49	389.60	25004	25004	18558	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	403.38	395.66	29000	29000	21525	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	403.75	398.21	37002	37002	30284	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	403.93	399.44	40722	40722	30295	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	416.82	494.78	90369	90369	30928	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	429.80	602.86	136522	136522	43692	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	435.17	651.53	167533	167533	70490	0	0.00	0	0	0	0	0	0	0	0	0	0	0
20	439.45	691.72	191482	191482	87307	0	0.00	0	0	0	0	0	0	0	0	0	0	0
25	442.53	721.38	211227	211227	98760	0	0.00	0	0	0	0	0	0	0	0	0	0	0
35	448.80	783.74	243016	243016	115000	0	0.00	0	0	0	23	23	0	0	0	0	0	0
50	457.34	872.50	279485	279485	115000	0	0.00	0	0	0	50	50	0	0	0	0	0	0
65	464.38	948.85	308218	308218	115000	0	0.00	0	0	0	68	68	0	0	0	0	0	0
80	470.37	1016.12	332148	332148	115000	0	0.00	0	0	33	84	84	0	0	0	0	0	0
100	**476.35**	**1085.39**	**359078**	**359078**	**123107**	**0**	**0.00**	**0**	**0**	**52**	**105**	**91**	**0**	**0**	**0**	**0**	**0**	**0**
130	475.79	1078.77	392399	392399	222593	0	0.00	0	0	46	100	85	22	0	14	0	20	0
150	476.38	1085.73	411351	411351	292965	0	0.00	0	0	42	96	81	24	0	18	0	-6	28
175	474.78	1066.96	432395	432395	403445	0	0.00	0	0	27	90	74	27	0	21	10	56	146
200	**476.33**	**1085.18**	**451163**	**451163**	**444310**	**0**	**0.00**	**0**	**0**	**27**	**92**	**76**	**29**	**0**	**23**	**12**	**-6**	**88**
225	476.68	1089.26	468139	468139	461029	0	0.00	0	0	28	94	78	33	0	25	14	74	70
250	476.65	1088.92	483665	483665	476319	0	0.00	0	0	28	93	78	34	0	27	16	68	100
325	477.59	1099.94	523757	523757	515802	0	0.00	0	0	31	97	83	38	0	31	20	55	101
400	478.55	1111.42	556967	556967	546433	0	0.00	0	0	34	100	88	42	0	35	22	38	96
500	479.62	1124.16	594159	594159	554268	0	0.00	0	0	39	109	93	48	0	40	26	31	85

TABLE A-6: W01 MAX (R000_800CF_No Fix_115_FP470_P1_20080914)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	406.42	416.85	5000	5000	4242	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	406.76	419.28	20002	20002	16967	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	406.90	420.25	25004	25004	21210	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	407.01	421.03	29000	29000	24600	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	407.22	422.55	37002	37002	30425	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	407.31	423.19	40722	40722	30425	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	417.33	498.81	90369	90369	31248	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	429.70	601.95	136522	136522	52675	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	435.68	656.20	167533	167533	72904	0	0.00	0	0	0	0	0	0	0	0	0	0	0
20	440.67	703.42	191482	191482	92040	0	0.00	0	0	0	0	0	0	0	0	0	0	0
25	444.39	739.61	211227	211227	108290	0	0.00	0	0	0	0	0	0	0	0	0	0	0
35	450.77	803.74	243016	243016	115000	0	0.00	0	0	0	30	30	0	0	0	0	0	0
50	458.92	889.35	279485	279485	115000	0	0.00	0	0	0	54	54	0	0	0	0	0	0
65	465.45	960.66	308218	308218	115000	0	0.00	0	0	0	71	71	0	0	0	0	0	0
80	470.97	1022.96	332148	332148	115000	0	0.00	0	0	36	86	86	0	0	0	0	0	0
100	**476.32**	**1085.03**	**359078**	**359078**	**124034**	**0**	**0.00**	**0**	**0**	**52**	**105**	**91**	**0**	**0**	**0**	**0**	**0**	**0**
130	475.79	1078.80	392399	392399	222320	0	0.00	0	0	46	100	85	22	0	14	0	20	0
150	476.39	1085.81	411351	411351	293316	0	0.00	0	0	42	96	81	24	0	18	0	-6	28
175	474.87	1068.07	432395	432395	411752	0	0.00	0	0	26	90	74	27	0	21	10	57	150
200	**476.37**	**1085.67**	**451163**	**451163**	**444310**	**0**	**0.00**	**0**	**0**	**28**	**93**	**77**	**29**	**0**	**23**	**12**	**-6**	**89**
225	476.67	1089.18	468139	468139	461029	0	0.00	0	0	28	94	78	33	0	25	14	68	70
250	476.66	1089.00	483665	483665	476319	0	0.00	0	0	28	94	78	34	0	27	16	49	99
325	477.74	1101.76	523757	523757	515802	0	0.00	0	0	31	97	83	38	0	32	20	53	95
400	478.68	1112.95	556967	556967	548181	0	0.00	0	0	36	101	88	42	0	36	22	32	98
500	479.76	1125.81	594159	594159	554678	0	0.00	0	0	39	111	93	49	0	40	26	53	81

TABLE A-7: W01 MIN (R000_800CF_No Fix_115_FP470_P1_20080914)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	386.34	290.07	5000	6419	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	398.86	365.50	20002	20133	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	402.75	391.34	25004	24305	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	405.77	412.26	29000	27959	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	411.50	453.90	37002	35274	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	412.84	464.05	40722	38674	9546	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	417.31	498.68	90369	84059	31233	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	428.58	592.07	136522	126249	49521	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	434.39	644.26	167533	154598	68674	0	0.00	0	0	0	0	0	0	0	0	0	0	0
20	437.99	677.88	191482	176491	81089	0	0.00	0	0	0	0	0	0	0	0	0	0	0
25	440.84	705.03	211227	194541	92975	0	0.00	0	0	0	0	0	0	0	0	0	0	0
35	445.30	748.65	243016	223601	111456	0	0.00	0	0	0	0	0	0	0	0	0	0	0
50	451.35	809.74	279485	256938	115000	0	0.00	0	0	0	32	32	0	0	0	0	0	0
65	456.85	867.28	308218	283204	115000	0	0.00	0	0	0	50	50	0	0	0	0	0	0
80	461.62	918.59	332148	305080	115000	0	0.00	0	0	0	62	62	0	0	0	0	0	0
100	**466.62**	**973.78**	**359078**	**329825**	**115000**	**0**	**0.00**	**0**	**0**	**14**	**75**	**75**	**0**	**0**	**0**	**0**	**0**	**0**
130	474.76	1066.72	392399	360850	115000	0	0.00	0	0	49	105	94	0	0	0	0	0	0
150	476.90	1091.89	411351	381289	135890	0	0.00	0	0	54	116	104	0	0	0	0	0	0
175	475.90	1080.08	432395	407507	203141	0	0.00	0	0	48	105	92	22	0	13	0	29	0
200	**475.92**	**1080.38**	**451163**	**429875**	**277213**	**0**	**0.00**	**0**	**0**	**41**	**97**	**84**	**25**	**0**	**18**	**0**	**73**	**27**
225	475.85	1079.48	468139	448786	314895	0	0.00	0	0	36	97	83	27	0	21	10	97	0
250	475.00	1069.51	483665	465352	435147	0	0.00	0	0	23	89	75	29	0	23	11	162	58
325	475.98	1080.98	523757	506439	499294	0	0.00	0	0	23	92	77	33	0	27	15	-6	147
400	476.25	1084.24	556967	540033	509928	0	0.00	0	0	27	96	81	39	0	31	19	106	156
500	477.41	1097.86	594159	577133	529188	0	0.00	0	0	31	104	88	45	0	36	22	70	132

TABLE A-8: W02 BASE (R060_800FM_No Fix_115_FP470_P1_20080908)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	399.42	369.20	5000	5000	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	402.83	391.87	20002	20002	14057	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	402.49	389.60	25004	25004	18558	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	403.38	395.66	29000	29000	21525	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	403.67	397.61	37002	37002	33505	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	403.53	396.67	40722	40722	37708	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	403.99	399.85	90369	90369	83680	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	408.97	435.18	136522	136522	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	415.21	482.19	167533	167533	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
20	421.58	532.97	191482	191482	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
25	427.80	585.26	211227	211227	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
35	433.71	638.02	243016	243016	115000	0	0.00	0	0	0	29	29	0	0	0	0	0	0
50	443.02	726.21	279485	279485	115000	0	0.00	0	0	0	54	54	0	0	0	0	0	0
65	449.41	789.86	308218	308218	115000	0	0.00	0	0	0	68	68	0	0	0	0	0	0
80	454.76	845.21	332148	332148	115000	0	0.00	0	0	0	81	81	0	0	0	0	0	0
100	**461.00**	**911.80**	**359078**	**359078**	**115000**	**0**	**0.00**	**0**	**0**	**0**	**102**	**102**	**0**	**0**	**0**	**0**	**0**	**0**
130	467.81	987.06	392399	392399	115000	0	0.00	0	0	23	127	127	0	0	0	0	0	0
150	472.83	1044.29	411351	411351	115000	0	0.00	0	0	43	138	126	0	0	0	0	0	0
175	476.38	1085.74	432395	432395	129972	0	0.00	0	0	54	147	133	0	0	0	0	0	0
200	**476.65**	**1088.93**	**451163**	**451163**	**169173**	**0**	**0.00**	**0**	**0**	**152**	**53**	**14**	**20**	**0**	**0**	**0**	**3**	**0**
225	474.79	1067.11	468139	468139	268061	0	0.00	0	0	80	56	15	24	0	17	0	55	0
250	475.23	1072.29	483665	483665	331691	0	0.00	0	0	62	58	14	25	0	19	8	-5	45
325	478.02	1105.13	523757	523757	415711	0	0.00	0	0	62	62	15	30	0	24	13	-6	80
400	479.76	1125.81	556967	556967	465830	0	0.00	0	0	63	65	15	34	0	28	16	-5	80
500	480.97	1140.34	594159	594159	627077	25	0.47	0	0	47	68	13	40	0	32	20	-2	77

TABLE A-9: W02 MAX (R060_800FM_No Fix_115_FP470_P1_20080908)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	406.42	416.85	5000	5000	4242	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	406.76	419.28	20002	20002	16967	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	406.90	420.25	25004	25004	21210	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	407.01	421.03	29000	29000	24600	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	407.22	422.55	37002	37002	31387	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	407.31	423.19	40722	40722	34542	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	408.59	432.46	90369	90369	76656	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	412.41	460.77	136522	136522	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	418.11	505.04	167533	167533	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
20	423.57	549.39	191482	191482	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
25	428.52	591.54	211227	211227	115000	0	0.00	0	0	0	10	10	0	0	0	0	0	0
35	434.66	646.79	243016	243016	115000	0	0.00	0	0	0	32	32	0	0	0	0	0	0
50	443.71	732.89	279485	279485	115000	0	0.00	0	0	0	55	55	0	0	0	0	0	0
65	450.81	804.21	308218	308218	115000	0	0.00	0	0	0	72	72	0	0	0	0	0	0
80	456.24	860.80	332148	332148	115000	0	0.00	0	0	0	86	86	0	0	0	0	0	0
100	**463.05**	**934.22**	**359078**	**359078**	**115000**	**0**	**0.00**	**0**	**0**	**0**	**113**	**113**	**0**	**0**	**0**	**0**	**0**	**0**
130	470.95	1022.74	392399	392399	115000	0	0.00	0	0	37	135	135	0	0	0	0	0	0
150	475.46	1074.96	411351	411351	118897	0	0.00	0	0	51	146	130	0	0	0	0	0	0
175	476.56	1087.80	432395	432395	148180	0	0.00	0	0	53	149	132	0	0	0	0	0	0
200	**474.94**	**1068.80**	**451163**	**451163**	**228405**	**0**	**0.00**	**0**	**0**	**99**	**57**	**17**	**22**	**0**	**15**	**0**	**53**	**0**
225	474.96	1069.02	468139	468139	318472	0	0.00	0	0	63	59	17	26	0	18	6	64	38
250	476.00	1081.29	483665	483665	357755	0	0.00	0	0	59	60	16	26	0	20	9	-5	57
325	478.22	1107.42	523757	523757	421382	0	0.00	0	0	63	64	16	31	0	25	14	-6	80
400	479.93	1127.86	556967	556967	470310	0	0.00	0	0	62	66	15	35	0	29	17	-5	77
500	481.08	1141.63	594159	594159	663803	33	0.58	0	0	47	70	14	41	0	33	21	-2	78

TABLE A-10: W02 MIN (R060_800FM_No Fix_115_FP470_P1_20080908)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	386.34	290.07	5000	6419	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	398.86	365.50	20002	20133	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	402.75	391.34	25004	24305	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	405.77	412.26	29000	27959	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	411.50	453.90	37002	35274	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	412.84	464.05	40722	38674	9546	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	415.33	483.15	90369	84059	50000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	418.32	506.69	136522	126249	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	421.73	534.18	167533	154598	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
20	425.96	569.46	191482	176491	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
25	429.85	603.33	211227	194541	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
35	434.59	646.18	243016	223601	115000	0	0.00	0	0	0	22	22	0	0	0	0	0	0
50	441.93	715.57	279485	256938	115000	0	0.00	0	0	0	46	46	0	0	0	0	0	0
65	448.57	781.34	308218	283204	115000	0	0.00	0	0	0	63	63	0	0	0	0	0	0
80	453.72	834.34	332148	305080	115000	0	0.00	0	0	0	79	79	0	0	0	0	0	0
100	**460.26**	**903.83**	**359078**	**329825**	**115000**	**0**	**0.00**	**0**	**0**	**0**	**100**	**100**	**0**	**0**	**0**	**0**	**0**	**0**
130	467.01	978.09	392399	360850	115000	0	0.00	0	0	16	127	127	0	0	0	0	0	0
150	469.43	1005.36	411351	381289	115000	0	0.00	0	0	32	134	134	0	0	0	0	0	0
175	474.36	1062.07	432395	407507	115124	0	0.00	0	0	50	147	130	0	0	0	0	0	0
200	**476.58**	**1088.06**	**451163**	**429875**	**132562**	**0**	**0.00**	**0**	**0**	**55**	**152**	**136**	**0**	**0**	**0**	**0**	**0**	**0**
225	476.63	1088.71	468139	448786	166144	0	0.00	0	0	155	55	15	20	0	0	0	3	0
250	474.88	1068.11	483665	465352	238763	0	0.00	0	0	95	57	16	24	0	17	0	50	15
325	476.43	1086.35	523757	506439	375796	0	0.00	0	0	55	61	15	28	0	22	10	-6	68
400	478.35	1108.97	556967	540033	425258	0	0.00	0	0	57	64	15	33	0	26	14	-1	84
500	480.11	1129.97	594159	577133	475823	0	0.00	0	0	47	68	15	39	0	30	17	-2	83

TABLE A-11: W03 BASE (R060_800DR3.5e_115_FP470_P1_20080907)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	399.42	369.20	5000	5000	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	402.83	391.87	20002	20002	14057	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	402.49	389.60	25004	25004	18558	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	403.38	395.66	29000	29000	21525	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	403.67	397.61	37002	37002	33505	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	403.53	396.67	40722	40722	37708	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	403.99	399.85	90369	90369	83680	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	408.97	435.18	136522	136522	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	415.21	482.19	167533	167533	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
20	421.58	532.97	191482	191482	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
25	427.80	585.26	211227	211227	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
35	433.71	638.02	243016	243016	115000	0	0.00	0	0	0	29	29	0	0	0	0	0	0
50	443.02	726.21	279485	279485	115000	0	0.00	0	0	0	54	54	0	0	0	0	0	0
65	449.41	789.86	308218	308218	115000	0	0.00	0	0	0	68	68	0	0	0	0	0	0
80	454.76	845.21	332148	332148	115000	0	0.00	0	0	0	81	81	0	0	0	0	0	0
100	**461.00**	**911.80**	**359078**	**359078**	**115000**	**0**	**0.00**	**0**	**0**	**0**	**102**	**102**	**0**	**0**	**0**	**0**	**0**	**0**
130	467.81	987.06	392399	392399	115000	0	0.00	0	0	23	127	127	0	0	0	0	0	0
150	472.81	1044.11	411351	411351	115088	0	0.00	0	0	43	138	126	0	0	0	0	0	0
175	476.78	1090.42	432395	432395	122131	0	0.00	0	0	55	149	135	0	0	0	0	0	0
200	**478.67**	**1112.80**	**451163**	**451163**	**138359**	**0**	**0.00**	**0**	**0**	**60**	**154**	**140**	**0**	**0**	**0**	**0**	**0**	**0**
225	478.38	1109.31	468139	468139	176952	0	0.00	0	0	162	56	15	24	0	0	0	15	0
250	477.27	1096.17	483665	483665	232803	0	0.00	0	0	150	58	14	25	0	18	0	34	0
325	477.72	1101.50	523757	523757	394043	0	0.00	0	0	72	62	15	30	0	24	13	-6	75
400	479.49	1122.65	556967	556967	457102	0	0.00	0	0	76	65	15	34	0	28	16	-5	74
500	481.31	1144.50	594159	594159	510279	0	0.00	0	0	77	68	14	40	0	32	20	-2	75
PMF	486.00	1201.47	905770	905770	1105372	214	2.00	0	0	131	134	18	93	0	61	49	247	146

TABLE A-12: W03 MAX (R060_800DR3.5e_115_FP470_P1_20080907)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	406.42	416.85	5000	5000	4242	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	406.76	419.28	20002	20002	16967	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	406.90	420.25	25004	25004	21210	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	407.01	421.03	29000	29000	24600	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	407.22	422.55	37002	37002	31387	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	407.31	423.19	40722	40722	34542	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	408.59	432.46	90369	90369	76656	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	412.41	460.77	136522	136522	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	418.11	505.04	167533	167533	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
20	423.57	549.39	191482	191482	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
25	428.52	591.54	211227	211227	115000	0	0.00	0	0	0	10	10	0	0	0	0	0	0
35	434.66	646.79	243016	243016	115000	0	0.00	0	0	0	32	32	0	0	0	0	0	0
50	443.71	732.89	279485	279485	115000	0	0.00	0	0	0	55	55	0	0	0	0	0	0
65	450.81	804.21	308218	308218	115000	0	0.00	0	0	0	72	72	0	0	0	0	0	0
80	456.24	860.80	332148	332148	115000	0	0.00	0	0	0	86	86	0	0	0	0	0	0
100	**463.05**	**934.22**	**359078**	**359078**	**115000**	**0**	**0.00**	**0**	**0**	**0**	**113**	**113**	**0**	**0**	**0**	**0**	**0**	**0**
130	470.95	1022.74	392399	392399	115000	0	0.00	0	0	37	135	135	0	0	0	0	0	0
150	475.37	1073.85	411351	411351	118010	0	0.00	0	0	51	146	130	0	0	0	0	0	0
175	477.72	1101.61	432395	432395	129653	0	0.00	0	0	57	152	135	0	0	0	0	0	0
200	**478.72**	**1113.42**	**451163**	**451163**	**157288**	**0**	**0.00**	**0**	**0**	**60**	**156**	**138**	**0**	**0**	**0**	**0**	**0**	**0**
225	477.50	1098.98	468139	468139	219082	0	0.00	0	0	151	59	18	25	0	17	0	24	0
250	476.79	1090.52	483665	483665	275466	0	0.00	0	0	105	60	16	26	0	20	0	53	7
325	478.10	1106.01	523757	523757	408380	0	0.00	0	0	73	64	16	31	0	25	13	74	61
400	479.87	1127.11	556967	556967	467639	0	0.00	0	0	77	66	15	35	0	29	16	71	59
500	481.43	1147.07	594159	594159	513811	0	0.00	0	0	78	70	15	41	0	33	21	-2	72

TABLE A-13: W03 MIN (R060_800DR3.5e_115_FP470_P1_20080907)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	386.34	290.07	5000	6419	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	398.86	365.50	20002	20133	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	402.75	391.34	25004	24305	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	405.77	412.26	29000	27959	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	411.50	453.90	37002	35274	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	412.84	464.05	40722	38674	9546	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	415.33	483.15	90369	84059	50000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	418.32	506.69	136522	126249	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	421.73	534.18	167533	154598	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
20	425.96	569.46	191482	176491	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
25	429.85	603.33	211227	194541	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
35	434.59	646.18	243016	223601	115000	0	0.00	0	0	0	22	22	0	0	0	0	0	0
50	441.93	715.57	279485	256938	115000	0	0.00	0	0	0	46	46	0	0	0	0	0	0
65	448.57	781.34	308218	283204	115000	0	0.00	0	0	0	63	63	0	0	0	0	0	0
80	453.72	834.34	332148	305080	115000	0	0.00	0	0	0	79	79	0	0	0	0	0	0
100	**460.26**	**903.83**	**359078**	**329825**	**115000**	**0**	**0.00**	**0**	**0**	**0**	**100**	**100**	**0**	**0**	**0**	**0**	**0**	**0**
130	467.01	978.09	392399	360850	115000	0	0.00	0	0	16	127	127	0	0	0	0	0	0
150	469.43	1005.36	411351	381289	115000	0	0.00	0	0	32	134	134	0	0	0	0	0	0
175	474.21	1060.36	432395	407507	115938	0	0.00	0	0	49	146	128	0	0	0	0	0	0
200	**477.18**	**1095.22**	**451163**	**429875**	**122877**	**0**	**0.00**	**0**	**0**	**57**	**154**	**138**	**0**	**0**	**0**	**0**	**0**	**0**
225	478.80	1114.32	468139	448786	135427	0	0.00	0	0	61	158	143	0	0	0	0	0	0
250	479.05	1117.37	483665	465352	161583	0	0.00	0	0	171	57	16	23	0	0	0	0	0
325	476.54	1087.58	523757	506439	310409	0	0.00	0	0	83	61	15	28	0	22	9	55	38
400	478.05	1105.51	556967	540033	406670	0	0.00	0	0	64	64	15	33	0	26	14	-1	78
500	479.89	1127.38	594159	577133	468932	0	0.00	0	0	68	68	16	39	0	30	16	77	70

TABLE A-14: NA1-145 BASE (R000_800CF_No Fix_145_FP470_P1_20080919)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	399.42	369.20	5000	5000	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	402.39	388.94	20002	20002	16328	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	402.53	389.84	25004	25004	20411	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	402.78	391.51	29000	29000	24600	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	403.17	394.19	37002	37002	30237	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	402.43	389.16	40722	40722	30183	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	415.74	486.34	90369	90369	30848	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	429.13	596.95	136522	136522	43127	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	434.65	646.67	167533	167533	69092	0	0.00	0	0	0	0	0	0	0	0	0	0	0
20	439.01	687.48	191482	191482	86500	0	0.00	0	0	0	0	0	0	0	0	0	0	0
25	442.69	722.96	211227	211227	99738	0	0.00	0	0	0	0	0	0	0	0	0	0	0
35	448.44	780.03	243016	243016	115000	0	0.00	0	0	0	22	22	0	0	0	0	0	0
50	457.01	868.92	279485	279485	115000	0	0.00	0	0	0	49	49	0	0	0	0	0	0
65	461.09	912.80	308218	308218	135000	0	0.00	0	0	0	61	61	0	0	0	0	0	0
80	466.44	971.77	332148	332148	135000	0	0.00	0	0	9	74	74	0	0	0	0	0	0
100	**470.81**	**1021.10**	**359078**	**359078**	**145000**	**0**	**0.00**	**0**	**0**	**39**	**92**	**92**	**0**	**0**	**0**	**0**	**0**	**0**
130	475.31	1073.15	392399	392399	177012	0	0.00	0	0	49	105	105	20	1	0	0	14	0
150	475.74	1078.26	411351	411351	218286	0	0.00	0	0	49	106	106	23	0	16	0	18	0
175	476.07	1082.12	432395	432395	268700	0	0.00	0	0	47	104	103	25	0	19	0	-6	16
200	**476.40**	**1086.00**	**451163**	**451163**	**320142**	**0**	**0.00**	**0**	**0**	**45**	**104**	**102**	**28**	**0**	**21**	**11**	**65**	**42**
225	476.58	1088.08	468139	468139	363164	0	0.00	0	0	41	103	102	31	0	24	12	48	42
250	476.67	1089.18	483665	483665	412114	0	0.00	0	0	36	101	99	32	0	26	14	-5	47
325	477.17	1095.00	523757	523757	484550	0	0.00	0	0	35	102	101	37	0	30	18	56	49
400	477.83	1102.80	556967	556967	503557	0	0.00	0	0	38	107	107	41	0	35	21	37	46
500	479.01	1116.85	594159	594159	512982	0	0.00	0	0	42	129	115	47	0	39	25	30	52

TABLE A-15: NA1-145 MAX (R000_800CF_No Fix_145_FP470_P1_20080919)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	406.42	416.85	5000	5000	4242	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	406.74	419.09	20002	20002	16967	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	406.86	419.97	25004	25004	21210	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	406.97	420.78	29000	29000	24600	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	407.19	422.35	37002	37002	30423	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	407.29	423.06	40722	40722	30424	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	417.33	498.81	90369	90369	31248	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	429.70	601.95	136522	136522	52675	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	435.68	656.20	167533	167533	72904	0	0.00	0	0	0	0	0	0	0	0	0	0	0
20	440.67	703.42	191482	191482	92040	0	0.00	0	0	0	0	0	0	0	0	0	0	0
25	444.39	739.61	211227	211227	108290	0	0.00	0	0	0	0	0	0	0	0	0	0	0
35	450.77	803.74	243016	243016	115000	0	0.00	0	0	0	30	30	0	0	0	0	0	0
50	458.92	889.35	279485	279485	115000	0	0.00	0	0	0	54	54	0	0	0	0	0	0
65	462.29	925.84	308218	308218	135000	0	0.00	0	0	0	65	65	0	0	0	0	0	0
80	467.20	980.23	332148	332148	135000	0	0.00	0	0	16	78	78	0	0	0	0	0	0
100	**471.07**	**1024.11**	**359078**	**359078**	**145000**	**0**	**0.00**	**0**	**0**	**40**	**92**	**92**	**0**	**0**	**0**	**0**	**0**	**0**
130	475.32	1073.28	392399	392399	178071	0	0.00	0	0	48	105	105	20	0	0	0	13	0
150	475.75	1078.35	411351	411351	218943	0	0.00	0	0	49	106	106	23	0	17	0	14	0
175	476.08	1082.17	432395	432395	269028	0	0.00	0	0	47	104	103	25	0	19	0	-6	15
200	**476.41**	**1086.03**	**451163**	**451163**	**320618**	**0**	**0.00**	**0**	**0**	**45**	**104**	**102**	**28**	**0**	**22**	**11**	**56**	**42**
225	476.59	1088.23	468139	468139	366078	0	0.00	0	0	40	104	102	31	0	24	12	50	42
250	476.67	1089.19	483665	483665	413033	0	0.00	0	0	36	102	99	32	0	26	14	-5	46
325	477.19	1095.24	523757	523757	485904	0	0.00	0	0	35	102	101	37	0	31	18	45	47
400	477.84	1102.98	556967	556967	503676	0	0.00	0	0	39	108	108	41	0	35	21	36	47
500	479.02	1116.98	594159	594159	513077	0	0.00	0	0	42	126	115	48	0	39	25	44	52

TABLE A-16: NA1-145 MIN (R000_800CF_No Fix_145_FP470_P1_20080919)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	386.34	290.07	5000	6419	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	398.86	365.50	20002	20133	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	402.75	391.34	25004	24305	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	405.77	412.26	29000	27959	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	411.50	453.90	37002	35274	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	412.98	465.10	40722	38674	8916	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	417.13	497.21	90369	84059	31233	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	428.58	592.07	136522	126249	49521	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	433.77	638.60	167533	154598	67040	0	0.00	0	0	0	0	0	0	0	0	0	0	0
20	437.47	672.98	191482	176491	78462	0	0.00	0	0	0	0	0	0	0	0	0	0	0
25	440.35	700.34	211227	194541	90191	0	0.00	0	0	0	0	0	0	0	0	0	0	0
35	444.94	745.01	243016	223601	109419	0	0.00	0	0	0	0	0	0	0	0	0	0	0
50	451.06	806.80	279485	256938	115000	0	0.00	0	0	0	31	31	0	0	0	0	0	0
65	456.61	864.68	308218	283204	115000	0	0.00	0	0	0	48	48	0	0	0	0	0	0
80	458.74	887.48	332148	305080	135000	0	0.00	0	0	0	56	56	0	0	0	0	0	0
100	**463.26**	**936.53**	**359078**	**329825**	**135000**	**0**	**0.00**	**0**	**0**	**0**	**68**	**68**	**0**	**0**	**0**	**0**	**0**	**0**
130	468.87	998.98	392399	360850	145000	0	0.00	0	0	26	84	84	0	0	0	0	0	0
150	472.83	1044.26	411351	381289	145000	0	0.00	0	0	47	103	103	0	0	0	0	0	0
175	475.66	1077.28	432395	407507	164525	0	0.00	0	0	52	118	118	14	1	0	0	2	0
200	**475.58**	**1076.33**	**451163**	**429875**	**207706**	**0**	**0.00**	**0**	**0**	**50**	**117**	**117**	**23**	**0**	**17**	**0**	**4**	**0**
225	475.81	1079.03	468139	448786	249188	0	0.00	0	0	48	118	118	25	0	19	0	-5	5
250	476.10	1082.45	483665	465352	290568	0	0.00	0	0	45	106	106	27	0	21	0	-5	21
325	476.63	1088.66	523757	506439	397225	0	0.00	0	0	36	105	104	32	0	26	13	-6	92
400	476.97	1092.73	556967	540033	470504	0	0.00	0	0	32	104	103	37	0	30	18	-1	63
500	478.01	1105.02	594159	577133	505120	0	0.00	0	0	36	121	110	43	0	34	21	-2	50

TABLE A-17: NA2-145 BASE (R060_800FM_No Fix_145_FP466_P1_20080916)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	399.42	369.20	5000	5000	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	402.39	388.94	20002	20002	16328	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	402.53	389.84	25004	25004	20411	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	402.78	391.51	29000	29000	24600	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	403.59	397.11	37002	37002	26005	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	403.18	394.30	40722	40722	25215	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	413.74	470.92	90369	90369	44261	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	421.65	533.58	136522	136522	71655	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	424.92	560.66	167533	167533	115000	0	0.00	0	0	0	26	26	0	0	0	0	0	0
20	428.02	587.24	191482	191482	115000	0	0.00	0	0	0	36	36	0	0	0	0	0	0
25	431.43	617.37	211227	211227	115000	0	0.00	0	0	0	45	45	0	0	0	0	0	0
35	437.15	669.98	243016	243016	115000	0	0.00	0	0	0	57	57	0	0	0	0	0	0
50	442.97	725.68	279485	279485	115000	0	0.00	0	0	0	75	75	0	0	0	0	0	0
65	449.11	786.85	308218	308218	115000	0	0.00	0	0	0	103	103	0	0	0	0	0	0
80	453.74	834.47	332148	332148	115000	0	0.00	0	0	0	127	127	0	0	0	0	0	0
100	**460.46**	**906.02**	**359078**	**359078**	**115000**	**0**	**0.00**	**0**	**0**	**0**	**137**	**137**	**0**	**0**	**0**	**0**	**0**	**0**
130	461.49	917.22	392399	392399	145000	0	0.00	0	0	0	144	125	0	0	0	0	0	0
150	466.34	970.57	411351	411351	145000	0	0.00	0	0	11	153	134	0	0	0	0	0	0
175	469.94	1011.13	432395	432395	151924	0	0.00	0	0	33	160	142	0	0	0	0	0	0
200	**470.02**	**1012.12**	**451163**	**451163**	**210332**	**0**	**0.00**	**0**	**0**	**25**	**160**	**142**	**21**	**0**	**15**	**0**	**0**	**0**
225	470.31	1015.33	468139	468139	260498	0	0.00	0	0	21	160	143	25	0	18	0	-5	19
250	470.65	1019.31	483665	483665	309673	0	0.00	0	0	18	160	144	26	0	20	9	-5	35
325	471.23	1025.87	523757	523757	464074	0	0.00	0	0	13	183	144	30	0	24	13	-6	111
400	471.61	1030.22	556967	556967	545951	0	0.00	0	0	12	189	146	34	0	28	16	-5	176
500	472.08	1035.62	594159	594159	594159	0	0.00	0	0	14	196	150	40	0	32	20	-2	153
PMF	477.51	1099.03	905770	905770	812199	0	0.00	0	0	57	255	129	85	0	55	43	0	146

TABLE A-18: NA2-145 MAX (R060_800FM_No Fix_145_FP466_P1_20080916)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	406.42	416.85	5000	5000	4242	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	406.74	419.09	20002	20002	16967	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	406.86	419.97	25004	25004	21210	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	406.97	420.78	29000	29000	23588	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	407.19	422.35	37002	37002	27464	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	407.29	423.06	40722	40722	30225	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	414.02	473.00	90369	90369	54221	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	423.56	549.32	136522	136522	81913	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	427.18	579.96	167533	167533	115000	0	0.00	0	0	0	28	28	0	0	0	0	0	0
20	430.25	606.84	191482	191482	115000	0	0.00	0	0	0	38	38	0	0	0	0	0	0
25	433.17	633.13	211227	211227	115000	0	0.00	0	0	0	47	47	0	0	0	0	0	0
35	438.57	683.35	243016	243016	115000	0	0.00	0	0	0	59	59	0	0	0	0	0	0
50	444.11	736.88	279485	279485	115000	0	0.00	0	0	0	77	77	0	0	0	0	0	0
65	450.07	796.61	308218	308218	115000	0	0.00	0	0	0	105	105	0	0	0	0	0	0
80	456.02	858.42	332148	332148	115000	0	0.00	0	0	0	128	128	0	0	0	0	0	0
100	**461.90**	**921.63**	**359078**	**359078**	**115000**	**0**	**0.00**	**0**	**0**	**0**	**139**	**139**	**0**	**0**	**0**	**0**	**0**	**0**
130	460.99	911.73	392399	392399	145000	0	0.00	0	0	0	142	124	0	0	0	0	0	0
150	466.51	972.53	411351	411351	145000	0	0.00	0	0	14	153	135	0	0	0	0	0	0
175	469.98	1011.59	432395	432395	154629	0	0.00	0	0	32	178	142	0	0	0	0	0	0
200	**470.03**	**1012.15**	**451163**	**451163**	**209579**	**0**	**0.00**	**0**	**0**	**25**	**180**	**142**	**21**	**0**	**15**	**0**	**0**	**0**
225	470.31	1015.44	468139	468139	262069	0	0.00	0	0	21	182	143	25	0	18	0	-5	10
250	470.71	1019.97	483665	483665	314605	0	0.00	0	0	18	183	143	26	0	20	9	-5	25
325	471.20	1025.58	523757	523757	466105	0	0.00	0	0	13	187	144	31	0	25	14	-6	100
400	471.75	1031.94	556967	556967	556967	0	0.00	0	0	13	193	145	35	0	29	17	-5	143
500	471.90	1033.55	594159	594159	594159	0	0.00	0	0	13	201	150	40	0	32	21	-2	140

TABLE A-19: NA2-145 MIN (R060_800FM_No Fix_145_FP466_P1_20080916)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	386.34	290.07	5000	6419	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	398.86	365.50	20002	20133	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	402.75	391.34	25004	24305	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	405.77	412.26	29000	27959	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	411.50	453.90	37002	35274	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	412.98	465.10	40722	38674	8916	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	416.16	489.65	90369	84059	50000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	424.05	553.36	136522	126249	65753	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	428.10	587.92	167533	154598	84559	0	0.00	0	0	0	0	0	0	0	0	0	0	0
20	428.64	592.60	191482	176491	115000	0	0.00	0	0	0	25	25	0	0	0	0	0	0
25	431.48	617.85	211227	194541	115000	0	0.00	0	0	0	33	33	0	0	0	0	0	0
35	436.67	665.48	243016	223601	115000	0	0.00	0	0	0	48	48	0	0	0	0	0	0
50	442.99	725.90	279485	256938	115000	0	0.00	0	0	0	62	62	0	0	0	0	0	0
65	448.29	778.56	308218	283204	115000	0	0.00	0	0	0	81	81	0	0	0	0	0	0
80	451.74	813.77	332148	305080	115000	0	0.00	0	0	0	106	106	0	0	0	0	0	0
100	**458.45**	**884.30**	**359078**	**329825**	**115000**	**0**	**0.00**	**0**	**0**	**0**	**131**	**131**	**0**	**0**	**0**	**0**	**0**	**0**
130	465.67	963.13	392399	360850	116941	0	0.00	0	0	0	146	118	0	0	0	0	0	0
150	463.97	944.31	411351	381289	145000	0	0.00	0	0	0	146	127	0	0	0	0	0	0
175	468.50	994.84	432395	407507	145000	0	0.00	0	0	31	156	138	0	0	0	0	0	0
200	**470.21**	**1014.21**	**451163**	**429875**	**175825**	**0**	**0.00**	**0**	**0**	**32**	**159**	**141**	**19**	**1**	**0**	**0**	**5**	**0**
225	470.28	1015.10	468139	448786	194960	0	0.00	0	0	29	160	144	21	0	0	0	0	0
250	470.16	1013.63	483665	465352	228088	0	0.00	0	0	23	161	146	23	0	17	0	-5	0
325	470.84	1021.39	523757	506439	339880	0	0.00	0	0	17	162	147	28	0	22	10	-6	67
400	471.55	1029.61	556967	540033	488931	0	0.00	0	0	13	162	148	33	0	26	14	-1	119
500	471.80	1032.40	594159	577133	568037	0	0.00	0	0	12	180	150	39	0	30	17	-2	229

TABLE A-20: NA3-145 BASE (R060_800DR3.5e_145_FP471.5_P1_20080916)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	399.42	369.20	5000	5000	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	402.39	388.94	20002	20002	16328	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	402.53	389.84	25004	25004	20411	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	402.78	391.51	29000	29000	24600	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	403.59	397.11	37002	37002	26005	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	403.18	394.30	40722	40722	25215	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	413.74	470.92	90369	90369	44261	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	421.65	533.58	136522	136522	71655	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	424.92	560.66	167533	167533	115000	0	0.00	0	0	0	26	26	0	0	0	0	0	0
20	428.02	587.24	191482	191482	115000	0	0.00	0	0	0	36	36	0	0	0	0	0	0
25	431.43	617.37	211227	211227	115000	0	0.00	0	0	0	45	45	0	0	0	0	0	0
35	437.15	669.98	243016	243016	115000	0	0.00	0	0	0	57	57	0	0	0	0	0	0
50	442.97	725.68	279485	279485	115000	0	0.00	0	0	0	75	75	0	0	0	0	0	0
65	449.11	786.85	308218	308218	115000	0	0.00	0	0	0	103	103	0	0	0	0	0	0
80	453.74	834.47	332148	332148	115000	0	0.00	0	0	0	127	127	0	0	0	0	0	0
100	**460.46**	**906.02**	**359078**	**359078**	**115000**	**0**	**0.00**	**0**	**0**	**0**	**137**	**137**	**0**	**0**	**0**	**0**	**0**	**0**
130	461.49	917.22	392399	392399	145000	0	0.00	0	0	0	144	125	0	0	0	0	0	0
150	466.26	969.69	411351	411351	145000	0	0.00	0	0	7	152	133	0	0	0	0	0	0
175	469.90	1010.67	432395	432395	145000	0	0.00	0	0	34	160	142	0	0	0	0	0	0
200	**474.92**	**1068.57**	**451163**	**451163**	**145000**	**0**	**0.00**	**0**	**0**	**53**	**171**	**153**	**0**	**0**	**0**	**0**	**0**	**0**
225	477.03	1093.42	468139	468139	171154	0	0.00	0	0	56	173	156	19	1	0	0	4	0
250	477.36	1097.31	483665	483665	197562	0	0.00	0	0	56	174	158	23	0	0	0	7	0
325	477.22	1095.62	523757	523757	300796	0	0.00	0	0	48	196	157	28	0	22	10	-6	78
400	477.90	1103.69	556967	556967	399130	0	0.00	0	0	39	201	158	32	0	26	14	-5	100
500	478.32	1108.60	594159	594159	558062	0	0.00	0	0	28	205	159	38	0	30	18	-2	151

TABLE A-21: NA3-145 MAX (R060_800DR3.5e_145_FP471.5_P1_20080916)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	406.42	416.85	5000	5000	4242	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	406.74	419.09	20002	20002	16967	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	406.86	419.97	25004	25004	21210	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	406.97	420.78	29000	29000	23588	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	407.19	422.35	37002	37002	27464	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	407.29	423.06	40722	40722	30225	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	414.02	473.00	90369	90369	54221	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	423.56	549.32	136522	136522	81913	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	427.18	579.96	167533	167533	115000	0	0.00	0	0	0	28	28	0	0	0	0	0	0
20	430.25	606.84	191482	191482	115000	0	0.00	0	0	0	38	38	0	0	0	0	0	0
25	433.17	633.13	211227	211227	115000	0	0.00	0	0	0	47	47	0	0	0	0	0	0
35	438.57	683.35	243016	243016	115000	0	0.00	0	0	0	59	59	0	0	0	0	0	0
50	444.11	736.88	279485	279485	115000	0	0.00	0	0	0	77	77	0	0	0	0	0	0
65	450.07	796.61	308218	308218	115000	0	0.00	0	0	0	105	105	0	0	0	0	0	0
80	456.02	858.42	332148	332148	115000	0	0.00	0	0	0	128	128	0	0	0	0	0	0
100	**461.90**	**921.63**	**359078**	**359078**	**115000**	**0**	**0.00**	**0**	**0**	**0**	**139**	**139**	**0**	**0**	**0**	**0**	**0**	**0**
130	460.99	911.73	392399	392399	145000	0	0.00	0	0	0	142	124	0	0	0	0	0	0
150	466.41	971.34	411351	411351	145000	0	0.00	0	0	9	151	133	0	0	0	0	0	0
175	470.14	1013.42	432395	432395	145000	0	0.00	0	0	34	179	143	0	0	0	0	0	0
200	**#N/A**	**#N/A**	**451163**	**451163**	**#N/A**	**#N/A**	**#N/A**	**0**	**0**	**15**	**74**	**#N/A**	**5**	**#N/A**	**0**	**0**	**#N/A**	**#N/A**
225	477.06	1093.72	468139	468139	172840	0	0.00	0	0	56	195	156	19	0	0	0	4	0
250	477.19	1095.30	483665	483665	202925	0	0.00	0	0	55	197	157	23	0	17	0	1	0
325	477.39	1097.70	523757	523757	320734	0	0.00	0	0	47	199	156	29	0	22	11	100	35
400	478.01	1104.97	556967	556967	430723	0	0.00	0	0	37	205	157	32	0	26	14	-5	100
500	478.08	1105.79	594159	594159	558062	0	0.00	0	0	27	210	159	38	0	30	18	-2	167

TABLE A-22: NA3-145 MIN (R060_800DR3.5e_145_FP471.5_P1_20080916)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	386.34	290.07	5000	6419	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	398.86	365.50	20002	20133	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	402.75	391.34	25004	24305	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	405.77	412.26	29000	27959	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	411.50	453.90	37002	35274	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	412.98	465.10	40722	38674	8916	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	416.16	489.65	90369	84059	50000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	424.05	553.36	136522	126249	65753	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	428.10	587.92	167533	154598	84559	0	0.00	0	0	0	0	0	0	0	0	0	0	0
20	428.64	592.60	191482	176491	115000	0	0.00	0	0	0	25	25	0	0	0	0	0	0
25	431.48	617.85	211227	194541	115000	0	0.00	0	0	0	33	33	0	0	0	0	0	0
35	436.67	665.48	243016	223601	115000	0	0.00	0	0	0	48	48	0	0	0	0	0	0
50	442.99	725.90	279485	256938	115000	0	0.00	0	0	0	62	62	0	0	0	0	0	0
65	448.29	778.56	308218	283204	115000	0	0.00	0	0	0	81	81	0	0	0	0	0	0
80	451.74	813.77	332148	305080	115000	0	0.00	0	0	0	106	106	0	0	0	0	0	0
100	**458.45**	**884.30**	**359078**	**329825**	**115000**	**0**	**0.00**	**0**	**0**	**0**	**131**	**131**	**0**	**0**	**0**	**0**	**0**	**0**
130	465.98	966.59	392399	360850	115000	0	0.00	0	0	0	147	147	0	0	0	0	0	0
150	463.97	944.31	411351	381289	145000	0	0.00	0	0	0	146	127	0	0	0	0	0	0
175	468.21	991.54	432395	407507	145000	0	0.00	0	0	23	155	137	0	0	0	0	0	0
200	**471.93**	**1033.95**	**451163**	**429875**	**145000**	**0**	**0.00**	**0**	**0**	**44**	**164**	**146**	**0**	**0**	**0**	**0**	**0**	**0**
225	474.23	1060.55	468139	448786	145000	0	0.00	0	0	52	169	153	0	0	0	0	0	0
250	476.87	1091.48	483665	465352	145000	0	0.00	0	0	60	176	161	0	0	0	0	0	0
325	481.26	1143.79	523757	506439	182469	0	0.00	0	0	69	184	169	22	0	0	0	10	0
400	485.04	1189.63	556967	540033	406641	80	1.04	0	0	61	182	168	25	0	17	6	167	63
500	486.04	1201.93	594159	577133	670948	220	2.04	0	0	49	197	167	32	0	23	10	-2	440

TABLE A-23: NA1-160 BASE (R000_800CF_No Fix_160_FP470_P1_20081214)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	399.42	369.20	5000	5000	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	402.39	388.94	20002	20002	16328	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	402.53	389.84	25004	25004	20411	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	402.78	391.51	29000	29000	24600	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	403.60	397.18	37002	37002	25945	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	403.08	393.58	40722	40722	25891	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	418.26	506.23	90369	90369	26643	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	431.09	614.37	136522	136522	43519	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	436.58	664.64	167533	167533	71079	0	0.00	0	0	0	0	0	0	0	0	0	0	0
20	440.71	703.82	191482	191482	87949	0	0.00	0	0	0	0	0	0	0	0	0	0	0
25	444.54	741.14	211227	211227	104311	0	0.00	0	0	0	0	0	0	0	0	0	0	0
35	450.77	803.76	243016	243016	115000	0	0.00	0	0	0	28	28	0	0	0	0	0	0
50	459.13	891.67	279485	279485	115000	0	0.00	0	0	0	54	54	0	0	0	0	0	0
65	462.93	932.91	308218	308218	135000	0	0.00	0	0	0	65	65	0	0	0	0	0	0
80	468.15	990.91	332148	332148	135000	0	0.00	0	0	23	78	78	0	0	0	0	0	0
100	**472.32**	**1038.47**	**359078**	**359078**	**145000**	**0**	**0.00**	**0**	**0**	**43**	**96**	**96**	**0**	**0**	**0**	**0**	**0**	**0**
130	475.29	1072.93	392399	392399	186741	0	0.00	0	0	48	104	102	30	10	0	0	22	0
150	475.86	1079.58	411351	411351	236150	0	0.00	0	0	48	105	102	32	8	17	0	36	5
175	476.03	1081.62	432395	432395	268705	0	0.00	0	0	48	105	103	34	9	19	0	82	17
200	**476.37**	**1085.66**	**451163**	**451163**	**321017**	**0**	**0.00**	**0**	**0**	**45**	**104**	**102**	**37**	**9**	**22**	**11**	**53**	**42**
225	476.56	1087.85	468139	468139	361431	0	0.00	0	0	41	104	102	40	9	24	12	64	42
250	476.64	1088.84	483665	483665	408551	0	0.00	0	0	38	103	100	41	9	26	14	71	46
325	477.14	1094.64	523757	523757	482854	0	0.00	0	0	35	102	101	48	12	30	18	86	49
400	477.86	1103.24	556967	556967	503865	0	0.00	0	0	38	107	107	41	0	35	21	36	48
500	479.04	1117.15	594159	594159	513195	0	0.00	0	0	43	129	115	48	0	39	25	32	51

TABLE A-24: NA1-160 MAX (R000_800CF_No Fix_160_FP470_P1_20081214)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	406.42	416.85	5000	5000	4242	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	406.74	419.09	20002	20002	16967	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	406.86	419.97	25004	25004	21210	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	406.97	420.78	29000	29000	24600	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	407.19	422.35	37002	37002	26113	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	407.29	423.06	40722	40722	26125	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	419.62	517.12	90369	90369	27084	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	431.28	616.04	136522	136522	54716	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	438.30	680.77	167533	167533	78433	0	0.00	0	0	0	0	0	0	0	0	0	0	0
20	443.02	726.15	191482	191482	97176	0	0.00	0	0	0	0	0	0	0	0	0	0	0
25	446.43	759.84	211227	211227	114092	0	0.00	0	0	0	0	0	0	0	0	0	0	0
35	452.77	824.45	243016	243016	115000	0	0.00	0	0	0	34	34	0	0	0	0	0	0
50	460.96	911.37	279485	279485	115000	0	0.00	0	0	0	59	59	0	0	0	0	0	0
65	464.23	947.20	308218	308218	135000	0	0.00	0	0	0	69	68	0	0	0	0	0	0
80	468.90	999.41	332148	332148	135000	0	0.00	0	0	27	82	80	0	0	0	0	0	0
100	**472.51**	**1040.60**	**359078**	**359078**	**145000**	**0**	**0.00**	**0**	**0**	**44**	**96**	**96**	**0**	**0**	**0**	**0**	**0**	**0**
130	475.13	1071.01	392399	392399	178470	0	0.00	0	0	48	102	102	30	10	0	0	9	0
150	475.70	1077.77	411351	411351	219943	0	0.00	0	0	48	104	103	32	9	17	0	45	0
175	476.05	1081.83	432395	432395	270444	0	0.00	0	0	48	105	103	34	9	19	0	86	15
200	**476.38**	**1085.69**	**451163**	**451163**	**321521**	**0**	**0.00**	**0**	**0**	**45**	**104**	**102**	**37**	**9**	**22**	**11**	**51**	**42**
225	476.57	1087.95	468139	468139	363644	0	0.00	0	0	41	104	102	40	9	24	12	69	42
250	476.65	1088.93	483665	483665	410822	0	0.00	0	0	37	102	99	41	9	26	14	77	46
325	477.16	1094.95	523757	523757	484299	0	0.00	0	0	35	103	101	48	11	31	18	48	48
400	477.82	1102.73	556967	556967	503510	0	0.00	0	0	38	107	107	51	10	35	21	49	46
500	479.01	1116.84	594159	594159	512982	0	0.00	0	0	43	127	115	57	9	39	25	36	52

TABLE A-25: NA1-160 MIN (R000_800CF_No Fix_160_FP470_P1_20081214)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	386.34	290.07	5000	6419	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	398.86	365.50	20002	20133	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	402.75	391.34	25004	24305	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	405.77	412.26	29000	27959	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	411.50	453.90	37002	35274	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	412.98	465.10	40722	38674	8916	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	418.60	508.91	90369	84059	27017	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	430.16	606.08	136522	126249	50159	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	435.32	652.92	167533	154598	66881	0	0.00	0	0	0	0	0	0	0	0	0	0	0
20	438.84	685.88	191482	176491	81222	0	0.00	0	0	0	0	0	0	0	0	0	0	0
25	441.67	713.08	211227	194541	90784	0	0.00	0	0	0	0	0	0	0	0	0	0	0
35	446.19	757.45	243016	223601	112689	0	0.00	0	0	0	0	0	0	0	0	0	0	0
50	452.28	819.34	279485	256938	115000	0	0.00	0	0	0	33	33	0	0	0	0	0	0
65	457.86	877.97	308218	283204	115000	0	0.00	0	0	0	50	50	0	0	0	0	0	0
80	459.50	895.65	332148	305080	135000	0	0.00	0	0	0	56	56	0	0	0	0	0	0
100	**464.68**	**952.16**	**359078**	**329825**	**135000**	**0**	**0.00**	**0**	**0**	**0**	**70**	**70**	**0**	**0**	**0**	**0**	**0**	**0**
130	470.22	1014.37	392399	360850	145000	0	0.00	0	0	34	87	87	0	0	0	0	0	0
150	471.89	1033.48	411351	381289	160000	0	0.00	0	0	45	99	98	22	24	0	0	0	0
175	475.26	1072.52	432395	407507	173176	0	0.00	0	0	50	111	111	31	10	0	0	8	0
200	**475.59**	**1076.50**	**451163**	**429875**	**215563**	**0**	**0.00**	**0**	**0**	**50**	**110**	**110**	**33**	**9**	**17**	**0**	**27**	**0**
225	475.83	1079.24	468139	448786	257292	0	0.00	0	0	48	107	106	34	8	20	0	65	28
250	476.10	1082.41	483665	465352	293291	0	0.00	0	0	46	107	106	36	8	22	0	65	49
325	476.60	1088.34	523757	506439	392913	0	0.00	0	0	36	106	105	40	8	26	14	90	61
400	476.93	1092.23	556967	540033	467440	0	0.00	0	0	32	105	104	49	12	30	17	74	65
500	477.96	1104.34	594159	577133	504670	0	0.00	0	0	36	124	111	55	12	34	20	87	52

TABLE A-26: NA2-160 BASE (R060_800FM_No Fix_160_FP466_P1_20090106)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	399.42	369.20	5000	5000	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	402.39	388.94	20002	20002	16328	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	402.53	389.84	25004	25004	20411	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	402.78	391.51	29000	29000	24600	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	403.59	397.11	37002	37002	26005	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	403.18	394.30	40722	40722	25215	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	413.74	470.92	90369	90369	44261	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	421.65	533.58	136522	136522	71655	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	425.56	566.08	167533	167533	115000	0	0.00	0	0	0	24	24	0	0	0	0	0	0
20	428.70	593.15	191482	191482	115000	0	0.00	0	0	0	33	33	0	0	0	0	0	0
25	432.02	622.68	211227	211227	115000	0	0.00	0	0	0	42	42	0	0	0	0	0	0
35	437.51	673.33	243016	243016	115000	0	0.00	0	0	0	56	56	0	0	0	0	0	0
50	444.04	736.19	279485	279485	115000	0	0.00	0	0	0	75	75	0	0	0	0	0	0
65	449.69	792.72	308218	308218	115000	0	0.00	0	0	0	101	101	0	0	0	0	0	0
80	454.35	840.92	332148	332148	115000	0	0.00	0	0	0	125	125	0	0	0	0	0	0
100	**461.31**	**915.15**	**359078**	**359078**	**115000**	**0**	**0.00**	**0**	**0**	**0**	**134**	**134**	**0**	**0**	**0**	**0**	**0**	**0**
130	459.65	897.26	392399	392399	160000	0	0.00	0	0	0	137	121	30	31	0	0	0	0
150	464.33	948.31	411351	411351	160000	0	0.00	0	0	0	146	131	32	33	0	0	0	0
175	467.74	986.26	432395	432395	160000	0	0.00	0	0	26	156	141	30	31	0	0	0	0
200	**470.09**	**1012.88**	**451163**	**451163**	**196633**	**0**	**0.00**	**0**	**0**	**26**	**157**	**143**	**37**	**17**	**0**	**0**	**37**	**0**
225	470.16	1013.72	468139	468139	248894	0	0.00	0	0	21	156	143	40	16	17	0	85	3
250	470.44	1016.88	483665	483665	296022	0	0.00	0	0	18	157	144	41	16	19	0	128	7
325	471.17	1025.16	523757	523757	458379	0	0.00	0	0	13	176	144	44	14	24	13	127	110
400	471.32	1026.88	556967	556967	523129	0	0.00	0	0	13	183	146	47	13	28	16	120	127
500	471.57	1029.74	594159	594159	594159	0	0.00	0	0	12	191	149	53	14	31	20	175	146
PMF	477.46	1098.49	905770	905770	811646	0	0.00	0	0	58	246	124	109	18	56	44	100	139

TABLE A-27: NA2-160 MAX (R060_800FM_No Fix_160_FP466_P1_20090106)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	406.42	416.85	5000	5000	4242	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	406.74	419.09	20002	20002	16967	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	406.86	419.97	25004	25004	21210	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	406.97	420.78	29000	29000	23588	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	407.19	422.35	37002	37002	27464	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	407.29	423.06	40722	40722	30225	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	415.59	485.14	90369	90369	54221	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	423.58	549.49	136522	136522	81913	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	427.91	586.22	167533	167533	115000	0	0.00	0	0	0	26	26	0	0	0	0	0	0
20	430.94	612.96	191482	191482	115000	0	0.00	0	0	0	36	36	0	0	0	0	0	0
25	434.32	643.67	211227	211227	115000	0	0.00	0	0	0	45	45	0	0	0	0	0	0
35	439.26	689.88	243016	243016	115000	0	0.00	0	0	0	59	59	0	0	0	0	0	0
50	446.18	757.39	279485	279485	115000	0	0.00	0	0	0	78	78	0	0	0	0	0	0
65	451.66	812.98	308218	308218	115000	0	0.00	0	0	0	104	104	0	0	0	0	0	0
80	457.54	874.57	332148	332148	115000	0	0.00	0	0	0	126	126	0	0	0	0	0	0
100	**462.60**	**929.22**	**359078**	**359078**	**115155**	**0**	**0.00**	**0**	**0**	**0**	**136**	**106**	**0**	**0**	**0**	**0**	**0**	**0**
130	461.22	914.25	392399	392399	160000	0	0.00	0	0	0	136	123	30	31	0	0	0	0
150	464.46	949.80	411351	411351	160000	0	0.00	0	0	0	145	131	32	33	0	0	0	0
175	467.90	988.09	432395	432395	160000	0	0.00	0	0	27	154	141	30	31	0	0	0	0
200	**470.10**	**1012.99**	**451163**	**451163**	**195966**	**0**	**0.00**	**0**	**0**	**26**	**176**	**143**	**37**	**17**	**0**	**0**	**33**	**0**
225	470.20	1014.16	468139	468139	254566	0	0.00	0	0	20	177	143	40	16	17	0	92	2
250	470.35	1015.82	483665	483665	288029	0	0.00	0	0	18	179	144	41	16	19	0	118	7
325	471.14	1024.90	523757	523757	452926	0	0.00	0	0	13	185	145	44	14	24	14	175	94
400	471.33	1027.02	556967	556967	540048	0	0.00	0	0	12	189	146	47	13	28	17	175	120
500	471.55	1029.62	594159	594159	594159	0	0.00	0	0	13	197	149	53	13	32	21	175	107

TABLE A-28: NA2-160 MIN (R060_800FM_No Fix_160_FP466_P1_20090106)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	386.34	290.07	5000	6419	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	398.86	365.50	20002	20133	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	402.75	391.34	25004	24305	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	405.77	412.26	29000	27959	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	411.50	453.90	37002	35274	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	412.98	465.10	40722	38674	8916	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	416.16	489.65	90369	84059	50000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	424.05	553.36	136522	126249	65753	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	428.30	589.62	167533	154598	84559	0	0.00	0	0	0	0	0	0	0	0	0	0	0
20	429.46	599.84	191482	176491	115000	0	0.00	0	0	0	23	23	0	0	0	0	0	0
25	432.18	624.13	211227	194541	115000	0	0.00	0	0	0	31	31	0	0	0	0	0	0
35	437.35	671.86	243016	223601	115000	0	0.00	0	0	0	45	45	0	0	0	0	0	0
50	443.50	730.90	279485	256938	115000	0	0.00	0	0	0	61	61	0	0	0	0	0	0
65	448.76	783.26	308218	283204	115000	0	0.00	0	0	0	80	80	0	0	0	0	0	0
80	452.90	825.76	332148	305080	115000	0	0.00	0	0	0	116	116	0	0	0	0	0	0
100	**459.22**	**892.62**	**359078**	**329825**	**115000**	**0**	**0.00**	**0**	**0**	**0**	**129**	**129**	**0**	**0**	**0**	**0**	**0**	**0**
130	466.33	970.48	392399	360850	121233	0	0.00	0	0	9	143	119	0	0	0	0	0	0
150	463.02	933.87	411351	381289	160000	0	0.00	0	0	0	140	125	27	28	0	0	0	0
175	467.23	980.56	432395	407507	160000	0	0.00	0	0	23	150	137	25	26	0	0	0	0
200	**470.09**	**1012.92**	**451163**	**429875**	**176230**	**0**	**0.00**	**0**	**0**	**30**	**153**	**140**	**33**	**14**	**0**	**0**	**6**	**0**
225	470.13	1013.35	468139	448786	198409	0	0.00	0	0	26	154	143	36	15	0	0	35	0
250	470.11	1013.14	483665	465352	227979	0	0.00	0	0	23	156	146	38	15	17	0	68	0
325	470.67	1019.48	523757	506439	327556	0	0.00	0	0	17	158	147	42	14	22	10	125	38
400	471.18	1025.30	556967	540033	463776	0	0.00	0	0	13	159	149	47	14	26	14	125	114
500	471.42	1028.03	594159	577133	544670	0	0.00	0	0	12	175	151	52	14	29	17	175	177

TABLE A-29: NA3-160 BASE (R060_800DR3.5e_160_FP471.5_P1_20081215)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	399.42	369.20	5000	5000	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	402.39	388.94	20002	20002	16328	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	402.53	389.84	25004	25004	20411	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	402.78	391.51	29000	29000	24600	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	403.59	397.11	37002	37002	26005	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	403.18	394.30	40722	40722	25215	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	413.74	470.92	90369	90369	44261	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	421.65	533.58	136522	136522	71655	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	425.56	566.08	167533	167533	115000	0	0.00	0	0	0	24	24	0	0	0	0	0	0
20	428.70	593.15	191482	191482	115000	0	0.00	0	0	0	33	33	0	0	0	0	0	0
25	432.02	622.68	211227	211227	115000	0	0.00	0	0	0	42	42	0	0	0	0	0	0
35	437.51	673.33	243016	243016	115000	0	0.00	0	0	0	56	56	0	0	0	0	0	0
50	444.04	736.19	279485	279485	115000	0	0.00	0	0	0	75	75	0	0	0	0	0	0
65	449.69	792.72	308218	308218	115000	0	0.00	0	0	0	101	101	0	0	0	0	0	0
80	454.35	840.92	332148	332148	115000	0	0.00	0	0	0	125	125	0	0	0	0	0	0
100	**461.31**	**915.15**	**359078**	**359078**	**115000**	**0**	**0.00**	**0**	**0**	**0**	**134**	**134**	**0**	**0**	**0**	**0**	**0**	**0**
130	459.65	897.26	392399	392399	160000	0	0.00	0	0	0	137	121	30	31	0	0	0	0
150	464.33	948.31	411351	411351	160000	0	0.00	0	0	0	146	131	32	33	0	0	0	0
175	467.47	983.26	432395	432395	160000	0	0.00	0	0	17	153	138	35	36	0	0	0	0
200	**472.47**	**1040.14**	**451163**	**451163**	**160000**	**0**	**0.00**	**0**	**0**	**46**	**164**	**150**	**32**	**33**	**0**	**0**	**0**	**0**
225	476.20	1083.60	468139	468139	160000	0	0.00	0	0	57	170	157	34	35	0	0	0	0
250	477.15	1094.82	483665	483665	193667	0	0.00	0	0	54	170	157	41	19	0	0	18	0
325	477.08	1093.97	523757	523757	294943	0	0.00	0	0	48	189	157	44	16	22	0	78	4
400	477.78	1102.31	556967	556967	405477	0	0.00	0	0	38	195	158	47	15	26	14	100	81
500	478.03	1105.25	594159	594159	534386	0	0.00	0	0	28	202	160	53	16	29	17	107	150

TABLE A-30: NA3-160 MAX (R060_800DR3.5e_160_FP471.5_P1_20081215)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	406.42	416.85	5000	5000	4242	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	406.74	419.09	20002	20002	16967	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	406.86	419.97	25004	25004	21210	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	406.97	420.78	29000	29000	24600	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	407.19	422.35	37002	37002	26113	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	407.29	423.06	40722	40722	26125	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	419.62	517.12	90369	90369	27084	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	431.28	616.04	136522	136522	54716	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	438.30	680.77	167533	167533	78433	0	0.00	0	0	0	0	0	0	0	0	0	0	0
20	443.02	726.15	191482	191482	97176	0	0.00	0	0	0	0	0	0	0	0	0	0	0
25	446.43	759.84	211227	211227	114092	0	0.00	0	0	0	0	0	0	0	0	0	0	0
35	452.77	824.45	243016	243016	115000	0	0.00	0	0	0	34	34	0	0	0	0	0	0
50	460.96	911.37	279485	279485	115000	0	0.00	0	0	0	59	59	0	0	0	0	0	0
65	464.23	947.20	308218	308218	135000	0	0.00	0	0	0	69	68	0	0	0	0	0	0
80	468.90	999.41	332148	332148	135000	0	0.00	0	0	27	82	80	0	0	0	0	0	0
100	**472.51**	**1040.59**	**359078**	**359078**	**145000**	**0**	**0.00**	**0**	**0**	**44**	**96**	**96**	**0**	**0**	**0**	**0**	**0**	**0**
130	475.46	1074.96	392399	392399	187473	0	0.00	0	0	49	103	103	20	0	0	0	5	0
150	475.86	1079.56	411351	411351	229570	0	0.00	0	0	49	104	103	23	0	17	0	-6	6
175	476.20	1083.56	432395	432395	279376	0	0.00	0	0	47	104	102	26	0	20	0	47	8
200	**476.47**	**1086.84**	**451163**	**451163**	**329343**	**0**	**0.00**	**0**	**0**	**44**	**104**	**102**	**28**	**0**	**22**	**11**	**-6**	**41**
225	476.60	1088.35	468139	468139	376509	0	0.00	0	0	40	103	101	31	0	24	12	-5	42
250	476.70	1089.55	483665	483665	421762	0	0.00	0	0	37	102	99	33	0	26	14	56	48
325	477.24	1095.85	523757	523757	488365	0	0.00	0	0	35	103	101	37	0	31	19	-6	42
400	477.87	1103.32	556967	556967	503936	0	0.00	0	0	38	107	107	42	0	35	21	45	48
500	479.04	1117.22	594159	594159	513243	0	0.00	0	0	43	127	115	48	0	39	25	30	51

TABLE A-31: NA3-160 MIN (R060_800DR3.5e_160_FP471.5_P1_20081215)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	386.34	290.07	5000	6419	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	398.86	365.50	20002	20133	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	402.75	391.34	25004	24305	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	405.77	412.26	29000	27959	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	411.50	453.90	37002	35274	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	412.98	465.10	40722	38674	8916	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	416.16	489.65	90369	84059	50000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	424.05	553.36	136522	126249	65753	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	428.30	589.62	167533	154598	84559	0	0.00	0	0	0	0	0	0	0	0	0	0	0
20	429.46	599.84	191482	176491	115000	0	0.00	0	0	0	23	23	0	0	0	0	0	0
25	432.18	624.13	211227	194541	115000	0	0.00	0	0	0	31	31	0	0	0	0	0	0
35	437.35	671.86	243016	223601	115000	0	0.00	0	0	0	45	45	0	0	0	0	0	0
50	443.50	730.90	279485	256938	115000	0	0.00	0	0	0	61	61	0	0	0	0	0	0
65	448.76	783.26	308218	283204	115000	0	0.00	0	0	0	80	80	0	0	0	0	0	0
80	452.90	825.76	332148	305080	115000	0	0.00	0	0	0	116	116	0	0	0	0	0	0
100	**459.22**	**892.62**	**359078**	**329825**	**115000**	**0**	**0.00**	**0**	**0**	**0**	**129**	**129**	**0**	**0**	**0**	**0**	**0**	**0**
130	467.26	980.92	392399	360850	115000	0	0.00	0	0	19	144	144	0	0	0	0	0	0
150	463.02	933.87	411351	381289	160000	0	0.00	0	0	0	140	125	27	28	0	0	0	0
175	467.04	978.39	432395	407507	160000	0	0.00	0	0	14	147	134	31	32	0	0	0	0
200	**470.56**	**1018.21**	**451163**	**429875**	**160000**	**0**	**0.00**	**0**	**0**	**36**	**155**	**142**	**33**	**34**	**0**	**0**	**0**	**0**
225	472.71	1042.91	468139	448786	160000	0	0.00	0	0	49	162	151	31	32	0	0	0	0
250	474.90	1068.38	483665	465352	160000	0	0.00	0	0	55	168	158	33	35	0	0	0	0
325	477.32	1096.76	523757	506439	214967	0	0.00	0	0	57	173	162	42	17	18	0	40	0
400	477.15	1094.84	556967	540033	310772	0	0.00	0	0	47	172	162	47	16	24	11	89	15
500	477.79	1102.40	594159	577133	420080	0	0.00	0	0	34	187	163	52	16	27	14	125	96

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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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

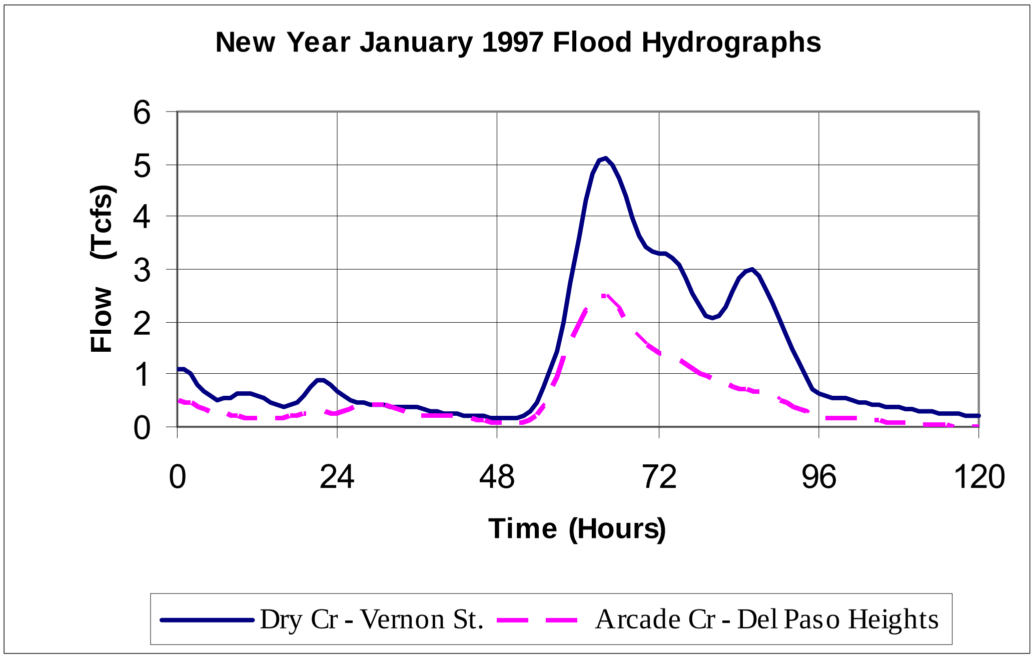


Figure 1. New Year January 1997 Flood Hydrographs Modeled for Dry Creek at Vernon Street and Arcade Creek at Del Paso Heights Gage

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 <u>Arcade Creek Three-Day Flow Frequency Curves</u>. 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 <u>Peak Flows</u>. 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.

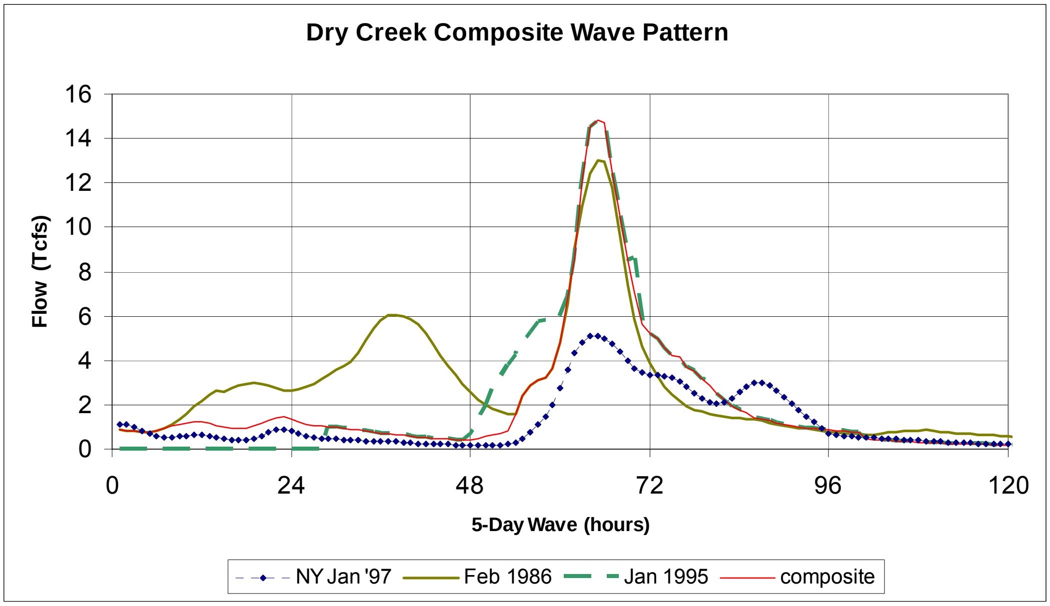


Figure 2. Development of Composite 5-Day Wave Pattern Hydrograph for Dry Creek at Vernon Street, for the 1-, 0.5-, and 0.2% Balanced Flood Hydrographs

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.

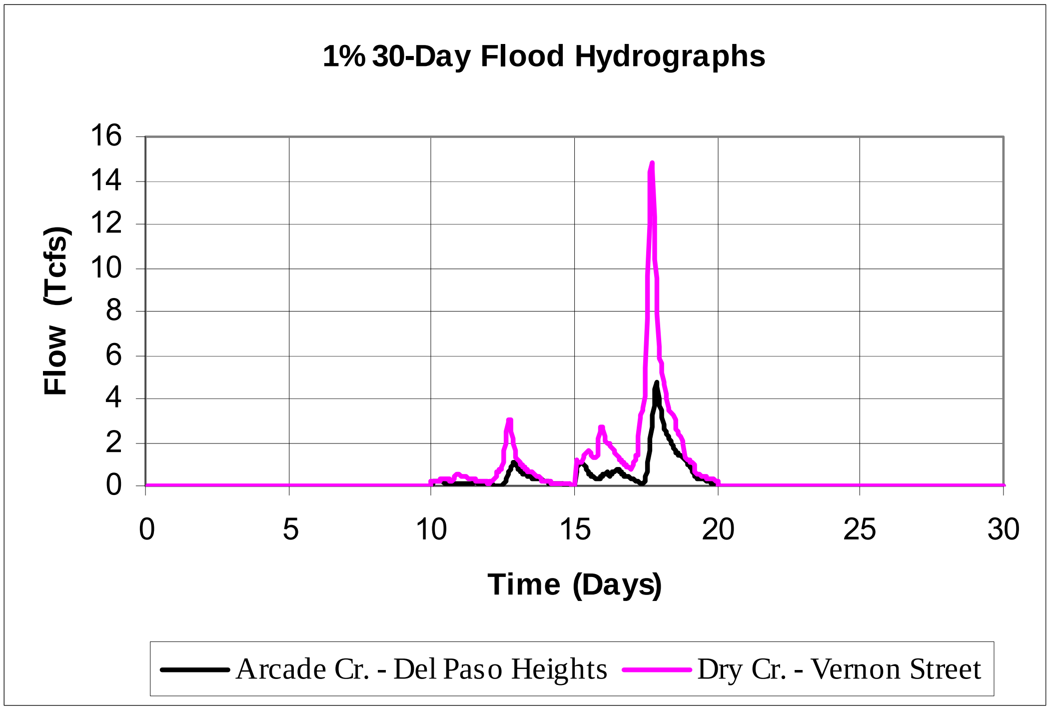


Figure 3. Synthetic 1% Flood 30-Day Wave Hydrographs for Dry Creek at Vernon Street and Arcade Creek at Del Paso Heights Gage

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

1. American River Common Features Project General Reevaluation Report, Natomas Cross Canal and Steelhead Creek Watersheds, Placer, Sacramento, and Sutter Counties, California, Appendix A, Synthetic Hydrology Technical Documentation. U.S. Army Corps of Engineers, Sacramento District. Revised January 2009.

2. Dry Creek Hydrology Draft Appendix 3, "Peak Flow Frequency Relationships for Dry Creek at Vernon Street and Arcade Creek at American River." Dry Creek Hydrology/Hydraulics Peer Review and Consensus Effort. 22 May 1996.

3. Statement of Findings Regarding the Historic Peak Flow and Frequency Frequency of Dry Creek at Vernon Street in Roseville, CA. Dry Creek Hydrology/Hydraulics Peer Review and Consensus Effort. 6 November 1996.

4. Sacramento County ALERT System gage map. Accessed 16 November 2009 at <http://www.sacflood.org/alrtloc1.htm>

5. Flood Frequency Analysis HEC-FFA: User's Manual. U.S. Army Corps of Engineers, Hydrologic Engineering Center. May 1992.

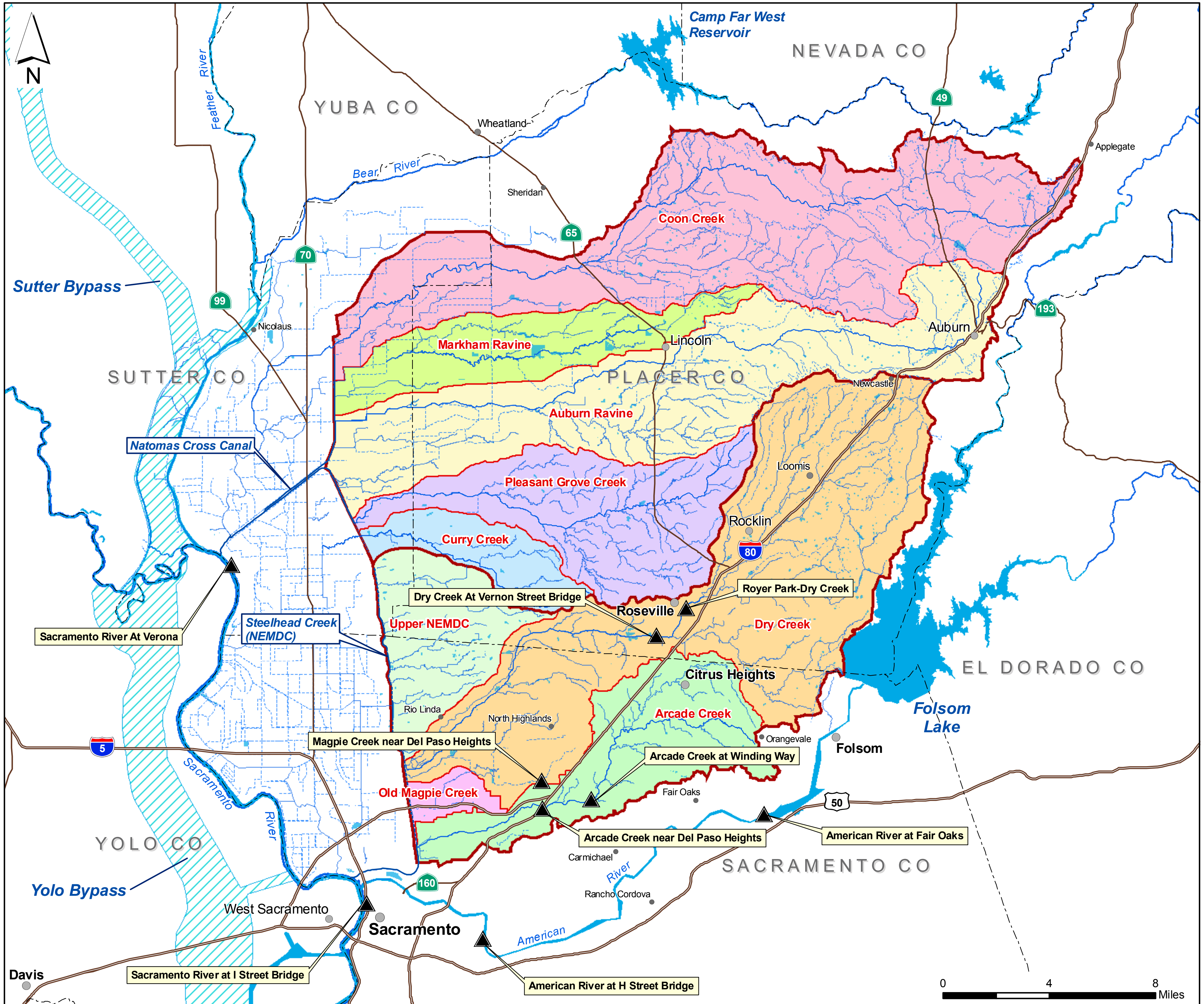
6. Dry Creek, Placer and Sacramento Counties, California, Hydrology Office Report. U.S. Army Corps of Engineers, Sacramento District. July 1984, revised April 1988.

7. REGFQ, Regional Frequency Computation User's Manual. U.S. Army Corps of Engineers, Hydrologic Engineering Center. July 1972. Accessed 16 November 2009 at <http://www.hec.usace.army.mil/publications/ComputerProgramDocumentation/REGFQ_UsersManual_(CPD-27).pdf> [This program performs frequency computations of annual maximum hydrologic events necessary to a regional frequency study.]

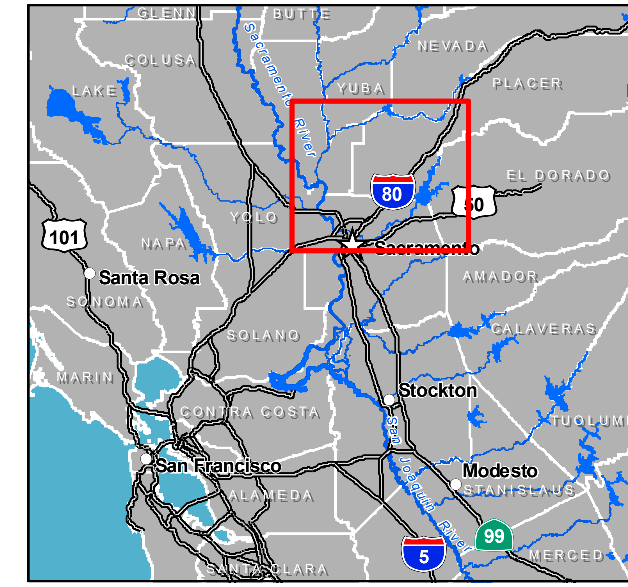
8. Sacramento City/County Drainage Manual, Volume 2, Hydrology Standards. Sacramento County Public Works Agency, Department of District Engineering, Water Resources Division. City of Sacramento Department of Utilities and Public Works Engineering Division. December 1996. Accessed 16 November 2009 at <http://www.msa.saccounty.net/waterresources/drainage/vol2.asp>.

9. Natomas General Reevaluation Report, Natomas Cross Canal and Steelhead Creek Watersheds, Placer, Sacramento, and Sutter Counties, Hydrology Appendix. U.S. Army Corps of Engineers, Sacramento District. October 2006.

10. Sacramento and San Joaquin River Basins Comprehensive Study; Technical Studies Documentation, Appendix B, Synthetic Hydrology Technical Documentation. U.S. Army Corps of Engineers, Sacramento District. December 2002.



Prepared by J.S.M



Legend

- Stream Gage
- Watershed
- Sub-Watershed
- Lake or Major River
- River or Stream
- Canal or Ditch
- Freeway
- Highway
- County Boundary
- City or Town

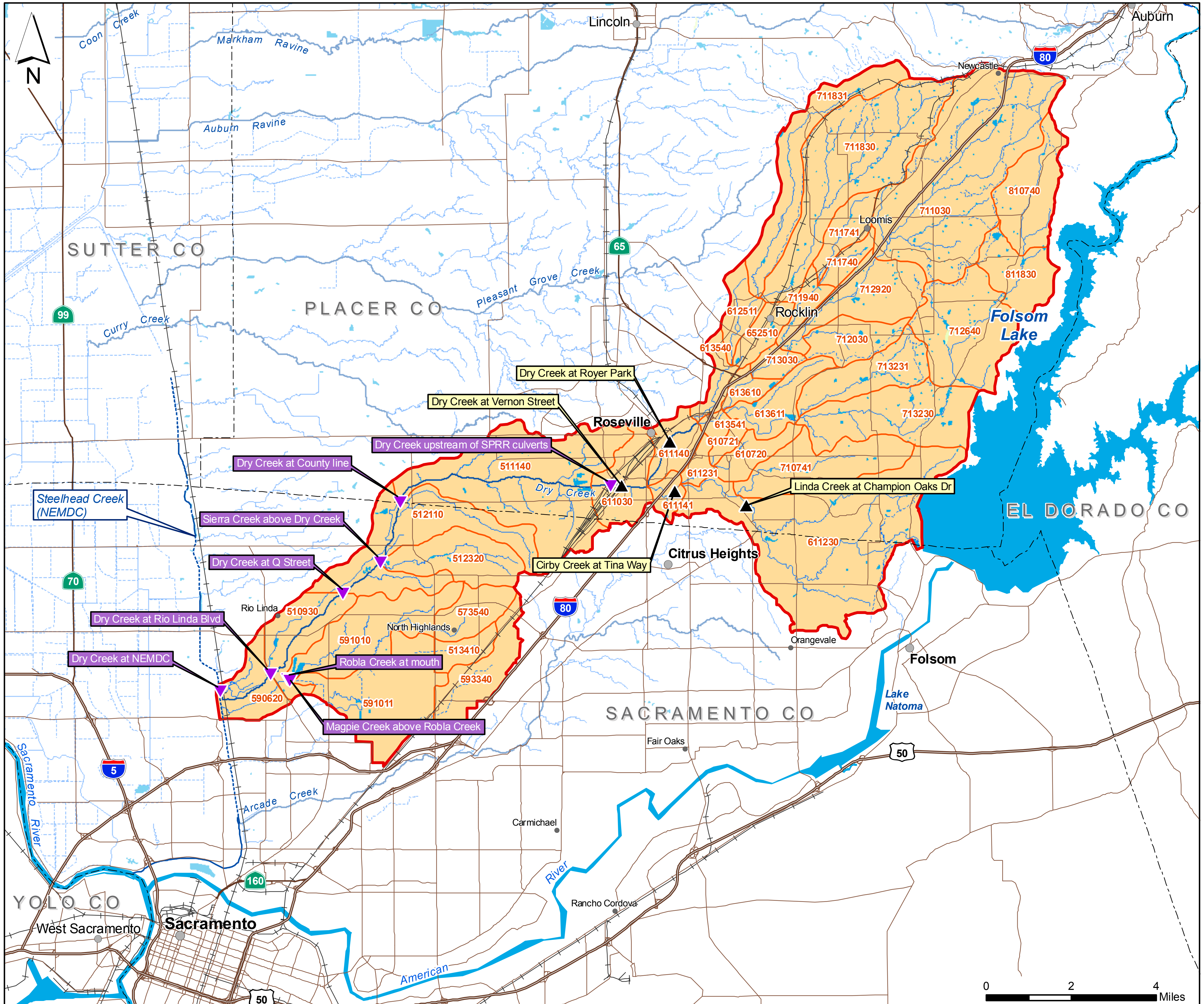
American River Common Features GRR
Placer, Sacramento, Sutter Counties, California

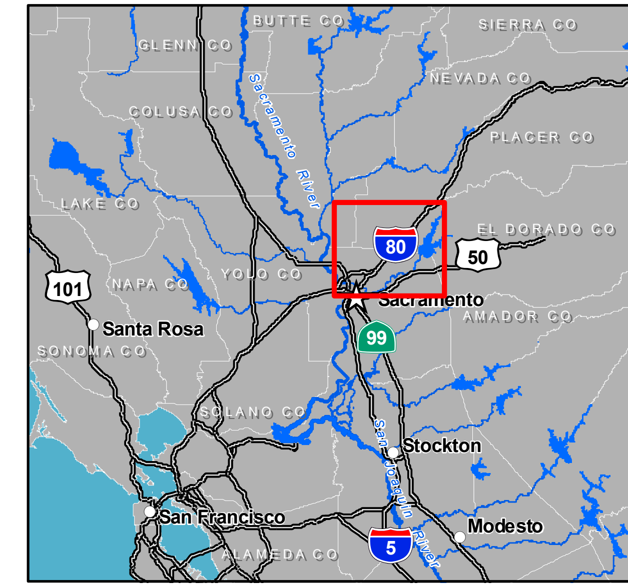
GENERAL MAP

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

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

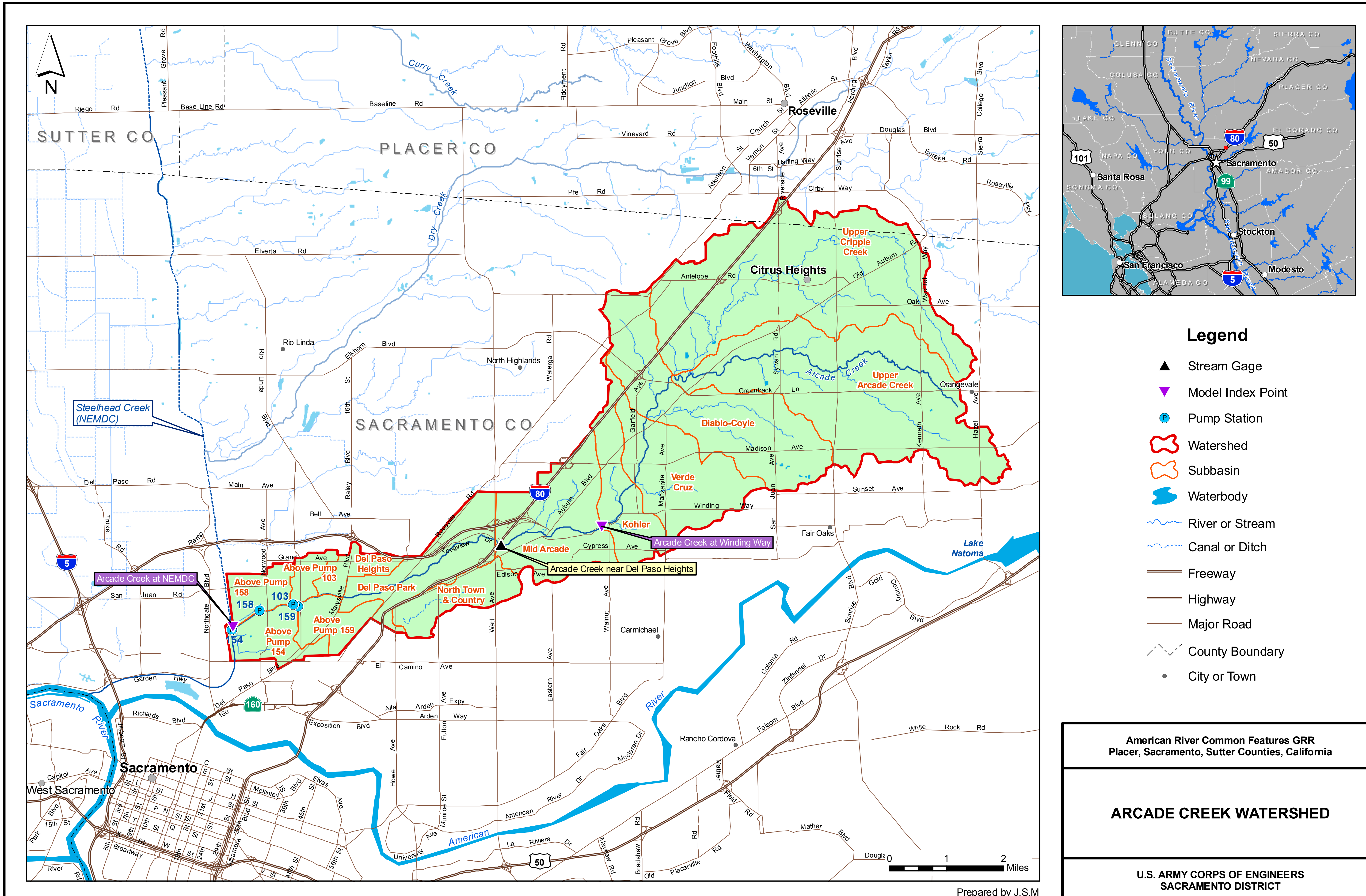
Prepared by J.S.M

American River Common Features GRR
Placer, Sacramento, Sutter Counties, California

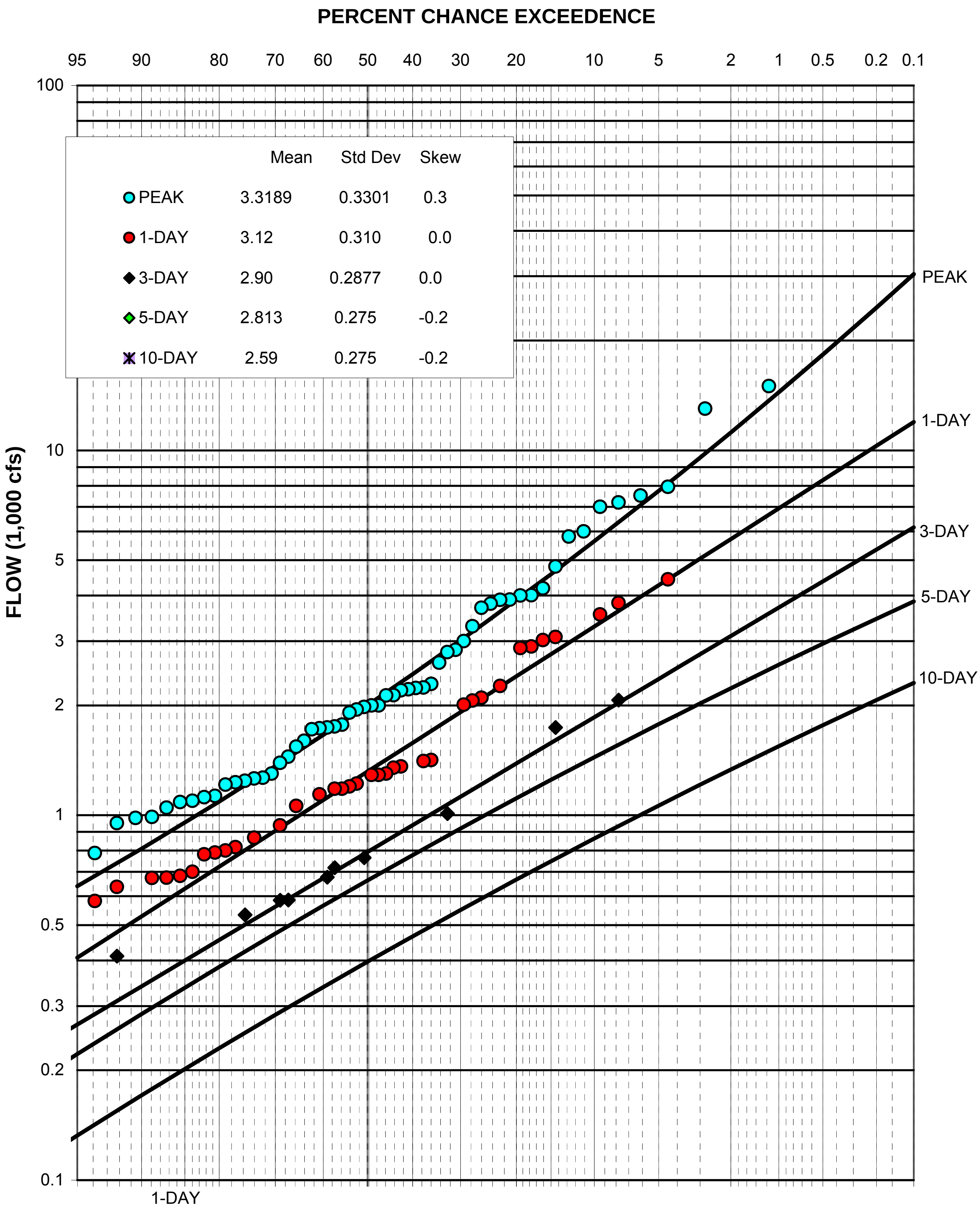
DRY CREEK WATERSHED

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

NOV 2009 PLATE 2



NOV 2009 PLATE 3



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.

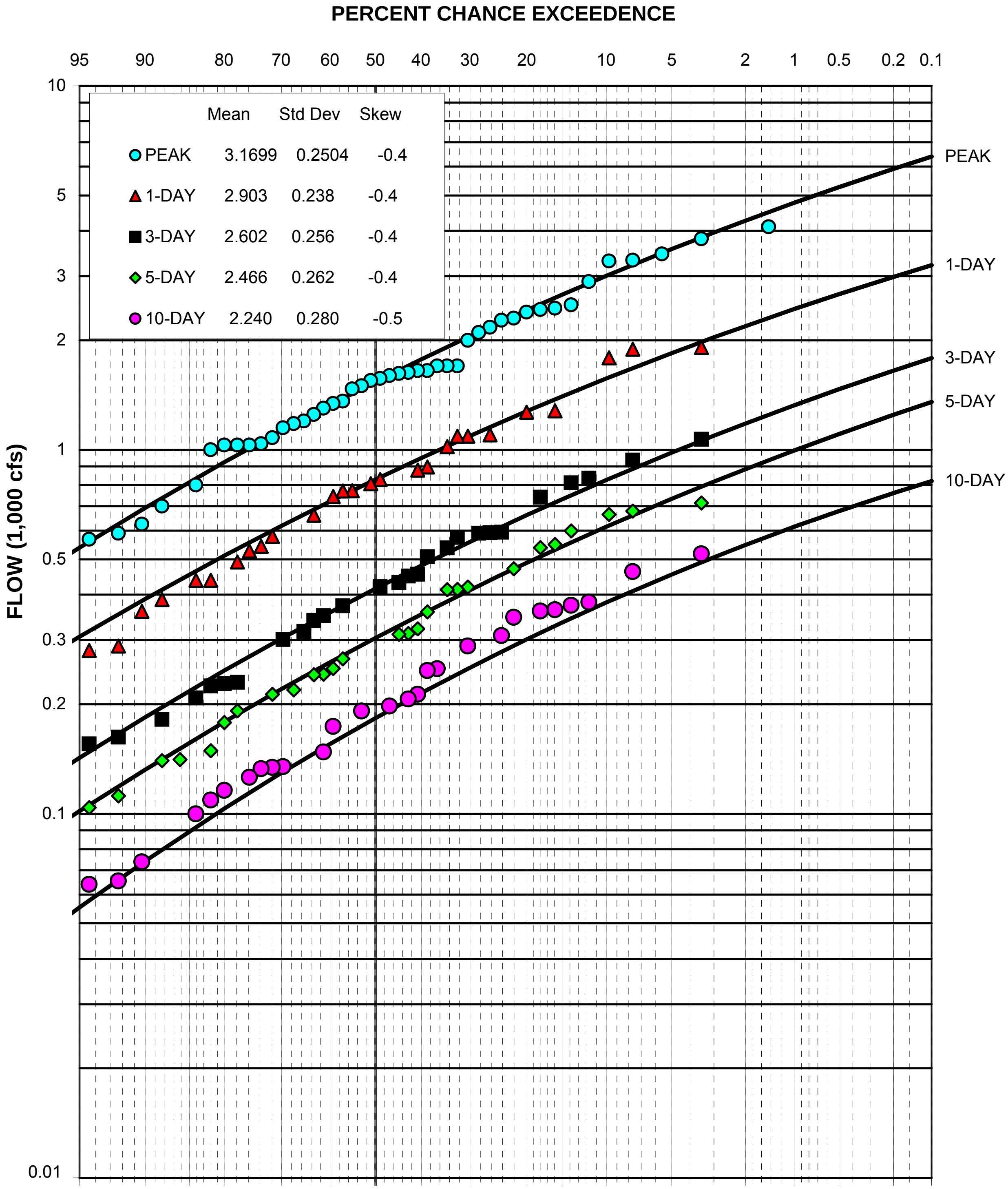
Developed by LLW and prepared by JLB

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

NOV 2009



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

NOV 2009

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 IV — 1-26-2009

John M. High
Chief, Water Management Section, SPK

Date

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 IV — 1-26-2009

John M. High
Chief, Water Management 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

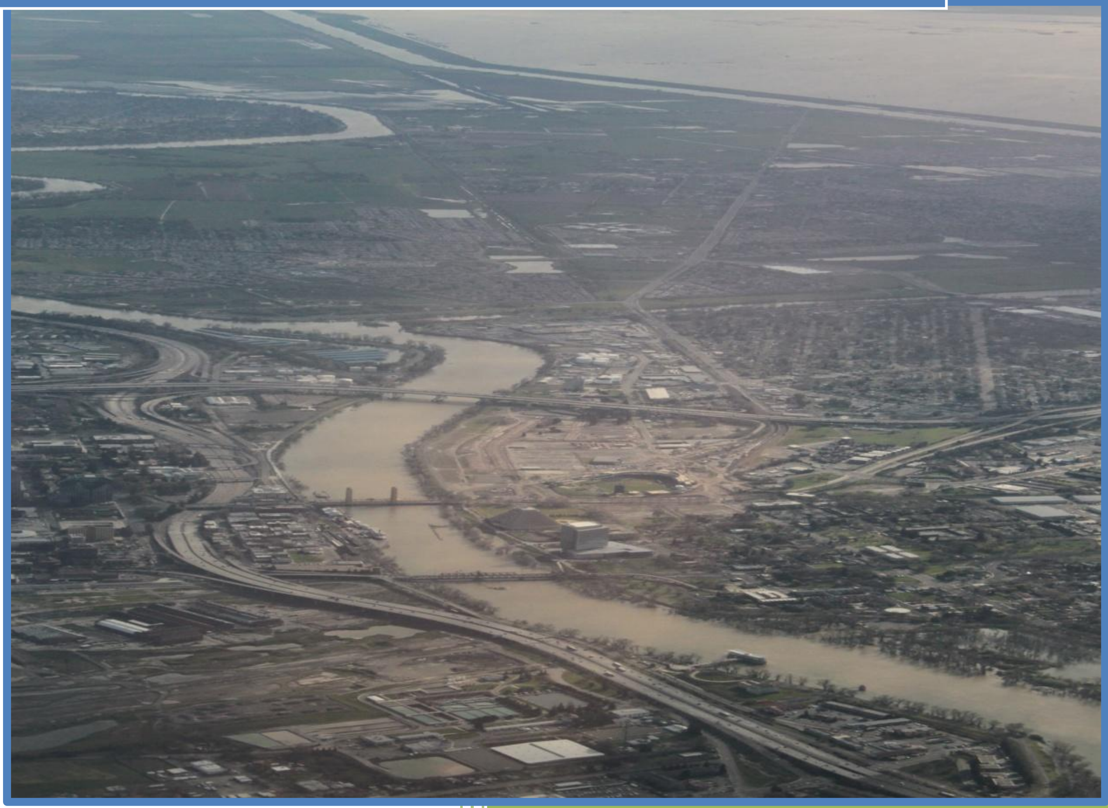
Date 10/19/2010

Gregory A. Kukas, Branch Chief
Hydrology & Hydraulics Branch, SPK

Date 10/19/2010

December 2015

West Sacramento Project General Reevaluation Report



US Army Corps of Engineers ®
Sacramento District

Central Valley Flood Protection Board
Public Safety and Flood Management
State of California

WSAFCA
West Sacramento Area Flood Control Agency

Final Report

Hydraulic Report

Cover Photo: Sacramento River, West Sacramento, and Yolo Bypass, March 2011

Photo courtesy of Chris Austin.

WEST SACRAMENTO PROJECT, CALIFORNIA
GENERAL REEVALUATION REPORT

Final Report Documentation

Hydraulic Report

U.S. Army Corps of Engineers
Sacramento District

December 2015

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WEST SACRAMENTO PROJECT, CALIFORNIA
GENERAL REEVALUATION REPORT
Hydraulic Report

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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)
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11. Climate Change Memo
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1 - STUDY DESCRIPTION

1.1 INTRODUCTION

This report summarizes hydraulic analysis performed to support the West Sacramento GRR and has been prepared to meet the intention of the new USACE SMART Planning process – Specific, Measurable, Attainable, Risk-informed and Timely. It contains information regarding the hydraulic analyses conducted in support of the West Sacramento General Re-evaluation Investigation. The hydraulic modeling analysis undertaken for this investigation will be used to (1) evaluate the existing level of protection and project performance used for the evaluation of design improvements to levee's surrounding the city of West Sacramento California, (2) provide frequency-discharge-stage information necessary for the evaluation of measures to improve project performance, and (3) to produce data needed for economic evaluation for the selection of the National Economic Development (NED) plan.

This document references a collection of technical memorandums prepared for the American River Common Features (ARCF) GRR and West Sacramento (West Sac) GRR Hydraulic analysis. The two projects are on adjacent sides of the Sacramento River and much of the analysis for both projects is based on the same HEC-RAS hydraulic model. 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 and will be provided on request.

Several significant factors justify a reevaluation of the West Sacramento Project at this time:

1. Since the last authorization of the West Sacramento Project, the scope and cost of levee improvements have increased.
2. New hydraulic modeling and geotechnical studies suggest potential issues with the levees along the Sacramento River, Yolo Bypass, Sacramento Bypass and Sacramento Deep Water Ship Channel. Specifically, the levees have shown evidence of geotechnical deficiencies specifically through-seepage and under-seepage that could result in a high probability of levee failure. Such a failure could cause significant flooding in the city of West Sacramento.

1.2 LOCATION

The West Sacramento GRR study area is located in eastern Yolo County in the north central region of California's Central Valley (see Plates 1 & 2 for watershed and topographic maps). The study area approximately corresponds with the city limit for the City of West Sacramento comprising 13,000 acres of mixed-use land and an estimated population of 44,000 residents. The City of West Sacramento is located directly across the Sacramento River from the City of Sacramento, the State's Capitol.

The study area is almost completely bound by floodways and levees (Plate 3). The study area is bound by the Yolo Bypass to the west, the Sacramento Bypass to the north, the Sacramento River to the east and a non-project levee, called the South Cross Levee, in the south. Further, the City of West Sacramento is bifurcated by the Sacramento River Deep Water Ship Channel (DWSC) and Barge Canal. The associated levee system currently protecting the study area includes nearly 50 miles of levees in Reclamation District (RD) 900, RD 537, Maintenance Area 4, and along the DWSC and Barge Canal.

Flood control channels and other features in the West 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 4 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 benefits from three natural basins – Butte, Sutter, and Yolo. These basins run parallel to the Sacramento River and receive excess flows from the Sacramento, Feather, and American rivers via natural overflow channels and constructed weirs. During floods, the three basins form one continuous waterway.

1.3 TOPOGRAPHIC DATA

Existing topography and bathymetry were used for most of the study's hydraulic modeling efforts. 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 Comp Study (Ayres, 1998 & 2003).

The City of West Sacramento provided light detection and ranging (LiDAR) topographic data for the entire West Sacramento basin. The City of West Sacramento obtained the LiDAR from the Sacramento Area Council of Governments where:

> *"Merrick and Company flew a mapping mission from February 18, 2006 to April 19, 2006 to capture LIDAR surface data and aerial photography over 1052 square miles of SACOG project area. The topo area is approximately 89 square miles of 2 foot interval raw topo created from a 2 foot grid (DEM) with a gaussian smoothing filter of 30. The final output .tif files are 0.5 foot pixel resolution."*

All topographic data used for this study is referenced the North American Vertical Datum of 1988 (NAVD88). Projection is in California State Plane Zone 2. The horizontal units are in feet (NAD83). See both the Technical Memorandum (USACE May2013c) on model datum conversion and the reference on the Comprehensive Study topography conversion (HJW Geospatial, 2010). Further details of the LIDAR survey conducted for this study can be found with the Sacramento Area Council of Governments (SACOG) GIS Department.

1.4 STUDY APPROACH

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 analysis used the same basic models that were developed and refined for the existing conditions (F3, July 2011). HEC-RAS was used to model the main flood control channels of the system to determine the water surface profiles and flood hydrographs into the floodplain areas. This HEC-RAS model includes much of the Sacramento River Basin. 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 order to generate flood damages for economic evaluations, floodplains were delineated for the 1/2-, 1/10-, 1/25-, 1/50-, 1/100-, 1/200-, and 1/500- Annual Chance Exceedance (ACE) events. The analysis was limited to flooding within the basin from levee breaches and does not include localized flooding from rainfall-runoff.

Floodplain delineations presented in this study are based on a single levee break within a levee reach. The West Sacramento Levee System was divided up into 8 reaches for this analysis. 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 future without-project condition and the alternatives.

This report presents a very specific and detailed analysis of the with- and without-project conditions for West Sacramento. In light of SMART Planning, some analyses typically found in a hydraulic appendix have been reduced to a sensitivity analysis or have been postponed to a later date and will likely be completed during design. The assumptions made to reduce the level of detail or postponed analyses until the design phase are captured in the Risk Register. These efforts are summarized below:

Efforts analyzed using sensitivity:

- Climate change
- Sea level rise

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 to be completed in 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: West Sacramento Hydraulic Analyses and Key Assumptions

WEST SAC HYDRAULIC DELIVERABLES	KEY ASSUMPTIONS
Evaluation of final alternatives for evaluation (HEC-RAS)	For alternative analysis, large cost measures screened out qualitatively. No locally preferred plan analyzed. Many features reduced and combined into final array of alternatives.
Alternative 5, Setback levee	The Sacramento River setback levee is not included in the hydraulic model. It is assumed a setback levee will be hydraulically neutral.
With-project floodplain analysis (Flo-2D)	Used without-project floodplains to represent with-project. Rating curve in FDA input represents hydraulics of with-project conditions.
Hydraulic Impacts (HEC-RAS)	The baseline for hydraulic impacts is based on future operation at Folsom Dam with all authorized features added (JFP Spillway, Dam Raise, target release 160k cfs).
Systems Risk and Uncertainty	HEC methodology used based on Risk Analysis of Modifications to SRFCP (HEC, 2009).
Climate Change	Used same methodology as Sutter Feasibility Study, sensitivity analysis only (USACE, 2013b).
Sea Level Rise	Used Information from recent study in the Delta and existing sensitivity analysis (Dynamic Solutions, 2011).
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.
Vegetation Variance	Deferred, 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
ER 1105-2-101	Risk Analysis for Flood Damage Reduction Studies

2 - PROJECT DESCRIPTION

2.1 PROJECT AREA LIMITS

West Sacramento is divided into two sub-basins and shown in Plate 3. A description of the sub-basins and the levee reaches that comprise each includes the following:

Northern Sub-basin – The northern sub-basin, representing approximately 6,100 acres, is bounded by the DWSC to the south, the Sacramento River West Levee to the north and east, the Sacramento Bypass Levee to the north, and the Yolo Bypass Levee to the west. This area is traversed by the right bank of the Sacramento River from River Mile (RM)[1] 63.0 to RM 57.5.

- ***Sacramento River North Levee*** extends for approximately 5.5 miles along the Sacramento River right bank levee from the Sacramento Bypass south to the confluence of the Barge Canal and the Sacramento River.
- ***Sacramento Bypass Levee*** extends for approximately 1.1 miles along the Sacramento Bypass left bank levee from the Sacramento Weir west to the Yolo Bypass Levee.
- ***Yolo Bypass Levee*** extends for approximately 3.7 miles along the Yolo Bypass levee left bank from the confluence of the Sacramento Bypass and the Yolo Bypass south to the Navigation Levee (DWSC West).
- ***Port North Area*** extends for approximately 4.5 miles along the DWSC right bank levee from the Barge Canal west past the bend in the DWSC where it meets the Yolo Bypass Levee.

Southern Sub-Basin – The Southern Sub-Basin encompasses approximately 6,900 acres and is bounded by the Port South Levee and the DWSC to the north, the Sacramento River West-South Levee to the east, the South Cross Levee to the south, and the DWSC East Levee to the west. The right bank of the Sacramento River extends from RM 57.5 to RM 51.5.

- ***Port South Levee*** extends for approximately 4 miles along the DWSC left bank levee from the Barge Canal west past the bend in the DWSC.
- ***Deep Water Ship Channel West Levee*** extends for approximately 21.4 miles along the DWSC right bank levee from the bend in the DWSC at the intersection of Port North Levee and Yolo Bypass Levee south to Miners Slough. The DWSC West levee protects West Sacramento from flood flows in the Yolo Bypass.
- ***Deep Water Ship Channel East Levee*** extends for approximately 2.8 miles along the DWSC left bank levee from the end of Port South Levee south to South Cross Levee.

[1] River Mile (RM) refers to river miles from the Sacramento Basin HEC-RAS model and UNET Comp Study model.

- ***Sacramento River South Levee*** extends approximately 5.9 miles along the Sacramento River right bank levee from the confluence of the Barge Canal and the Sacramento River south to the South Cross Levee.

- ***South Cross Levee*** extends along the South Cross levee for approximately 1.2 miles from Jefferson Boulevard to the Sacramento River where it intersects the southern end of Sacramento River West South Levee.

The majority of the levees within the study area are part of the SRFCP. The few exceptions are the Port South Levee, the DWSC West levee and the South Cross Levee. The Port South and DWSC West levees were constructed as part of the Port of Sacramento. The South Cross Levee is a private levee. Although the DWSC West levee was constructed as part of the navigation project supporting the Port of Sacramento, this levee provides significant flood benefits to portions of both the northern and southern sub-basins. During the large flood events, the water surface elevation in the Yolo Bypass can be more than 10-feet higher than the water surface elevation in the DWSC at the northern limit of the DWSC West levee and is still greater than 10-feet between these two water courses downstream near the vicinity of the South Cross Levee.

2.2 WITH AND WITHOUT-PROJECT CONDITIONS

West Sacramento is in close proximity to two other federally authorized projects that will affect the flows and stages at West Sacramento. The American Rivers Common Features (ARCF) GRR includes repairing levees along the American River and the left bank of the Sacramento River adjacent to West Sacramento. The Joint Federal Project (JFP) includes improvements at Folsom Dam: construction of a new spillway, a new Water Control Manual (reoperation of the dam utilizing the new spillway) and a Folsom Dam raise.

The future without-project condition 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. Any work beyond the future without-project condition, proposed under the West Sacramento GRR, is considered part of the with-project condition.

As part of the Sacramento Bank Protection Study (Sac Bank) a setback levee on the Sacramento River adjacent to the City of West Sacramento (River Mile 57.2) is currently being constructed. The Sac Bank hydraulic analysis (USACE, 2010e) determined there are no significant hydraulic impacts with a setback levee at this location. This setback levee is not included in the HEC-RAS future Without-Project condition; however, since the setback levee will not change the hydraulics of the system, it will not affect the modeled results.

3 - CHANNEL HYDRAULICS

3.1 BACKGROUND

This chapter documents continued HEC-RAS model development and calibration for the Sacramento River Basin river system in support of the West Sacramento 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 various portions of the Sacramento Basin.

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 2013j).

The HEC-RAS model was further updated to include refinements of the Turning Basin of the Sacramento Deep Water Ship Channel (DWSC) and the South Cross Levee. The Turning Basin of the DWSC was updated with new bathymetry and LiDAR data (described in DWSC Technical Memorandum). Because of the importance of the Sacramento DWSC to the City of West Sacramento, the latest available topographic data was used to reduce the uncertainty of the hydraulic results. Also, the topography of the South Cross Levee was updated with LiDAR data; this corrected low spots that were a result of limited topographic information in the area.

3.2 HYDROLOGY

There were no updates made to the existing hydrology used in the F3 analysis. For details regarding all hydrologic inputs, see the Natomas Post Authorization Change Report Hydrology Appendix. The executive summary and certification of district quality control (DQC) review for the hydrology analysis is included as Appendix A to this report.

3.3 MODEL CALIBRATION

The accuracy and quality of the hydraulic modeling results are limited by the availability of data used in the calibration. The Comp Study model was largely calibrated using gage data. For this phase of modeling the Sacramento Basin with HEC-RAS, high-water mark data was used more extensively than in the Comp Study modeling efforts. The Calibration Technical Memorandum (USACE, May 2013a) includes additional information on the calibration efforts.

The model was calibrated to the 1997 event. The calibration was complicated by the challenges of accurately representing breach flow through two levee failures during that event; however, the modeled water surface profiles reasonably matched measured highwater marks and gage data. The 1986 and 2006 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 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 highwater 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 to the system 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.

The model results for the 1997 event calibration show very good agreement with the observed data at the peak stage. The overall shape of the flood wave through the model is very similar after the calibration with only a few locations with a slight difference in shape.

The stage data is accurate within plus or minus a foot. As a result, this can alter the shape of the stage hydrograph that actually occurred during the flood pulse. The way that the shape is altered may not be a uniform constant over the entire hydrograph as a difference in datum would be. For example, the stage at one time step could be 0.6 ft off and at another time step could be 1 ft.

Overall the locations reviewed in these model validation and calibration efforts represent a good overall estimate of the stage especially in the project area. The current calibration effort uses the 2006 event and the results show that the Sacramento River has a good replication of the event downstream of the Fremont Weir. Slight variations in shape were common as well as a delay of an hour for the peak calculated values. These were considered acceptable and in most cases are likely due to some implicit variability in the model and uncertainty in the measurements of the observed data. Several locations studied needed further adjustments and analysis to determine why large variations in magnitude and shape of the resulting hydrographs appear. However, these were largely outside the project area and not examined further.

3.4 WATER SURFACE PROFILES

The HEC-RAS model was used to develop water surface profiles for all reaches surrounding the West Sacramento basin. A suite of seven *n*-year frequency profiles (1/2-, 1/10-, 1/25-, 1/50-, 1/100-, 1/200-, 1/500- ACE) is shown in Plates 6-10 for the future without-project condition (FWOP). The FWOP will serve as the baseline for alternative comparison.

The levees along the Sacramento River (upstream of American River), Sacramento Bypass and Yolo Bypass are high enough to contain the 1/200 ACE event (within the project area). As shown in Plate 7, the levee along the Sacramento River (downstream of the American River confluence) is high enough to contain the 1/100 ACE event flows but overtops the levee at two locations during the 1/200 ACE event.

There is a unique feature in the water surface profile on Plate 6. 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 decreasing water surface profile downstream of the Sacramento Weir (RM 64).

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 West Sacramento GRR. Historical precedent shows that 1,000 feet (which USACE 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 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.

- 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 fortifying the existing flood defense system are described below, with additional information found in the geotechnical and civil design appendices.

From a hydraulic perspective, measures to reduce the probability of inundation generally fall into four categories:
1. Levee improvements
2. Upstream transitory storage
3. Diversions, and
4. 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. For purposes of the current study, the following measures were therefore removed from further consideration:
- Upstream storage on the American River
- Transitory storage on the Sacramento River
- Reoperation of upstream reservoirs
- Yolo Bypass improvements
- I-Street diversion structure

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 - 4.6). These five alternatives are compared to the FWOP condition to determine the Tentatively Selected Plan (TSP), see Table 4-1.

- Alt 1: Improve levees in place
- Alt 2: Improve levees in place with the Sacramento Bypass widening
- Alt 3: Improve levees in place with DWSC closure structure
- Alt 4: Improve levees in place with Sacramento Bypass widening and DWSC closure structure
- Alt 5: Improve levees in place with South Sacramento River Setback

Alternative Measure	Improve Levees In-Place	Widen the Sacramento Bypass	Construct a DWSC Closure Structure	Construct a Sacramento River Setback
1	X			
2	X	X		
3	X		X	
4	X	X	X	
5	X			X

Table 4-1: Alternative Measures Matrix

Plates 11-20 show the water surface elevations for alternatives 1-4 and the future without-project condition for both the 1/10 ACE and the 1/200 ACE events respectively. Profiles for all frequencies are available at request. To reduce the number of plates (for a shorter concise document to support SMART planning), the 1/10 ACE and 1/200 ACE are considered representative events for high and low frequencies. As shown in Plates 11-20, the water surface elevation profiles for alternatives 2 & 4 are the same and the water surface elevation profiles for alternatives 1 & 3 are the same (besides in the DWSC). Overall, the alternatives that include the Sacramento Bypass widening (Alternative 2 & 4) have lower stages in the Sacramento River and higher in the Yolo Bypass compared to alternatives that do not include the widening (Alternative 1 & 3).

After the hydraulic analysis was completed for alternatives 1-4, the PDT further screened out alternatives that included the Sacramento Bypass widening (alternatives 2 & 4). Since this decision was made after the analysis was complete, all alternatives are reported in this appendix.

4.2 ALTERNATIVE 1: IMPROVE LEVEES IN PLACE

Alternative 1 is to strengthen existing levees that protect West Sacramento in place. This involves the construction of levee remediation measures to address concerns such as seepage, slope stability, overtopping, and erosion along the Sacramento River; the Sacramento Bypass; Yolo Bypass; the Sacramento DWSC; and the South Cross Levee. Plate 21 shows locations of levee strengthening. This alternative combines construction of improvement measures while maintaining the present levee alignment (fix-in-place). The stated purpose of this alternative would be to improve the performance of the flood damage reduction system to safely convey flood flows up to a level that maximizes net benefits including the potential for a levee raise.

The work in Alternative 1 primarily calls for improvements to levees that do not change in-channel geometry or characteristics; therefore, the hydraulics of the system does not change. As shown in Plates 16-20, the water surface elevation between the FWOP and Alternative 1 are the same for the 1/200 ACE event.

A crest elevation for the Future Without-Project of 1/200 ACE plus 3 feet was compared to the current top of levee. This assumption is based on both the intent of the Folsom JFP to control releases up to a 1/200 ACE event and the local sponsor's Urban Levee Design Criteria (DWR 2012). Levee raises are identified when the current top of levee falls below this profile. The typical amount of height needed is approximately 1 to 2 feet. Table 4-1 shows the extent (length) of levee raises needed per reach. There will likely be additional evaluations in Pre-construction , Engineering and Design.

Table 4-2: Levee Height Raises in Project Area

HEIGHT DEFICIENCY TABLE			
RIVER	1/200 ACE W.S. + 3'		
	UPSTREAM RM	DOWNSTREAM RM	LENGTH (FT) Approx.
Sacramento River	62.45	62.26	1,000
Sacramento River	62.19	62.09	530
Sacramento River	60.63	60.35	1,480
Sacramento River	60.02	59.96	320
Sacramento River	59.69	59.62	370
Sacramento River	59.25	58.77	2,530
Sacramento River	58.64	58.56	420
Sacramento River	58.46	58.19	1,430
Sacramento River	51.88	51.81	370
Sacramento River	51.67	51.5	900
Sacramento River	51.25	51.2	264
Sacramento River	51.14	50.29	4,500
Sacramento River	50.07	50.03	210
Yolo Bypass	40.95	38.9	10,800
Yolo Bypass	38.14	37.13	5,300
Yolo Bypass	36.93	34.49	12,900
South Cross Levee	0.98	0	5,170
Port South Levee	44.5	43.99	2,700
Port North	44.5	42.95	8,200

4.3 ALTERNATIVE 2: IMPROVE LEVEES IN PLACE AND WIDEN SACRAMENTO BYPASS

Alternative 2 starts with Alternative 1 (improve levees in place) as a base and adds the widening of the Sacramento Bypass/Weir, as shown in Plate 22. The purpose of this alternative is to redirect more water from the Sacramento River to the Yolo Bypass and thereby reduce the extent of levee repairs required along the Sacramento River downstream of the American River confluence. 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 a threshold of 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. The overall affect would be to lower the water surface elevation on the Sacramento River downstream of the confluence with the American River and subsequently reduce the need for levee raises along that reach of the Sacramento River.

The widening of the Sacramento Bypass and Weir was analyzed using the HEC-RAS model and expanding the weir 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. With this alternative the stages at the downstream portion of West Sacramento (near the Pocket) would be reduced by approximately 1 foot (compared to the FWOP condition).

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).

4.3.1 Potential Hydraulic Impacts to the Yolo Bypass

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 4-3 and 4-4 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.

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

4.4 ALTERNATIVE 3: IMPROVE LEVEES IN PLACE AND DWSC CLOSURE STRUCTURE

Alternative 3 starts with Alternative 1 (improve levees in place) as a base and adds construction of a closure structure in the DWSC (Plate 23). The purpose of this alternative is to reduce the stage in the DWSC (upstream of the closure structure) and within the Port of West Sacramento. The closure structure prevents flood flows from reaching the upper portion of the DWSC and eliminates the need for levee raises along the North and South Port levees. Also, a closure structure reduces the need to improve the DWSC east levee (downstream of the closure structure) and the DWSC west levee (upstream of the closure structure).

The operation of the closure structure and the resultant change in stages in the DWSC has not been analyzed with a hydraulic model. However, since the DWSC does not convey flood flows and is connected to the Yolo Bypass 15 miles downstream of the project area, it is assumed the water surface elevations in the project area (Sacramento River, Sacramento Bypass and Yolo Bypass) will not change with the addition of a closure structure on DWSC.

The gate operation of the closure structure could be dependent on a number of conditions within the study area. The timing of when the gates of the closure structure start to close may be based on one of the following:

- Stages in the Yolo Bypass at the Lisbon Gage. Once a target stage (not yet determined) is reached at the Lisbon gage (located in the Yolo Bypass approximately 2 miles south of the South Cross Levee), the gates of the closure structure would begin to close.
- Operation of the Sacramento Weir. The gates of the closure structure would begin to close based on conditions at the Sacramento Weir (when Sacramento Weir is opened and/or how many gates are opened).
- Stages at the Port of Sacramento. When the stage at the Port of Sacramento reaches a threshold of 15 feet (NAVD88), the gates would begin to close. It is assumed by the time the gates are closed, the water surface elevation in the DWSC (upstream of the closure structure) will remain

at 16 feet (NAVD88). This is assumed to be a non-damaging stage; it is the same elevation as the landside levee toe at the Port of Sacramento.

The operation of the DWSC closure structure will be further refined if selected as the TSP. For the purposes of this analysis, operation of the closure structure was assumed to be dependent on the stage at the Port of Sacramento. Based on this assumption, the gates are closed between the 1/10- and 1/25-ACE events while the stage in the DWSC (upstream of the closure structure) remains constant at 16 feet (NAVD88).

4.5 ALTERNATIVE 4: IMPROVE LEVEES IN PLACE WITH WIDEN SACRAMENTO BYPASS AND DWSC CLOSURE STRUCTURE

Alternative 4 includes improving the levees protecting West Sacramento (described in Alternative 1); widening the Sacramento Bypass by 1500 feet to allow more flood flows to enter the Yolo Bypass and reduce flows in Sacramento River downstream of the American River confluence (described in Alternative 2); and constructing a closure structure along the DWSC to reduce flood flows in the Port of West Sacramento and reduce levee improvements along the DWSC and the port levees (described in Alternative 3). Alternative 4 is shown in Plate 24.

4.6 ALTERNATIVE 5: IMPROVE LEVEES IN PLACE WITH SACRAMENTO RIVER SETBACK LEVEE

Alternative 5 includes improving levees in place plus a setback levee along the Sacramento River, shown in Plate 25. The setback levee is based on the local sponsor’s design submitted as part of the 408 application. The proposed setback levee is optimized from river mile 56.75 and extends 4.25 miles south with a typical offset distance of approximately 400 feet between the setback levee from the existing levee.

The applicant has completed a hydraulic analysis with the setback levee as part of the 408 submittal. Based on this analysis, there is a slight rise in stage downstream of the setback at the Pocket (0.13 foot and 0.17 foot rise for the 1/100 and 1/200 ACE, respectively). These results were used for determination of hydraulic impacts. This design may be further evaluated to ensure that hydraulic impacts are minimized. Please see MEMORANDUM FOR FILE: American River Common Features GRR and West Sacramento GRR Tentatively Selected Plan Comparison, dated 17 Feb 2015, for more information.

For purposes of SMART planning, the 408 hydraulic analyses are considered appropriate to use for evaluation of this alternative. A slight change in stage is not expected to impact the economic analysis because it is assumed the Expected Annual Damages (EAD) is not sensitive to small stage increases for less frequent events.

4.6.1 FEASIBILITY LEVEL IMPROVEMENTS

Levee elevations for Port North, Port South and Navigation are as defined in the existing Sacramento Deep Water Ship Channel Operations and Maintenance manual. These elevations were converted from USED to NAVD88 datum and supplied to Civil Design for use. Please see MEMORANDUM FOR FILE SUBJECT: Deep Water Ship Channel Levee Improvements vs. Interior Port Levee Improvements, for more information. For the Port North and South Levees, the top of levee is to be set to 3 feet above the project design water surface elevation (17.5 NAVD 88) at 20.5 feet NABVD88.

Levee elevations for the proposed South Cross Levee have been set to 30.5 ft NAVD88. This value corresponds to the authorized “1957” design profile at this location. Please see the attached graphic labeled “WestSacSouthCrossLeveeHeightAnalysis.pdf” for a graphical representation of the elevation evaluation.

There has been a further refinement in the feasibility level design of the Sacramento River North Erosion measure. In the past SPK has used a typical “Sac Bank” fix as a placeholder. Upon further investigation, it was determined that this reach has an existing erosion measure in place and the robust erosion measure was not needed. As much of this reach has an erosion repair, the primary focus was changed to preserving existing riverbank with longitudinal stone toe protection. Using the latest aerial imagery, USACE was able to assess locations that lacked stone protection and created a created a table with locations of toe protection needed, in River Miles. This information was handed off to Civil Design for use.

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 Sacramento Bypass, Sacramento River, Yolo Bypass and Sacramento DWSC. An existing calibrated HEC-RAS model of the Sacramento and American River system (described in Chapter 3) was used to develop breach hydrographs at all seven frequencies (1/2-, 1/10-, 1/25-, 1/50-, 1/100-, 1/200-, 1/500- ACE) at each breach location. The F3 Hydraulic Technical Documentation (USACE, 2011a) provides detailed information on the FLO-2D model development. Plates 26-33 show the resulting Without-Project floodplains for all eight index locations.

The West Sacramento basin acts much like a polder. As a breach occurs, floodwaters are contained by the surrounding levees and the area fills up. The West Sacramento Basin is generally not impacted by roadways and other obstructions in modeling large flood events such as a levee breach. With average annual precipitation of 18.51 inches and existing interior pumping infrastructure, interior flooding is considered insignificant when compared to the volume that would occur 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 following key assumptions were used in the development of the West Sacramento floodplain FLO-2D model:

- **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 = 6,676,317 and Y = 1,984,490.** 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 flood delineation, especially given the significant volume of water that would overwhelm the streets in the study area.

- **No rainfall on the interior floodplain modeled.** A clear sky was assumed at the time of the levee breaches.

- **Soundwalls along freeways are not modeled.** In most areas within this project study footprint the road embankments are 2 to 3 feet thereby eliminating the need to separately model soundwalls. As soundwalls are not built to the same structural integrity as an engineered floodwall it is assumed that existing soundwalls would fail with 2 to 3 feet of differential head. 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 DWSC are assumed to be inoperable.** Flooding from a levee breach would significantly overwhelm the existing interior pumping infrastructure. It is not designed to the capacity necessary to pump the volume necessary to keep the area dry. Additionally, pumping plants could remain inoperable by 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 for the Common Features GRR to determine how a breach hydrograph is impacted by selection of levee breach elevation, timing of breach, breach formation duration and breach width. A point 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 volumes were used to evaluate the sensitivity of the selected breach parameters at both the 1/25- and 1/200- ACE events. 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, though caution must be used in drawing specific conclusions from the results found in 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 on testing done for the Sutter County Feasibility Study.

- Floodplains are sensitive to breach width during frequent flood events (1/25 ACE) but not infrequent flood events (1/200 ACE). However, many Sacramento Corps feasibility studies generally use infrequent flood events (such as the 1/100 ACE event) based on historical levee breach information. It is also important to have consistent breach widths (500 ft) for the full sweep 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

The hydraulics of the West Sacramento Basin does not significantly change with the proposed alternatives; instead, the With-project levee repairs (a component to all alternatives) reduces the chance of levee failure (or breaching). Therefore, the same floodplains are used for With- and Without-Project conditions. Levee performance is represented in the FDA Levee Fragility Curves.
For alternatives 1 & 3, there are no proposed changes to the footprint of the existing channel system; the breach hydrographs and floodplains at each of the index points will be the same as the Without-Project condition.

For alternative 2 & 4, the hydraulics of the system will change as more water is conveyed down the Sacramento and Yolo Bypasses and less water flows down the Sacramento River (downstream of the American River confluence). The difference in water surface elevation between the future Without-Project condition and alternatives 2 & 4 on the Sacramento River and Yolo Bypass is approximately 1 and 0.2 feet, respectively.

It was considered appropriate to use Without-Project floodplains for alternative 2 & 4 for the following reasons:

- The rating curves in FDA do represent the hydraulics for alternatives 2 & 4.
- The levees in the project area will be improved and the chance of failure is significantly reduced. For all index points, the with-project fragility curves show a 1-in-7% chance of failure at the 1/50 ACE event. Therefore FDA will rarely utilize floodplains for the 1/2-, and 1/50- ACE events.
- West Sacramento is a closed basin and functions like a polder; when a levee breach occurs; the basin is inundated and fills like a bathtub. Flood waters can be significantly deep as portions of the basin are below sea level. After the basin is filled with 4-5 feet of flooding, as represented by the 1/50 ACE floodplain, the damages calculated in FDA do not significantly change with additional depth of flooding.
- This is a conservative approach in calculating With-Project damages.

6 - RISK ANALYSIS

USACE requires the use of risk analysis procedures for formulating and evaluating flood risk management measures (EM 1110-2-1619, ER 1105-2-101). These documents describe how to quantify uncertainty in discharge-exceedance probability, stage-discharge, stage-damage functions, geotechnical probability of failure relationship, and incorporate it into economic and engineering performance analyses of alternatives. The process applies Monte Carlo simulation, a numerical-analysis procedure that computes the expected value of damage while explicitly accounting for the uncertainty in the basic parameters used to determine flood inundation damage.

A risk analysis was performed following the established USACE guidelines described above. Inputs were generated for risk analysis from the existing hydraulic modeling as described. The Hydrologic Engineering Center's Flood Damage Analysis modeling software (HEC-FDA) is the principal tool used by USACEs to calculate flood damage risks. The software follows functional elements of a study involving coordinated study layout and configuration, hydrologic engineering analyses, economic analyses, and plan formulation and evaluation. HEC-FDA is used continuously throughout the planning process as the study evolves from the base year without-project condition analysis through the analyses of alternative plans over their project life. Hydrologic engineering and portions of the economics are performed separately, but in a coordinated manner after specifying the study configuration and layout, and merged for the formulation and evaluation of the potential flood risk management plans.

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 the project life, and the conditional non-exceedance probability (CNP) for specific events (the probability of non-failure).

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 West Sacramento, already separated by a waterway, are further divided into reaches represented by similar geotechnical conditions, as described in the geotechnical appendix. Each reach is represented by a single index point located at the same position as the geotechnical Fragility Curve. The index points are shown on Plate 5. They are also listed in Table 6-1.

TABLE 6-1: INDEX POINTS

INDEX POINT	SUB-BASIN	PROJECT REACH	RIVER MILE
1	North	Sacramento River	61.5
2	North	Sacramento River	60
3	North	Yolo Bypass	42.62
4	North	Sacramento Bypass	1.49
5	South	Sacramento River	56.75
6	South	Sacramento River	52.75
7	South	Yolo Bypass	40.95
8	South	Sacramento DWSC	43.75

6.2 STAGE-DISCHARGE FREQUENCY CURVES

Peak stage data for all index points was derived for the 10-year through the 500-year events in the same manner for both with- and without-project conditions. Results were taken directly from the HEC-RAS model runs. However, 1-year and 2-year event 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 2-7, flow-frequency and stage-discharge relationships were generated for the HEC-FDA analysis (see Plate 5 for location of index points). A stage-stage relationship similar to a stage frequency relationship was used for Index Points 1 and 8 due to reverse flows and backwater effects, respectively.

6.3 UNCERTAINTY

6.3.1 Hydraulic Uncertainty

Previous studies by HEC and SAFCA were used to determine the hydraulic uncertainty. Both studies covered hydraulic uncertainty through a system approach as described previously. These values were checked against the minimum value recommended in Engineer Manual EM 1110-2-1619, “Risk-Based Analysis for Flood Damage Reduction Studies.” If less than the minimum value, then the minimum value was used. For all index points a total stage uncertainty of 0.7 feet (within one standard deviation) was used. In further refinement a more detailed analysis will be completed.

6.3.2 Hydrologic Uncertainty

Hydrologic uncertainty, specified with period of record, was chosen based upon the PR-71, Hydrologic Engineering Center report “Documentation and Demonstration of a Process for Risk Analysis Proposed Modifications to the Sacramento River Flood Control Project Levees”, 2009. The period of record (equivalent years of record) for all index points are between 71-73 years. Results from locations closest to index points were used. For Index Points 2 through 7, the flow frequency analysis is based on the graphical method. Graphical methods provide qualitative and quantitative forms of assessing event frequency. In these methods, flows are ranked according to magnitude, and return period is assessed by calculating the probability of each data using the Weibull formula.

$$P = \frac{m}{n+1}$$

Where P is the exceedance probability, m is the event rank, and n is the total sample size.

This formula can be used to assess the exceedance probability, and the return period of the event can be calculated as the inverse of the probability (*T=1/P*).

Index points 1 & 8 are based on stage frequency. At Index Point 1, Flood flow changes direction due to the influence of the Sacramento Weir opening. Through the operation of the Sacramento Weir, Flood flows from the American River will reverse the flows in the Sacramento River between the confluence of the American to the Sacramento Weir. The DWSC (index point 8) is tidally influenced and does not convey flood flows.

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 the West Sacramento Basin. Levee failures were simulated for each reach using seven frequencies (1/2-, 1/10-, 1/25-, 1/50-, 1/100-, 1/200-, 1/500- ACE) to generate a stage-damage relationship for each reach for the economic analysis. As described in Section 5.3, levee failure runs were made only using the without-project condition. Plates 34 through 41 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: Improve levees in place
- Alternative 2: Improve levees in place with Sacramento Bypass widening
- Alternative 3: Improve levees in place with DWSC Closure Structure
- Alternative 4: Improve levees in place with Sacramento Bypass widening and DWSC Closure Structure
- Alternative 5: Improve levees in place with a Sacramento River Setback

A summary of the key results are described below:

- For index points 1 through 7, there are no significant changes in stage or flow (from the future Without-Project condition) when levees are fixed in place or when the DWSC closure structure is in place (Alternatives 1 & 3)
- As expected, there are reductions in stage and flow on the Sacramento River Reach below the confluence with the American River (at Index Points 2, 5 & 6) when Alternatives 2 & 4 are compared to the without-project condition.
- The results for the Yolo Bypass (Index Points 3 & 7) are similar for all conditions.

6.4.1 Upstream Levee Performance

As part of the Common Features 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 West Sacramento GRR assumes no upstream levee failures.

6.5 FLOOD RISK: PROBABILITY & PERFORMANCE- WITHOUT PROJECT

Army Field Manual FM-5-19, Composite Risk Management (US Army 2006) defines risk as:
"*Risk: probability and severity of loss linked to hazards.*" Risk can be described in terms of the chance of some undesirable event occurring and the potential consequences should that undesirable event occur. In Flood Risk Management (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 Future Without-Project condition.

6.5.1 Annual Exceedance Probability

Annual exceedance probability (AEP) is a statistic used to describe the chance of flooding in any given year within a consequence 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. Table 8 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 consequence area. Each area is considered to be protected by a system of levees, and flooding to the area could potentially occur from various sources. For example, in West Sacramento, flooding can occur from the Sacramento River, Sacramento Bypass, Yolo Bypass, or Deep Water Ship Channel; further, the risk of flooding along either water source varies depending on the location along the source. In this respect, the AEP values listed in Table 6-2 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 6-2: Annual Exceedance Probability by index Point (Future Without Project)

INDEX POINT	SOURCE	AEP	1/AEP
1	Sacramento River	0.055	1 in 18
2	Sacramento River	0.008	1 in 119
3	Yolo Bypass	0.089	1 in 11
4	Sacramento Bypass	0.000	N/A
5	Sacramento River	0.024	1 in 42
6	Sacramento River	0.041	1 in 25
7	DWSC	0.123	1 in 8
8	DWSC	0.012	1 in 83

6.5.2 Long-Term Risk by Index Point

Engineer Manual 1110-2-1619, Risk-Based Analysis for Flood Damage Reduction Studies (USACE 1996) gives the definition: of long-term risk as *"The probability of capacity exceedance during a specified period. For example, 30-year risk refers to the probability of one or more exceedances of the capacity of a measure during a 30-year period."* HEC-FDA computes long-term risk statistics for 10-, 30-, and 50-year periods. Table 6-3 displays the without-project long-term risk results for each index point.

TABLE 6-3: Long-Term Risk Results by Index Point (Future Without Project)

INDEX POINT	SOURCE	LONG-TERM RISK (%)		
		10 YEARS	30 YEARS	50 YEARS
1	Sacramento River	43	82	94
2	Sacramento River	8	22	35
3	Yolo Bypass	61	94	99
4	Sacramento Bypass	0	0	0
5	Sacramento River	21	51	70
6	Sacramento River	34	72	88
7	DWSC	75	98	100
8	DWSC	12	31	46

6.5.3 Assurance

Assurance, previously referred to as conditional non-exceedance probability (CNP), describes the likelihood of a stream/river being able to pass a specific flow event, for example the 1/100 ACE flood 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 under the without-project condition are listed in Table 6-4 below. Taking Index Point 3 as an example, the information indicates that there is a 72% chance of passing the 10% flow event, but only a 23% chance of passing the 1% flow event.

TABLE 6-4: Long-Term Risk Results by Index Point (Future Without Project)

INDEX POINT	SOURCE	ASSURANCE (%)					
		10%	4%	2%	1%	0.4%	0.2%
1	Sac River	94	84	80	75	49	24
2	Sac River	100	93	91	88	65	31
3	Yolo BP	72	39	31	23	13	9
4	Sac BP	100	100	100	100	100	100
5	Sac River	96	89	87	85	72	65
6	Sac River	93	91	91	90	89	86
7	DWSC	53	22	17	12	9	9
8	DWSC	100	89	82	70	47	28

6.6 WITH-PROJECT PERFORMANCE RESULTS: AEP, LONG-TERM RISK, & ASSURANCE

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, at Index Point 3 on the Yolo Bypass, without-project AEP is about 1 in 11. With improvements, flood risk as estimated at IP3 is reduced to about a 1 in 111 for all Alternatives. The long-term risk statistics indicate that the chance of flooding over specified time periods is also reduced. For example, at IP3 the chance of flooding over a 10-year and 30-year period improves significantly with a project in place, going from a 61% and 94% chance for a 10-year and 30-year period without a project, respectively, to a 9% and 24% chance with a project in place. The assurance results describe the chance a specified flow event would be contained within the channels of a water source (at a specific index point location). For example, for IP3 the chance of containing the 1% flow event under the without-project condition is about 23%. With improvements made to the Yolo Bypass, the chance of containing the 1% flow event increases to about 93% (all alternatives).

TABLE 6-5: Without-Project & With-Project Conditions

INDEX POINT	ANNUAL EXCEEDANCE PROBABILITY (AEP)[1]				
	WITHOUT	ALTS. 1 and 5 (NO LEVEE RAISES)	ALTS. 1 and 5 (WITH LEVEE RAISES)	ALT. 3 (NO LEVEE RAISES)	ALT. 3 (WITH LEVEE RAISES)
1	0.055	0.006	0.006	0.006	0.006
2	0.008	0.004	0.003	0.004	0.003
3	0.089	0.009	0.009	0.009	0.009
4	0.000	0.000	0.000	0.000	0.000
5	0.024	0.001	0.001	0.001	0.001
6	0.041	0.003	0.003	0.003	0.003
7	0.129	0.003	0.003	0.003	0.003
8	0.012	0.007	0.007	0.000	0.000

[1]Engineering performance results at index points 5 and 6 on the Sacramento River were assumed the same for Alternatives 1 and 5; additional hydraulic modeling of Alternative 5 will occur in the future.

TABLE 6-6: Long-Term Risk (%) - Without-Project & With-Project Conditions

INDEX POINT	LONG-TERM RISK[1]									
	WITHOUT		ALTS. 1 AND 5 (NO LEVEE RAISES)		ALTS. 1 AND 5 (WITH LEVEE RAISES)		ALT. 3 (NO LEVEE RAISES)		ALT. 3 (WITH LEVEE RAISES)	
	10 Years	30 Years	10 Years	30 Years	10 Years	30 Years	10 Years	30 Years	10 Years	30 Years
1	43	82	5	15	5	15	5	15	5	15
2	8	22	4	10	3	9	4	10	3	9
3	61	94	9	24	9	24	9	24	9	24
4	0	0	0	0	0	0	0	0	0	0
5	21	51	1	3	1	3	1	3	1	3
6	34	72	3	10	3	10	3	10	3	10
7	75	98	3	9	3	9	3	9	3	9
8	12	31	7	20	7	20	0	0	0	0

[1]Engineering performance results at index points 5 and 6 on the Sacramento River were assumed the same for Alternatives 1 and 5; additional hydraulic modeling of Alternative 5 will occur in the future.

TABLE 6-6: Assurance (%) - Without-Project & With-Project Conditions

INDEX POINT	ASSURANCE[1]														
	WITHOUT			ALTS. 1 AND 5 (NO LEVEE RAISES)			ALTS. 1 AND 5 (WITH LEVEE RAISES)			ALT. 3 (NO LEVEE RAISES)			ALT. 3 (WITH LEVEE RAISES)		
	4%	1%	.2%	4%	1%	.2%	4%	1%	.2%	4%	1%	.2%	4%	1%	.2%
1	84	75	24	97	96	28	97	96	28	97	96	28	97	96	28
2	93	88	31	98	97	48	98	97	63	98	97	48	98	97	63
3	39	23	9	93	93	92	93	93	92	93	93	92	93	93	92
4	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
5	89	85	65	99	98	97	99	98	97	99	98	97	99	98	97
6	91	90	86	98	98	97	98	98	97	98	98	97	98	98	97
7	22	12	9	96	93	90	96	93	90	96	93	90	96	93	90
8	89	70	28	96	79	33	96	79	33	99	99	99	99	99	99

[1]Engineering performance results at index points 5 and 6 on the Sacramento River were assumed the same for Alternatives 1 and 5; additional hydraulic modeling of Alternative 5 will occur in the future.

6.7 CONSIDERATIONS AND ASSUMPTIONS

The results of the risk analysis are affected by technical considerations and assumptions regarding the input to HEC-FDA. For example, geotechnical studies developed relationships that characterize the reliability of the levees. These were utilized to trigger levee failures in the hydraulic models that in turn affected the stage-frequency curves used in the risk analysis. 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.

6.8 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 repaired levees brought up to 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 the basin using this proposed project and the ongoing West Sacramento Levee Improvement Program (WSLIP). 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. At a minimum this would be likely be completed by ensuring that there is 3 three feet of freeboard above the 1/100 ACE event for all the levees in the project area.

6.9 URBAN LEVEE DESIGN CRITERIA (ULDC)

Urban Levee Design Criteria (ULDC) is a standard established by the California Department of Water Resources. SB-5 defines "Urban level of flood protection" means the level of protection that is necessary to withstand flooding that has a 1-in-200 chance of occurring in any given year…" SB-5 Also goes on to mandate CA DWR to "implement certain flood protection improvements"… and "for construction in areas protected by the facilities of the Central Valley Flood Protection Plan where levels are anticipated to exceed 3 feet for the 200-year flood event. The department would be required to develop a cost-sharing formula for specified bond funds for repairs or improvements of facilities included in the plan." Under State law, urban levees are required to have at least 3 feet of freeboard 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 3 feet of freeboard was set as a target on all reaches in the basin.

6.10 SYSTEMS RISK AND UNCERTAINTY

Each of the final alternatives include setting the top of levee profile at the 1 in 200 ACE plus 3 feet benchmark, and a systems risk analysis was conducted to determine the location of the hydraulic impacts from a levee raise. 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 West Sacramento 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 following three scenarios:

- Future without-project baseline condition
- Alternative 1: Fix in place
- Alternative 2: Fix in place with Sacramento Bypass widening
- Alternative 5: Fix in place with a Sacramento River Setback

Alternatives 3 & 4 were not analyzed. Both alternatives include a portion of alternative 1 & 2 plus a closure structure along the DWSC. A DWSC closure structure will not impact the water surface elevations within the SRFCP.

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 future Without-Project baseline condition:

- There was no significant change in median AEP
- There was no significant change in expected AEP (rounded at three significant figures)
- There are small changes in the CNP/assurance, mostly in the thousandths place.

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.

Superiority is the levee design approach that identifies an initial overtopping location in the least hazardous location of a levee reach. This can be achieved by specifically setting the top of levee lower in the chosen overtopping location.

The two primary sources of residual flood risk for the Natomas Basin would be:

-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]

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, Yolo Bypass, Sacramento Bypass, and Sacramento Deep Water Ship Channel.

The West Sacramento Basin Levees do 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 West Sacramento Basin. Also it is very likely the other rural parts of the system that are not being improved would begin to overtop and would limit the amount of water that reaches the West Sac levees. The American River water is limited by both flows out of Folsom and channel capacity where once flows exceed 200,000 cfs excess water leaves the channel and travels into the American River North and South Basins but not into the West Sacramento basin.). However, any failure of the levee system surrounding West Sacramento will continue to have consequences given the significant population, limited warning time from an unforcasted geotechnical failure and floodplains with depths greater than 10 feet.

The likely first overtopping locations would be along the Sacramento River downstream of the Tower Bridge. The levee at this location has been completely backfilled several hundred feet inland. Overtopping flows from the Sacramento River would flow gently overland and likely make their way into Sacramento Deep Water Ship Channel. There would not be catastrophic waterfall effect over the levee. The Sacramento Deep Water Ship Channel also serves a natural drain to water in the basin. Overtopping flows in the north basin would mostly go into the Ship Channel. Large Breach events would overwhelm the ship channel and flows would also go into the southern basin.

The extents of the floodplains for the unforcasted geotechnical failure would be similar to the without project floodplains found on Plates 26-33.

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.

7.2 CLIMATE CHANGE – HYDROLOGY

A sensitivity analysis was conducted to assess the impact of climate change for the American River Common Features GRR and is applicable to the West Sacramento 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 1/25-, 1/100-, 1/200- and 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: Global Circulation Model Climate Change Differences for Northern Sierra Nevada, WY 2049

Frequency	% Difference in 3-day Flow		
	CNRM CM3[1]	GFDL CM2.1[2]	NCAR PCM1[3]
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

1. CNRM CM3: French National Centre de Recherché Meteorlogiques Climate Models.
2. GFDL: Geophysical Fluids Dynamics Laboratory model version 2.1
3. NCAR PCM 1: National Center for Atmospheric Research Parallel Climate Model

A sensitivity analysis was conducted at two locations near West Sacramento 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 exceedance probability (AEP) 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
AEP	Flow (cfs)	ACE	ACE	ACE
1/2	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
AEP	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. The levee crest elevation for future conditions was set at a 200-year 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 no levee raise is needed in response to climate change. However, for the Sacramento River Verona gage, it appears that the left levee crest would need to be raised an average of 3 feet and the right levee crest will need to be raised by 3.5 feet in response to climate change. The current alternatives have an average levee height raise of 1-2 feet, so 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 West Sacramento 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 into the future. A subsidence rate was also applied to the low and high calculated 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 1165-2-211, 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 tidal signal at San Francisco with the seasonal cycle removed.

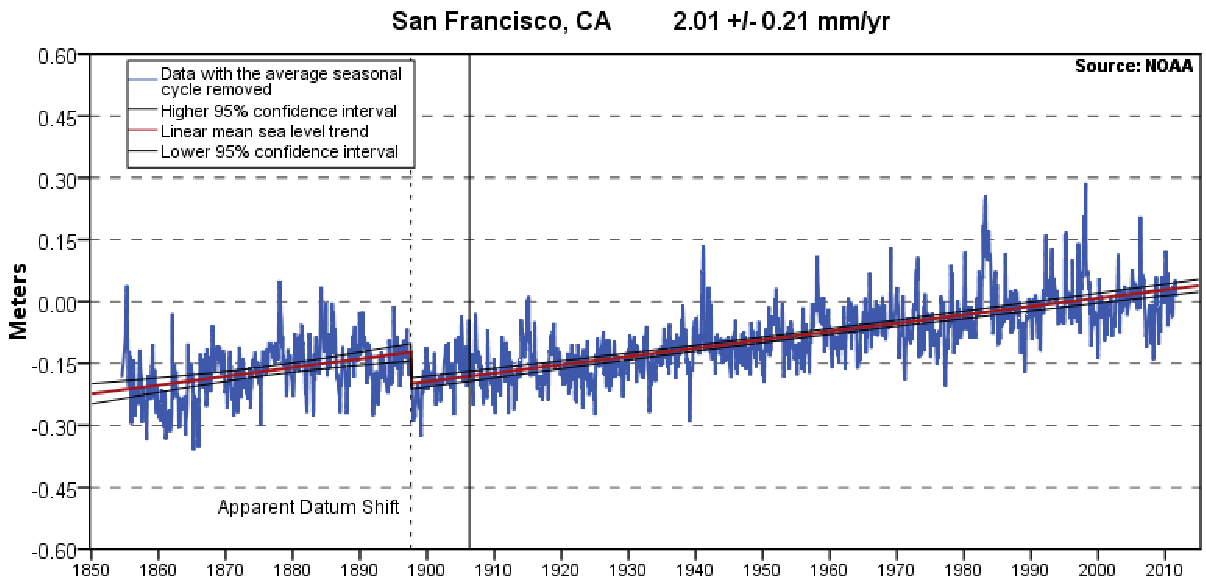

Figure 7- 1. Sea Level Trend at San Francisco (NOAA, 2009)

The red line shows the mean sea level trend of 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 2.01 mm/yr was chosen for the low case. This sea level rise value resulted in a 50-year increase of 0.10 m and a 100-year increase of 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

$$E(t_2) - E(t_1) = 0.0017(t_2 - t_1) + b({t_2}^2 - {t_1}^2)$$

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 2.36E-5 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 0.20 m and 0.52 m were 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 1.005E-4. 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 0.59 m was calculated for 50 years, and 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 (M)	100-YEAR RISE (M)
Low	0.10	0.20
Intermediate	0.20	0.52
High	0.59	1.68

Table 7-5: Sea Level Rise Values Seen in Literature

SOURCE	100-YEAR SEA LEVEL RISE RANGE (M)
California Climate Change Center – Projecting Future Sea Level Rise (CCCC, 2006)	0.13–0.89
International Panel on Climate Change – Synthesis Report (IPCC, 2007)	0.18–0.59
Delta Risk Management Strategy (DRMS) – Climate Change (DRMS, 2008)	0.20–1.40

As shown in the above tables, the 100-year range calculated from EC 1165-2-211 of 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 2.75 m NAVD88. After applying the 2.01 mm/yr sea level rise, an average of 2.77 m was predicted. This matched well with the observed average in 2010 of 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 West Sacramento 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 West Sacramento project were 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 the 10-Yr event on the Sacramento River at Freeport, and the average difference in stage was one-hundredth of a foot or less for the 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 indicate that the project water surface profiles are not sensitive to reasonably estimated future sea level rise conditions.

7.4 INTERIOR DRAINAGE

The City of West Sacramento is surrounded on all sides by water so when a rain event over the basin occurs, all the water has to be collected and pumped out of the basin. There is an existing interior drainage system already in place to accomplish this task. An evaluation of that system was conducted by HDR and documented in the Interior Drainage Evaluation Report (HDR, 2010). The report establishes the existing conditions and it will be further used in the refinement of the TSP and requirements for possible FEMA levee accreditation. The general findings and conclusions from Section 6.1.1 in the report are that:

> *"This report provides an internal evaluation of the north and south basins for the City of West Sacramento. This section provides a summary discussion of the findings from the HDR evaluation for both the north and south basins. The internal drainage system is a combination of underground gravity flow pipes, earthen channels and various internal pump stations that appear to be adequate for the City's existing storm water drainage system. Review of the requested frequency storms indicates isolated residual floodplain impacts to the City's north basin. The residual floodplain for the south basin indicated no flooding impacts for the 100-year frequency storms in the existing basins. The 200-year frequency storm volumes showed limited or no freeboard in the basins."*

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 overall data for 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. It is important to note that these numbers are still preliminary and subject to change after presented to the Levee Safety Oversight Group (LSOG).

Table 7-6: Life Safety and Life Loss Information from USACE's Levee Screening Tool

WEST SACRAMENTO	
Population at Risk (Day)	50,720
Population at Risk (Night)	48,821
Loss of Life (Day)	124
Loss of Life (Night)	90

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. There have been many studies on erosion, sediment transport, and channel stability in the study area.

The plan for erosion is ongoing; more analysis (likely in PED) is expected to provide greater insight. Erosion repairs are expected to be part of all alternatives and refinement efforts will continue beyond the Tentatively Selected Plan (TSP) milestone. Existing erosion conditions in the project area are presented in greater detail in the following section.

8.2 EXISTING BANK EROSION CONDITIONS

Two reports by NHC and URS evaluated erosion sites along the project levees. The NHC analysis identified erosion sites by boat and vehicle inspections. URS used an erosion screening process which consisted of a three tier analysis including: (1) a flow velocity and erosion surface adequacy analysis, (2) wind-wave shear and erosion surface adequacy test, and (3) a field evaluation.

Table 8-2 shows the erosion sites from both reports that were combined to create one master table that describes the locations of erosion sites along the levees. If there was an overlap between the two studies, the sites were combined to create one reach. Although URS and NHC used different methods to analyze erosion along the levees, both reports were able to identify where the levees needed repair.

Table 8-2: NHC & URS Combined Erosion Locations

RIVER MILE	SITE LENGTH	STARTING POINT
SACRAMENTO RIVER WEST LEVEE		
62.90	1848	Upstream
62.50	4224	Upstream
61.00	457	Upstream
60.35	528	Upstream
60.00	250	Upstream
59.90	1584	Upstream
58.65	528	Upstream
57.65	1320	Upstream
57.14	2851	Upstream
56.21	6230	Upstream
54.95	2904	Upstream
54.00	1700	Upstream
53.80	528	Upstream
53.60	528	Upstream
SACRAMENTO BYPASS		
1.25	140	Middle

RIVER MILE	SITE LENGTH	STARTING POINT
SACRAMENTO RIVER WEST LEVEE		
1.15	20	Middle
0.75	2006	Middle
0.20	2693	Middle
YOLO BYPASS (BYPASS SIDE)		
37.11	100	Middle
30.41	100	Middle
27.57	100	Middle
YOLO BYPASS (DWSC SIDE)		
25.41	100	Middle
24.76	100	Middle
23.81	100	Middle
23.68	100	Middle
PORT OF SACRAMENTO & DWSC EAST LEVEES		
40.54	100	Middle
38.83	100	Middle

During feasibility level design updates were made to erosion considerations for the selected plan. In the table above, the Sacramento River West Levee locations are being incorporated into the setback design. The Yolo Bypass erosion is considered to be more wind wave related and is discussed in section 8.4. The Port of Sacramento and DWSC levees are considered to be small site repairs. The Sacramento Bypass site was assumed to be fixed as part of the early implementation site as no additional work is being planned for that reach.

For the Sacramento River West Levee, There has been a further refinement in the feasibility level design of the Sacramento River North Erosion measure. In the past SPK has used a typical “Sac Bank” fix as a placeholder. Upon further investigation, it was determined that this reach has an existing erosion measure in place and the robust erosion measure was not needed. As much of this reach has an erosion repair, the primary focus was changed to preserving existing riverbank with longitudinal stone toe protection. Using the latest aerial imagery, USACE was able to assess locations that lacked stone protection and created a created a table with locations of toe protection needed, in River Miles. This information was handed off to Civil Design for use.

8.3 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 Sacramento River reach (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.

8.4 WIND-WAVE

Wind-wave analysis was done to evaluate the risk of failure due to wave erosion for about 22 miles of Federal Project levees surrounding West Sacramento in Yolo County for coincident 200-year water levels and extreme wind events (NHC, 2011). 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 50-year return period. No studies were performed to determine the coincident probability of the 1/200 ACE 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 then generalized to nearby sites, which were expected to experience similar wave heights and which had similar geometry and protection. Overall, 6.5 miles of levee were determined to be at high risk of failure due to wind wave erosion during coincident extreme wind and water levels, 12 miles were determined to be of moderate risk, and 3.5 miles were assumed to be low risk. Plate 42 shows locations of high, medium and low risk. High risk sections are likely to require repair for the levee to meet erosion standards for the 1/200 ACE flood. 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.

8.5 BOAT WAVE EROSION

Boat wave erosion has not been accounted for in this analysis because there is no boating in the Sacramento Bypass and Yolo Bypass and the impact of boat wave erosion along the Sacramento River is unlikely to be significant. Majority of boats operating on the Sacramento River are smaller recreational boats with few ocean-going yachts. It is assumed that any boat wave erosion that may occur will be addressed by the Sacramento River Bank Protection Project and by standard operation and maintenance of the levees.

Boat wave erosion on the Deep Water Ship Channel will be further analyzed and addressed after the selection of the TSP. The current assumption is that any repairs needed from boat waves would likely be addressed as part of standard operation and maintenance of the DWSC levees.

8.6 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 during the refinement of the tentatively selected plan.

8.7 BRIDGE SCOUR

There are over 6 bridges crossing the channel on multiple reaches in the project area. Bridges along the Sacramento River 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 the refinement of the tentatively selected plan.

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LEGEND

- Rivers
- Sacramento Watershed
- Lakes and Reservoirs
- Designated Floodways

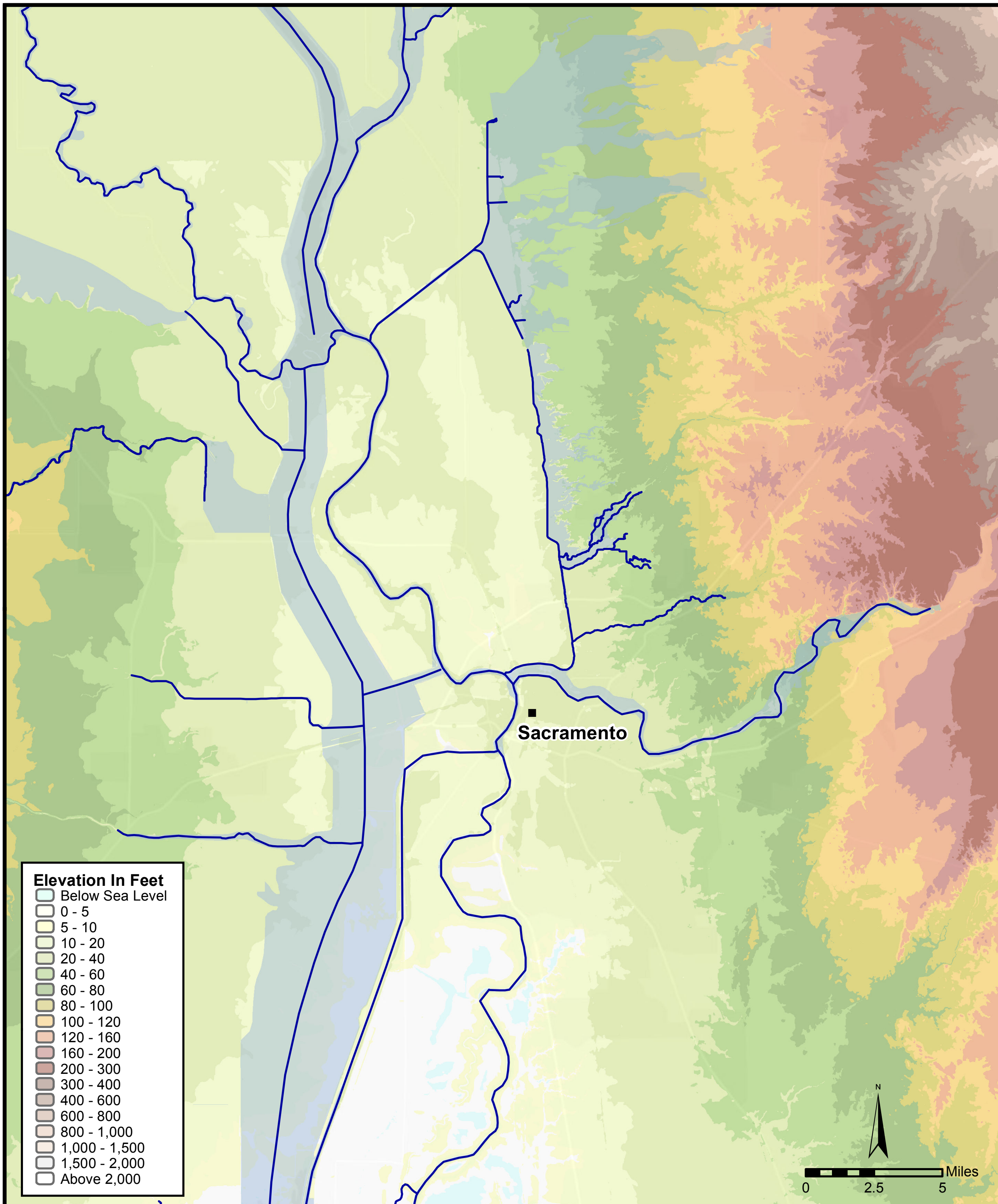
WEST SACRAMENTO GRR
SACRAMENTO, CALIFORNIA

SACRAMENTO RIVER WATERSHED

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

JULY 2015

Plate 1



LEGEND

Rivers

Floodways

WEST SACRAMENTO GRR
SACRAMENTO, CALIFORNIA

GENERAL TOPOGRAPHIC MAP

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

JULY 2015

July 2015

US Army Corps of Engineers

WSAFCA

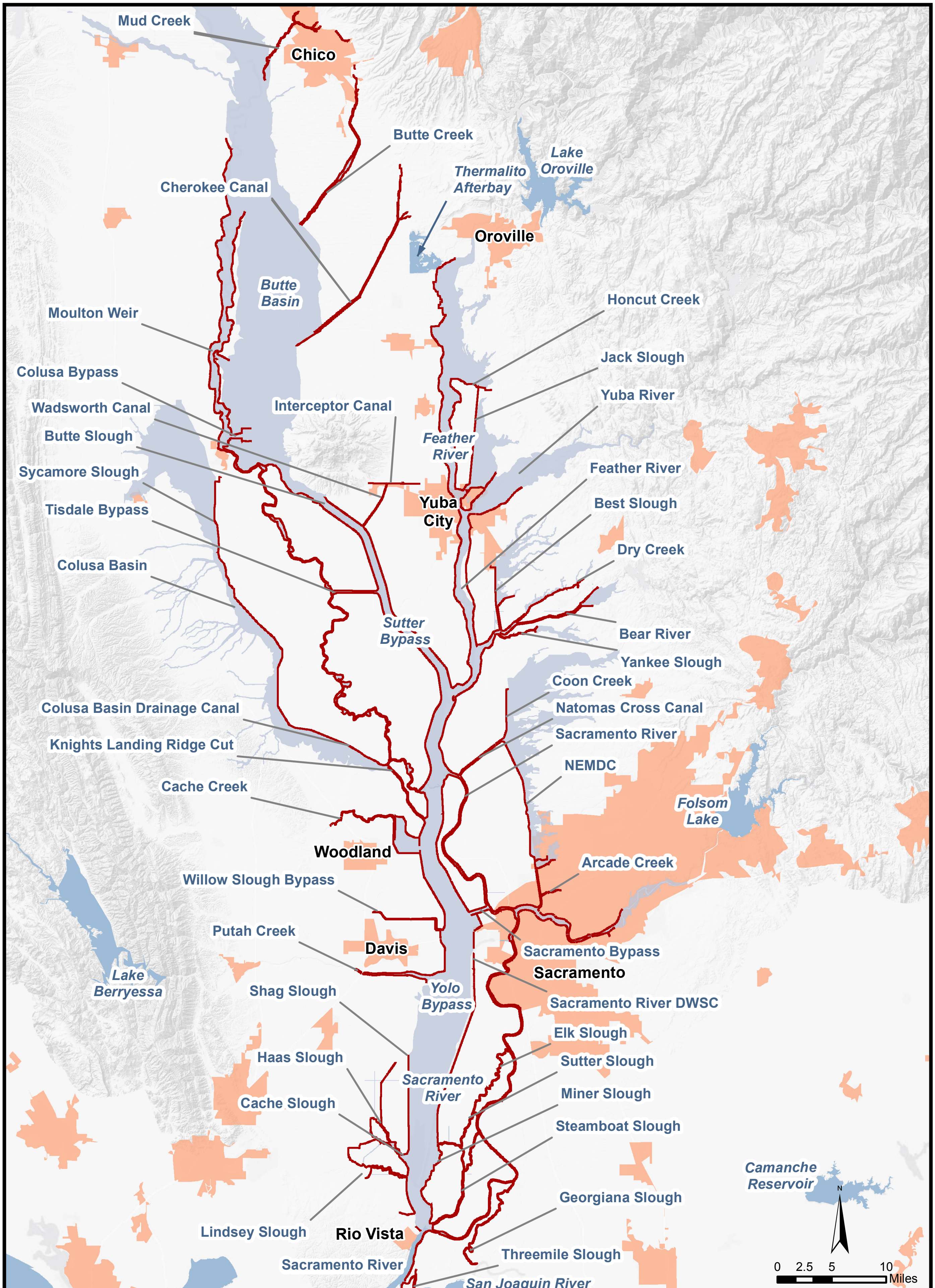
West Sacramento Project
General Reevaluation Report

West Sacramento Study Location Map

U.S. Army Corps of Engineers
Sacramento District

Legend

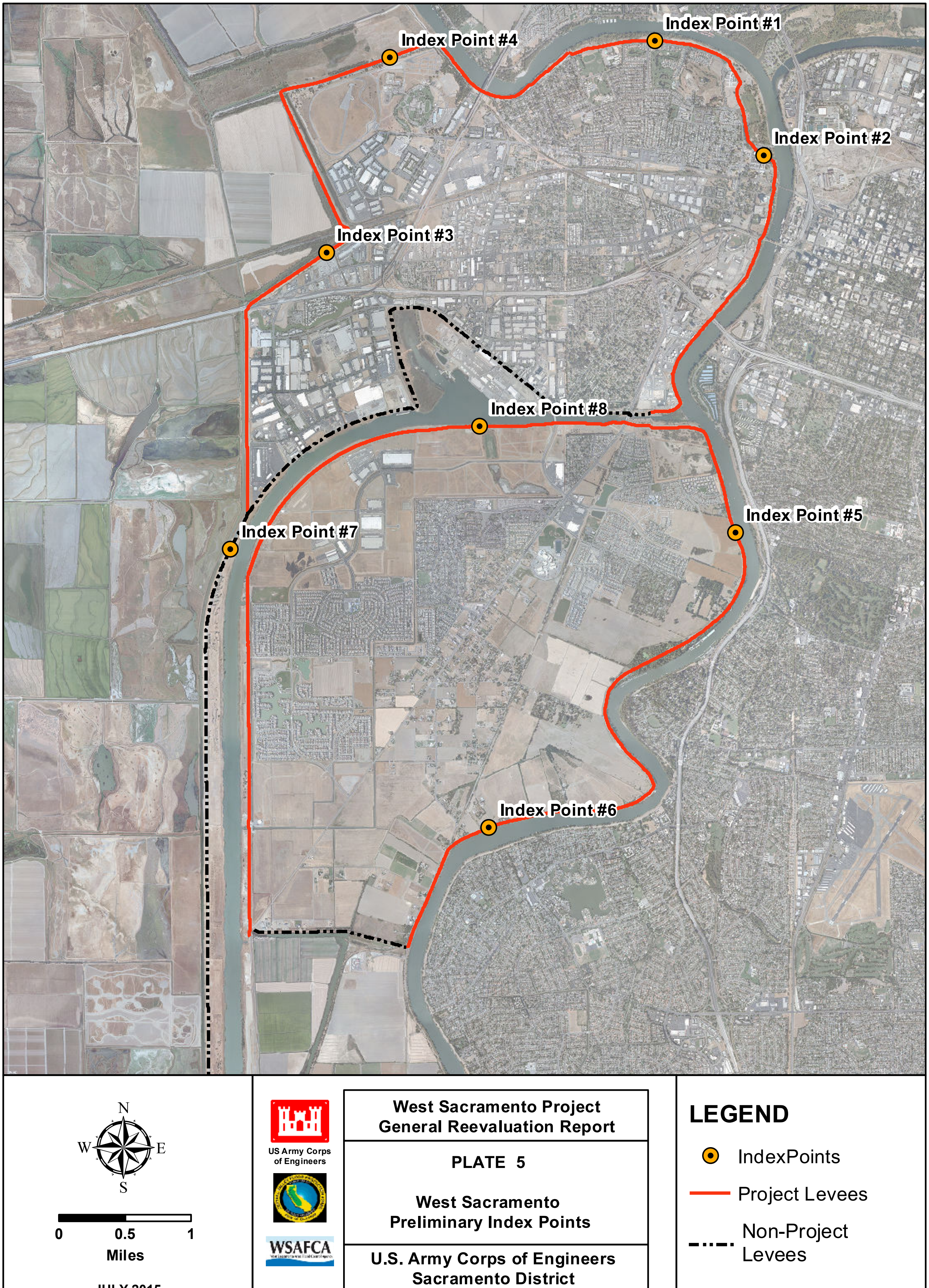
Project Levees
Non-Project Levees



WEST SACRAMENTO GRR WEST SACRAMENTO, CALIFORNIA	**Sacramento River Flood Control System**	U.S. ARMY CORPS OF ENGINEERS SACRAMENTO DISTRICT

Feb 2013

Plate 4



JULY 2015

US Army Corps of Engineers

WSAFCA

West Sacramento Project
General Reevaluation Report

PLATE 5

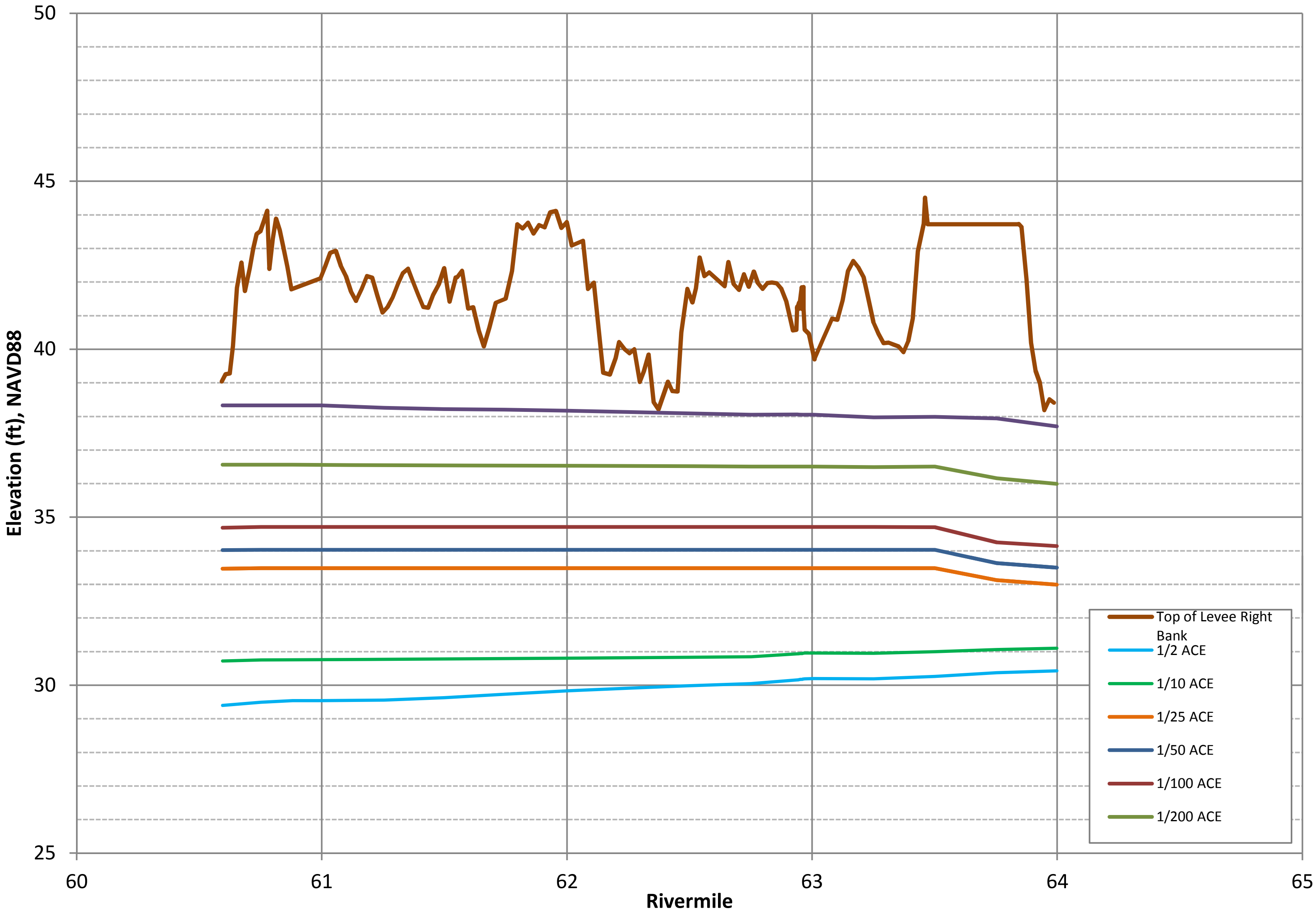
West Sacramento
Preliminary Index Points

U.S. Army Corps of Engineers
Sacramento District

LEGEND

- IndexPoints
- Project Levees
- Non-Project Levees

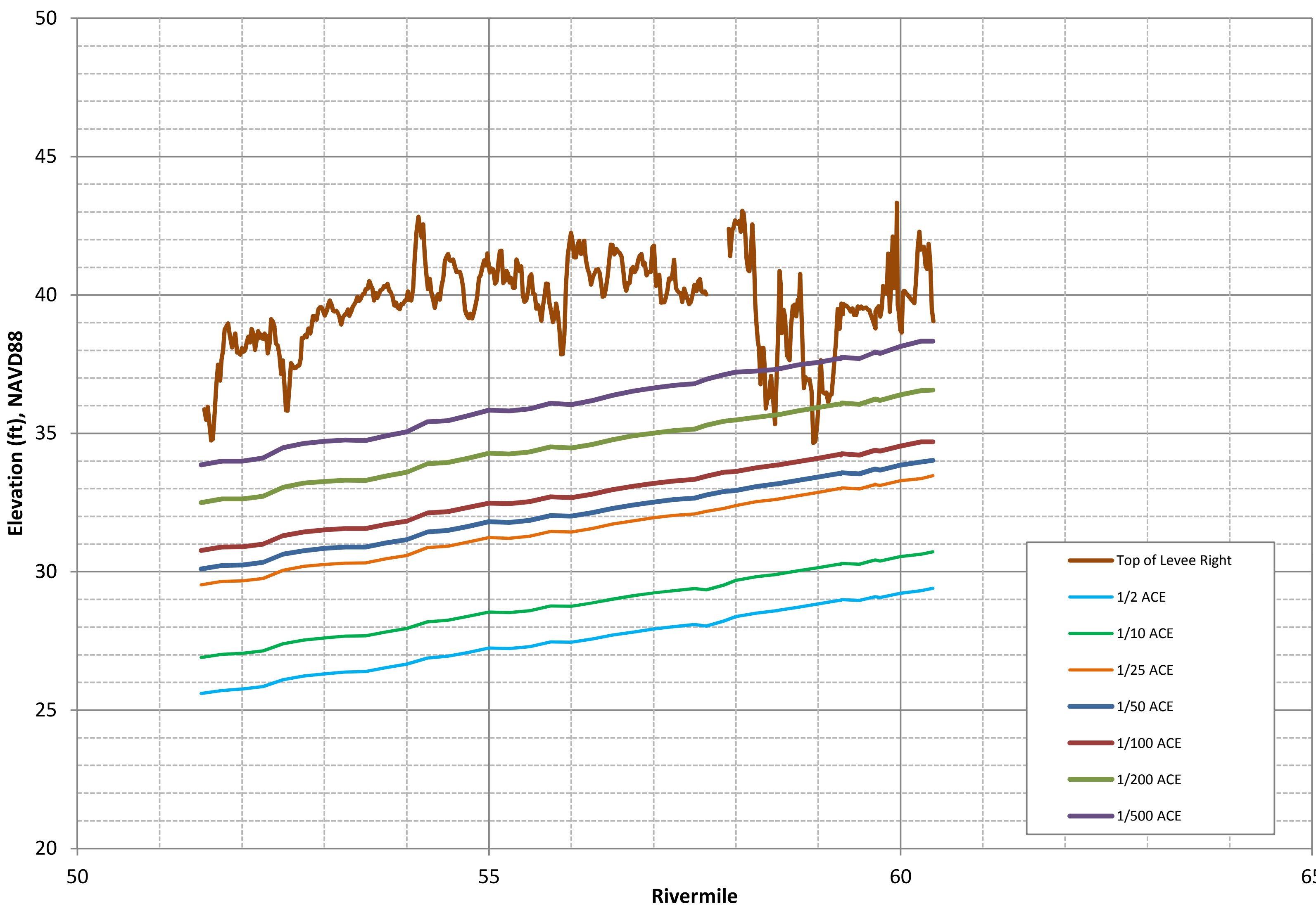
Sacramento River (Upstream of the American River) - Future Without Project 1/n ACE Mean Water Surface Profile



WEST SACRAMENTO GRR FEASIBILITY STUDY, SACRAMENTO, CA	SACRAMENTO RIVER RIGHT BANK LEVEE UPSTREAM OF THE AMERICAN RIVER	US ARMY CORPS OF ENGINEERS SACRAMENTO DISTRICT

Plate 6

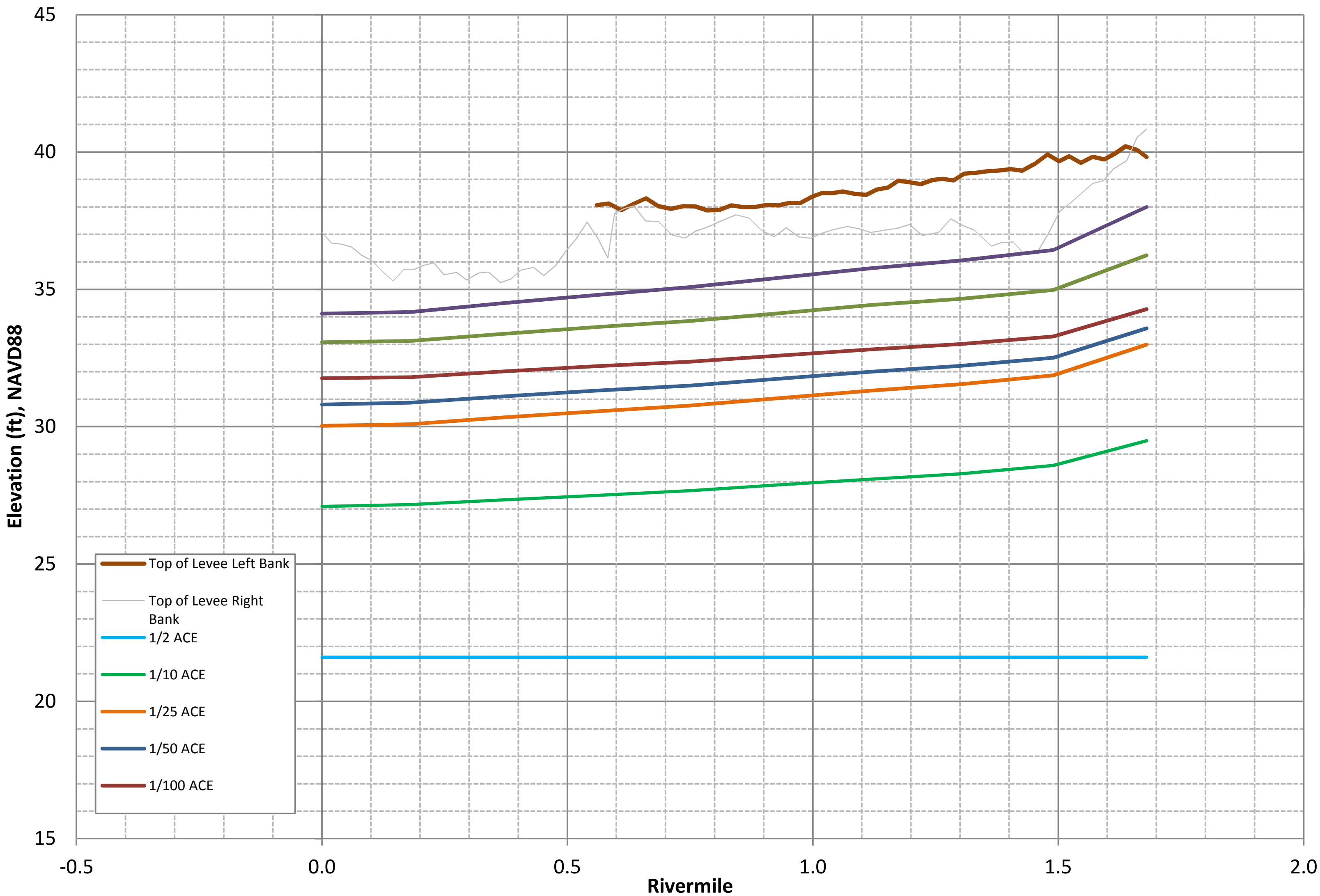
Sacramento River (Downstream of the American River) - Future Without Project - 1/n ACE Mean Water Surface Profile



WEST SACRAMENTO GRR FEASIBILITY STUDY, SACRAMENTO, CA	SACRAMENTO RIVER RIGHT BANK LEVEE DOWNSTREAM OF THE AMERICAN RIVER	US ARMY CORPS OF ENGINEERS SACRAMENTO DISTRICT

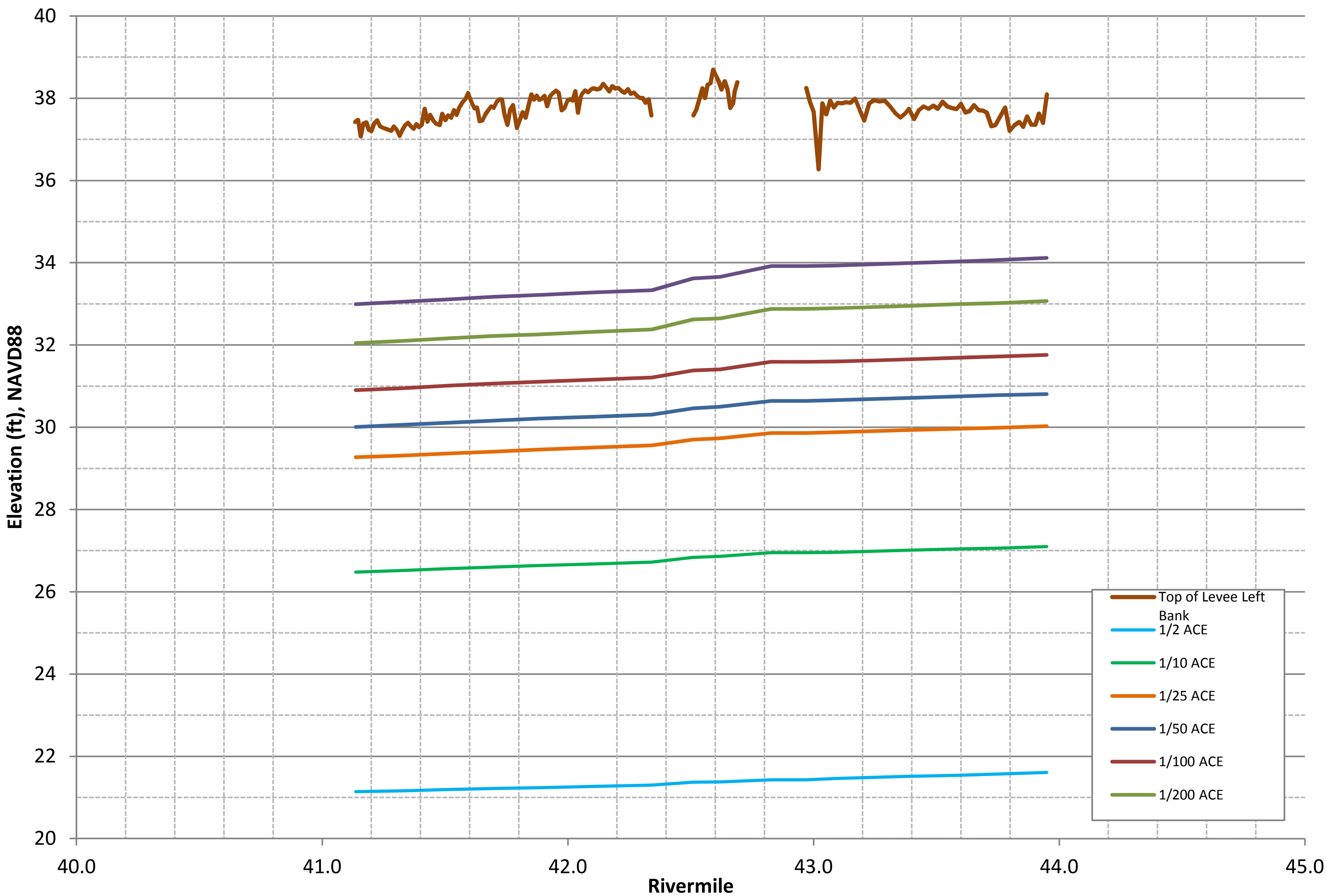
Plate 7

Sacramento Bypass - Future Without Project
1/n ACE Mean Water Surface Profile



WEST SACRAMENTO GRR FEASIBILITY STUDY, SACRAMENTO, CA	SACRAMENTO BYPASS	US ARMY CORPS OF ENGINEERS SACRAMENTO DISTRICT

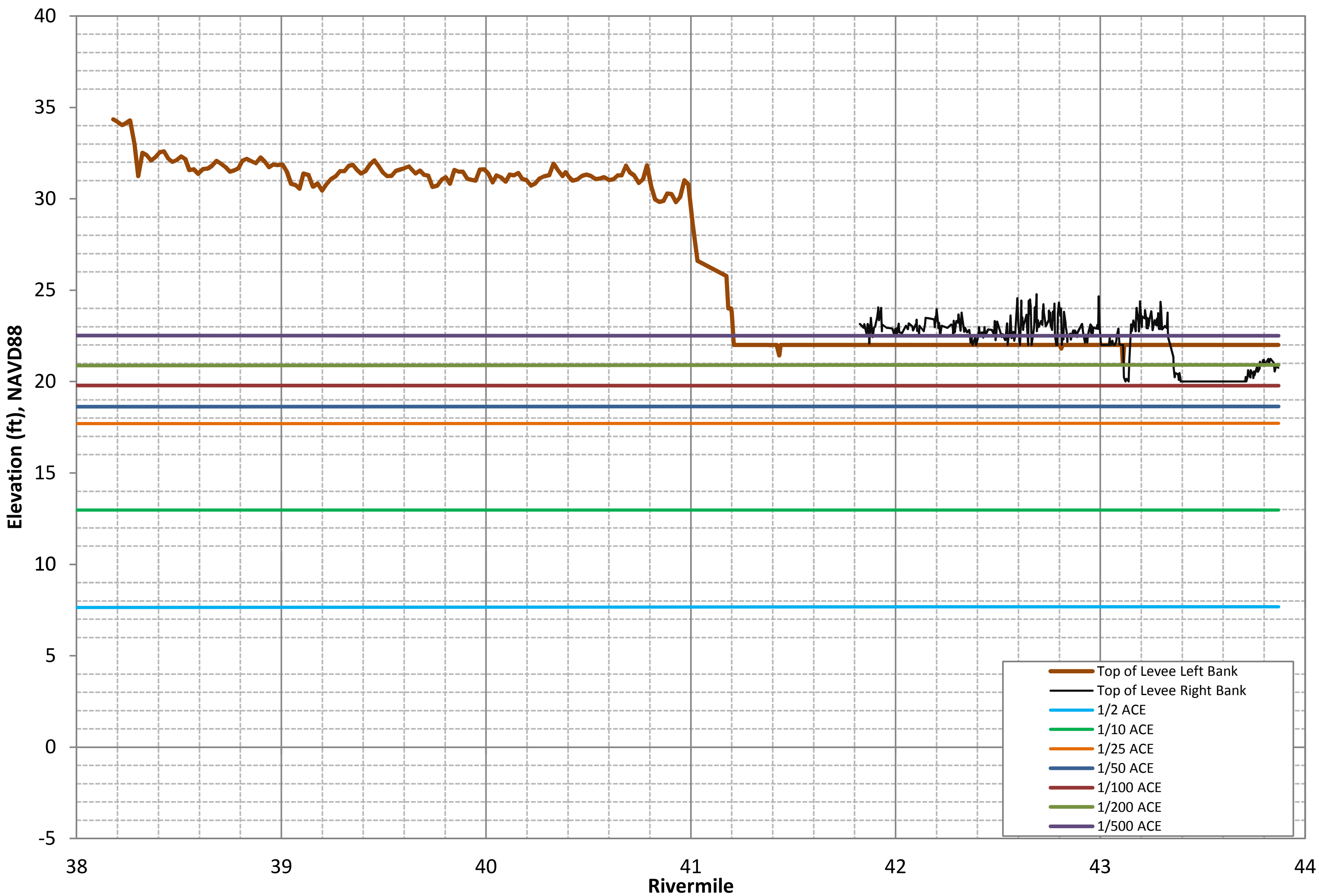
Yolo Bypass - Future Without Project
1/n ACE Mean Water Surface Profile



WEST SACRAMENTO GRR FEASIBILITY STUDY, SACRAMENTO, CA	YOLO BYPASS	US ARMY CORPS OF ENGINEERS SACRAMENTO DISTRICT

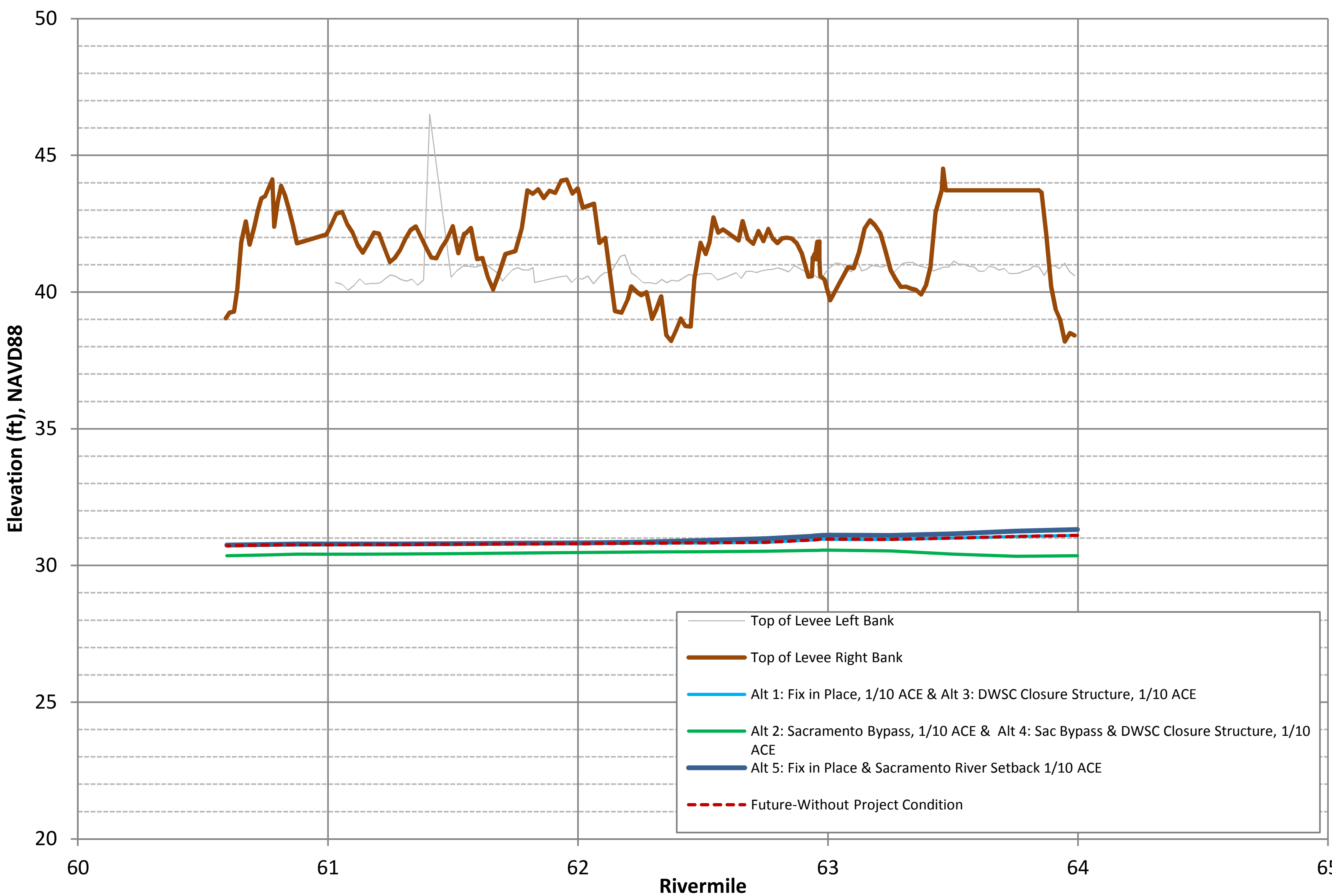
Plate 9

Sacramento Deep Water Ship Channel Future Without Project 1/n ACE Mean Water Surface Profile



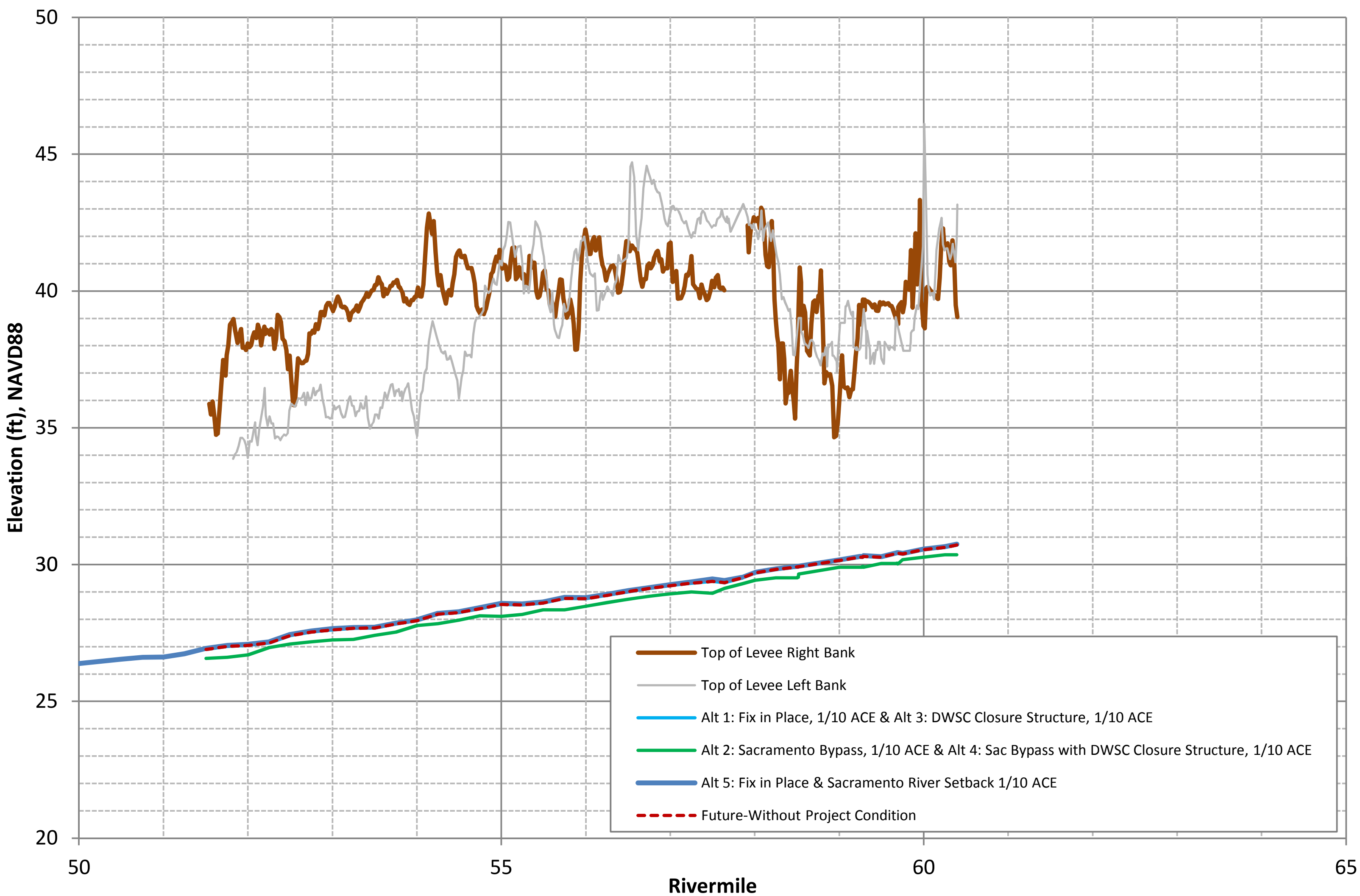
WEST SACRAMENTO GRR FEASIBILITY STUDY, SACRAMENTO, CA	SACRAMENTO DEEP WATER SHIP CHANNEL	US ARMY CORPS OF ENGINEERS SACRAMENTO DISTRICT

Sacramento River (Upstream of the American River) - 1/10 ACE Mean Water Surface Profile



WEST SACRAMENTO GRR FEASIBILITY STUDY, SACRAMENTO, CA	1 in 10 ACE WATER SURFACE PROFILES WITH-PROJECT ALTERNATIVES	US ARMY CORPS OF ENGINEERS SACRAMENTO DISTRICT

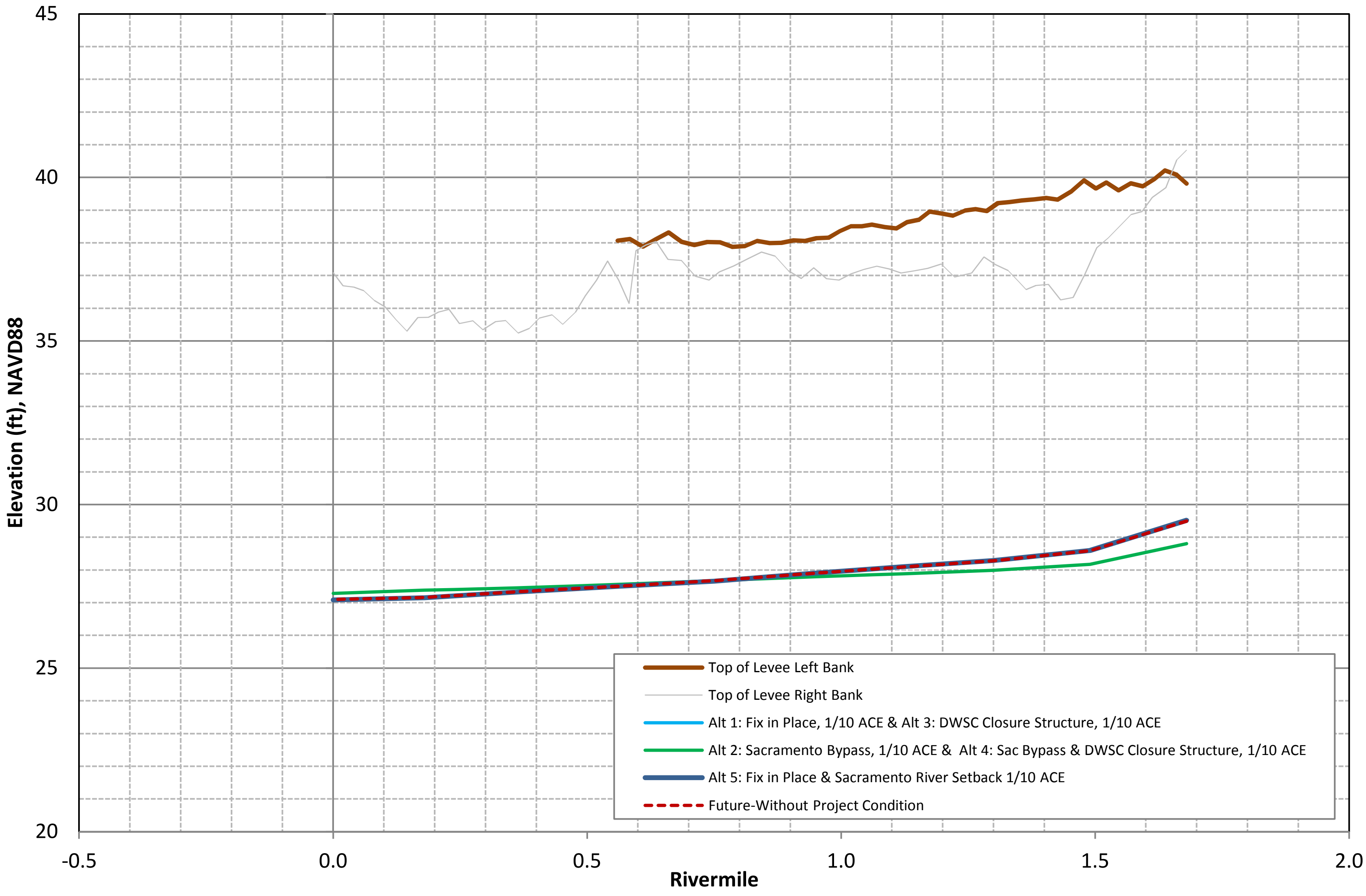
Sacramento River (Downstream of the American River) - 1/10 ACE Mean Water Surface Profile



WEST SACRAMENTO GRR FEASIBILITY STUDY, SACRAMENTO, CA	1 in 10 ACE WATER SURFACE PROFILES WITH-PROJECT ALTERNATIVES	US ARMY CORPS OF ENGINEERS SACRAMENTO DISTRICT

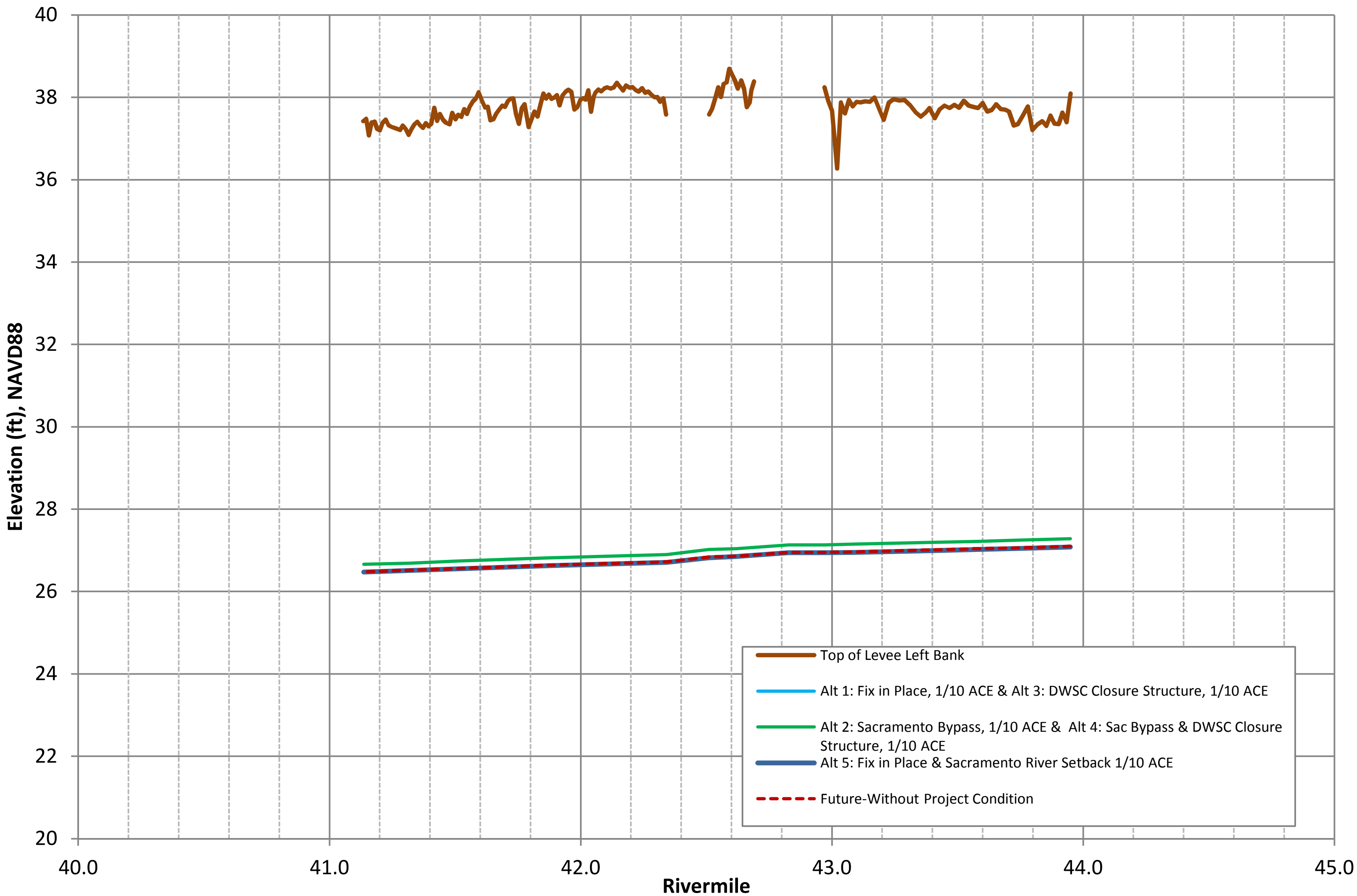
PLATE 12

Sacramento River Bypass - 1/10 ACE Mean Water Surface Profile



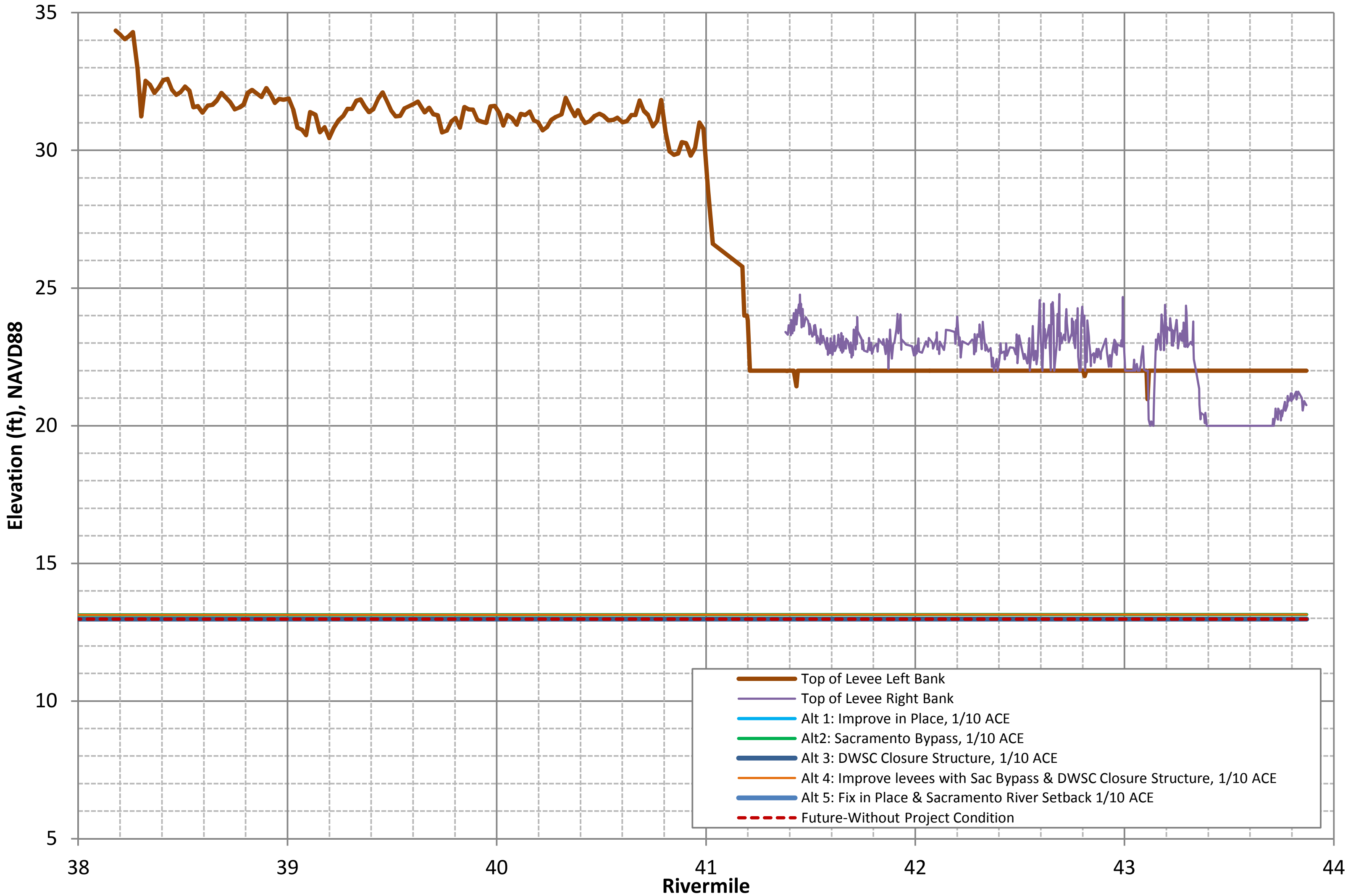
WEST SACRAMENTO GRR FEASIBILITY STUDY, SACRAMENTO, CA	1 in 10 ACE WATER SURFACE PROFILES WITH-PROJECT ALTERNATIVES	US ARMY CORPS OF ENGINEERS SACRAMENTO DISTRICT

Yolo Bypass - 1/10 ACE Mean Water Surface Profile



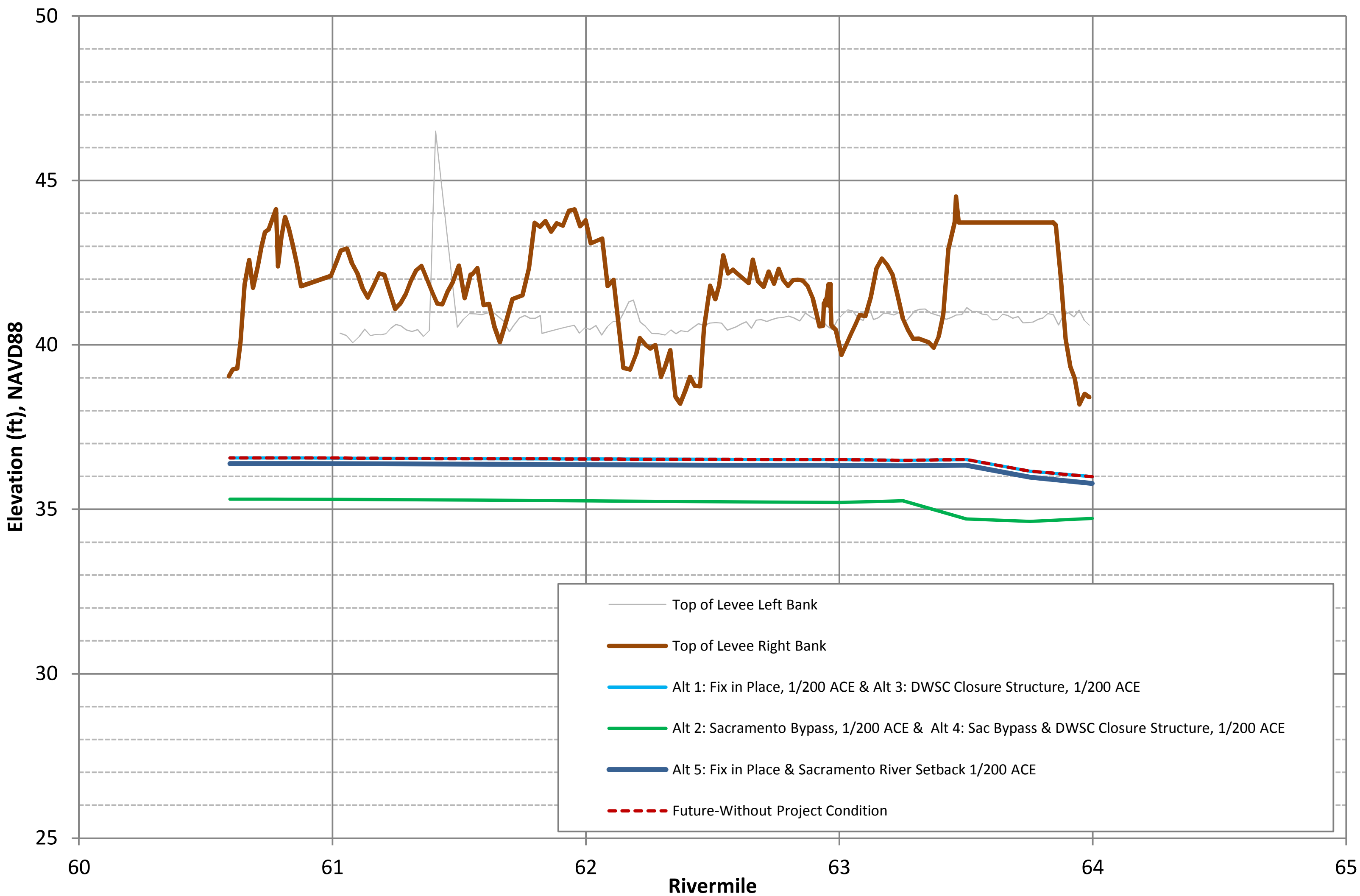
WEST SACRAMENTO GRR FEASIBILITY STUDY, SACRAMENTO, CA	YOLO BYPASS 1/10 ACE WSEL WITH-PROJECT ALTERNATIVES	US ARMY CORPS OF ENGINEERS SACRAMENTO DISTRICT

Sacramento Deep Water Ship Channel- 1/10 ACE Mean Water Surface Profile



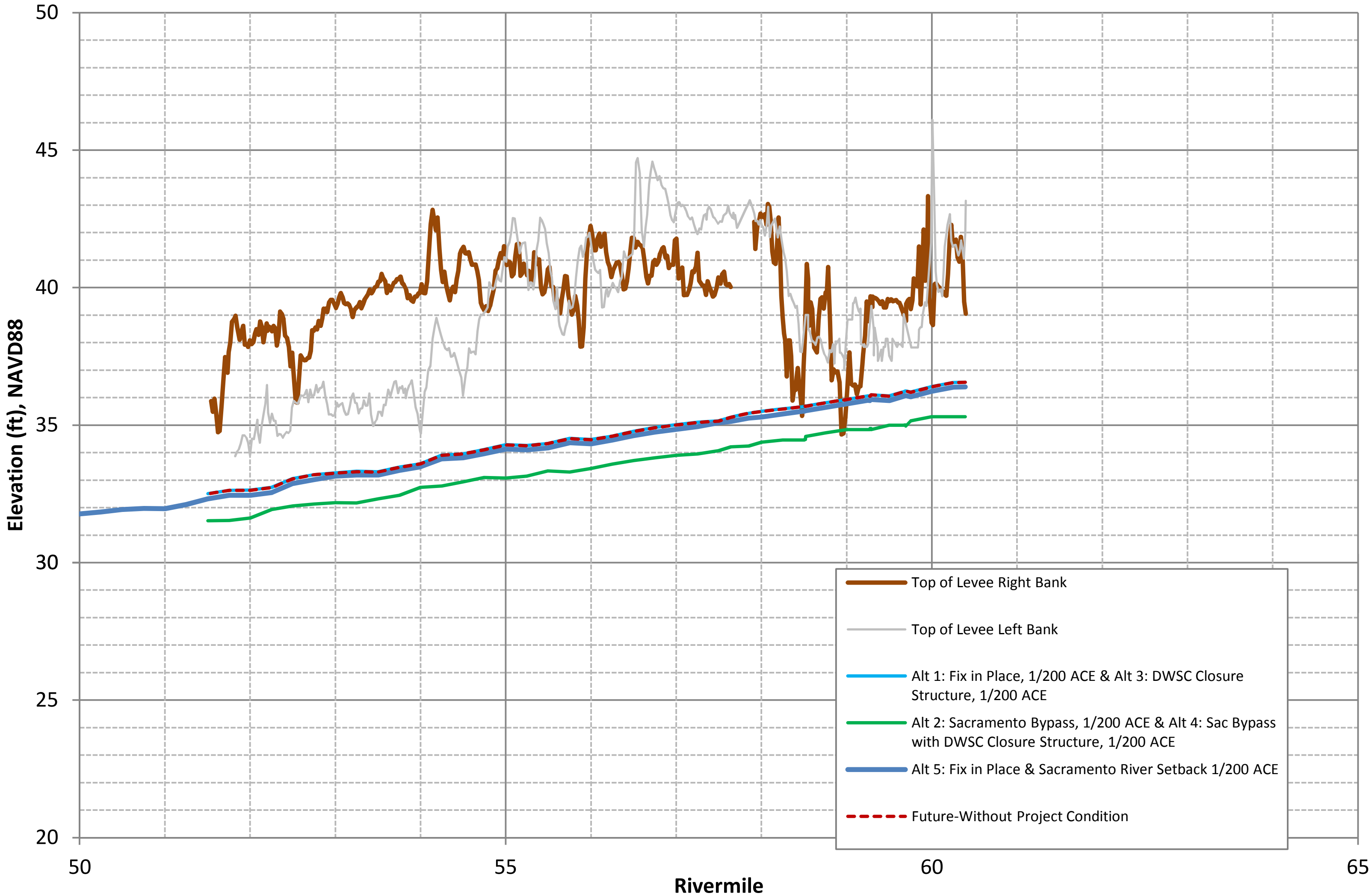
WEST SACRAMENTO GRR FEASIBILITY STUDY, SACRAMENTO, CA	SACRAMENTO DEEP WATER SHIP CHANNEL	US ARMY CORPS OF ENGINEERS SACRAMENTO DISTRICT

Sacramento River (Upstream of the American River)-
1/200 ACE Mean Water Surface Profile



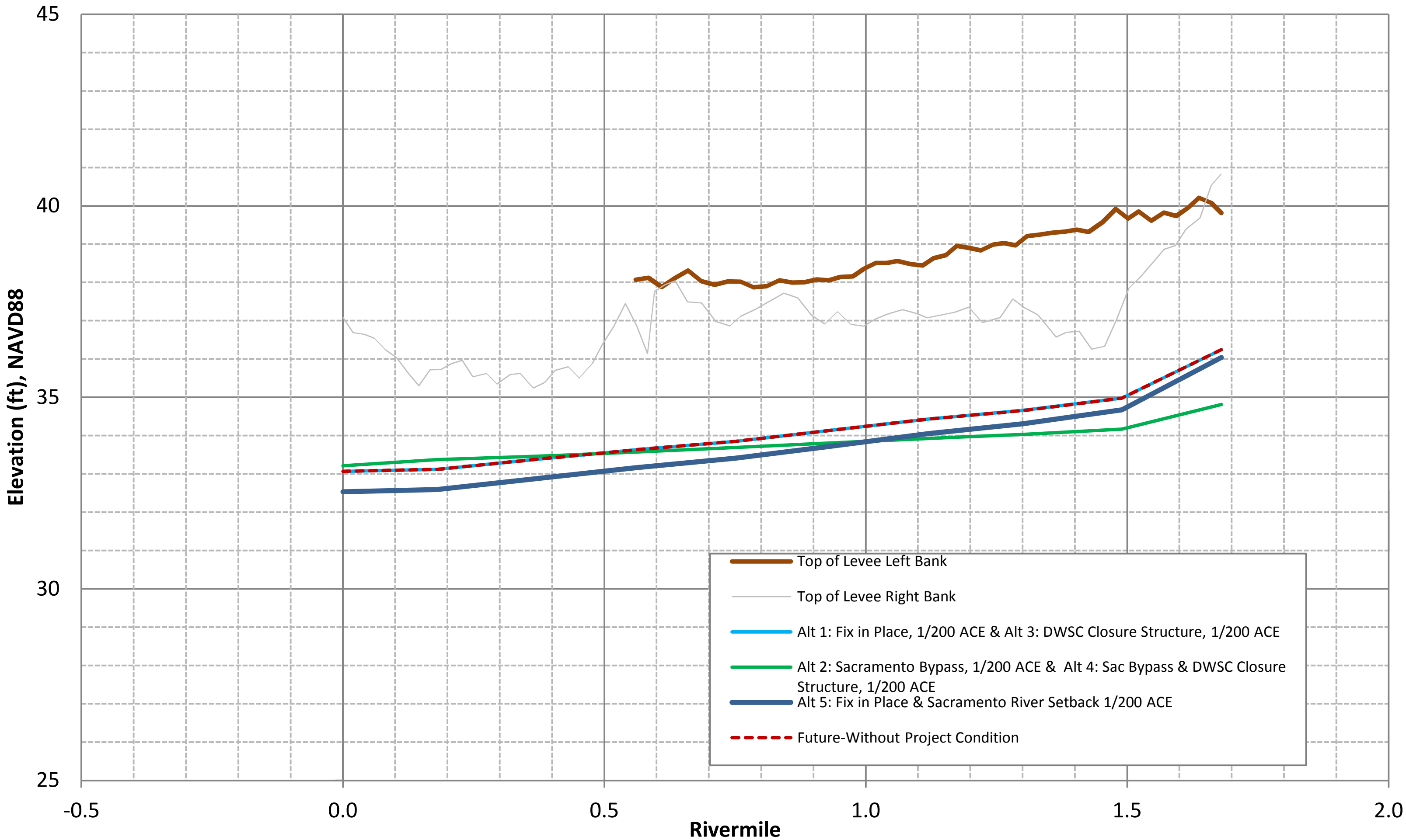
WEST SACRAMENTO GRR FEASIBILITY STUDY, SACRAMENTO, CA	SACRAMENTO RIVER UPSTREAM OF THE AMERICAN RIVER	US ARMY CORPS OF ENGINEERS SACRAMENTO DISTRICT

Sacramento River (Downstream of the American River) - 1/200 ACE Mean Water Surface Profile



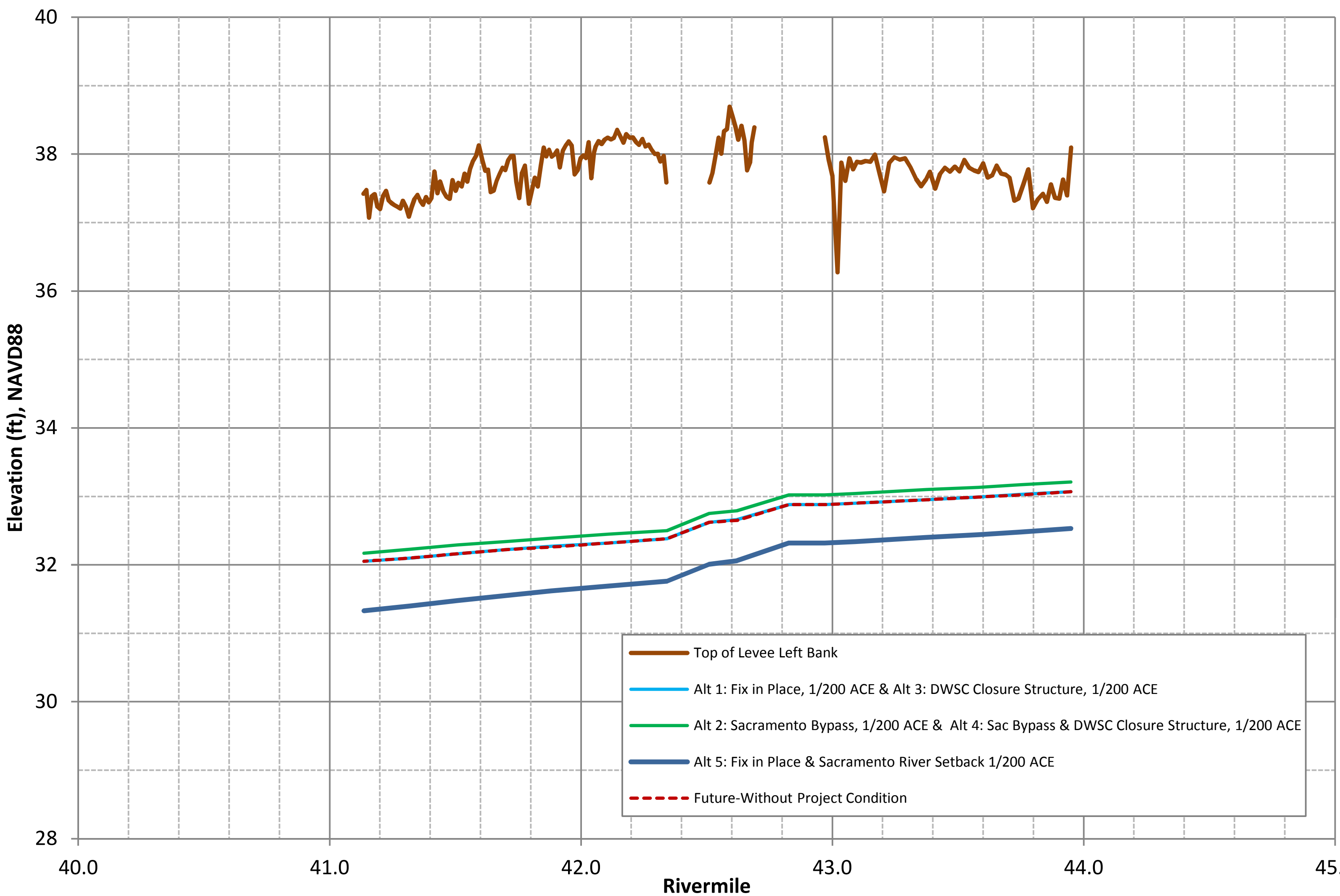
WEST SACRAMENTO GRR FEASIBILITY STUDY, SACRAMENTO, CA	SACRAMENTO RIVER RIGHT BANK LEVEE DOWNSTREAM OF THE AMERICAN RIVER	US ARMY CORPS OF ENGINEERS SACRAMENTO DISTRICT

Sacramento Bypass - 1/200 ACE Mean Water Surface Profile



WEST SACRAMENTO GRR FEASIBILITY STUDY, SACRAMENTO, CA	SACRAMENTO BYPASS LEFT BANK LEVEE	US ARMY CORPS OF ENGINEERS SACRAMENTO DISTRICT

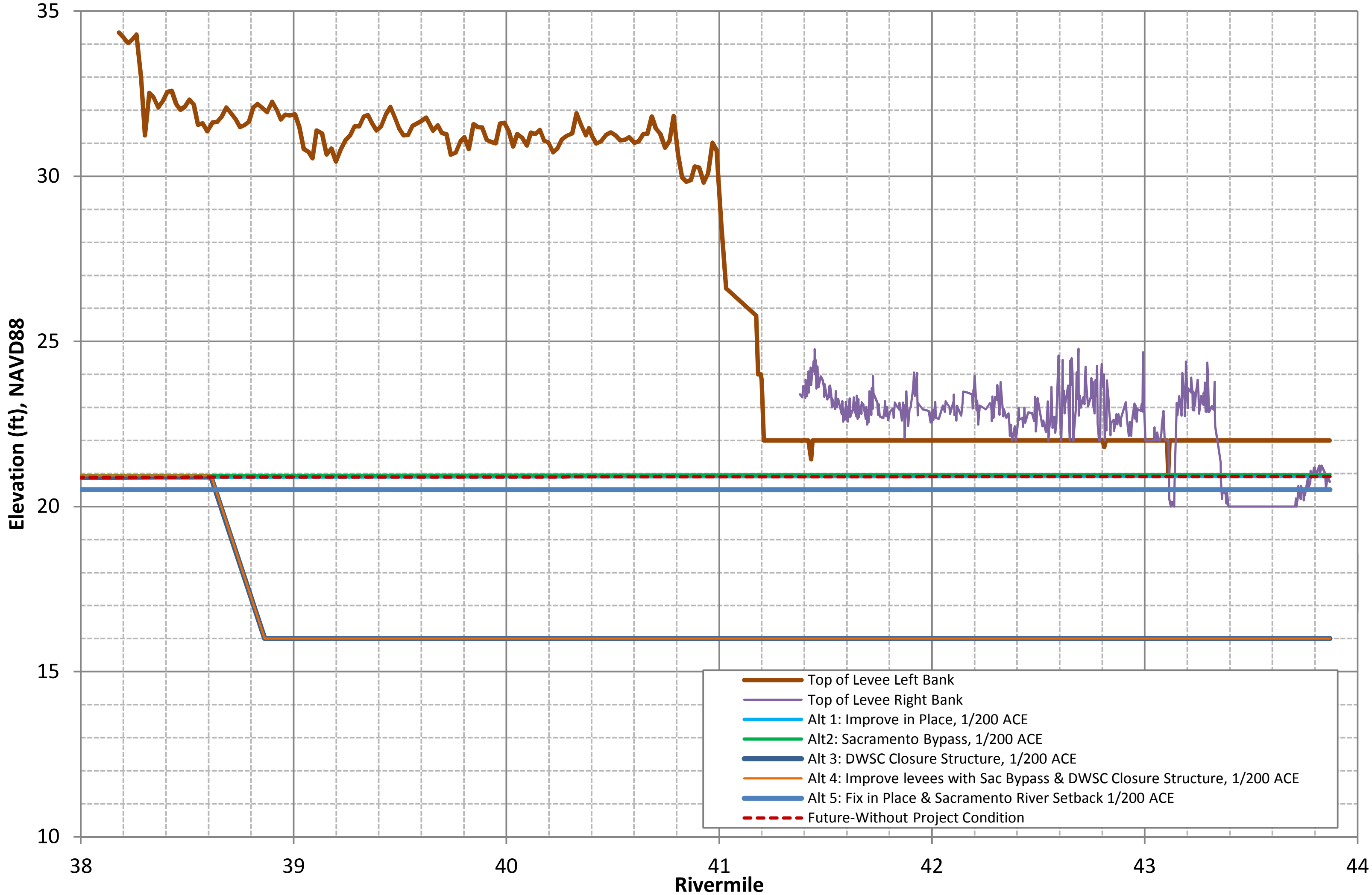
Yolo Bypass - 1/200 ACE Mean Water Surface Profile



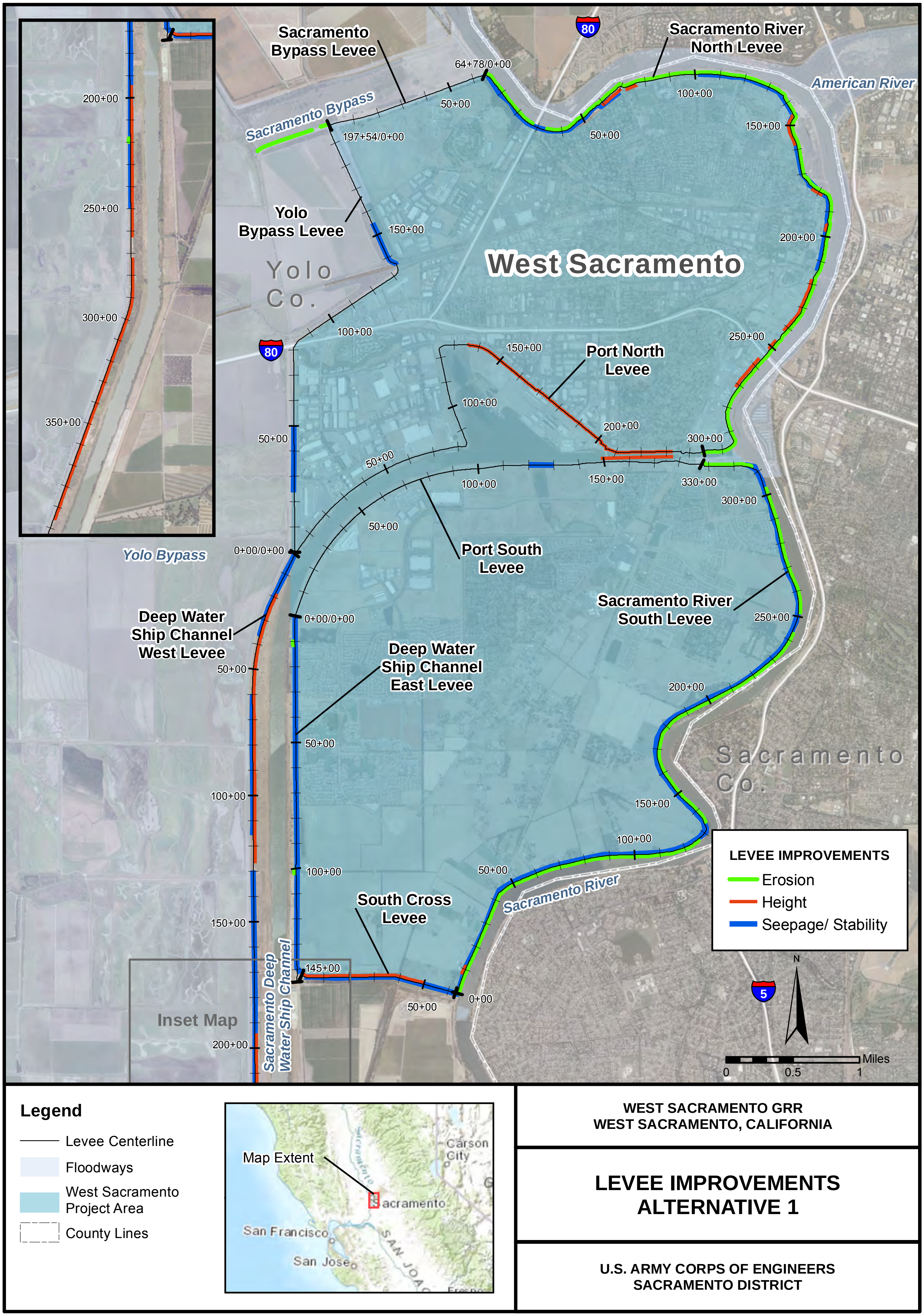
WEST SACRAMENTO GRR FEASIBILITY STUDY, SACRAMENTO, CA	YOLO BYPASS 1/200 ACE WSEL WITH-PROJECT ALTERNATIVES	US ARMY CORPS OF ENGINEERS SACRAMENTO DISTRICT

PLATE 19

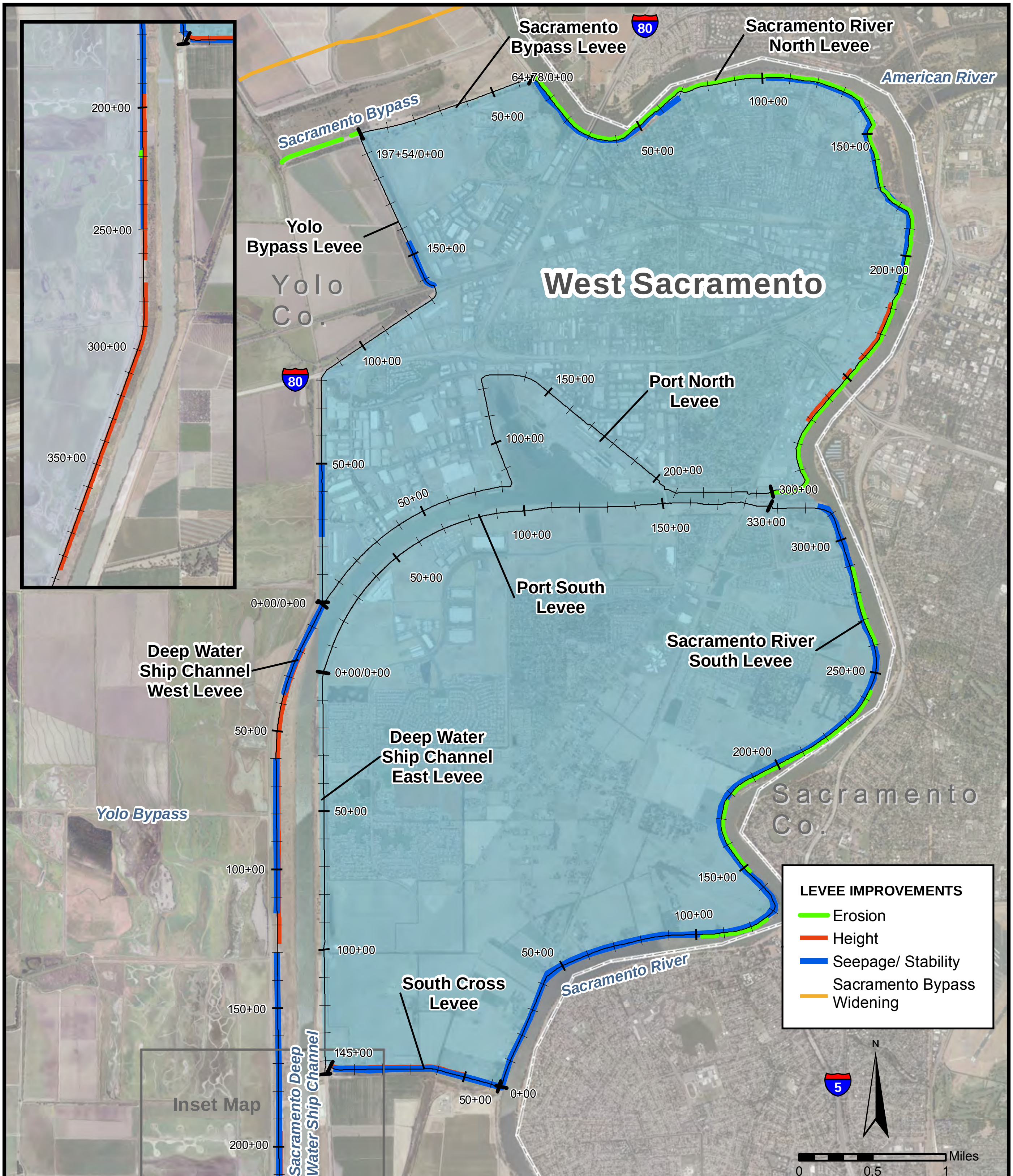
Sacramento Deep Water Ship Channel Future
1/200 ACE Mean Water Surface Profile



WEST SACRAMENTO GRR FEASIBILITY STUDY, SACRAMENTO, CA	SACRAMENTO DEEP WATER SHIP CHANNEL	US ARMY CORPS OF ENGINEERS SACRAMENTO DISTRICT



Sacramento Bypass Levee
Sacramento River North Levee
American River
Sacramento Bypass
64+78/0+00
50+00
197+54/0+00
100+00
150+00
200+00
250+00
300+00
330+00
Yolo Bypass Levee
Yolo Co.
West Sacramento
Port North Levee
Port South Levee
Deep Water Ship Channel West Levee
Deep Water Ship Channel East Levee
Sacramento River South Levee
South Cross Levee
Sacramento River
Sacramento Deep Water Ship Channel
Sacramento Co.
Yolo Bypass
0+00/0+00
145+00
0+00
350+00
Inset Map
LEVEE IMPROVEMENTS
Erosion
Height
Seepage/ Stability
Miles
0
0.5
1
N
80
5
Legend
Levee Centerline
Floodways
West Sacramento Project Area
County Lines
Map Extent
Carson City
Sacramento
San Francisco
San Jose
WEST SACRAMENTO GRR
WEST SACRAMENTO, CALIFORNIA
LEVEE IMPROVEMENTS
ALTERNATIVE 1
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

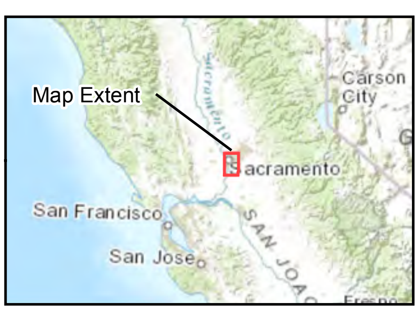


Legend

Levee Centerline

West Sacramento Project Area

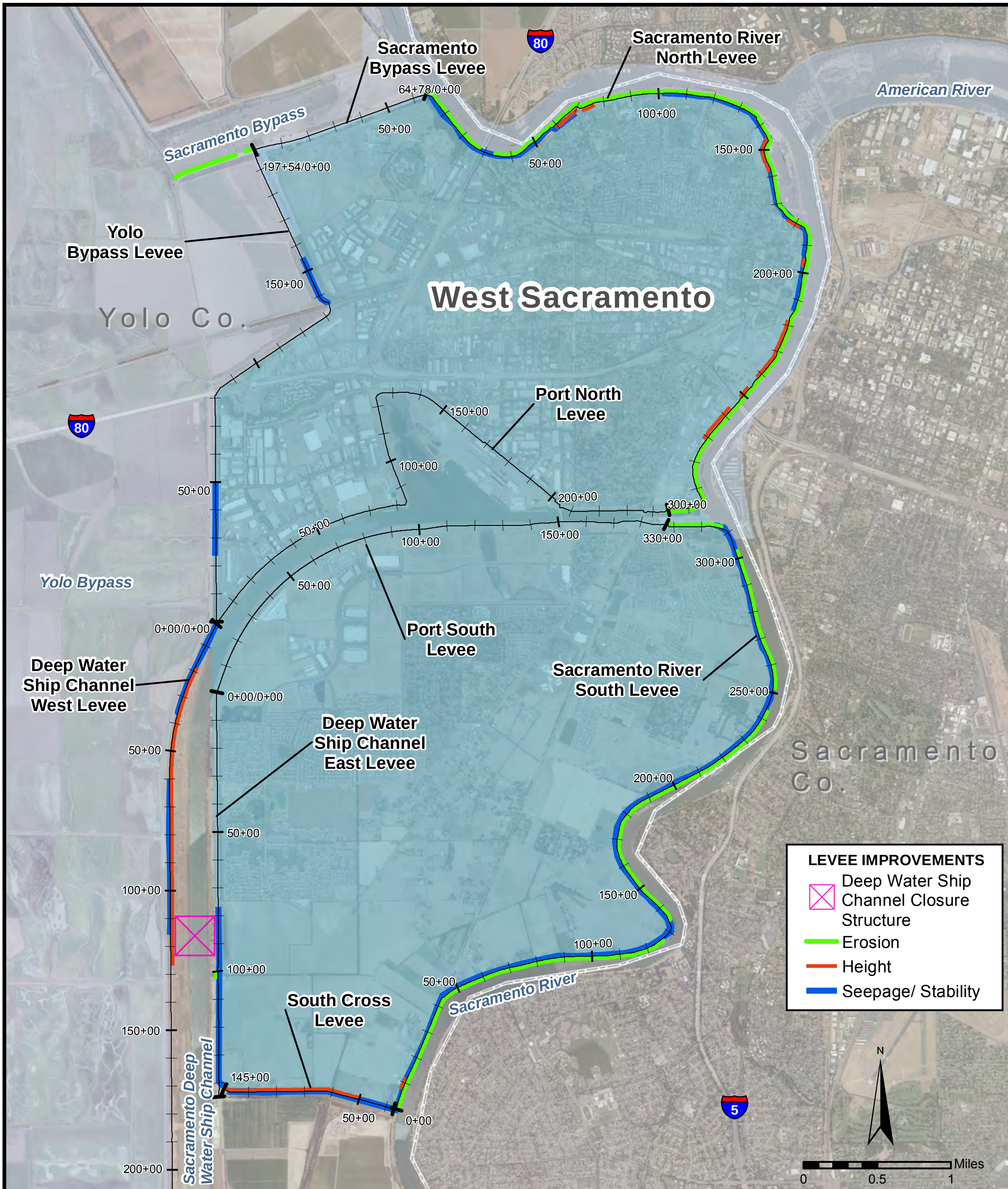
County Lines



WEST SACRAMENTO GRR
WEST SACRAMENTO, CALIFORNIA

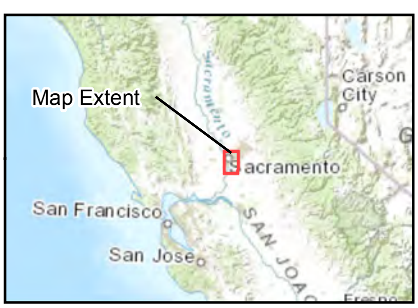
LEVEE IMPROVEMENTS ALTERNATIVE 2

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



Legend

- Levee Centerline
- Floodways
- West Sacramento Project Area
- County Lines

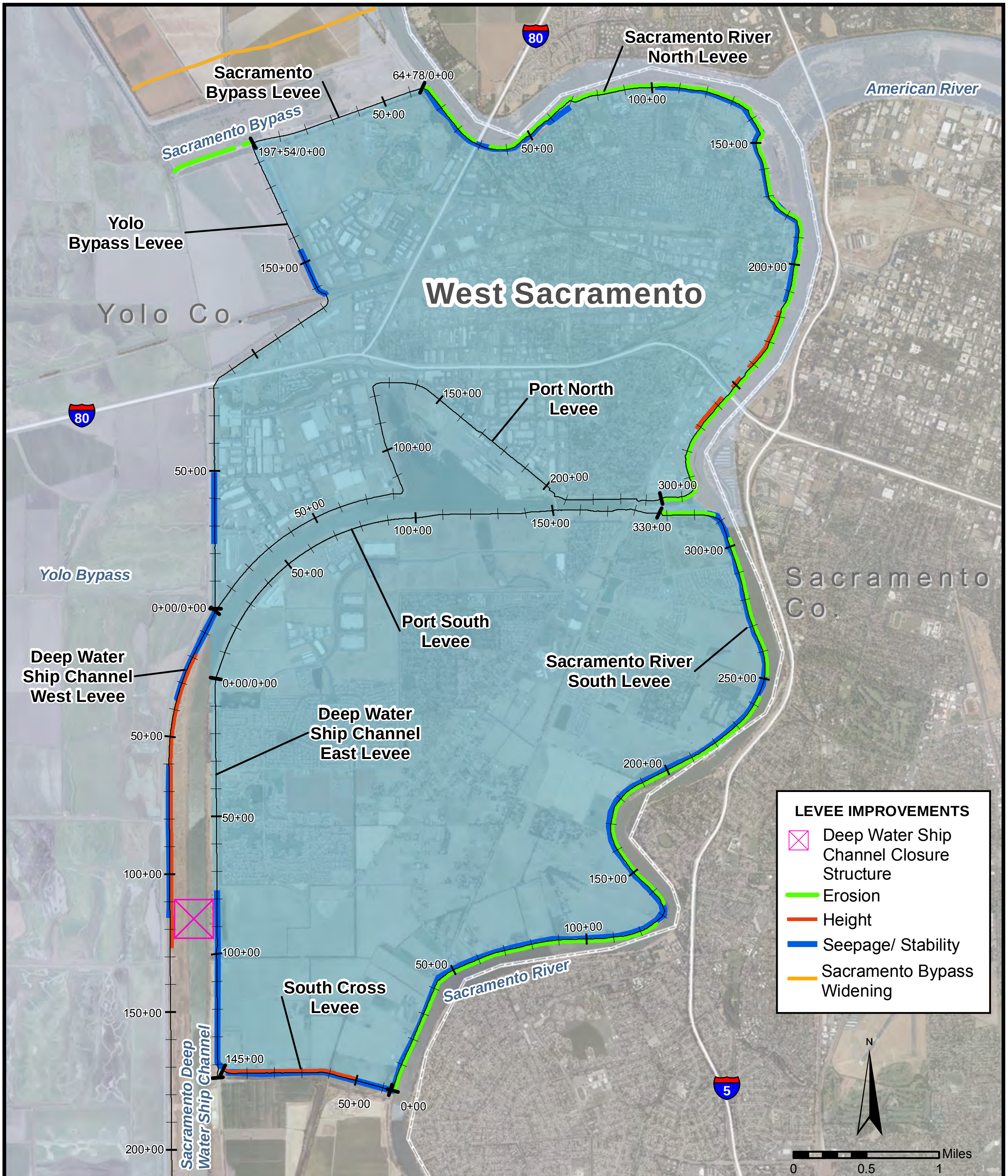


WEST SACRAMENTO GRR
WEST SACRAMENTO, CALIFORNIA

LEVEE IMPROVEMENTS ALTERNATIVE 3

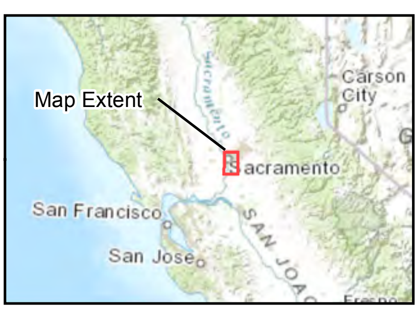
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Plate 23



Legend

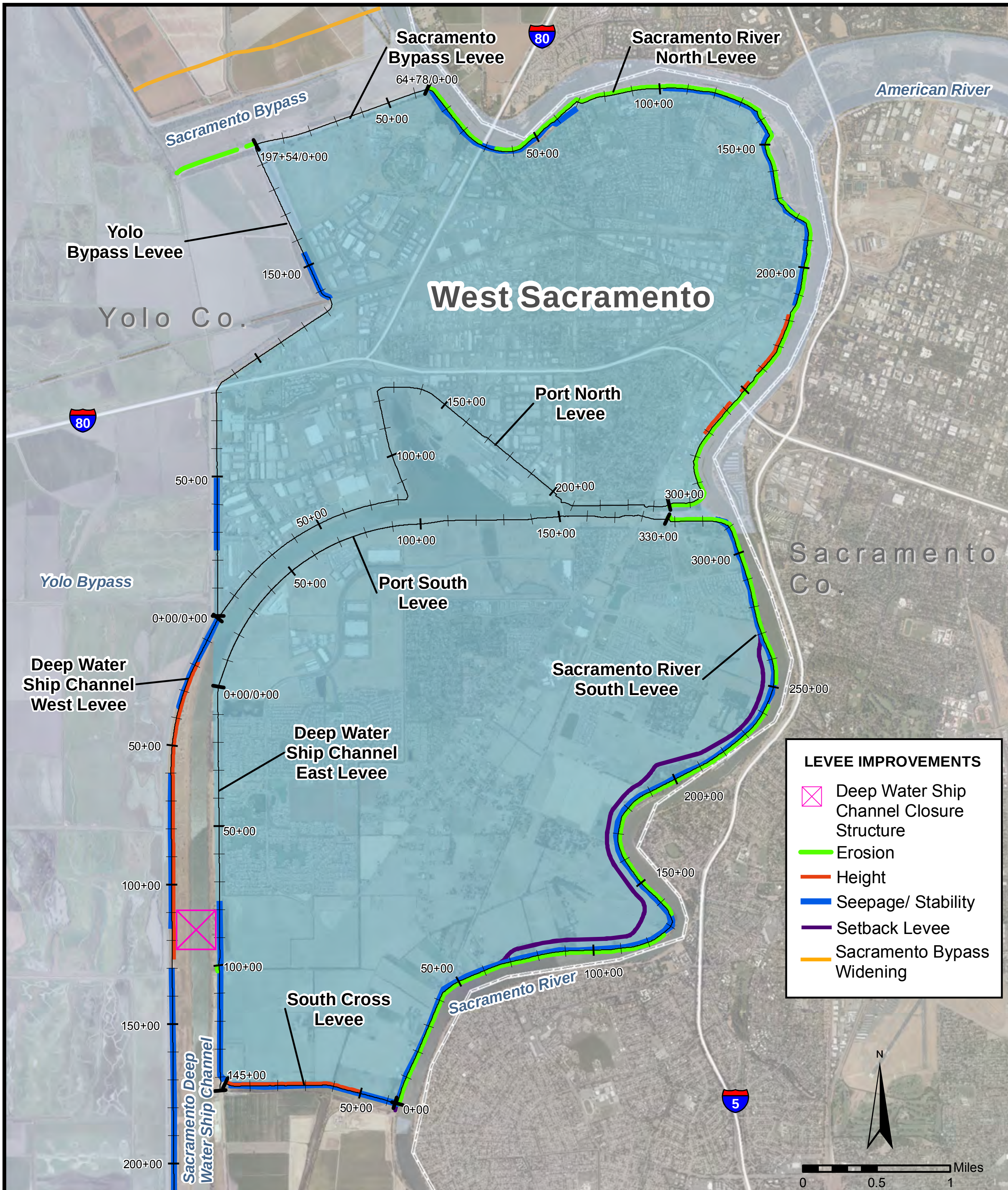
- Levee Centerline
- West Sacramento Project Area
- Floodways
- County Lines



WEST SACRAMENTO GRR
WEST SACRAMENTO, CALIFORNIA

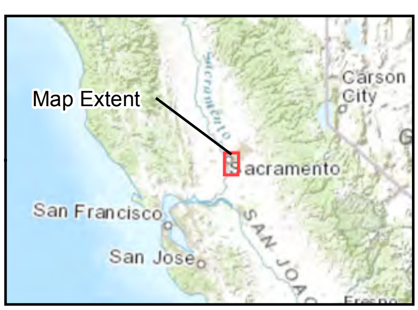
LEVEE IMPROVEMENTS ALTERNATIVE 4

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



Legend

- Levee Centerline
- Floodways
- West Sacramento Project Area
- County Lines

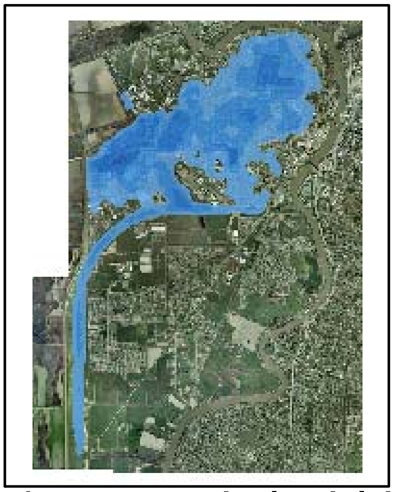


WEST SACRAMENTO GRR
WEST SACRAMENTO, CALIFORNIA

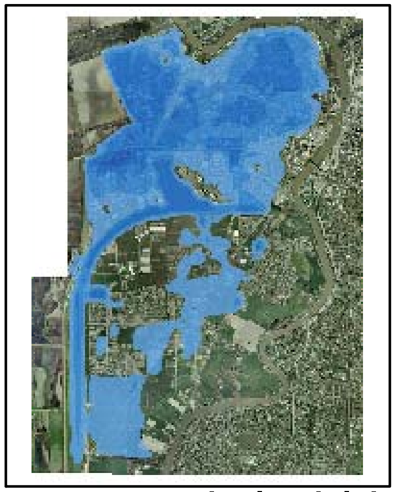
LEVEE IMPROVEMENTS ALTERNATIVE 5

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

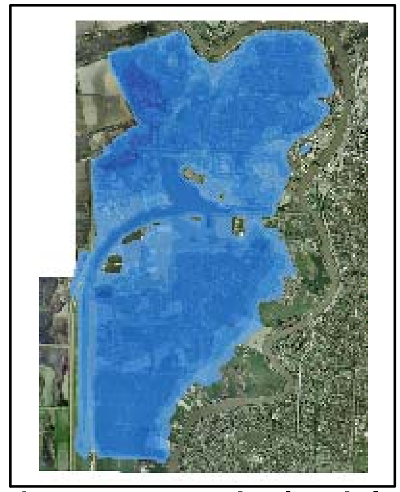
Plate 25



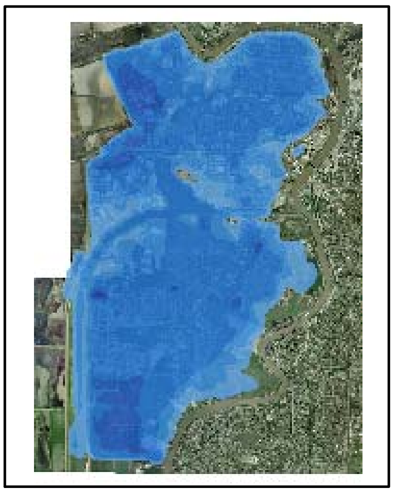
1/2 ACE Breach Floodplain



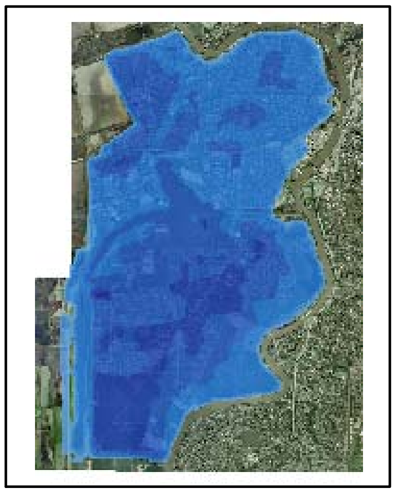
1/10 ACE Breach Floodplain



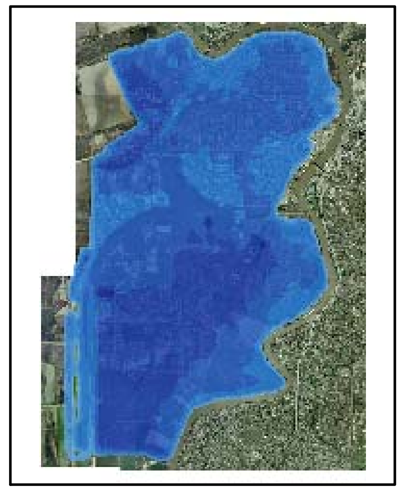
1/25 ACE Breach Floodplain



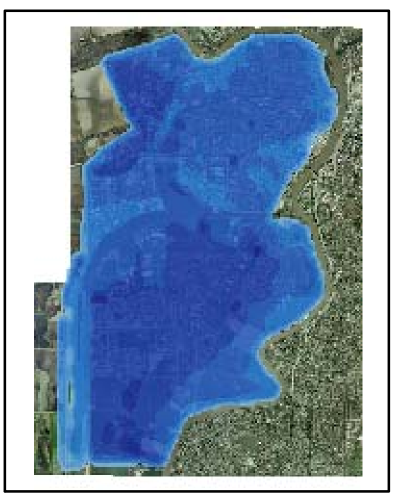
1/50 ACE Breach Floodplain



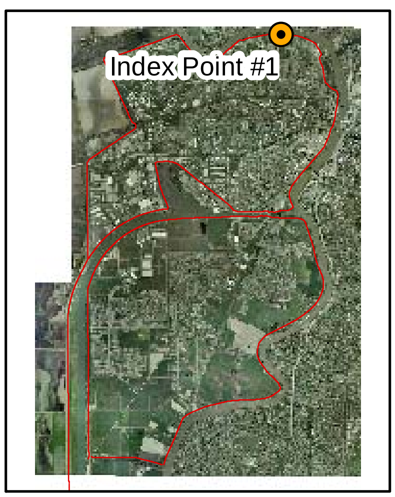
1/100 ACE Breach Floodplain



1/200 ACE Breach Floodplain



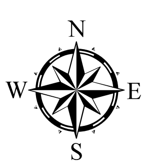
1/500 ACE Breach Floodplain



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



0 1.5 3
Miles

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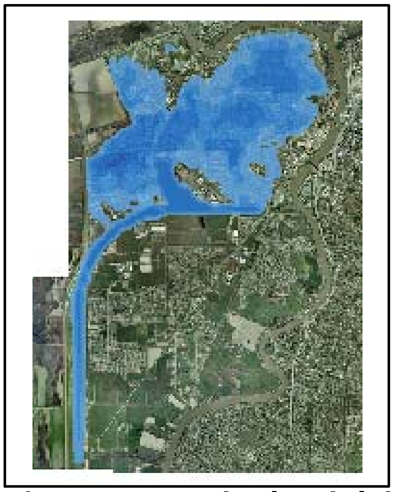
West Sacramento Project
General Reevaluation Report

1/2- Through 1/500- ACE
Breach Floodplains
Index Point 1
Sacramento River RM 61

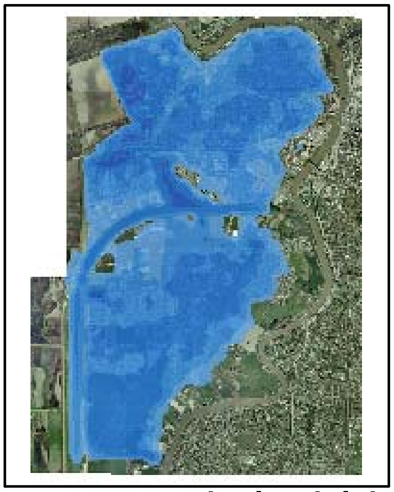
U.S. Army Corps of Engineers
Sacramento District

These Without-Project condition floodplains are based on a single levee breach at the Index Point flooding the West Sacramento Basin.

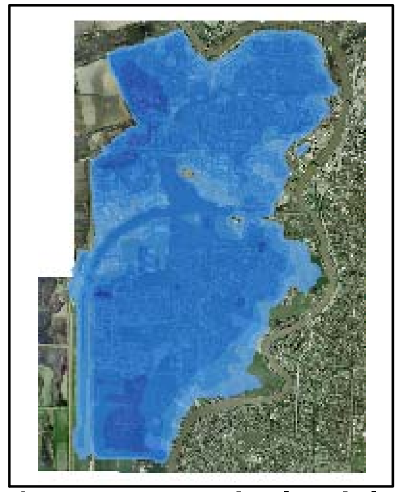
Plate 26. West Sacramento Index Point 1



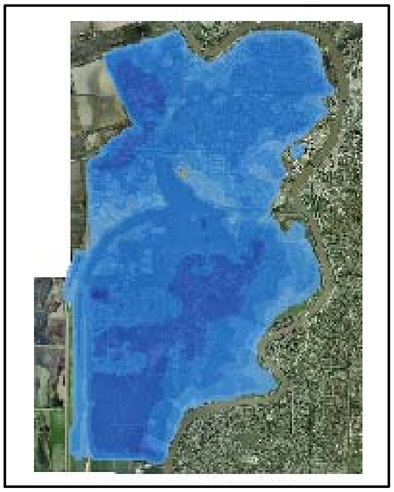
1/2 ACE Breach Floodplain



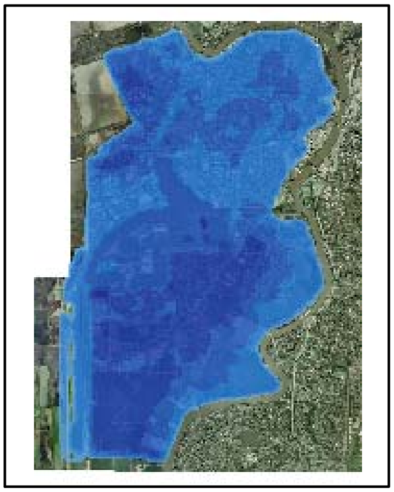
1/10 ACE Breach Floodplain



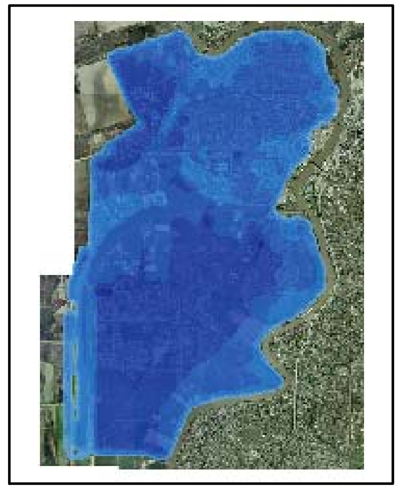
1/25 ACE Breach Floodplain



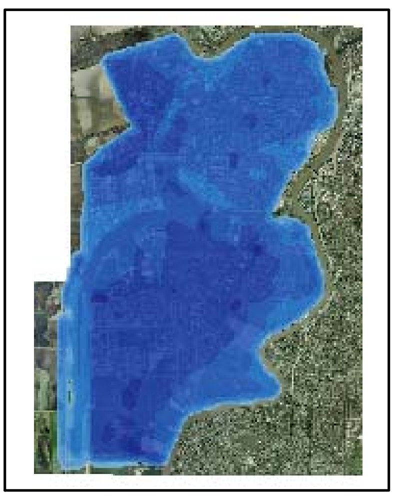
1/50 ACE Breach Floodplain



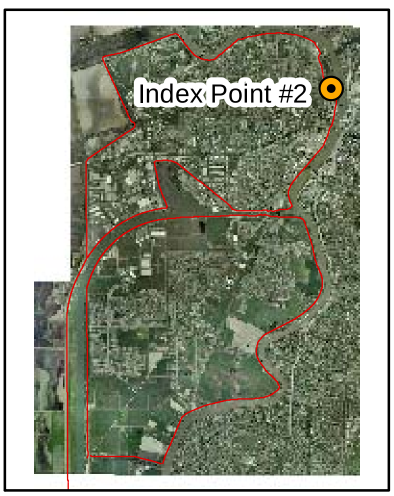
1/100 ACE Breach Floodplain



1/200 ACE Breach Floodplain



1/500 ACE Breach Floodplain

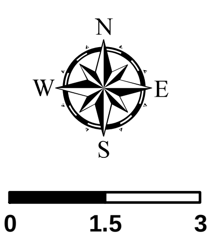


Basemap

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



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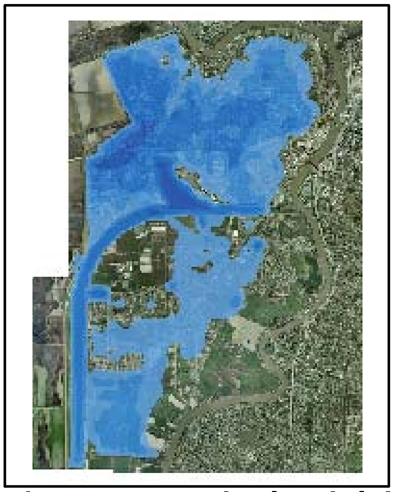
General Reevaluation Report

1/2- Through 1/500-ACE
Breach Floodplains
Index Point 2
Sacramento River RM 60

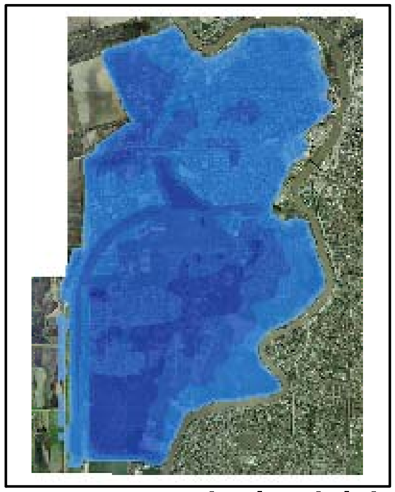
U.S. Army Corps of Engineers
Sacramento District

These Without-Project condition floodplains are based on a single levee breach at the Index Point flooding the West Sacramento Basin.

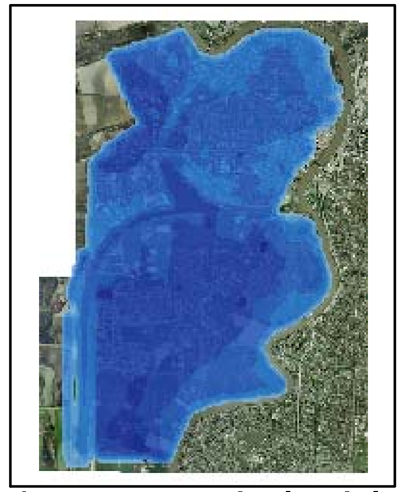
Plate 27. West Sacramento Index Point 2



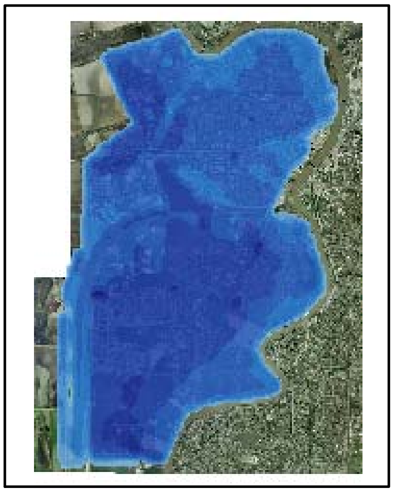
1/2 ACE Breach Floodplain



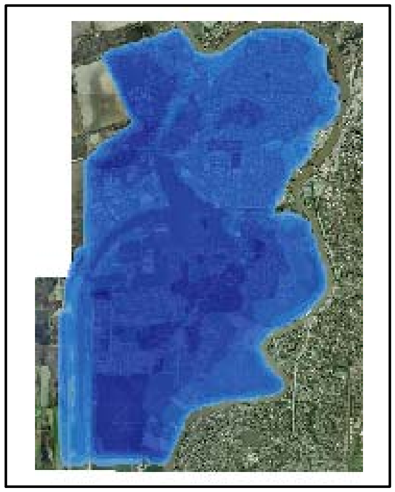
1/10 ACE Breach Floodplain



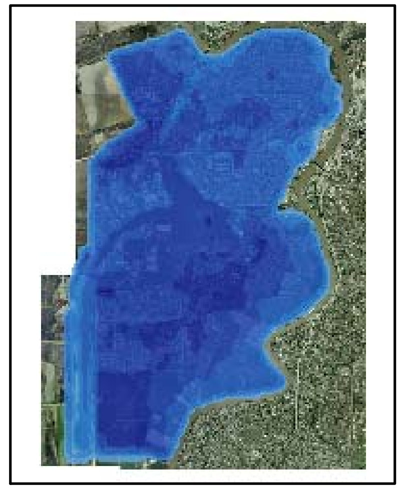
1/25 ACE Breach Floodplain



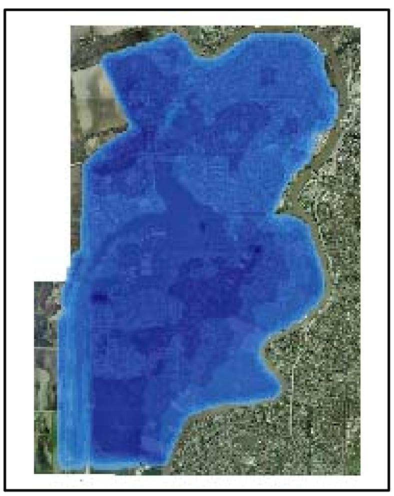
1/50 ACE Breach Floodplain



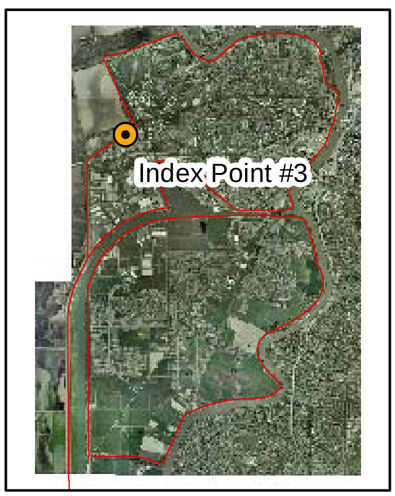
1/100 ACE Breach Floodplain



1/200 ACE Breach Floodplain



1/500 ACE Breach Floodplain

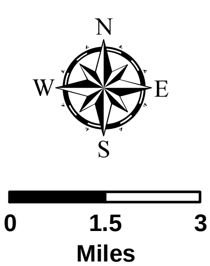


Basemap

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



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General Reevaluation Report

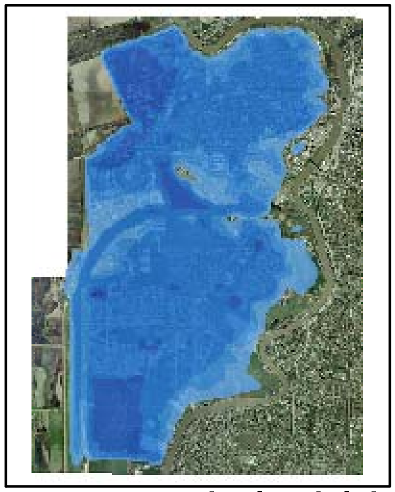
1/2- Through 1/500-ACE
Breach Floodplains
Index Point 3
Yolo Bypass RM 42

U.S. Army Corps of Engineers
Sacramento District

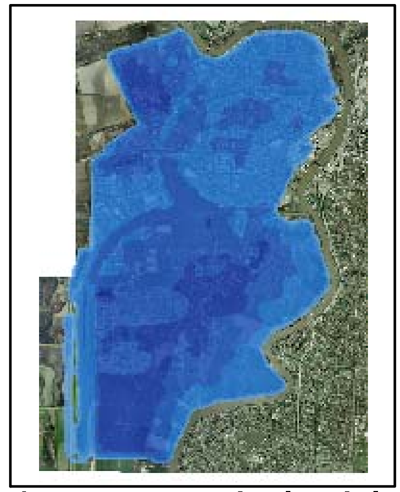
These Without-Project condition floodplains are based on a single levee breach at the Index Point flooding the West Sacramento Basin.

Plate 28. West Sacramento Index Point 3

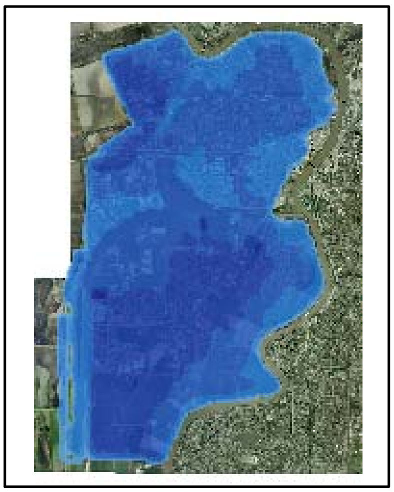
1/2 ACE Breach Floodplain



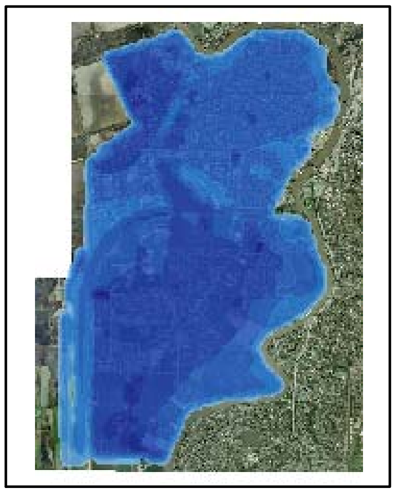
1/10 ACE Breach Floodplain



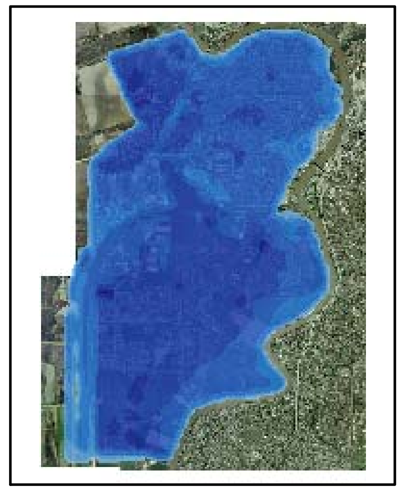
1/25 ACE Breach Floodplain



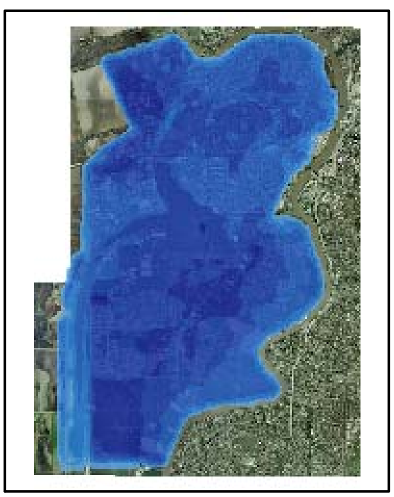
1/50 ACE Breach Floodplain



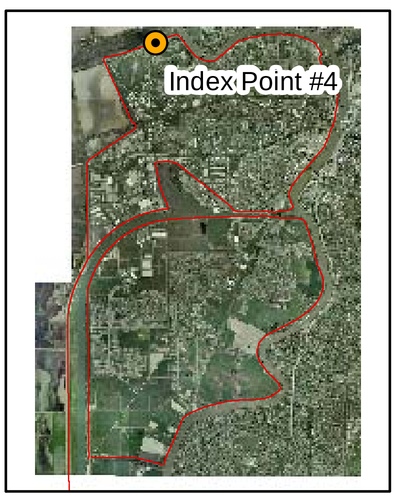
1/100 ACE Breach Floodplain



1/200 ACE Breach Floodplain



1/500 ACE Breach Floodplain

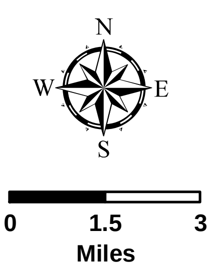


Basemap

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



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West Sacramento Project
General Reevaluation Report

1/2- Through 1/500-ACE
Breach Floodplains
Index Point 4
Sac Bypass RM 1.5

U.S. Army Corps of Engineers
Sacramento District

These Without-Project condition floodplains are based on a single levee breach at the Index Point flooding the West Sacramento Basin.

Plate 29. West Sacramento Index Point 4

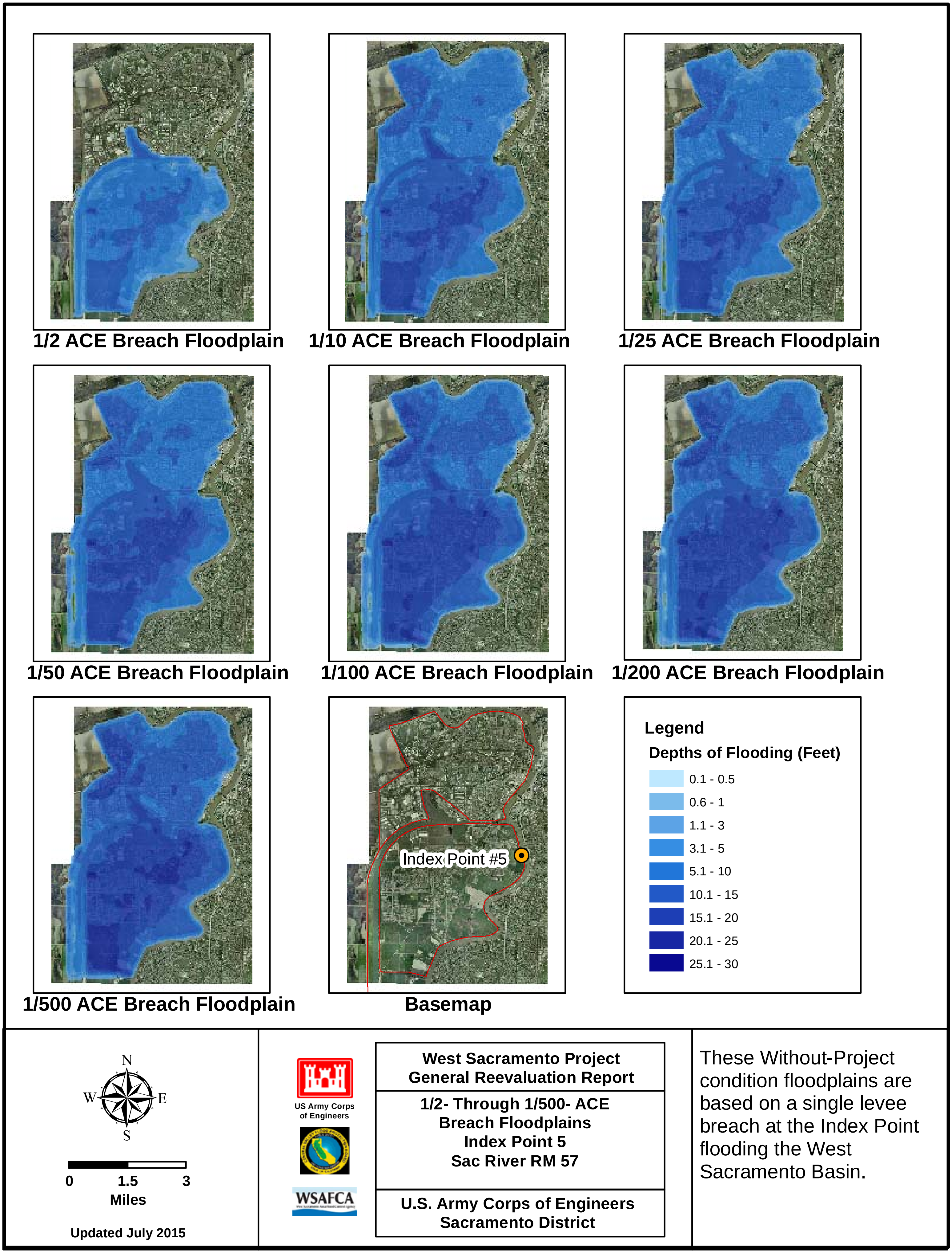


Plate 30. West Sacramento Index Point 5

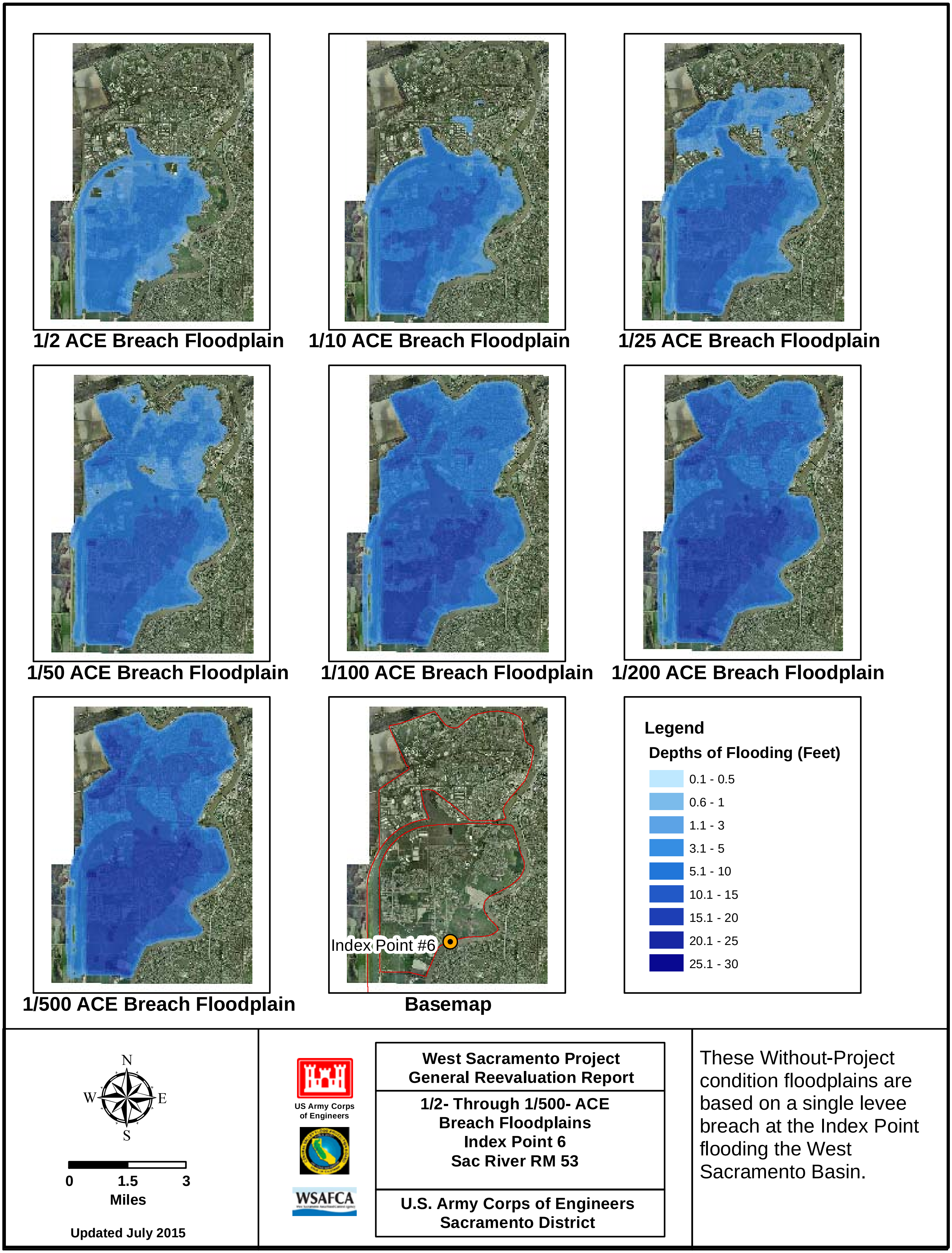
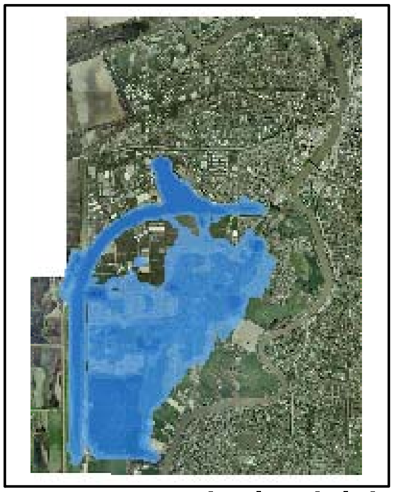
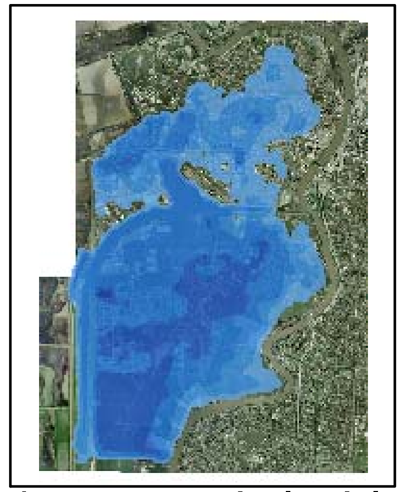
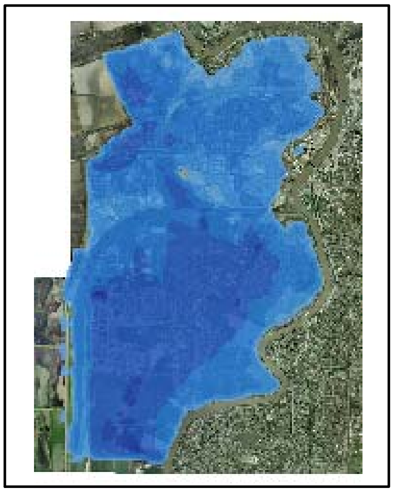


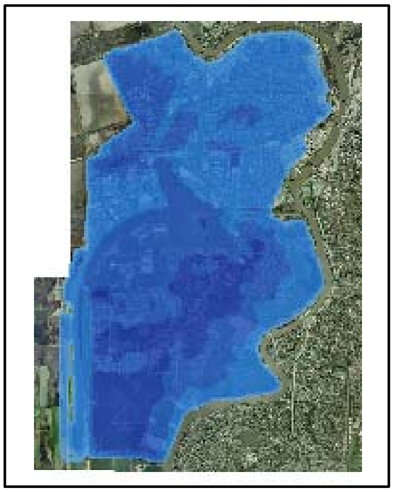
Plate 31. West Sacramento Index Point 6

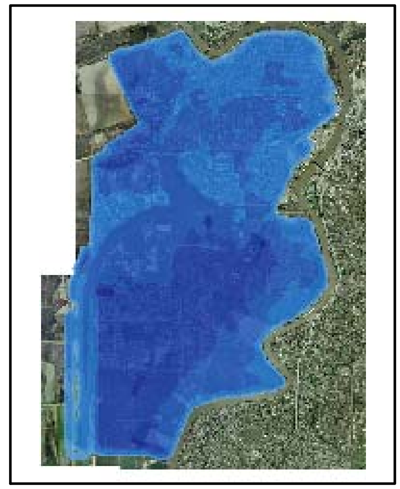

1/2 ACE Breach Floodplain

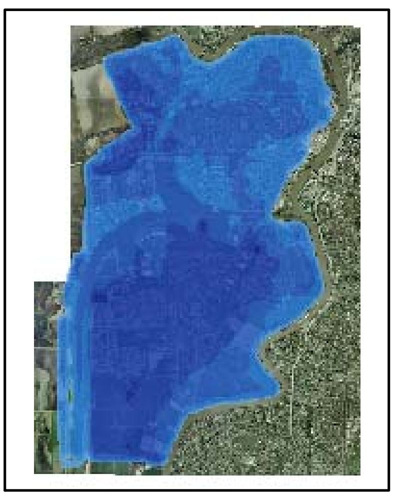

1/10 ACE Breach Floodplain

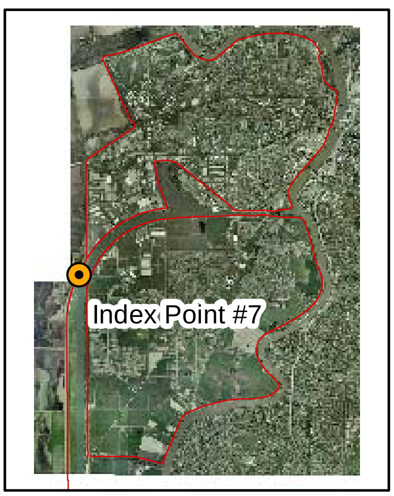

1/25 ACE Breach Floodplain


1/50 ACE Breach Floodplain


1/100 ACE Breach Floodplain


1/200 ACE Breach Floodplain


1/500 ACE Breach Floodplain



Basemap

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 W E S

0 1.5 3
Miles

Updated July 2015

US Army Corps of Engineers

WSAFCA

West Sacramento Project
General Reevaluation Report

1/2- Through 1/500- ACE
Breach Floodplains
Index Point 7
Yolo Bypass RM 41

U.S. Army Corps of Engineers
Sacramento District

These Without-Project condition floodplains are based on a single levee breach at the Index Point flooding the West Sacramento Basin.

Plate 32. West Sacramento Index Point 7

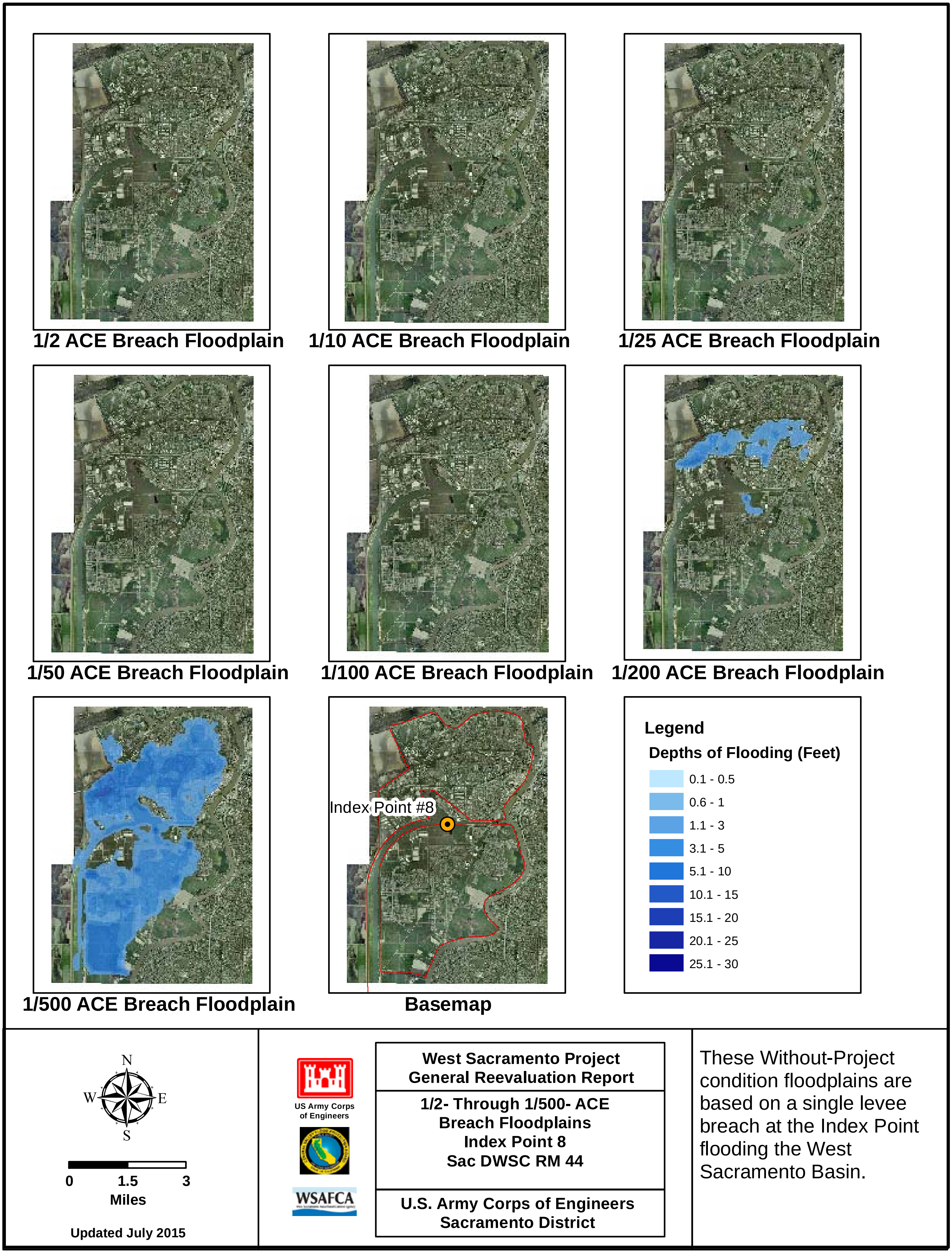


Plate 33. West Sacramento Index Point 8

Index Point 1					
Sacramento River, RM 61.5					
	Future Without Project Condition	Alternative 1: Improve Levees in Place	Alternative 2: Sacramento Bypass Widening	Alternative 3: DWSC Closure Structure	Alternative 4: Improve Levees with Sacramento Bypass and DWSC Closure Structure
Frequency	**Stage (NAVD 88)**				
1yr = .999	27.0	27.0	27.0	27.0	27.0
2yr = .5	29.6	29.6	28.3	29.6	28.3
10yr = .1	30.8	30.8	30.4	30.8	30.4
25yr = .04	33.5	33.5	32.2	33.5	32.2
50yr = .02	34.0	34.0	32.8	34.0	32.8
100yr = .01	34.7	34.7	33.6	34.7	33.6
200yr = .005	36.5	36.5	35.3	36.5	35.3
500yr = .002	38.2	39.0	37.8	39.0	37.8
Frequency	**Flow (CFS)**				
2yr = .5	66903	66903	59539	66903	59539
10yr = .1	26078	26078	33817	26078	33817
25yr = .04	N/A	N/A	N/A	N/A	N/A
50yr = .02	N/A	N/A	N/A	N/A	N/A
100yr = .01	N/A	N/A	N/A	N/A	N/A
200yr = .005	N/A	N/A	N/A	N/A	N/A
500yr = .002	N/A	N/A	N/A	N/A	N/A

Source: Hydraulic Analysis Section, Sacramento District, USACE

WEST SACRAMENTO GRR
SACRAMENTO, CALIFORNIA

SACRAMENTO RIVER
INDEX POINT 1
RISK ANALYSIS INPUTS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Index Point 2 Sacramento River, RM 60					
	Future Without Project Condition	Alternative 1: Improve Levees in Place	Alternative 2: Sacramento Bypass Widening	Alternative 3: DWSC Closure Structure	Alternative 4: Improve Levees with Sacramento Bypass and DWSC Closure Structure
Frequency	**Stage (NAVD 88)**				
1yr = .999	26.4	26.4	26.4	26.4	26.4
2yr = .5	29.2	29.2	27.9	29.2	27.9
10yr = .1	30.6	30.6	30.2	30.6	30.2
25yr = .04	33.3	33.3	32.0	33.3	32.0
50yr = .02	33.9	33.9	32.6	33.9	32.6
100yr = .01	34.5	34.5	33.4	34.5	33.4
200yr = .005	36.4	36.4	35.2	36.4	35.2
500yr = .002	38.1	39.0	38.0	39.0	38.0
Frequency	**Flow (CFS)**				
2yr = .5	94610	94610	87518	94610	87518
10yr = .1	101171	101171	100611	101171	100611
25yr = .04	115657	115657	107696	115657	107696
50yr = .02	118223	118223	110481	118223	110481
100yr = .01	121798	121798	114821	121798	114821
200yr = .005	134255	134255	125027	134255	125027
500yr = .002	158351	179092	155226	179092	155226

Source: Hydraulic Analysis Section, Sacramento District, USACE

WEST SACRAMENTO GRR
SACRAMENTO, CALIFORNIA

SACRAMENTO RIVER
INDEX POINT 2
RISK ANALYSIS INPUTS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Index Point 3
Yolo Bypass, RM 42.62

	Future Without Project Condition	Alternative 1: Improve Levees in Place	Alternative 2: Sacramento Bypass Widening	Alternative 3: DWSC Closure Structure	Alternative 4: Improve Levees with Sacramento Bypass and DWSC Closure Structure
Frequency	**Stage (NAVD 88)**				
1yr = .999	20.7	20.7	20.7	20.7	20.7
2yr = .5	21.4	21.4	21.6	21.4	21.6
10yr = .1	26.9	26.9	27.0	26.9	27.0
25yr = .04	29.7	29.7	29.9	29.7	29.9
50yr = .02	30.5	30.5	30.6	30.5	30.6
100yr = .01	31.4	31.4	31.5	31.4	31.5
200yr = .005	32.7	32.7	32.8	32.7	32.8
500yr = .002	33.7	33.9	34.1	33.9	34.1
Frequency	**Flow (CFS)**				
2yr = .5	106012	106012	110902	106012	110902
10yr = .1	297332	297332	305785	297332	305785
25yr = .04	443711	443711	451721	443711	451721
50yr = .02	483253	483253	490850	483253	490850
100yr = .01	535233	535233	542398	535233	542398
200yr = .005	610692	610692	620024	610692	620024
500yr = .002	674197	688445	703688	688445	703688

Source: Hydraulic Analysis Section, Sacramento District, USACE

WEST SACRAMENTO GRR
SACRAMENTO, CALIFORNIA

YOLO BYPASS
INDEX POINT 3
RISK ANALYSIS INPUTS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Index Point 4 Sacramento Bypass, RM 1.49					
	Future Without Project Condition	**Alternative 1: Improve Levees in Place**	**Alternative 2: Sacramento Bypass Widening**	**Alternative 3: DWSC Closure Structure**	**Alternative 4: Improve Levees with Sacramento Bypass and DWSC Closure Structure**
Frequency	**Stage (NAVD 88)**				
1yr = .999	20.6	20.6	20.6	20.6	20.6
2yr = .5	21.6	21.6	22.0	21.6	22.0
10yr = .1	28.6	28.6	28.2	28.6	28.2
25yr = .04	31.9	31.9	31.1	31.9	31.1
50yr = .02	32.5	32.5	31.8	32.5	31.8
100yr = .01	33.3	33.3	32.6	33.3	32.6
200yr = .005	35.0	35.0	34.2	35.0	34.2
500yr = .002	36.4	37.0	36.2	37.0	36.2
Frequency	**Flow (CFS)**				
2yr = .5	100	100	13922	100	13922
10yr = .1	65843	65843	77979	65843	77979
25yr = .04	107318	107318	118544	107318	118544
50yr = .02	111170	111170	121818	111170	121818
100yr = .01	115016	115016	124798	115016	124798
200yr = .005	148940	148940	163703	148940	163703
500yr = .002	183940	206912	252396	206912	252396

Source: Hydraulic Analysis Section, Sacramento District, USACE

WEST SACRAMENTO GRR
SACRAMENTO, CALIFORNIA

SACRAMENTO BYPASS
INDEX POINT 4
RISK ANALYSIS INPUTS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Index Point 5 Sacramento River, RM 56.75					
	Future Without Project Condition	Alternative 1: Improve Levees in Place	Alternative 2: Sacramento Bypass Widening	Alternative 3: DWSC Closure Structure	Alternative 4: Improve Levees with Sacramento Bypass and DWSC Closure Structure
Frequency	**Stage (NAVD 88)**				
1yr = .999	24.5	24.5	24.5	24.5	24.5
2yr = .5	27.8	27.8	26.5	27.8	26.5
10yr = .1	29.1	29.1	28.7	29.1	28.7
25yr = .04	31.8	31.8	30.6	31.8	30.6
50yr = .02	32.4	32.4	31.2	32.4	31.2
100yr = .01	33.1	33.1	32.0	33.1	32.0
200yr = .005	34.9	34.9	33.7	34.9	33.7
500yr = .002	36.5	37.3	36.5	37.3	36.5
Frequency	**Flow (CFS)**				
2yr = .5	94603	94603	87493	94603	87493
10yr = .1	100694	100694	100249	100694	100249
25yr = .04	115596	115596	107593	115596	107593
50yr = .02	118180	118180	110452	118180	110452
100yr = .01	121791	121791	114819	121791	114819
200yr = .005	133454	133374	124912	133374	124912
500yr = .002	148690	159123	146731	159123	146731

Source: Hydraulic Analysis Section, Sacramento District, USACE

WEST SACRAMENTO GRR
SACRAMENTO, CALIFORNIA

SACRAMENTO RIVER
INDEX POINT 5
RISK ANALYSIS INPUTS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Index Point 6 Sacramento River, RM 52.75					
	Future Without Project Condition	**Alternative 1: Improve Levees in Place**	**Alternative 2: Sacramento Bypass Widening**	**Alternative 3: DWSC Closure Structure**	**Alternative 4: Improve Levees with Sacramento Bypass and DWSC Closure Structure**
Frequency	**Stage (NAVD 88)**				
1yr = .999	22.9	22.9	22.9	22.9	22.9
2yr = .5	26.2	26.2	25.0	26.2	25.0
10yr = .1	27.5	27.5	27.1	27.5	27.1
25yr = .04	30.2	30.2	29.0	30.2	29.0
50yr = .02	30.8	30.8	29.6	30.8	29.6
100yr = .01	31.4	31.4	30.4	31.4	30.4
200yr = .005	33.2	33.2	32.1	33.2	32.1
500yr = .002	34.6	35.2	34.6	35.2	34.6
Frequency	**Flow (CFS)**				
2yr = .5	94600	94600	87436	94600	87436
10yr = .1	100688	100688	99871	100688	99871
25yr = .04	115493	115493	107433	115493	107433
50yr = .02	118153	118153	110430	118153	110430
100yr = .01	121789	121789	114818	121789	114818
200yr = .005	133257	133257	124809	133257	124809
500yr = .002	148535	159087	146618	159087	146618

Source: Hydraulic Analysis Section, Sacramento District, USACE

WEST SACRAMENTO GRR
SACRAMENTO, CALIFORNIA

SACRAMENTO RIVER
INDEX POINT 6
RISK ANALYSIS INPUTS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Index Point 7
Yolo Bypass, RM 40.95

	Future Without Project Condition	Alternative 1: Improve Levees in Place	Alternative 2: Sacramento Bypass Widening	Alternative 3: DWSC Closure Structure	Alternative 4: Improve Levees with Sacramento Bypass and DWSC Closure Structure
Frequency	**Stage (NAVD 88)**				
1yr = .999	20.4	20.4	20.4	20.4	20.4
2yr = .5	21.1	21.1	21.3	21.1	21.3
10yr = .1	26.4	26.4	26.6	26.4	26.6
25yr = .04	29.2	29.2	29.4	29.2	29.4
50yr = .02	30.0	30.0	30.1	30.0	30.1
100yr = .01	30.9	30.9	31.0	30.9	31.0
200yr = .005	32.0	32.0	32.1	32.0	32.1
500yr = .002	32.9	33.1	33.3	33.1	33.3
Frequency	**Flow (CFS)**				
2yr = .5	105590	105590	110517	105590	110517
10yr = .1	297134	297134	305595	297134	305595
25yr = .04	442953	442953	450891	442953	450891
50yr = .02	482620	482620	490260	482620	490260
100yr = .01	534852	534852	542033	534852	542033
200yr = .005	610023	610023	619245	610023	619245
500yr = .002	673789	687476	702730	687476	702730

Source: Hydraulic Analysis Section, Sacramento District, USACE

WEST SACRAMENTO GRR
SACRAMENTO, CALIFORNIA

YOLO BYPASS
INDEX POINT 7
RISK ANALYSIS INPUTS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Index Point 8
Sacramento DWSC, RM 43.41

	Future Without Project Condition	Alternative 1: Improve Levees in Place	Alternative 2: Sacramento Bypass Widening	Alternative 3: DWSC Closure Structure	Alternative 4: Improve Levees with Sacramento Bypass and DWSC Closure Structure
Frequency	**Stage (NAVD 88)**				
1yr = .999	7.4	7.4	7.4	7.4	7.4
2yr = .5	7.7	7.7	7.7	7.7	7.7
10yr = .1	13.0	13.0	13.1	13.0	13.1
25yr = .04	17.7	17.7	17.8	16.000	16.000
50yr = .02	18.6	18.6	18.7	16.001	16.001
100yr = .01	19.8	19.8	19.8	16.002	16.002
200yr = .005	20.9	20.9	21.0	16.003	16.003
500yr = .002	22.5	22.7	22.7	16.004	16.004
Frequency	**Flow (CFS)**				
2yr = .5	N/A	N/A	N/A	N/A	N/A
10yr = .1	N/A	N/A	N/A	N/A	N/A
25yr = .04	N/A	N/A	N/A	N/A	N/A
50yr = .02	N/A	N/A	N/A	N/A	N/A
100yr = .01	N/A	N/A	N/A	N/A	N/A
200yr = .005	N/A	N/A	N/A	N/A	N/A
500yr = .002	N/A	N/A	N/A	N/A	N/A

Source: Hydraulic Analysis Section, Sacramento District, USACE

WEST SACRAMENTO GRR
SACRAMENTO, CALIFORNIA

SACRAMENTO DEEP WATER SHIP CHANNEL
INDEX POINT 8
RISK ANALYSIS INPUTS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Data Source: NAIP Color Orthoimagery, 2009. ESRI StreetMap USA Roads, 2008.

Legend

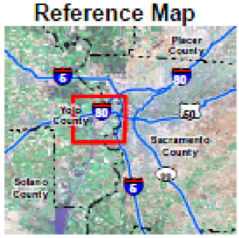
Roads
- Interstate
- Major Road

USGS River Miles

nhc Study Sites

Levee Risk
- High Risk
- Low Risk
- Moderate Risk

Reference Map



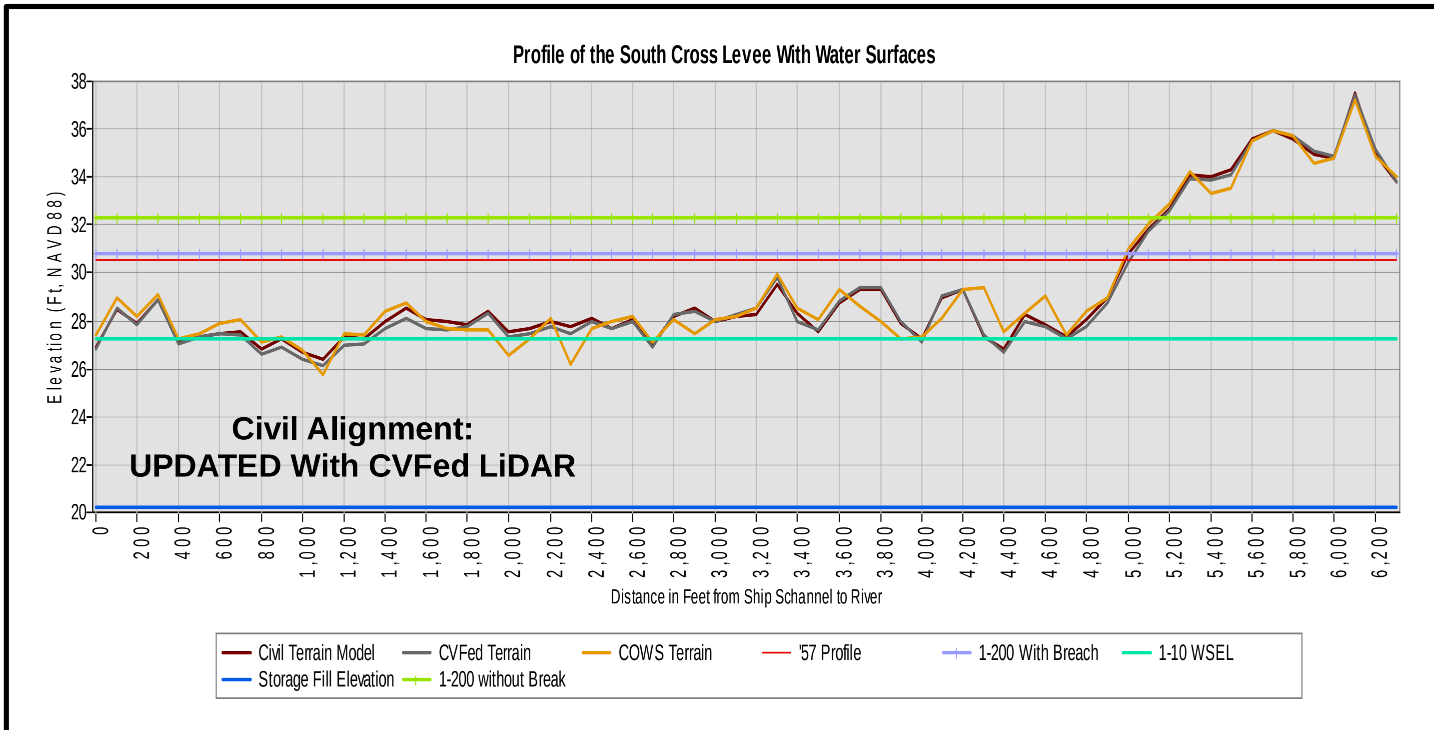
West Sacramento GRR Support

Risk from wind-wave by Reach

1 inch = 6,000 feet   Scale - 1:72,000

0   3,000   6,000   12,000 Feet

CA State Plane, Zone II	horz. datum: NAD 83	horz. units: feet
northwest hydraulic consultants	project no. 50618	February 2011



NOTE:
South Cross Levee Elevations have been extracted from terrain provided by the Sponsor.
Water surface elevations are based on best available hydraulic models supplied by USACE.

The Minimum Elevation is 26.4 ft.
The WSEL for the '57 Profile at this location is 30.5 ft.
The WSEL for the 1/200 ACE With Breach is 30.83 ft.
The WSEL in the Storage area downstream from Breach Approx. 20.2 ft.
The WSEL for the 1/200 ACE Without Breach is 32.32 ft.
The WSEL for the 1/10 ACE is 27.23 ft.

SOUTH CROSS LEVEE
WEST SACRAMENTO, CA
WEST SACRAMENTO GRR

SOUTH CROSS LEVEE
TERRAIN & WATER SURFACES
WEST SACRAMENTO, CA

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by G Maak

June 2015

PLATE 1

West Sacramento Project

Yolo County, California
General Reevaluation Report

Appendix E - Geotechnical

WSAFCA
West Sacramento Area Flood Control Agency

CENTRAL VALLEY FLOOD PROTECTION BOARD
PUBLIC SAFETY AND FLOOD MANAGEMENT
STATE OF CALIFORNIA

US Army Corps
of Engineers ®
Sacramento District

WEST SACRAMENTO PROJECT

GENERAL REEVALUATION REPORT
GEOTECHNICAL APPENDIX

US Army Corps of Engineers
Sacramento District

PREPARED BY

GEOTECHNICAL ENGINEERING BRANCH

December 2015

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ENCLOSURES

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
DWSCWL	Deep Water Ship Channel West Levee
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 Project0
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
O&M	Operations and Maintenance (USACE)
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
PNL	Port North Levee
Pr(f)	Probability of Failure
PSHA	Probabilistic Seismic Hazard Analysis
PSL	Port South Levee
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
SBSL	Sacramento Bypass South Levee
SCB	Soil-Cement-Bentonite
SCL	South Cross Levee
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
SRWL	Sacramento River West Levee
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
YB	Yolo Bypass
YBEL	Yolo Bypass East Levee

1.0 INTRODUCTION

This report is an appendix to a General Reevaluation Report (GRR) for the West Sacramento Project. The project area includes portions of the Sacramento and American River Watersheds. The Sacramento and American Rivers, in the Sacramento area, form a flood plain covering roughly 110,000 acres at their confluence. The flood plain includes the City of West Sacramento, within Yolo County, California. The study area also includes other flood facilities, including the Fremont and Sacramento Weirs, Sacramento Bypass, and Yolo Bypass.

1.1 PURPOSE AND SCOPE

This Report presents the results of geotechnical analyses and feasibility level geotechnical recommendations to address levee height, geometry, erosion, access, vegetation, seepage, and slope stability deficiencies within the West Sacramento GRR study area. For this geotechnical engineering evaluation of the West Sacramento study area, the following tasks were performed and are summarized in this Report.

- Review currently available geology, geomorphology, and geotechnical information
- Review past performance and flood control system construction history/improvements
- Identification of levee performance deficiencies through analyses of the past performances, geotechnical analysis and engineering judgment
- Probabilistic geotechnical analysis and development of levee performance curves
- Deterministic geotechnical analysis of improvement measures and alternatives
- Erosion study of the Sacramento and American Rivers
- Seismic study of existing levees
- Development of geotechnical conclusions and recommendations

1.2 PROJECT DESCRIPTION

The West Sacramento Project authorization was provided in Section 209 of the Flood Control Act of 1962 (Public Law 87-874). Additional authority was provided in Section 101(4) of the Water Resource Development Act (WRDA) of 1992 (Public Law 102-580) and revised and supplemented through the Energy and Water Development and Appropriations Act of 1999 (Public Law 105-245) and 2010 (Public Law 111-85).

The following briefly outlines pertinent geotechnical information regarding a General Reevaluation Report (GRR) for the West Sacramento 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 West Sacramento GRR study area.

The project area includes portions of the Sacramento and American River Watersheds. The flood plain includes the City of Sacramento within Yolo County, California. The study area also includes other flood facilities, including the Fremont and Sacramento Weirs, Sacramento Bypass, and Yolo Bypass. The West Sacramento GRR study area has been divided into two sub-basins; the North Sub-Basin and the South Sub-Basin, which were further subdivided into study reaches. The North Sub-Basin includes:

- 5.5 miles of the Sacramento River West (Right) Bank Levee from the Sacramento Bypass south to the confluence of the Barge Canal and the Sacramento River.
- 1.1 miles of the Sacramento Bypass South (Left) Bank Levee from the Sacramento Weir west to the Yolo Bypass Levee. 1.7 miles of the North Levee (Right) of the Sacramento Bypass levee, while not providing direct flood protection to the North Sub-basin, will be discussed to provide clarification to potential bypass widening alternatives
- 3.7 miles of the Yolo Bypass East (Left) Bank Levee from the confluence of the Sacramento Bypass and the Yolo Bypass south to the Deep Water Ship Channel Navigation Levee.
- 4.9 miles of the DWSC West (Right) Bank Navigation Levee (referred to as the Port North Levee) from the Stone Locks west to the cut in the Yolo Bypass East Bank Levee.

The South Sub-Basin includes:

- 4.0 miles of the DWSC East (Left) Bank Navigation Levee (referred to as the Port South Levee) from the Stone locks west past to the beginning of the Yolo Bypass East Bank Levee.
- 21.4 miles of the DWSC West (Right) Bank Navigation Levee from the intersection of Port North Levee and Yolo Bypass Levee south to Miners Slough. The DWSC West Bank Levee would act as the line of protection if the DWSC East Bank Levee were to breach; thus the embankment is included in the South Sub-Basin.
- 2.8 miles of the Yolo Bypass East (Left) Bank Levee from the end of Port South Levee south to South Cross Levee.
- 5.9 Miles of the Sacramento River West (Right) Bank Levee from the confluence of the Barge Canal and the Sacramento River south to the South Cross Levee.
- 1.2 Miles of the Babel Slough North Levee (referred to as the South Cross Levee) DWSC to the Sacramento River.

The West Sacramento GRR is evaluating federal interest in alternatives to reduce flood risk in the study area. The West Sacramento 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 potential seepage and slope stability distress, erosion protection, and evaluate a closure structure on the Deep Water Ship Channel (DWSC) as a constructible element in conjunction with proportionate structural measures for seepage and stability mitigation.

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1.3 PROJECT STATIONING

In this report, project stationing (Sta. XX+XX) is the primary method used to describe locations. However, several various alignments have been developed which may occasionally be referenced including the Department of Water Resources (DWR) Urban Levee Evaluation (ULE) stationing, levee mile (LM), river mile (RM), and USACE O&M Levee Unit. Table 1-1 shows the analysis sections within the study area of the West Sacramento Project, in terms of RM and LM and maintenance agency where applicable.

Table 1-1: West Sacramento GRR Project Levees

Basin	Analysis Section	Maintenance Agency[1]	Unit	LM	RM
NORTH	PNL-STA. 117+37	Port of West Sacramento	-	-	42.83
	SBSL-STA. 32+00	DWR-MA08	2	0.62	1.22
	SBSL-STA. 52+00			0.24	1.60
	SRWL-STA. 96+00	DWR-MA04	1	1.2	61.67
	SRWL-STA. 190+00			2.59	30.20
	YBEL-STA. 36+00	RD 900	2	1.89	41.90
	SBNL-STA. 8+30	DWR-MA08	1	1.29	0.40
SOUTH	DWSCWL-STA. 12+00	USACE	-	-	41.21
	PSL-STA. 123+55	Port of West Sacramento	-	-	43.45
	SCL-STA. 17+50	RD 900	-	-	38.25
	SRWL-STA. 264+00	RD 900	1	2.80	53.74
	SRWL-STA. 80+00			6.33	53.08
	SRWL-STA. 35+22	RD 765	1	0.67	51.07
	YBEL-STA. 10+00	RD 900	2	3.24	40.82
	YBEL-STA. 53+96	RD 999	1	1.07	37.22

Note – MA: Maintenance Area, RD: Reclamation District

1.4 PROJECT DATUM

Elevation references in this report are in feet and are based on the North American Vertical Datum of 1988 (NAVD88) unless otherwise noted. Conversion factors ranged between +2.44 to +2.54 feet were obtained from the software program Corpscon 6.0, produced by the USACE Topographic Engineering Center (TEC), Survey Engineering and Mapping Center of Expertise, was applied to convert Geodetic Vertical Datum of 1929 (NGVD29) elevations to NAVD88. 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).

1.5 SOURCES OF DATA

The subsurface conditions and material properties of the levee embankment and foundation soils have been characterized by several studies in the past. These studies have been prepared for feasibility and design projects by the USACE, DWR, and WSAFCA among others.

Through Assembly Bill AB 142, the State has appropriated $500 million of funding to DWR to begin a comprehensive program of levee evaluation and upgrades. The ULE Program evaluates levee systems estimated to protect more than 10,000 people. DWR has retained a team led by URS Corporation (URS) to assist in the geotechnical evaluation of the state's project levees. The ULE Program has generated Technical Review Memorandums (TRM), Phase 1 Geotechnical Data Reports (P1GDR), Supplemental Geotechnical Data Reports (SGDR), Phase 1 Geotechnical Evaluation Reports (P1GER), and Geotechnical Evaluation Reports (GER) for the Study Area.

The available geotechnical data from the above mentioned sources includes borings and CPTs drilled along the levee; crest, landside toe and field, and waterside toe, geology and geomorphology studies, and geophysical surveys. The levee geometry was based on the existing data in the National Levee Database (NLD) supplemented by recent Light Detection and Ranging (LiDAR) survey and bathymetric survey provided by the DWR as part of the ULE program. A summary of reference documentation is contained in Section 18.0

1.6 WITHOUT PROJECT CONDITIONS DESCRIPTION

Levee construction and remediation has occurred within the study area since the middle of the 19th century. While the modern levee system was constructed in the early 20th century and remediated in the 1940s through 1950's, the vast majority of the construction and remediation consisted of soil embankment alterations through various methods. Beginning in the early 1990s and continuing through present day, internal improvements have been and continue to be constructed. These mostly consist of through and underseepage cutoff walls as well as placement of a stability berm and related features to address through seepage. The following paragraphs present how the modern improvements have been incorporated in the West Sacramento project and details the without project conditions.

In coordination between USACE, WSAFCA, the Reclamation Board, and the DWR two flood control project have been completed. The first, constructed from 1990 to 1993, as part of the Sacramento Urban Area Levee Reconstruction Project (SUALRP). Under SUALRP, a stability berm and related features to address through seepage along the entire length of the Sacramento River levee bordering the Southport area were constructed. The second, the West Sacramento Project, constructed levee raises on portions of the southern levee of the Sacramento and Yolo Bypass between 1998 and 2002 to provide the City of West Sacramento with greater than 200yr level protection.

When the design efforts of the West Sacramento Project neared completion, underseepage was noted along the RD 537 maintained portion of Sacramento Bypass south levee in 1997. Downstream of RD 537, the Yolo Bypass east levee, which is adjoining to the Sacramento Bypass south levee and maintained by RD 900, experienced stability issues in 1998 along the levee in 1998. The City of West Sacramento, RD 537 and RD 900 requested the USACE to conduct further geotechnical investigations and incorporate design changes to mitigate these issues. The completed West Sacramento Project included the incorporation of the entire reconstruction of one section of RD 537 levee replacing the original clay and organic material within the embankment and upper foundation with engineered fill and construction of a 60-70ft deep slurry wall to mitigate under seepage at the confluence of the Sacramento and Yolo Bypass (RD 900).

1.7 WITH PROJECT CONDITIONS DESCRIPTION

The West Sacramento GRR is evaluating federal interest in alternatives to reduce flood risk in the study area. The West Sacramento 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 and slope stability, provide erosion protection and include non structural measures such as widening of the Sacramento Bypass to lower the risk. The with project conditions will address project authorization covering a range of levels of protection. Notably, the range is bounded from a 25yr to 500yr level of protection. Typically, the with project condition will achieve a 200yr level of protection. In certain locations it should be noted that the existing levee height may be at an elevation above the 200yr requirement and range to approximately meet a 500yr requirement.

2.0 GEOLOGY AND GEOMORPHOLOGY

2.1 GEOLOGIC SETTING

The West Sacramento 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. Figure 2-1 shows the surficial soil deposits of the Sacramento region based on a reconnaissance soil survey performed by the United States Department of Agriculture (USDA) in 1913.

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. The Sacramento River Basin and associated subregions are shown on Figure 2-2.

The study area has been mapped by a number of geologists on a regional scale including published maps by Jennings et al., (1977), Wagner et al., (1981), and Helley and Harwood (1985). The Jennings and Wagner maps are both compilation maps that reflect mapping by previous authors and thus show geologic interpretation similar to those of Helley and Harwood. Helley and Harwood’s mapping focused on Quaternary geologic units based on geomorphology and was performed at a scale of 1:62,500.

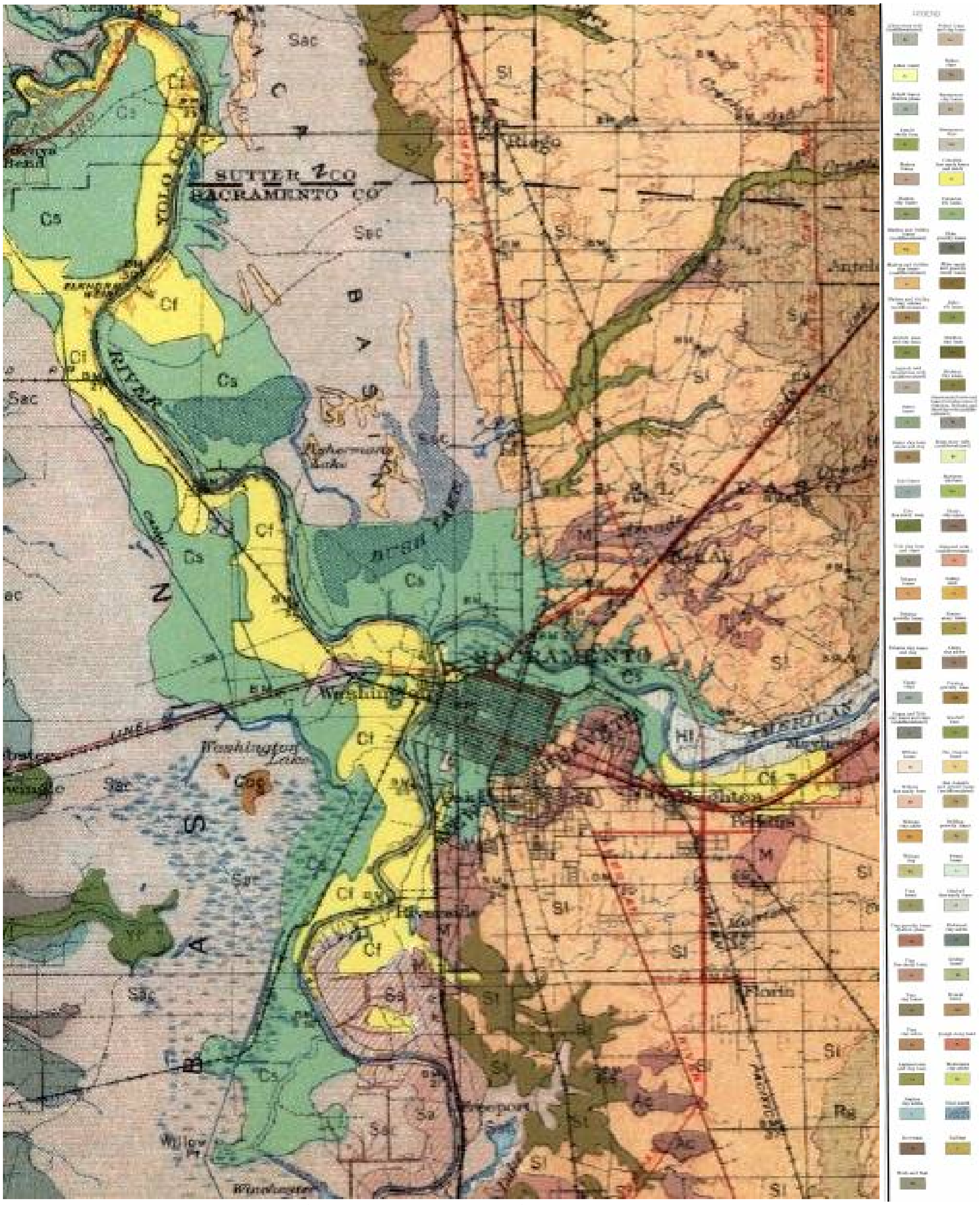

Figure 2-1: USDA Surficial Soil Survey of the Sacramento Region, 1913

Figure 2-2: Map of the Sacramento River Basin

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.

Because of the low topographic position and proximity to the confluence of the two large rivers, the West Sacramento area has been subjected to periodic inundation by floodwaters during late Holocene time, and consequently is underlain by a relative thick package of young alluvial deposits. The floodwaters of the Sacramento River deposit fine sand and silt-rich alluvium along the flanks of the river bank, and carry finer-grained clay and silt in suspension onto the distal floodplain. This sorting process creates a “natural levee” landform with a topographic gradient that slopes away from the river. The topographically low area west of the Sacramento River, known as the Yolo Basin, was a frequently inundated swampland prior to historic reclamation. Flood overflow fed thousands acres of sloughs, swamps, and dense marshes of bulrushes creating a region then known as the Tule, and today as the Yolo Basin. Sources of water and sediment contributing to the Yolo Basin include not only the Sacramento River, but the Cache Creek and Putah Creek systems directly northwest and west of West Sacramento, respectively. Cache and Putah Creek channels do not currently connect directly to the Sacramento River, and deposit clay, silt, and fine sand into the low-lying area of Yolo Basin via a network of sloughs, channels, small sinks (lakes) and islands.

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.

2.4 SACRAMENTO BYPASS AND SOUTH CROSS LEVEE GEOLOGY

The Sacramento Bypass levee and South Cross levee at Garcia Bend traverse the study area in a generally east-west orientation and thus overlie coarser-grained river deposits and finer-grained basin deposits, from east to west. Shallow subsurface deposits here should interfinger and alternate between the river and basin deposits, reflecting changes in the position of river and basin depositional processes in time. Also, because these two levees are sub-orthogonal and proximal to the present-day river, there may be complex erosional relationships in the subsurface stratigraphy from past positions of the Sacramento River.

The stratigraphic deposits beneath the Sacramento Bypass levee vary from east to west and vertically with depth. The deposits directly beneath the levee consist of Holocene and historical splay and overbank deposits from the Sacramento River, laid down prior to the construction of the Sacramento Bypass levee, and chiefly consist of soft to medium stiff silt and clay with sand in the upper 10 feet. The sediment has more silt and sand closer to the river, grading to silt and clay westerly. At the surface, a historical crevasse splay deposit is delineated beneath the Sacramento Bypass levee in this reach, extending toward the northwest. The splay is well-expressed in aerial photographs, and trends “up valley” following the slope of the natural levee toward the basin. The levee fill overlies this feature. The crevasse splay deposit is a locally sandier deposit about two- to three-feet-thick, mantling the adjacent sediment. About 20 feet of Holocene sandy silty clay and fat basin clay underlie much of the historical alluvium beneath the levee. Two layers of sand and gravel in turn underlie the Holocene alluvium and basin deposits, each about 20 feet thick. These layers are encountered deeper in the subsurface environment along and are separated by a hard sandy silt to silt. Adjacent to the Sacramento River, the coarse grained deposits are not present in the borings which show soft, fine-grained deposits consisting of chiefly elastic silt. These soft, fine-grained sediments may have been deposited in former flood-basin, lagoonal, or abandoned-channel environments. Deeper subsurface gravels, perhaps representing high-energy Pleistocene floodplain deposits, may extend north-south beneath the levee.

The South Cross levee connects the Sacramento East Levee River with the Yolo Bypass East Levee and crosses the transition between coarser-grained natural levee deposits (Holocene Alluvium, Ha) and finer-grained basin deposits (Qs) primarily consisting of medium stiff fat clays and elastic silts. High plasticity fat clay is present at the ground surface and along the western half of the reach which coincides with the characteristics of marsh deposits. Deeper foundation deposits include medium dense to dense silty sands with increasing clay trending westward.

2.5 SACRAMENTO RIVER GEOLOGY

Along the eastern side of the study area, adjacent to the Sacramento River, the subsurface stratigraphy is complex. The stratigraphy is expressed as abrupt lateral or vertical changes in sediment grain size and/or consolidation. This pattern is a result of the dynamic processes commonly associated with large rivers, such as: (1) post-depositional erosion of sediments and subsequent backfilling with different sediments; (2) river migration and resulting meander scroll deposits (Figure 2-3); or (3) local crevasse splay and overbank activity. Generally, the subsurface stratigraphy adjacent to the river exhibits a fining-upward sequence of gravel, sand, silt. Gravel of about 20 feet thick appears laterally extensive at the base of the aquifer layer in the northern part of the map area, and underlies both sides of the Sacramento River near the I Street Bridge; whereas, in the south part of the map area (i.e., downstream of the Deep Water Ship Channel), gravel is only locally present or is absent.

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, relatively 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.

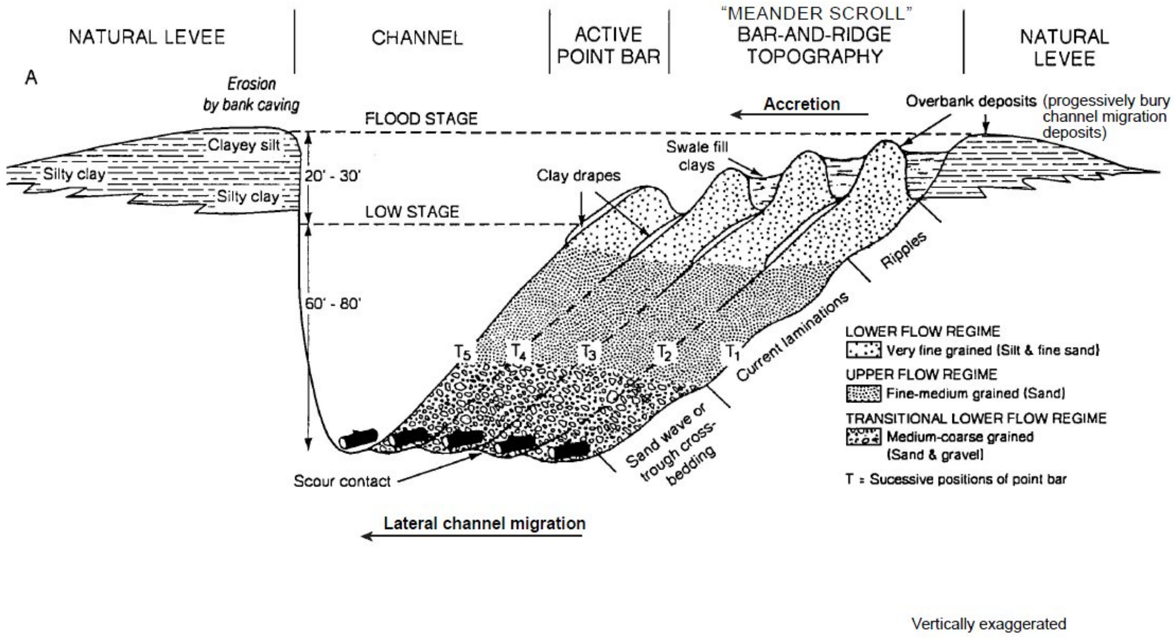

Figure 2-3: Cross Section of a Meander Scroll

2.6 YOLO BYPASS GEOLOGY

Broadly speaking, west of the present-day Sacramento River, relatively thick packages of elastic (fat) clay comprise the upper stratigraphy of the marsh and basin deposits. The basin deposits typically are up to about 20 feet thick, and in rare instances, up to 80 feet thick, and occasionally are interbedded with soft-to-stiff silt or medium dense sand and silty sand. Packages of dense coarse-grained (i.e. sand and gravel) deposits generally occur below present-day sea level, and probably represent latest Pleistocene deposits now buried by Holocene basin deposits.

2.7 PORT NORTH AND PORT SOUTH LEVEE GEOLOGY

The present-day Port North and Port South region is generally comprised of fine-grained silt and clay and fine sand basin depostits (Qn) of the Holocene period which primarily trend westward. The basin deposits may be obscured by cultivation from agricultural activities in the region. The Port South Levee is intersected from the south by a marsh deposit which trends in a north-south manner containing organically rich silts and clays. The channel within the levee embankments is predominantly laden with open active stream channel without permanent vegetation.

2.8 DEEP WATER SHIP CHANNEL EAST AND WEST LEVEE GEOLOGY

The Deep Water Ship Channel East and West Levees regionally overlies, moving from south to north numerous distinct units which include: remnant islands (knobs) of a Pleistocene alluvial fan that may be derived from the Putah Creek unit (Pf – semi-consolidated silts, sands, sandy clays and fine to coarse subrounded gravel), marsh deposits (Qs – silts and clays likely rich in organics) and basin deposits (Qn – fine sands, silts and clays subject to recent cultivation). Existing subsurface data suggests that the Pleistocene fan areas are medium dense to dense sand with silt at roughly twenty feel below the levee base and are covered by elastic clays. Surficial deposits along the Deep Water Ship Channel are fine-grained and stiff to very stiff, and may have lessened susceptibility to underseepage relative to the Sacramento River due to the overall low permeability characteristics of the thick basin deposits.

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 Sacramento and Yolo Bypass and the Sacramento River, including new and reconstructed levees. 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 SACRAMENTO AND YOLO BYPASS LEVEES

In 1927, the California State Legislature specified the portions of the SRFCP that would be operated and maintained by the State of California; the Sacramento and Yolo Bypasses was included as two of these features. The construction method of the Sacramento Bypass levees is not known; however, it was built as part of the SRFCP and likely using the same method as the Yolo Bypass levees. The Yolo Bypass levees were constructed using the clamshell method where a clamshell was used to excavate material from the waterside toe of the levee and then pile the material to form the levee. After the excavated material consolidated, the levees were dressed and shaped to their final form. This construction method usually resulted in a ditch at the waterside levee toe. Figure 3-1 shows the dredge Vulcan constructing levees on the Yolo Bypass just south of West Sacramento around 1911. There was typically no compaction of the material placed for levees constructed with this method. Therefore, the material in the levee is usually loose and consisting of materials similar in composition to the surrounding native materials; primarily silts, clays and fine sands typical of basin deposits as well as, on portions of the Sacramento Bypass, which contain coarse sands with minor gravel lenses typically noted in splay deposits.

The West Sacramento Project was authorized in the WRDA of 1992 and the design was documented in the 1996 Basis of Design report. The West Sacramento Project consisted of raising and enlarging several levee sections of the Sacramento and Yolo Bypass. Contract A was completed in 1998 and consisted of levee raises, widening, berms, and internal drainage systems on the Yolo Bypass levee from the DWSC to the Sacramento Bypass, Figure 3-2. Contract B was completed in 1999 and consisted of levee raises, widening, berms, internal drainage systems, and a waterside cutoff wall, Figure 3-3. Repairs due to flood events to the Contract A levees were completed in 2010 and 2011 as part of Contract C and D respectively which included a stability berm, internal drainage systems, slope flattening and levee widening. The WSAFCA constructed a soil-bentonite cutoff wall along the levee centerline through portions of the Contract B reach as part of their CHP Academy Early Implementation Project in 2011 as a response to seepage deficiencies during the 2006 flood event.

Figure 3-1: Dredge Vulcan Constructing Yolo Bypass Levee South of West Sacramento

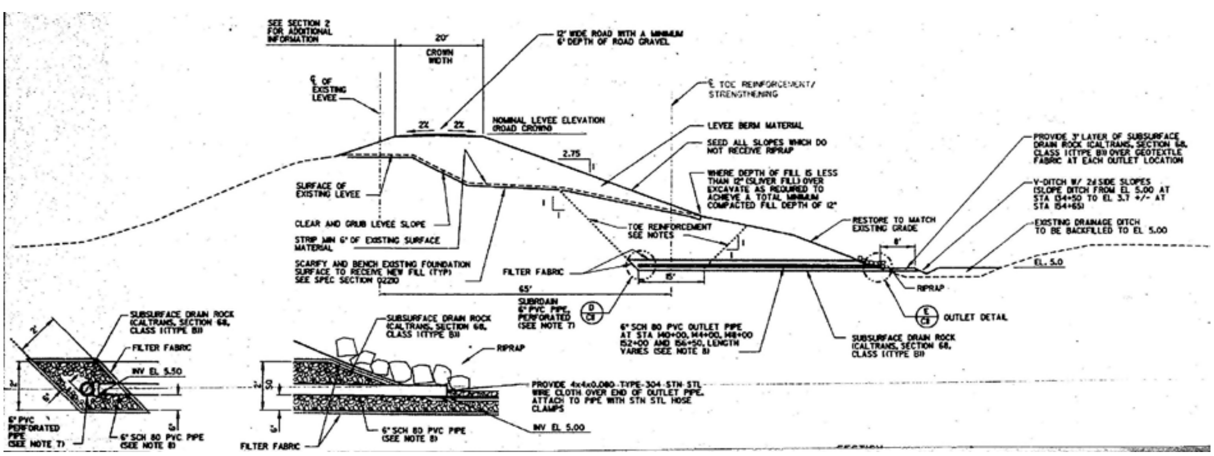

Figure 3-2: West Sacramento Project Contract A Typical Section

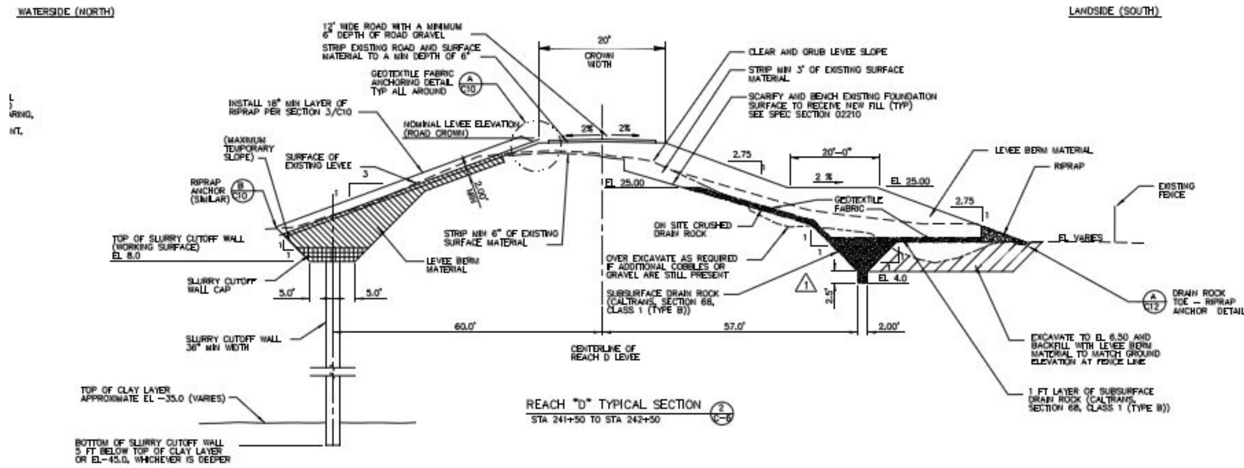

Figure 3-3: West Sacramento Project Contract B Typical Section

3.2 SACRAMENTO RIVER WEST LEVEE

The levees along the Sacramento River were constructed by local interests using clamshell dredges excavating material from the Sacramento River in the early 1900's. Figure 3-4 shows the Dredge Neptune placing material at RM 57.3 in 1942 during construction of the Sacramento Bank Protection Project. Figure 3-5 was taken around 1911 near Davis Road in West Sacramento and shows the recently constructed Sacramento River levee. 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 mainly silts and gravels. Numerous riverbank and levee waterside slope protection were constructed along the Sacramento west bank levee.

In 1990 the SUALRP constructed a drained stability berm along the Sacramento River levee from the DWSC to the South Cross levee, a typical section is shown in Figure 3-6. The WSAFCA constructed a DSM cutoff wall (approximately 130ft in depth) and a shallow soil-bentonite cutoff wall (approximately 35ft in depth) as part of the Rivers and I Street EIPs in 2011 and 2010 respectively. The Rivers EIP DSM wall provided mitigation for underseepage while conversely the I Street EIP shallow wall mitigated for through seepage concerns.

Figure 3-4: Dredge Neptune at RM 57.3 in 1942

Figure 3-5: Levee Constructed Near Davis Road, West Sacramento

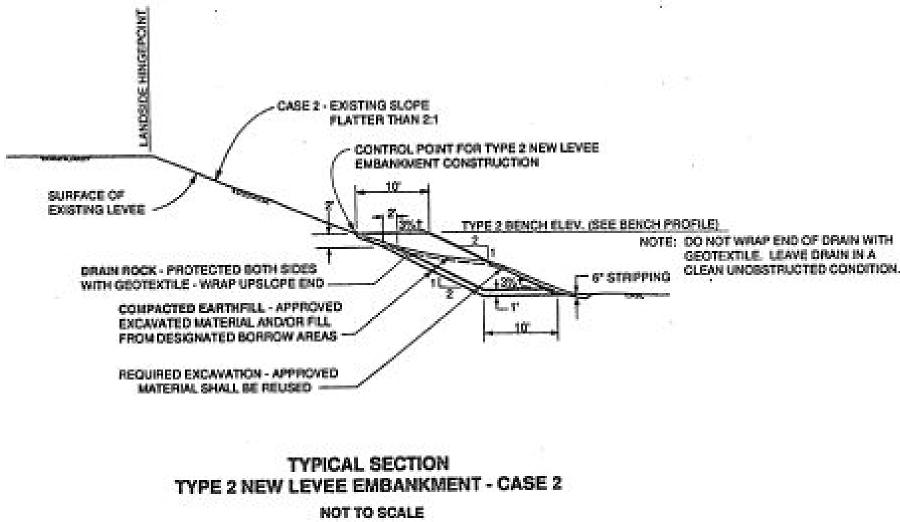

Figure 3-6: Sacramento River Levee - Typical Stability Berm Section

3.3 DEEP WATER SHIP CHANNEL, PORT NORTH AND SOUTH, AND NAVIGATION LEVEES

In late 1940s through the 1960s the USACE designed and constructed a navigation levee east of the Yolo Bypass levee, the DWSC was constructed via dredging operations west of this levee to allow ship traffic into the Port of West Sacramento. The DWSC cut through the project levee and a new navigation levee constructed west of the DWSC to separate the DWSC from the Yolo Bypass. The construction methods are not known but likely using clam shell using materials from the excavation of the channel. The levee embankments are comprised of predominantly silts, clays, and fine sands typical of marsh and basin deposits respectively.

3.4 SOUTH CROSS LEVEE

No construction history was available regarding the south cross levee as it is a non-federally constructed, operated, and maintained levee. The levee embankment typically contains high plasticity (fat) clays and silts.

4.0 PAST PERFORMANCE

Despite levee improvements, recent flood events in 2006, 1997, 1986, and 1957 have caused levee distress in the form of seepage, boils, and slope instability. The levee embankments were approximately loaded 30% to 50% of the effective levee height during these events.

Erosion events were noted on the Sacramento Bypass South levee, Yolo Bypass East levee, and the Sacramento River West levee during the events of 1997 and 2006. These events, most prevalent on the Yolo Bypass East levee and less so on the Sacramento River West levee, can be attributed to high water, wavewash, surface runoff, pier scour adjacent to bridge abutments, or movement of rock revetment.

4.1 SACRAMENTO RIVER BYPASS SOUTH LEVEE

During the high water events of 1997 and 1998, multiple seepage boils occurred along the Sacramento River Bypass Levee just landward of the levee toe in between RM 0.6 and RM 1.7 which required floodfighting. The seepage boils ranged in diameter from 2 to 12 inches in diameter and were ringed with sandbags as a floodfighting measure. The embankment was loaded to approximately 50% of the levee height for the flood events of 1997 and 1998. Underseepage was found extending into the CHP Academy according to CHP personnel, but DWR personnel indicated that the drainage originated from the drain beneath the seepage berm.

4.2 SACRAMENTO RIVER WEST LEVEE – NORTH BASIN

In April 2006, a segment of the Sacramento North Levee along Fountain Drive (west of Westlake Drive) experienced heavy seepage and boils along the landside toe according to eyewitness reports. Water was seen bubbling up around a large fence pillar and from a buried irrigation control box in an area recently developed for residential use. The water surface elevation at that time was 29.8 feet (NGVD29) , 32.3 feet (NAVD88), at the I-Street Bridge staff gage. Also along this levee, 470 lineal feet of sloughing on the waterside embankment just south of the Tower Bridge was reported during the 1997 flood event. The sloughing was intermittent over the 470 lineal feet, and ranged dimensionally from 4-16ft in width to 2-10ft in depth.

4.3 SACRAMENTO RIVER WEST LEVEE – SOUTH BASIN

Many seepage and slope stability problems arose along the Sacramento River South levee during the flood events of 1997 and 2006. In 1997, numerous slides and sloughing occurred on the waterside embankment between RM 57.5 and RM 56.5. Dimensionally, the sloughs ranged from 4-8ft vertical faces and instability ranged in length from 100 feet to over 700 feet potentially induced by an erosion event. Further downstream, in the area of Bee’s Lakes, pin boils were observed along the landside toe of the secondary levee. Finally, in the region extending from Oak Hall Bend to Clay Bank Bend, three slides occurred that were up to 300 feet in length with 3-5ft vertical faces. In 2006, between Chicory Bend (RM 55) and Oak Hall Bend (RM 54), numerous seepage boils were reported near the landside toe near Davis Road.

4.4 YOLO BYPASS EAST LEVEE

In 1998, approximately one half-mile south of Interstate 80, the excavation of an exploration trench along the landside toe produced significant fissures and cracks indicating the initiation of a slide along a portion of the levee. In the same area in 2006, multiple slips were observed on the waterside slope after a prolonged storm event.

In the region just north of Interstate 80, three slides were observed on the landside embankment in 1995. The sliding started in January and continued at a slow rate until the end of March. The most prominent slide was 100 feet long and had a vertical displacement of two feet at the headscarp. The water elevation in the Yolo Bypass was 22 feet (NGVD29) at the time of the slip. In the same area in 2006, seepage was noted through and under the landside embankment which resulted in a shallow toe slide that was 75 feet in length and about 75 feet wide. Vertical displacement at the headscarp was about 1.5 feet. Finally, in the area just south of the UPRR line, two slope failures occurred on the waterside embankment in 2001, presumably due to the presence of an organic layer in the foundation.

Two landside slope failures were observed along the Yolo Bypass levee just north of the UPRR line in February 1983. The first slide had a base width of 114 feet and had a vertical displacement of 4 feet at the headscarp. The second slide had a base width of 89 feet and had 9 feet of vertical displacement at the headscarp.

These slides occurred presumably due to the presence of a weak organic layer with inadequate shear strength along with development of excess pore pressures due to underseepage and through seepage within the upper foundation and embankment.

4.5 DEEP WATER SHIP CHANNEL EAST LEVEE

In 2006, incidents of landside instability were reported. The instability occurred in a region just north of the South Cross levee and were generally shallow, rain-induced slumps that were considered maintenance issues.

4.6 PORT NORTH AND PORT SOUTH LEVEES

Limited information is available as to the past performance of both the Port North levee. CA DWR reported seepage distresses via field observations in numerous areas throughout the entire alignment in both 1963 and 1965. This area is located from the barge canal to the beginning of the DWSC due west of the Port of Sacramento.

4.7 SOUTH CROSS LEVEE

CA DWR reported seepage distresses via field observations in the extent areas of the alignment in both 1963 and 1965. These locations are noted as the eastern most portion near the Sacramento River West Levee; and western most area nearing Jefferson Blvd. and the DWSC East Levee.

5.0 GEOTECHNICAL REACH DESCRIPTIONS

The following sections describe the geometric project features and locations. Figure 5-1 displays the study area and project features.

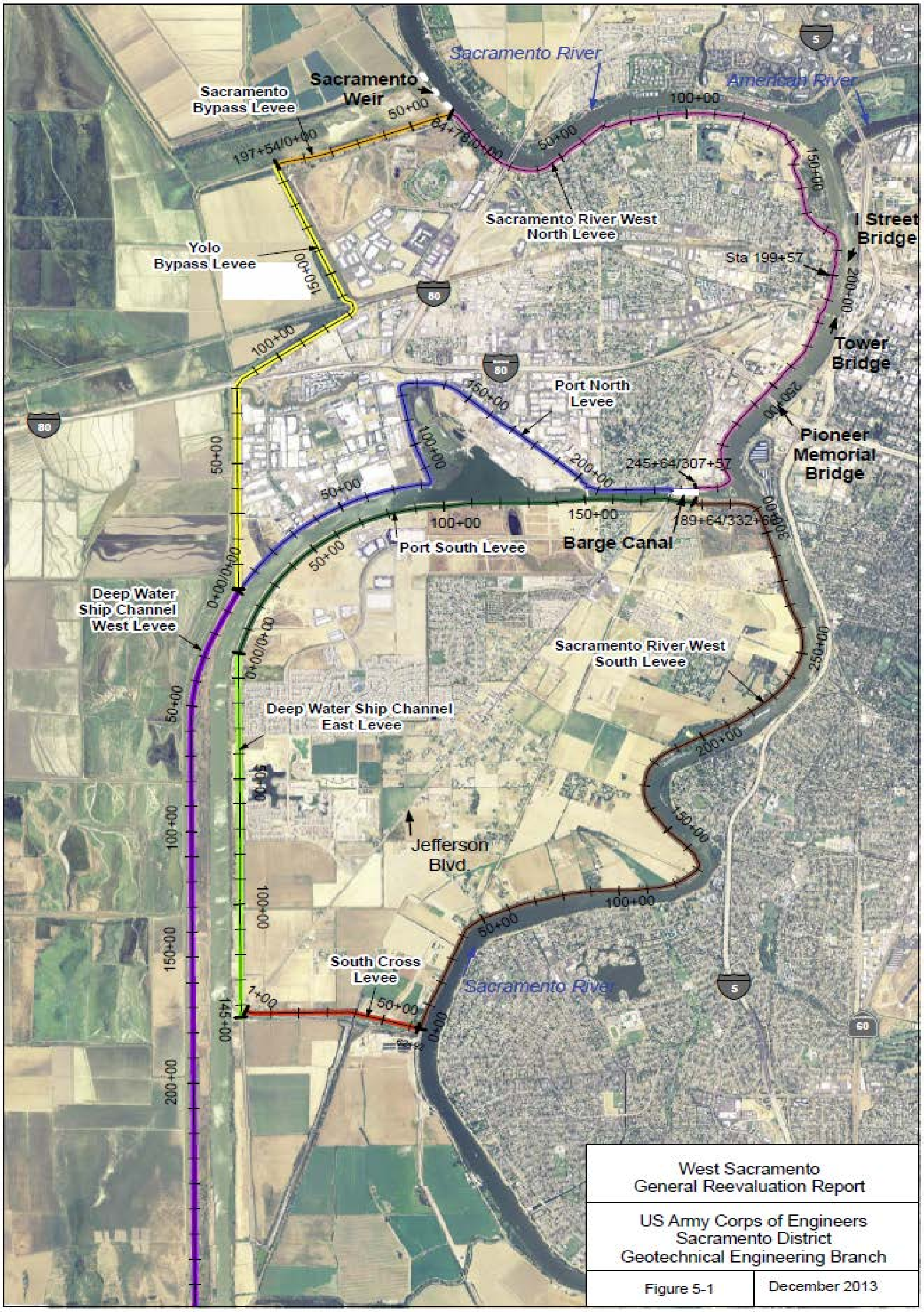

Figure 5-1 December 2013

5.1 WEST SACRAMENTO – NORTH BASIN

The North Basin of the West Sacramento Project includes levees on the south bank (left) of the Sacramento Bypass, west bank (right) of the Sacramento River from the Sacramento Bypass downstream to the Stone Lock structure and continues on the north bank of the Port of Sacramento (right) to the Yolo Bypass East Levee (left) thence upstream to meet the Sacramento Bypass south levee. Table 5-1 displays data on the levee alignment for each channel.

Table 5-1: West Sacramento – North Basin – Levee Properties

Channel	Begin	End	Crest Width (ft)	LS Levee Slope	WS Levee Slope	Levee Height (ft)
	Sta.	Sta.				
SBSL	0+00	64+80	20-30	2.0-2.5:1	2.0-2.5:1	15-25
SRWL	0+00	307+60	20-30	2.0-2.5:1	3.5:1	15-25
PNL	0+00	245+65	20-25	2.5-3.0:1	2.75-3.0:1	5-8
YBEL	0+00	197+55	20-30	2.5-3.0:1	3.0:1	15-20
SBNL	0+00-DWR	33+66-DWR	15-20	3.0:1	2.5-3.0:1	15-20

5.1.1 SACRAMENTO BYPASS SOUTH LEVEE

As part of the Rivers EIP construction the maintaining agency, CA DWR removed the vegetation in compliance with current guidance. In some areas, there is moderate landside vegetation (mostly large trees) existing near the levee toe, but few at the levee toe or on the levee slope. Encroachments include utility poles near the landside toe along the levee alignment. The levee crest surface is an aggregate road base with access ramps following the alignment on the landside levee slope.

The levee embankment is predominantly comprised of poorly graded sands and silty sand at the upstream portion (Sta. 35+00 to Sta. 64+80) and more finer grained silts and fat clays nearing the downstream end (Sta. 0+00 to Sta. 35+00). The levee is underlain by a thick (15-20ft) silt and clay blanket layer which is underlain by pervious poorly graded sand and gravel aquifer.

5.1.2 SACRAMENTO RIVER WEST LEVEE

On the Sacramento River west levee (Sta. 0+00 to Sta. 307+60) there is significant vegetation on the waterside bench which varies in thickness. Typically within the reach, the waterside bench becomes wider moving downstream from the confluence with the Sacramento Bypass and vegetation increases to a point (Sta. 190+00) and then begins to taper in width heading towards the more downstream portions nearing the Stone Lock. In some areas, there is significant landside vegetation (mostly large trees) existing near the levee toe, or on the levee slope. On the landside numerous encroachments including fences at or near the landside levee toe, parking lots built, significant residential/commercial developments and industrial facilities nearing the downstream portion of the alignment exist. The levee crest surface varies between asphaltic concrete pavement and aggregate road base with numerous access points across the alignment within the adjacent residential/commercial developments and at the I St. Bridge, as well as near the Stone Lock structure.

The levee embankment is predominantly comprised of poorly graded silty sands, silty sands, and silts. The levee is underlain by a thin (5-10ft) silt and clay blanket layer which is underlain by pervious poorly graded sand and silty sand aquifer.

5.1.3 PORT NORTH LEVEE

The Port North levee (Sta. 0+00 to Sta. 245+55) contains sparse riparian habitat (vegetation) adjacent to the levee embankment. There is very little landside vegetation existing near the levee toe or on the levee slope. On the waterside bench moderate vegetation exists, mostly trees lining the turning basin of the Port of West Sacramento. Encroachments include utility poles near the landside toe along the levee alignment, multiple railroad tracks, and commercial developments. The levee crest surface is an aggregate road base with access points along the alignment within the Port of West Sacramento facility and in the adjacent commercial developments near the downstream portion of the alignment (Sta. 0+00 to Sta. 80+00).

The levee embankment is predominantly comprised of fat and lean clays. The levee is underlain by a thick (7-15ft) fat and lean clay blanket layer which is underlain by semi-pervious silt layer. The embankment, blanket and semi-pervious silt layer are underlain by a poorly graded sand and silty sand pervious aquifer.

5.1.4 YOLO BYPASS EAST LEVEE

On the Yolo Bypass east levee (Sta. 0+00 to Sta. 197+65) there is moderate riparian habitat (vegetation) on the existing waterside bench the majority of which are medium to large trees. There is very little landside vegetation existing near the levee toe or on the levee slope. Encroachments include fences, utility poles near the landside toe along the levee alignment, commercial/industrial developments, the I-80 freeway overcrossing, and railroad tracks. The levee crest surface is an aggregate road base with access points along the alignment within the adjacent commercial/industrial facilities.

The levee embankment is predominantly comprised of fat and lean clays. The levee is underlain by a fat and lean clay blanket layer varying in thickness (5-20ft) with discontinuous thin layers of poorly graded silty sands within the upper foundation which is underlain by semi-pervious silt layer. The embankment, blanket and semi-pervious silt layer are underlain by a poorly graded sand and silty sand pervious aquifer.

5.1.5 SACRAMENTO BYPASS NORTH LEVEE

The Sacramento Bypass north levee contains moderate riparian habitat (vegetation) adjacent to the levee embankment. The landside vegetation is very sparse, with little to no vegetation at the landside toe, or on the landside slope. On the waterside, there are notable amounts of large trees near the waterside berm and continuing out laterally into the channel for the majority of the alignment. Few encroachments are present along the alignment; nearing the upstream limit, a small pump station is adjacent to the landside levee slope. The levee crest surface is an aggregate road base with access gates at each end, east and west, of the alignment on County Rd. 126 .

The levee embankment is predominantly comprised of fat and lean clays throughout the alignment. The levee is underlain by a thick (15-20ft) lean and fat clay blanket layer which is underlain by a semi-pervious clayey sand of varied thickness. At the landside of the embankment, a berm was constructed of pit-run fill of predominantly cobbles and fine gravels with clay to aide in embankment stability.

The description of Sacramento Bypass North Levee is included to aid in explanation of the overall project area. Although the Sacramento Bypass North Levee, is not part of the federally authorized project nor a project levee, the overall project alternatives address a potential widening of the bypass and thus a discussion of the existing geotechnical properties is warranted.

5.2 WEST SACRAMENTO SOUTH BASIN

The South Basin of the West Sacramento Project includes levees on the south bank (left) of the Port of West Sacramento, west bank (right) of the Sacramento River from the Stone Lock structure and continues downstream to the South Cross Levee to the Yolo Bypass East Levee (left). The Deep Water Ship Channel west levee (right) is also included in the south basin which is located adjacent to the Yolo Bypass East Levee Table X-X displays data on the levee alignment for each channel.

Table 5-2: West Sacramento - South Basin - Levee Properties

Channel	Begin Sta.	End Sta.	Crest Width (ft)	LS Leve Slope	WS Levee Slope	Levee Heigh t (ft)
PSL	0+00	189+65	25-35	4.0-5.5:1	3.0-3.5:1	8-12
SRWL	0+00	332+70	25-35	1.75-2.25:1	2.0:1	15-25
SCL	0+00	65+00	15-20	3.0:1	2.75:1	15-20
DWSCWL	0+00	1133+14	20-30	4.0-6.0:1	4.0-6.0:1	20-30
YBEL	0+00	145+00	15-25	2.25-3.0:1	3.0-10.0:1	15-20

5.2.1 PORT SOUTH LEVEE

The Port South levee (Sta. 0+00 to Sta. 189+65) contains sparse riparian habitat (vegetation) adjacent to the levee embankment. There is very little landside vegetation existing near the levee toe or on the levee slope. On the waterside bench moderate vegetation exists, mostly trees lining the adjacent downstream portion near the Stone Lock structure. Encroachments include the Daniel C. Palmadessi bridge overcrossing, and commercial/industrial facility structures near the landside of the levee embankment. The levee crest surface is an aggregate road base with access points along the alignment within the adjacent developments including at the Barge Canal Access at the upstream limit of the alignment (Sta. 170+00).

The levee embankment is predominantly comprised of fat and lean clays. The levee is underlain by a thick (15-20ft) fat and lean clay blanket layer. The embankment and blanket layers are underlain by a poorly graded sand and silty sand pervious aquifer.

5.2.2 SACRAMENTO RIVER WEST LEVEE

On the Sacramento River west levee (Sta. 0+00 to Sta. 332+70) there is significant vegetation on the waterside bench which varies in thickness. Typically within the reach, the waterside bench becomes wider moving downstream at the Bee’s Lake area, and then decreases sharply in width as the embankment is directly adjacent to the channel. In some areas, there is significant landside vegetation (mostly large trees) existing near the levee toe, or on the levee slope. On the landside, numerous encroachments including residential subdivisions, fence lines, driveways, and irrigation ditches exist throughout the alignment. The levee crest surface contains the roadway surface of the South River Road which is asphaltic concrete pavement with numerous access points across the alignment mostly at roadway intersections. The intersections include Lake Washington Blvd., Linden Rd., and Gregory Ave.

The levee embankment is predominantly comprised of poorly graded silty sands, silty sands, and silts. The levee is underlain by a silt and clay blanket layer (8-15ft) which is underlain by pervious poorly graded sand and silty sand aquifer.

5.2.3 SOUTH CROSS LEVEE

The South Cross levee (Sta. 0+00 to Sta. 65+00) contains moderate riparian habitat (vegetation) adjacent to the levee embankment. There is very little landside vegetation existing near the levee toe or on the levee slope. At the waterside bench, moderate vegetation exists, sporadic trees line the edge of the channel. Encroachments include residential homes, fencelines, and various outstructures near the landside of the levee embankment. The levee crest surface is an aggregate road base with access points at both the upstream and downstream limits of the alignments as well as various access ramps throughout the adjacent properties.

The levee embankment is predominantly comprised of fat and lean clays. The levee is underlain by a thick (15-20ft) lean and fat clay and silt blanket layer. The embankment and blanket layers are underlain by a poorly graded sand and poorly graded silty sand pervious aquifer.

5.2.4 DEEP WATER SHIP CHANNEL WEST LEVEE

The Deep Water Ship Channel west levee (Sta. 0+00 to Sta. 1133+14) contains sparse riparian habitat (vegetation) adjacent to the levee embankment on both the landside and waterside. There is a significant waterside bench throughout the alignment as the channel is offset from the levee centerline approximately 500ft. There are few encroachments throughout the alignment which include fences and utility poles. The levee crest surface is an aggregate road base with access points most prevalent near the upstream limit of the alignment.

The levee embankment is predominantly comprised fat and lean clays. The levee is underlain by a lean and fat clay blanket layer which varies in thickness (5-25ft). The embankment and blanket layers are underlain by a poorly graded sand and poorly graded silty sand pervious aquifer.

5.2.5 YOLO BYPASS EAST LEVEE

On the Yolo Bypass east levee (Sta. 0+00 to Sta. 145+00) there is very limited riparian habitat (vegetation) on the existing waterside bench the majority of which are medium to large trees. Encroachments include fences, utility poles near the landside toe along the levee alignment, residential developments, a pump station facility near the downstream limit of the alignment, and an irrigation ditch at the landside levee toe. The levee crest surface is an aggregate road base with access points along the alignment at the Jefferson Blvd. intersection, along with additional location adjacent to Marshall Rd. and the various commercial facilities near the levee embankment.

The levee embankment is predominantly comprised of fat and lean clays. The levee is underlain by a fat and lean clay blanket layer varying in thickness (10-20ft) which is underlain by semi-pervious silt layer. The embankment, blanket and semi-pervious silt layer are underlain by a poorly graded sand and silty sand pervious aquifer.

6.0 POTENTIAL FAILURE MODES

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.

6.1 SEEPAGE

Seepage is subdivided into two categories, seepage through the levee embankment (through-seepage) and seepage beneath the levee embankment through foundation layers (under-seepage). Through-seepage occurs when water from the river passes through a pervious levee and weakens the interior of the existing levee causing internal erosion and leads to slope instability or movement of embankment material. Concentrated under-seepage that carries silt and sand up to the surface through a more or less open channel in the top stratum (usually of clays and/or silts) is known as a sand boil. Active erosion of sand or other soils from under a levee or top stratum as a result of substratum pressure and concentration of seepage in localize d channels is known as piping. If the hydrostatic pressure in the pervious substratum landward of a levee becomes greater than the submerged weight of the top stratum, the excess pressure will cause heaving of the top stratum, or a rupture at one or more weak spots. This results in a concentration of seepage flow that may cause sand boils and/or underground piping as shown in Figure 6-1.

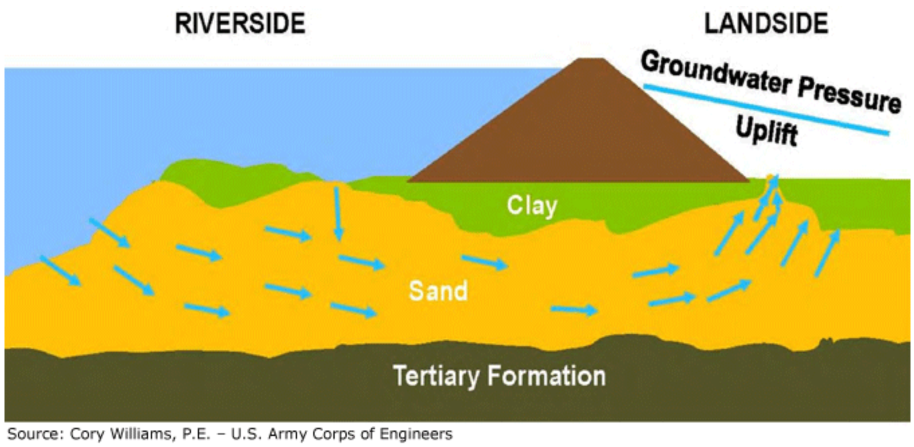

Figure 6-1: Underseepage Distress

6.2 SLOPE STABILITY

Hydraulic loading of the levee during a flood event reduces the strength of the levee embankment materials causing instability in the embankment slope. Additionally, uplift pressures caused by an excess in pore water pressure at the landside levee toe, can lead to the movement of embankment material within the levee due to seepage cause levee instability, as shown in Figure 6-2.

Levee instability can occur on both the waterside and landside of the embankment. Slope stability of the landside slope is typically analyzed and in instances where the waterside slope is somewhat steep, waterside slope stability may be analyzed as well. Cases will also exist where a levee is constructed of less permeable materials and rapid drawdown condition occurs. Rapid drawdown conditions arise when a submerged slope experiences a sudden reduction in water level. This change in water surface elevation causes a change in pore water pressure within the embankment having a low permeable material. The excess pore water pressure contained in the embankment may lead to a waterside slope stability failure. While waterside and rapid drawdown slope stability are potential failure modes, they typically have limited affect on feasibility level designs and are therefore considered design level analysis. Rapid drawdown slope failures pose different life safety risks as compared to landside slope failures and seldom dictate design. Stability failures can also occur due to erosion along the waterside bank progressing towards the levee embankment.

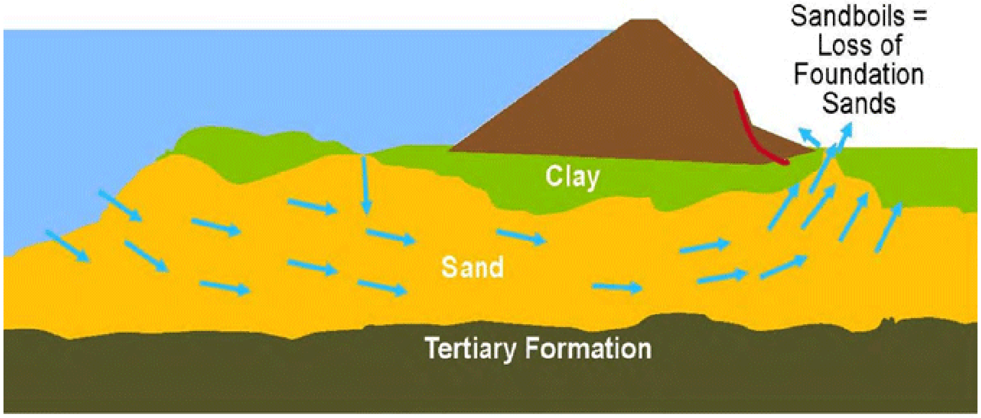

Figure 6-2: Underseepage Induced Slope Instability Distress

6.3 EROSION

Erosion is the wearing away of the riverbank and or waterside levee slope due to high flows. Erosion can also cause the degradation of the channel invert (scour) causing slope instability. Erosion can occur on the landside of the levee to due overtopping. Erosion occurs when the velocity of the river generates an effective hydraulic shear stress greater than the critical shear stress of the soil over which it flows. As the critical shear stress of the soil is exceeded, soil particle movement begins. As the amount of time the flow is applied, erosion will occur and the rate at which vary. Loosely compacted cohesionless soils are most susceptible to erosion; whereas cohesive engineered fill is less susceptible. Erosion events can also lead to catastrophic waterside bank and levee embankment stability failure as the time of applied flow increases throughout a flood event.

6.4 SEISMIC

Levees can fail as result of a seismic load which may cause degradation due to liquefaction. Liquefaction can lead to detrimental consequences such as loss of freeboard due to embankment instability, transverse crack-induced piping, and loss of freeboard due to settlement. Evaluations are typically completed to determine the liquefaction resistance of soils, this is known as liquefaction triggering. Other seismically induced failures include lateral spreading which can cause vertical displacement of the levee leading to loss of freeboard and levee stability.

6.5 OVERTOPPING

Overtopping occurs when the water surface elevation is greater than the elevation of the levee crest. In this case, water will flow over the crest, onto the landside of the levee. As the levee is overtopped, the action of the water flowing down the levee slope and into the basin may cause backside erosion of the landside levee slope and levee toe. This backside erosion may lead to sloughing of the levee and/or breeches.

7.0 CRITERIA

The following paragraphs will present USACE standard levee design and construction criteria as established in both national (HQ) and local (District and Division) policy documents and a discussion on how the PDT has made assumptions in applying those criteria to the West Sacramento project.

7.1 SEEPAGE AND SLOPE STABILITY

Seepage and slope stability vertical exit gradient and factor of safety criteria respectively for the geotechnical analysis that forms the basis of the geotechnical improvement measures were established based on ETL 1110-2-569 *Design Guidance for Levee Underseepage*, EM 1110-2-1913 *Design and Construction of Levees*, SOP-003, and the *Urban Levee Design Criteria*. Steady state seepage analysis for the water at the design elevation considered a maximum allowable vertical exit gradient at the toe of the levee to be less than 0.5. In general, this provides a factor of safety against uplift failure of about 1.60 considering the impervious blanket saturated unit weight of 112 pounds per cubic foot (pcf). Steady state seepage analysis for the water at the top of levee elevation considered a maximum allowable vertical exit gradient at the toe of the levee to be less than 0.8. In general, this provides a factor of safety against uplift failure of about 1.00 considering the impervious blanket saturated unit weight of 112 pounds per cubic foot (pcf). The minimum required factor of safety for the same design water surface elevation for the landside steady state slope stability analysis is 1.40. The minimum required factor of safety for the top of levee water surface elevation for the landside steady state slope stability analysis is 1.20. For landside seepage berms a maximum gradient of 0.8 is required at the berm toe. During construction, post construction, rapid drawdown, and waterside partial pool analysis cases were considered to be design level and were therefore not performed for this feasibility study.

7.2 EROSION

The Sacramento and American Rivers have well established susceptibility to erosion distress which has lead to several near levee failures. In general, there is no set of criteria for determining need for erosion improvements. However; the Sacramento River Bank Protection Program (SRBPP) since 1974 has prioritized critical erosion site repair. While the original method of site selection was simple field inspection, subsequent methodologies have adopted more quantitative selection criteria that have evolved over time. In 2007, Ayres Associates developed a Site Priority Ranking Report that account for several factors including; existing bank erosion in the levee prism, berm width less than 35 feet, bank slope, erosion length, as well as several other factors. In 2011, the Sacramento District updated the site priority ranking methodology.

7.3 SEISMIC

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. Following an earthquake, a repair must be implemented to establish a 10yr level of protection within 8 weeks after the event.

Many levees are constructed over alluvial deposits, which may be susceptible to liquefaction or degradation by earthquakes. Levees meeting static stability criteria likely have sufficient factors of safety to resist the additional loading from earthquakes unless the levee or foundation materials lose significant strength due to liquefaction. Since many levees are infrequently loaded and thus the embankment is likely to be unsaturated at the time of a large earthquake, the material in the levee often can be considered non-liquefiable due to lack of saturation. As a result, the integrity of most levees following a strong earthquake is controlled by the liquefaction potential of its foundation soil.

Major concerns during and after a seismic event are transverse cracks that may develop between liquefied levee reaches and non-liquefied levee reaches and at locations where liquefied levee reaches contain or abut appurtenant structures with rigid or deep foundations. Such zones should be identified and given special attention.
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 0.3 m or 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).

7.4 GEOMETRY

The typical USACE levee section, established by EM 1110-2-1913, is nationally considered to have a minimum 10-foot crest with waterside and landside slopes not steeper than 2:1 (horizontal: vertical). 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 use of Sacramento District standard sections is generally limited to levees of moderate height, less than 25 feet, in reaches where there are no serious underseepage problems, weak foundation soils, or constructed of unsuitable materials. The standard levee section may have more than the minimum allowable factor of safety relative to slope stability and seepage, its slopes being established primarily on the basis of construction and maintenance considerations. The SOP-003, 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. The SOP-003 accepted a reduced crest width of 15 feet for levees along minor creeks or minor tributaries.

7.5 VEGETATION, ENCROACHMENT, AND ACCESS

Vegetation, encroachment, and access policy includes EM 1110-2-1913, SOP-003, 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. Figure 7-1 is a representation of the vegetation-free zone of a basic levee cross-section.

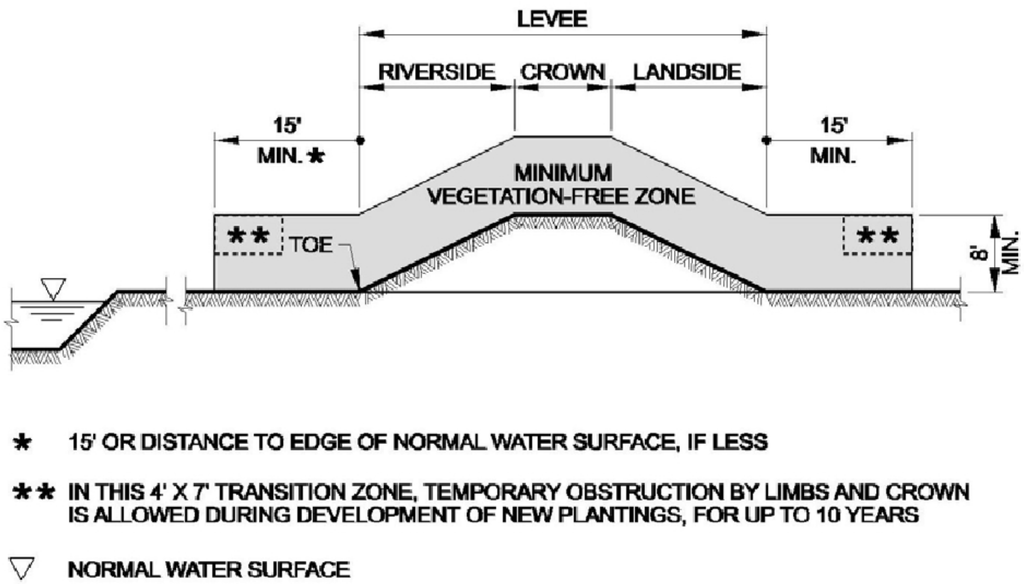

Figure 7-1: Vegetation-Free Zone of Basic Levee

The primary purpose of the vegetation-free zone is to prevent any damages of the levee embankment due to vegetation (including seepage along the woody vegetation root system, additional scouring of the waterside slope due to trees uprooting, and attraction of rodents) and to provide a reliable corridor of access to and along the flood-control structure for flood fighting, inspection and maintenance of the flood control structures. This corridor must be an all weather access and free of obstructions to assure adequate access by personnel and equipment for surveillance, inspection, maintenance, monitoring, and flood-fighting. In the case of flood-fighting, this access corridor must also provide the unobstructed space needed for the construction of temporary flood-control structures. Access is typically by four-wheel-drive vehicle, but for some purposes, such as maintenance and flood-fighting, access is required for larger equipment, such as tractors, bulldozers, dump trucks, and helicopters. Accessibility is essential to the reliability of flood damage reduction systems. SOP-003 established a minimum landside levee toe access width of 20 feet for newly constructed levees. The EM 1110-2-193 however does not specify the corridor width for access along the levee, it requires only access to be provided on the levee slopes and crest.

For a levee section to be considered compliant with USACE vegetation policy it must either have been cleared of vegetation within the vegetation free zone or eligible for a variance from USACE policy on vegetation in ETL 1110-2-571. Since the publication of ETL 1110-2-571, a Policy Guidance Letter (PGL) has been developed stating that waterside planting berm is acceptable. The variance must assure that safety, structural integrity, and functionality are retained, and accessibility for maintenance, inspection, monitoring, and flood-fighting are retained. The variance may require structural measures to mitigate vegetation, such as overbuilt sections, to improve levee system reliability, redundancy, or resiliency with respect to the detrimental impacts of the vegetation.

8.0 TYPICAL 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, earth reinforcement, flattened embankment slopes, flood walls, retaining walls, sliver fills, riprap slope protection, and various other measures were included in development of conceptual alternative cross-sections. This section of the report discusses the various different improvement measures considered at a conceptual level, and not as applied to a specific reach.

8.1 UNDERSEEPAGE

8.1.1 CUTOFF WALLS

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 layer. Cutoff walls generally require no additional permanent levee footprint. The crown of the levee should be degraded by one third of the levee height or as much as necessary to provide sufficient working surface (minimum 35 feet) and prevent hydraulic fracture of the levee. The levee would then be rebuilt either with the existing levee material and an impervious cap above the cutoff wall or with imported impervious levee fill material. Cutoff walls are typically constructed of either a soil bentonite (SB), soil cement bentonite (SCB), or cement bentonite (CB) mixture depending on in-situ soil conditions and desired construction method.

The conventional slurry method is an open trench method that uses an excavator with a long-stick boom to excavate the slurry trench. A bentonite-water slurry is used to keep the trench open and stable prior to backfilling. Soil from excavation or borrow area is mixed with bentonite (or with cement and bentonite) then pushed into the trench, displacing the bentonite-water slurry. The cutoff wall trench can also be backfilled with self-hardening slurry mixture (cement-slag-bentonite). The self-hardening slurry backfill can be used to keep the trench open and stable allowing excavation of a new section without waiting for the entire trench to be excavated. 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. Jet grouting uses the injection of high pressure grout to create soil-cement-bentonite mixtures in overlapping columns or panels within the subsurface soils. Cutter soil mixing uses a cutter head with typically two cutter wheels around a horizontal axis that allows vertical penetration within the subsurface soils. Bentonite and/or cement slurry are injected during the penetration and withdrawal of the cutter head. Like jet grouting, overlapping primary and secondary panels is necessary to complete the cutoff wall.

8.1.2 RELIEF WELLS

Pressure relief wells relieve excess pore pressures that can build up beneath a surficial impervious 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. Drainage from relief wells can either be into an existing (sewers or roadways) or proposed drainage system necessitating either gravity flow or potentially requiring pumping facilities. Relief wells usually require long term maintenance to ensure they operated efficiently. In general, the maintenance required to retain efficiency, require capacity in existing urban interior drainage systems, and may not be suitable for all types of soil stratigraphy. The operations and maintenance program increases the long term costs, however the application of relief wells in certain cases may still be cost effective as compared to alternative improvement measures.

8.1.3 SEEPAGE BERMS

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. Minimum thickness at the levee toe is typically 5 feet and 3 ft at the berm toe. Seepage berms can be pervious, semi-pervious, or impervious and require a significant amount of land. For urban areas, due to adjacent property uses, there is not sufficient room on the landside toe for a seepage berm without real estate impacts and without relocations.

8.2 SLOPE STABILITY

8.2.1 SLOPE FLATTENING

Slope flattening is a structural method to reinforce unstable slopes. Both the waterside and landside slopes can be re-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.

8.2.2 STABILITY BERMS

Stability berms are constructed of a random fill material placed on the levee slope to increase the slope stability. These berms may be constructed of any compacted random material placed on a chimney drain along the existing levee slope connected to a drainage blanket underneath the berm to capture the seepage through the levee and drain it outside the levee prism, or, if seepage through the levee is not an issue, it can be constructed directly over the levee slope as needed to increase the slope stability only. In case a chimney drain is used a thin filter sand layer is placed between the drainage layer and the levee embankment and native soils. Geotextile fabric may be placed between the free drainage layer and the levee fill. Typically the height of the stability berm in 2/3rd of the height of the levee or to the design water surface elevation (WSE) and extends for approximately 15 ft in width or as determined by the structural needs of the levee along that reach.

8.3 HEIGHT

8.3.1 FLOODWALL/RETAINING WALL

Floodwalls are an efficient, space-conserving method for containing unusually high water surface elevations. They are often used in highly developed areas, where space is limited. They are primarily constructed from pre-fabricated materials, although they may be cast or constructed in place. Floodwalls consist of relatively short elements constructed on the levee crest, making the connections very important to their stability. Floodwalls are typically located along a levee waterside hinge point to allow vehicular access along the crown. The drawback is that floodwalls prohibit access to or from the slopes, and may inhibit visual inspection of the waterside slope and toe areas from the crown if the wall is of sufficient height during inspection.

8.3.2 EMBANKMENT FILL

To address deficiencies found in the required levee freeboard various methods of raising the existing levee crown elevation could be implemented. The two most likely alternatives include a crown-only raise and a full levee raise. 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 and slopes 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.

8.4 EROSION

8.4.1 LAUNCHABLE ROCK TRENCH

To protect against waterside erosion in areas where a waterside berm exists, a launchable rock trench may be constructed. The intent of the trench is to prevent further waterside erosion into the levee embankment particularly at the waterside levee toe. This is accomplished by placing rip-rap a certain height 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 eroded, 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. The rip-rap previously contained in the trench will protect against further erosion landward in to the levee embankment.

8.4.2 BANK PROTECTION (ON-BANK AND ON-SLOPE)

In areas that have no or minimal waterside berm, 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. Existing vegetation would be removed within the vegetation free zone. Grass would be allowed in this area.

Additionally a rip-rap waterside berm could be constructed from the base of the erosion to above the mean summer water surface level (MSWL) and then placing stone protection on the levee or bank slope above the MSWL. The rock berm would support riparian vegetation and provide a place to anchor in-stream woody material (IWM). This design provides near-bank, shallow-water habitat for fish.

8.5 GEOMETRY, VEGETATION, ACCESS, AND ENCROACHMENTS

8.5.1 STANDARD LEVEE GEOMETRY

The levee needs to be regaraded to the minimum requirements of the SOP003. The minimum levee section for new construction should have a 3H:1V waterside slope, minimum crest width of 20 feet for mainline levees, major tributary levees, and bypass levees; a minimum of crest width of 12 feet for minor tributary levees, and a 3H:1V landside slope as required in SOP-003. Existing levees with landside slopes as steep as 2H:1V may be used in rehabilitation projects if the landside slope performance has been good and if the slope stability analyses determined the factors of safety are adequate.

8.5.2 TOE ACCESS

The purpose of the toe access easement is to allow for necessary maintenance, inspection, and floodfight access. SPK guidance in SOP 003 requires a 20 ft. wide easement landside of the levee for new levees as well for existing levees. Research throughout the USACE districts concluded that the minimum toe access required in most applications was 10 ft. This 10 ft. width would accommodate an all weather road along the landside levee toe.

8.5.3 VEGETATION

The design effort will completed to comply with the USACE vegetation policy. Where vegetation management standards do not meet the ETL requirements, a variance may be approved 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. The requester must demonstrate that a variance is the only reasonable means to achieve the required criteria as stated in ETL 1110-2-571. A more detailed description of the requirements and process for requesting the vegetation variance can be found in the above stated ETL and associated policy guidance letters (PGL).

8.5.4 PLANTING BERMS

Planting berms can be both on the waterside and landside of the levee. The difference is that landside planting berms are allowed by the ETL and waterside planting berm have to be approved as a variance from the ETL. These berms are additional cross sectional areas required to accommodate desired vegetation. It preserves access and protects the prism from root-related damage.

8.5.5 ENCROACHMENTS

Encroachments are reviewed on a case-by-case basis. Encroachment types may vary from fences, non-permitted access gates, staircases, gardens, irrigation systems, lighting and various other occurrences adjacent to, at the levee toe, or on the landside/waterside levee slope. If an encroachment inhibits inspection or maintenance activities of the levee, consideration should be given to removing or relocating the encroachment to allow proper maintenance and inspection.

8.6 SACRAMENTO WEIR AND BYPASS WIDENING

The existing Sacramento Weir and Bypass, which allow high flows in the Sacramento River to be diverted into the Yolo Bypass, could be expanded to accommodate increased bypass flows. The increased flows from the Sacramento River to the Yolo Bypass would serve to reduce the stage on the levees downstream thereby negating a potential need for levee raises. The existing north levee of the Sacramento Bypass would be degraded and a new levee constructed to the north. The existing Sacramento Weir would be expanded to match the wider bypass.

8.7 DEEP WATER SHIP CHANNEL CLOSURE STRUCTURE

Construction of an operable closure structure on the Deep Water Ship Channel located just downstream of the Port South levee and Yolo Bypass East Levee (South Basin) cconfluence is being examined. The structure would include multiple gates to be operated allowing both flows in and out of the north basin providing a level of protection comparable to other improvement measures. The cross channel structure would also incorporate tie-in levees to the existing embankments of the Yolo Bypass East Levee and the Deep Water Ship Channel West Levee with the use of T-walls and/or levees. A closure structure of this nature is similar to an evaluation completed by USACE 2012 would evaluated the feasibility of constructing a closure structure near the I Street Bridge on the Sacramento River. Similar considerations with respect to cost and constructability should be taken in this application as well.

9.0 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 and topographical survey completed in November 2008 for the DWR, ULE project. The natural soil layers were delineated based on boring logs and laboratory test results. Cross-sections of existing levee geometry and subsurface conditions at each index point are included as Enclosure 3.

Typically one cross section per reach was selected for analysis and is referred to as an index point. Within each reach the same index point is used in hydraulic, economic, and geotechnical analysis. In some cases, multiple cross sections were analyzed in each reach to verify the initial location. Table 9-1 presents the cross-sections where geotechnical analyses were performed, not all were incorporated into the economic analyses which would be referred to as index points.

Table 9-1: Geotechnical Analysis Locations

Basin	Location	Bank	River Mile	Sta.	Economic Analyses
NORTH	Port North Levee	North	42.83	117+37	N
NORTH	Sacramento Bypass South Levee	South	1.6	32+00	N
NORTH	Sacramento Bypass South Levee	South	1.6	52+00	Y
NORTH	Sacramento River West Levee	West	61.67	96+00	Y
NORTH	Sacramento River West Levee	West	60.20	190+00	Y
NORTH	Yolo Bypass East Levee	East	41.90	36+00	N
NORTH	Yolo Bypass East Levee	East	43.10	107+31	Y
NORTH	Sacramento Bypass North Levee	North	0.4	8+30	N
SOUTH	Deep Water Ship Channel West Levee	West	41.21	12+00	Y
SOUTH	Port South Levee	South	43.45	123+55	Y
SOUTH	South Cross Levee	South	38.25	17+50	N
SOUTH	Sacramento River West Levee	West	56.74	264+00	Y
SOUTH	Sacramento River West Levee	West	53.08	80+00	Y
SOUTH	Sacramento River West Levee	West	51.07	35+22	N
SOUTH	Yolo Bypass East Levee	East	40.82	10+00	N
SOUTH	Yolo Bypass East Levee	East	37.22	53.96	N

10.0 HYDRAULIC LOADING CONDITIONS

Water surface profiles for the West Sacramento 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 10yr, 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). Tables 10-1 and 10-2 below summarize the water surface elevations deterministically analyzed at each index point, by basin.

Table 10-1: West Sacramento - North Basin Analyses Water Surface Elevations

Index Point	Event	Stage	Head	Index Point	Event	Stage	Head
PNL_STA_ 117+37	Crest	22.2	5.19	SRWL_ST A_96+00	Crest	40.90	18.50
	500yr	22.28	N/A		500yr	38.19	15.78
	200yr	20.93	3.90		200yr	36.17	13.76
	100yr	19.83	2.80		100yr	34.71	12.30
	50yr	18.71	1.68		50yr	34.03	11.62
	25yr	17.78	0.65		25yr	33.49	11.08
SBSL_STA _ 32+00	Crest	36.63	20.85	SRWL_ST A_190+00	Crest	39.47	11.47
	500yr	35.95	20.17		500yr	38.27	10.27
	200yr	34.38	18.60		200yr	36.14	8.14
	100yr	33.04	17.26		100yr	34.66	6.66
	50yr	32.23	16.45		50yr	33.95	5.95
	25yr	31.42	15.64		25yr	33.36	5.36
YBEL_STA ._36+00	Crest	37.15	17.79	SBNL_STA _8+30	Crest	36.00	19.16
	500yr	33.20	13.84		500yr	34.53	17.69
	200yr	32.25	12.89		200yr	33.36	16.52
	100yr	31.22	11.86		100yr	32.16	15.32
	50yr	30.32	10.96		50yr	31.24	14.40
	25yr	29.41	10.05		25yr	30.33	13.49

Table 10-2: West Sacramento - South Basin Analyses Water Surface Elevations

Index Point	Event	Stage	Head	Index Point	Event	Stage	Head
DWSCWL_STA_12+00	Crest	34.44	31.94	PSL_STA_123+55	Crest	21.67	14.50
	500yr	22.28	19.78		200yr	20.93	13.76
	200yr	20.92	18.42		100yr	19.83	12.66
	100yr	19.83	17.33		50yr	18.71	11.54
	50yr	18.71	16.21		25yr	17.68	10.51
	25yr	17.68	15.18				
SCL_STA_17+50	Crest	27.55	18.74	SRWL_STA_35+22	Crest	34.65	19.92
	500yr	33.98	N/A		500yr	33.48	18.75
	200yr	32.29	N/A		200yr	31.85	17.12
	100yr	30.89	N/A		100yr	30.47	15.74
	50yr	30.32	N/A		50yr	29.81	15.08
	25yr	29.65	N/A		25yr	29.23	14.50
	10yr	27.01	18.2				
SRWL_STA_264+00	Crest	40.52	20.90	YBEL_STA_10+00	Crest	31.93	22.04
	500yr	36.50	16.88		500yr	32.86	N/A
	200yr	34.53	14.91		200yr	31.93	22.04
	100yr	33.08	13.46		100yr	30.92	21.03
	50yr	32.41	12.79		50yr	30.03	20.14
	25yr	31.83	12.21		25yr	29.13	19.24
SRWL_STA_80+00	Crest	39.00	21.44	YBEL_STA_53+96	Crest	32.71	32.28
	500yr	34.71	17.15		500yr	31.15	30.72
	200yr	32.93	15.37		200yr	30.26	29.83
	100yr	31.53	13.97		100yr	29.29	28.86
	50yr	30.86	13.30		50yr	28.42	27.99
	25yr	30.28	12.72		25yr	27.53	27.10

11.0 SEEPAGE AND SLOPE STABILITY ANALYSIS

11.1 STEADY STATE SEEPAGE ANALYSIS METHODOLOGY

Deterministic steady state seepage analysis was performed using SEEP2D within GMS 6.5 (Groundwater Modeling System), a finite element program. 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 extents 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 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 to the end of available topographic information on the waterside which includes bathymetric information when available. Figure 11-1 shows a typical GMS SEEP2D seepage model.

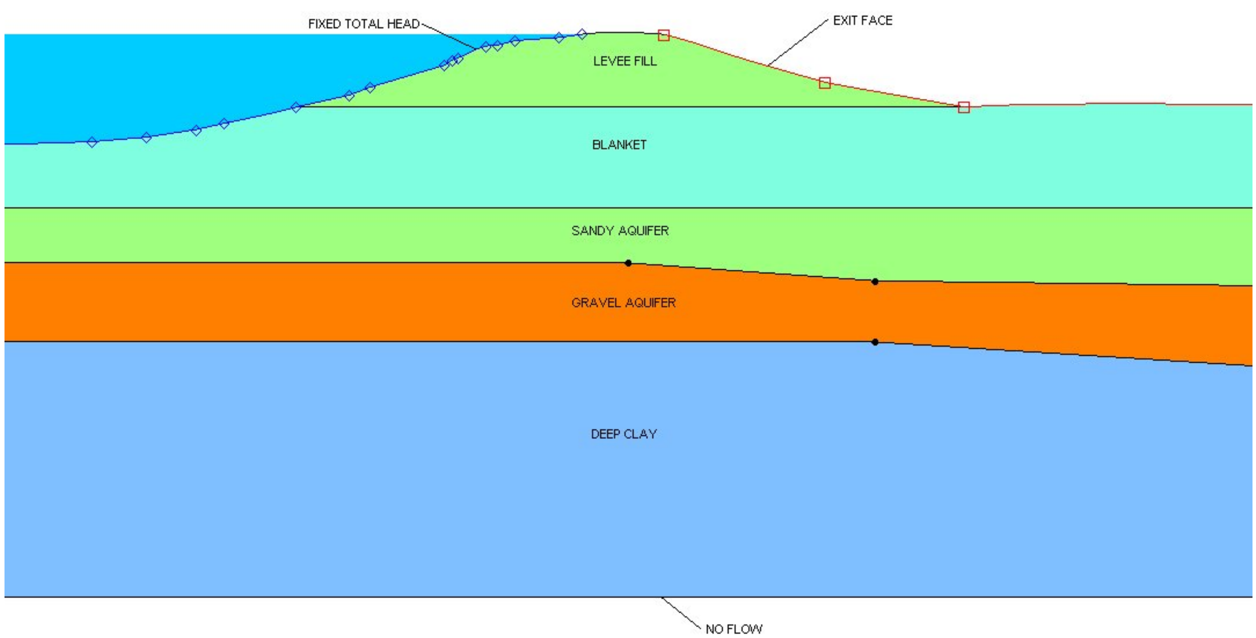

Figure 11-1: Typical GMS SEEP2D Seepage Analysis Model

Levees constructed either of fine grained clays, having stability berms with drainage layers extended along the levee slope that captures any seepage through the levee, or having cutoff walls constructed through the levee embankment are unlikely to be susceptible to through-seepage caused internal erosion. Levees of silt, silty sand, and sand were considered to be susceptible to internal erosion caused by through seepage and could potentially be considered as deficient from a through seepage perspective.

11.2 STEADY STATE SLOPE STABILITY ANALYSIS METHODOLOGY

Embankment slope 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 are expected on the failure surface due to the nature of the material (clay usually is producing cracks during dry weather), a crack with water to a certain depth in the crack was considered to eliminate the tensile stresses, but not compressive stresses. The appropriate depth for a crack is the one producing the minimum factor of safety, which corresponds to the depth where tensile, but no compressive, stresses are eliminated. If a crack was required, the maximum crack depth was set to producing the lowest factor of safety, typically two to four feet. Figure 11-2 shows a typical UTEXAS4.0 model.

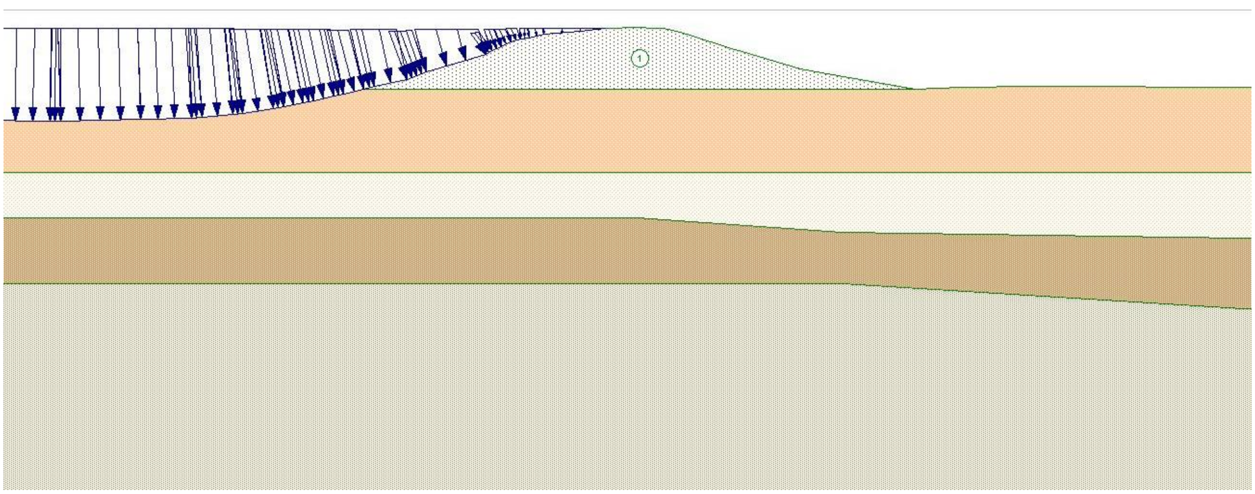

Figure 11-2: Typical UTEXAS4.0 Slope Stability Analysis Model

The long term evaluation with steady state seepage based on the assumption of a fully developed phreatic surface through the embankment was considered. Saturated unit weights are used in the embankment and the pore water pressure is imported from SEEP2D. External water pressures from the channel are applied as a distributed load against the landside slope. Effective shear strength parameters c' and Φ' were used for all materials.

11.3 MATERIAL PROPERTIES

Material properties including hydraulic conductivity for seepage analysis and drained (effective) shear strength and unit weight for slope stability analysis were determined based on 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.

From the generalized parameters, conservative seepage and slope stability analysis parameters were developed for the soil layers based on regression of site-specific field and laboratory test results and correlations at the location of the analyzed cross-section. Specific correlations included SPT blow counts, CPT tip resistance and sleeve frictions, Atterberg Limits, consolidations testing, and grain size distribution tests. Less conservative values (higher strength and lower hydraulic conductivity) were often present in individual tests or soil layers/borings; however, uncertainty exists in the field and laboratory testing based on the spacing between explorations, frequency of testing, appropriateness of correlations, and limitations of field and laboratory testing methods. The hydraulic conductivities, shear strengths, and unit weights used in the seepage and slope stability analysis are included as Enclosure 2.

Hydraulic conductivities were assigned based on soil classification and fines content using typical values developed and evolved from soil index property and hydraulic conductivity testing on samples gathered by the many subsurface investigations coupled with limited in-situ testing and engineering judgment performed by USACE, DWR, URS, Kleinfelder, and others on similar levees and in similar geologic conditions to this project. These values have been adapted for this project and are presented in Table 11-1 below. Prior to being used in analysis, the hydraulic conductivities presented in Table 11-1 were compared to sieve analysis and hydrometer correlations such as Kozeny-Carmen (Chapius, 2003), Chapuis's empirical equation (Chapuis, 2004), Hazen (extended by Chapuis, 2004), and the United States Bureau of Reclamation (USBR, 2011).

Most soil deposits have a different horizontal hydraulic conductivity than vertical hydraulic conductivity. The ratio of horizontal hydraulic conductivity divided by vertical hydraulic conductivity is referred to as anisotropy ratio (K_H/K_V). Anisotropy between horizontal and vertical conductivities is influenced by a number of factors including a variation in material properties within a modeled layer (interbedded lenses of sand in a silt or clay layer), cracks within the layer, etc. The analyses were performed using a soil anisotropy ratio of 4 for most naturally deposited layers. Thin clay blankets were given an anisotropy of 1 to 0.10 (assumed to be cracked) and some sands and gravels were given an anisotropy of 10.

Table 11-1: Hydraulic Conductivities

Material Type	Soil Description	Hydraulic Conductivity				
		K_H (cm/sec)	K_H (ft/day)	K_H/K_V	K_V (cm/sec)	K_V (ft/day)
Cutoff Wall	SCB, SB, CB	1.0E-06	0.0028	1	1.0E-06	0.0028
Clay	Engineered Embankment	1.0E-06	0.0284	1	1.0E-0.6	0.0284
	Non-Engineered Embankment	1.0E-05	0.0284	4	2.5E-06	0.007
	Blanket ≥10ft Thick or Embankments	1.0E-05	0.0284	4	2.5E-06	0.007
	Blanket 5ft<>10ft Thick	1.0E-05	0.0284	1	1.0E-05	0.0284
	Blanket ≤5ft Thick	1.0E-05	0.0284	0.10	1.0E-04	0.284
Silt	Elastic (plastic)	5.0E-05	0.14	4	1.3E-05	0.035
	Non-plastic	2.0E-04	0.57	4	5.0E-05	0.14
Clayey Sand to Sand	30-49% fines	5.0E-05	0.14	4	1.3E-05	0.035
	13-29% fines	1.0E-04	0.28	4	2.5E-05	0.071
	8-12% fines	1.0E-03	2.8	4	2.5E-04	0.71
	0-7% fines	5.0E-03	14	4	1.3E-04	3.5
Silty Sand to Sand	30-49% fines	5.0E-04	1.4	4	1.3E-04	0.35
	13-29% fines	1.0E-03	2.8	4	2.5E-04	0.71
	8-12% fines	5.0E-03	14	4	1.3E-03	3.5
	0-7% fines	1.0E-02	28	4	2.5E-03	7.1
Gravel	28-49% fines	4.0E-04	1.13	4	1.0E-04	0.28
	18-27% fines	1.0E-03	2.8	4	2.5E-04	0.71
	13-17% fines	6.0E-03	17	10	6.0E-04	1.7
	8-12% fines	1.2E-02	34	10	1.2E-03	3.4
	0-7% fines	2.5E-02	71	10	2.5E-3	7.1
Gravel with Cobbles and Sand	28-49%fines	4.0E-04	1.13	4	1.0E-04	0.28
	18-27% fines	1.0E-03	2.8	4	2.5E-04	0.71
	13-17% fines	1.0E-02	28	10	1.0E-03	2.8
	8-12% fines	1.0E-01	284	10	1.0E-02	28
	0-7% fines	2.0E-01	570	10	2.0E-02	57
Drain Rock	Gravel	1.0E01	2835	1	1.0E01	2835

The resistance to penetration of the soils measured in blows per foot (field N-value) during the driving of Standard Penetration Test (SPT) samplers and Cone Penetrometer Test (CPT) tip resistance served as a site specific data source for the determination of shear strength parameters for granular, cohesionless soils through empirical correlations. Empirical correlations with SPT N-values by Uchida (1996) and Peck (1974) were used for the estimation of the drained (effective stress) angle of internal friction Φ'. For cohesive soils (including clays and plastic silts), the empirical correlations by Mitchell (1976) and Bowles (1996) were used for estimation of Φ' using the Plasticity Index (PI) of the soil. Correlation values were compared with available shear strength laboratory testing.

For both cohesive and cohesionless materials, the shear strengths selected for analysis were typically equal to or less than the 1/3rd percentile of the data set. Shear strengths predicted by correlations were compared to typical published values and values used in previous analysis in similar materials, and then adjusted based on engineering judgment. Typical shear strengths, by material classification, used in steady state slope stability analysis are shown in Table 11-2.

Table 11-2: Shear Strength of Soils

Material Type	**Soil Description**	**Shear Strength**		
		C' (psf)	**Φ' (°)**	**γ(pcf)**
Cutoff Wall	SB	50	0	85
	SCB	500		
	CB	5000		
Clay	Clay Foundation	50-100	20-30	115
	Clay Engineered Embankment	50-200	28-30	115
	Clay Non-engineered Embankment	50-100	22-26	115
Silt		0	28-32	120
Clayey Sand and Silty Sand		0	28-33	125
Sand		0	30-35	130
Gravel and Drain Rock		0	35-40	135

11.4 SEEPAGE AND STABILITY ANALYSIS RESULTS

The following section presents the results of geotechnical steady state seepage and slope stability analyses, in accordance with the methodology described in the Section 11.1 through 11.3. The analyses cross-sections were evaluated in accordance with design criteria described in Section 7, for water surface elevations ranging from the 25 year flood frequency to the levee crest elevation, as shown in Section 10. The analyses for each location was first performed for the without project conditions as described in Section 1.6, essentially accounting for the constructed and/or authorized levee configuration, and, if the without project conditions analyses did not meet criteria, improvements were incorporated into the analyses cross-section until criteria was met (with project conditions as described in Section 1.7). The levee improvements analyzed in this section of the report are discussed in greater detail in Section 15 in context with recommendations to address other failure modes.

Enclosure 2 contains compiled tables of hydraulic conductivities and material strength parameters assigned for each cross-section used in analysis. Enclosure 3 contains a tabulation of the complete analyses results (seepage gradients and slope stability factors of safety for various WSE). Plates of cross-section geometry, stratigraphy, total head contours (seepage analysis) and failure surfaces (slope stability analysis) for the 200 year water surface elevation are included in the enclosure.

The following sections present the analyses results for without and with project conditions at each of the cross-section locations. Figures presented for each cross-section display underseepage average vertical exit gradient calculated at the landside levee toe and slope stability factor of safety for the analyzed water surface elevations.

11.4.1 NORTH BASIN – PORT NORTH LEVEE – STA. 117+37

The without project conditions seepage and landside slope stability analysis of the Port North Levee Sta. 117+37 met both gradient and stability criteria for all water surface elevations analyzed. The freeboard criteria, corresponding to the 200yr WSE plus 3 ft (23.9 ft NAVD88), was not met. The with project condition analyzed a saddled embankment raise of select levee fill with a keyway on the landside to an elevation of 23.9 ft NAVD88. The with project conditions seepage and landside slope stability analysis met both gradient and stability criteria for all water surface elevations analyzed. Figure 11-3 displays the without project conditions analyses results and Figure 11-4 displays the with project analyses results for analyzed flood frequencies.

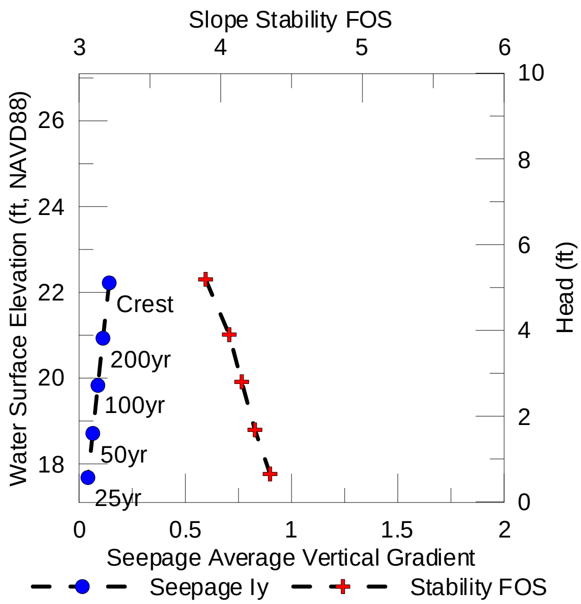

Figure 11-3: North Basin – Port North Levee – Sta. 117+37 - Without Project Analyses Results

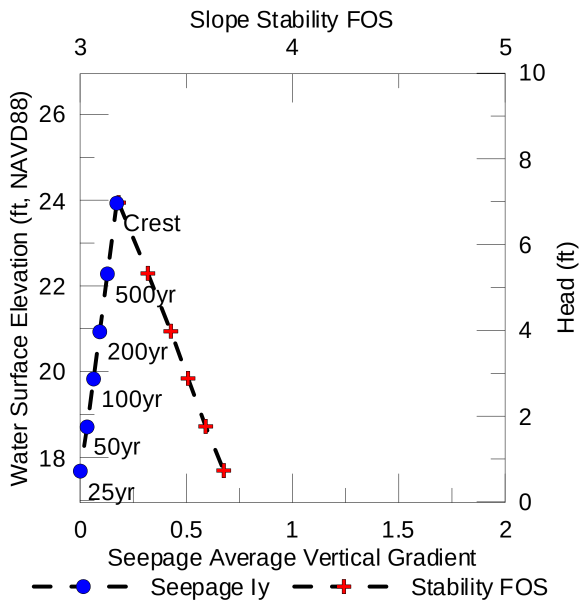

Figure 11-4: North Basin – Port North Levee – Sta. 117+37 - With Project Analyses Results

11.4.2 NORTH BASIN – SACRAMENTO BYPASS SOUTH LEVEE – STA. 32+00

The without project conditions seepage analysis of the Sacramento Bypass South Levee Sta. 32+00 have shown the potential for seepage gradients to exceed criteria beginning at the 25 yr flood frequency event due to shallow leaky silty sand (SM) layer at the levee base as well as a directly charged poorly graded silty sand (SP & SP-SM) and silty sand (SM) aquifer. Without project conditions landside stability analysis met criteria for all water surface elevations analyzed. The 25 yr flood frequency event corresponds to a water surface elevation of 31.42 ft and 16.24 ft of head on the levee embankment.

The with project conditions analyses addressed the underseepage deficiencies by incorporating a cutoff wall keyed-in to a low permeability confining layer at elevation -40.0 ft. With the improvement measures described above, the seepage and stability analyses met criteria at all flood frequencies. Figure 11-5 displays the without project conditions analyses results and Figure 11-6 displays the with project analyses results for analyzed flood frequencies.

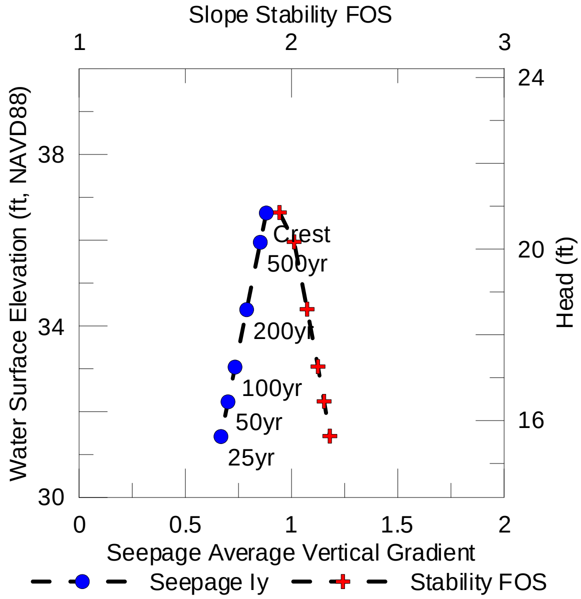

Figure 11-5: North Basin – Sacramento Bypass South Levee – Sta. 32+00 - Without Project Analyses Results

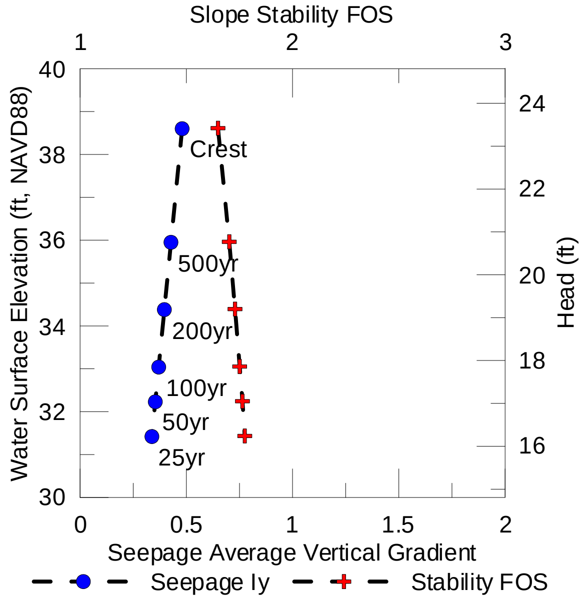

Figure 11-6: North Basin – Sacramento Bypass South Levee – Sta. 32+00 - With Project Analyses Results

11.4.3 NORTH BASIN – SACRAMENTO BYPASS SOUTH LEVEE – STA. 52+00

The without project conditions seepage analysis of the Sacramento Bypass South Levee Sta. 52+00 met criteria for all water surface elevations analyzed. Stability analyses showed the potential for landside slope instability with water surfaces near the crest of the embankment. Subsurface conditions and landside slopes are analogous to the analysis section at Sta. 32+00. Sacramento Bypass South Levee Sta. 52+00 was completed as part of the West Sacramento Levee System F3 Geotechnical Reevaluation Report – June 2011. The F3 report focused on locating deficiencies; as such, the report did not analyze mitigation measures. Figure 11-7 displays the without project conditions analyses results. Following review of subsurface conditions and past performance in the reach, the anticipated remedial improvement measure prescribed is a shallow cutoff wall constructed to elevation 5ft (NAVD 88).

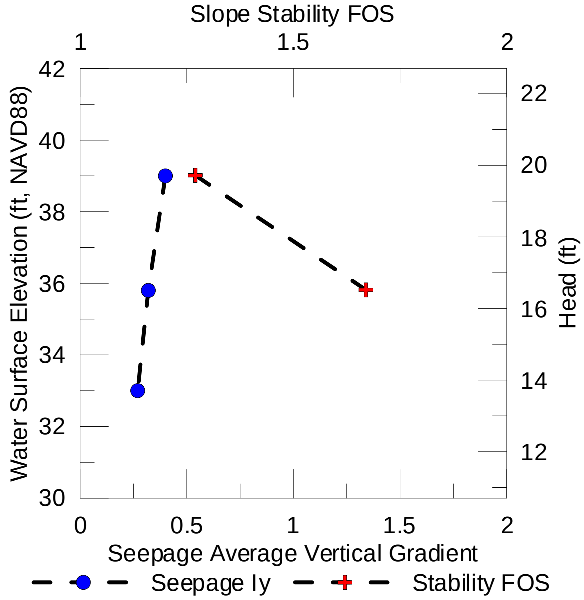

Figure 11-7: North Basin – Sacramento Bypass South Levee – Sta. 52+00 - Without Project Analyses Results

11.4.4 NORTH BASIN – SACRAMENTO RIVER WEST LEVEE – STA. 96+00

The without project conditions seepage analyses of the Sacramento River West Levee Sta. 96+00 have shown the potential for seepage gradients to exceed criteria beginning at the 50 yr flood frequency event. The 50 ft thick aquifer layer of poorly graded silty sand (SP & SP-SM) and poorly graded sands with gravels (SP) is directly charged which contributes to the underseepage issue. Without project conditions landside stability analysis did not meet criteria for all water surfaces analyzed beginning at the 25 yr flood frequency. In comparison to past performance, there was no mention detailing a slope stability concern. However, the potential for an underseepage driven slope stability failure may exist for this location. The 50 yr flood frequency event corresponds to a water surface elevation of 34.03 ft and 11.62 ft of head and the 25 yr flood frequency event corresponds to a water surface elevation of 33.49 ft and 11.08 ft of head on the levee embankment.

The with project conditions analyses addressed the underseepage and landside slope stability deficiencies by incorporating a cutoff wall keyed-in to a low permeability confining layer at elevation -65.0 ft. The with project conditions analyses evaluated the recommendation contained in the Rivers Early Implementation Program (EIP). With the improvement measures described above, the seepage and stability analyses met criteria at all flood frequencies. Figure 11-8 displays the without project conditions analyses results and Figure 11-9 displays the with project analyses results for analyzed flood frequencies.

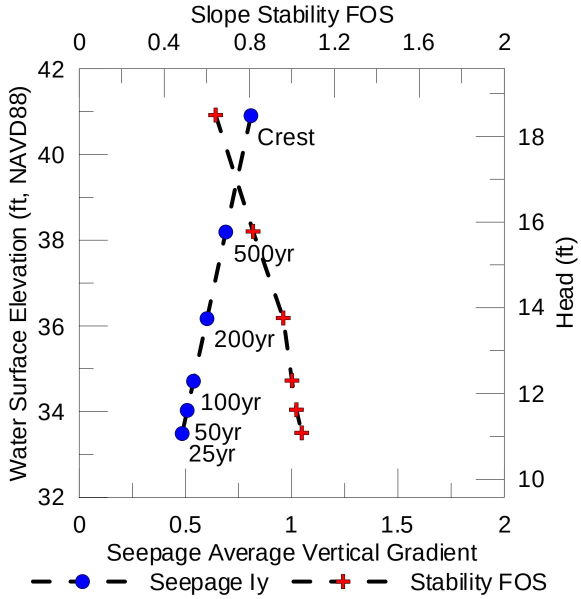

Figure 11-8: North Basin – Sacramento River West Levee – Sta. 96+00 - Without Project Analyses Results

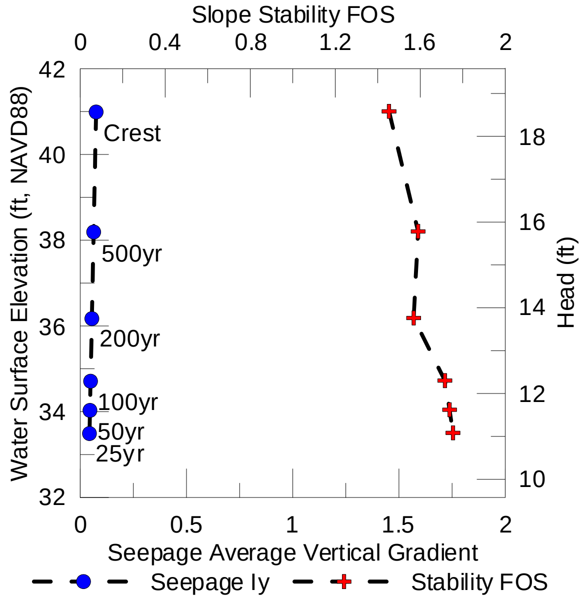

Figure 11-9: North Basin – Sacramento River West Levee – Sta. 96+00 - With Project Analyses Results

11.4.5 NORTH BASIN – SACRAMENTO RIVER WEST LEVEE – STA. 190+00

The without project conditions seepage analysis of the Sacramento River West Levee Sta. 190+00 met gradient criteria for all water surface elevations analyzed. Without project conditions landside stability analysis did not meet criteria for all water surfaces analyzed beginning at the 25 yr flood frequency. The slope stability issue can be attributed to an oversteepened landside slope and high plasticity clays in the levee embankment. The 25 yr flood frequency event corresponds to a water surface elevation of 33.36 ft and 5.36 ft of head on the levee embankment.

The with project conditions analyses addressed the landside slope stability deficiencies by incorporating a cutoff wall keyed-in to a low permeability confining layer at elevation -65.0 ft and flattening of the landside slope to a minimum of 3H:1V. While the without project conditions show the criteria for seepage being met, the recommendation of a keyed-in cutoff wall would provide continuity to adjoining project reaches as well as mitigate against potential defects in the blanket layer. The construction of the cutoff wall would also address the aquifer layer as a whole. With the improvement measures described above, the seepage and stability analyses met criteria at all flood frequencies. Figure 11-10 displays the without project conditions analyses results and Figure 11-11 displays the with project analyses results for analyzed flood frequencies.

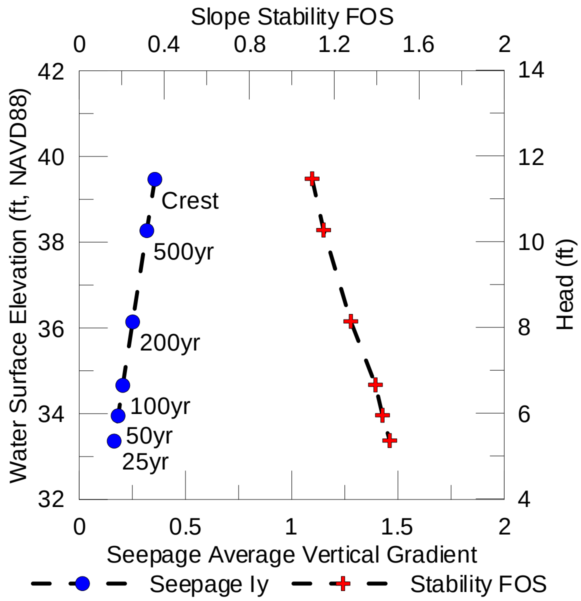

Figure 11-10: North Basin – Sacramento River West Levee – Sta. 190+00 - Without Project Analyses Results

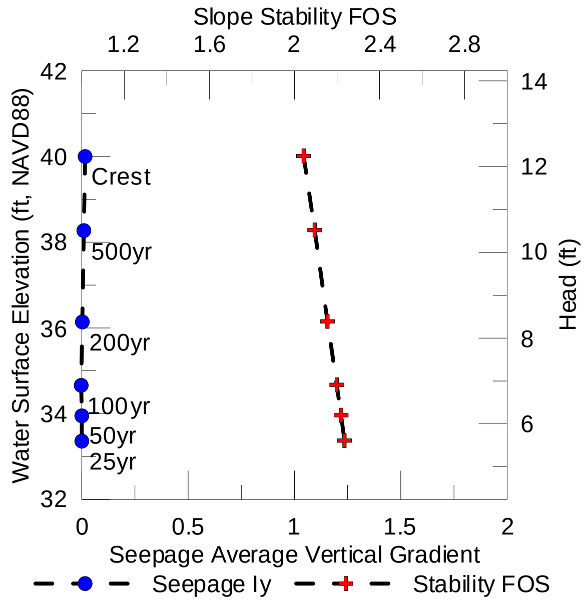

Figure 11-11: North Basin – Sacramento River West Levee – Sta. 190+00 - With Project Analyses Results

11.4.6 NORTH BASIN –YOLO BYPASS EAST LEVEE– STA. 36+00

The without project conditions seepage analysis of the Yolo Bypass East Levee Sta. 36+00 did not meet gradient criteria for all water surface elevations analyzed beginning at the 25 yr flood frequency. A shallow foundation silty sand (SM) layer at the base of the embankment coupled with a directly charged deeper aquifer comprised of a poorly graded silty sand (SP-SM) contribute to the seepage deficiency. Without project conditions landside stability analysis met criteria for all water surfaces analyzed. The 25 yr flood frequency event corresponds to a water surface elevation of 29.41 ft and 10.05 ft of head on the levee embankment.

When relating the past performance of this area to the analysis results, a discrepancy can be noted. This can be attributed to construction actions which placed and compacted clay fill over the existing levee embankment, which is accounted for in the without project conditions. This construction followed the flood events of 1997 and was completed between 1998 and 2002. The placement of compacted clay fill may have mitigated a potential landside slope instability problem, but did not address the potential shallow underseepage deficiency of the silty sand layer.

The with project conditions analyses addressed both shallow and deep underseepage deficiencies by incorporating a cutoff wall keyed-in to a low permeability confining layer at elevation -10.0 ft and flattening of the landside slope to a minimum of 3H:1V. With the improvement measures described above, the seepage and stability analyses met criteria at all flood frequencies. Figure 11-12 displays the without project conditions analyses results and Figure 11-13 displays the with project analyses results for analyzed flood frequencies.

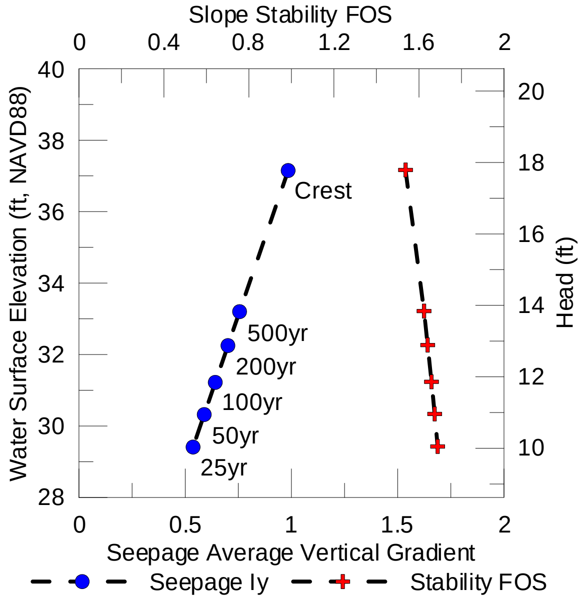

Figure 11-12: North Basin – Yolo Bypass East Levee – Sta. 36+00 - Without Project Analyses Results

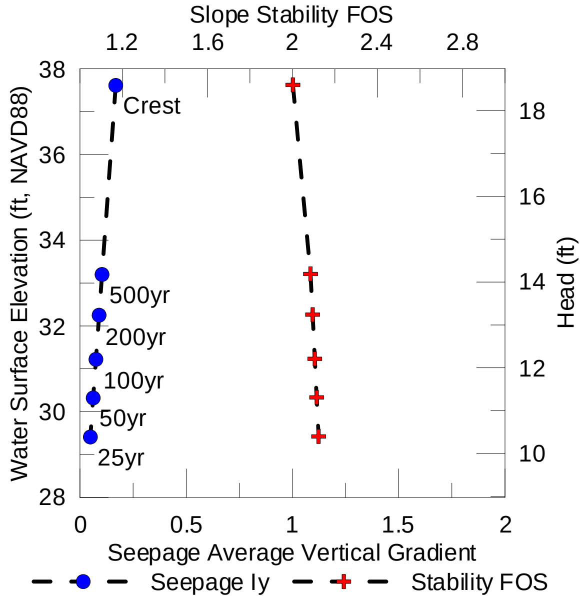

Figure 11-13: North Basin – Yolo Bypass East Levee – Sta. 36+00 - With Project Analyses Results

11.4.7 NORTH BASIN –YOLO BYPASS EAST LEVEE– STA. 107+31

The without project conditions seepage and landside slope stability analysis of the Yolo Bypass East Levee Sta. 107+31 did not meet gradient criteria for all water surface elevations analyzed. The cases analyzed for Yolo Bypass East Levee Sta. 107+31 were contained within the West Sacramento Levee System F3 Geotechnical Reevaluation Report – June 2011. The F3 report focused on locating deficiencies; as such, the report did not analyze mitigation measures under Contract C (Sta. 104+73 to 118+50) which was not finalized at the time of the analysis. The results identified both a seepage and stability deficiency. Figure 11-14 displays the without project conditions analyses results.

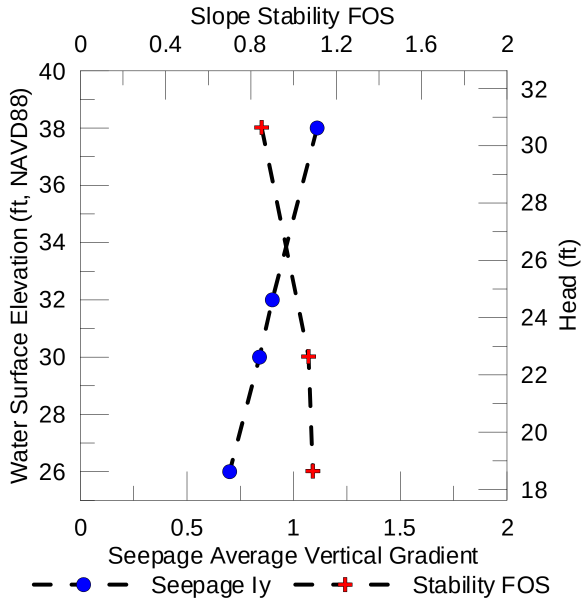

Figure 11-14: North Basin – Yolo Bypass East Levee – Sta. 107+31 - Without Project Analyses Results

11.4.8 SOUTH BASIN –DEEP WATER SHIP CHANNEL WEST LEVEE– STA. 12+00

The without project conditions seepage analysis of the Deep Water Ship Channel West Levee Sta. 12+00 did not meet gradient criteria for all water surface elevations analyzed beginning at the 25 yr flood frequency. A directly charged deeper aquifer comprised of a poorly graded silty sand (SP-SM) and poorly graded sand (SP) contributed to the underseepage deficiency. Without project conditions landside stability analysis met criteria for all water surfaces analyzed beginning at the 25 yr flood frequency as the existing embankment slopes are greater than 4H:1V. The 25 yr flood frequency event corresponds to a water surface elevation of 17.68 ft and 15.18 ft of head on the levee embankment. The DWSC West Levee, while notable in length of 21 miles, the analysis section characterizes approximately 25% of the reach length where the critical geometry and soil conditions exist within the northern most portion of the reach. The location of the analysis section is at the most critical from a levee height and net head on the embankment perspective. Moving further downstream for the remainder of the project reach, there are no recommended mitigation measures as the embankment geometry widens, the embankment slopes are flattened, and the net head on the embankment is decreased.

The with project conditions analyses addressed underseepage deficiencies by incorporating a cutoff wall keyed-in to a low permeability confining layer at elevation -60.0 ft. With the improvement measures described above, the seepage and stability analyses met criteria at all flood frequencies. Figure 11-15 displays the without project conditions analyses results and Figure 11-16 displays the with project analyses results for analyzed flood frequencies.

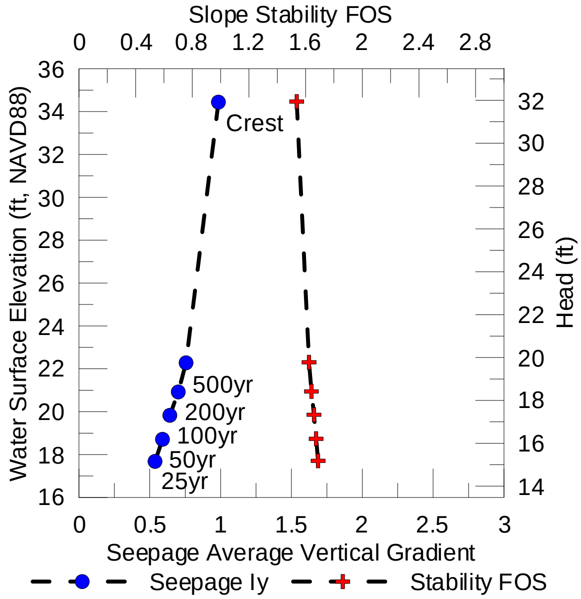

Figure 11-15: South Basin – Deep Water Ship Channel West Levee– Sta. 12+00 - Without Project Analyses Results

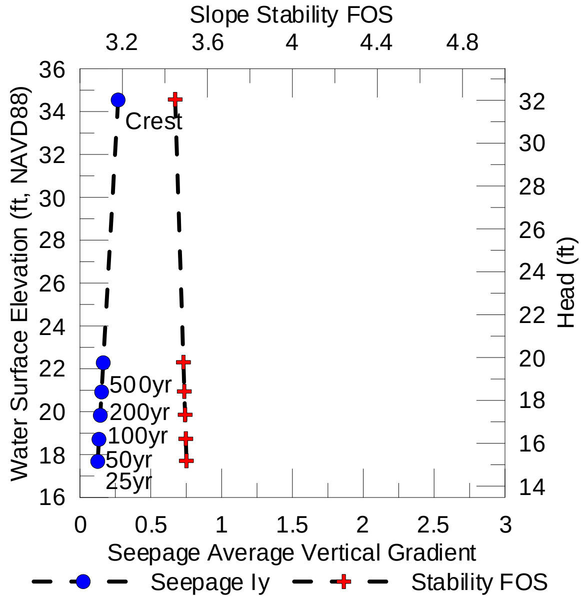

Figure 11-16: South Basin – Deep Water Ship Channel West Levee– Sta. 12+00 - With Project Analyses Results

11.4.9 SOUTH BASIN – PORT SOUTH LEVEE – STA. 123+55

The without project conditions seepage and landside slope stability analysis of the Port South Levee Sta. 123+55 met both gradient and stability criteria for all water surface elevations analyzed. The freeboard criteria, corresponding to the 200yr WSE plus 3 ft (23.93 ft NAVD88), was not met. The with project condition analyzed an embankment raise of select levee fill to an elevation of 23.93 ft NAVD88.

The with project conditions seepage and landside slope stability analysis met both gradient and stability criteria for all water surface elevations analyzed and also incorporated a cutoff wall keyed into a low permeability layer at elevation -53.0ft to address potential variations in the blanket materials that may lead to the development of preferential seepage paths. The recommended mitigation of an underseepage cutoff wall addresses the historic seepage concerns inherent to the adjacent area. From Sta. 120+00 to Sta. 130+00, along the landside of the levee embankment the basin of historic Lake Washington exists. The former lake bed contains basin and channel deposits beneath the foundation of the present day embankment which are susceptible to underseepage. Inclusion of a cutoff wall in this location would mitigate against this potential. Figure 11-17 displays the without project conditions analyses results and Figure 11-18 displays the with project analyses results for analyzed flood frequencies.

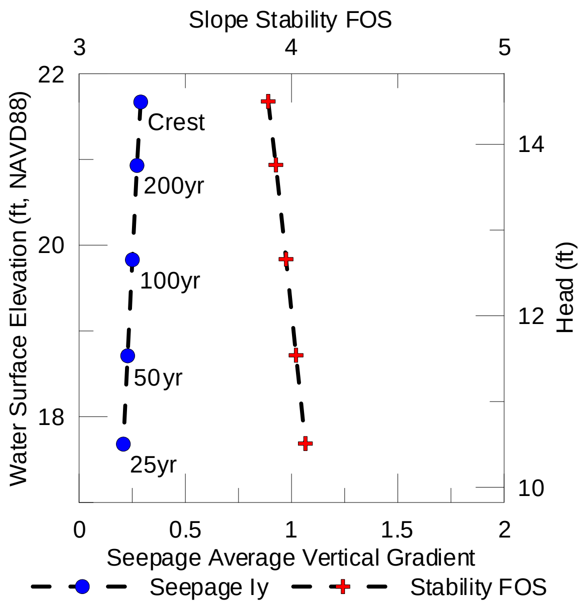

Figure 11-17: South Basin – Port South Levee – Sta. 123+55 - Without Project Analyses Results

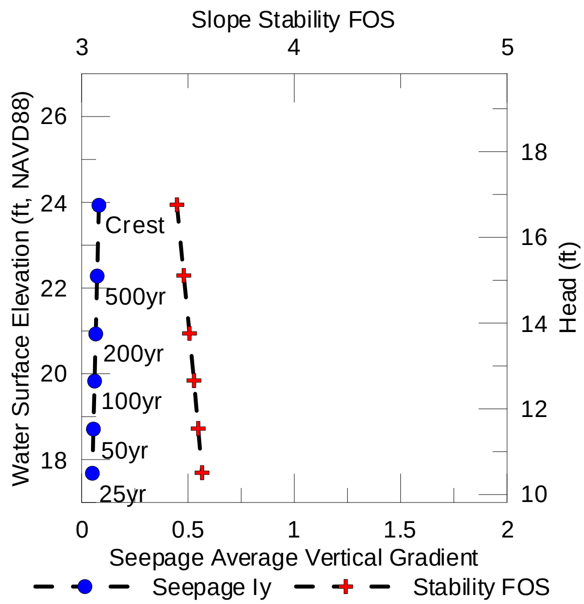

Figure 11-18: South Basin – Port South Levee – Sta. 123+55 - With Project Analyses Results

11.4.10 SOUTH BASIN–SOUTH CROSS LEVEE– STA. 17+50

The without project conditions seepage and landside slope stability analysis of the South Cross Levee Sta. 17+50 did not meet both gradient and stability criteria for all water surface elevations analyzed. This coincides with the past performance issues noted during the seepage events of 1963 and 1965. The freeboard criteria, corresponding to the 200yr WSE plus 3 ft (32.29 ft NAVD88), was not met. The with project condition analyzed an embankment raise of select levee fill to an elevation of 35.29 ft NAVD88.

The with project conditions seepage and landside slope stability analysis met both gradient and stability criteria for all water surface elevations analyzed by incorporating landside relief wells spaced parallel to the levee alignment at 50 ft spacing to a depth of 70 ft. The 70 ft well depth will include 2 screened intervals from an elevation of -9.5 to -23.5 ft and from -39.5 to -58 ft NAVD88. Further detail of the calculations is provided in Appendix 9. The analysis results showed that with a loading to the top of the levee embankment, the uplift gradient criteria was met at a well spacing of 50ft. Figure 11-19 displays the without project conditions analyses results. With project results incorporating relief well analysis will contain calculations for total flow and well spacing; current software constraints do not allow for steady state seepage and landside stability analysis using FEM. Further detail to the relief well design will be included in feasibility level design documentation.

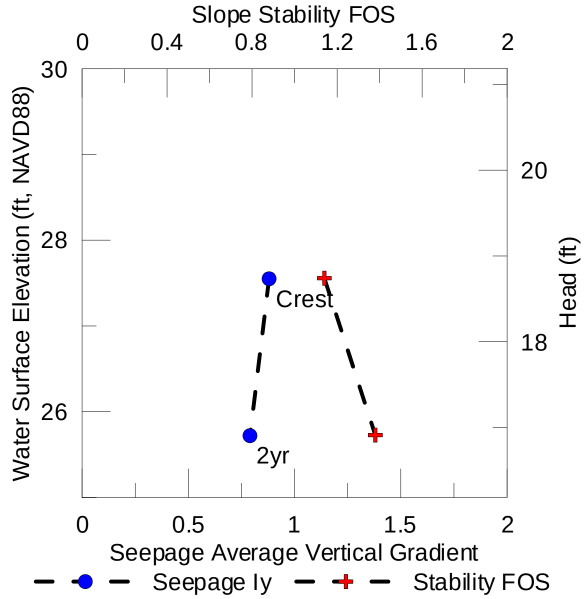

Figure 11-19: South Basin –South Cross Levee – Sta. 17+50 - Without Project Analyses Results

11.4.11 SOUTH BASIN –SACRAMENTO RIVER WEST LEVEE– STA. 264+00

The without project conditions seepage and landside slope stability analysis of the Sacramento River West Levee Sta. 264+00 did not meet either gradient and stability criteria for all water surface elevations analyzed beginning at the 25 yr flood frequency. The 25 yr flood frequency event corresponds to a water surface elevation of 31.83 ft and 12.21 ft of head on the levee embankment. Primarily, the existing levee embankment and upper foundation is comprised of poorly graded sand (SP) and poorly graded silty sand which contribute to a shallow underseepage and through seepage issues.

The with project conditions analyses addressed seepage and landside slope stability deficiencies by incorporating a hanging cutoff wall to elevation -5.0 ft and placement of a 80 ft wide drained seepage berm. While the analysis at this location shows a hanging cutoff wall the analysis section represents the critical cases for the project reach. It should be noted that throughout the reach there maybe portions of hanging cutoff wall as well as keyed-in portions to a low permeability confining layer. Figure 11-20 displays the without project conditions analyses results and Figure 11-21 displays the with project analyses results for analyzed flood frequencies.

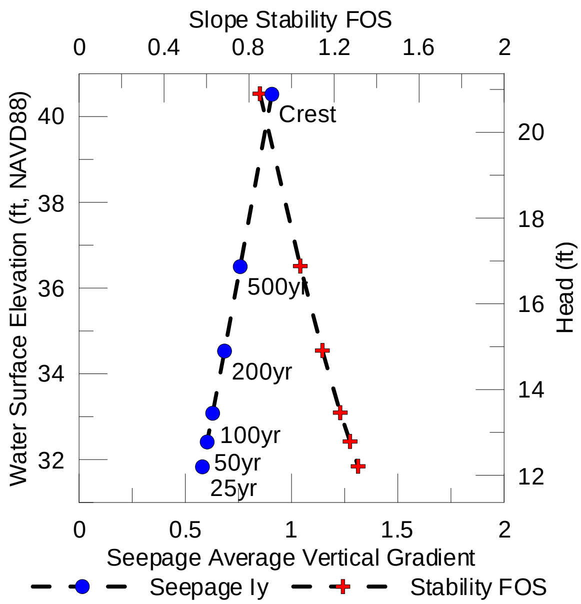

Figure 11-20: South Basin – Sacramento River West Levee – Sta. 264+00 - Without Project Analyses Results

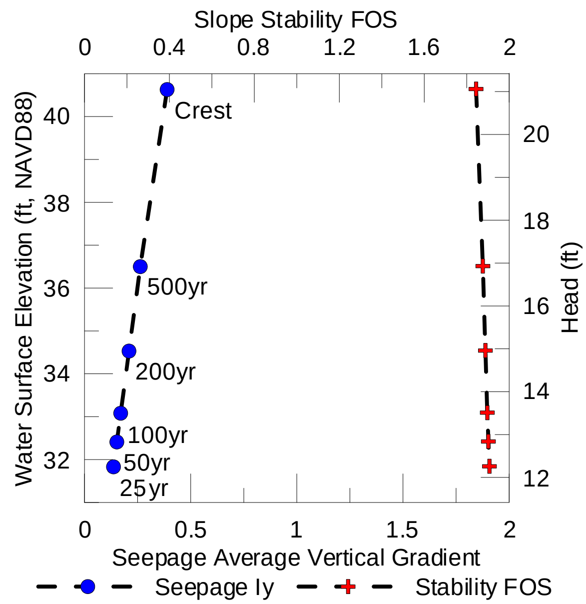

Figure 11-21: South Basin – Sacramento River West Levee – Sta. 264+00 - With Project Analyses Results

11.4.12 SOUTH BASIN –SACRAMENTO RIVER WEST LEVEE– STA. 80+00

The without project conditions seepage and stability analysis of the Sacramento River West Levee Sta. 80+00 met gradient for all water surface elevations analyzed. Primarily, the existing levee embankment and upper foundation are comprised of poorly graded sand (SP) and poorly graded silty sand which contributes to shallow underseepage and through seepage issues. Both the levee embankment and upper foundation materials are directly charged from the channel further contributing to potential distresses.

The with project conditions analyses addressed through seepage deficiencies and shallow underseepage concerns by incorporating a cutoff wall keyed-in to a low permeability confining layer at elevation -5.0 ft and placement of a 80 ft wide drained seepage berm. Figure 11-22 displays the without project conditions analyses results and Figure 11-23 displays the with project analyses results for analyzed flood frequencies.

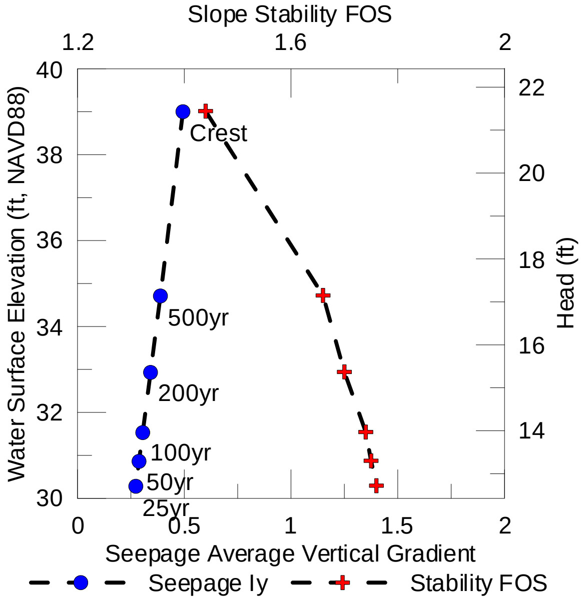

Figure 11-22: South Basin – Sacramento River West Levee – Sta. 80+00 - Without Project Analyses Results

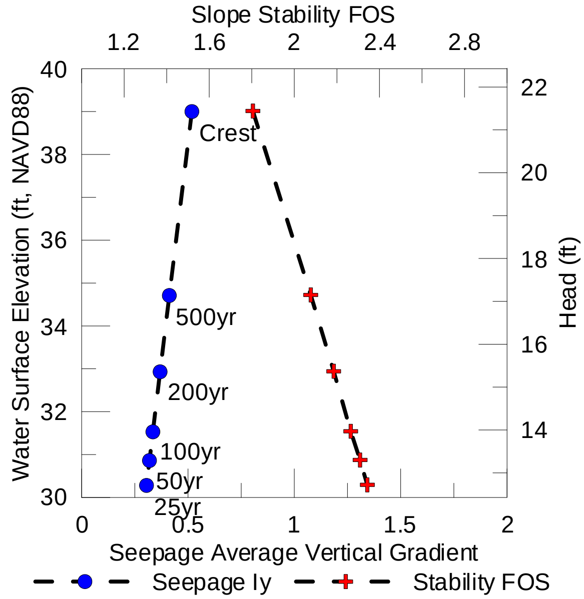

Figure 11-23: South Basin – Sacramento River West Levee – Sta. 80+00 - With Project Analyses Results

11.4.13 SOUTH BASIN –SACRAMENTO RIVER WEST LEVEE– STA. 35+22

In this project reach the SUALRP constructed a shallow through seepage cutoff wall in the early 1990s; subsequent flood events resulted in boils and seepage distresses in both 1995 and 1998. The without project conditions analysis did not correlate to past performance. The through seepage cutoff wall was not included in the analysis section as the past performance events resulting in seepage distress leads way to the overall functionality of the wall itself. The without project conditions seepage and stability analysis of the Sacramento River West Levee Sta. 35+22 met gradient and factor of safety requirements for all water surface elevations analyzed. Primarily, the existing levee embankment and upper foundation are comprised of silts and silty sands (ML and SM) and sands interbedding the clay and silt foundation layers respectively.

The with project conditions analyses addressed the potential deficiencies by incorporating a keyed-in cutoff wall to tip elevation -5.0 feet which would mitigate the interbedding of the upper foundation and allow for excess uplift gradient pressures to be relieved. Figure 11-24 displays the without project conditions analyses results and Figure 11-25 displays the with project analyses results for analyzed flood frequencies.

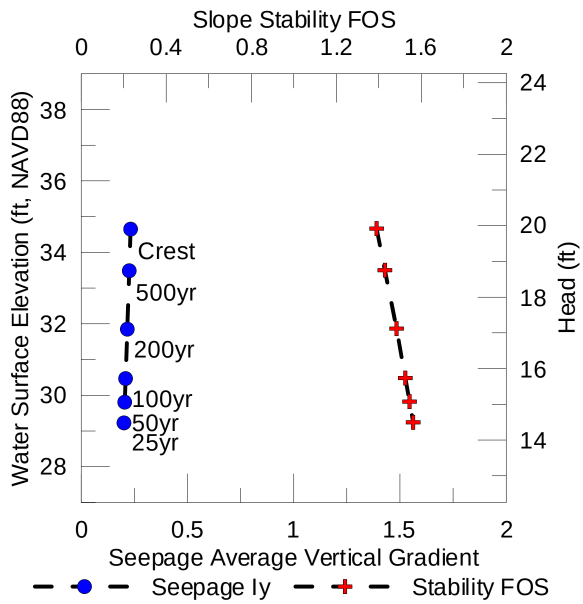

Figure 11-24: South Basin – Sacramento River West Levee – Sta. 35+22 - Without Project Analyses Results

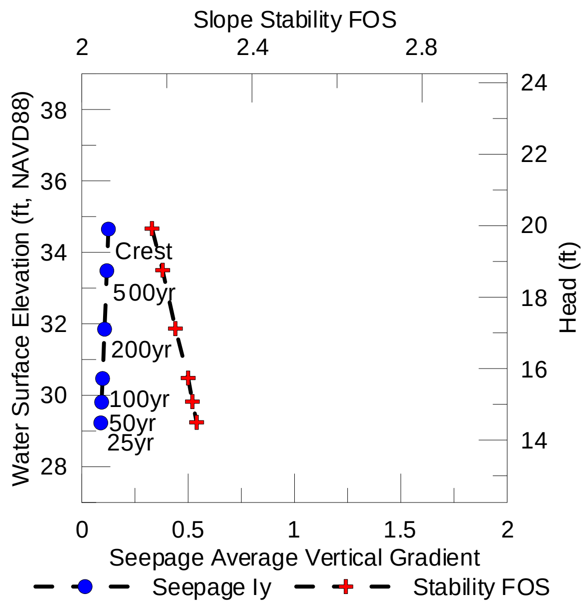

Figure 11-25: South Basin – Sacramento River West Levee – Sta. 35+22 - With Project Analyses Results

11.4.14 SOUTH BASIN –YOLO BYPASS EAST LEVEE– STA. 10+00

The without project conditions seepage and landside slope stability analysis of the Yolo Bypass East Levee Sta. 10+00 met gradient and stability criteria for all water surface elevations analyzed. The freeboard criteria, corresponding to the 200yr WSE plus 3 ft (34.93 ft NAVD88), was not met. The with project condition analyzed an embankment raise of select levee fill to an elevation of 34.93 ft NAVD88.

The with project conditions seepage and landside slope stability analysis met both gradient and stability criteria, as well as satisfied the freeboard height requirement. For all water surface elevations analyzed, a cutoff wall keyed into a low permeability layer was included at elevation -60.0 ft to address potential variations in the blanket materials that and foundation layers that may lead to deep underseepage issues as the channel directly charges the foundation layers. Figure 11-26 displays the without project conditions analyses results and Figure 11-27 displays the with project analyses results for analyzed flood frequencies.

The feasibility analysis at the Sacramento River north levee does not demonstrate the need for seepage or stability mitigation. Several other reports prepared for WSAFCA by others indicated the need for seepage or stability mitigation modifications. Based on the information available at the feasibility level, and the conflict between recommendations from the sponsor and the Corps, the geotechnical recommendation was to recommend work in this area, with the final determination of need to be made during PED.

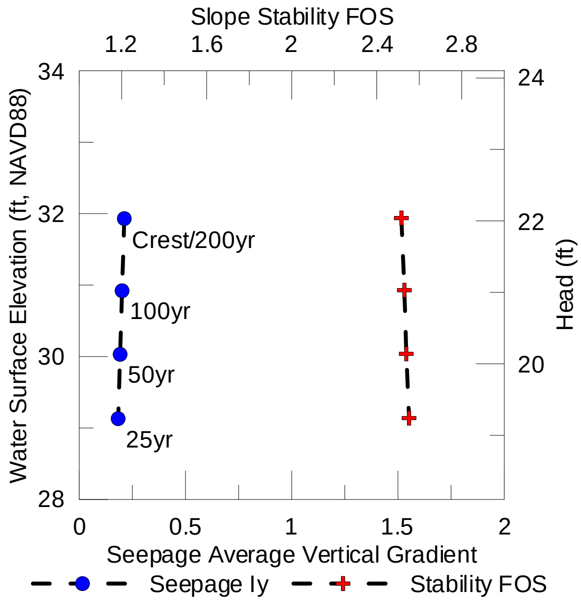

Figure 11-26: South Basin – Yolo Bypass East Levee – Sta. 10+00 - Without Project Analyses Results

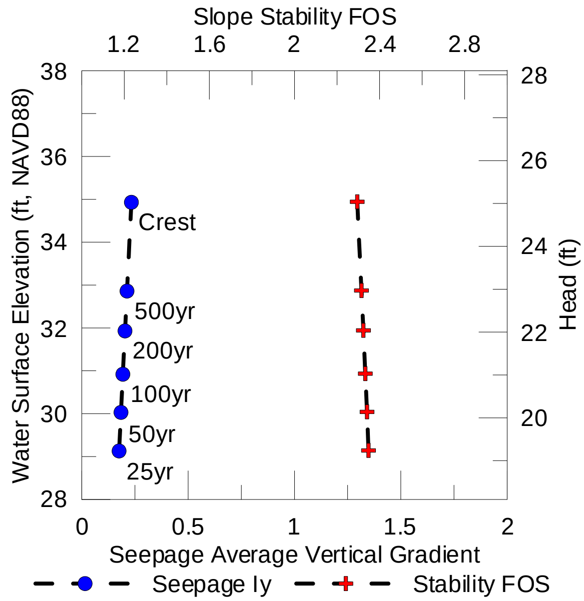

Figure 11-27: South Basin – Yolo Bypass East Levee – Sta. 10+00 - With Project Analyses Results

11.4.15 SOUTH BASIN – YOLO BYPASS EAST LEVEE – STA. 53+96

The without project conditions seepage and landside slope stability analysis of the Yolo Bypass Levee Sta. 53+96 did not meet either gradient and stability criteria for all water surface elevations analyzed beginning at the 25 yr flood frequency. The gradients and factors of safety incorporated a ditch at landside levee toe; a ditch empty case was analyzed. The 25 yr flood frequency event corresponds to a water surface elevation of 27.53 ft and 27.10 ft of head on the levee embankment. The amount of differential head on the levee embankment coupled with the foundation materials being directly charged by the channel and a thick poorly graded sand layer, each contribute to the seepage and slope stability deficiencies. The freeboard criteria, corresponding to the 200yr WSE plus 3 ft (33.26 ft NAVD88), was not met. The with project condition analyzed an embankment raise of select levee fill to an elevation of 33.26 ft NAVD88.

The with project conditions analyses addressed the seepage and landside slope stability deficiencies by incorporating an 80 ft wide drained seepage berm at the landside levee toe, slope flattening to a minimum of 3.0H:1.0V, and an embankment raise to satisfy freeboard requirements. Figure 11-28 displays the without project conditions analyses results and Figure 11-29 displays the with project analyses results for analyzed flood frequencies.

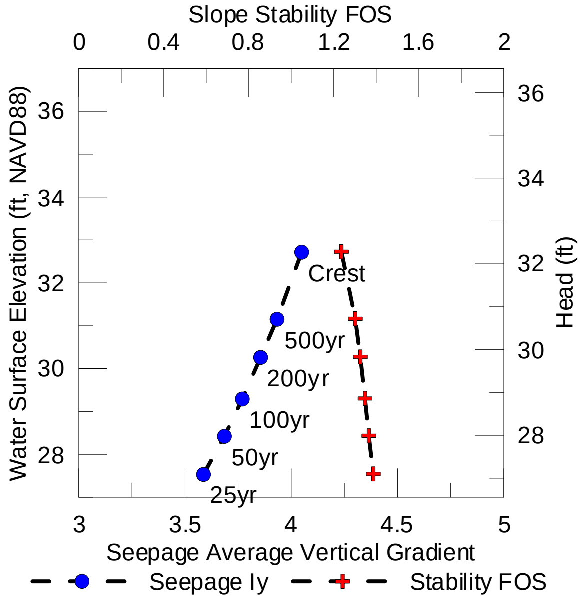

Figure 11-28: South Basin – Yolo Bypass East Levee – Sta. 53+96 - Without Project Analyses Results

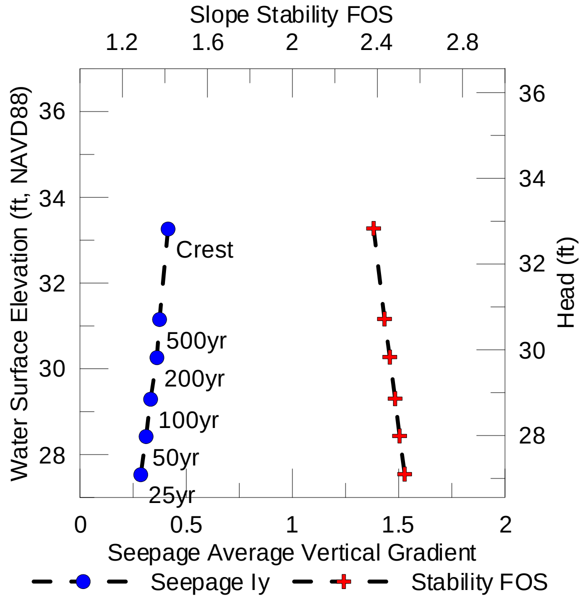

Figure 11-29: South Basin – Yolo Bypass East Levee – Sta. 53+96 - With Project Analyses Results

11.5 SACRAMENTO BYPASS NORTH LEVEE

As the Sacramento Bypass North levee is located to the north of the north project basin; a separate discussion of the results is provided irrespective of the project basins.

11.5.1 NORTH BASIN –SACRAMENTO BYPASS NORTH LEVEE– STA. 8+30

The without project conditions seepage analysis of the Sacramento Bypass North Levee Sta. 8+30 met both gradient for all water surface elevations analyzed. The freeboard criteria, corresponding to the 200yr WSE plus 3 ft (36.36 ft NAVD88), was not met. The with project condition analyzed an embankment raise of select levee fill to an elevation of 36.36 ft NAVD88. Slope stability criteria was not met for all water surface elevations were not met

The with project conditions analyses addressed landside slope stability deficiencies by incorporating an 80 ft wide drained berm at the landside levee toe, and an embankment raise was also included to satisfy freeboard requirements. Figure 11-30 displays the without project conditions analyses results and Figure 11-31 displays the with project analyses results for analyzed flood frequencies.

Analyses was performed on the existing Sacramento Bypass north levee to determine the performance of that levee as well as the general material composition of the levee. However, the project alternative recommendation was for a relocated north levee. There are no existing borings or other geotechnical data available for the location of the new north Sacramento bypass levee. Therefore, a conservative assumption was made regarding potential seepage or stability improvements required for the new north levee. These assumptions were intended to reasonably maximize real estate and environmental impacts for the planning study, with final determination of need to be determined in PED.

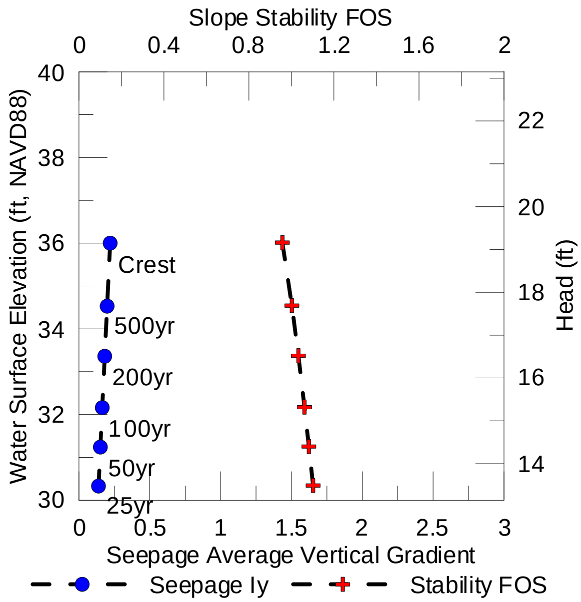

Figure 11-30: Sacramento Bypass North Levee – Sta. 8+30 - Without Project Analyses Results

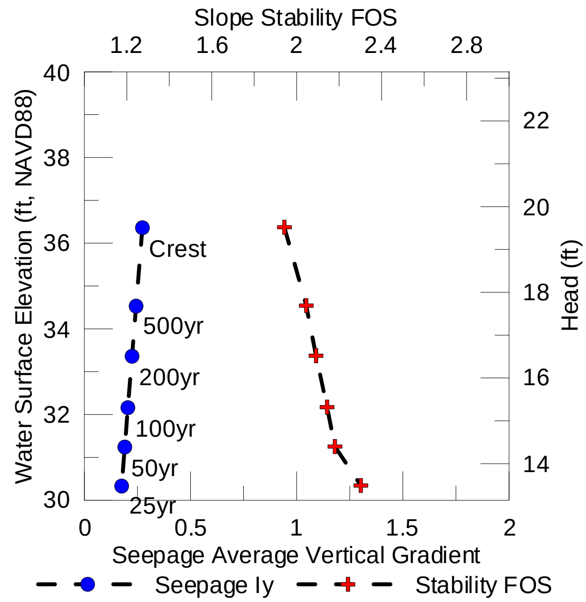

Figure 11-31: Sacramento Bypass North Levee – Sta. 8+30 - With Project Analyses Results

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 National Center for Earthquake Engineering Research (NCEER) and 1998 NCEER/National Science Foundation (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 seismic assessment is included as Enclosure 6.

Probabilistic Seismic Hazard Analysis (PSHA) based on the 2008 Next Generation Attenuation (NGA) relationships was used to develop the seismic loading parameters in this study. The deaggregations are from the United States Geologic Survey (USGS) developed 2008 Interactive Deaggregations web program. The mean magnitude or the weighted average considering the percent contribution to the total hazard for the used for the study levees is 6.60 to 6.67 dependent on location. A peak horizontal ground horizontal acceleration contour map is produced using outputs from the USGS deaggregation program for 20% exceedance in 50 years (224-year average return period). Site Class D as defined by the USGS site classification for seismic assessment was used for this study because the locations selected for evaluation contain harmonic mean N_{60} blow counts ranged between 9.9 and 19.9 and a median value of 15.4. The corresponding shear wave velocity, V_{s30}, is 234 m/s for the study area.

The consequences of triggering liquefaction include flow slide or post earthquake instability and lateral spreading. Where static driving shear stress is greater than the resisting strengths (residual strength), a global or structural failure can occur, leading to loss of freeboard, cracking, and increased piping. Lateral deformation can also develop as a consequence of instability due to loss of shear strength or as accumulation of shear strains throughout the soil profile. Lateral spreading towards any open channel or face can occur in mildly sloping ground and extend to very large distances away from the open face. Vertical displacement can develop as a consequence of reconsolidation of the liquefied soil. For this study, global or structural stability is evaluated where liquefiable layers with factor of safety less than 1.4 is found. Lateral spreading and post-liquefaction reconsolidation settlement were considered only when structural stability had a factor of safety greater than 1.0.

Where liquefiable layers were found to have a factor of safety less than one and between 1.0 and 1.4, static limit equilibrium stability analysis using UTEXAS4 based on Spencer’s method was performed. Automatic circular shear surface search and non-circular or wedge shear surface search were performed for both the landside and waterside in UTEXAS4. Post-earthquake residual shear strength was used for the liquefiable layers. The residual strength was estimated per Olson and Stark, 2002.

The post seismic flood protection ability for each section analyzed is summarized below. The post-seismic flood protection ability is defined as the ability to assume the current or designed flood protection ability after a 200yr earthquake. Further discussion of analysis results and methodologies are contained in Enclosure 6

NORTH BASIN		SOUTH BASIN	
Reach	**Post-Seismic Flood Protection Ability**	**Reach**	**Post-Seismic Flood Protection Ability**
Sacramento River West North Levee	Low Vulnerability	South Cross Levee	Low Vulnerability
Sacramento Bypass Levee*	Medium Vulnerability	Deep Water Ship Channel East Levee	Low Vulnerability
Yolo Bypass Levee*	Low Vulnerability	Deep Water Ship Channel West Levee	Low Vulnerability
Port North Levee	Low Vulnerability	Port South Levee	Low Vulnerability
		Sacramento River West South Levee**	High Vulnerability

*No water behind the levee during non-flood season.

13.0 GEOTECHNICAL RECOMMENDATIONS FOR LEVEE IMPROVEMENTS

As presented in previous sections of this report, the levees protecting the West Sacramento study area are susceptible to through seepage, underseepage, slope stability, and erosion. In some locations, on the levees along the West Sacramento study area, early implementation projects have been constructed and/or are in design by local stakeholders. However, deficiencies still remain throughout the project area. This section presents methods for addressing the geotechnical deficiencies that remain for the levees within the West Sacramento study area.

To address seepage and seepage related slope stability deficiencies the predominant recommendation is cutoff walls in conjunction with seepage berms where applicable, particularly considering the urban development close to the levee embankment. In other locations not necessarily as prevalent as the cutoff wall fixes relief wells, drained stability berms, and landside slope flattening were recommended. To further detail cutoff wall depth to account for variation in elevations of confining key-in layers, a review of existing subsurface information through available plan and subsurface profiles was completed. The resulting tables in the subsequent section account for this as well as coincide with deterministic analysis results.

Based on hydraulic modeling, various locations did not meet the freeboard requirement and the embankment will be raised placing fill.

In addition to geotechnical seepage and slope stability improvement recommendations to assure levee integrity; existing irrigation and drainage ditches landside of the levee would need to be relocated to a distance where there is no adverse impact on levee performance (minimum 50 feet), penetrations through the levee would be relocated and/or modified in conformance with the USACE levee safety policy, and vegetation would be managed in accordance with Section 8.5 of this report.

The following sections will detail the geotechnical recommendation and extent of their locations throughout the project area.

13.1 NORTH BASIN

Within the north basin of the project, the predominant recommended fix is a cutoff wall. Although the tip elevation, nature of the key-in material, and method of construction may differ, overall the main component remains the cutoff wall. The tables below detail the extent and various combinations of the geotechnical recommendations per channel.

Table 13-1 – Geotechnical Recommendations - Sacramento Bypass South Levee

Sacramento Bypass - South Levee				
Station			Levee	Recommended Improvements
From	-	To		
0+00	-	18+00	In Place	None
18+00	-	40+00	In Place	Cutoff Wall to Elev. -40 ft (65 ft Deep)
40+00	-	64+50	In Place	Cutoff Wall to Elev. 5 ft (20 ft Deep)
64+50	-	64+80	In Place	None

Table 13-2 – Geotechnical Recommendations – Sacramento River West Levee

Sacramento River North - West Levee				
Station			Levee	Recommended Improvements
From	-	To		
0+00	-	71+50	In Place	Cutoff Wall to Elev. 0 ft (30 ft Deep)
71+50	-	101+00	In Place	None
101+00	-	140+30	In Place	Cutoff Wall to Elev. 0 ft (30 ft Deep)
140+30	-	155+00	In Place	Cutoff Wall to Elev. -50 ft (80 ft Deep)
155+00	-	185+30	In Place	Cutoff Wall to Elev. -80 ft (110 ft Deep)
185+30	-	194+60	In Place	Cutoff Wall to Elev. -80 ft (110 ft Deep)
194+60	-	199+60	In Place	Cutoff Wall to Elev. -5 ft (45 ft Deep)
199+60	-	215+30	In Place	Cutoff Wall to Elev. -80 ft (110 ft Deep)
215+30	-	307+60	In Place	None

Table 13-3 – Geotechnical Recommendations – Port North Levee

Port North Levee				
Station			Levee	Recommended Improvements
From	-	To		
0+00	-	245+65	In Place	None

Table 13-4 – Geotechnical Recommendations – Yolo Bypass North – East Levee

Yolo Bypass North - East Levee				
Station			Levee	Recommended Improvements
From	-	To		
0+00	-	25+00	In Place	None
25+00	-	50+00	In Place	Cutoff Wall to Elev. -10 ft (40 ft Deep)
50+00	-	65+00	In Place	None
65+00	-	111+35	In Place	None
111+35	-	136+00	In Place	None
136+00	-	155+00	In Place	Cutoff Wall to Elev. -70 ft (100 ft Deep)
155+00	-	197+55	In Place	None

13.2 SOUTH BASIN

Within the south basin of the project, the predominant recommended fix is a cutoff wall and implementation is similar to the north basin. A notable variation is that on the Sacramento River levees, the recommendations could be constructed as fix-in-place using the existing footprint, adjacent levee to the existing embankments, or a setback levee. From discussion with the state and local sponsors, consideration is giving to including a setback or adjacent levee. This process will be detailed programmatically from a project perspective additional to the geotechnical concerns as USACE HQ approval is typically required. In conjunction with a cutoff wall, a seepage berm may be constructed as well to mitigate deep underseepage concerns. Other recommendations include relief wells and drained landside stability berms.

Common to the Sacramento River within the south basin, is a silty sand embankment underlain by an interbedded clay and silt blanket. The sand stringers interbedding the blanket pose uncertainty to potential development of seepage paths. Construction of a shallow keyed-in cutoff wall would mitigate against the development of the underseepage and through seepage gradients.

The tables below detail the extent and various combinations of the geotechnical recommendations per channel.

Table 13-5 – Geotechnical Recommendations – Sacramento River South – West Levee

Sacramento River South - West Levee				
Station			**Levee**	**Recommended Improvements**
From	**-**	**To**		
0+00	-	43+00	Adjacent	Cutoff Wall to Elev. -5 ft (35 ft Deep)
43+00	-	65+00	Adjacent	Cutoff Wall to Elev. -5 ft (35 ft Deep) and Seepage Berm 70 ft wide
65+00	-	167+00	Setback Levee or Adjacent	Cutoff Wall to Elev. -5 ft (25 ft Deep) and Seepage Berm 80 ft wide
167+00	-	275+00	Setback Levee or Adjacent	Cutoff Wall to Elev. 0 ft (20 ft Deep) and Seepage Berm 100 ft wide
275+00	-	295+00	Adjacent	Cutoff Wall to Elev. -70 ft (100 ft Deep)
295+00	-	315+00	Setback Levee	None
315+00	-	332+70	In Place	None
South Extension			In Place or Adjacent	Cutoff Wall to Elev. -5 ft (40 ft Deep) with Landside Slope Flattening (from ±2:1 to 3:1) and Seepage Berm 80 ft wide

Table 13-6 – Geotechnical Recommendations – South Cross Levee

South Cross Levee				
Station			**Levee**	**Recommended Improvements**
From	**-**	**To**		
0+00	-	5+00	In Place	Landside Drained Stability Berm
5+00	-	55+00	In Place	Relief Wells with Screen Intervals From -9.5 to -23.5 and -39.5 to -58, Total Well Depth = 70 ft Spaced @ 50 ft
55+00	-	65+00	In Place	Landside Drained Stability Berm

Table 13-7 – Geotechnical Recommendations – Port South Levee

Port South Levee				
Station			Levee	Recommended Improvements
From	-	To		
0+00	-	120+00	In Place	None
120+00	-	130+00	In Place	Cutoff Wall to Elev. -55 ft (70 ft Deep)
130+00	-	189+65	In Place	None

Table 13-8 – Geotechnical Recommendations – Yolo Bypass South – East Levee

Yolo Bypass South - East Levee (Deep Water Ship Channel East Levee)				
Station			Levee	Recommended Improvements
From	-	To		
0+00	-	15+00	In Place	Cutoff Wall to Elev. -100 ft (120 ft Deep)
15+00	-	85+55	In Place	Cutoff Wall to Elev. -110 ft (130 ft Deep)
85+55	-	145+00	In Place	Cutoff Wall to Elev. -30 ft (50 ft Deep)
South Extension			In Place	Levee Degrade and Reconstruction with Landside Slope Flattening (from ±2:1 to 3:1) and Seepage Berm 80 ft wide and Relocate High Line Canal

Table 13-9 – Geotechnical Recommendations – Deep Water Ship Channel West Levee

Deep Water Ship Channel West Levee				
Station			Levee	Recommended Improvements
From	-	To		
0+00	-	35+00	In Place	Cutoff Wall to Elev. -60 ft (85 ft Deep)
35+00	-	60+00	In Place	None
60+00	-	115+00	In Place	Cutoff Wall to Elev. -60 ft (85 ft Deep)
115+00	-	130+00	In Place	None
130+00	-	200+00	In Place	Cutoff Wall to Elev. -30 ft
200+00	-	290+00	In Place	Cutoff Wall to Elev. -55 ft (75 ft Deep)
290+00	-	1133+14	In Place	None

Table 13-10 – Geotechnical Recommendations – Sacramento Bypass North Levee

Sacramento Bypass North Levee				
Station			Levee	Recommended Improvements
From	-	To		
0+00	-	33+66	New Levee	New Levee (20ft Crest Width 3:1 side slopes, inspection trench) with seepage berms 300ft wide. Or New Levee (20ft Crest Width 3:1 side slopes, with Seepage Berm 80ft in width and Cutoff Wall to El. -5ft (20ft deep))

14.0 PROBABILISTIC ANALYSIS

14.1 ANALYSIS METHODOLOGY

Index points were selected for geotechnical analysis to represent the critical surface and subsurface conditions of each planning reach in order to identify the geotechnical deficiencies of the reach. The sections were selected based on previous geotechnical analysis, past levee performance, existing levee improvements, subsurface data, laboratory test results, surface conditions, field reconnaissance, and levee geometry. The ground surface elevations used in the cross-sections were based on the LiDAR and bathymetric surveys. The analysis model stratigraphy was interpreted based on existing boring logs near the index point.

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.

The final result of the FOSM method is a reliability index, Beta (β), representing the amount of standard deviation of the performance function by which the expected value exceeds the limit equilibrium state. The limit equilibrium state was defined using a factor of safety of 1.0. The standard deviation and variance of the performance function are calculated from the standard deviation and variance of the foundation and embankment parameters using the Taylor's series method based on a Taylor's series expansion of the performance function about the expected values. The partial derivatives were calculated numerically using an increment of plus and minus one standard deviation centered on the expected mean value. The variance of the performance function was obtained by summing the products of the partial derivatives of the performance function considering the variance of the corresponding parameters. The probability of poor performance Pr(f) of the levee was expressed as a function of the river water elevation and the random variables of each performance function.

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 levee performance curves should represent probability of poor performance at multiple flood frequencies.

Sudden drawdown conditions may result in levee slope failure but it is unlikely to provide flooding of the area, the failure occurring when the water is at low elevation. Therefore this condition was not considered in the analysis. Additionally, a judgment based conditional probability of poor performance considering the existing and past erosion history of the levee and riverbank, maintenance, seepage/sand boils and sliding historical conditions, encroachments, vegetation on the levee slopes and within the levee critical area, animal burrows and other external damaging conditions were included in the risk and uncertainty analysis.

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 included the ratio of the horizontal permeability of the aquifer to the vertical permeability of the blanket, blanket thickness, and aquifer thickness. Random variables for through-seepage included critical tractive stress, porosity, and intrinsic permeability of the levee embankment material. Random variables for slope stability included effective friction angle, effective cohesion, and total unit weight of the levee embankment, and effective friction angle and cohesion of the foundation material.

It should be noted that poor performance can potentially range in description and severity. This range may include initiation of failure modes which can lead to minimal consequences, which could include seepage with no material being transported or surface slope sloughing. Conversely poor performance can also include levee failure due to slope stability, underseepage, and breach all of which pose a threat to the integrity of the levee during a flood event.

14.1.1 UNDERSEEPAGE

Underseepage analysis was performed using the blanket theory analysis (BTA) as described in the Corps ETL 1110-2-556, EM 1110-2-1913, and TM 3-424. Finite element analyses using the SEEP2D program, part of the GMS version 6.5 software package, were developed to independently check the blanket theory results. In general, the finite element and the empirical seepage calculations supported each other, predicting qualitatively similar results. Statistical analysis was used for each reach in determination of the coefficients of variation and standard deviation of the permeability ratios, blanket thickness and thickness of the underlying aquifer. A critical gradient of 0.80 was used, corresponding to 112pcf unit weight of the blanket. The unit weight of the blanket was considered the same at all index points. Values of vertical and horizontal permeabilities based on material classification and fines content are shown in Table 18-1 below and are based on the many past and ongoing geotechnical studies within the project area.

In comparison to the deterministic analysis which accounts for the most critical geotechnical conditions, the probabilistic analysis methodology accounted for potential subsurface material variations in the project reach in the vicinity of the cross section, and denoted a transformed blanket thickness and associated aquifer thickness using a number of borings near and at the project cross section. As a result, it may be possible that the transformed blanket thickness carried forward into the blanket theory calculation for underseepage gradients was greater than the deterministic value. This difference may yield opposing results in comparison between probabilistic and deterministic evaluations.

Table 14-1: Vertical and Horizontal Hydraulic Conductivity

Material Type	Soil Description	Hydraulic Conductivity				
		K_H (cm/sec)	K_H (ft/day)	K_H/K_V	K_V (cm/sec)	K_V (ft/day)
Clay	Blanket ≥10ft Thick	1.0E-05	0.028	4	2.5E-06	0.0071
	Blanket 5ft<>10ft Thick	1.0E-05	0.028	1	1.0E-05	0.028
	Blanket ≤5ft Thick	1.0E-05	0.028	0.1	1.0E-04	0.28
Silt	Elastic (plastic)	5.0E-05	0.14	4	1.3E-05	0.035
	Non-plastic	2.0E-04	0.57	4	5.0E-05	0.14
Clayey Sand to Sand	30-49% fines	5.0E-05	0.14	4	1.3E-05	0.035
	13-29% fines	1.0E-04	0.28	4	2.5E-05	0.071
	8-12% fines	1.0E-03	2.8	4	2.5E-04	0.71
	0-7% fines	5.0E-03	14	4	5.0E-04	3.5
Silty Sand to Sand	30-49% fines	5.0E-04	1.4	4	1.3E-04	0.35
	13-29% fines	1.0E-03	2.8	4	2.5E-04	0.71
	8-12% fines	5.0E-03	14	4	5.0E-04	3.5
	0-7% fines	1.0E-02	28	4	1.0E-03	7.1

Table 14-1: Vertical and Horizontal Hydraulic Conductivity (continued)

Material Type	Soil Description	Hydraulic Conductivity				
		K_H (cm/sec)	K_H (ft/day)	K_H/K_V	K_V (cm/sec)	K_V (ft/day)
Gravel	28-49% fines	4.0E-04	1.13	4	1.0E-04	0.28
	18-27% fines	1.0E-03	2.8	4	2.5E-04	0.71
	13-17% fines	6.0E-03	17	4	6.0E-04	4.3
	8-12% fines	1.2E-02	34	4	1.2E-03	8.5
	0-7% fines	2.5E-02	71	4	2.5E-3	17.8

14.1.2 THROUGH SEEPAGE

Levees constructed either of fine grained clays, having stability berms with drainage layers extended along the levee slope that captures any seepage through the levee, or having cutoff walls constructed through the levee embankment are unlikely to be susceptible to through-seepage caused internal erosion. Levees of silt, silty sand, and sand were considered to be susceptible to internal erosion and were evaluated using the modified Khilar, Folger, and Gray internal erosion model as prescribed in ETL 1110-2-556. Using this method the critical gradient through the levee embankment was calculated based on variations in the critical tractive stress, porosity, and intrinsic permeability of the levee material and compared with the predicted horizontal gradient through the levee embankment from the SEEP2D model. Table 14-2 shows the mean values of the random variables of the levee embankment material used to calculate the critical gradient were critical tractive stress (dynes/cm^2) which was taken as ten times the d_{50} (mm), the porosity based on material classification as proposed by Weight and Sonderegger in “Manual of Applied Hydrology”, and intrinsic permeability was taken as approximately 1x10^{-5} times the horizontal permeability (cm/sec). Table 14-3 presents coefficients of variation for the through-seepage analysis random variables that were obtained using methodologies outlined in ETL 1110-2-556.

Table 14-2: Through-Seepage Random Variables

Material	Tractive Stress (dynes/cm^2)	Porosity (%)	Intrinsic Permeability (cm^2)
Clay	0.3 - 0.4	40 - 70	1.0E-10
Silt	0.5 - 0.7	35 - 50	2.0E-9 – 5.0E-10
Sand	1.0 - 3.0	25 - 50	1.0E-6 – 5.0E-9
Gravel	Not Used	20 - 40	2.5.0E-6 – 4.0E-9
Sand and Gravel	Not Used	15 - 35	

Table 14-3: Variation of Through-Seepage Random Variables

Random Variable	Coefficient of Variation (%)
Critical Tractive Stress (T_c)	10
Porosity (n)	10
Intrinsic Permeability (K_o cm^2)	30

14.1.3 LANDSIDE SLOPE STABILITY

The cases analyzed for stability risk analyses considered long-term conditions with steady state seepage along the landside slope of the levee. The phreatic surface and pore water pressures for the different water surface elevations were developed for the steady state condition using the SEEP2D finite element computer program developed as part of the GMS, version 6.5. The limit equilibrium computer program UTEXAS4 was used to perform the stability analyses. Circular failure surfaces were assumed and the embankment was modeled as homogeneous. All analyses consisted of running a search routine to identify the critical failure surface using the Spencer’s Method.

A sensitivity study was done to determine which parameters in the slope stability calculations were most influential. For this study, the considered variables are soil strength and unit weights of the soil in the levee embankment and soil strength in the foundation. Statistical descriptors for these variables were determined using available site-specific information and published statistical data. The piezometric lines or pore water pressures for each water elevation were determined using the finite element program SEEP2D for the levee embankment and its foundation.

Soil strength parameters used in the stability analyses were the drained soil parameters, as shown in Table 14-4. The values in Table 14-4 were based on a generalized conservative assumption of shear strength by soil type from previous studies in the project area. For each index point the generalized assumption was compared with available field and laboratory testing from nearby explorations. The coefficients of variation for soil strength parameters and unit weight of the fill material in the levee or the top impervious blanket are shown in Table 14-5 and were obtained using methodologies outlined in ETL 1110-2-556, and those proposed by Harr in the

“Reliability-Based Design in Civil Engineering”, and Duncan in the “Manual for Geotechnical Engineering Reliability Calculations”.

Table 14-4: Drained Shear Strength of Soil

Material Type	Soil Description	Shear Strength		
		C'	**Φ' (°)**	**γ(pcf)**
Cutoff Wall	SCB, SB, CB	50	0	85
Clay	CH Levee Embankment	100	22	115
	CH Foundation	100	26	115
	CL Levee Embankment	50	24	115
	CL Foundation	50	28	115
Silt	ML Levee Embankment-	0	28	115
	ML Foundation	0	30	120
Clayey Sand and Silty Sand	-	0	33	125
Sand	-	0	35	130
Gravel and Drain Rock	-	0	35	135

Table 14-5: Variation of Drained Shear Strength Parameters

Random Variable	Coefficient of Variation (%)
Effective Friction Angle (Φ)	13
Effective Cohesion (c psf)	40
Total Unit Weight (γ pcf)	7

14.1.4 JUDGMENT

A judgment based conditional probability function was based on existing conditions of the levee such as encroachments on the levee slopes, vegetation on the levee slopes, existing cracks and holes due to animal burrows, and based on 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 judgment based curve is included for each analyzed levee cross section and in the combined curve of failure.

In June 2009, an expert elicitation was conducted for the purpose of developing the geotechnical judgment portion of the curves for the American River Common Features project, the meeting minutes are included as Enclosure 6. In relation to physical location, both the American River Common Features and West Sacrament Project are in close proximity to one another, lying on both the east and west of the Sacramento River. The findings of the expert elicitation were considered to be applicable as similar conditions are present in the West Sacramento Project area. The expert elicitation was conducted in accordance with ETL 1110-2-561, "Appendix E, Expert Elicitation in Geological and Geotechnical Applications" 31 January 2006. The members of the expert elicitation team were highly recognized professional specialists, representing the Reclamation Districts managing and operating the levee system, and specialists in erosion and in geotechnical issues. The expert elicitation focused on the judgment part of the geotechnical risk and uncertainty curves for the flood control structures. The expert elicitation was conducted over a three-day period in which the most representative reaches of each basin of the study were discussed. The expert elicitation team discussed and reached consensus on the impact of different factors of the judgment curve, such as:

a) The vegetation on the levees and within the levee right of way
b) Penetrations through the levee and foundation
c) Encroachments into the levee and levee right-of-way
d) Erosion of the riverbank and waterside slopes of the levee
e) Animal burrows

The conclusion reached by the panel was that the probability of poor performance, as a function of stage of the river, may be reduced by 50% when the river reached 4-5 feet above the landside toe, by 30% when the river stage is up to 8-9 feet above the landside levee toe, and by 10% when the river reaches 11-12 feet above the landside toe. This conclusion was considered to be applicable to each of the contributing factors on the judgment curve and the probabilities adjusted accordingly.

14.1.5 COMBINED CURVES

The total conditional probability of poor performance as a function of floodwater elevation has been developed by combining the probability of failure functions for four failure modes; underseepage, through-seepage, slope instability, and judgment.

14.2 LEVEE PERFORMANCE CURVES

The results of the geotechnical risk and uncertainty analyses are briefly discussed in the following sections. As previously discussed, underseepage, through seepage, and slope stability probabilities of poor performance were calculated analytically based on site specific subsurface information used to select material parameters and coefficients of variation. Included as Enclosure 4 are the spreadsheet analyses used to calculate the probabilities of poor performance, these spreadsheets include data from borings used to select parameters, the selected parameters, and the calculated results. The judgment curve remains as the non analytical component to the curve, those probabilities of failure were based on site specific conditions regarding vegetation, penetrations, encroachments, erosion and animal burrows. The reach description section of this report described in general terms the levee conditions regarding vegetation, penetrations, encroachments, and animal burrows. The erosion section of this report described the general erosion conditions for each reach. It should be noted that the subsurface conditions are compiled using geotechnical investigations at and adjacent to the analysis section and it may conclude that a variation in description of the subsurface is present when compared to the deterministic analysis section which accounts for the most critical geotechnical conditions. As such, the results may differ with respect to one another probabilistically and deterministically.

14.2.1 NORTH BASIN – SACRAMENTO RIVER WEST LEVEE – STA. 96+00

Borings chosen to be used in probabilistic analyses resulted in a mean blanket thickness value of 23.0 ft with a coefficient of variation of 17, and a mean aquifer thickness of 58.0 ft with a coefficient of variation of 12. The blanket was comprised of predominantly silts and lean clays. The aquifer was made up of poorly graded sands.

Probabilistic analyses resulted in potential poor performance due to landside slope stability yielding a Pr(f) of 93.7% at the crest. The without project judgment based probability portion of the curve was comprised mainly of erosion, and encroachments, accounting for 20.0% and 3.0% respectively at the crest. Overall judgment based contributions account for a Pr(f) of 24.7% of the without project combined curve at the levee crest. Figure 14-1 presents the without project conditions combined curve.

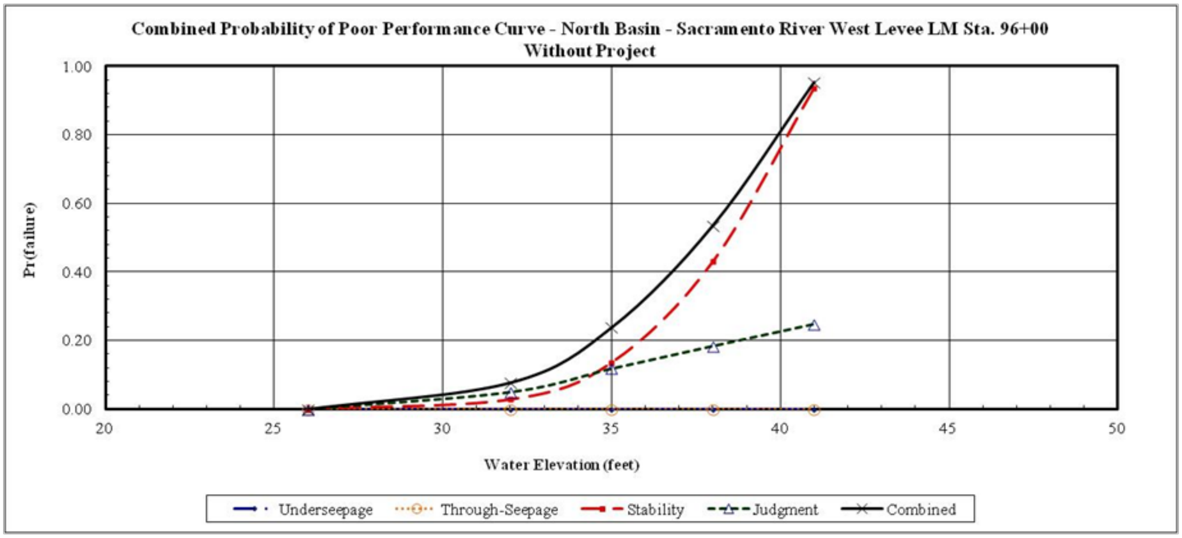

Figure 14-1: Combined Probability of Poor Performance for Without Project Conditions

With project improvement measures reduce judgment based probability due to erosion to a Pr(f) of 2.0% by placing rip rap erosion protection, and mitigate slope stability at the levee crest. Additionally, incorporation of a cutoff wall in this location addresses excess pore water pressure that lead to landside levee slope instability. Figure 14-2 presents the with project conditions combined curve.

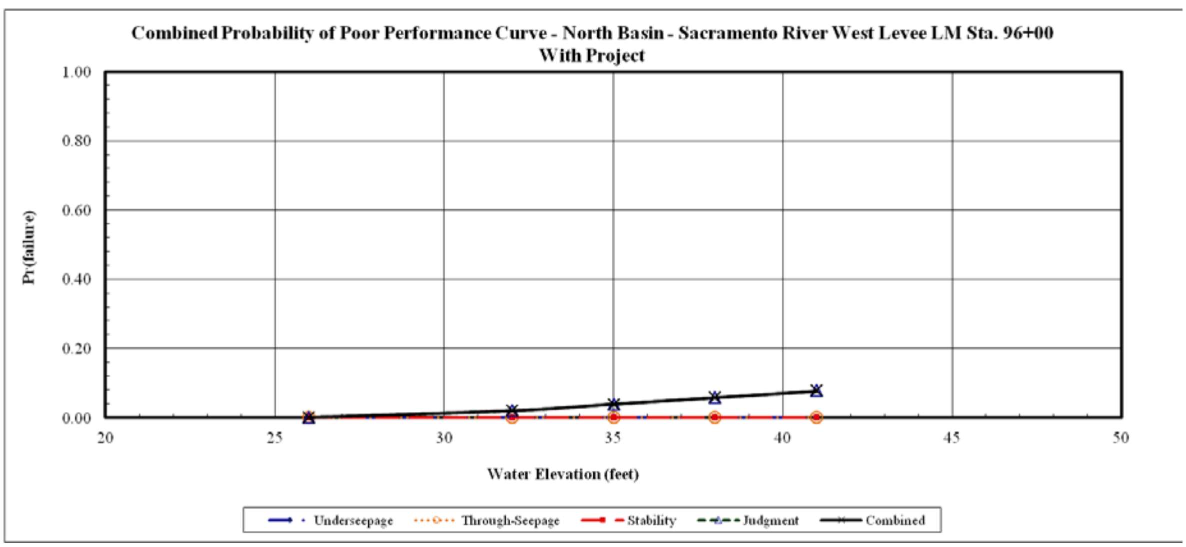

Figure 14-2: Combined Probability of Poor Performance for With Project Conditions

14.2.2 NORTH BASIN – SACRAMENTO RIVER WEST LEVEE – STA. 190+00

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 0, and a mean aquifer thickness of 63.0 ft with a coefficient of variation of 5. The blanket was comprised of predominantly silts and lean clays. The aquifer was made up of poorly graded silty sands.

Probabilistic analyses resulted in potential poor performance due to landside slope stability yielding a Pr(f) of 87.9% at the crest. The without project judgment based probability portion of the curve was comprised mainly of erosion, and encroachments, accounting for 20.0% and 3.0% respectively at the crest. Overall judgment based contributions account for a Pr(f) of 35.6% of the without project combined curve at the levee crest. Figure 14-3 presents the without project conditions combined curve.

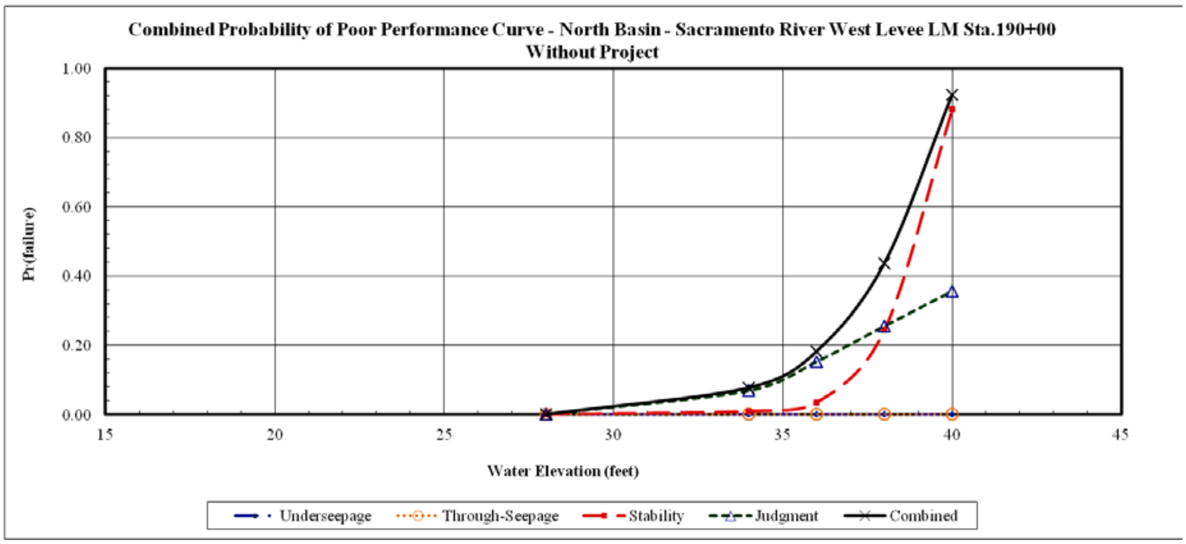

Figure 14-3: Combined Probability of Poor Performance for Without Project Conditions

With project improvement measures reduce judgment based probability due to erosion to a Pr(f) of 2.0% by placing rip rap erosion protection and mitigate slope stability at the levee crest and encroachments are reduced to a Pr(f) of 2.0%. The overall judgment based contribution account for a Pr(f) of 8.0%. Figure 14-4 presents the with project conditions combined curve.

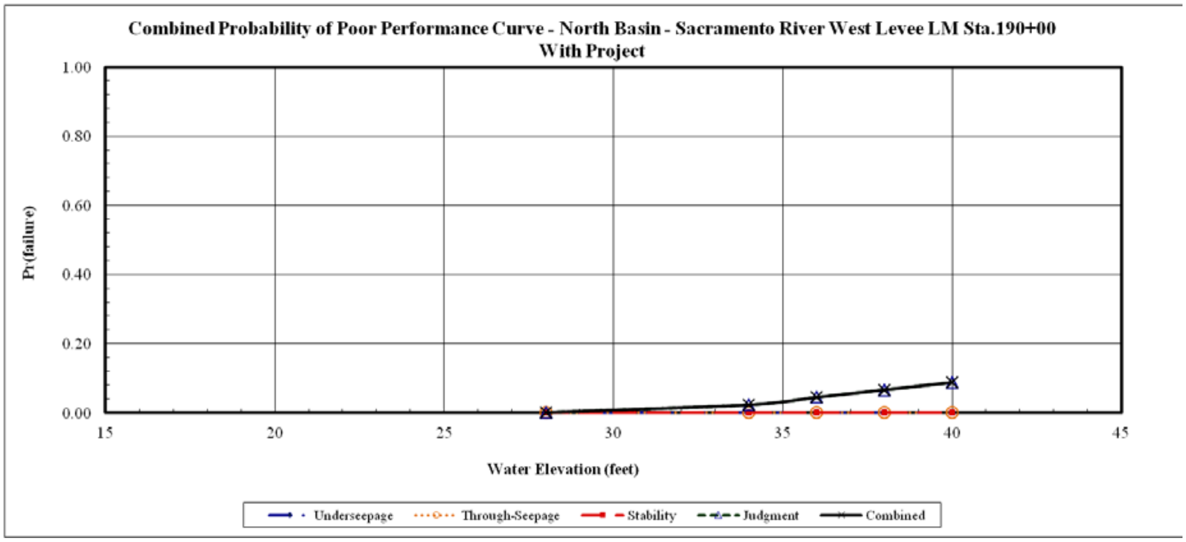

Figure 14-4: Combined Probability of Poor Performance for With Project Conditions

14.2.3 NORTH BASIN – YOLO BYPASS EAST LEVEE – STA. 107+31

Borings chosen to be used in probabilistic analyses resulted in a mean blanket thickness value of 22.0 ft with a coefficient of variation of 14, and a mean aquifer thickness of 27.0 ft with a coefficient of variation of 15. The blanket was comprised of predominantly fat clay. The aquifer was made up of poorly graded sand.

Probabilistic analyses resulted in potential poor performance due to underseepage and landside slope stability and yielding a Pr(f) of 99.57% and 88.7% at the crest respectively. The without project judgment based probability portion of the curve was comprised mainly of vegetation, and erosion, accounting for 5.0% and 4.0% respectively at the crest. Overall judgment based contributions account for a Pr(f) of 14.2% of the without project combined curve at the levee crest. Figure 14-5 presents the without project conditions combined curve.

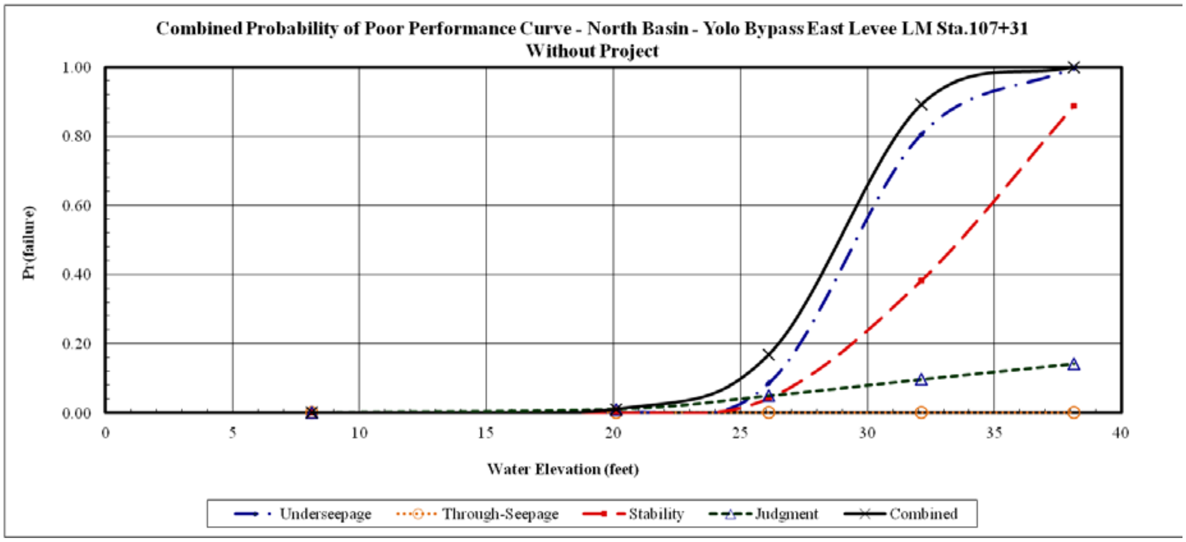

Figure 14-5: Combined Probability of Poor Performance for Without Project Conditions

With project conditions analyses were completed with the incorporation of embankment fill and drain. This improvement mitigated underseepage and landside slope stability concerns. With project improvement measures reduce judgment based probability due to vegetation to a Pr(f) of 1.0%. Figure 14-6 presents the with project conditions combined curve.

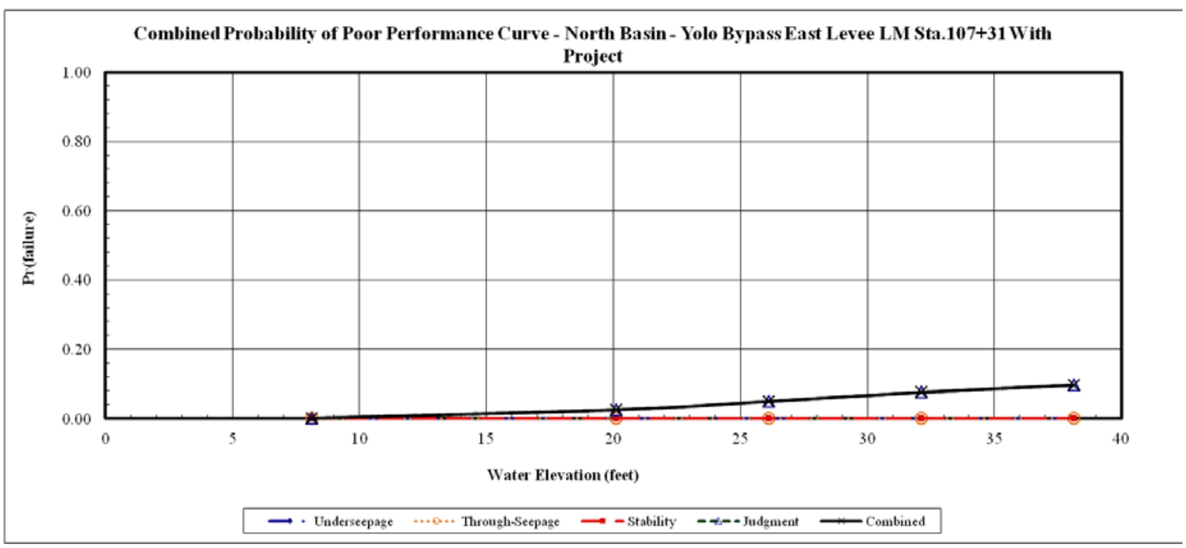

Figure 14-6: Combined Probability of Poor Performance for With Project Conditions

14.2.4 NORTH BASIN – SACRAMENTO BYPASS SOUTH LEVEE – STA. 52+00

Borings chosen to be used in probabilistic analyses resulted in a mean blanket thickness value of 36.0 ft with a coefficient of variation of 25, and a mean aquifer thickness of 36.0 ft with a coefficient of variation of 50. The blanket was comprised of predominantly lean clay. The aquifer was made up of poorly graded sands and well graded gravels.

Probabilistic analyses resulted in potential poor performance due to landside slope stability yielding a Pr(f) of 42.9% at the crest. The without project judgment based probability portion of the curve was comprised mainly of utilities, accounting for 5.0% at the crest. Overall judgment based contributions account for a Pr(f) of 5.0% of the without project combined curve at the levee crest. Figure 14-7 presents the without project conditions combined curve.

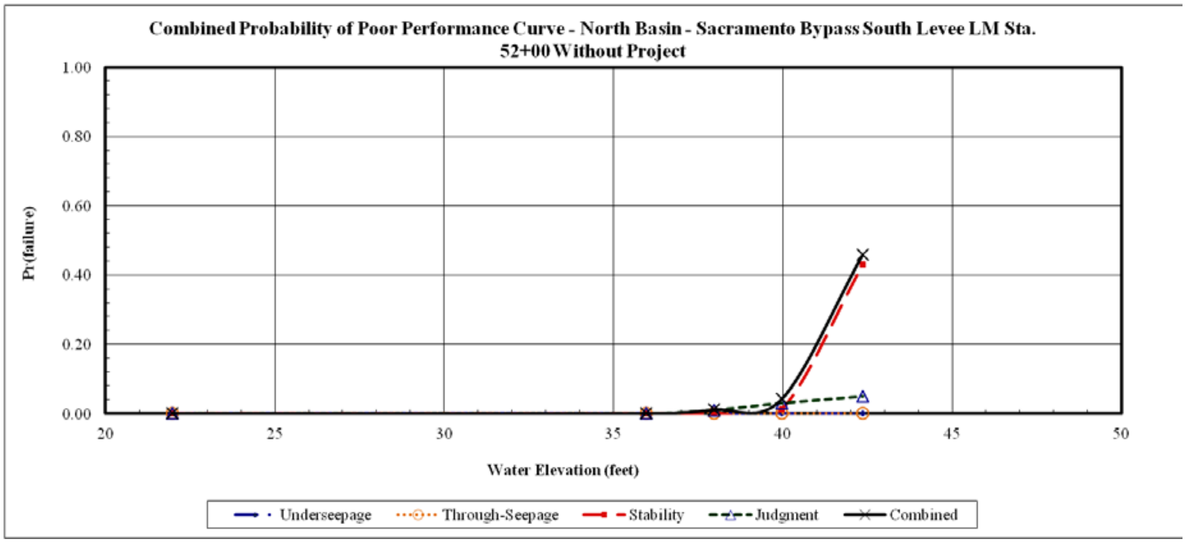

Figure 14-7: Combined Probability of Poor Performance for Without Project Conditions

With project conditions analyses were completed with the incorporation of a cutoff wall in this location to address excess pore water pressure that may lead to slope instability concerns of the landside levee slope. This improvement mitigated landside slope stability concerns. Figure 14-8 presents the with project conditions combined curve.

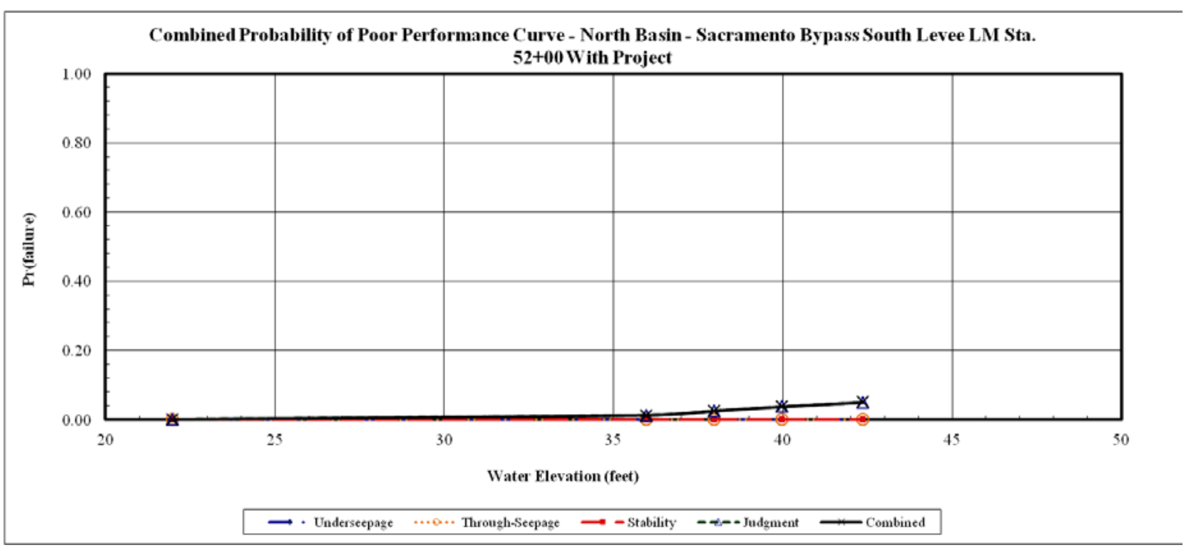

Figure 14-8: Combined Probability of Poor Performance for With Project Conditions

14.2.5 SOUTH BASIN – SACRAMENTO RIVER WEST LEVEE – STA. 264+00

Borings chosen to be used in probabilistic analyses resulted in a mean blanket thickness value of 16.0 ft with a coefficient of variation of 31, and a mean aquifer thickness of 50.0 ft with a coefficient of variation of 46. The blanket was comprised of predominantly lean clays and silts. The aquifer was made up of poorly graded sand and poorly graded silty sands.

Probabilistic analyses resulted in potential poor performance due to underseepage and landside slope stability and yielding a Pr(f) of 40.63% and 19.6% at the crest respectively. The without project judgment based probability portion of the curve was comprised mainly of vegetation accounting for 3.0% at the crest. Overall judgment based contributions account for a Pr(f) of 5.9% of the without project combined curve at the levee crest. Figure 14-9 presents the without project conditions combined curve.

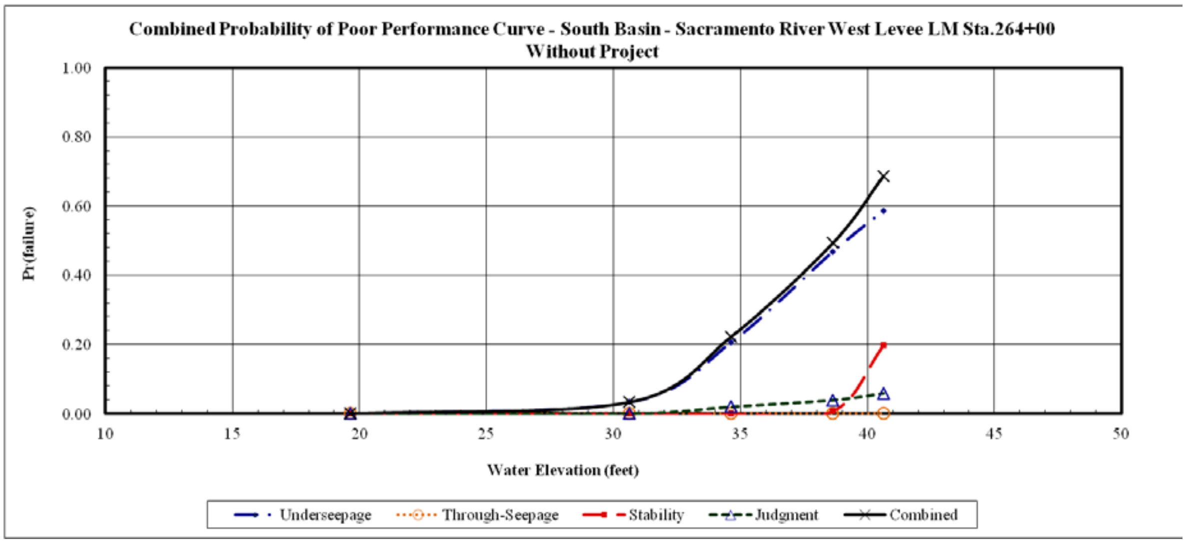

Figure 14-9: Combined Probability of Poor Performance for Without Project Conditions

With project conditions analyses were completed with the incorporation of an underseepage cutoff wall and seepage berm. These improvements mitigated underseepage and landside slope stability concerns. With project improvement measures reduce judgment based probability due to vegetation to a Pr(f) of 1.0%. Figure 14-10 presents the with project conditions combined curve.

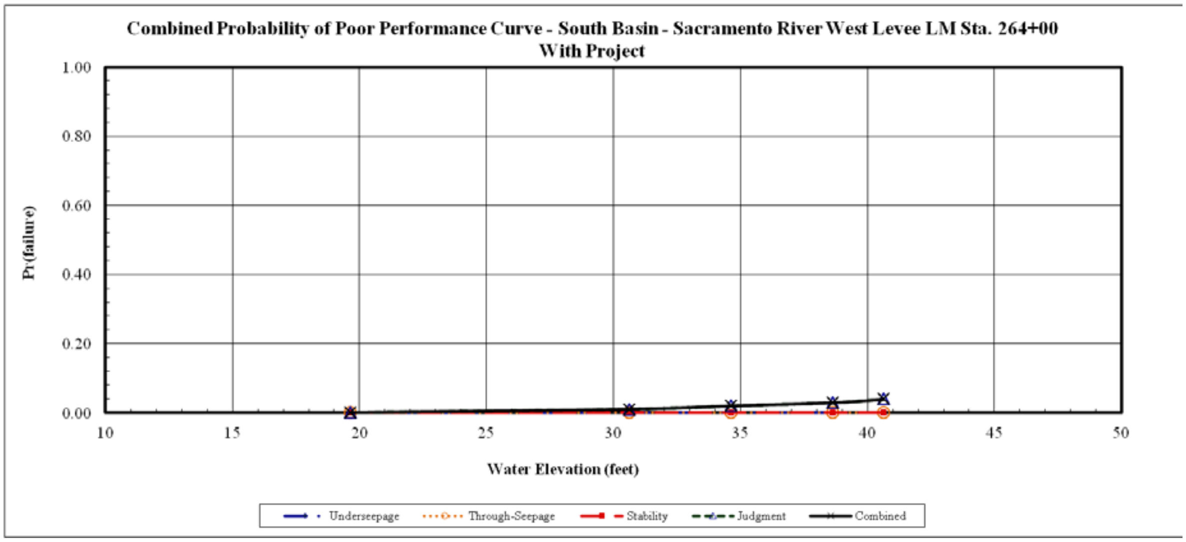

Figure 14-10: Combined Probability of Poor Performance for With Project Conditions

14.2.6 SOUTH BASIN – SACRAMENTO RIVER WEST LEVEE – STA. 80+00

Borings chosen to be used in probabilistic analyses resulted in a mean blanket thickness value of 24.0 ft with a coefficient of variation of 50, and a mean aquifer thickness of 39.0 ft with a coefficient of variation of 36. The blanket was comprised of predominantly silt. The aquifer was made up of poorly graded sand, poorly graded silty sands, and silty sand.

Probabilistic analyses resulted in potential poor performance due to underseepage yielding a Pr(f) of 9.6%. The without project judgment based probability portion of the curve was comprised mainly of vegetation accounting for 5.0% at the crest. Overall judgment based contributions account for a Pr(f) of 13.3% of the without project combined curve at the levee crest. Figure 14-11 presents the without project conditions combined curve.

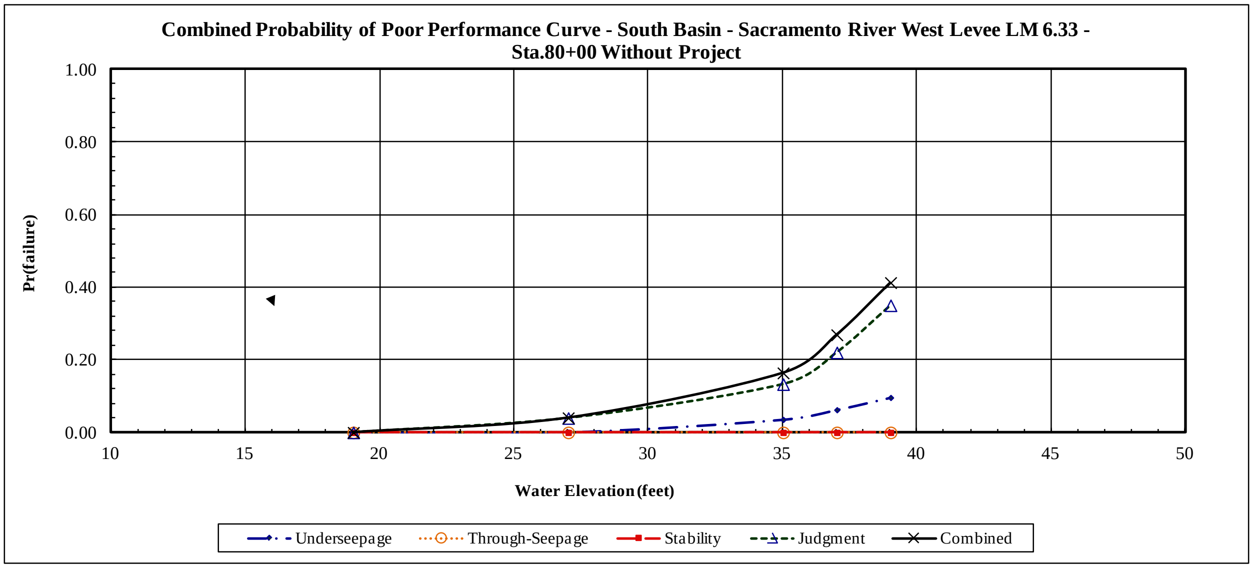

Figure 14-11: Combined Probability of Poor Performance for Without Project Conditions

With project conditions analyses were completed with the incorporation of an underseepage cutoff wall. These improvements mitigated underseepage and landside slope stability concerns by addressing excess pore water pressure that may develop leading to slope instability concerns of the landside levee slope. Figure 14-12 presents the with project conditions combined curve.

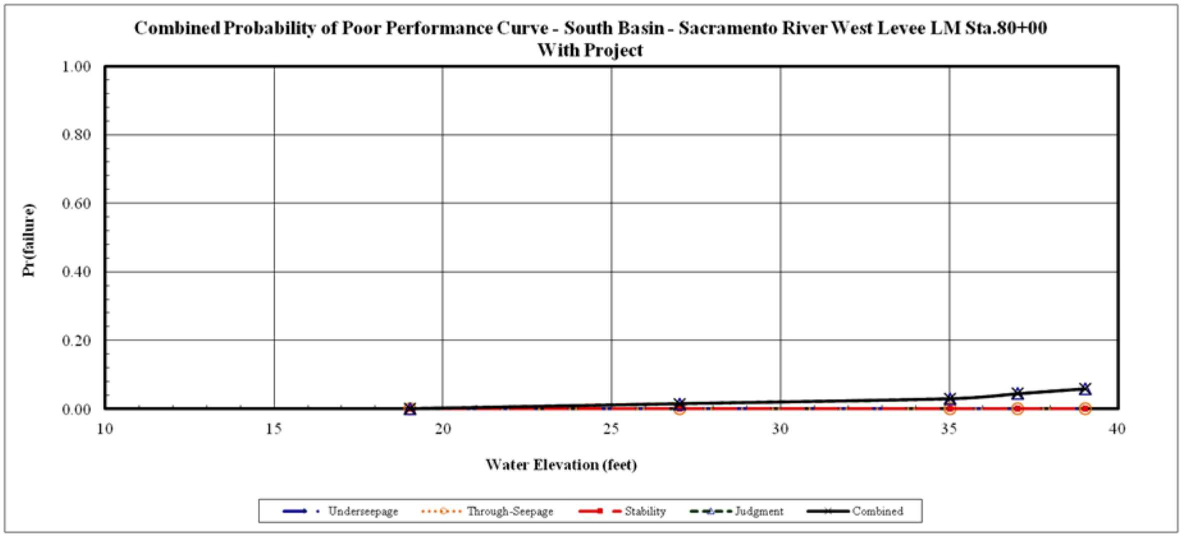

Figure 14-12: Combined Probability of Poor Performance for With Project Conditions

14.2.7 SOUTH BASIN – DEEP WATER SHIP CHANNEL WEST LEVEE – STA. 12+00

Borings chosen to be used in probabilistic analyses resulted in a mean blanket thickness value of 11.0 ft with a coefficient of variation of 18, and a mean aquifer thickness of 40.0 ft with a coefficient of variation of 10. The blanket was comprised of predominantly lean and fat clays. The aquifer was made up of poorly graded silty sands.

Probabilistic analyses resulted in potential poor performance due to underseepage and landside slope stability and yielding a Pr(f) of 99.0% and 3.0% at the crest respectively. The without project judgment based probability portion of the curve was comprised mainly of erosion accounting for 20.0% at the crest. Overall judgment based contributions account for a Pr(f) of 35.0% of the without project combined curve at the levee crest. Figure 14-13 presents the without project conditions combined curve.

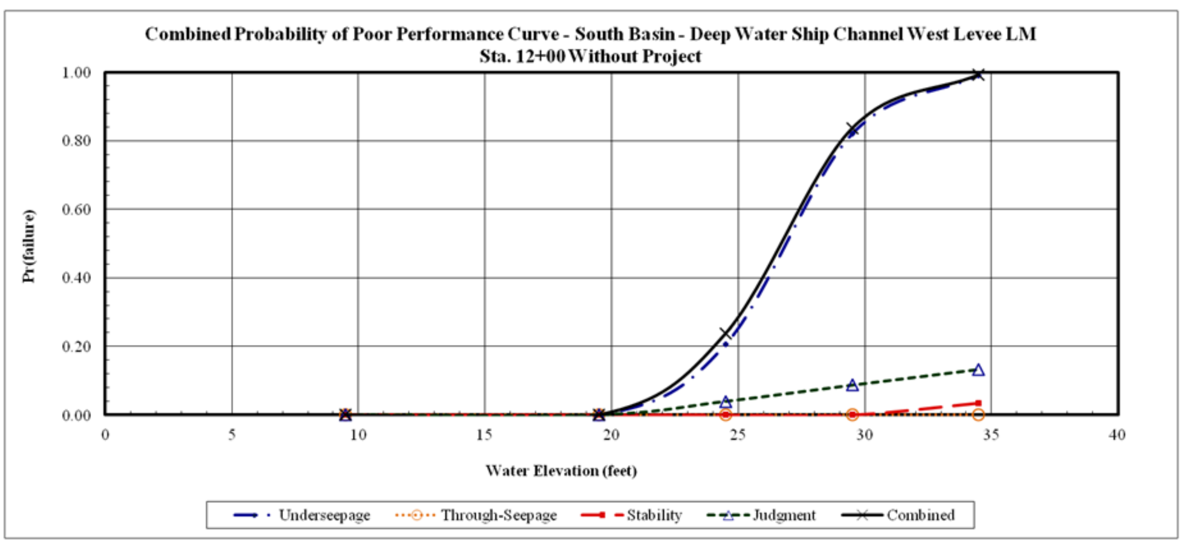

Figure 14-13: Combined Probability of Poor Performance for Without Project Conditions

With project conditions analyses were completed with the incorporation of an underseepage cutoff wall and seepage berm. These improvements mitigated underseepage and landside slope stability concerns. The remaining probability of failure was primarily attributed to the judgment based failure mode of erosion, is proposed to be mitigated through the placement riprap erosion protection. With project improvement measures reduce erosion to a Pr(f) of 2.0% at the levee crest. Figure 14-14 presents the with project conditions combined curve.

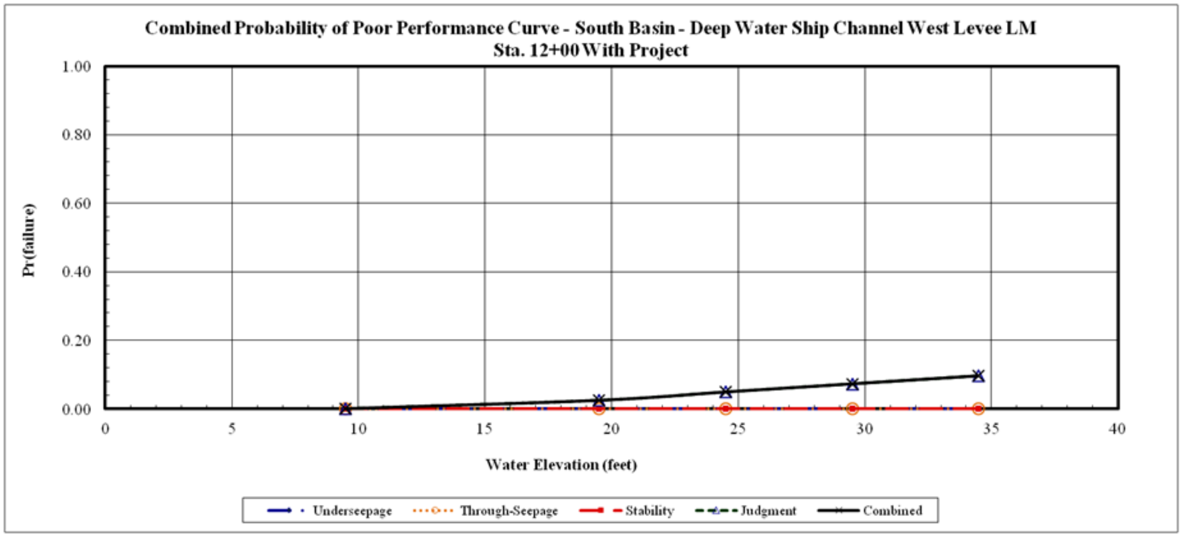

Figure 14-14: Combined Probability of Poor Performance for With Project Conditions

14.2.8 SOUTH BASIN – PORT SOUTH LEVEE – STA. 123+55

Borings chosen to be used in probabilistic analyses resulted in a mean blanket thickness value of 18.0 ft with a coefficient of variation of 67, and a mean aquifer thickness of 22.0 ft with a coefficient of variation of 14. The blanket was comprised of predominantly fat clays. The aquifer was made up of poorly graded sands.

Probabilistic analyses resulted in potential poor performance due to underseepage yielding a Pr(f) of 13.2% at the crest. The without project judgment based probability portion of the curve was comprised mainly of erosion accounting for 5.0% at the crest. Overall judgment based contributions account for a Pr(f) of 10.6% of the without project combined curve at the levee crest. Figure 14-15 presents the without project conditions combined curve.

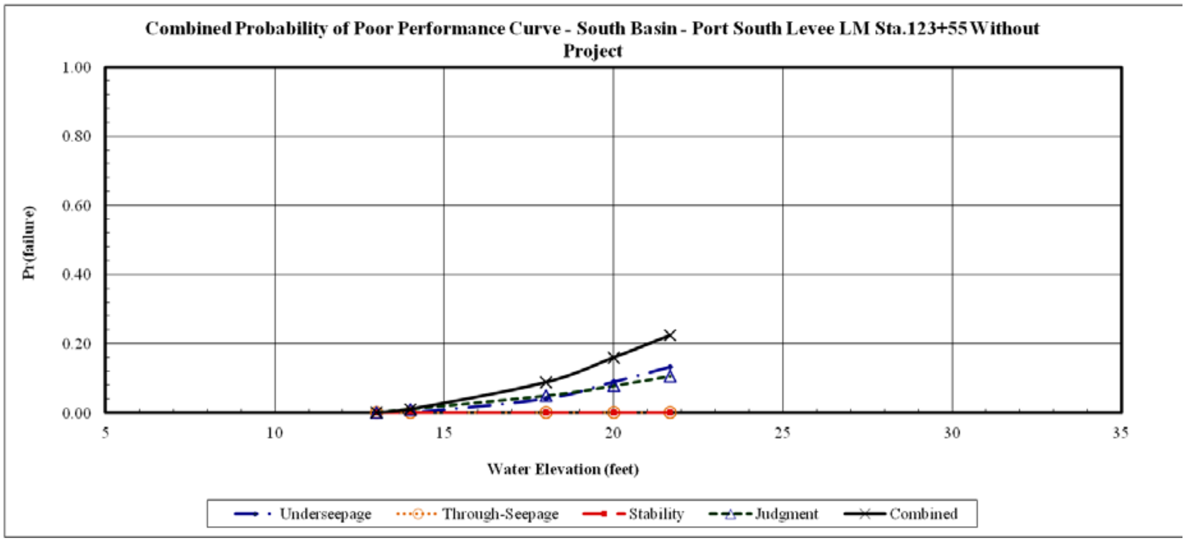

Figure 14-15: Combined Probability of Poor Performance for Without Project Conditions

With project conditions analyses were completed with the incorporation of an underseepage cutoff wall. These improvements mitigated underseepage concerns. The remaining probability of failure was primarily attributed to the judgment based failure mode of erosion, is proposed to be mitigated through the placement riprap erosion protection. Figure 14-16 presents the with project conditions combined curve.

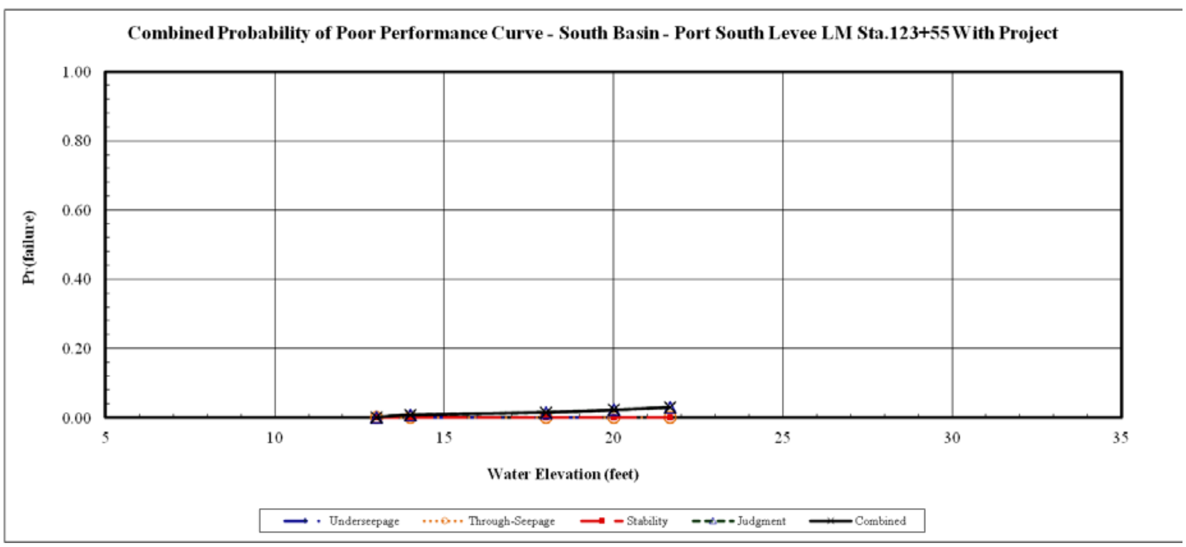

Figure 14-16: Combined Probability of Poor Performance for With Project Conditions

15.0 MATERIAL REQUIREMENTS

15.1 MATERIAL SPECIFICATIONS

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 following section describes proposed minimum material requirements.

15.1.1 TYPE I LEVEE FILL (SELECT LEVEE FILL)

The Sacramento District, Geotechnical Engineering Branch, SOP-03 established the requirements of engineered fill to be used for the construction of the levee embankments. This is referred to as either Type I Levee Fill or as Select Levee Fill and meets the following requirements:

- 100% passing the 2-inch sieve
- minimum 20% fines content (silt and clay size particles)
- fines must have a liquid limit less than 45 and a plasticity index between 7 and 15
- no organic material or debris may be present

15.1.2 RANDOM FILL

It is acknowledge that not all improvement features will require Type I Levee Fill and that a less stringent material specification is required for seepage berms, stability berms, and in some cases reconstructed embankment slopes. The actual specification of this material will be based on the type of material available at project borrow sites, but in general shall conform to the following requirements;

- 100% passing the 2-inch sieve
- minimum 12% fines content (silt and clay size particles)
- no organic material or debris may be present

15.1.3 RIP-RAP

Since 1936 the Sacramento District has placed rock erosion protection on the banks and levees of the Sacramento River and associated tributaries. The SRBPP uses a standard rip-rap and filter gradation for repair sites which may be appropriate within the ARCF GRR study area. However, Civil Design Section A, Sacramento District calculated rip-rap requirements for a typical channel section with an average channel velocity of 7.0 fps and one for 12.0 fps. The resulting D100 were 18.0 and 36.0 inches with D15 of 7.1 and 14.3 inches respectively. The actual gradations will be determined during design but the rip-rap should be angular in shape, sound, durable, and hard. Rip-rap should also be free from laminations, weak cleavages, undesirable weather, or blasting or handling induced fractures. The rip-rap stone should be of such character that it will not disintegrate from the action of air, water, or the conditions of handling and placing and should be free from earth, clay, refuse, or adherent coatings.

15.2 ANTICIPATED BORROW SITES

As stated previously, significant quantities of engineered fill of various specifications and rock erosion protection will be required to construct the proposed project. 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. Test pits and laboratory testing on materials collected from were provided by SAFCA as part of the NLIP 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.

15.2.1 DESKTOP REGIONAL BORROW STUDY

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.

The NCSS is a nationwide partnership of federal, regional, state and local agencies; and private entities and institutions, led by the NRCS for the USDA, that work together to cooperatively investigate, inventory, document, classify, interpret, disseminate, and publish information about soils of the United States. The NCSS data was obtained from the Soil Data Mart, http://soildatamart.nrcs.usda.giv, in the Soil Survey Geographic Database (SSURGO) format for Placer, Sutter, Sacramento, Yolo, and Solano Counties. This data set consisted of georeferenced digital map data (polygons of soil map unit [MUSYM] boundaries) and computerized attribute data (engineering properties, agricultural properties, etc). The MUSYM were linked to attributes in a relational database, which gave the proportionate extent of the component soils and their properties. The NCSS data delineated the MUSYM (typically several named soils) into specific depth horizons (layers) giving soil properties to each horizon. The NCSS data was reduced to only those units and horizons which met material requirements for Type I Levee Fill.

After merging the polygons of NCSS MUSYM that met Type I Levee Fill requirements with polygons representing areas of open or agricultural land, acreages of potential borrow sites could be calculated from the coincident polygons. To obtain an approximate available volume for each of the potential borrow sites, a thickness of suitable material had to be chosen. The reduced NCSS data was sorted by thickness and MUSYM and split into two groups, units with greater than or equal to 30-inches and units with less than 30-inches of suitable thickness. The first group was termed to have a high confidence in obtaining Type I Levee Fill and the second group was termed as having low confidence in obtaining Type I Levee Fill. The mean thickness of the high confidence group was 42-inches and the mean thickness of the low confidence group was 12-inches. A shrinkage of 30% was assumed given potential transportation loss and assuming a relative compaction of 85% of the native materials at the borrow site. Volumes were then calculated in million cubic yards (MCY) for each group. The total available quantity of potential soil borrow was calculated to be 212 MCY over 105,000 acres. Plates 6 and 7 show the high confidence and low confidence areas of potential borrow sites.

In subsequent design phases, futher detailed analysis efforts encompassing greater vertical depths, of greater than 3 feet, will be considered with respect to borrow.

15.2.2 FISHERMAN LAKE COMPLEX BORROW SITE

The borrow site is located south of Del Paso Road, north of Radio Road and east of Power Line Road, about 400 feet east of the proposed landside levee toe in the vicinity of the Pumping Plant No. 3. The area is near the historical Fisherman Lake and is reclaimed for agricultural purpose. This borrow site will be used for construction of the adjacent levee landside of the existing levee and for the seepage berms on the landside levee slope on the east bank of the Sacramento River and north bank of the American River levee remediation. The materials found in the proposed borrow area contains clays with low and high plasticity, silts and some sandy clays and silts.

15.2.3 SOUTH SUTTER BORROW SITE

The borrow site is located east of the Sacramento River East Levee, north of Elkhorn Boulevard, south of Teal Bend, west of the Sacramento International Airport, at approximate 500 feet from the levee landside toe. The material in this borrow area consists of lean clays, lean clays with sand, some high plasticity clays, silts and sandy silt, and poorly graded sand. The material from this borrow area may be used for the adjacent levee and seepage berms along the Sacramento River east bank levee, with the condition that the high plasticity berm is used only in the working platform for the seepage cut-off wall. The area is mainly agricultural land within 2 miles from the Sacramento Airport which regulates the land use. Special approval and conditions are required by the Federal Aviation Administration to be respected if the borrow area is used.

15.2.4 NORTH AIRPORT BORROW SITE

The North Airport borrow site is located about a half of mile east of the Sacramento River east bank levee, north of the Sacramento International Airport. The area is also located within 2 miles from the Sacramento International Airport and consequently the same requirements of the Federal Aviation Administration should be meet if the borrow area is used. The borrow area is currently agricultural land and is designated as buffer lands for the Airport runway approaches, the purpose of it being to prevent land uses that are incompatible with Airport runways. Materials encountered in the borrow area consist of low plasticity clays, sandy clay, some higher plasticity clays, silty clay, sandy silt and clayey sand. The material may be used for the construction of the adjacent levee on the landside of the Sacramento River east bank levee and American River north bank levee and for the landside seepage berms.

15.2.5 BROOKFIELD BORROW SITE

The borrow site is located at the corner of the Pleasant Grove Creek Canal where it meets the Natomas Cross Canal within the Natomas basin, approximate 300 feet from the levee landside toe. The land is used for agriculture. Testing of the materials in the borrow area shows the material consisting of mainly low plasticity clay with less than 5 % of higher plasticity clay (with the LL less than 55), some sandy or silty clay and silts. The material may be used for remediation of the Natomas Cross Canal south bank levee and for the Pleasant Grove Creek Canal west bank levee.

15.2.6 TRIANGLE BORROW SITE

The borrow area is located east of the Natomas Basin, outside the protected area, south of the Natomas Cross Canal. This area is proposed to be used in case the material from the other borrow areas is insufficient. There were no sample collected from the area and no testing on the material. However, based on geomorphologic studies the material in the upper 5-10 feet is suitable for levee construction.

15.2.7 DEEP WATER SHIP CHANNEL BORROW SITE

The Deep Water Ship Channel (DWSC) navigation levee was constructed on the east side of the City of West Sacramento near the Yolo Bypass and has been used for disposal of dredged soils from the DWSC. This dredge disposal material placed on the waterside of the navigation levee has been proposed as a potential borrow source for several levee construction projects and was investigated for suitability of materials in July of 2009 by the Sacramento District and again in May of 2010 by Ayres and Associates for the Sacramento Districts. Both studies found that the majority of material is composed of highly plastic clays and silts and does not meet the requirements of SOP-003. Consequently, without some modification, such as lime or fly ash stabilization, the DWSC dredge disposal areas cannot be used for levee construction. Based on the 2010 Ayres and Associates report, it is projected that approximately 400,000 cubic yards of material is available at this borrow site.

15.2.8 COMMERCIAL BORROW SOURCES

Several privately owned and operated commercial soil borrow sites are located within approximately 30 to 50 miles of the study area, within the unincorporated area of Sacramento County. In general, they are located between Kiefer Boulevard to the north, Excelsior Road to the east, Elder Creek Road to the south and Hedge Avenue to the west. These borrow sites have supplied import fill material on various USACE projects in the past. While either the total or annually available material and its classification at the commercial sites cannot be defined with any certainty due to their private ownership, the sites typically utilized on USACE projects range in size from approximately 100 acres to 400 acres (all sites combined totaling approximately 950 acres, including aggregate sites) and contain sandy lean clay to clayey sand.

15.2.9 EXISTING LEVEE MATERIAL

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.

15.2.10 SOURCES OF RIP-RAP

A list of quarries is provided below that have been field-checked by the USACE and which have supplied specification rock on previous projects. Not all of the listed quarries have current test results available and complete testing of rock materials would be required during design.

COOL QUARRY
Located near Cool, CA
Holly Sugar
(560) 885-4244

SAN RAFAEL ROCK QUARRY
Located in San Rafael, CA
Dutra Material Corp.
(415) 459-7740

BANGOR QUARRY
Located near Bangor, CA
Roy E. Ladd Co.
(916) 241-6102

SPRING VALLY QUARRY
Located near Marysville, CA
Carl Woods, Co.
(530) 673-7877

TABLE MOUNTAIN QUARRY
Located near Jamestown, CA
George Reed, Inc.
(209) 984-5202

SNAKE CANYON QUARRY
Located in Napa, CA
Syar Industries, Inc.
(707) 252-8711

IONE QUARRY
Located near Ione, CA
Cal West Rock Products
(209) 274-2436

PARKS BAR QUARRY
Located near Marysville, CA
Nordic Industries
(530) 745-7124

JACKSON VALLEY QUARRY
Located near Ione, CA
George Reed, Inc.
(206) 984-5202

LAKE HERMAN QUARRY
Located near Vallejo, CA
Syar Industries, Inc.
(707) 252-8711

WOODS CREEK QUARRY
Located near Jamestown, CA
Sierra Rock Products
(209) 984-5307

HOGAN QUARRY
Located near Valley Springs, CA
Fort Construction Co.
(209) 333-1116

CARMICHAEL (VINA) QUARRY
Located near Vina, CA
Carl Woods Co.
(530) 673-7877

16.0 CONCLUSIONS

This report presented the results of geotechnical analyses and feasibility level 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.

The results of the without project seepage and slope stability analyses indicated that the levees in north basin including Sacramento River West Levee, Sacramento Bypass South Levee, and the Yolo Bypass East Levee along with the south basin including the Sacramento River West Levee, Port South Levee, South Cross Levee, Yolo Bypass East Levee, and the Deep Water Ship Channel West Levee did not meet seepage and/or stability requirements. 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 cutoff walls which resulted in the with project levee analyses satisfying criteria. It should be noted that the entire project area reaches on the aforementioned locations were not deficient; a percentage each of the project reaches exhibited a deficiency. Further detailed of the deficiencies and mitigation measures were displayed in Section 11.0 and Section 13.0. The recommended mitigation measures included in this report will be reconsidered when a further detailed design-level analysis is performed.

The results of the liquefaction triggering analysis and liquefaction-induced post-earthquake deformation based on limit equilibrium analysis indicated that liquefaction potential is likely at the Sacramento Bypass levees within the north basin and along both the Port South levee and Sacramento River West levee in the 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.

The without project levee performance curves indicate that the levees in North basin including the on Sacramento River West Levee, Yolo Bypass East Levee, and Sacramento Bypass South Levee, and within the South Basin including the Sacramento River West Levee, and Deep Water Ship Channel West Levee would perform unsatisfactorily when minimally to moderately 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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DECEMBER 2015

General Reevaluation Report

US Army Corps of Engineers®
Sacramento District

CENTRAL VALLEY FLOOD PROTECTION BOARD
PUBLIC SAFETY AND FLOOD MANAGEMENT
STATE OF CALIFORNIA

WSAFCA
West Sacramento Area Flood Control Agency

Draft Report

Documentation

Cost Engineering Appendix

WEST SACRAMENTO PROJECT, CALIFORNIA
GENERAL REEVALUATION REPORT

Draft Report Documentation

Cost Engineering Appendix

U.S. Army Corps of Engineers
Sacramento District

December 2015

WEST SACRAMENTO PROJECT, CALIFORNIA

GENERAL REEVALUATION REPORT

Cost Engineering Appendix

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1. SCOPE

The purpose of this project is to improve levees for flood protection for the City of West Sacramento. On roughly 42 miles will involve, in general, the construction of slurry walls, rip rap rock protection, floodwalls, non-pervious soil plugs, relocation of utilities, removal and replacement of existing surface improvements.

2. OVERTIME

Overtime is not included in the estimate for construction of these improvements. It is assumed work will take place 5 days a week, 8 hr days.

3. AQUISITION PLAN

Project reaches are enough that acquisition is assumed to be competitive bid and not necessarily small business set aside.

4. CONTRACTING PLAN

The prime contractor for the various reaches will vary depending on what is the major driver for the cost of the project. Reaches that are have the slurry wall as the major cost driver and grading and subcontract work is of lesser value the Slurry contractor is assumed to be the prime and if heavy on subcontractors where slurry is not the large cost of the project will be the subcontractor. The grading contractor will be similar in nature.

5. SITE ACCESS

Site access varies on the individual reaches. All reaches have access, whether on the top of an existing levee, surface streets, or water. Some will require in and out on the same levee, other will have the entry point at one location and the exit point at another location. The estimate has tried to capture this situations on a reach by reach basis. The river and Deep Water Ship Channel (DWSC) have been used as the transport and placement route for the rip rap along the Sacramento River and the DWSC.

6. BORROW/DISPOSAL AREAS

Borrow areas for the levee construction are assumed to be from sources within 20 miles of the project locations.

7. CONSTRUCTION METHODOLOGY

The construction methodologies are standard with Deep Soil Mixing and Jet Grouting being the most non-standard types of construction used on the project.

8. UNUSUAL CONDITIONS

There are no known unusual soils conditions.

9. UNIQUE TECHNIQUES OF CONSTRUCTION

The construction techniques proposed on this project consist of standard technologies used on other projects.

10. EQUIPMENT, LABOR RATES, MATERIAL AND OTHER COSTS

Equipment and labor is available locally or within a 50-mile radius of Sacramento, CA. This estimate uses Davis Bacon labor rates for Yolo County in California, General Decision Number: CA140009 05/01/2015 CA9. Equipment rates used are from EP14R07, Region 7, 2014. Material prices were obtained from quotes, supply catalogs, historical data, and the MCACES Unit Price Book.

11. ENVIRONMENTAL CONCERNS

The project schedule accounts for a winter shut down period consistent with known sensitive animals and their normal breeding & migration habits.

12. COST AND PRICING CONTINGENCIES - PROFIT - ESCALATION

Profit is included in this estimate, using the weighted guidelines method, at 7.14% for the Prime Contractor. Sales tax of 8.25% is applied for this project to materials. Job Office Overhead is assumed to be 7%, Home Office Overhead is 10%, and Bond is assumed to be 1% since the prime contractors are assumed to not be small business.

Contingency is not included in this MII estimate, but is included in the TPCS for this project.

Escalation is not included in this MII estimate, but is included in the TPCS using the current CWCCIS tables.

13. DESCRIPTIONS OF REACHES

Training Dike

This reach consists of stripping existing grass off existing training dike and the placement of geotextile fabric and 3' thick layer (~83,000 tn) of stone protection on both sides of an existing training dike approximately 2800' long. Grass to be transported to the Yolo Landfill which will take this material for free with no dump fees charged.
Major risk on this project is the availablilty and hauling of rock material to site.

Yolo Bypass Levee (North) Sta. 136+00 to 155+00 = 1,900 lf = .36 mi

This reach consists of degrading the existing levee to approx. elevation 28 which will allow for a 30' wide working bench be built. This material will be stockpiled and reused during the reconstruction of the levee. Additional impervious fill material (clay cap) will be installed as well. A 3' thick soil/bentonite slurry wall varying from 78' to 38' deep from the working platform will be installed. Additional fill will also be placed on the landside of the levee at stations as shown on plans. At completion, a 20' wide aggregate base road 4" thick will be placed.

Yolo Bypass Levee (South) Sta. 0+00 to 64+60 = 6460 lf = 1.22 mi

This reach consists of degrading the existing levee to approx. elevation 28 which will allow for a 30' wide working bench will be built. This material will be stockpiled and reused during the reconstruction of the levee. Additional impervious fill material (clay cap) will be installed as well. A 3' thick soil/bentonite slurry wall varying from 78' to 38' deep from the working platform will be installed. Additional fill will also be placed on the landside of the levee at stations as shown on plans. A 12" water on the water side of levee will be relocated. At completion, a 20' wide aggregate base road 4" thick will be placed.

Lock Closure Levee

Project consists of placing sheet piling, removal of existing concrete and needed, removal of vegetation and trees in footprint area. Import and place 230,000 CY of embankment will be required to bring top of levee to grade. There are minor utility relocations as well associated with this reach.

DWSC West Station 0+00 to123+00 Length = 12,300' = 2.33 mi

This Levee Reach will be constructed as one of the first reaches on this project. This reach specifically states to a specific station, but in execution the exact stationing may vary. Additional costs if extended would be taken in the remainder of this levee included in 123+00 to 1002+60.
This reach generally consists of degrading for installation of new slurry walls, reconstruction of levee with imported soils for an impervious fill plug in the reconstructed levee degraded and installation of previous maintenance road. Rip rap will be placed on the Yolo Bypass side of the levee for wind/wave protection. This will most likely be a separate contract from the slurry wall work. Site will be hydro seeded at completion as needed.

DWSC West Levee (Navigation Levee) 123+00 - 1002+60 = 87,960 lf = 16.7 mi

This reach consists of installation of slurry wall along a portion this reach with associated degrade of existing levee, and replacement of levee with a new impervious core installed at the same time. Hydro seed will also be installed at the completion of the project. Also, this reach will include placement of rip rap on the Yolo Bypass side of the levee for wind/wave protection. This will most likely be a separate contract from the slurry wall work.

South Cross Levee Station 0+00 to 62+73 Length = 6,273' = 1.19mi

This reach consists of the construction of relief wells with associated v-ditch, installation of aggregate base roadway on top, removal of existing fence, installation of stability berm with associated sand and drain rock, the raising of State Highway 84/Jefferson Blvd which includes imported fill, aggregate base and asphaltic concrete and striping. Jet grouting around the existing 120” is currently under review as to whether it is necessary. This cost is included in the estimate at this time.
This reach will require the purchase of private property and removal of out buildings.

Port North Levee (No Improvements)

Port South Levee

This reach consist of underground utility relocation, approximately 1,000 LF of 82’ deep slurry wall, replacement of aggregate base at top of levees. Estimate also is carrying costs for additional AB due to unknown if entire levee needs AB.

DWSC East Station 0+00 to171+71 Length = 17,171' = 3.25 mi

This reach involves the relocation of existing utilities including 21 wooden power poles, relocate existing ditch away from existing levee toe. New construction consists of levee degrade, installation of slurry wall, Jet grouting around existing storm drain, Installation of 48” storm drain, re-installation of AB levee maintenance road, and hydro seeding as required.

Sac River - North Levee

Construction on this reach involves installation of slurry wall, removal and replacement of existing asphalt along top of existing levee, certain areas contain concrete tiles to be removed and replaced, removal & relocation of existing light poles, power poles, misc utilities to existing homes, levee degrade and restore including non-pervious plug and rip rap.

Sac River - South Levee - SET BACK LEVEE

This reach consists of the removal of the existing levee and associated road on top of it. The soils will be used for the construction of a new setback levee which will have a shallow slurry wall under it with an AB maintenance road. A new road will be built on the land side of the new levee.

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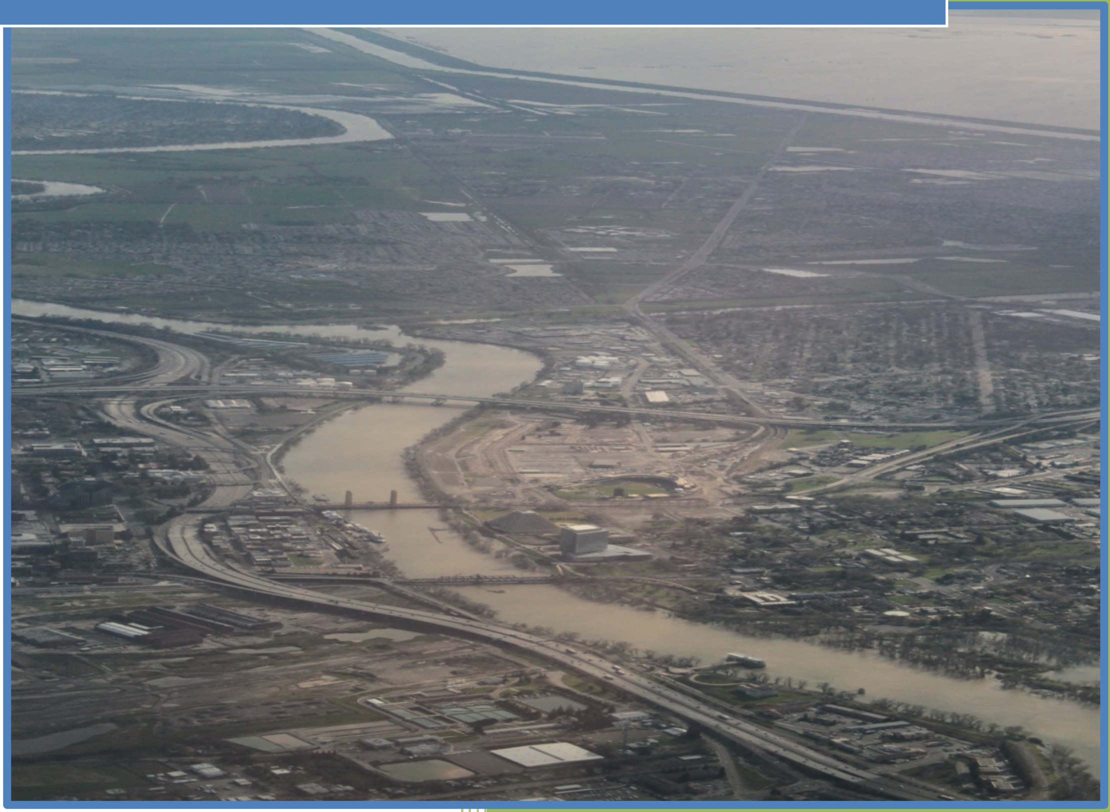
West Sacramento General Reevaluation Report



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Central Valley Flood Protection Board — Public Safety and Flood Management — State of California

WSAFCA West Sacramento Area Flood Control Agency

Draft Report Documentation

Civil Design Appendix

Cover Photo: Sacramento River, West Sacramento, and Yolo Bypass, March 2011

Photo courtesy of Chris Austin.

WEST SACRAMENTO PROJECT, CALIFORNIA
GENERAL REEVALUATION REPORT

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Sacramento District

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WEST SACRAMENTO PROJECT, CALIFORNIA
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1 - INTRODUCTION

This appendix documents the civil design for the West Sacramento Project General Reevaluation Report (West Sacramento GRR). The purpose of the West Sacramento GRR is to evaluate the additional levee improvements and measures necessary to reduce flood risk to the City of West Sacramento. The study area includes the Sacramento River, Yolo Bypass, and Deep Water Ship Channel. This appendix will summarize the design and site considerations required for construction of project features, access roads, staging areas, real estate requirements, relocations and quantities developed for the alternatives analyzed for the West Sacramento GRR. Design consideration information includes floodwall and levee construction guidance, EM-1110-2-1913 Design and Construction of Levees, ER 1110-2-1150 Engineering and Design for Civil Works Projects.

1.1 PROJECT LOCATION AND BACKGROUND

The West Sacramento GRR project area includes approximately 50 miles of levee and approximately corresponds with the city limits for the City of West Sacramento. The project area is bound by the Yolo Bypass to the west, the Sacramento Bypass to the north, and the Sacramento River to the east. Additionally, the Deep Water Ship Channel (DWSC) divides the project area into the North and South Basin. The project area has been split into nine reaches for technical evaluation. A description of the levee reaches is below:

- **Sacramento River North Levee** extends for approximately 5.5 miles along the Sacramento River right bank levee from the Sacramento Bypass south to the confluence of the Barge Canal and the Sacramento River.
- **Sacramento Bypass Levee** extends for approximately 1.1 miles along the Sacramento Bypass left bank levee from the Sacramento Weir west to the Yolo Bypass Levee.
- **Yolo Bypass Levee** extends for approximately 3.7 miles along the Yolo Bypass levee left bank from the confluence of the Sacramento Bypass and the Yolo Bypass south to the Navigation Levee (DWSC West).
- **Port North** extends for approximately 4.9 miles along the DWSC right bank from the Barge Canal west to the bend in the Navigation Levee.
- **Port South Levee** extends for approximately 4 miles along the DWSC left bank levee from the Barge Canal west past the bend in the DWSC.
- **DWSC West** extends for approximately 21.4 miles along the DWSC right bank levee from the bend in the DWSC at the intersection of Port North Levee and Yolo Bypass Levee south to Miners Slough.
- **DWSC East** extends for approximately 2.8 miles along the DWSC left bank levee from the end of Port South Levee south to South Cross Levee.
- **Sacramento River South Levee** extends approximately 5.9 miles along the Sacramento River right bank levee from the confluence of the Barge Canal and the Sacramento River south to the South Cross Levee.

- **South Cross Levee** extends along the South Cross levee for approximately 1.2 miles from Jefferson Boulevard to the Sacramento River where it intersects the southern end of Sacramento River South Levee.

1.2 COORDINATION

The project development team consisted of USACE Sacramento District. Additionally, USACE New Orleans District provided design assistance to the Sacramento District. Non-USACE team members include the State of California, City of West Sacramento and West Sacramento Area Flood Control Agency (WSAFCA).

2 - GENERAL DESIGN CONSIDERATIONS

2.1 TOPOGRAPHIC DATA

The topographic data used for civil design alternative quantity estimates were based on Light Detection and Ranging (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 River was also used in conjunction with the LiDAR surveys for Sacramento River North and Stone Lock. Bathymetric data was collected using post processed kinematic GPS for vertical and horizontal positioning of soundings.

2.2 DATUM

All horizontal and vertical coordinates of position from survey are presented in Universal Transverse Mercator (UTM), measured in feet, using the North American Datum of 1983 (NAD83). Horizontal coordinates were converted to the California State Plane Zone II coordinate system by Corpscon. All GPS derived elevations are referenced to North American Vertical Datum of 1988 (NAVD88). All elevations provided herein are relative to the NAVD88 vertical datum and NAD83 horizontal datum.

2.3 LEVEE GEOMETRY

Acceptable levee geometry was established by the Sacramento District's Geotechnical Section and their Standards of Practice. Levee geometry associated with a Fix In-Place method consisted of:

- Levee Crown of 20 feet
- Waterside Slope of 3H:1V
- Landside Slope of 3H:1V

New levee construction would require flatter levee slopes of 3H:1V for increased levee safety and stability. Slope benching or notching into the existing bank details will be address in the preconstruction engineering and design phase (PED). For stability berm for the south cross levee, there will be a drainage layer between the berm and levee, see figure 7. A geotextile fabric may be placed between the free draining layer and the berm fill as to not impede the drainage characteristics and design intent of the drainage layer. A comprehensive evaluation of performance deficiencies, including cross section analysis, geology and geomorphology, foundation conditions, and geotechnical risk and uncertainty analyses are found in the Geotechnical Appendix.

2.4 ALIGNMENTS AND STATIONING

Levee stationing in feet was developed for each feature for design purposes and quantity take-offs for purposes of this report. Alignments for existing levee improvements were determined by the existing features such as existing levee crown, landside or waterside toe, etc.

The landside toe was determined using the LiDAR data and recent aerial photos and was visually located by USACE Sacramento District Civil Design. Most of the access-related improvements were developed using offsets of this approximation.

2.5 LEVEE HEIGHT

In order to meet the state criteria of a 200-year Annual Exceedance Probability (AEP) plus 3 feet, levee crown profile for alternative selection was chosen as the design profile for the GRR project. In areas where the existing ground was higher than the criteria, that segment of ground was used for the design profile. The water surface data came from the modeling efforts of the Sacramento District Hydraulics Section.

2.6 LEVEE DEFICIENCIES

Within the study area, the geotechnical deficiencies of the levees were identified and grouped in the following categories:

- Seepage – Through seepage and underseepage
- Stability – Oversteepened slopes, typically less than 2H:1V
- Height – Levee overtopping
- Erosion – Highly erodible soils, significant scour and velocity issues

Table 1 describes levee deficiencies for each reach.

Table 1: Reach Deficiencies

REACH	REACH LENGTH FEET	FEATURE LENGTH FEET	IMPROVEMENT
Sacramento Bypass	6,478	-	None
Yolo Bypass	19,749	3,860	Stability
		2,500	Seepage, Stability
		1,900	Seepage
DWSC West Levee	100,260	9,000	Seepage, Height
		7,000	Seepage, Height
		9,000	Seepage, Height
		75,260	Height
		99,010	Erosion
DWSC East Levee	17,171	1,500	Seepage
		7,055	Seepage
		5,945	Seepage
		2,671	Height
Port North	23,225	8,245	Height
		14,170	Height
Port South	16,262	15,560	Height
		1,000	Seepage
South Cross Levee	6,273	1,100	Stability, Height
		5,000	Seepage, Height
Sacramento River North Levee	30,700	15,200	Erosion
		11,080	Seepage
		1,470	Seepage
		500	Seepage
		5,530	Seepage
		4,600	Height
Sacramento River South Levee	33,100	33,100	Seepage, Erosion
Sacramento Bypass Training Dike	3,000	3,000	Erosion Protection

2.7 RELOCATIONS AND UTILITIES

Relocations were based upon the work previously done by HDR, the Sacramento District Levee Safety section periodic inspection reports, and existing levee logs maintained by the Department of Water Resources. Many of the items were available in GIS and for the pump stations and various power poles the locations were mapped. If the levee height was increased, we assumed that pumps and pipes would be replaced. In addition, the City of West Sacramento provided utility mapping that detailed the pipe sizes and locations for water, sewer and gas.

2.8 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. Additional waterside access roads will be constructed for the bank protection sites for the Sacramento River levees.

For other site features, the permanent easements associated with this project are expected to be adequate for construction of the features. 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.

There are available sites such as farm land, parks, levee ramps, and vacant land available along the levees that may serve as staging areas. The exact need for staging areas and identification of areas will be completed during the PED phase.

2.9 REAL ESTATE REQUIREMENTS

Real estate requirements for the project area consisted of Permanent Flowage Easements (PFE), Flood Protection Levee Easements (FPLE), Bank Protection Easement (BPE), and vegetation free easements. These easements were needed to provide adequate construction room to build proposed flood mitigation features, secure lands needed for Operations and Maintenance (O&M), and acquire lands needed to comply with Corps vegetation policies. The easements are described in Sacramento District Standard Operating Procedures (SOP), and summarized below as they apply to the project.

- Bank Protection – 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 FPLE.
- Waterside 15 ft – Easement needed for O&M from the waterside toe and to restrict woody vegetation growth per Engineering Technical Letter (ETL) 1110-2-571. This easement includes the entire area from the waterside toe to an offset line 15 feet towards the river.

  The levees will have a permanent FPLE, which will provide space for the levee, landside seepage remediation, and a 20-foot operations and maintenance right-of-ways on the landside of the seepage remediation feature and waterside toe. Easements are necessary for maintenance, inspection, and flood fight access.
- Flood Protection Levee Easement – 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. Refinement of these footprints will be provided in final design prior to levee construction.

More information on the types of easements, relocations, and estimates can be found in the Real Estate Appendix.

2.10 OPERATION AND MAINTENANCE

The Non-Federal Sponsor is responsible for project Operation, Maintenance Repair, Replacement and Rehabilitation (OMRR&R) for project features. The West Sacramento GRR adds features to the existing flood protection system. Generally, the local sponsor will have to increase mowing, rodent control, and encroachments removal for the proposed levee improvements. The required maintenance for the floodwalls includes caulking and graffiti removal. For the closure structure proposed on the Deep Water Ship Channel the OMRR&R will include operation of the gate, dive team inspections, and dewatering.

For the selected plan, the project features will be determined whether they add any additional O&M responsibility for the Non-Federal Sponsor. If there are increased OMRR&R efforts for the project features, an appropriate cost will be quantified to reflect the addition effort as part of the final report.

3 - PROJECT DESIGN FEATURES AND ALTERNATIVES

3.1 ALTERNATIVES

A wide range of features were evaluated to reduce flood risk in the project area. For the purposes of this study, the alternatives were developed by combing measures. Below is the preliminary array of alternatives that were considered:

- Alternative 1 – Improve levees
- Alternative 2 – Improve levees and Sacramento Bypass widening
- Alternative 3 – Improve levees and DWSC Closure Structure
- Alternative 4 – Improve levees, Sacramento Bypass widening and DWSC closure structure
- Alternative 5 – Improve levees and Sacramento River South Setback Levee

The project development team further refined the array of alternatives by screening out the Sacramento Bypass widening measure. The final array of alternatives only includes alternatives 1, 3 and 5. The civil design for the project only considers the final array of alternatives.

3.1.1 Alternative 1 – Improve Levees

Alternative 1 involves the construction of levee remediation measures to address deficiencies such as seepage, slope instability, height, and erosion along the Sacramento River, the Sacramento Bypass, Yolo Bypass and the Sacramento DWSC. This alternative combines construction of improvement measures while maintaining the present levee alignment in its existing location (fix in place). A summary of the proposed improvement by reach is in Table 2.

Table 2: Alternative 1 – Proposed Features

ALTERNATIVE 1 – IMPROVE LEVEES					
REACH	REACH LENGTH FEET	FEATURE LENGTH FEET	IMPROVEMENT	FIGURE NUMBER	FEATURES
Sacramento Bypass	6,478	-	None	-	None
Yolo Bypass	19,749	3,860	Landside Slope	6	Flatten Landside Slope
		2,500	Seepage, Stability	5	Flatten Landside Slope/ 40' Slurry wall
		1,900	Seepage	4	100' Slurry Wall
DWSC West Levee	100,260	9,000	Height/Seepage	4	85' Slurry Wall
		7,000	Height/Seepage	4	50' Slurry Wall
		9,000	Height/Seepage	4	75' Slurry Wall
		75,260	Height	3	Embankment Fill
		99,010	Erosion	-	Bank Protection (120’x3’ depth)
DWSC East Levee	17,171	1,500	Seepage	4	120' Slurry Wall, DSM
		7,055	Seepage	4	130' Slurry Wall, DSM
		5,945	Seepage	4	50' Slurry Wall
		2,671	Height	3	Embankment Fill
Port North	23,225	8,245	Height	2	Floodwall, 4' to 10'
		14,170	Height	3	Embankment Fill
Port South	16,262	15,560	Height	3	Embankment Fill
		1,000	Seepage	4	70' Slurry Wall
South Cross Levee	6,273	1,100	Stability, Height	7	Stability Berm and Embankment Fill
		5,000	Seepage, Height	8	Relief Wells and Embankment Fill
Sacramento River North Levee	30,700	15,200	Erosion	11	Bank Protection
		11,080	Seepage	4	30' Slurry Wall
		1,470	Seepage	4	80' Slurry Wall
		500	Seepage	4	45' Slurry Wall
		5,530	Seepage	4	110' Slurry Wall
		4,600	Height	3	Embankment Fill
Sacramento River South Levee	33,100	33,100	Seepage, Height, Erosion	13	Slurry wall, 80’ Berm, Bank protection
Stone Lock	570	540	Flow Direction	9	Embankment Fill, Sheet Pile Wall
Sacramento Bypass Training Dike	3,000	3,000	Erosion	10	Bank Protection

Note: Where “DSM” is not shown indicate that open trench construction method may be applied.

3.1.2 Alternative 3 – Improve Levees and DWSC Closure Structure

Alternative 3 applies many of the levee remediation measures proposed in Alternative 1 (Improve Levees) and adds a closure structure along the DWSC. The closure structure eliminates the need for levee improvements along Port North and Port South. It also reduces the length of improvements from the DWSC West and DWSC East levees. A summary of the proposed improvements is in Table 3.

3.1.2.1 Deep Water Ship Channel Closure Structure

The DWSC closure structure (figure 12) will be a sector gated structure with a two hundred (200) foot wide opening and a sill elevation of -37.0 and top of structure elevation of + 34.0, constructed in the DWSC approximately five hundred (500) feet north of the South Basin Main Drain Pumping Plant. Tie-in levees are provided on either side of the structure to tie into the existing levees along the channel.

The structure consists of conventionally reinforced concrete and post tensioned concrete supported on a pipe pile foundation. The concrete structure will use float-in construction. The concrete shell will be built similar to barge type construction and designed using naval architecture methods for transportation and installation conditions. A graving site will be provided adjacent to the project site for construction of the reinforced concrete sector gate monolith. The float-in design eliminates the need for cofferdams, structure site dewatering systems, and structure site bypass.

The conceptual level design for the DWSC closure structure was developed by the New Orleans District (MVN).

Table 3: Alternative 3 – Proposed Features

ALTERNATIVE 3 – IMPROVE LEVEES AND DWSC CLOSURE STRUCTURE					
REACH	REACH LENGTH FEET	FEATURE LENGTH FEET	IMPROVEMENT	FIGURE NUMBER	FEATURES
Sacramento Bypass	6,478	-	None	-	None
Yolo Bypass	19,749	3,860	Landside Slope	6	Flatten Landside Slope
		2,500	Seepage, Stability	5	Flatten Landside Slope/ 40' Slurry wall
		1,900	Seepage	4	100' Slurry Wall
DWSC West Levee with Closure Structure	12,300	9,000	Seepage	4	85' Slurry Wall
		11,160	Height	3	Embankment Fill
		11,050	Erosion	-	Bank Protection
DWSC East Levee with Closure Structure	5,671	5,671	Seepage, Height	4	50' Slurry Wall
South Cross Levee	6,273	1,100	Stability, Height	7	Stability Berm and Embankment Fill
		5,000	Seepage ,Height	8	Relief Wells and Embankment Fill
Sacramento River North Levee	30,700	15,200	Erosion	11	Bank Protection
		11,080	Seepage	4	30' Slurry Wall
		1,470	Seepage	4	80' Slurry Wall
		500	Seepage	4	45' Slurry Wall
		5,530	Seepage	4	110' Slurry Wall
		4,600	Height	3	Embankment Fill
Sacramento River South Levee	33,100	33,100	Seepage, Height, Erosion	13	Slurry wall, 80' Berm, Bank protection
Stone Lock	570	540	Flow Direction	9	Embankment Fill, Sheet Pile Wall
Sacramento Bypass Training Dike	3,000	3,000	Erosion	10	Bank Protection
Closure Structure on DWSC	-	-	-	12	Closure Structure

Note: Deep Water Ship Channel (DWSC) includes Closure Structure (See Figure 12).

3.1.3 Alternative 5 – Improve Levees and Sacramento River South Setback Levee

Alternative 5 applies many of the levee remediation measures proposed in Alternative 1 (Improve Levees) except along the Sacramento River South levee reach. The Sacramento River South levee alignment includes fix-in-place, adjacent and a setback levee. This alignment is the same alignment that is being considered in the Non-Federal Sponsors Southport early implementation project (EIP). A summary of the proposed improvements is in Table 4.

The levee geometry improvement will include reestablishment of the levee height, widening the levee crown up to 20 feet, slope improvement on both the landside and riverside, and will provide gravel patrol road on the top of the levee.

Table 4: Alternative 5 – Proposed Features

RECOMMENDED PLAN – Improve Levees and Sacramento River South Setback					
Reach	**Reach Length Feet**	**Feature Length Feet**	**Improvement**	**Figure Number**	**Features**
Sacramento Bypass	6,478	-	None	-	None
Yolo Bypass	19,750	3,860	Landside Slope	9	Flatten Landside Slope
		2,500	Seepage, Stability	8	Flatten Landside Slope/ 40' Cutoff wall
		1,900	Seepage	7	100' Cutoff Wall
DWSC West Levee	100,260	9,000	Seepage, LGI	7	85' Cutoff Wall
		7,000	Seepage, LGI	7	50’ Cutoff Wall
		9,000	Seepage, LGI	7	75’ Cutoff Wall
		5,560	LGI	6	Embankment Fill
		99,010	Erosion	-	Bank Protection (120’ x3’ Depth)
DWSC East Levee	17,171	1,500	Seepage	7	120' Cutoff Wall, DSM
		7,055	Seepage	7	130' Cutoff Wall, DSM
		5,574	Seepage	7	50' Cutoff Wall
		1,800	LGI	6	Embankment Fill
Port North	24,140	2,000	Height	5	Floodwall, 4'
		3,352	LGI	6	Embankment Fill
		90	Height	-	Stop Log and Swing Gate, see below
Port South	17,720	2,950	LGI	6	Embankment Fill
		1,000	Seepage	7	70' Cutoff Wall
South Cross Levee	6,400	1,340	Stability, Height	10	Stability Berm and Embankment Fill
		5,000	Seepage ,Height	11	Relief Wells and Embankment Fill
		50	Height	-	Raise Jefferson Boulevard, see below
Sacramento River North Levee	30,700	14,300	Erosion	14	Bank Protection
		11,045	Seepage	7	30' Cutoff Wall
		1,470	Seepage	7	80' Cutoff Wall
		500	Seepage	7	45' Cutoff Wall
		5,520	Seepage	7	110' Cutoff Wall
		7,600	LGI	6	Embankment Fill
Sacramento River South Levee (Setback Levee)	33,100	7,400	Erosion	15-18	Bank Protection
		29,320	Seepage	15-23	Embankment Fill and Cutoff Wall/Berm
Stone Lock	570	540	Flow Direction	12	Embankment Fill, Sheet Pile Wall and Stone Protection

RECOMMENDED PLAN – Improve Levees and Sacramento River South Setback					
Reach	**Reach**	**Feature**	**Improvement**	**Figure**	**Features**
Sacramento Bypass Training Dike	3,000	3,000	Erosion	13	Bank Protection

Note: Where "DSM" is not shown indicate that open trench construction method may be applied. "LGI" stands for Levee Geometry Improvement.

3.2 CONSTRUCTION DURATION

For each of the alternatives, the minimum years to construct each reach was developed using the construction quantities and the production rates for the construction crews. The levee prioritization was developed based on economic data and input from the Non-Federal Sponsors. The actual construction duration for the reaches will depend on the available funding and environmental emissions constraints. The minimum years to construct for each alternative are summarized in Tables 5 - 7.

Table 5: Alternative 1 – Minimum Years to Construct

ALTERNATIVE 1 – MINIMUM YEARS TO CONSTRUCT					
REACH	REACH LENGTH FEET	FEATURE LENGTH FEET	IMPROVEMENT	YEARS TO CONSTRUCT	NOTES
Sacramento Bypass	6,478	-	None		No Repair
Yolo Bypass	19,749	3,860	Landside Slope	1	
		2,500	Seepage, Stability		
		1,900	Seepage		
DWSC West Levee	100,260	9,000	Height/Seepage	3	Requires 3 rock import crews
		7,000	Height/Seepage		
		9,000	Height/Seepage		
		75,260	Height		
		99,010	Erosion		
DWSC East Levee	17,171	1,500	Seepage	3	Requires 2 DSM crews
		7,055	Seepage		
		5,945	Seepage		
		2,671	Height		
Port North	23,225	8,245	Height	2	
		14,170	Height		
Port South	16,262	15,560	Height	1	
		1,000	Seepage		
South Cross Levee	6,273	1,100	Stability, Height	2	Requires 2 import crews
		5,000	Seepage, Height		
Sacramento River North Levee	30,700	15,200	Erosion	2	Requires 2 DSM crews, and 3 rock crews
		11,080	Seepage		
		1,470	Seepage		
		500	Seepage		
		5,530	Seepage		
		4,600	Height		
Sacramento River South Levee	33,100	33,100	Seepage, Height, Erosion	4	Requires 2 export crews, 2 rock crews, and 3 import crews
Sacramento Bypass Training Dike	3,000	3,000	Erosion	1	

Note: Where "DSM" is not shown indicate that open trench construction method may be applied.

Table 6: Alternative 3 – Minimum Years to Construct

ALTERNATIVE 3 – MINIMUM YEARS TO CONSTRUCT					
REACH	**REACH LENGTH FEET**	**FEATURE LENGTH FEET**	**IMPROVEMENT**	**YEARS TO CONSTRUCT**	**NOTES**
Sacramento Bypass	6,478	-	None		No Repair
Yolo Bypass	19,749	3,860	Landside Slope	1	
		2,500	Seepage, Stability		
		1,900	Seepage		
DWSC West Levee with Closure Structure	12,300	9,000	Seepage	2	
		11,160	Height		
		11,050	Erosion		
DWSC East Levee with Closure Structure	5,671	5,671	Seepage, Height	1	Requires 2 import crews
South Cross Levee	6,273	1,100	Stability, Height	2	
		5,000	Seepage, Height		
Sacramento River North Levee	30,700	15,200	Erosion	2	Requires 2 DSM crews, and 3 rock crews
		11,080	Seepage		
		1,470	Seepage		
		500	Seepage		
		5,530	Seepage		
		4,600	Height		
Sacramento River South Levee	33,100	33,100	Seepage, Height, Erosion	4	Requires 2 export crews, 2 rock crews, and 3 import crews
Sacramento Bypass Training Dike	3,000	3,000	Erosion	1	
Closure Structure on DWSC	-	-	-	3.5	

Note: Where "DSM" is not shown indicate that open trench construction method may be applied.

Table 7: Alternative 5 – Minimum Years to Construct

Alternative 5 – Minimum Years to Construct					
Reach	**Reach Length Feet**	**Feature Length Feet**	**Improvement**	**Years to Construct**	**Notes**
Sacramento Bypass	6,478	-	None		No Repair
Yolo Bypass	19,750	3,860	Landside Slope	1	
		2,500	Seepage, Stability		
		1,900	Seepage		
DWSC West Levee	100,260	9,000	Seepage, LGI	5	Requires 3 rock import crews
		7,000	Seepage, LGI		
		9,000	Seepage, LGI		
		5,560	LGI		
		99,010	Erosion		
DWSC East Levee	17,171	1,500	Seepage	1.4	Requires 2 DSM crews
		7,055	Seepage		
		5,754	Seepage		
		1,800	LGI		
Port North	24,140	2,090	Height	2	
		3,352	LGI		
Port South	17,720	2,950	LGI	0.5	
		1,000	Seepage		
South Cross Levee	6,400	1,340	Stability, Height	1	Requires 2 import crews
		5,000	Seepage, Height		
		50	Height		
Sacramento River North Levee	30,700	14,300	Erosion	2	Requires 2 DSM crews, and 3 rock crews
		11,045	Seepage		
		1,470	Seepage		
		500	Seepage		
		5,520	Seepage		
		7,600	LGI		
Sacramento River South Levee (Setback Levee)	33,100	7,400	Erosion	3.7	
		29,320	Seepage		
Stone Lock	570	540	Flow Direction	0.2	
Sacramento Bypass Training Dike	3,000	3,000	Erosion	1	

Note: Where "DSM" is not shown indicate that open trench construction method may be applied. "LGI" stands for Levee Geometry Improvement.

3.3 CIVIL ESTIMATES

Quantities were arrived at by producing templates corresponding to the recommendations Soils Design provided. InRoads, a product of Bentley, produced material summaries that were summarized by reach and displayed within Excel spreadsheets. Utilities came from a variety of sources, including HDR Utility Summary for West Sacramento, City of West Sacramento (water, storm sewer, and sanitary sewer maps), GIS data from our Levee Safety Section, Google Earth (obstructions, trees, utilities poles, and homes), and Department of Water Resources Levee Logs. Utilities were summarized by reach on a single Excel Spreadsheet. The Setback Levee, Alternative 5, is currently under final design and the quantities were taken directly from the designers.

3.4 RELOCATIONS

Relocation of power poles within each of the alternatives was determined by inspection of the footprints. Buildings falling within the footprints were demolished or moved based upon the easement requirements. If the levee profile height increased, then it was assumed that the discharge pumps and piping would be replaced for each occasion. The utility summary for each reach was made available to the estimator and can be reviewed upon request. It shows the type of fix required whether jet grouting or replacement occurs.

Acronym & Abbreviation

Cutoff Wall
A wall of impervious material (e.g., concrete, asphalt concrete, steel sheet, piling, etc.) built into the foundation to reduce the seep rate under the levee or dam.

Slurry Wall
Slurry wall is one of types of cutoff wall. It is a mixture of bentonite and water. The three main types of slurry walls are soil-bentonite, cement-bentonite, and soil-cement-bentonite.

DSM-deep soil mixing

DWSC -deep water ship channel

EIP- early implementation project

ETL-Engineering Technical Letter

FELE- Flood Protection Levee Easements

GRR- General Reevaluation Report

O&M- Operation & maintenance

OMRR&R -Operation, Maintenance repair, replacement and rehabilitation

PED preconstruction, Engineering and Design

PFE-permanent flowage easements

SOP-Standard operating procedures

ATTACHMENT 1 – FIGURES

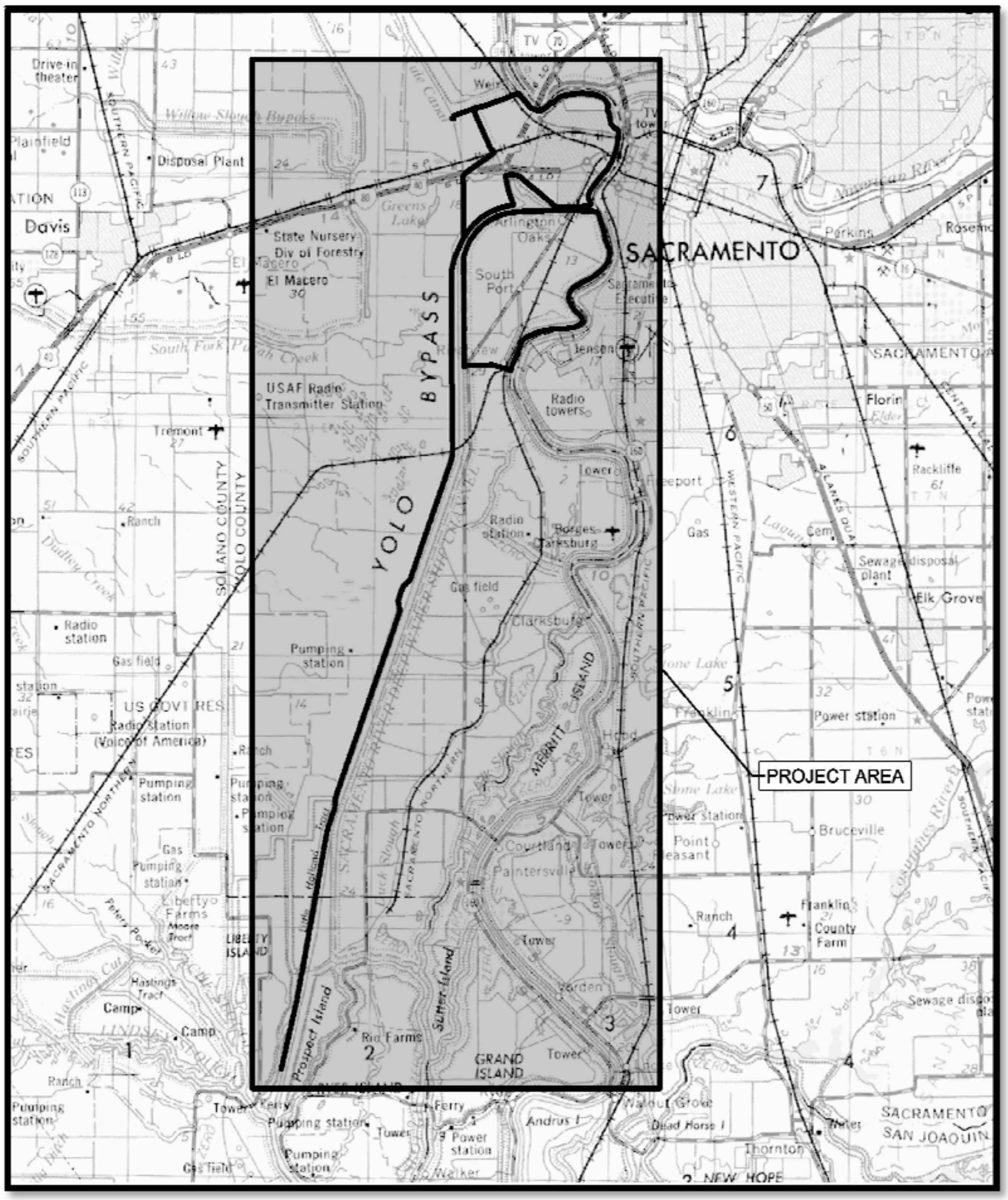


Figure 1: Project Location

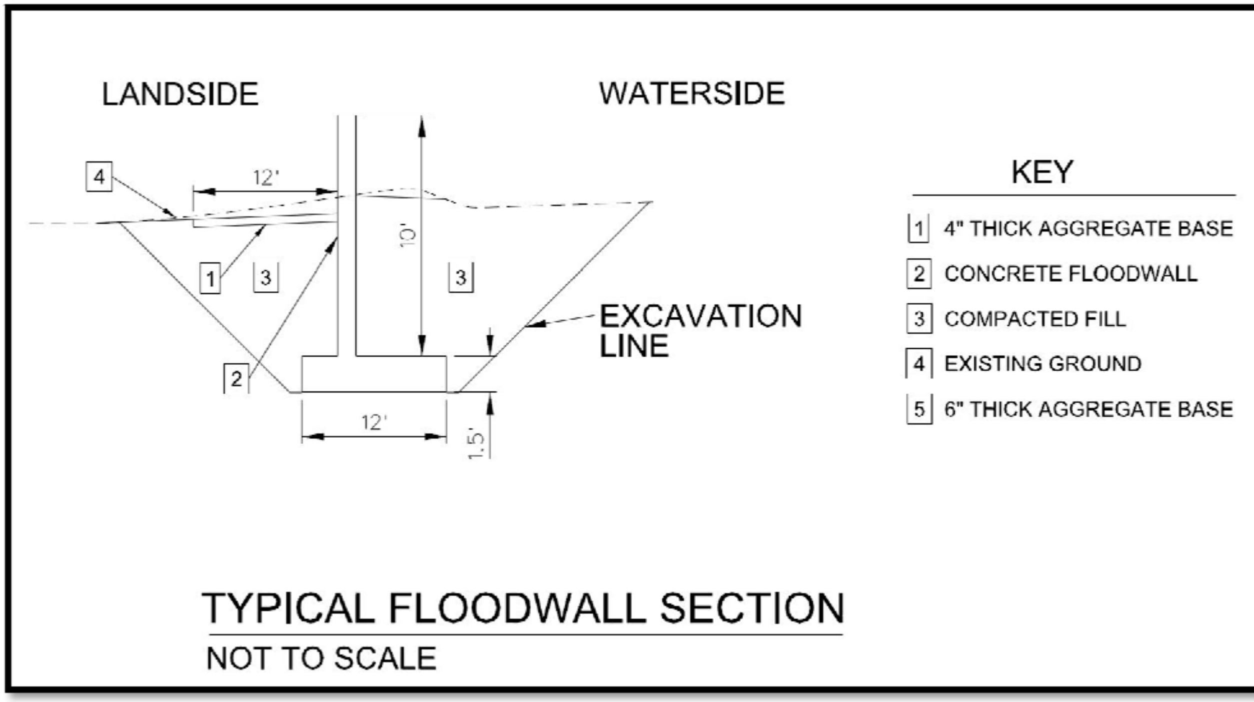


Figure 2: Typical Floodwall Section

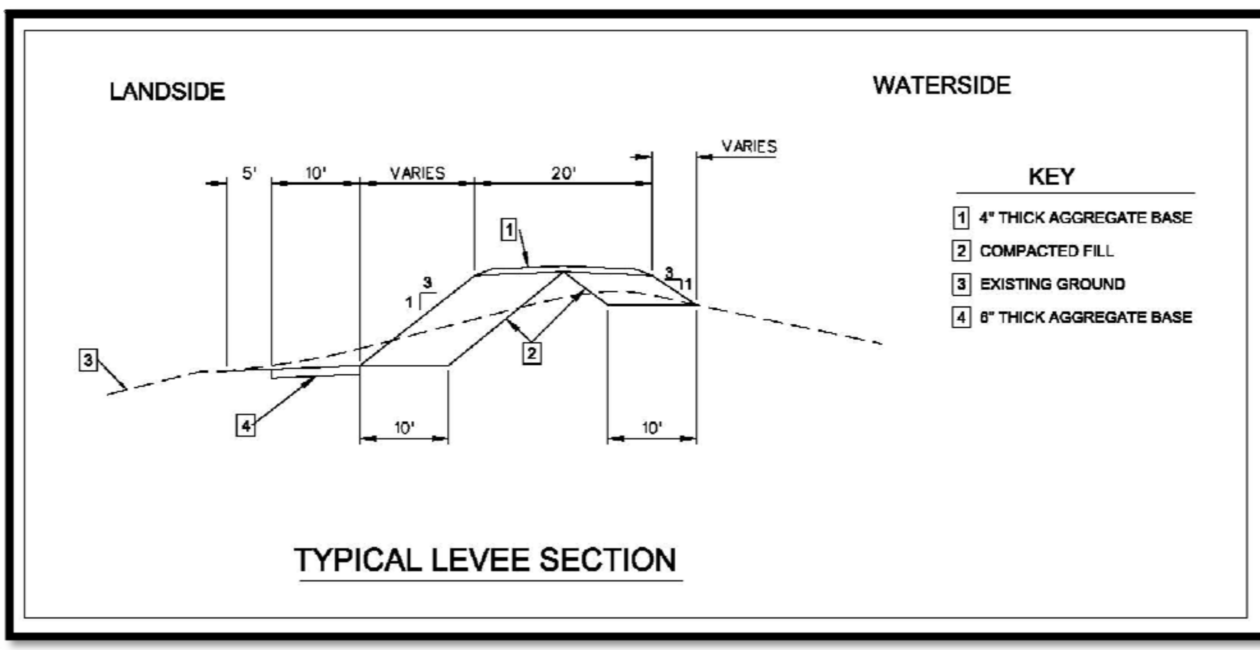


Figure 3: Typical Levee Section

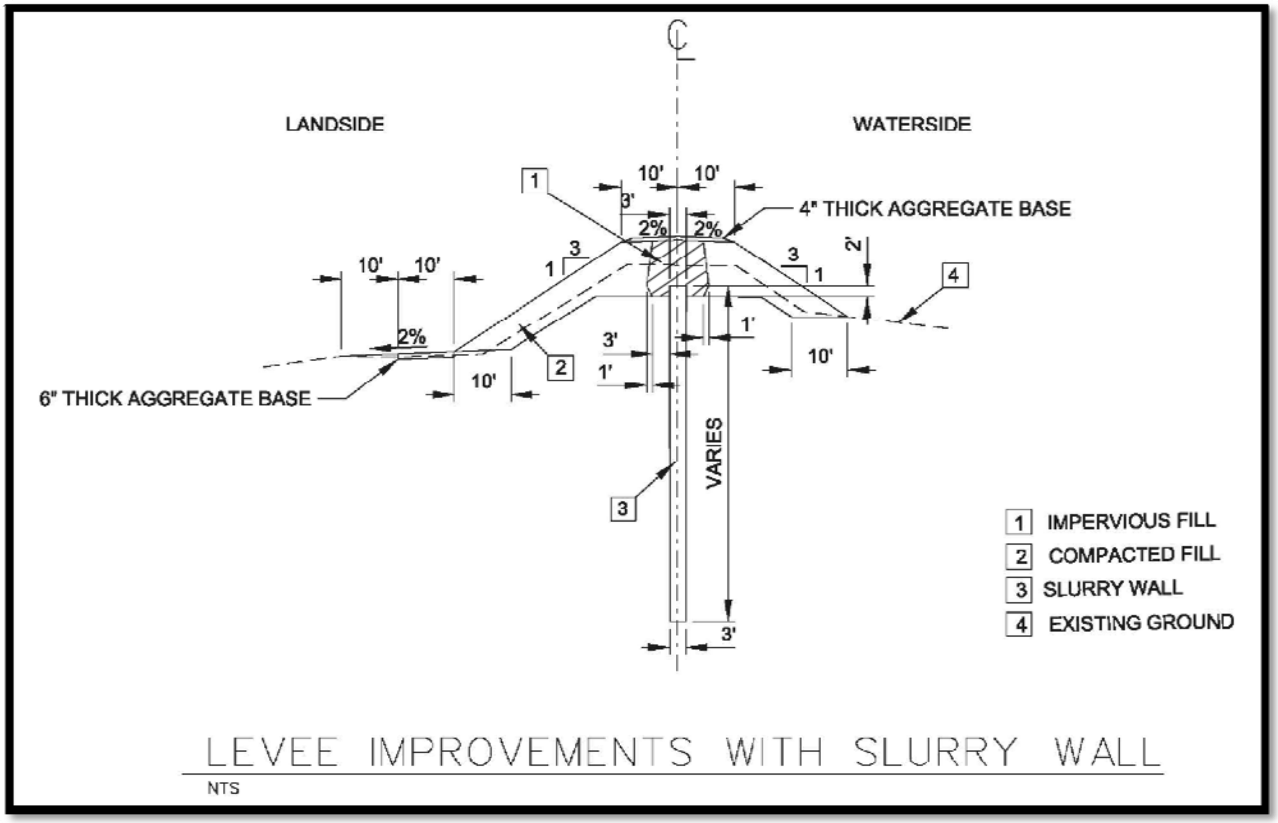


Figure 4: Levee Improvements with Slurry Wall

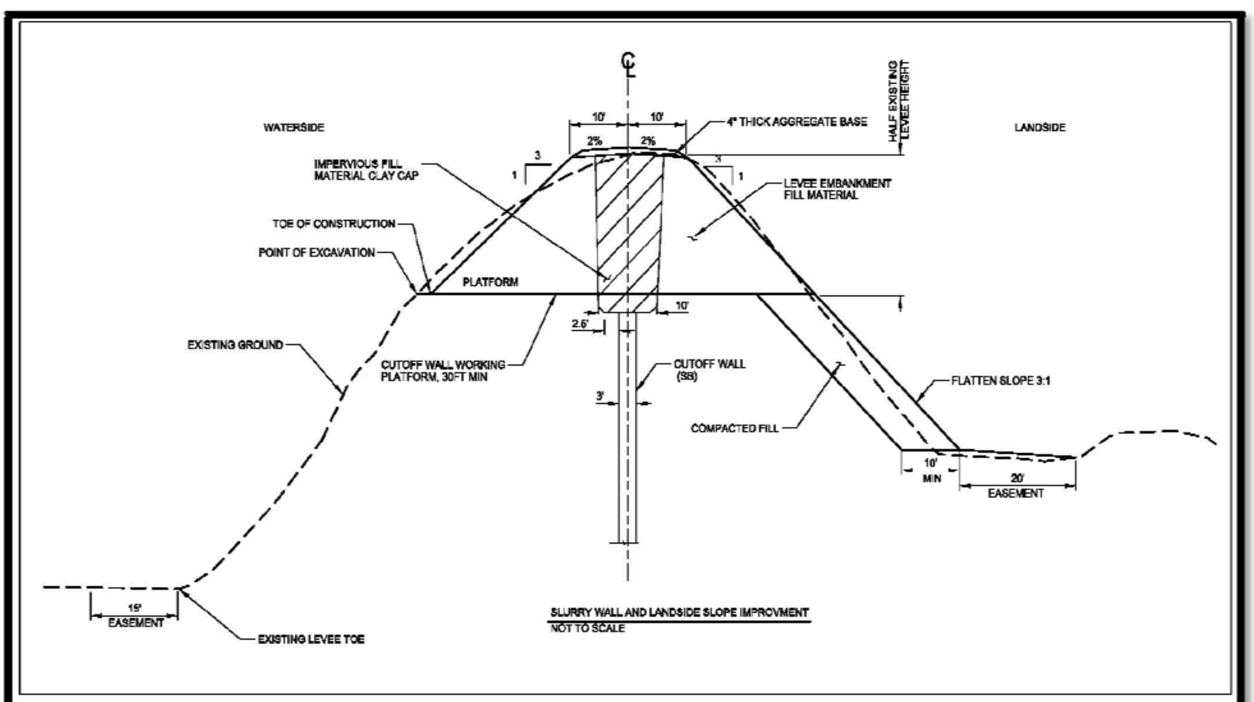


Figure 5: Slurry Wall and Landside Slope Improvement

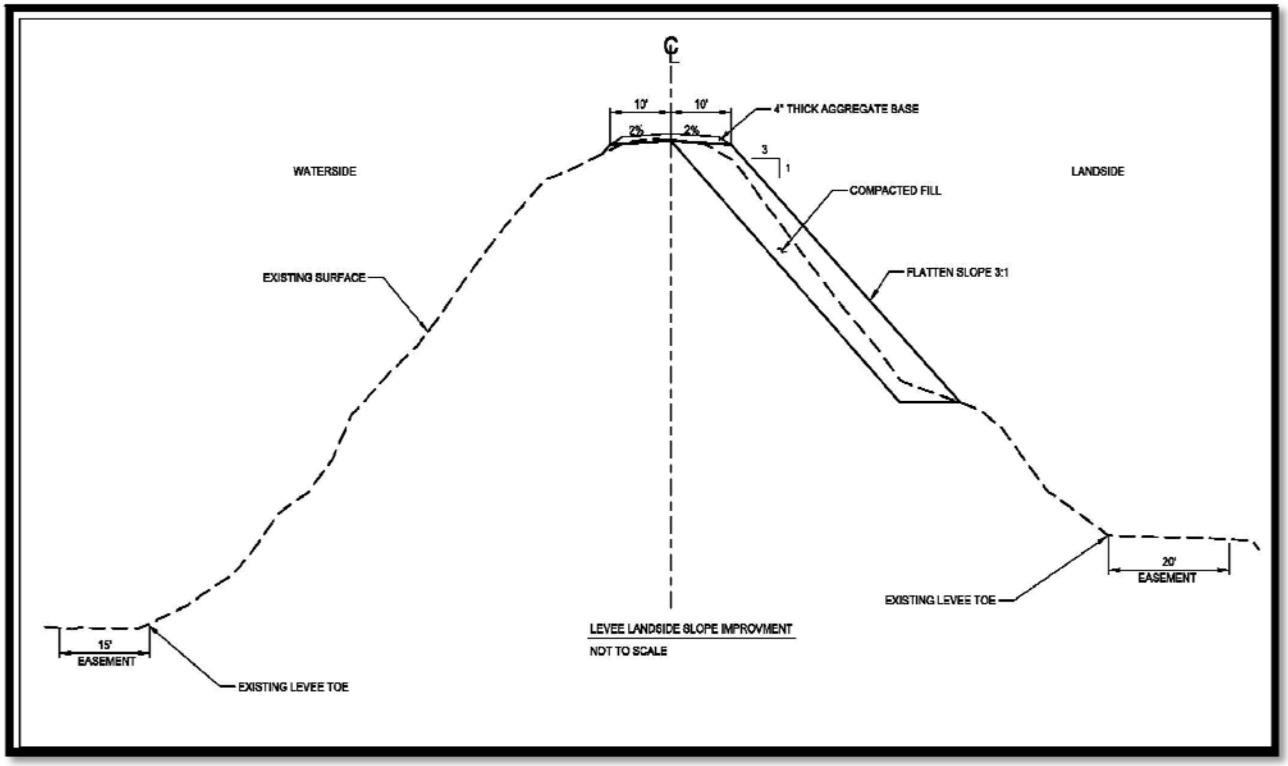


Figure 6: Levee Landside Slope Improvement

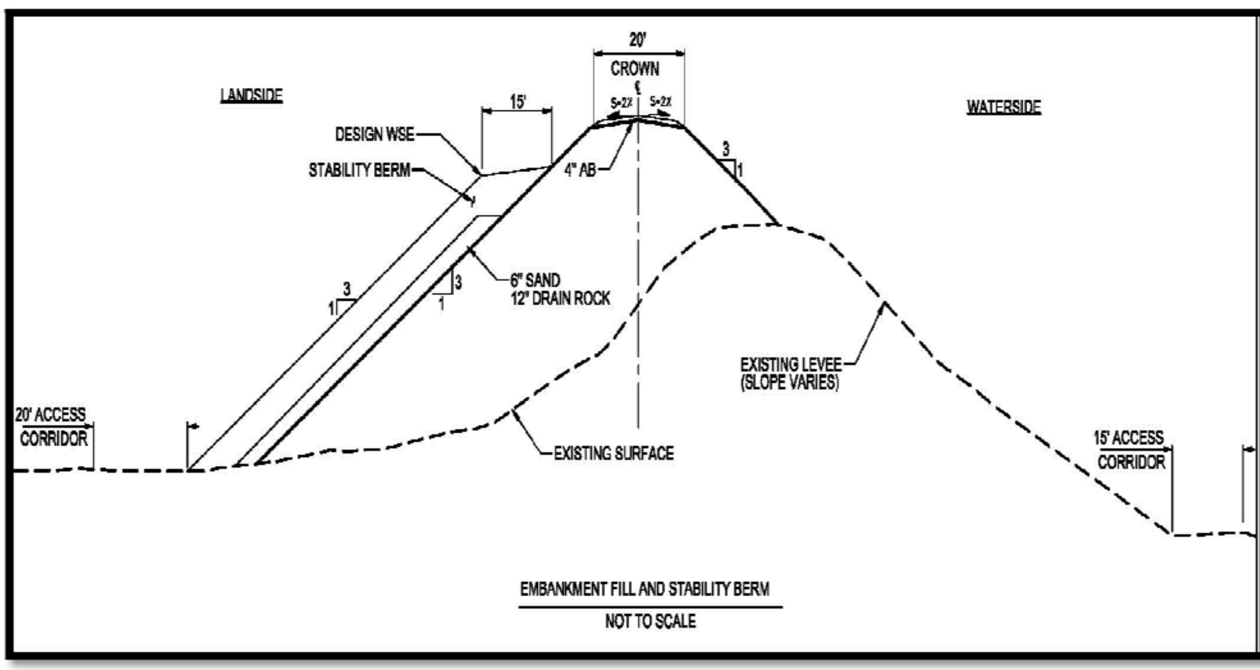


Figure 7: Embankment Fill and Stability Berm

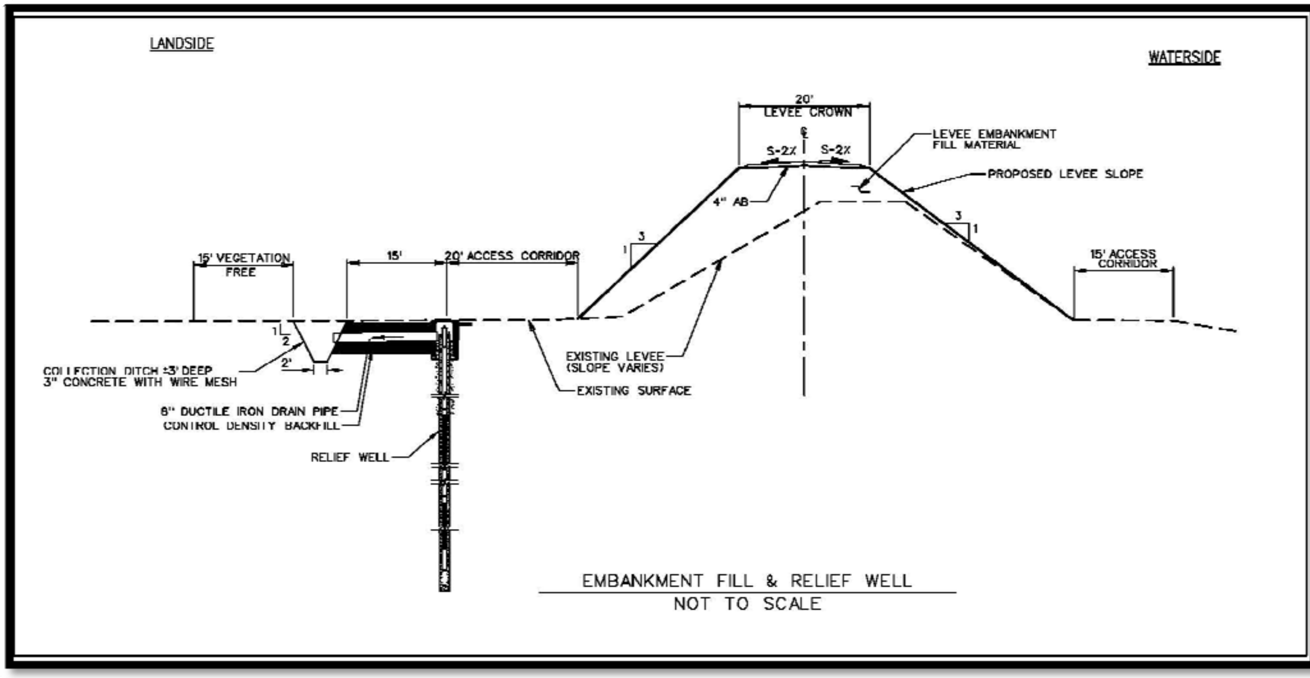


Figure 8: Embankment Fill & Relief Well

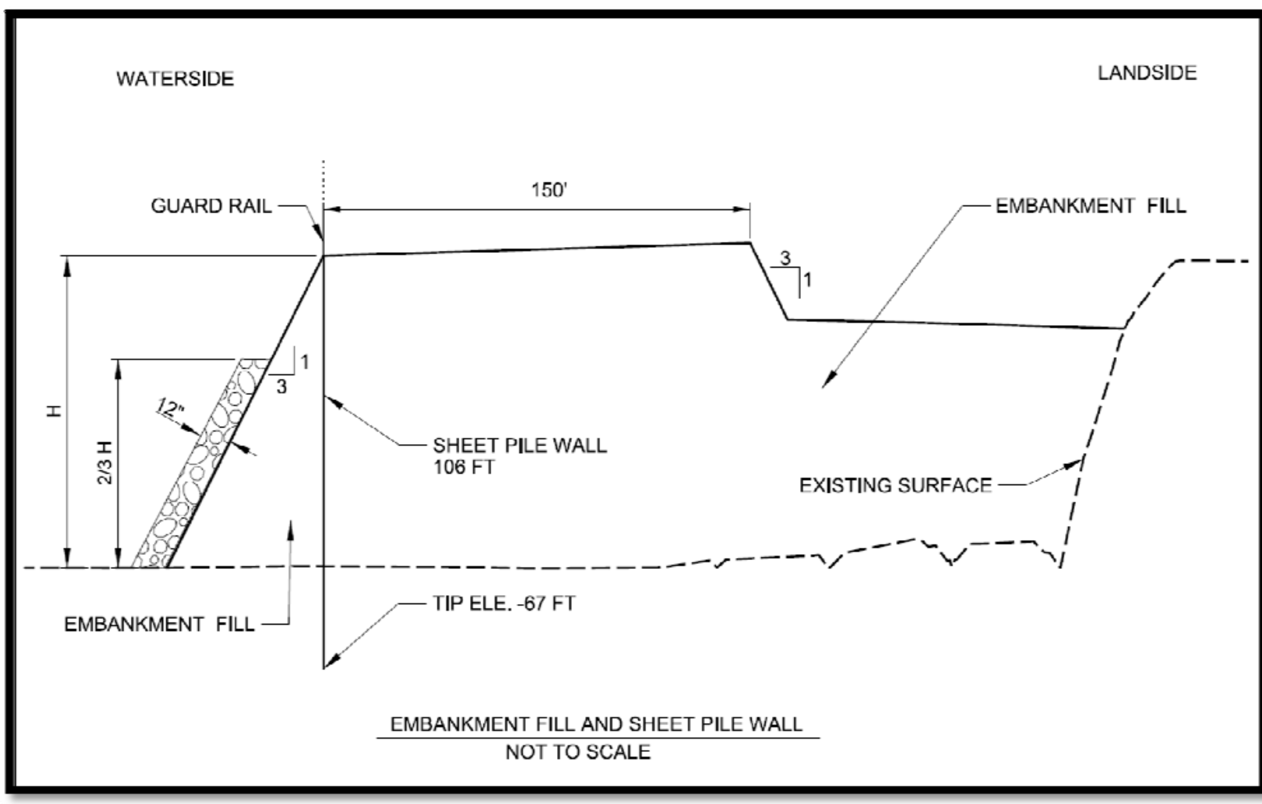


Figure 9: Embankment Fill and Sheet Pile Wall

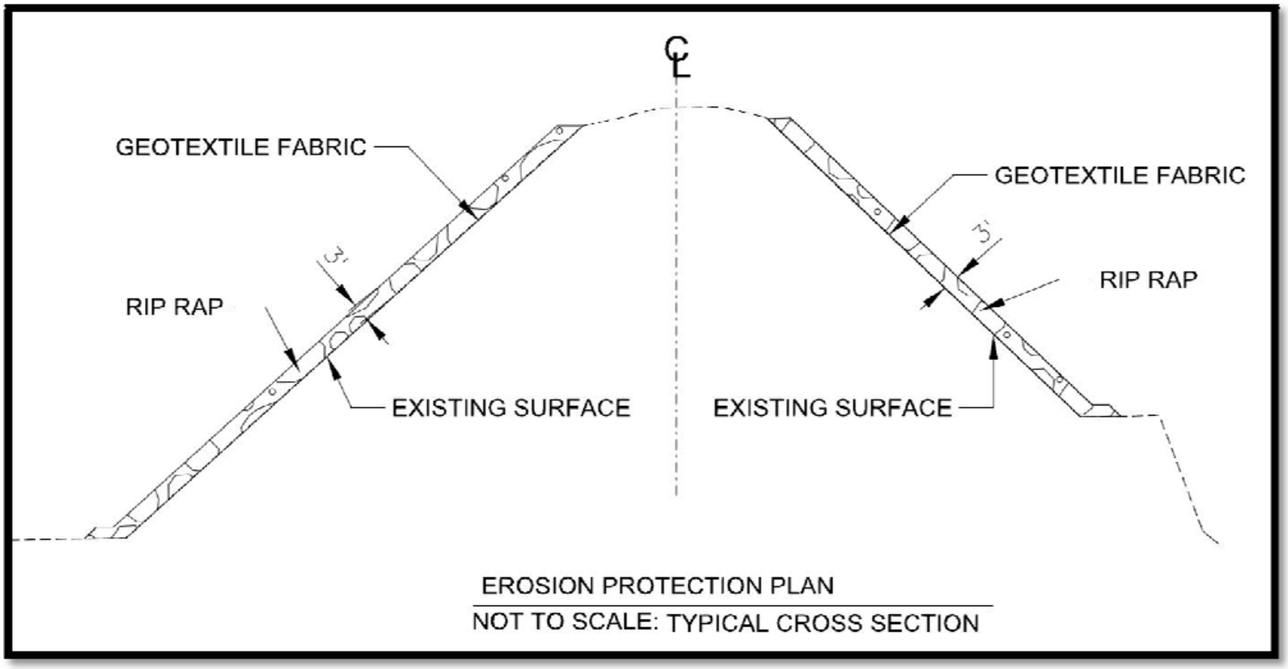


Figure 10: Erosion Protection Plan

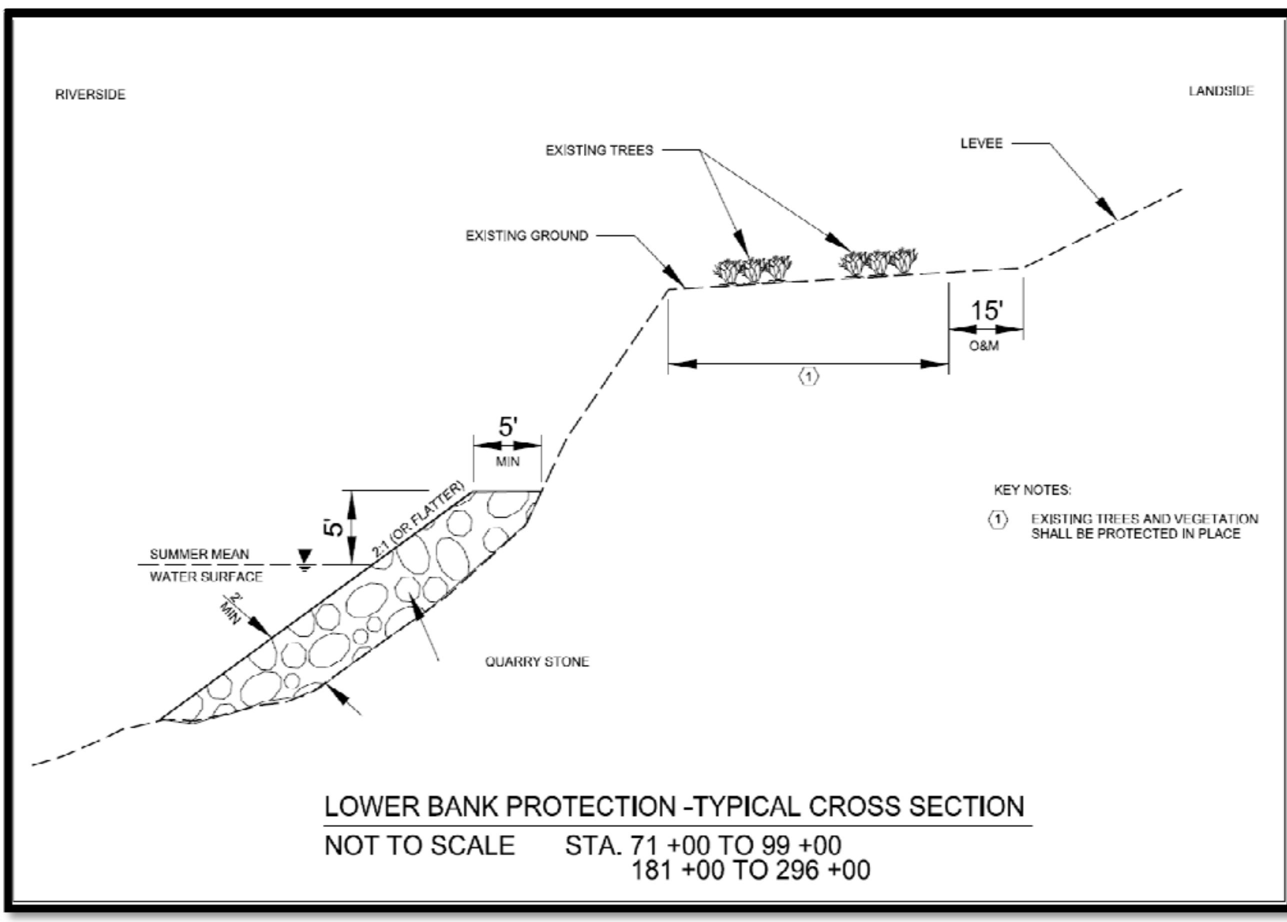


Figure 11: Bank Erosion Protection

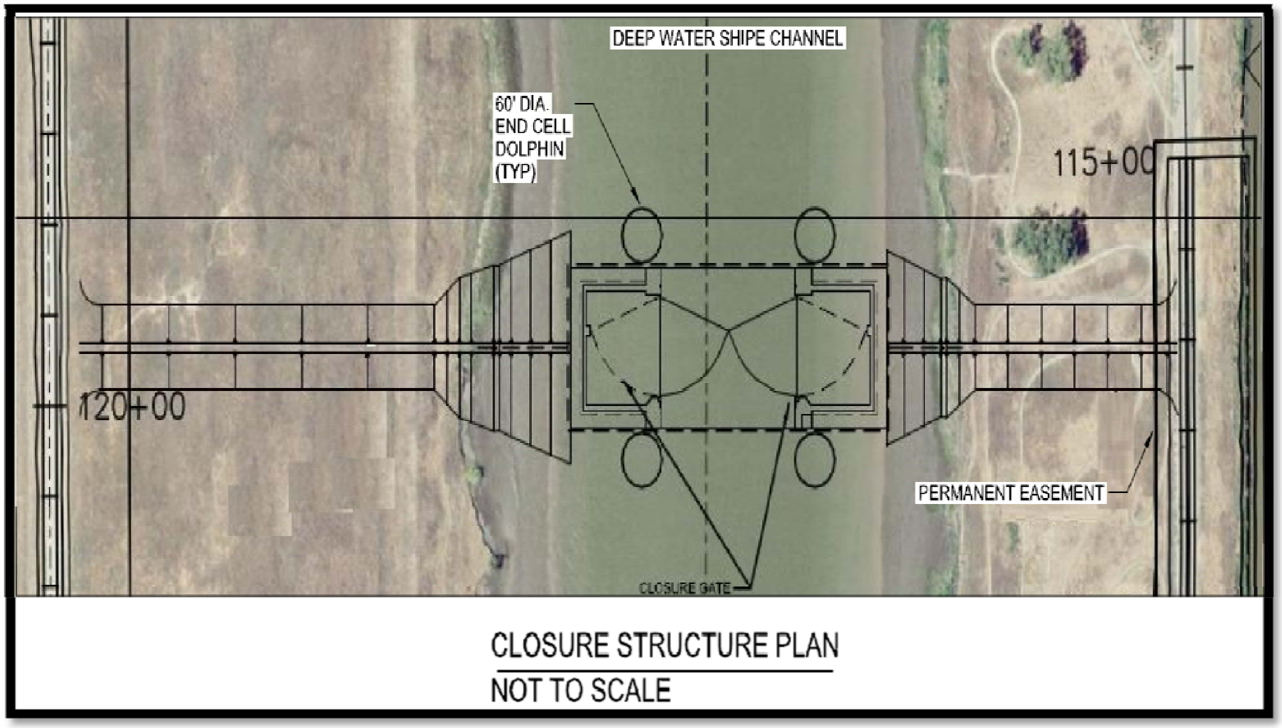


Figure 12: DWSC Closure Structure Plan

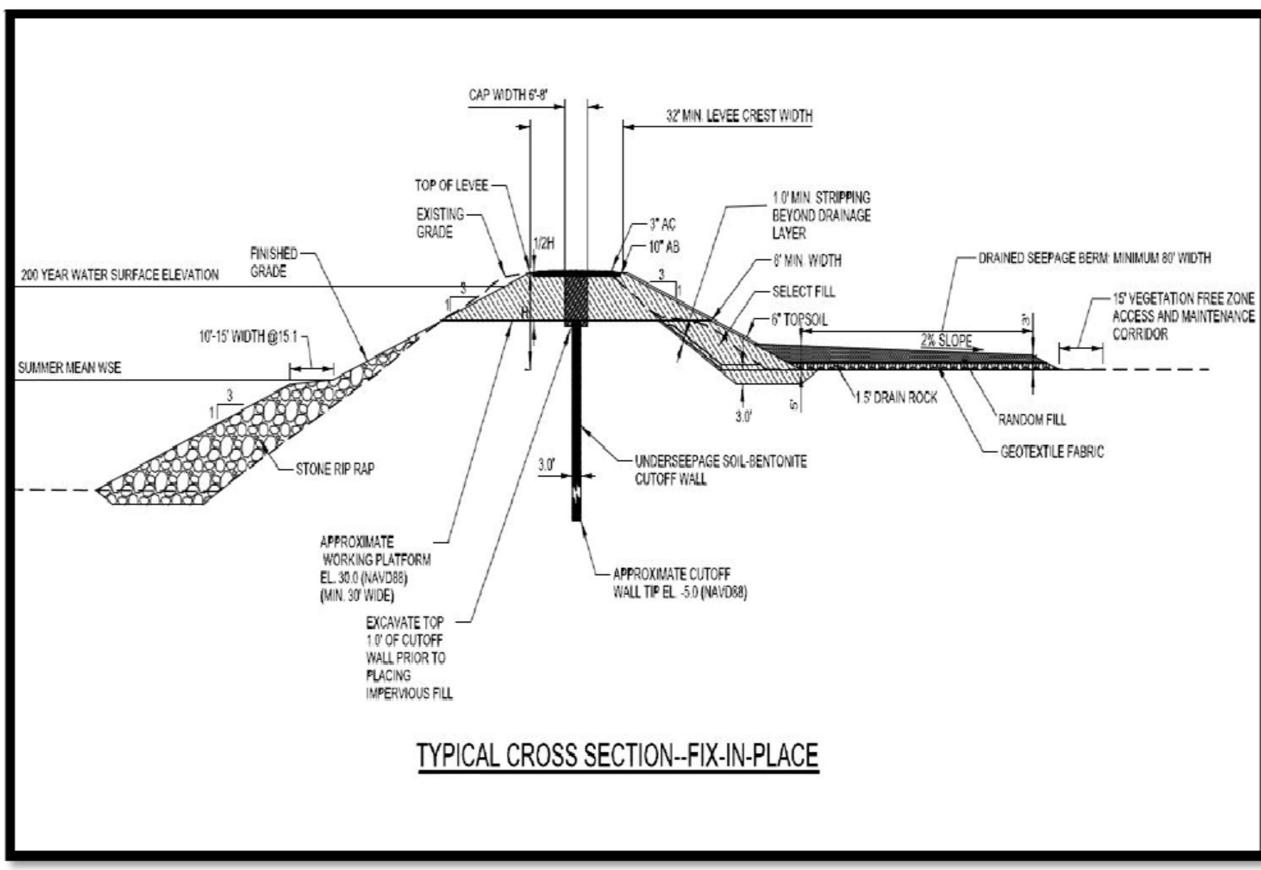


Figure 13: Typical Cross Section Fix-in-Place

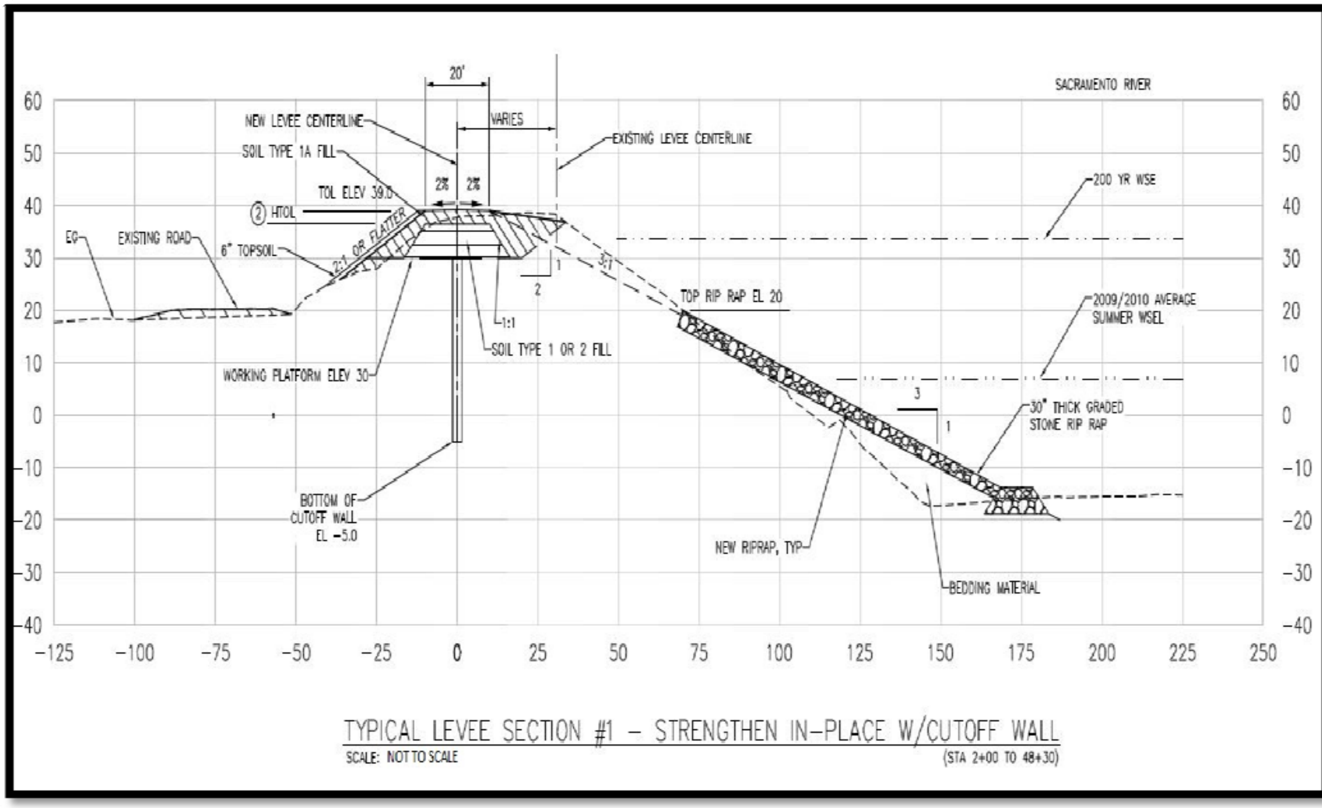


Figure 14: Typical Cross Section Strengthen In-Place with Cutoff wall

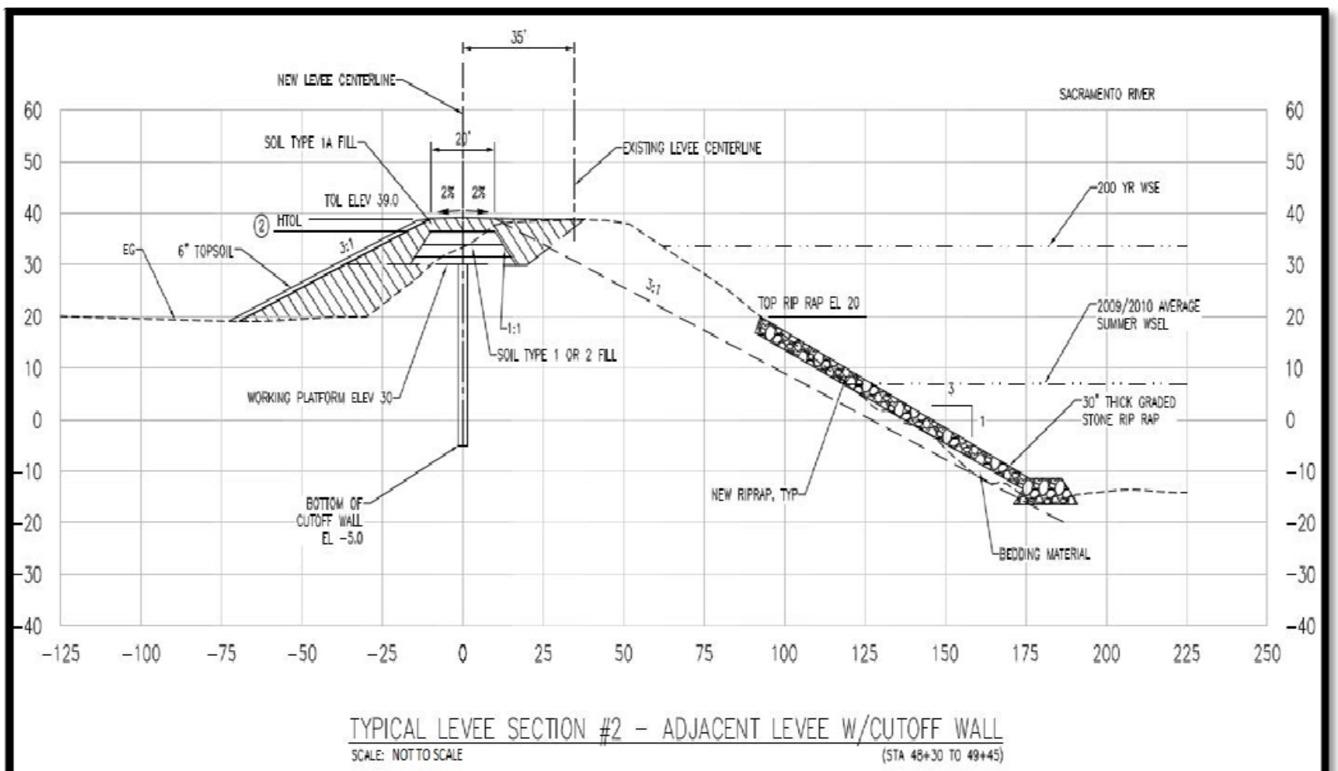


Figure 15: Typical Cross Section – Adjacent Levee with Cutoff Wall

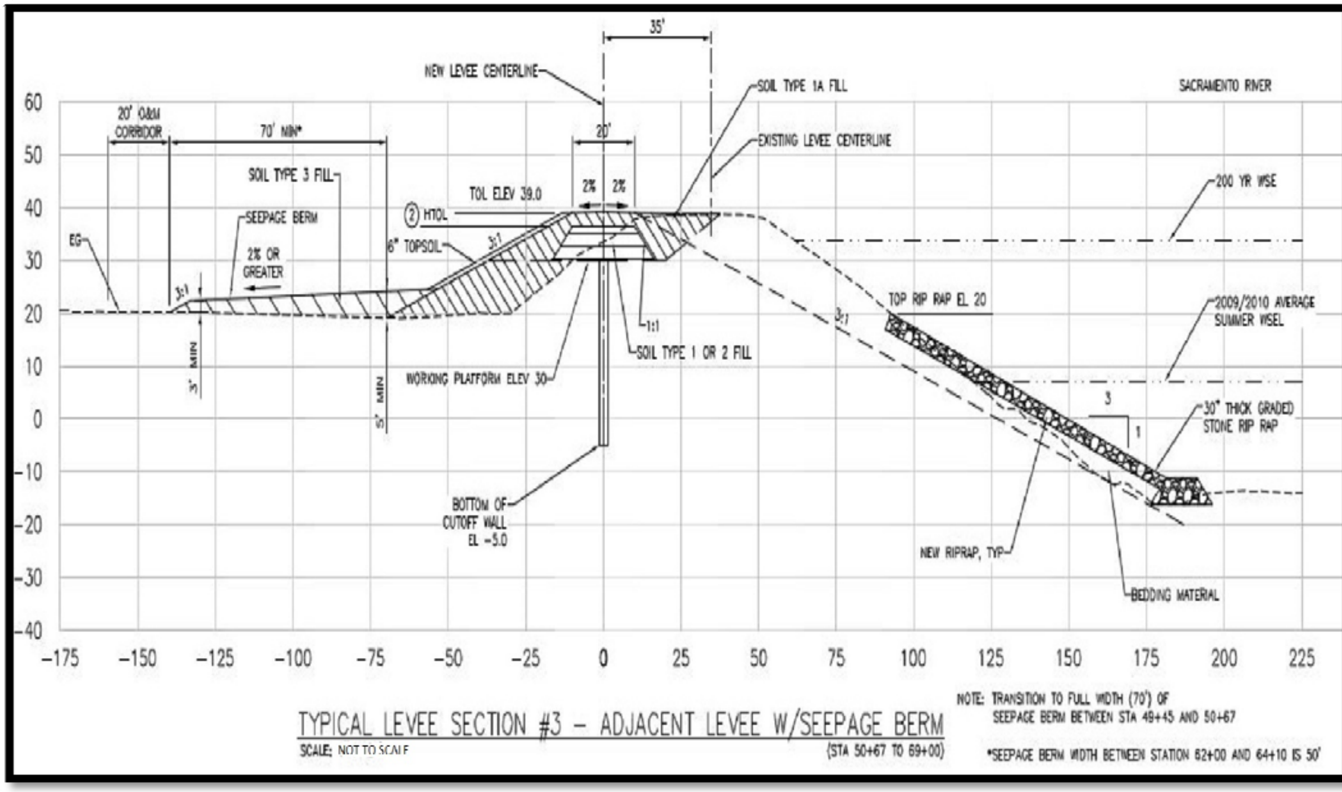


Figure 16: Adjacent Levee with Seepage Berm

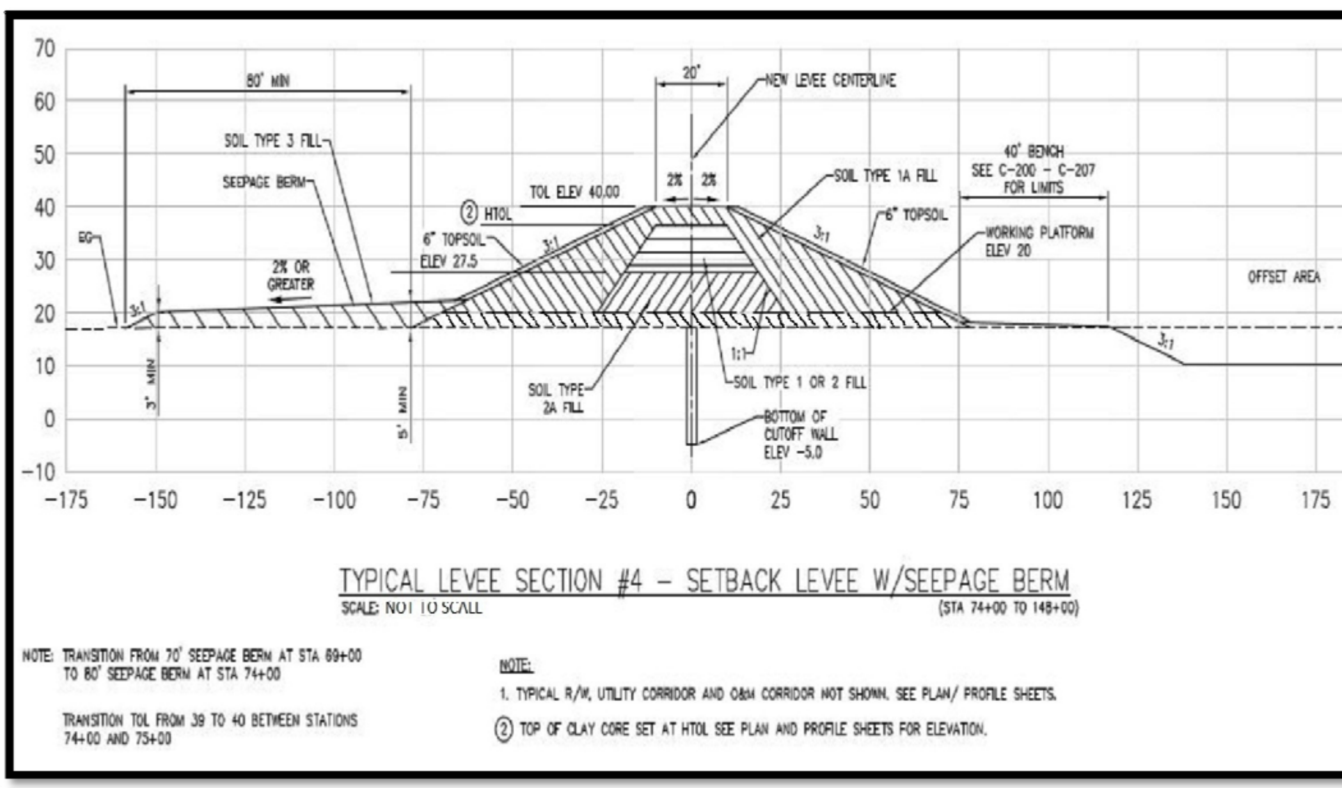


Figure 17: Setback Levee with Seepage Berm

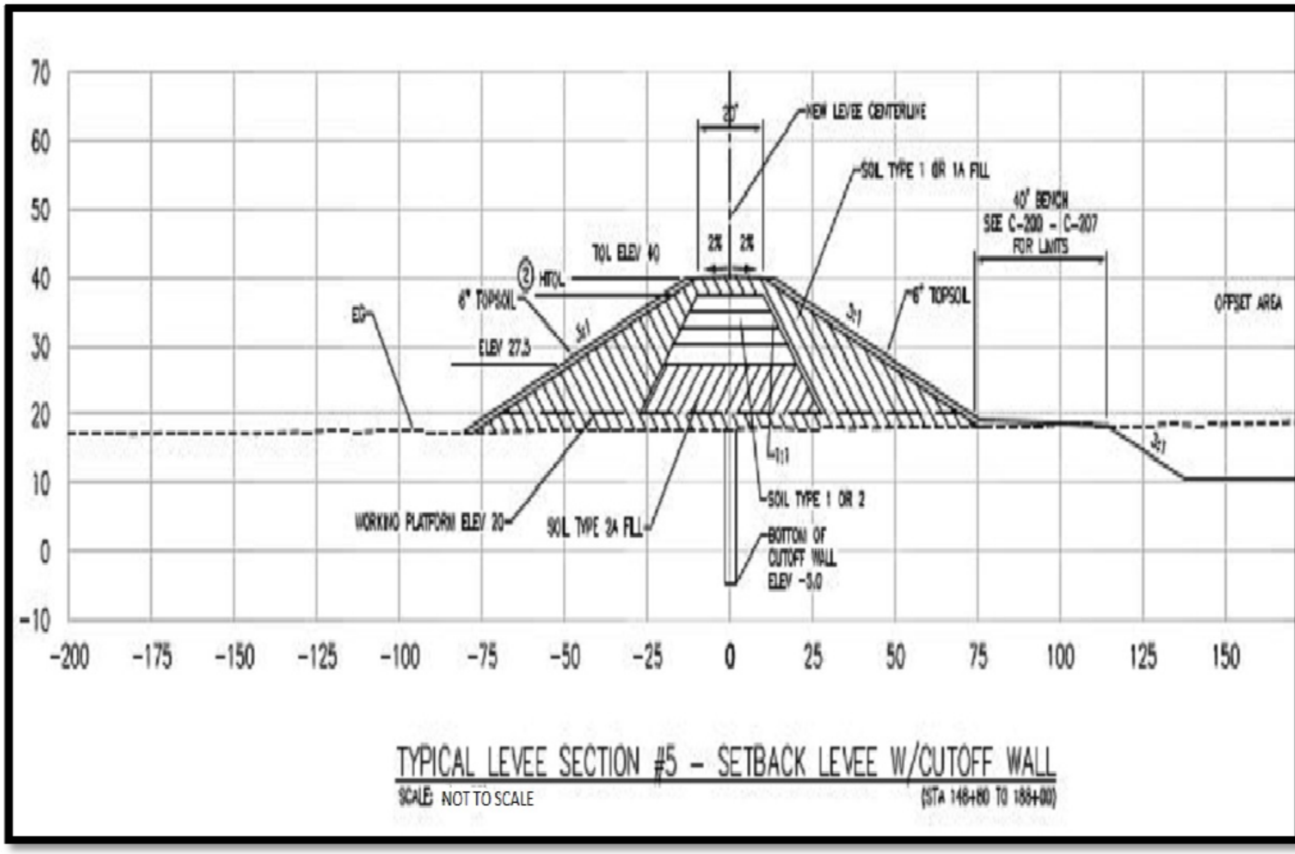


Figure 18: Setback Levee with Cutoff Wall

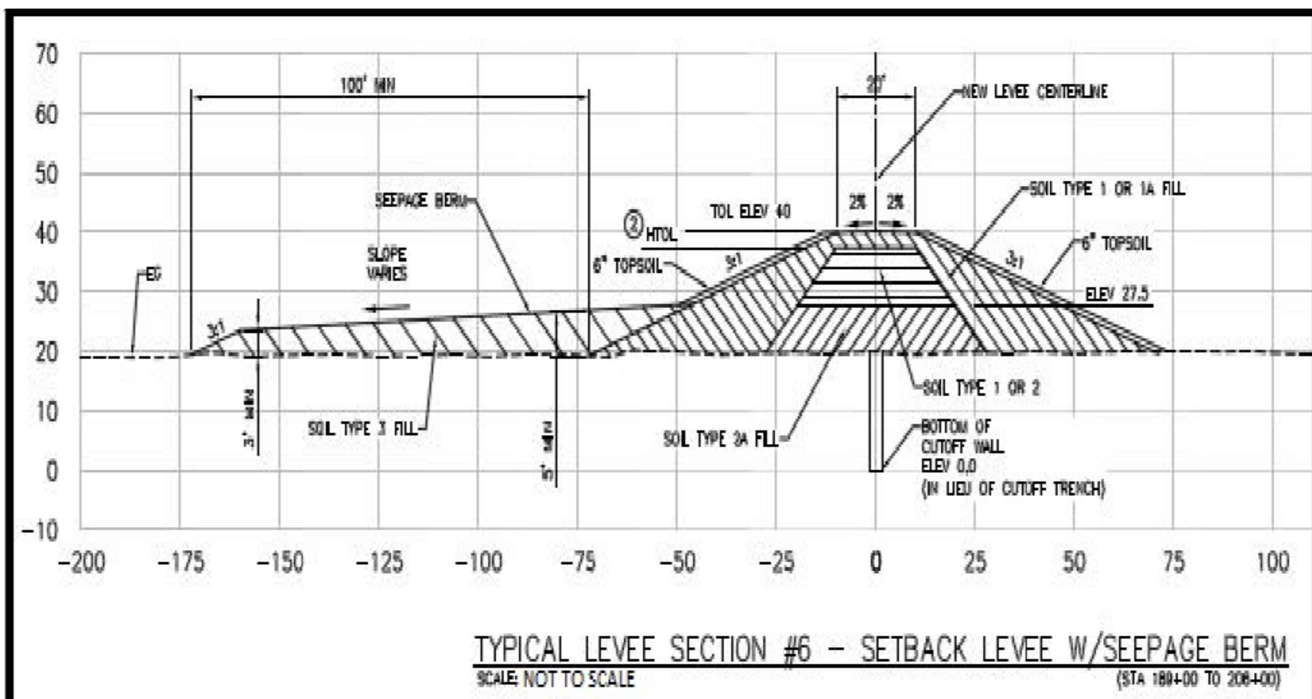


Figure 19: Setback Levee with Seepage Berm

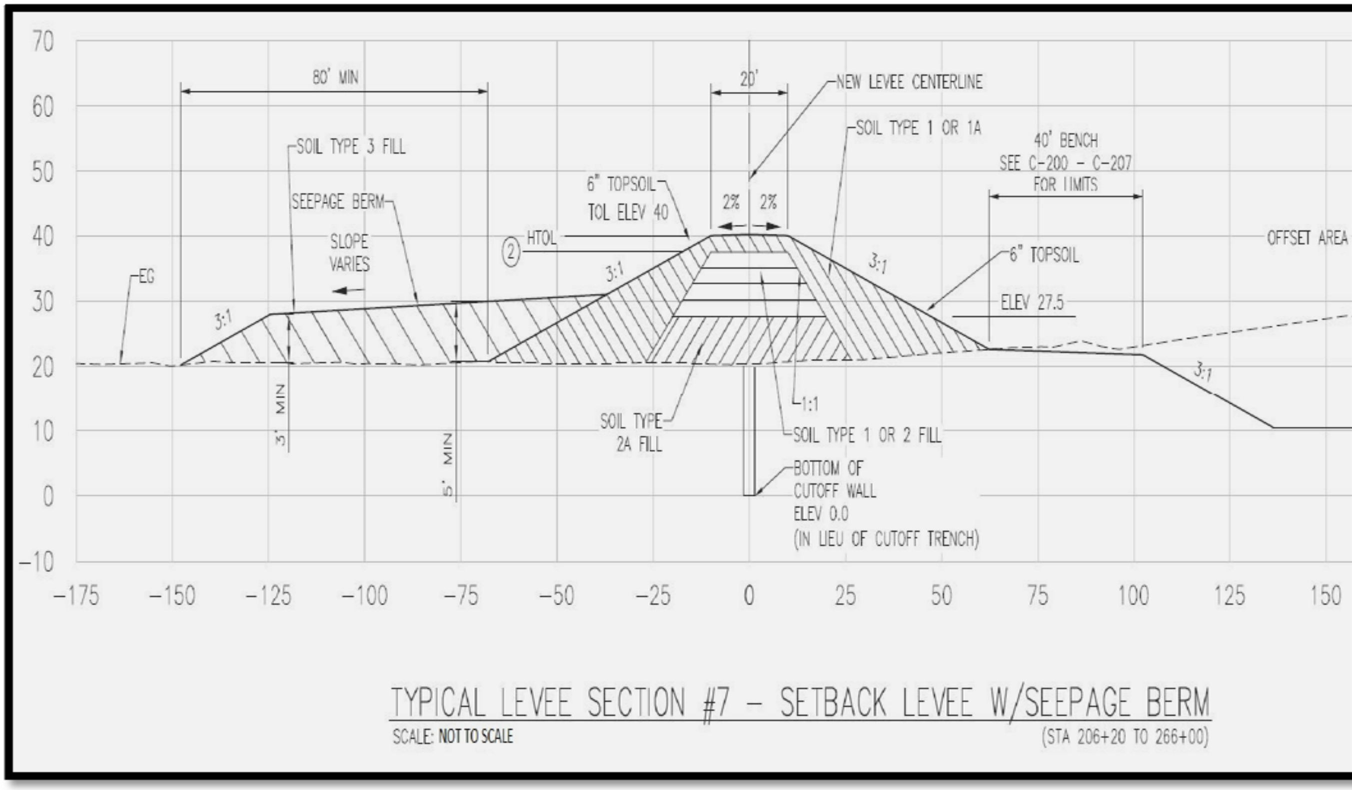


Figure 20: Setback Levee with Seepage Berm

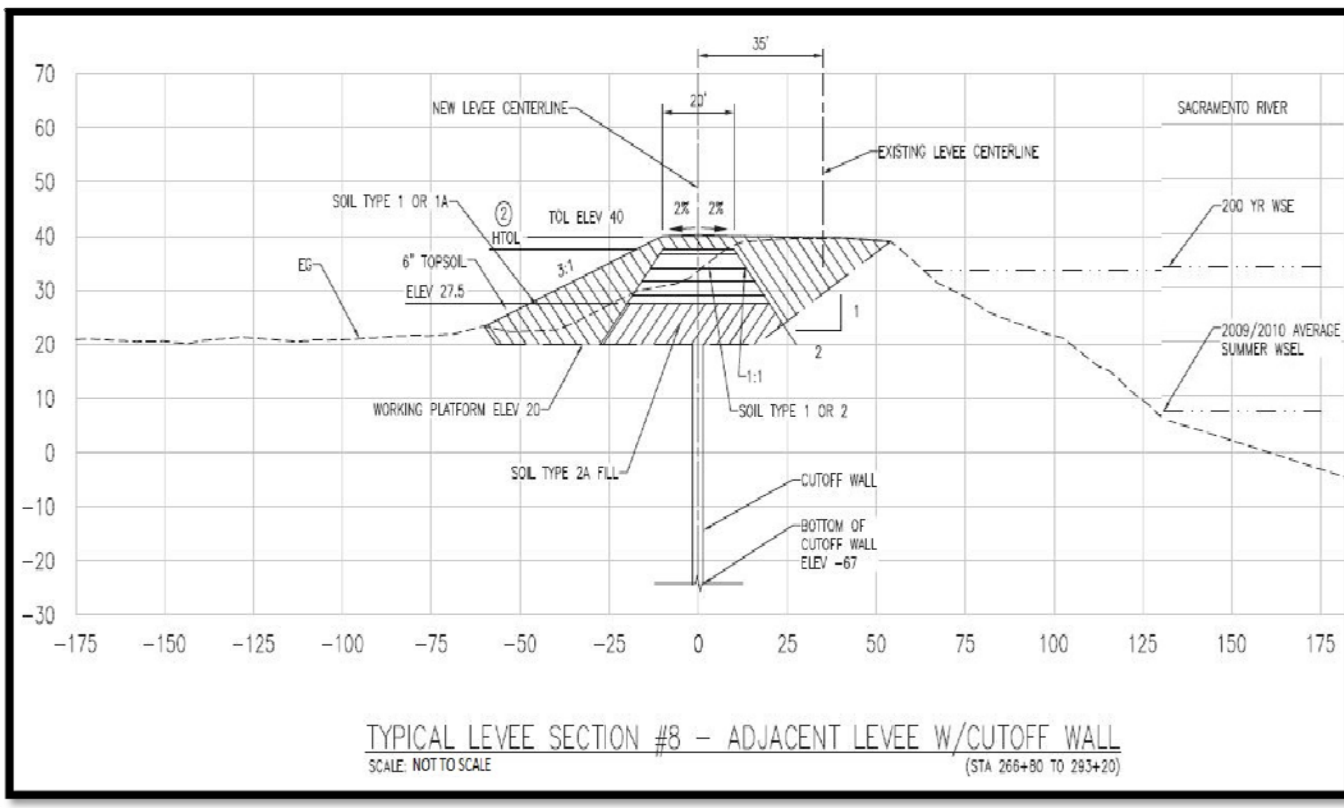
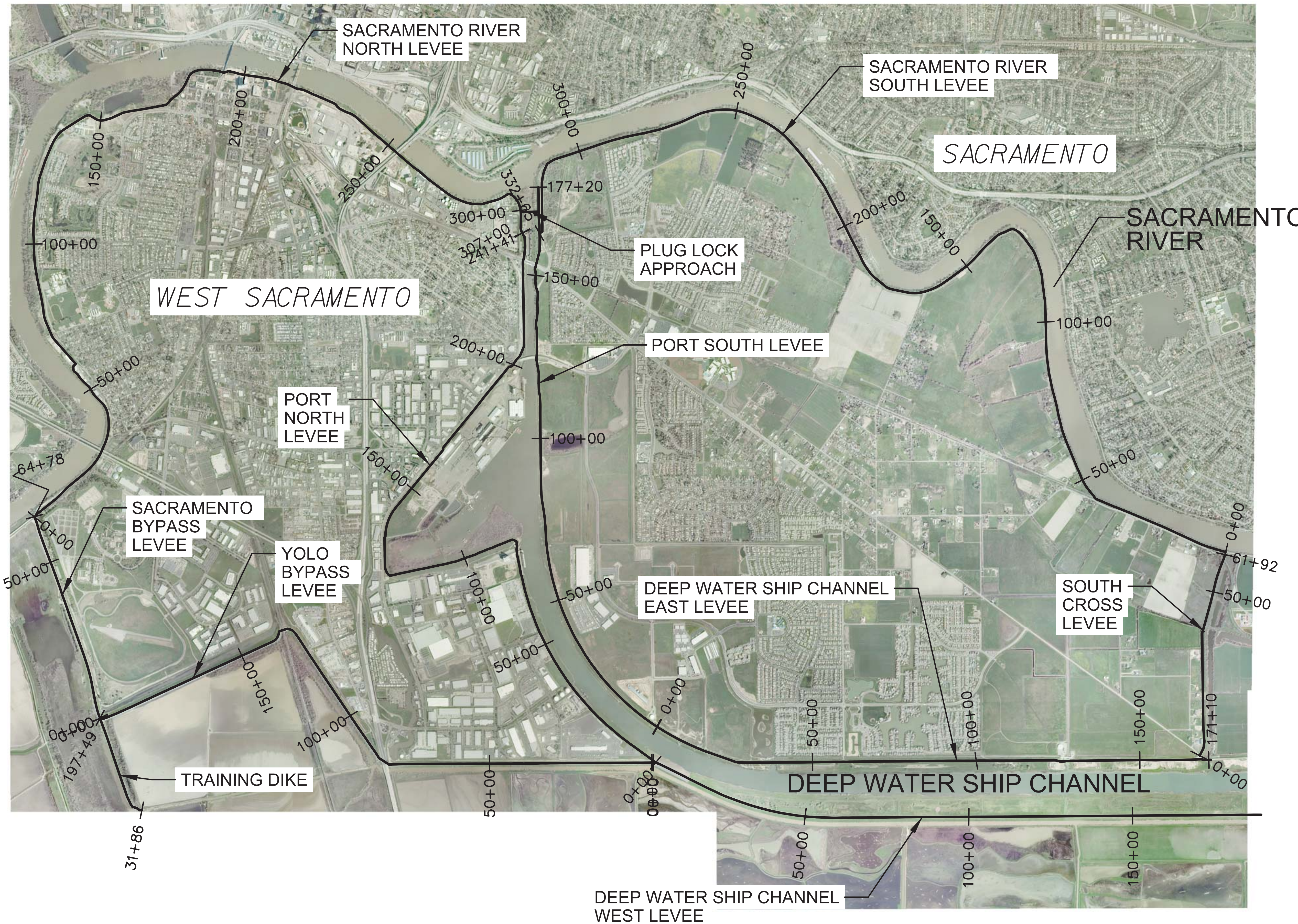


Figure 21: Adjacent Levee with Cutoff Wall



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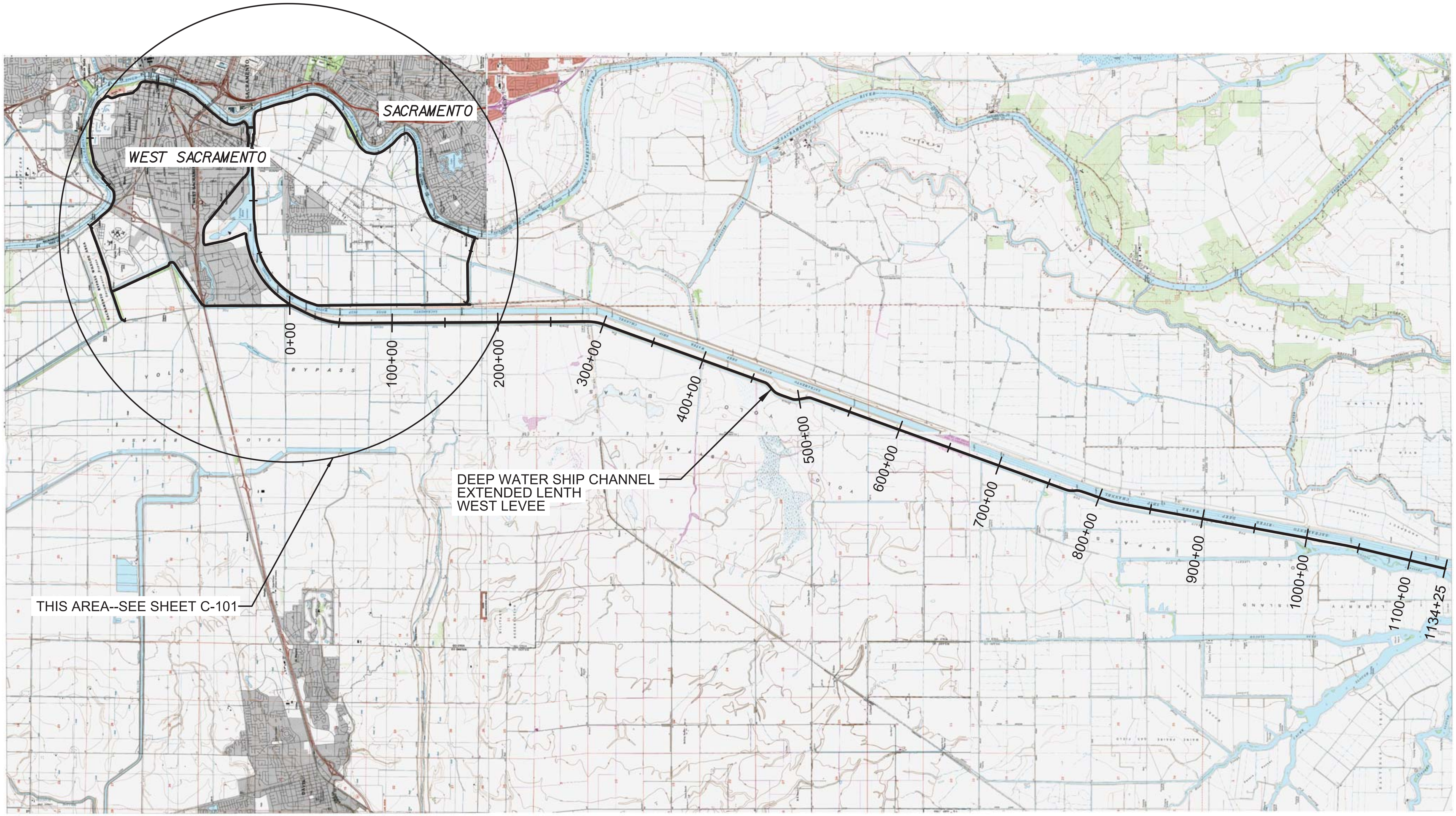
YOLO COUNTY CALIFORNIA
WEST SACRAMENTO PROJECT
GENERAL REEVALUATION REPORT
FLOOD RISK MANAGEMENT PROJECT

PROJECT LEVEE ALIGNMENTS ALTERNATIVE 1 FIX-IN-PLACE

Sheet reference number: PLATE 1



DEEP WATER SHIP CHANNEL WEST LEVEE EXTENSION

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GENERAL REEVALUATION REPORT
FLOOD RISK MANAGEMENT PROJECT

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ALTERNATIVE 1
FIX-IN-PLACE

Sheet reference number:
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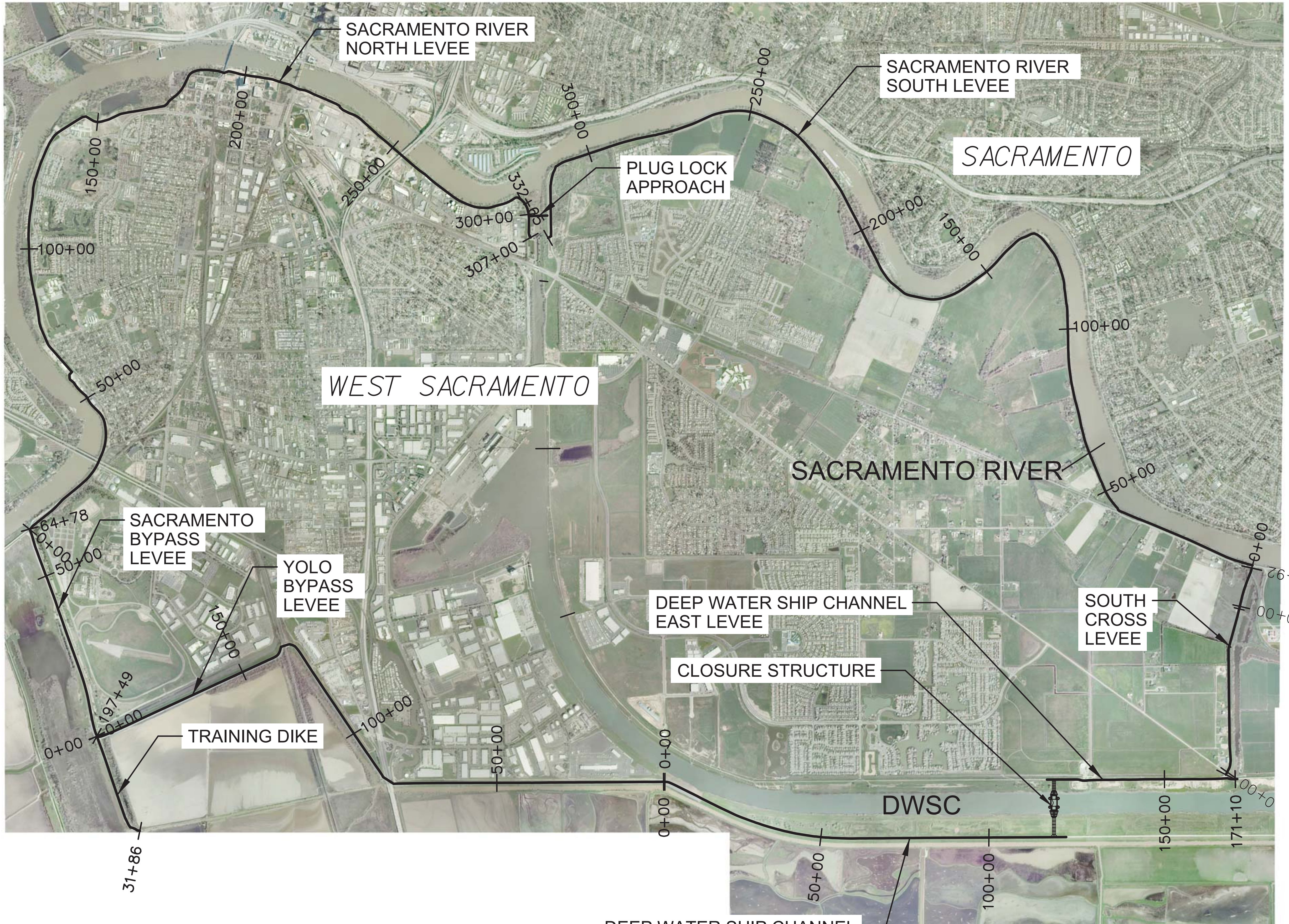

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GENERAL REEVALUATION REPORT
FLOOD RISK MANAGEMENT PROJECT

PROJECT LEVEE ALIGNMENTS
ALTERNATE 3
FIX-IN-PLACE & CLOSURE STR.

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FLOOD RISK MANAGEMENT PROJECT
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TRAINING DIKE PLAN

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TRAINING DIKE
PLAN AND CROSS SECTION

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YOLO BYPASS LEVEE PLAN VIEW

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YOLO BYPASS LEVEE
OVERALL MAP

Sheet reference number:
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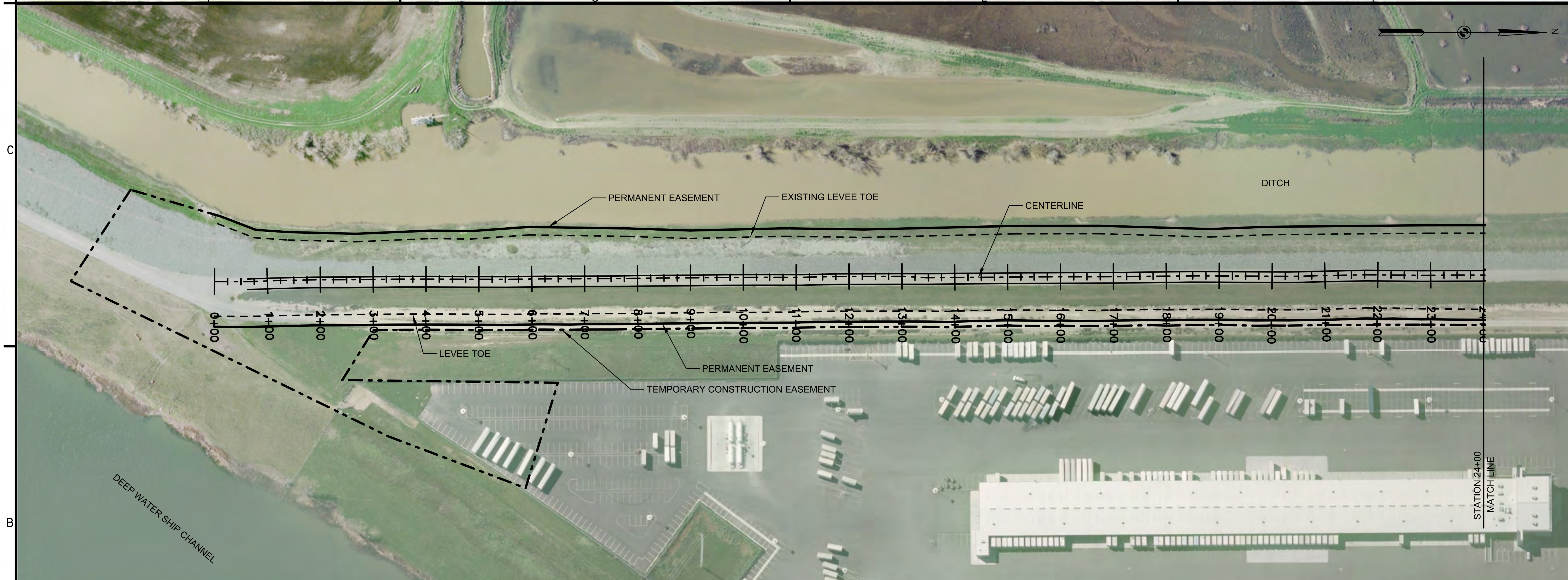
8.1.2 PLOT DATE: 19-AUG-2013 PLOT TIME: 10:56 \\AMETHYST\civcad\WestSacramento\WestSacramentoGRR\CADD\Civil\Yolo_Bypass_Levee\SheetFiles\C-010



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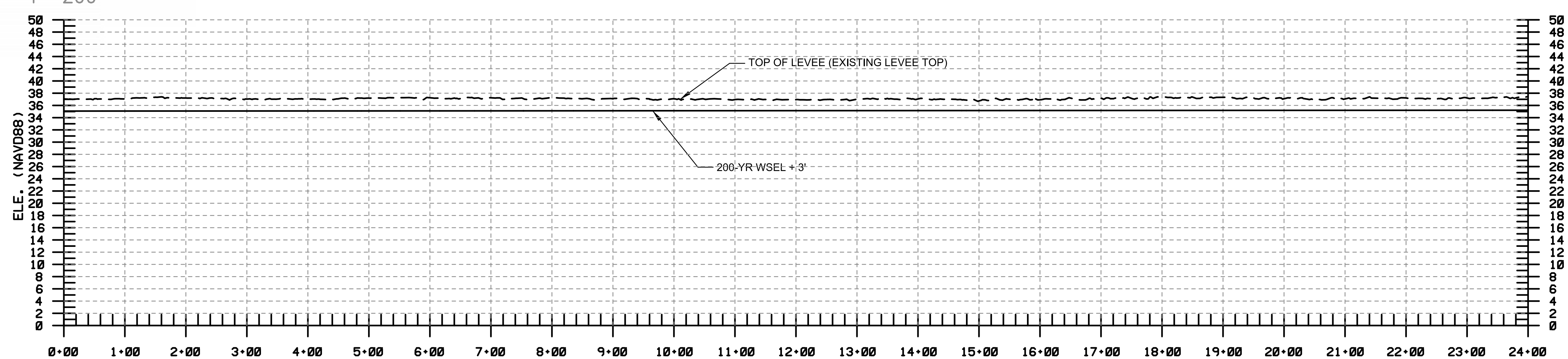

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AGENCY FLOOD RISK REDUCTION PROJECTS

YOLO BYPASS LEVEE
PLAN AND PROFILE

Sheet reference number:
PLATE 002

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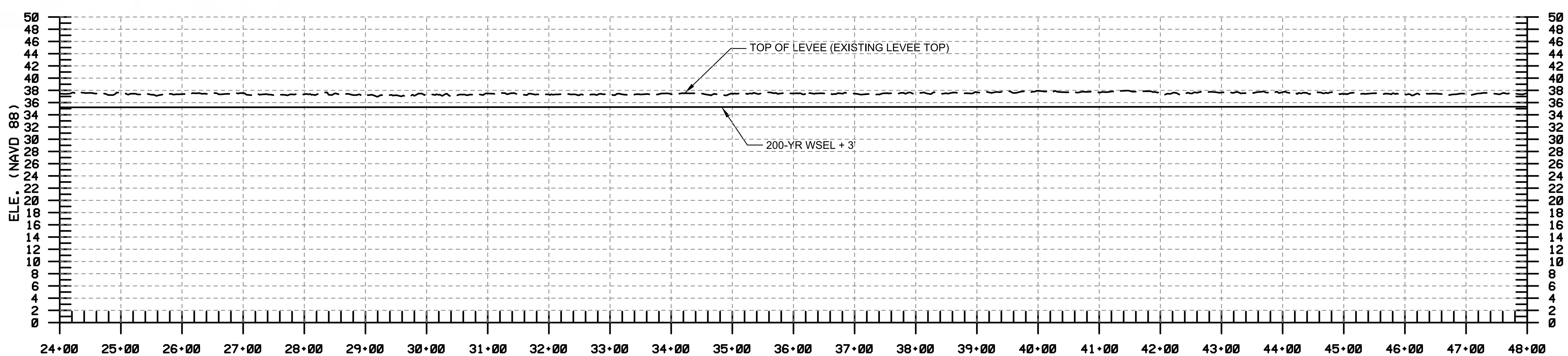

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Sheet reference number:
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PLOT DATE: 19-AUG-2013 PLOT TIME: 10:59 \\AMETHYST\civcad\WestSacramento\WestSacramentoGRR\CADD\Civil\Yolo_Bypass_Levee\SheetFiles\C-03

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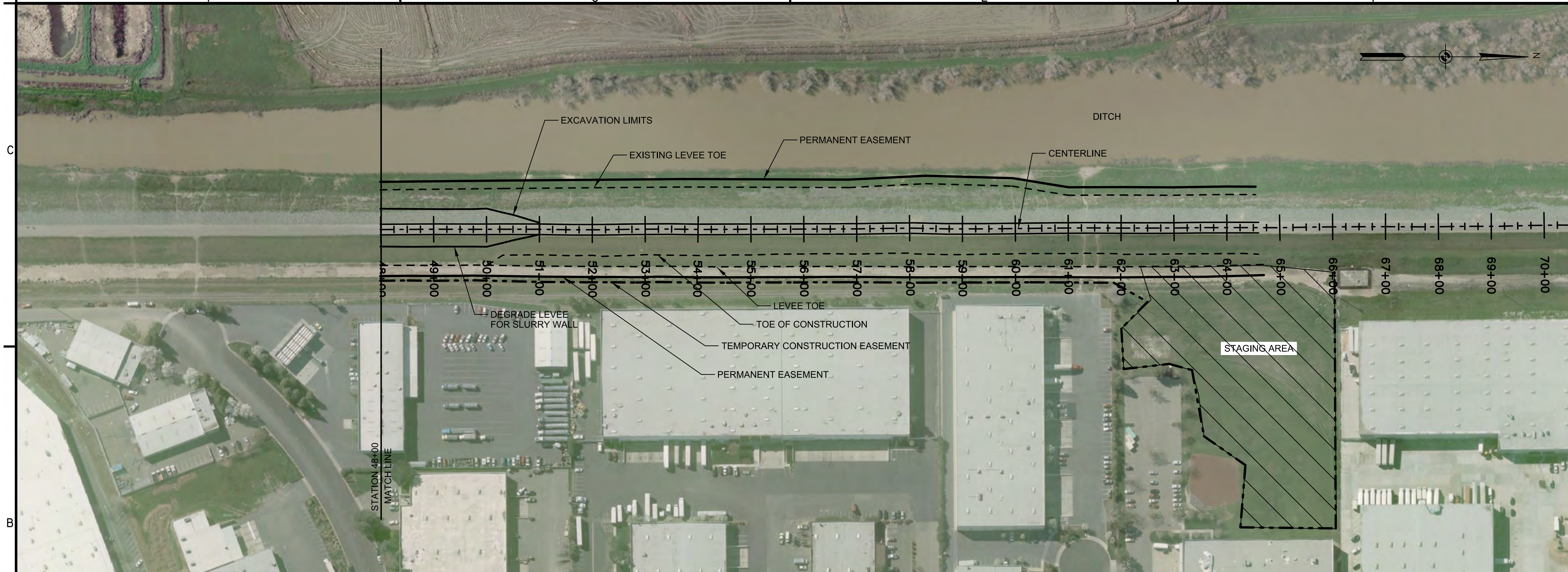

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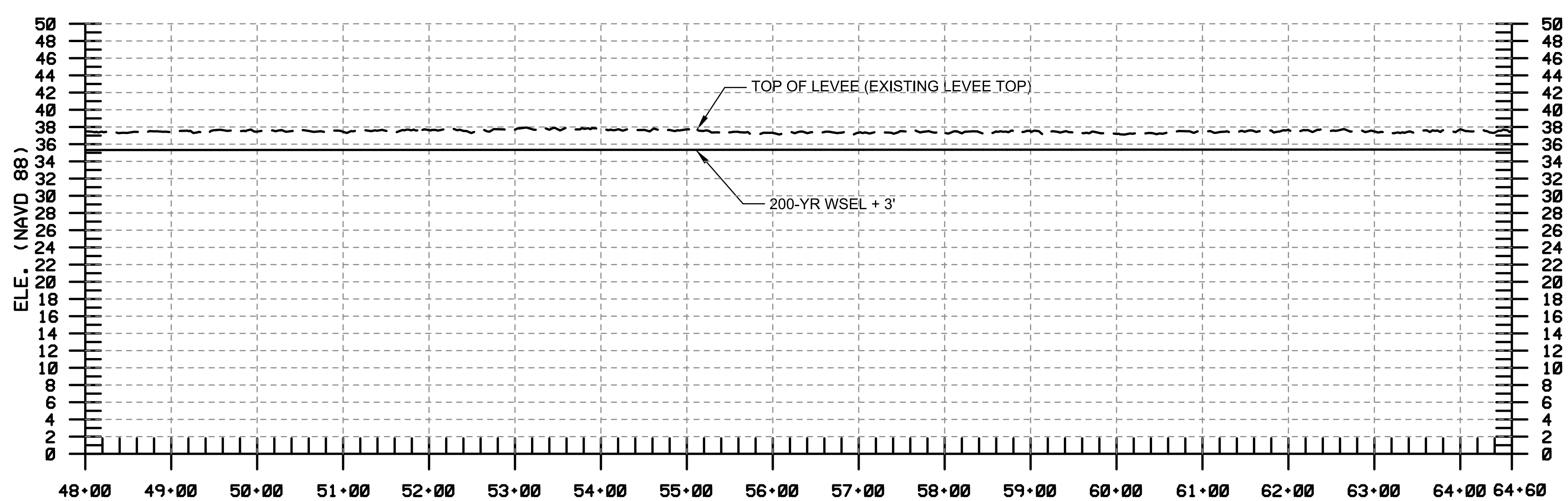

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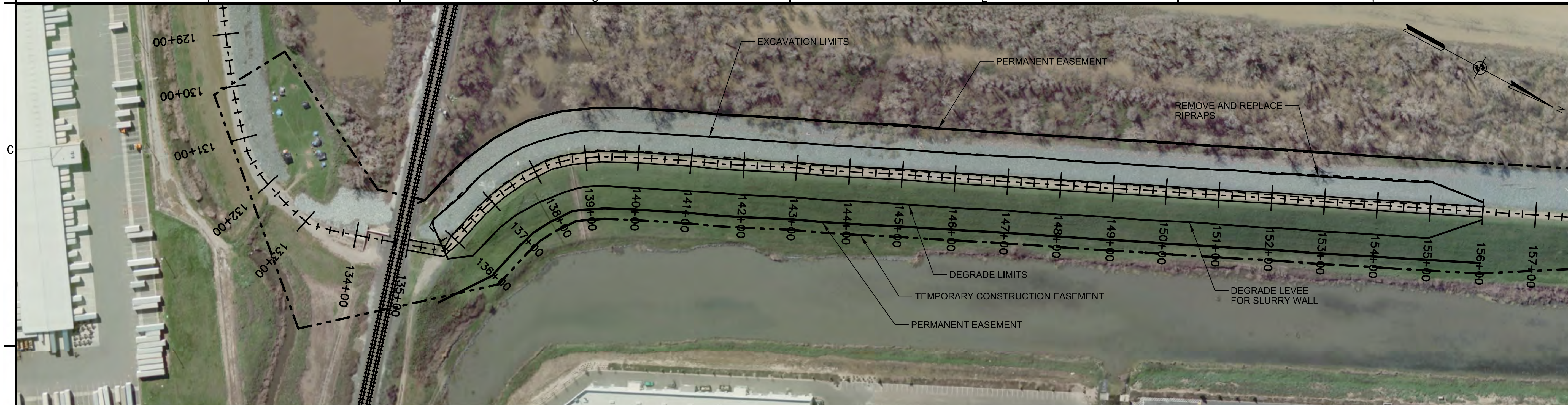
YOLO BYPASS LEVEE
PLAN AND PROFILE

Sheet reference number:
PLATE 004



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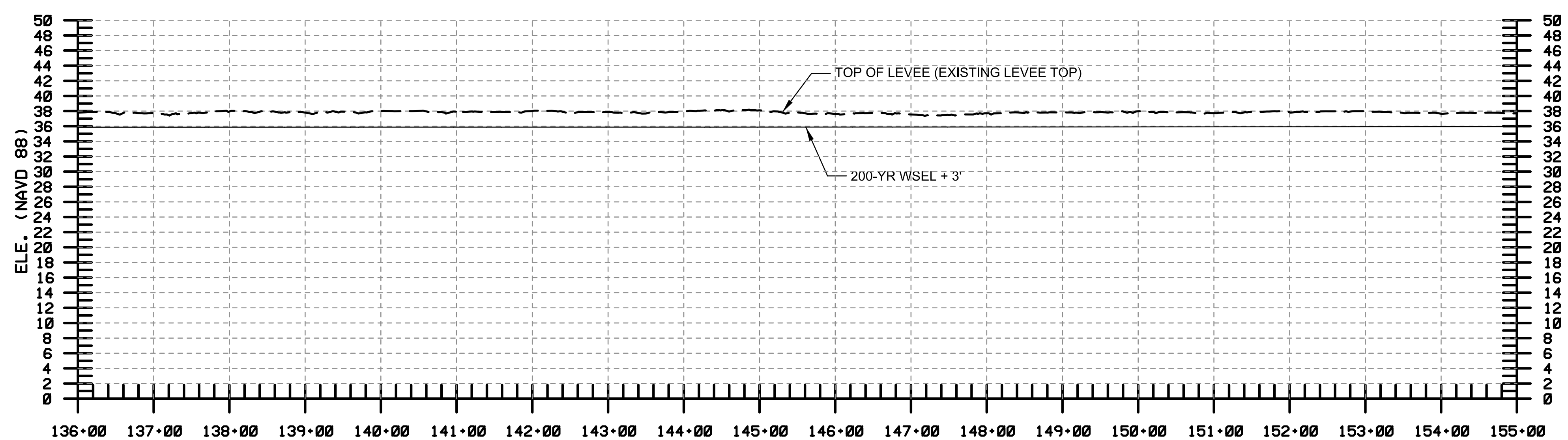

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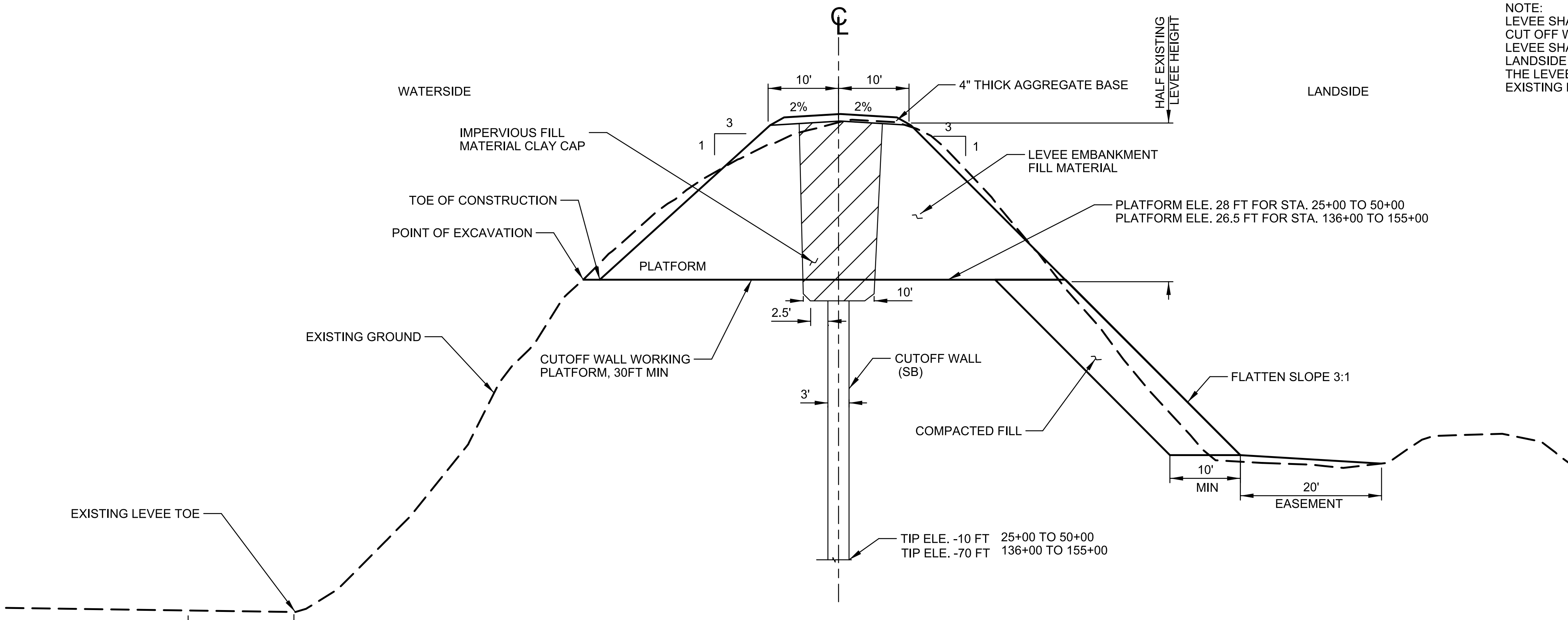
Sheet reference number:
PLATE 005

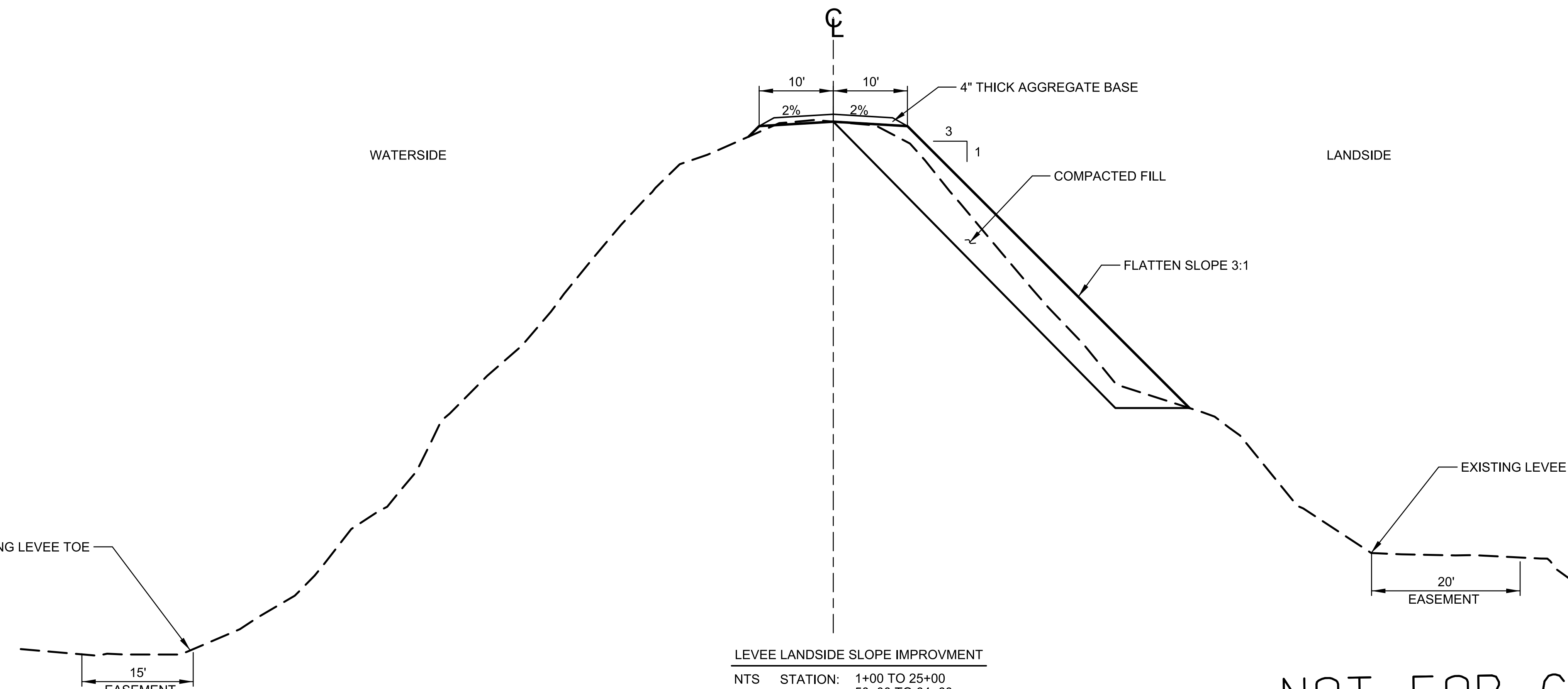
8.1.2 PLOT DATE: 19-AUG-2013 PLOT TIME: 11:02 \\AMETHYST\civcad\WestSacramento\WestSacramentoGRR\CADD\Civil\Yolo_Bypass_Levee\SheetFiles\C-105

NOTE:
LEVEE SHALL BE RESTORED TO EXISTING LEVEE HEIGHT ONCE CUT OFF WALL IS COMPLETED. FROM STATION 25+00 TO 50 +00, LEVEE SHALL BE CONSTRUCTED CUTOFF WALL AND FLATTENED LANDSIDE SLOPE TO 3H:1V. FROM STATION 136+00 TO 155+00, THE LEVEE SHALL BE CONSTRUCTED CUTOFF WALL, AND ITS EXISTING LANDSIDE SLOPE MEET 3H:1V REQUIREMENT.



LEVEE IMPROVMENT

NTS STATION: 25+00 TO 50+00
136+00 TO 155+00



LEVEE LANDSIDE SLOPE IMPROVMENT

NTS STATION: 1+00 TO 25+00
50+00 TO 64+60

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Sacramento District

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Dwn by: | Spec No.: | Design file no:
Reviewed by: | Drawing Code:
Submitted by: CHIEF, CIV ENGR DES SEC A | File name: | Plot date: | Plot scale:

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YOLO COUNTY CA
WEST SACRAMENTO AREA FLOOD CONTROL AGENCY FLOOD RISK REDUCTION PROJECTS
YOLO BYPASS LEVEE
TYPICAL CROSS SECTIONS

Sheet reference number:
PLATE 006

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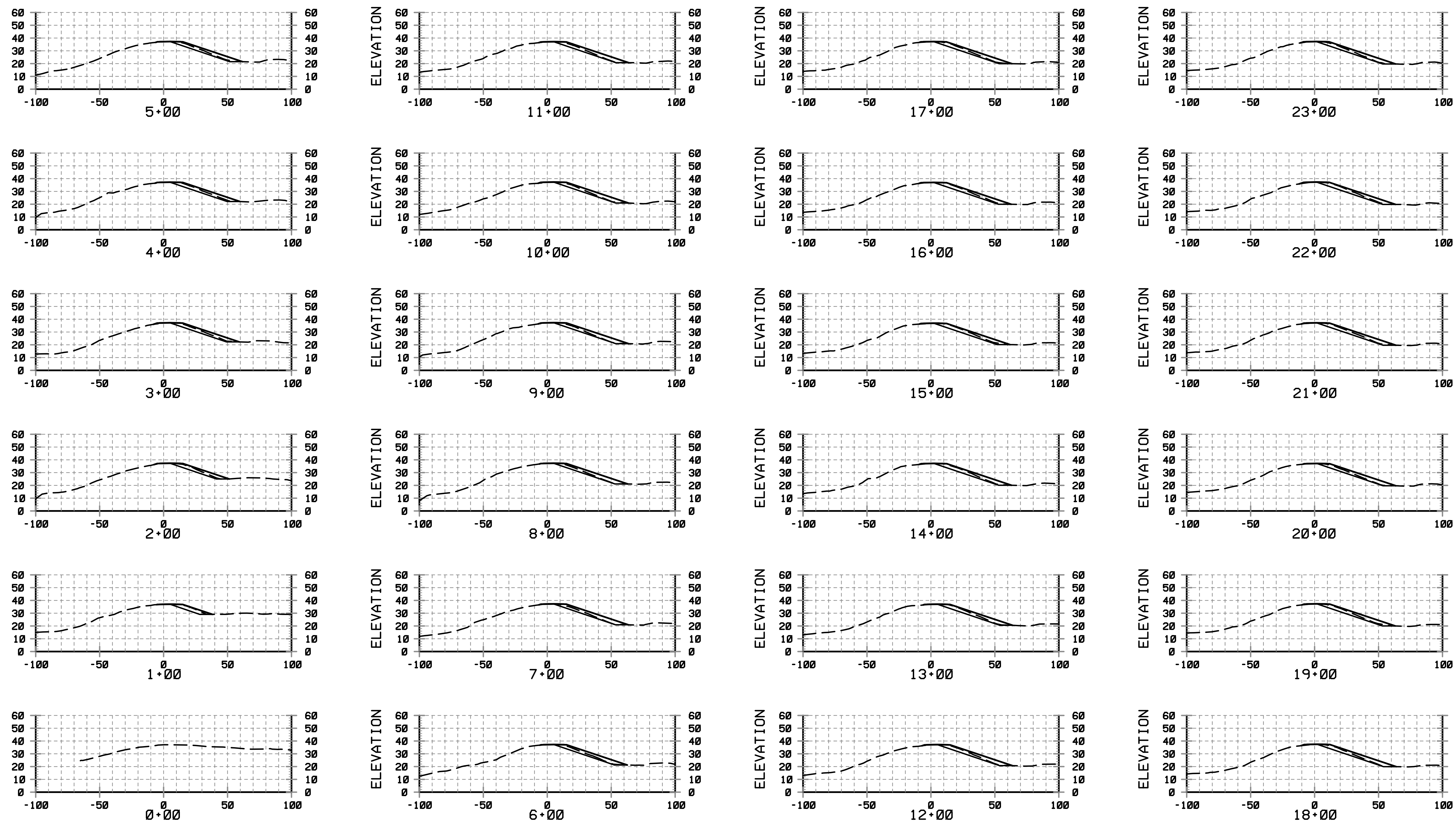

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AGENCY FLOOD RISK REDUCTION PROJECTS

YOLO BYPASS LEVEE
CROSS SECTION

Sheet reference number:
PLATE 007

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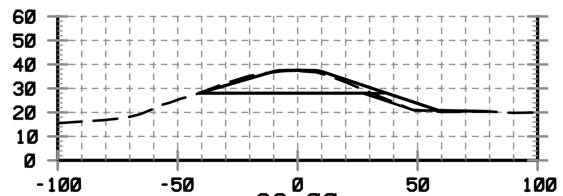
4 3 2 1



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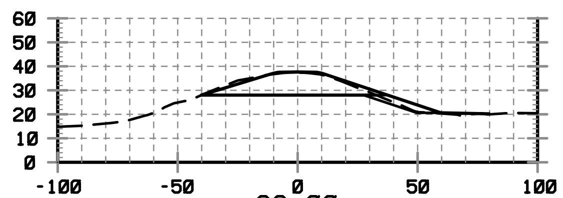

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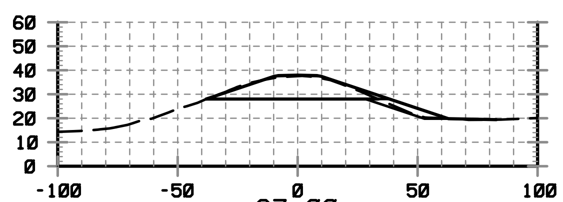

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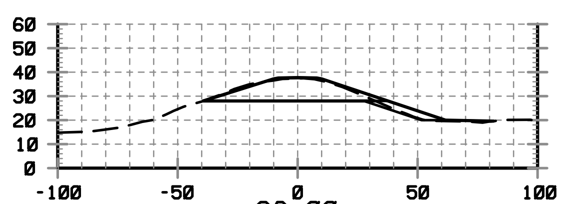

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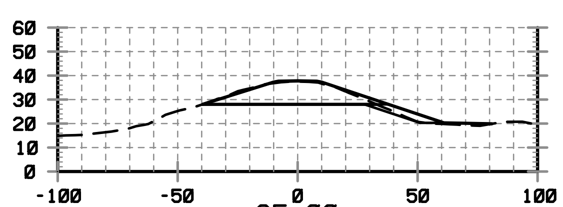

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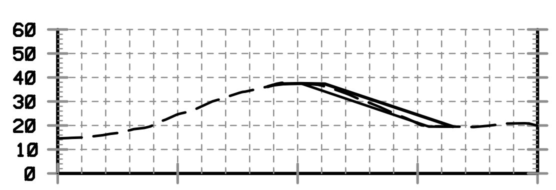

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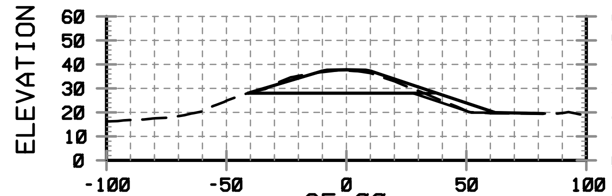

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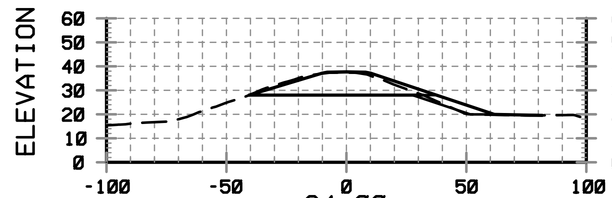

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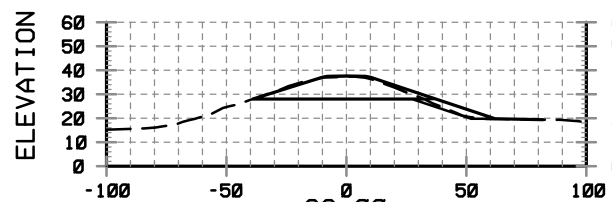

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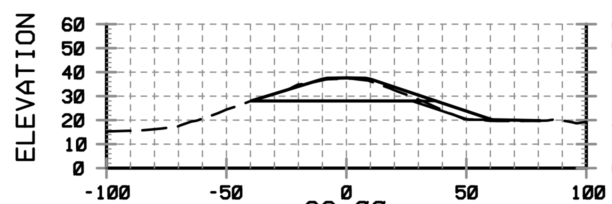

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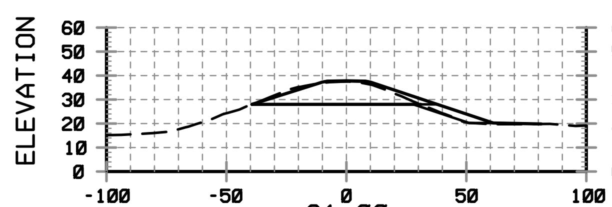

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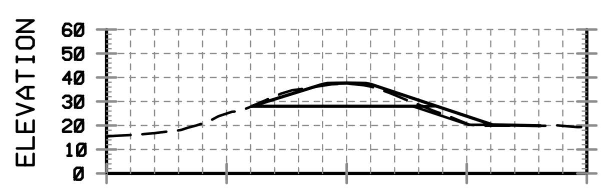

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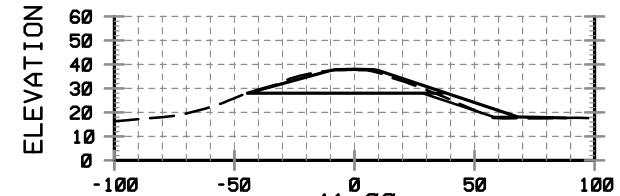

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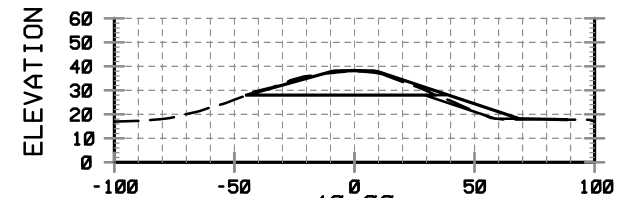

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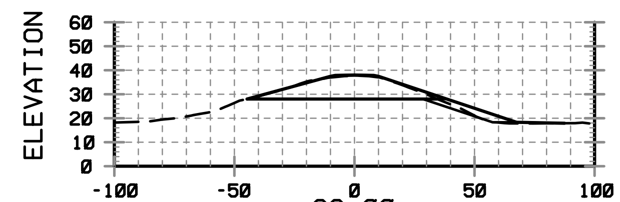

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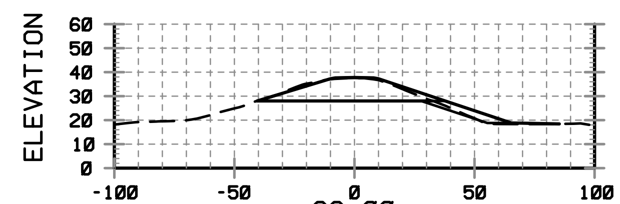

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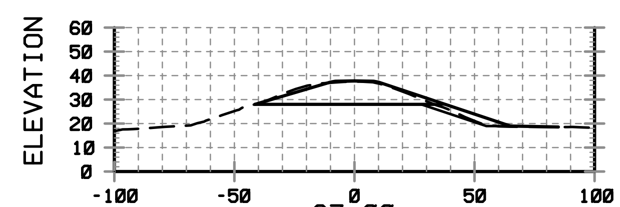

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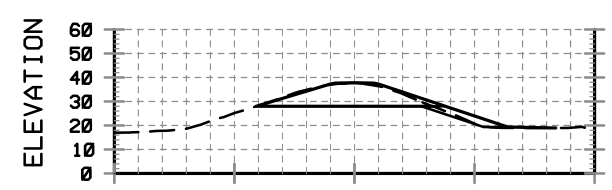

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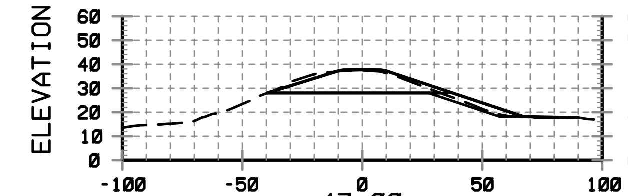

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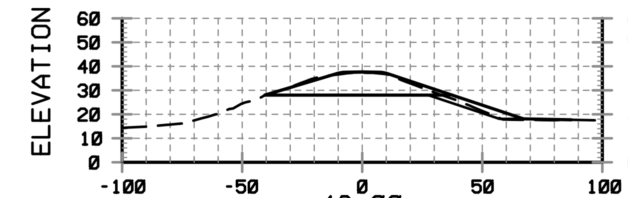

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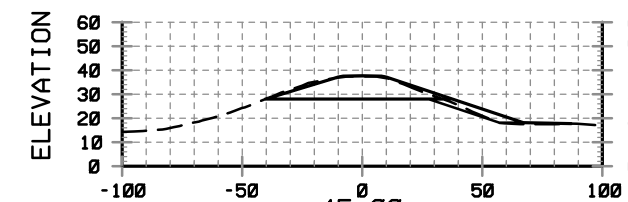

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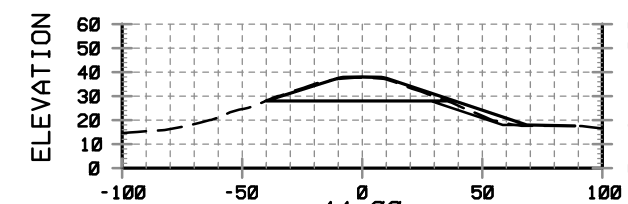

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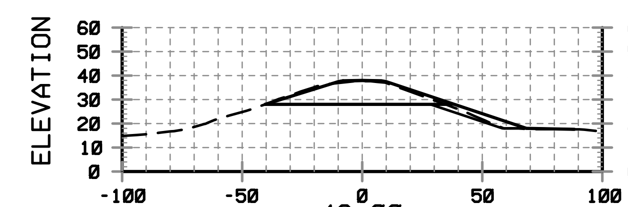

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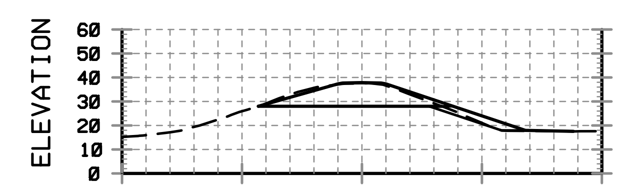

42+00

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YOLO COUNTY CA

WEST SACRAMENTO AREA FLOOD CONTROL
AGENCY FLOOD RISK REDUCTION PROJECTS

YOLO BYPASS LEVEE
CROSS SECTION

Sheet reference number:
PLATE 008

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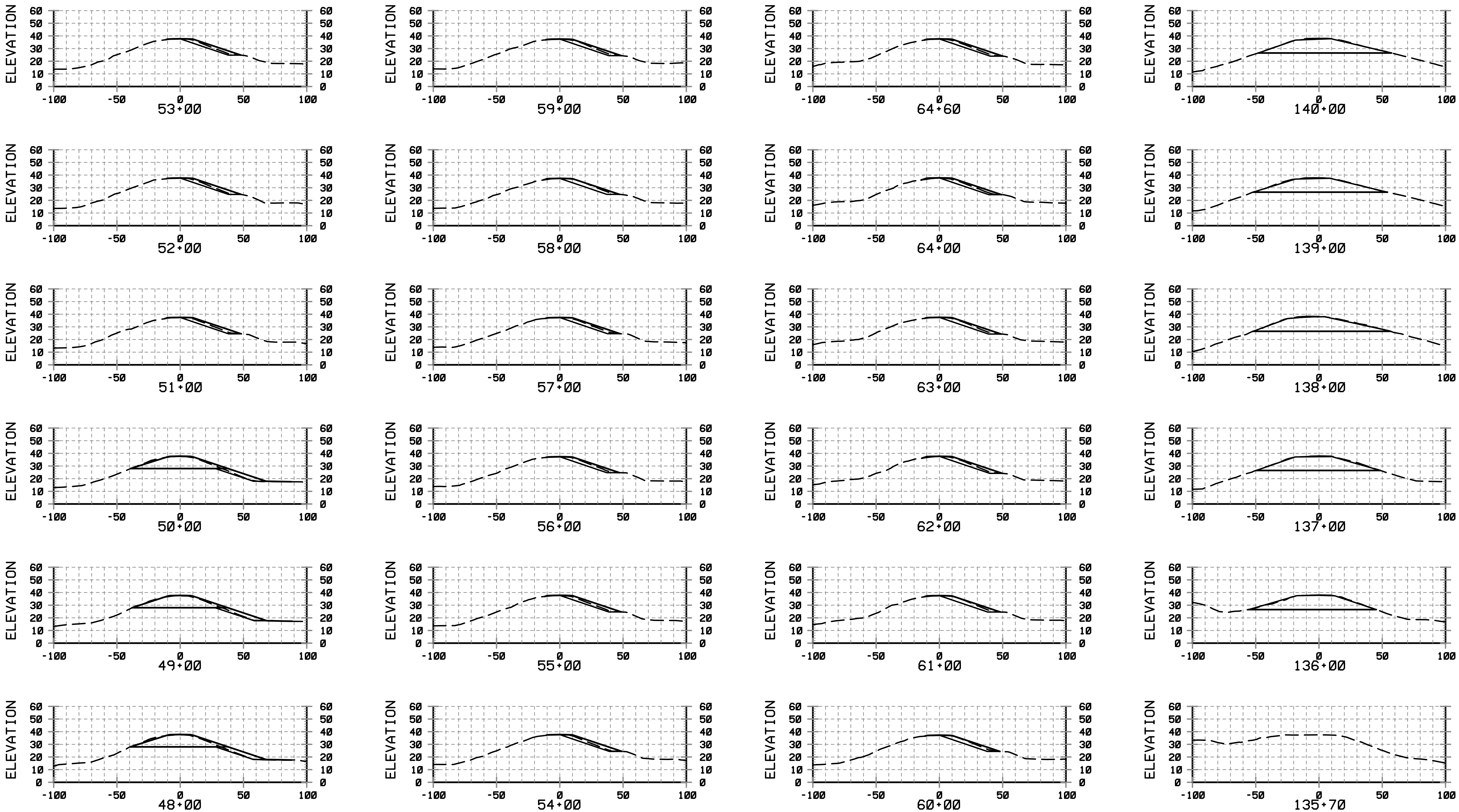

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YOLO BYPASS LEVEE
CROSS SECTION

Sheet reference number:
PLATE 009

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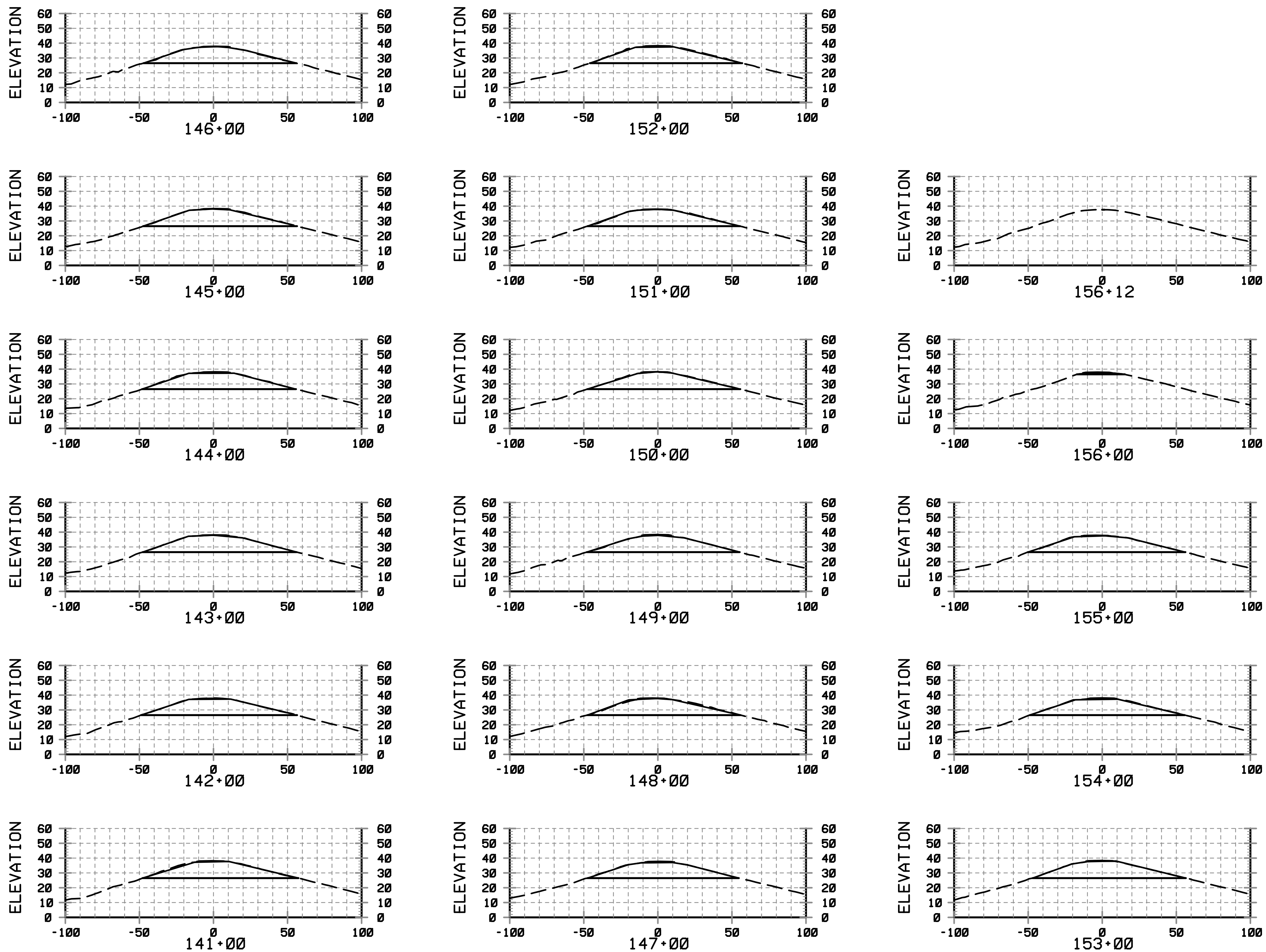
PLOT DATE: 19-AUG-2013 PLOT TIME: 11:04 \\AMETHYST\civcad\WestSacramento\WestSacramentoGRR\CADD\Civil\Yolo_Bypass_Levee\SheetFiles\C-30



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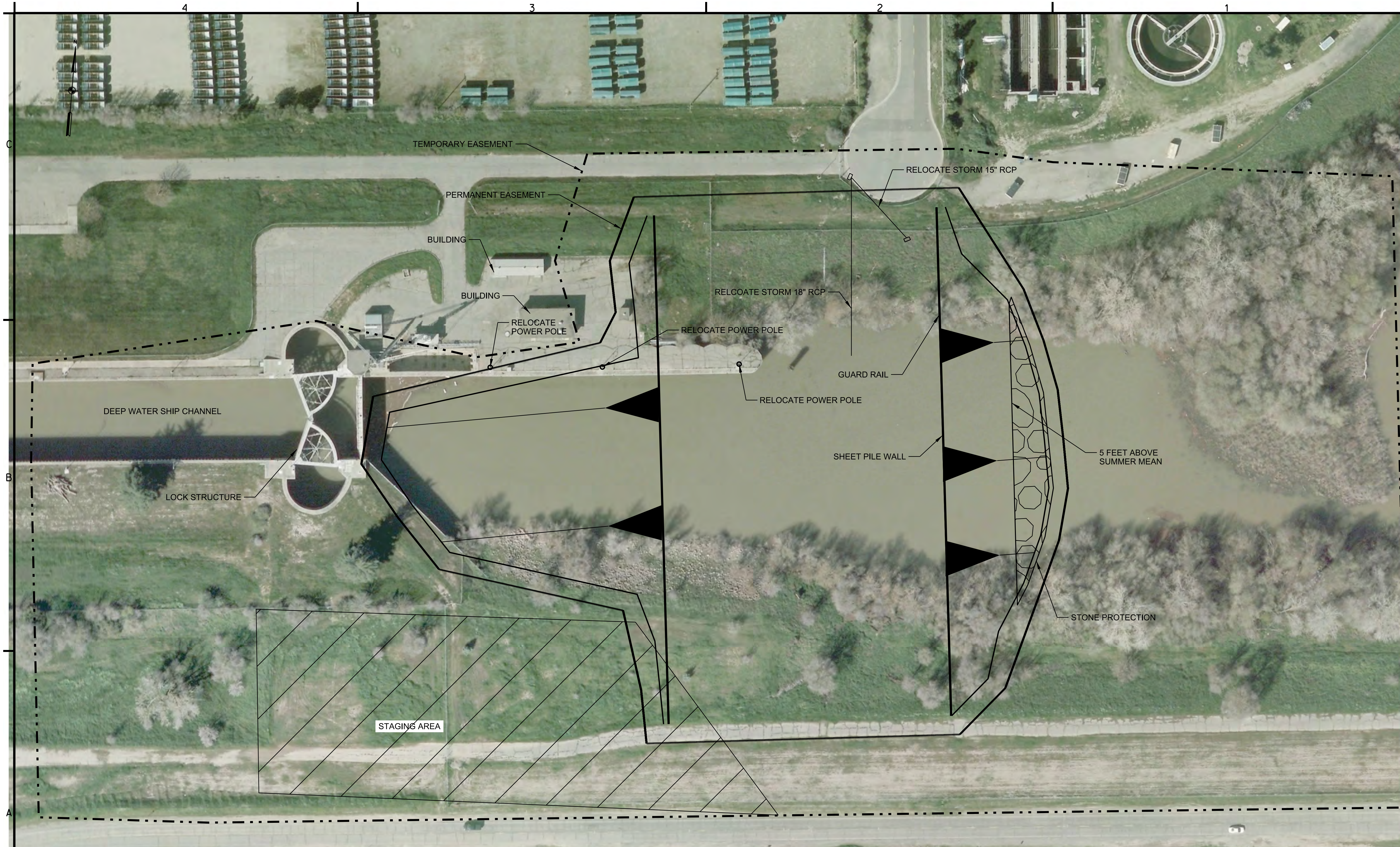
YOLO BYPASS LEVEE
CROSS SECTION

Sheet reference number:
PLATE 010

NOT FOR CONSTRUCTION

PLOT DATE: 19-AUG-2013 PLOT TIME: 11:04 \\AMETHYST\civcad\WestSacramento\WestSacramentoGRR\CADD\Civil\Yolo_Bypass_Levee\SheetFiles\C-30



PLAN VIEW

100' 50' 0 100'

1" =100'

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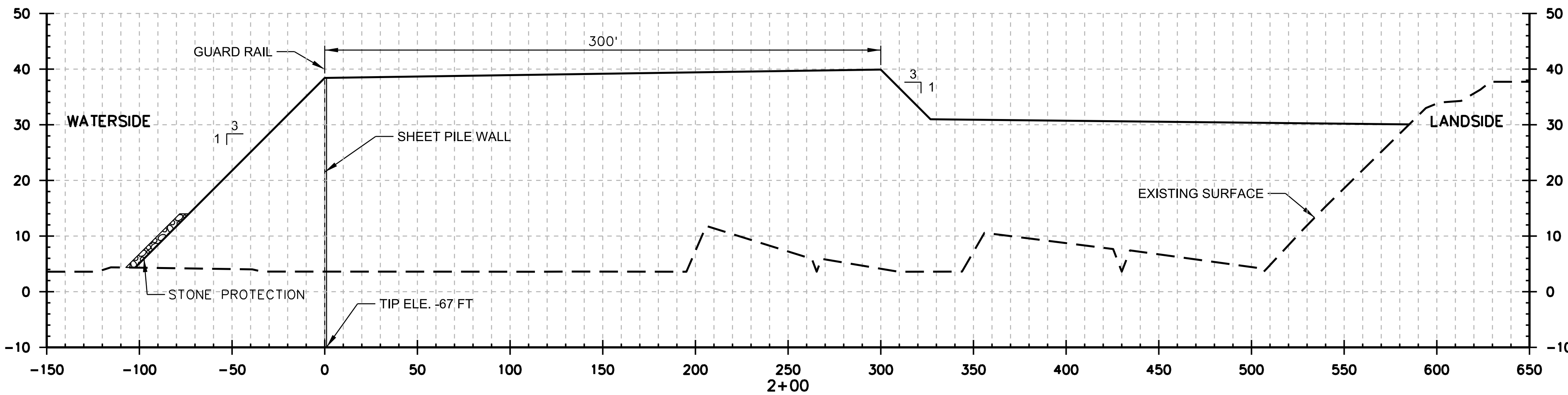
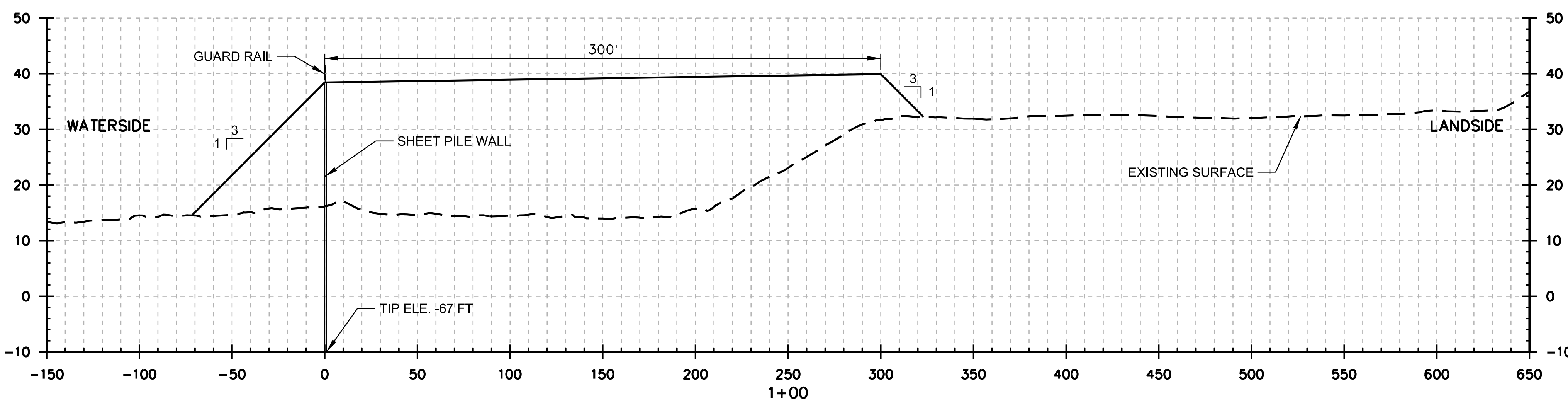
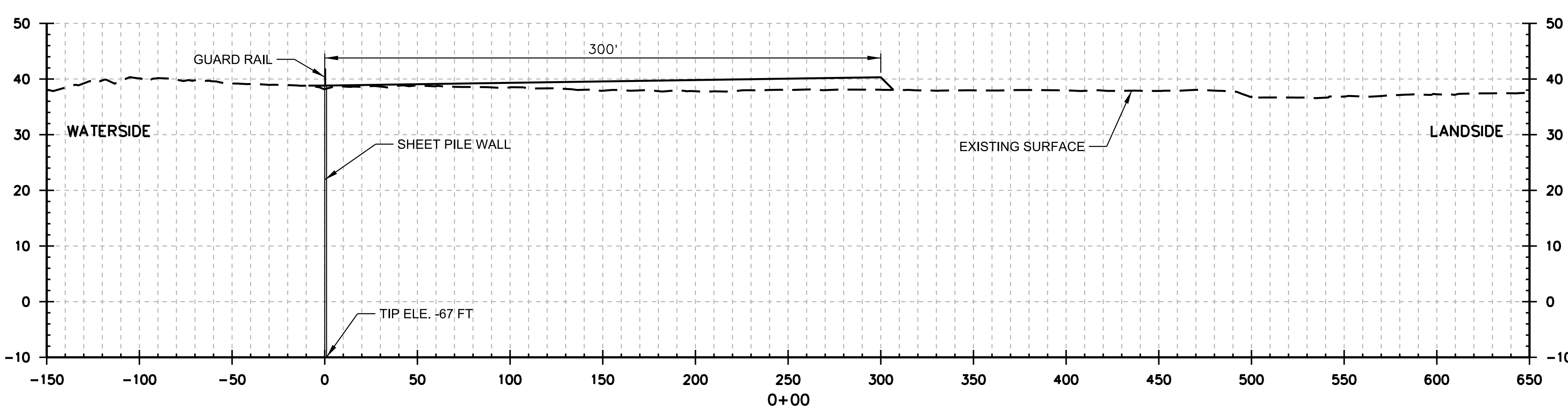
AGENCY FLOOD RISK REDUCTION PROJECTS

PLUG LOCK APPROACH
PLAN VIEW

Sheet reference number:
PLATE 01







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AGENCY FLOOD RISK REDUCTION PROJECTS

PLUG LOCK APPROACH
CROSS SECTIONS

Sheet reference number:
PLATE 02

PLOT DATE: 20-JUL-2015 PLOT TIME: 14:37

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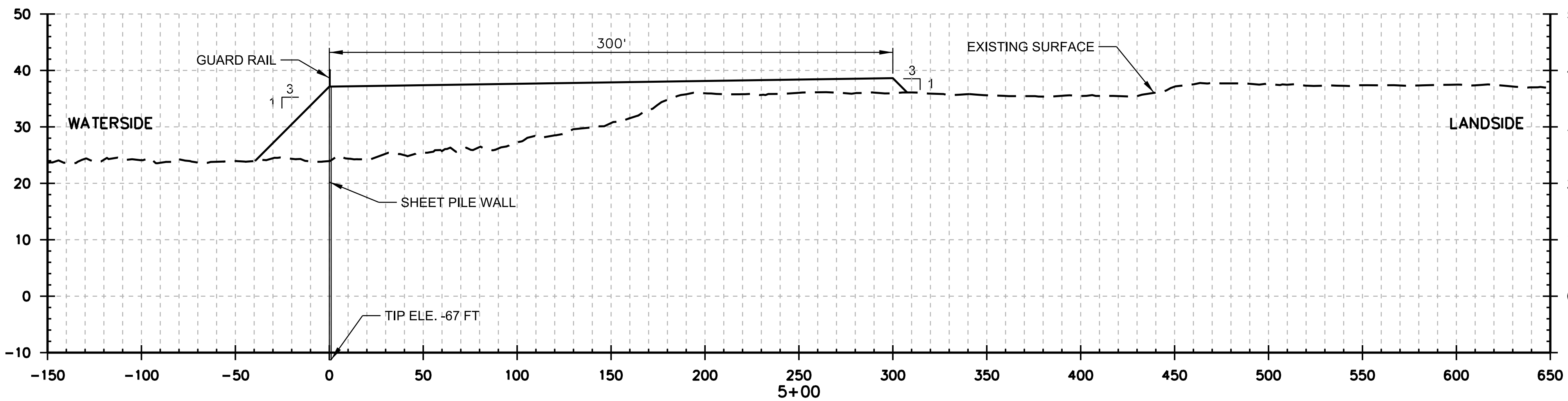

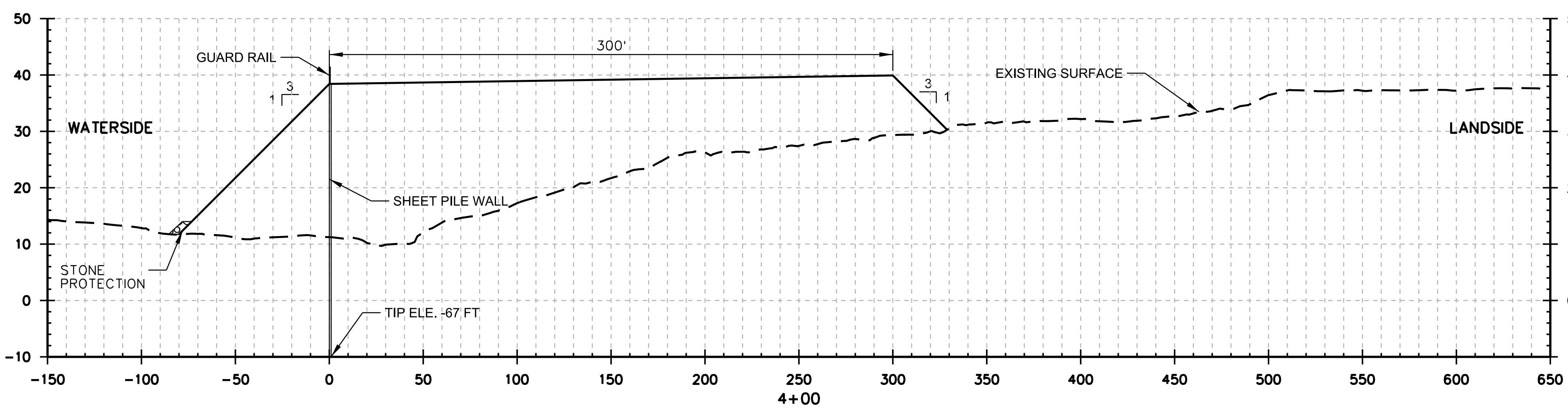

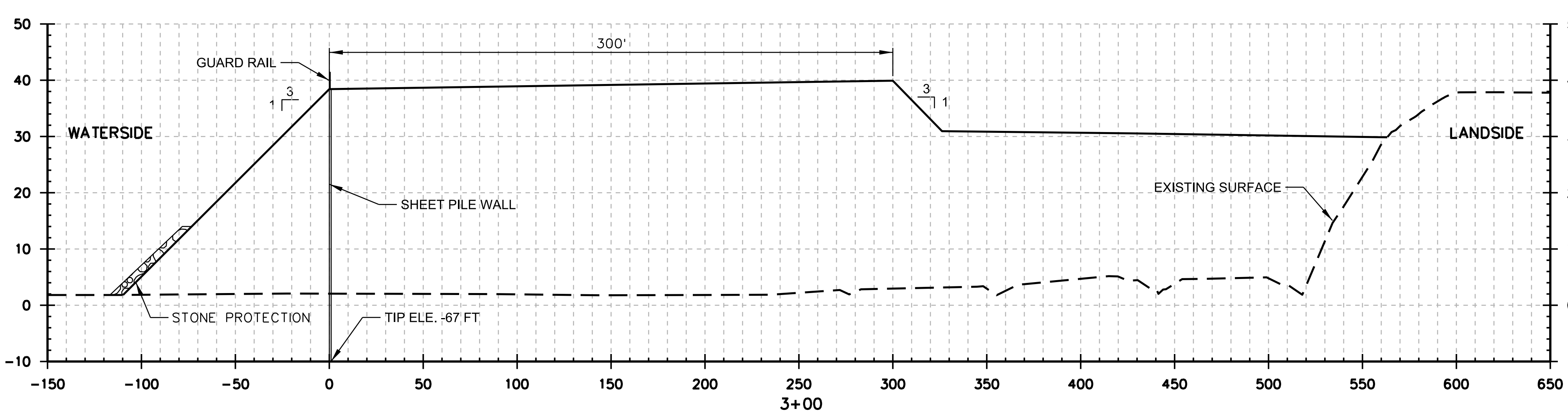

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PLUG LOCK APPROACH
CROSS SECTIONS

Sheet reference number:
PLATE 03

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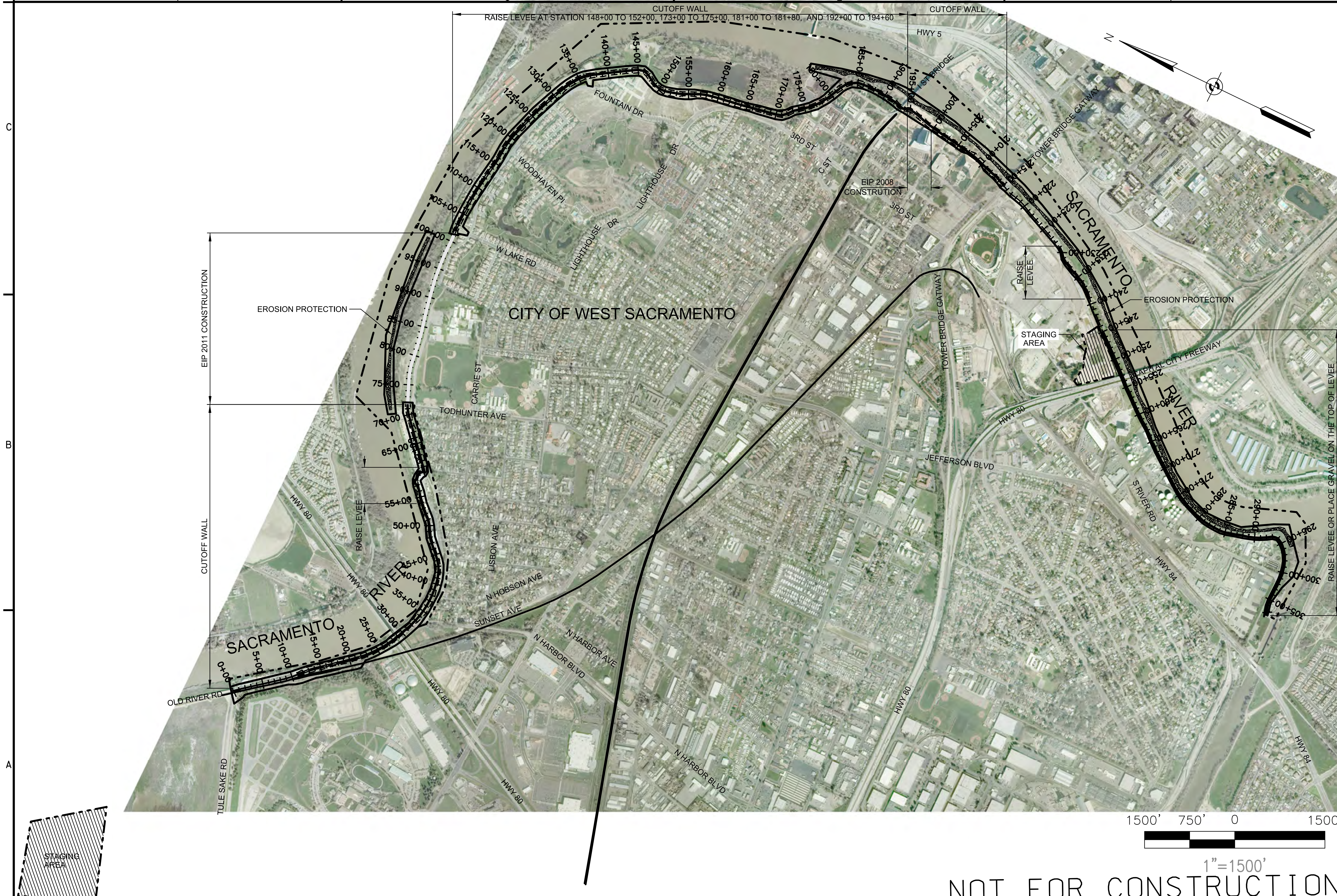
PLOT DATE: 20-JUL-2015 PLOT TIME: 14:37 \\AMETHYST\civcad\WestSacramento\WestSacramentoGRR\CADD\Civil\PlugLockApproach\SheetFile\C-302LC



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SACRAMENTO RIVER NORTH LEVEE
OVERVIEW

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PLATE 01
AM-XX

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WEST SACRAMENTO AREA FLOOD CONTROL AGENCY FLOOD RISK REDUCTION PROJECTS

SACRAMENTO RIVER NORTH LEVEE
KEYMAP

Sheet reference number:
PLATE 02

AM-XX

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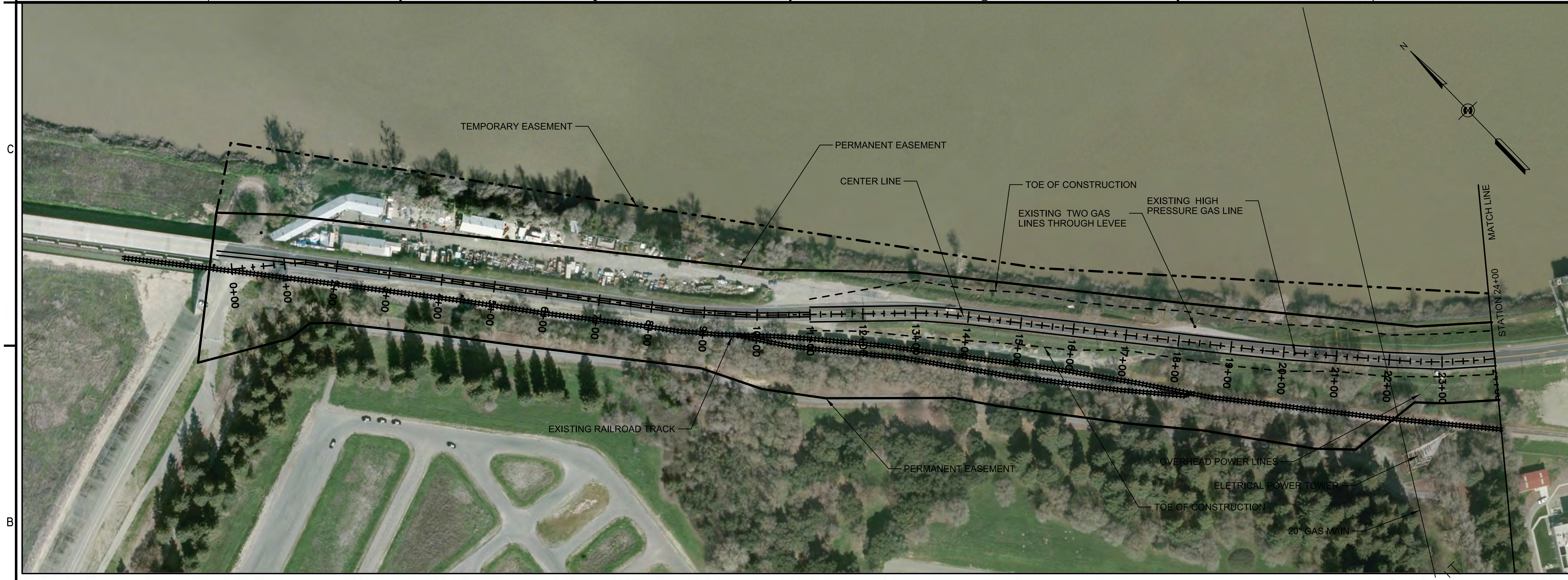
"=1500'

8.1.2

PLOT DATE: 24-OCT-2014 PLOT TIME: 16:00 \\AMETHYST\civcad\WestSacramento\WestSacramentoGRR\CADD\Civil\SacramentoRiverNorthLevee\Sheet\Fil



PLAN VIEW

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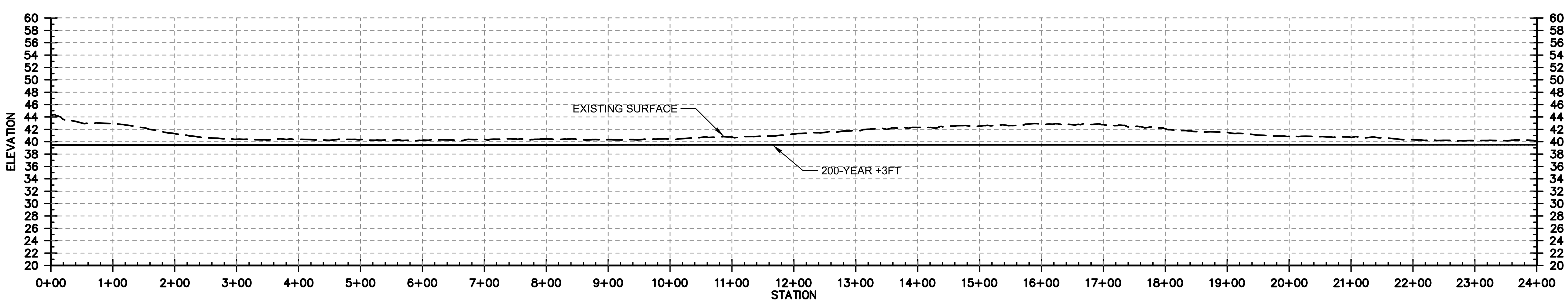
1"=200'



SACRAMENTO RIVER NORTH LEVEE PROFILE

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AGENCY FLOOD RISK REDUCTION PROJECTS

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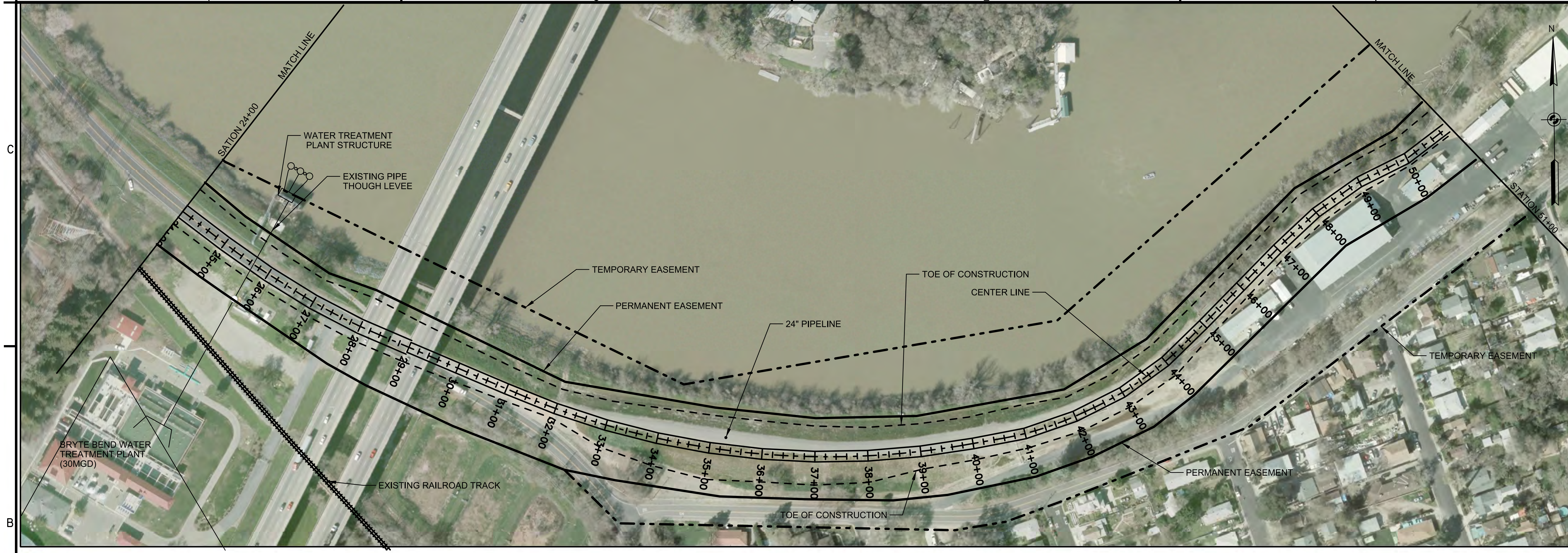
PLAN AND PROFILE

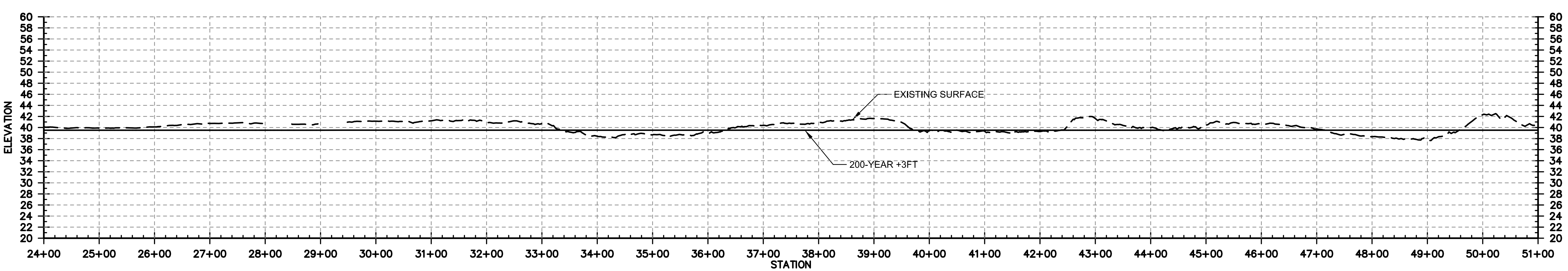
Sheet reference number:
PLATE 03



PLAN VIEW

200' 100' 0 200'

1"=200'



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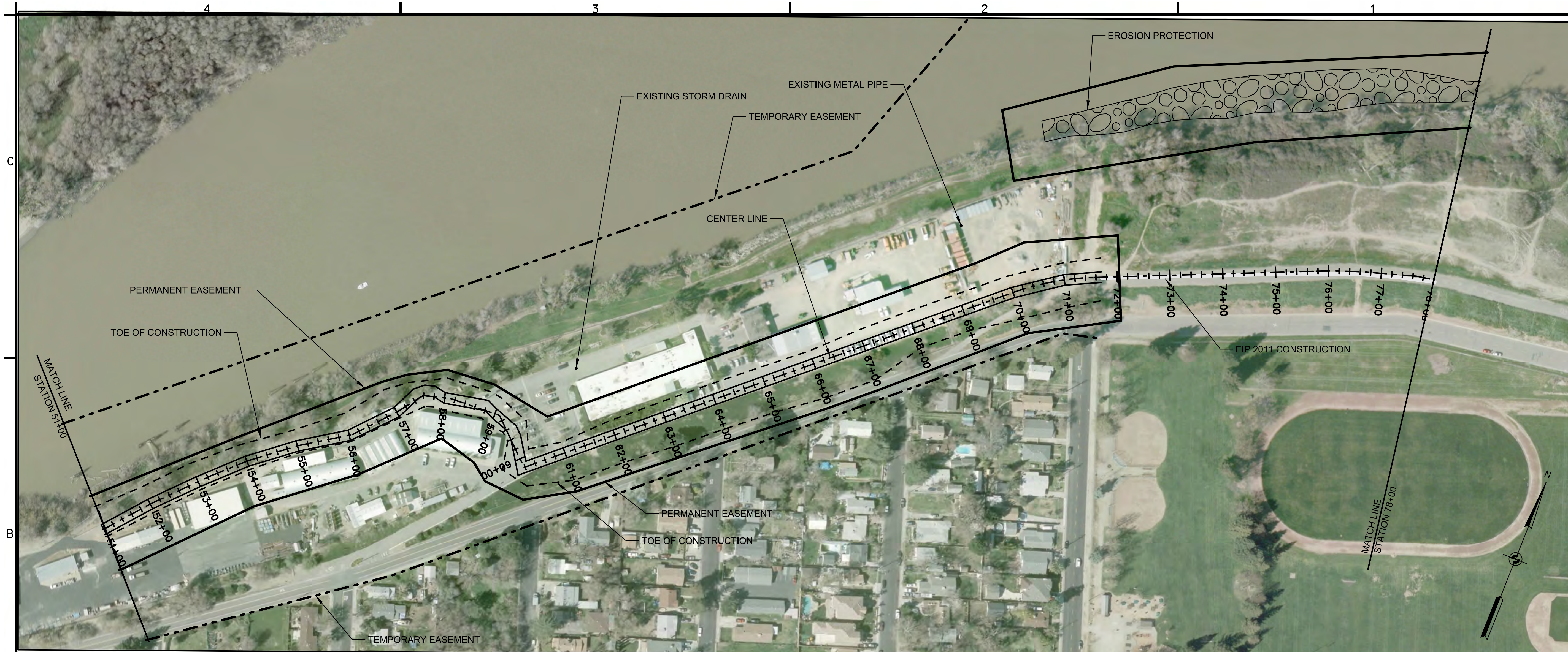
Sheet reference number:

PLATE 04

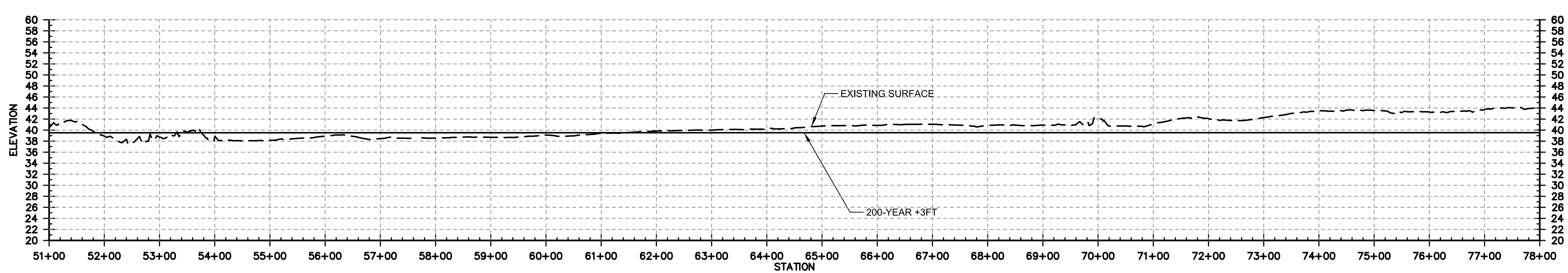
8.1.2 | PLOT DATE: 24-OCT-2014 | PLOT TIME: 16:02 | \\AMETHYST\civcad\WestSacramento\WestSacramentoGRR\CADD\Civil\SacramentoRiverNorthLevee\Sheet\Fil



PLAN VIEW

200' 100' 0 200'

1"=200'



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PLAN AND PROFILE

Sheet reference number:
PLATE 05

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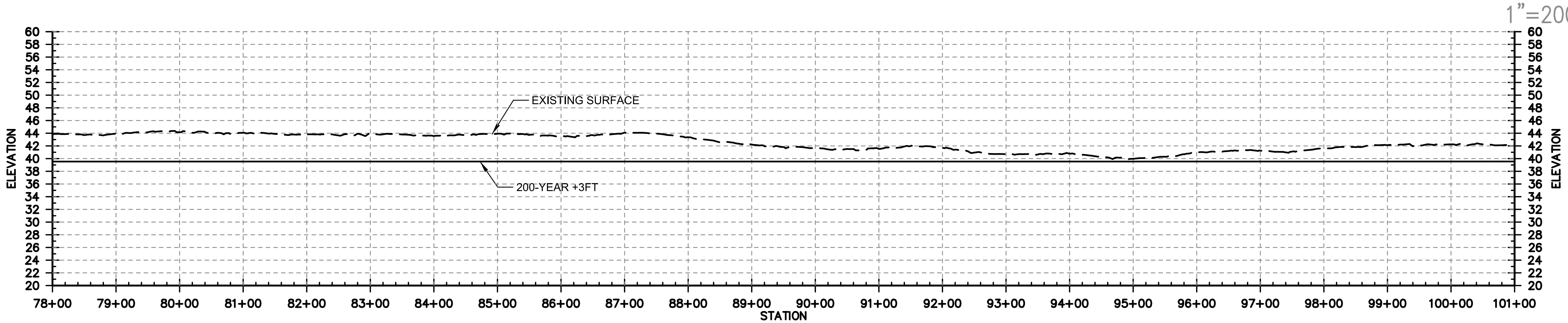
1"=200'

PLAN VIEW



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SACRAMENTO RIVER NORTH LEVEE
PLAN AND PROFILE

Sheet reference number:
PLATE 06

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4 3 2 1

PLAN VIEW

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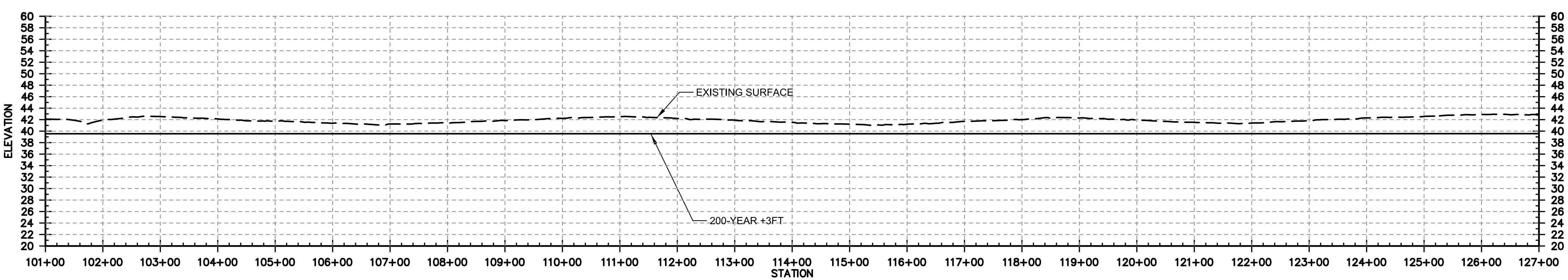
1"=200'



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SACRAMENTO RIVER NORTH LEVEE
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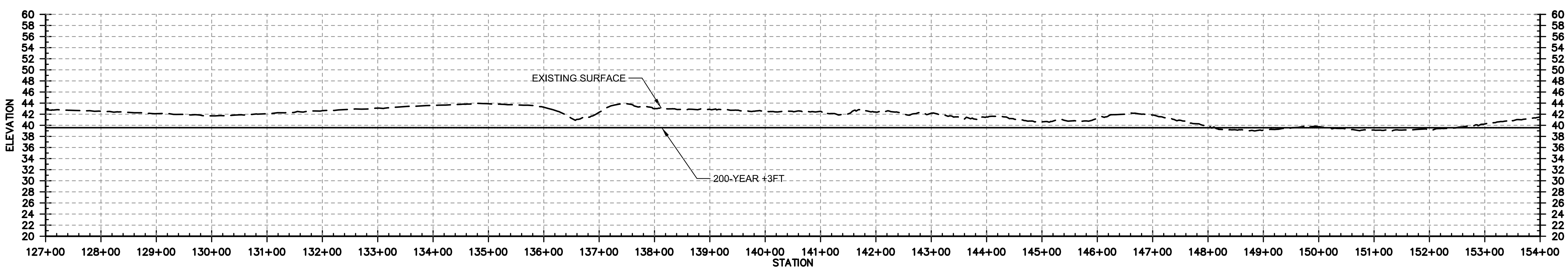
PLATE 07

8.1.2 PLOT DATE: 24-OCT-2014 PLOT TIME: 16:04 \\AMETHYST\civcad\WestSacramento\WestSacramentoGRR\CADD\Civil\SacramentoRiverNorthLevee\Sheet\Fil

PLAN VIEW

200' 100' 0 200'

1"=200'



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AGENCY FLOOD RISK REDUCTION PROJECTS

SACRAMENTO RIVER NORTH LEVEE
PLAN AND PROFILE

Sheet reference number:
PLATE 08

PLAN VIEW

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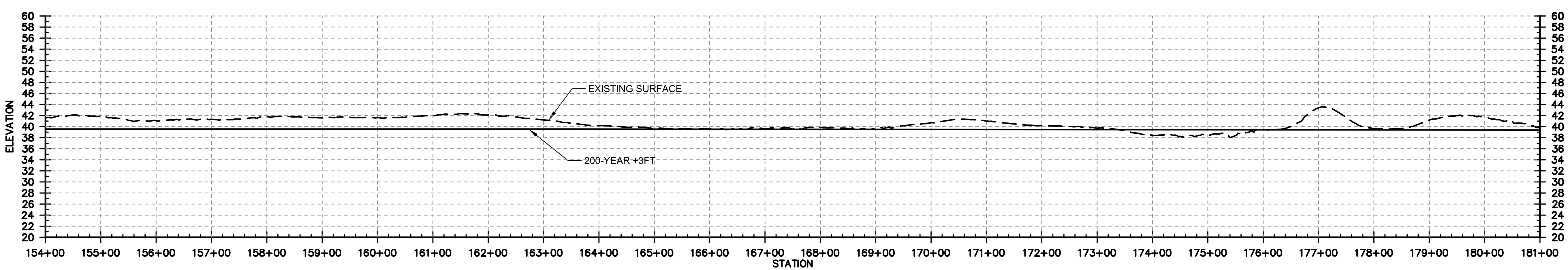
1"=200'



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SACRAMENTO RIVER NORTH LEVEE
PLAN AND PROFILE

Sheet reference number:
PLATE 09

PLAN VIEW

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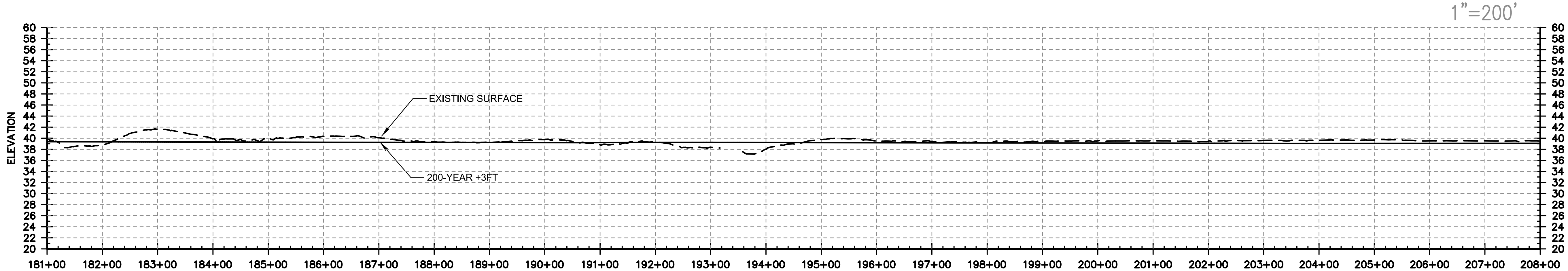
1"=200'



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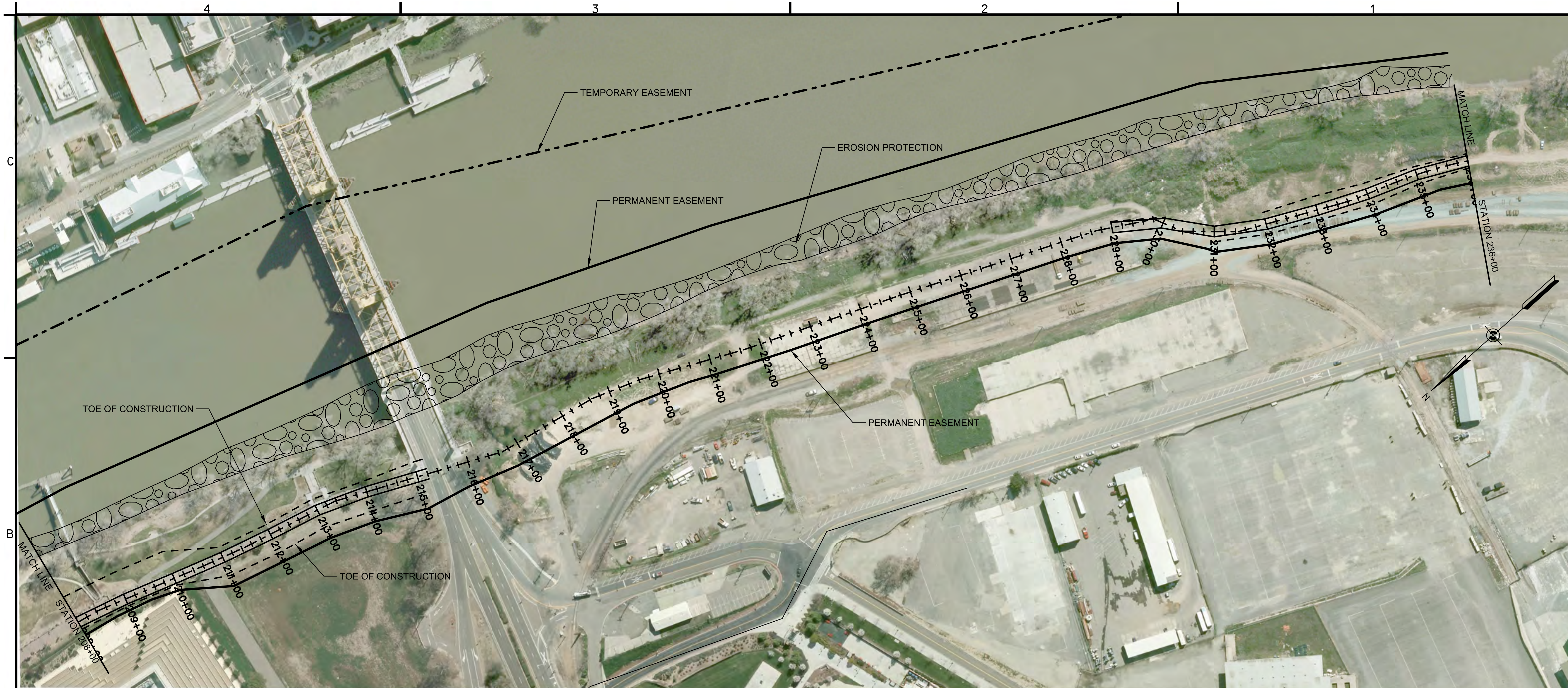
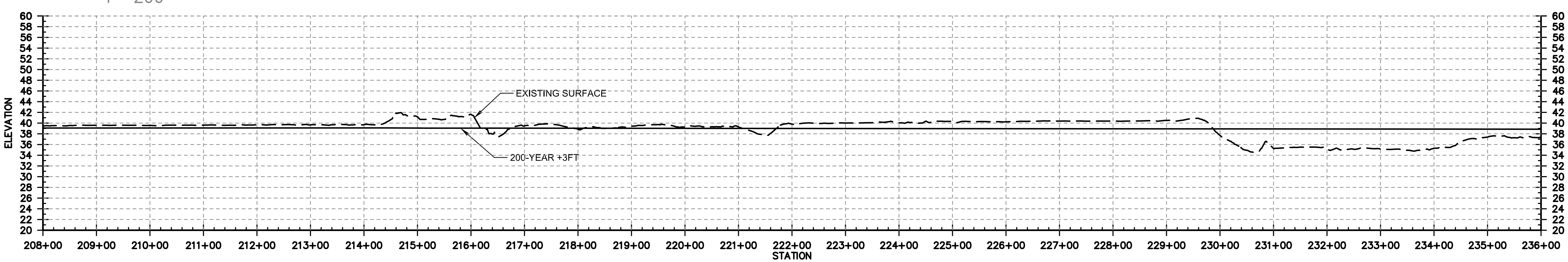
PLAN AND PROFILE

Sheet reference number:
PLATE 10

PLOT DATE: 24-OCT-2014 PLOT TIME: 16:06 \\AMETHYST\civcad\WestSacramento\WestSacramentoGRR\CADD\Civil\SacramentoRiverNorthLevee\Sheet Fil



PLAN VIEW



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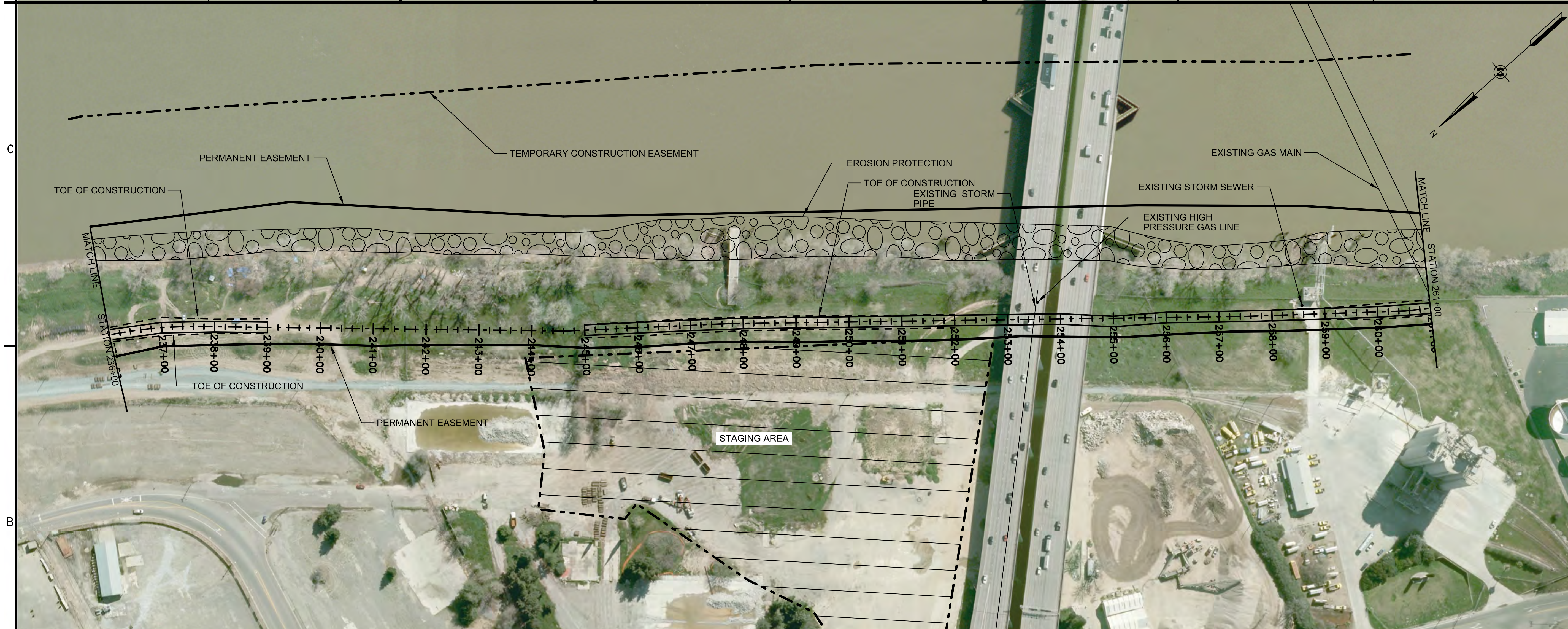
Sheet reference number:
PLATE 11

8.1.2 PLOT DATE: 24-OCT-2014 PLOT TIME: 16:07 \\AMETHYST\civcad\WestSacramento\WestSacramentoGRR\CADD\Civil\SacramentoRiverNorthLevee\Sheet\Fil



PLAN VIEW

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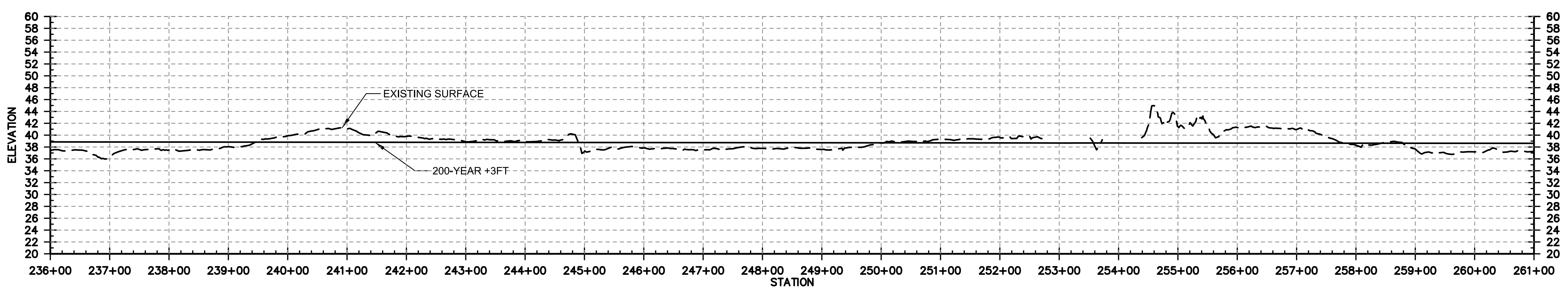
1"=200'



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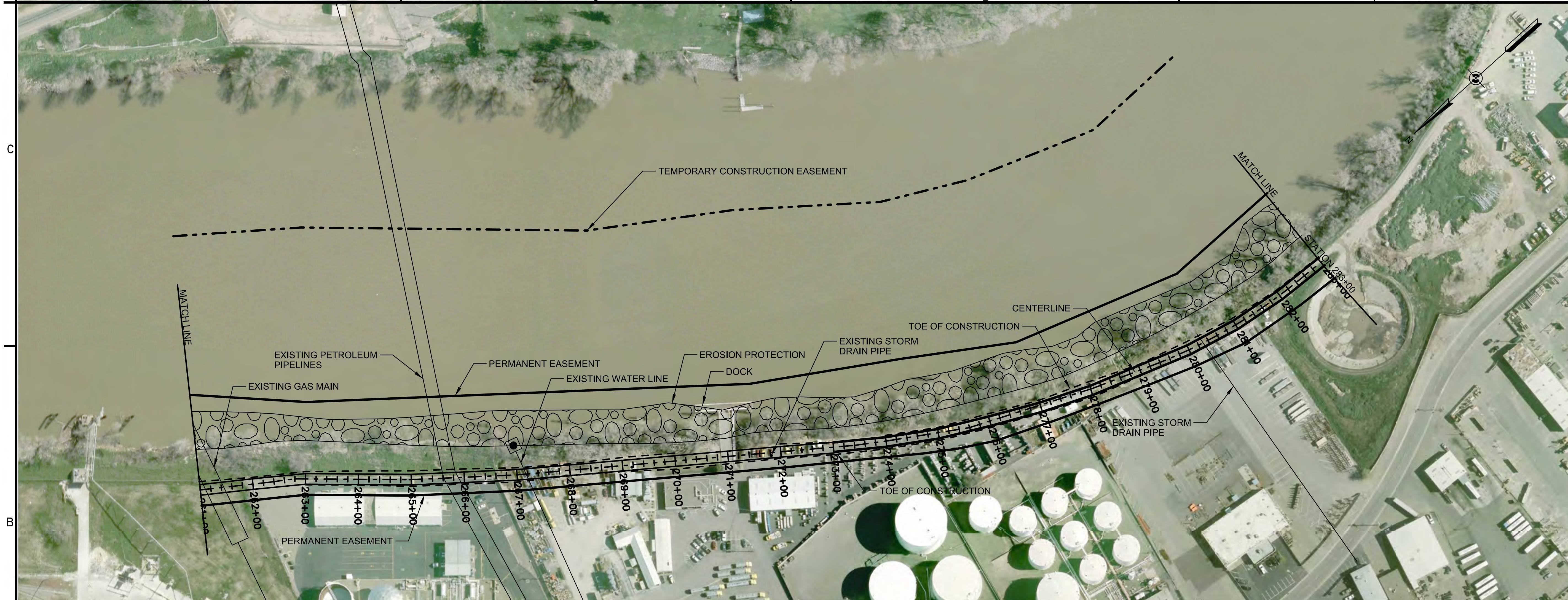
SACRAMENTO RIVER NORTH LEVEE
PLAN AND PROFILE

Sheet reference number:
PLATE 12



PLAN VIEW

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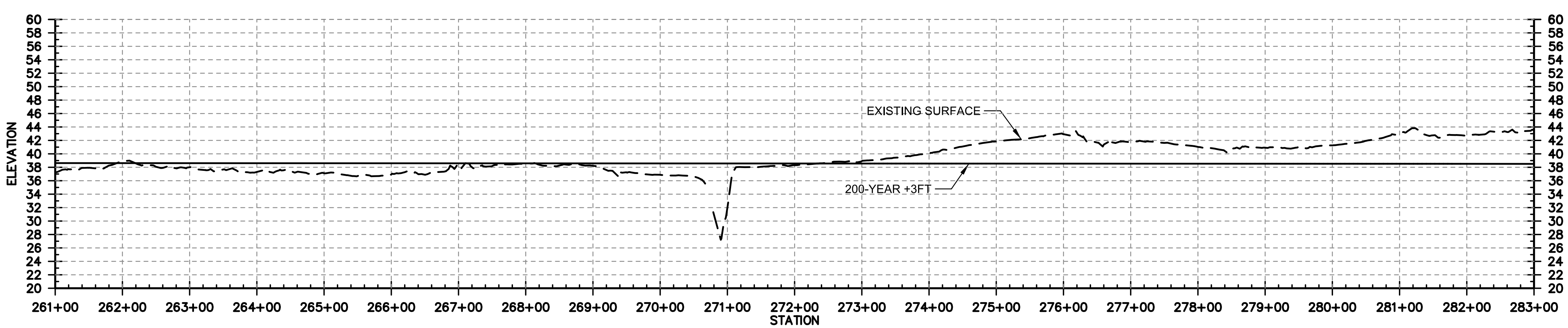
1"=200'



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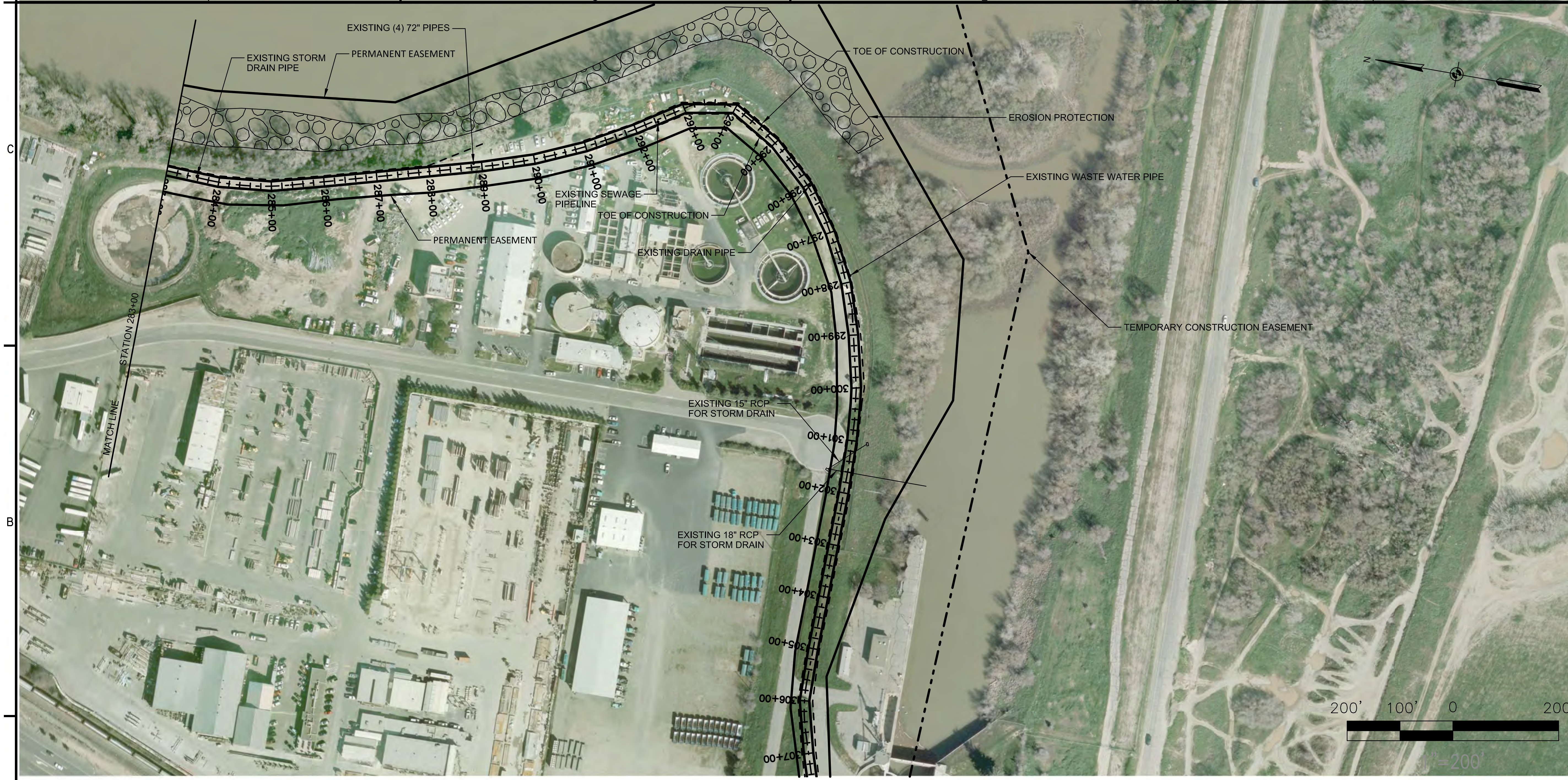
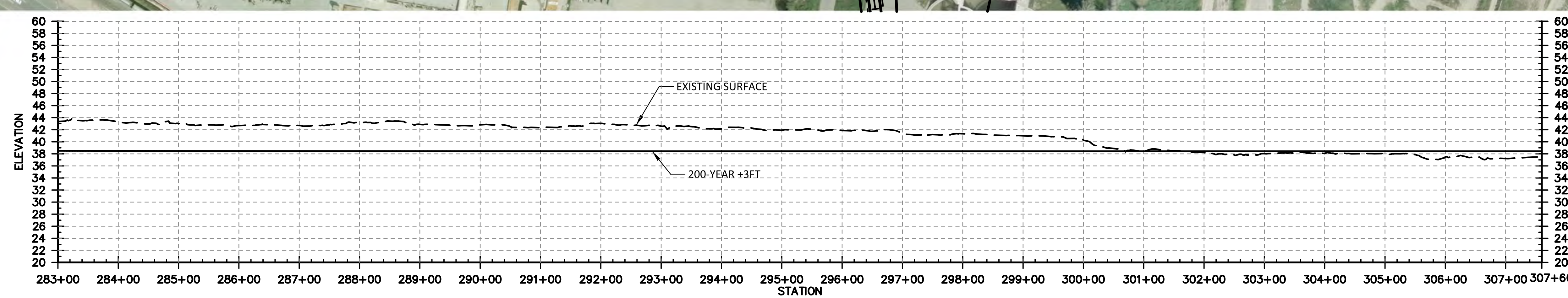
SACRAMENTO RIVER NORTH LEVEE
PLAN AND PROFILE

Sheet reference number:
PLATE 13





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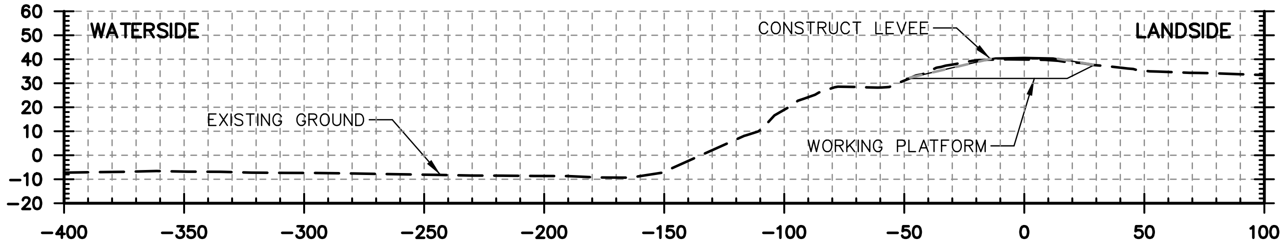
PLAN AND PROFILE

Sheet reference number:
PLATE 14

8.1.2 | PLOT DATE: 24-OCT-2014 | PLOT TIME: 16:09 | \\AMETHYST\civcad\WestSacramento\WestSacramentoGRR\CADD\Civil\SacramentoRiverNorthLevee\Sheet\Fil



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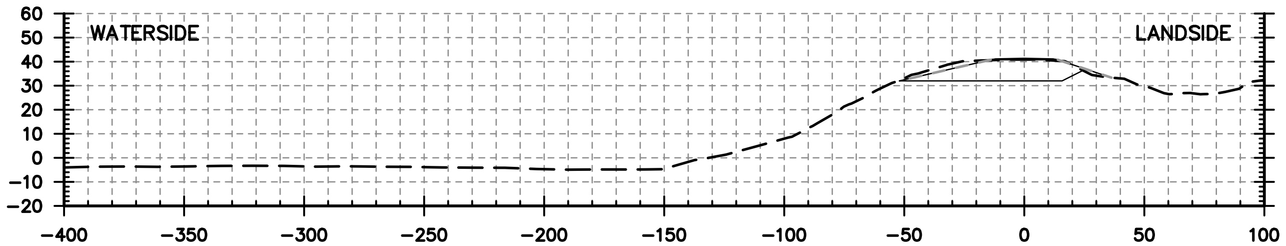

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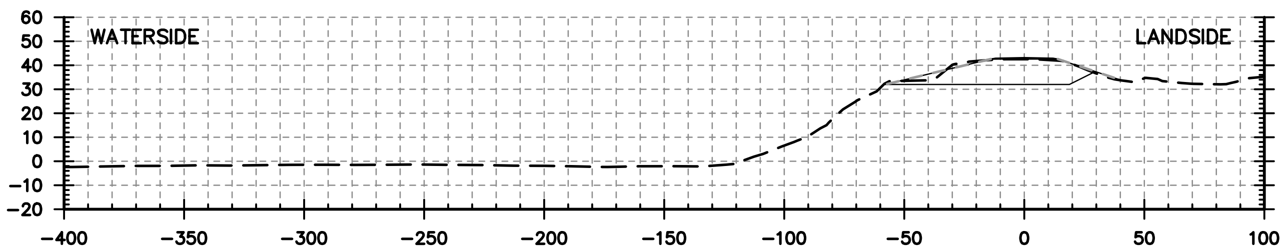

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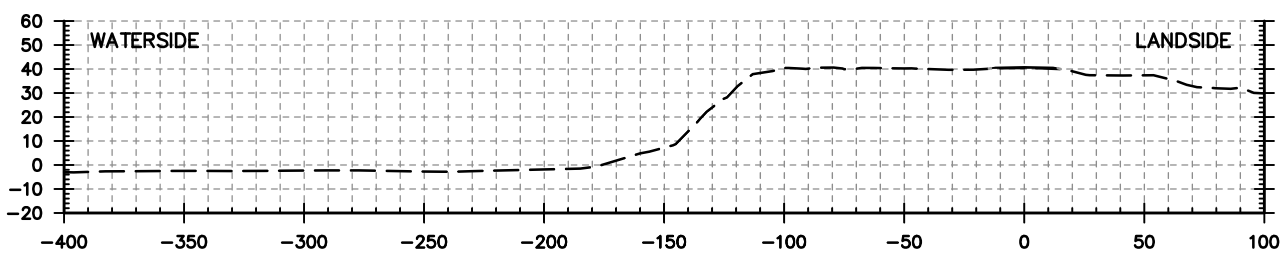

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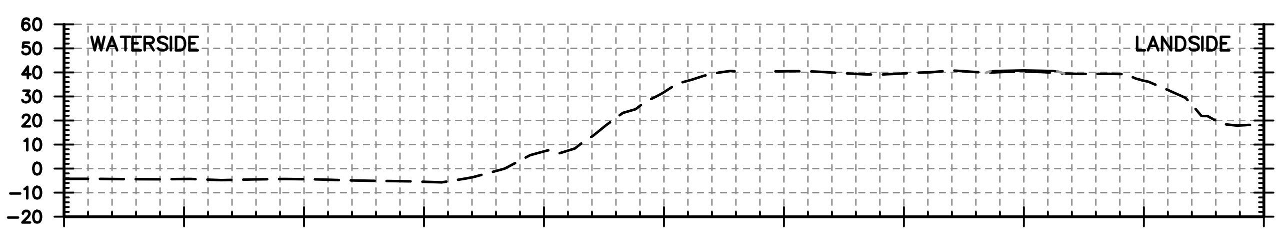

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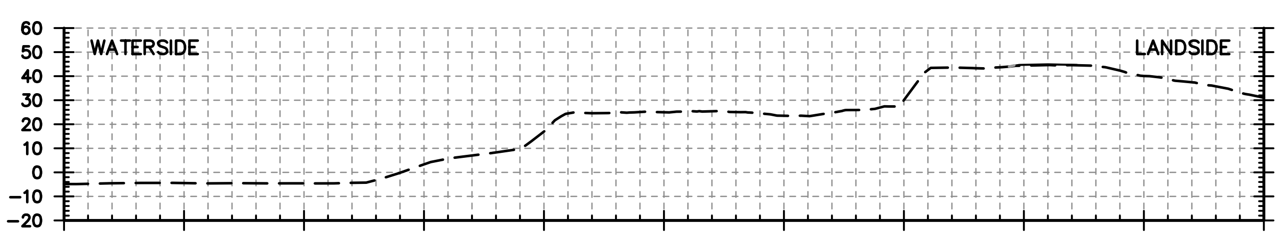

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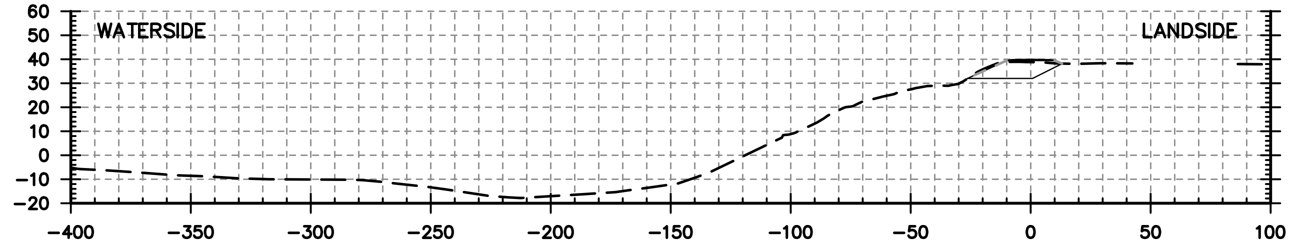

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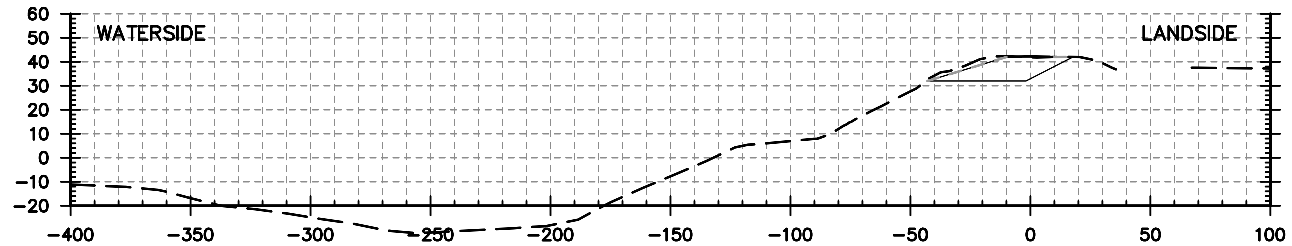

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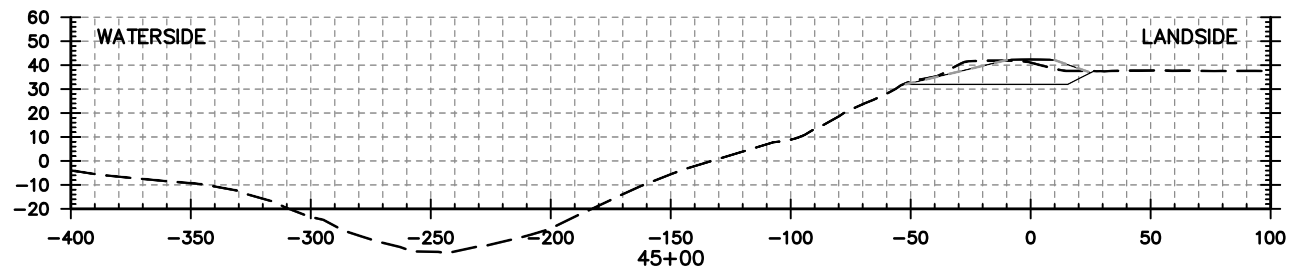

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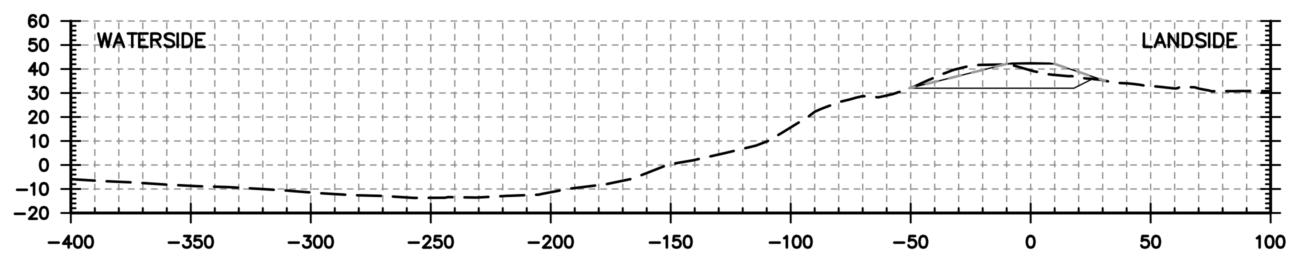

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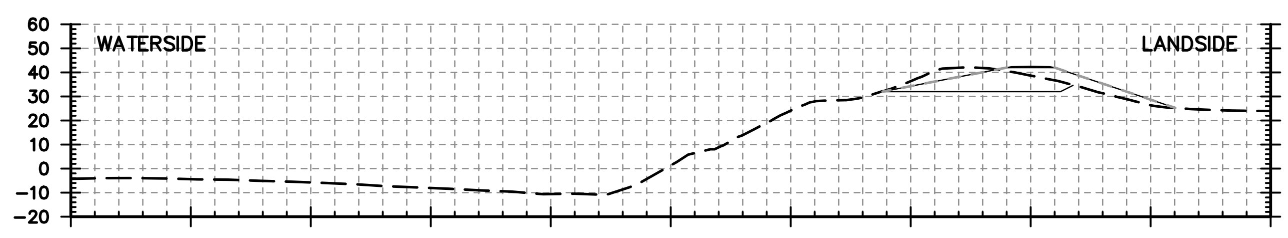

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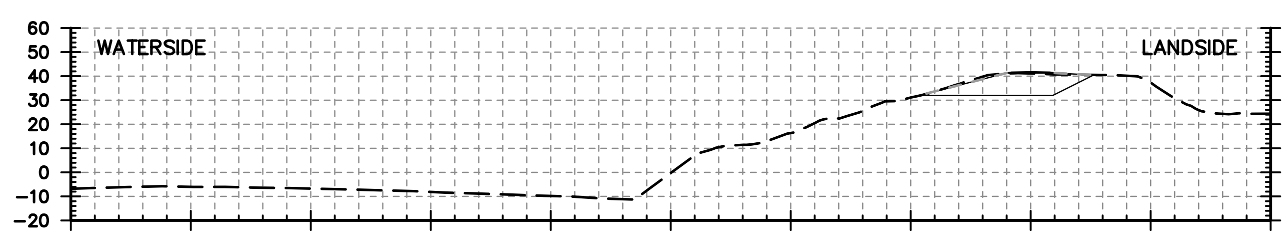

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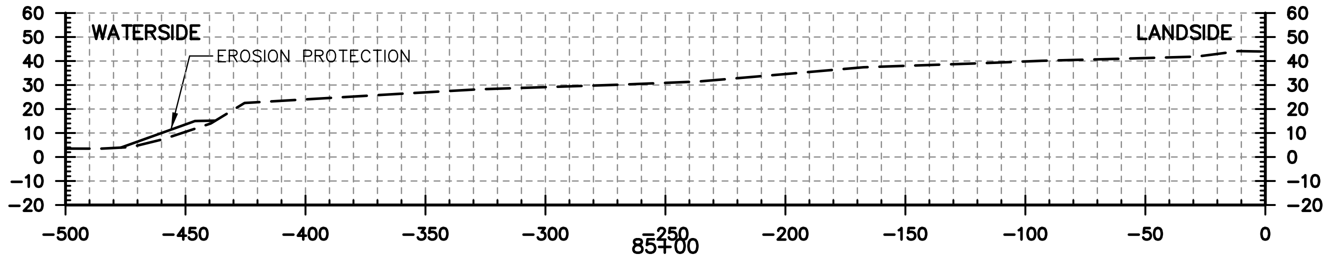
SACRAMENTO RIVER NORTH LEVEE
CROSS SECTIONS

Sheet reference number:
PLATE 15

PLOT DATE: 24-OCT-2014 PLOT TIME: 16:10 \\AMETHYST\civcad\WestSacramento\WestSacramentoGRR\CADD\Civil\SacramentoRiverNorthLevee\Sheet\Fil



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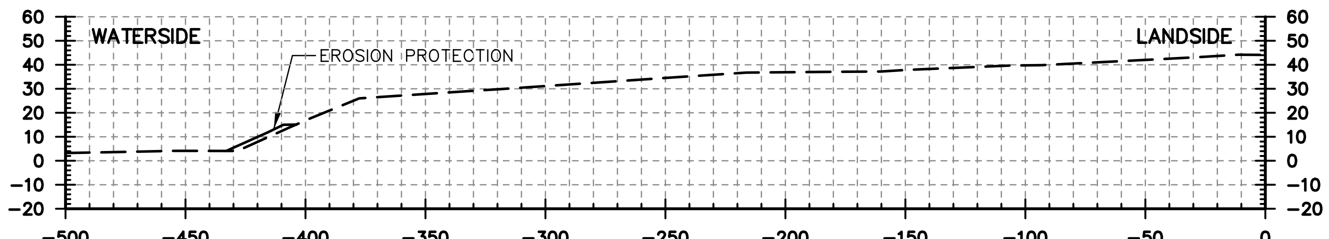

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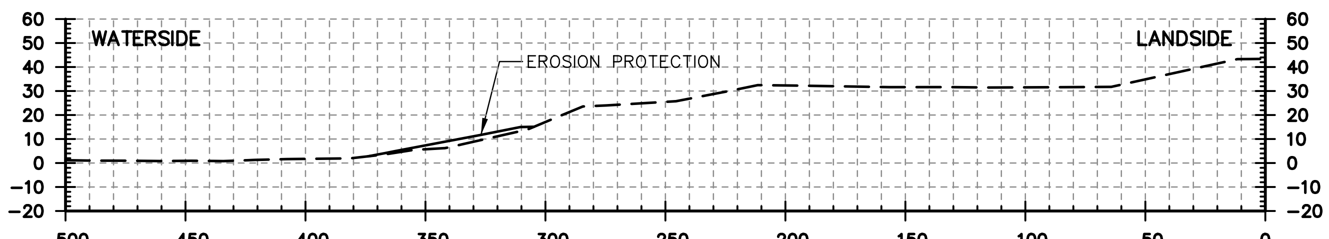

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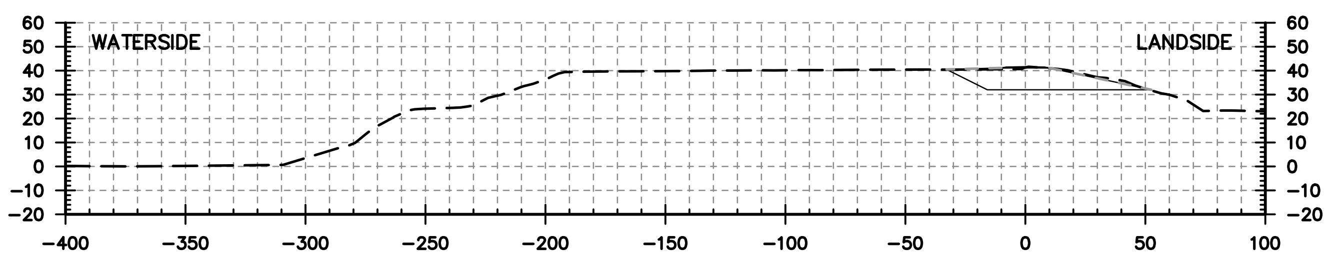

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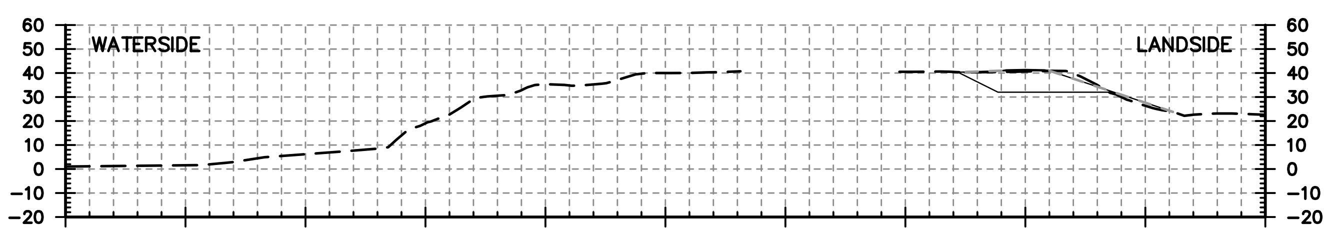

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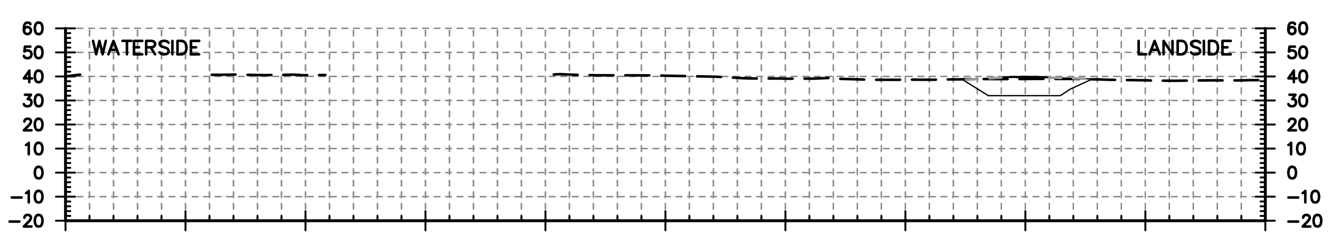

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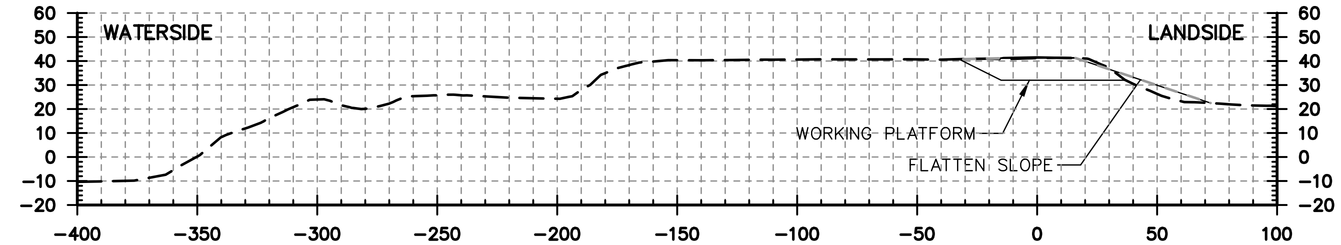

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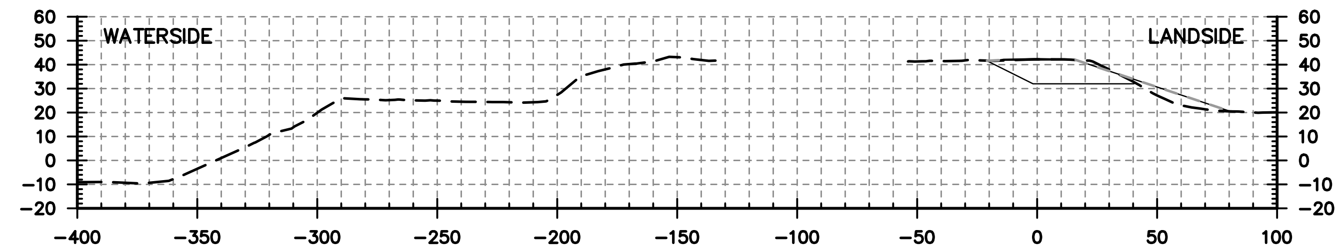

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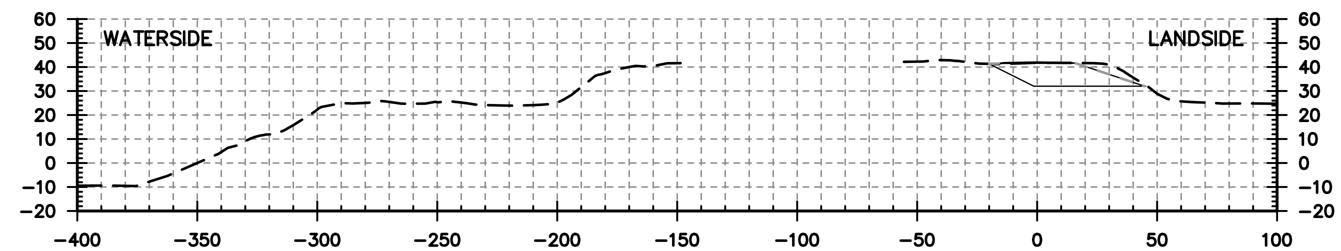

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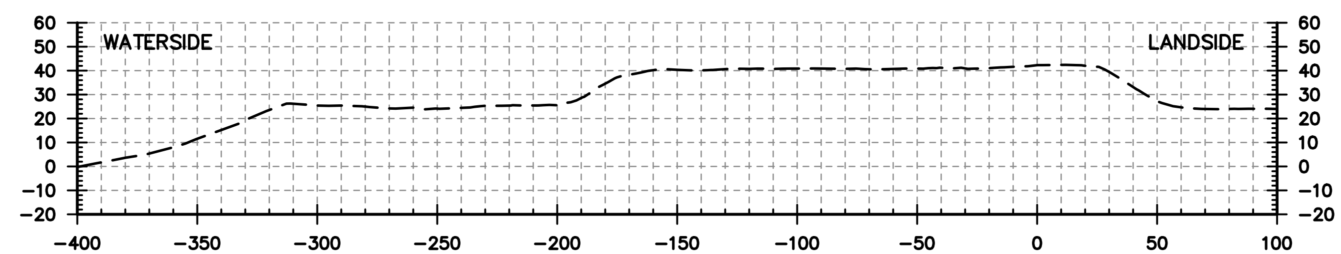

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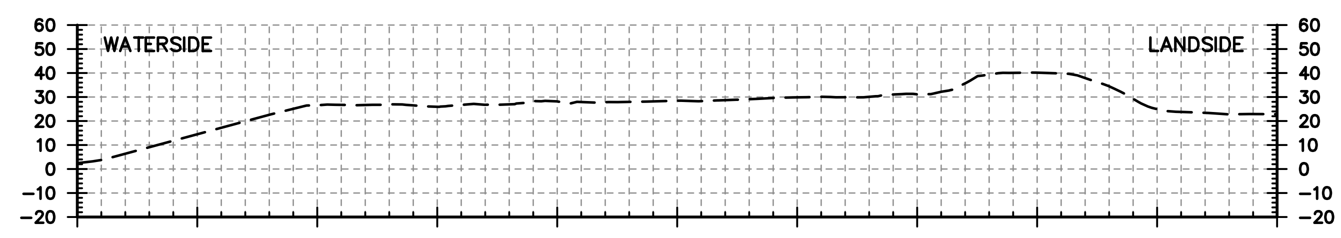

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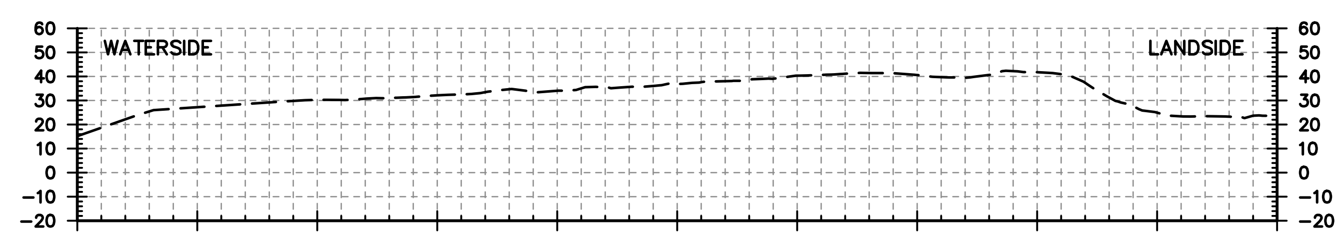

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SACRAMENTO RIVER NORTH LEVEE
CROSS SECTIONS

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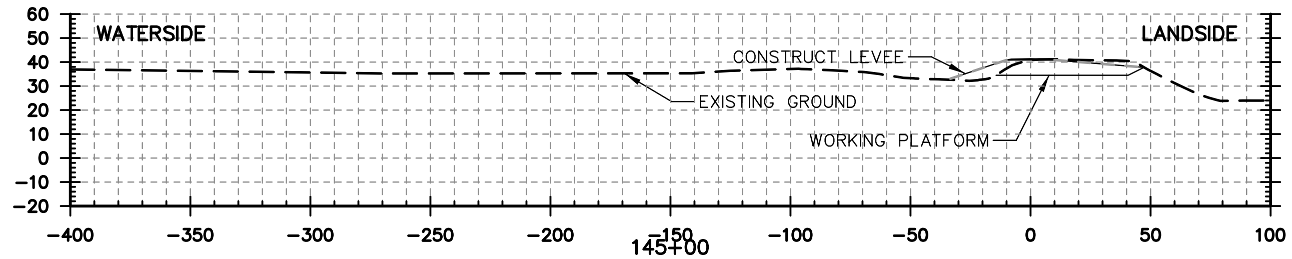
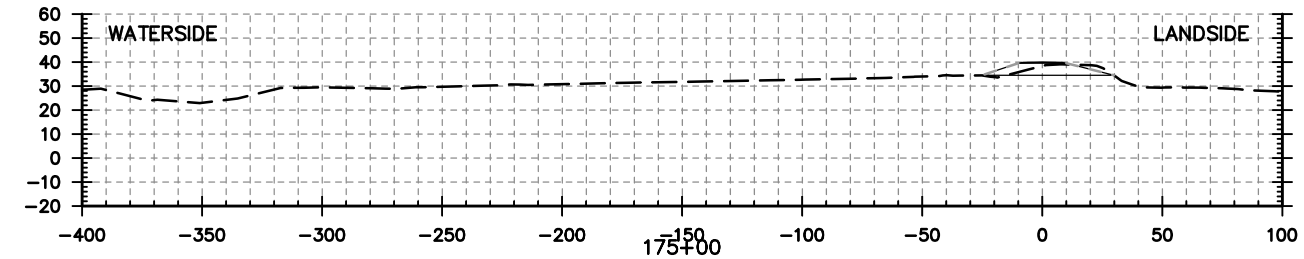
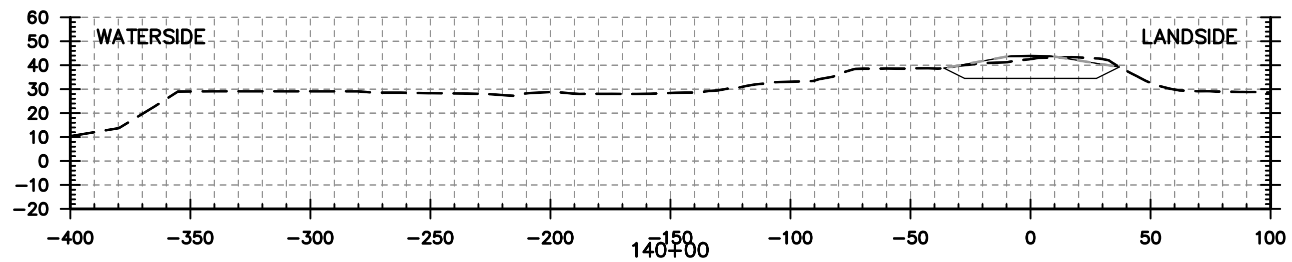
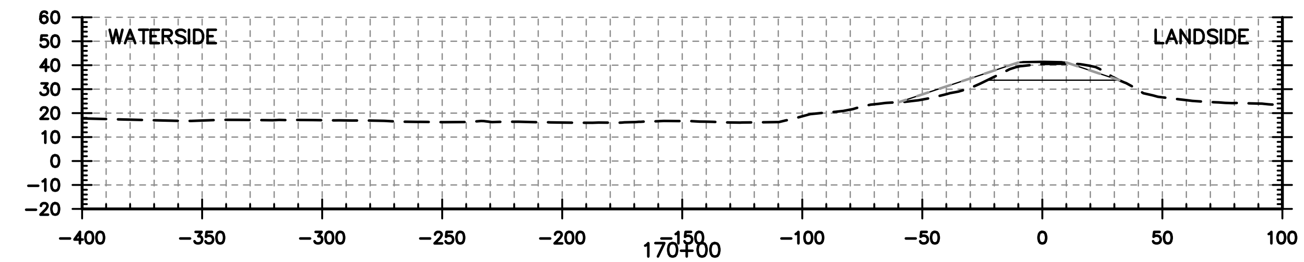
PLATE 16

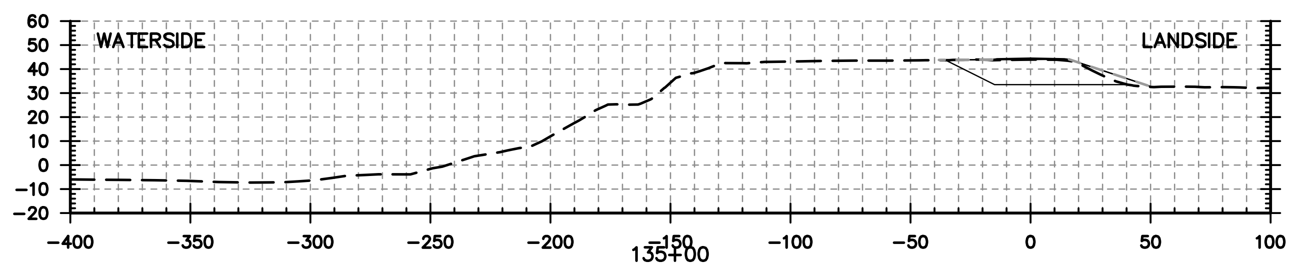
8.1.2 | PLOT DATE: 24-OCT-2014 | PLOT TIME: 16:10 | \\AMETHYST\civcad\WestSacramento\WestSacramentoGRR\CADD\Civil\SacramentoRiverNorthLevee\Sheet Fil

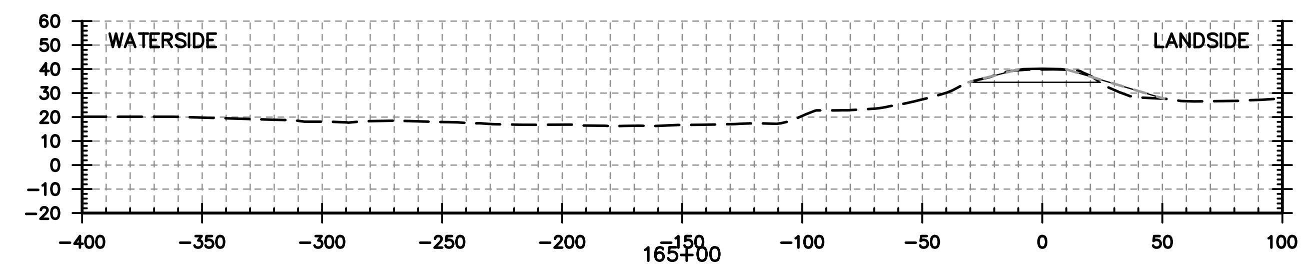


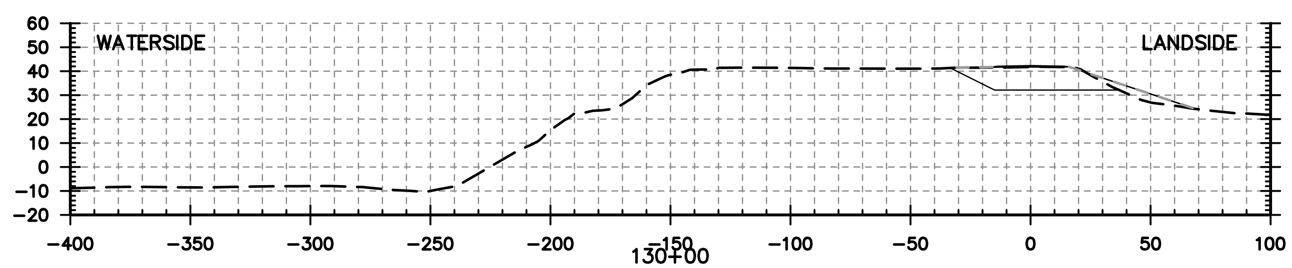


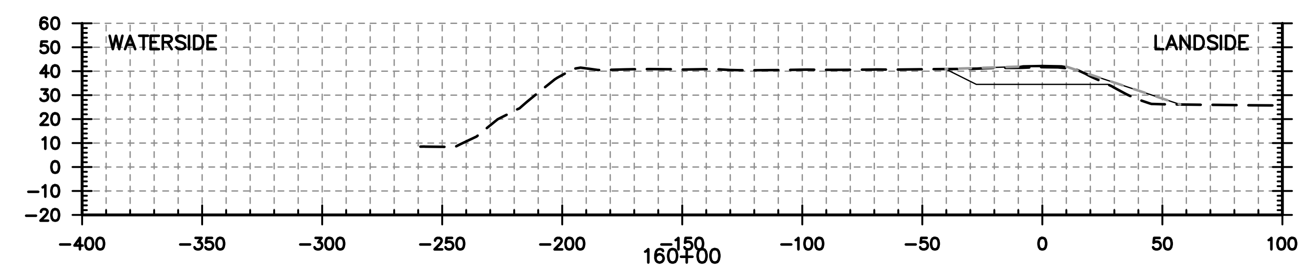


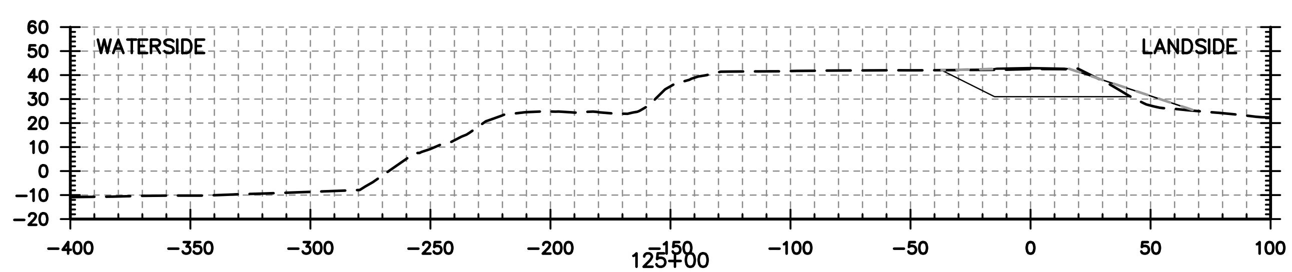


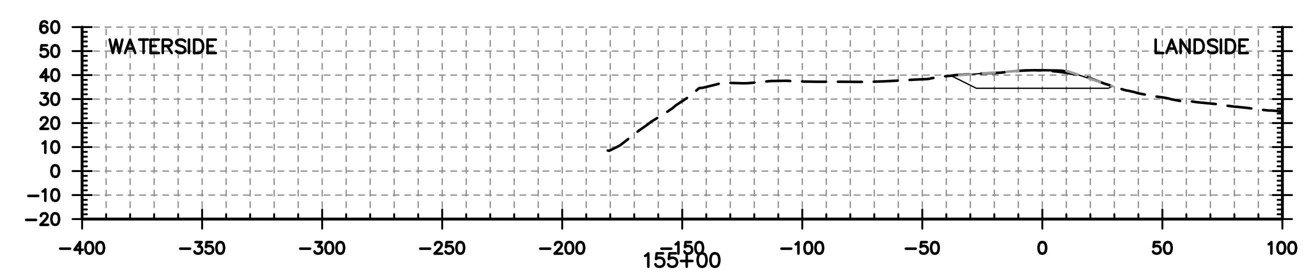


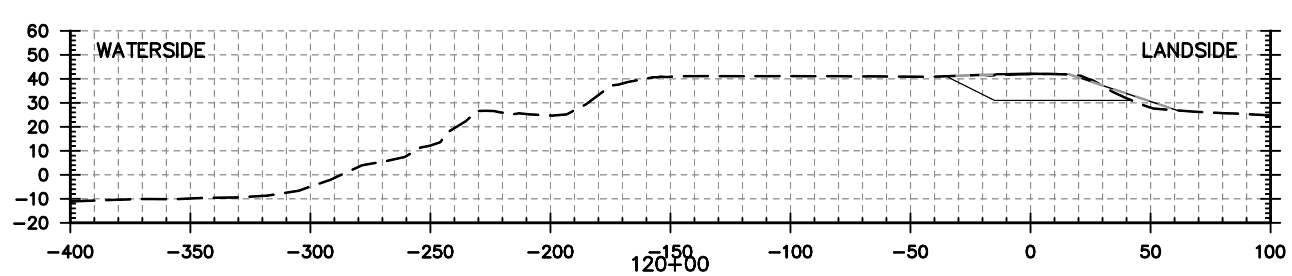


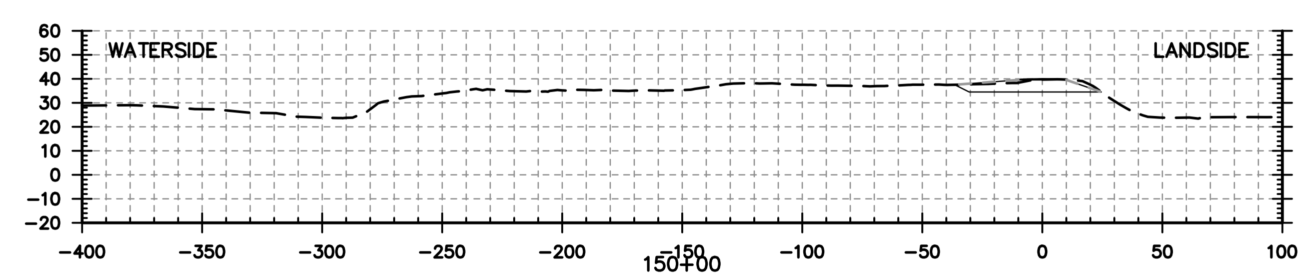












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SACRAMENTO RIVER NORTH LEVEE
CROSS SECTIONS

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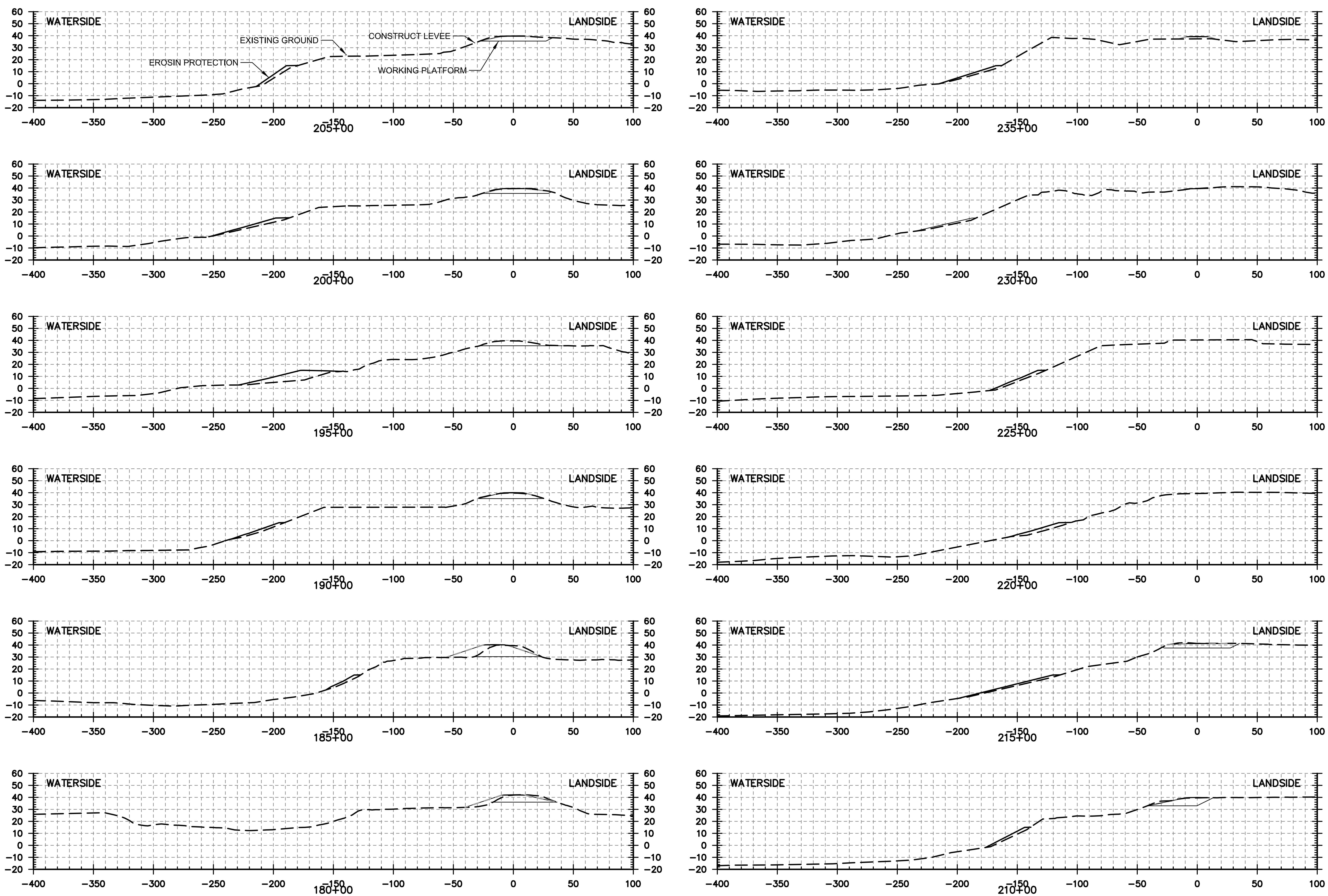
PLATE 17



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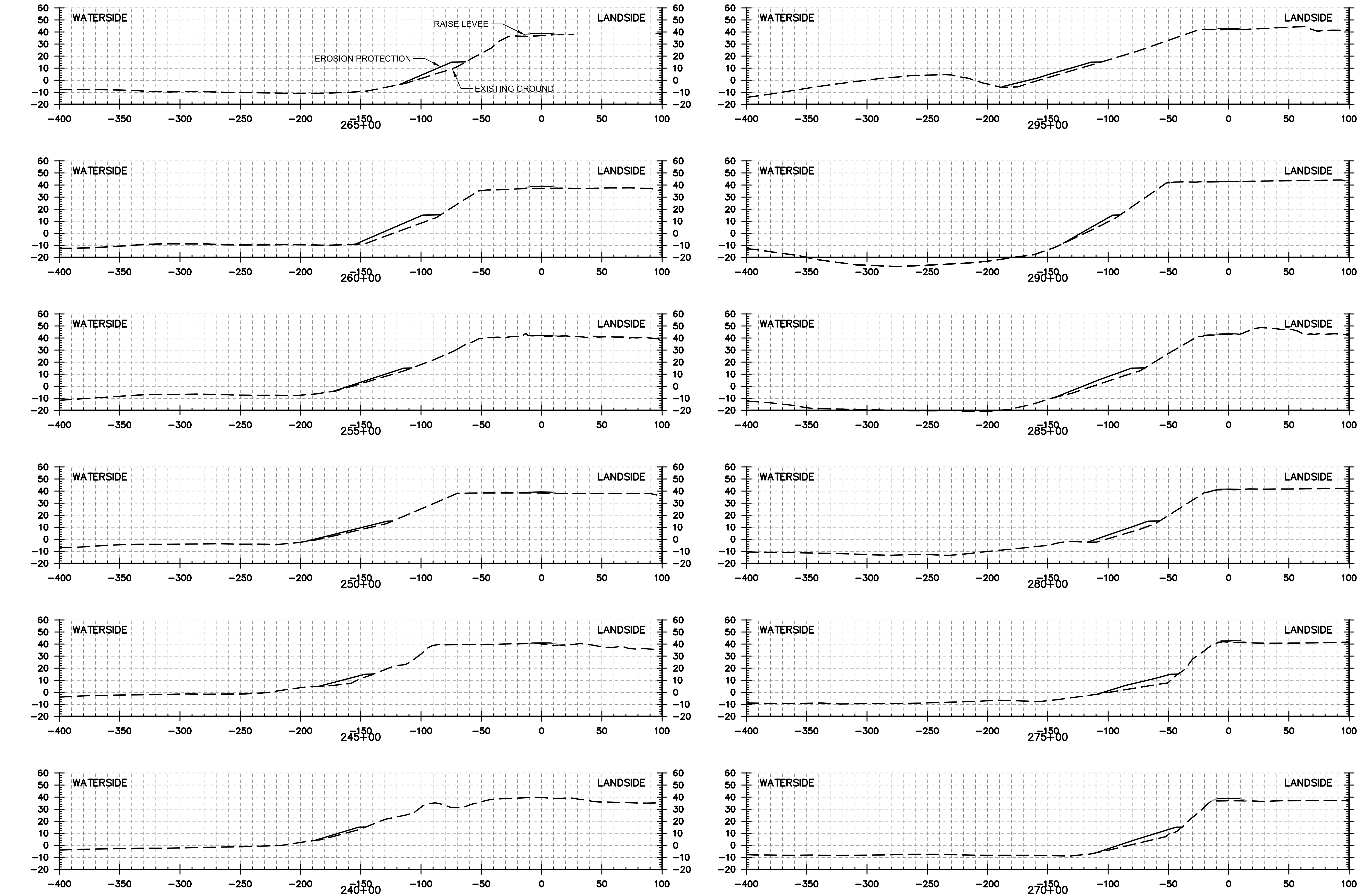
WEST SACRAMENTO AREA FLOOD CONTROL AGENCY FLOOD RISK REDUCTION PROJECTS

SACRAMENTO RIVER NORTH LEVEE
CROSS SECTIONS

Sheet reference number:
PLATE 18

PLOT DATE: 24-OCT-2014 PLOT TIME: 16:10 \\AMETHYST\civcad\WestSacramento\WestSacramentoGRR\CADD\Civil\SacramentoRiverNorthLevee\Sheet Fil

8.1.2



SEE TYPICAL SECTION FOR CUT OFF WALL DETAILS

NOT FOR CONSTRUCTION

US Army Corps of Engineers
Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 'J' STREET
SACRAMENTO, CA 95814-2922

WEST SACRAMENTO COUNTY CA

WEST SACRAMENTO AREA FLOOD CONTROL
AGENCY FLOOD RISK REDUCTION PROJECTS

SACRAMENTO RIVER NORTH LEVEE
CROSS SECTIONS

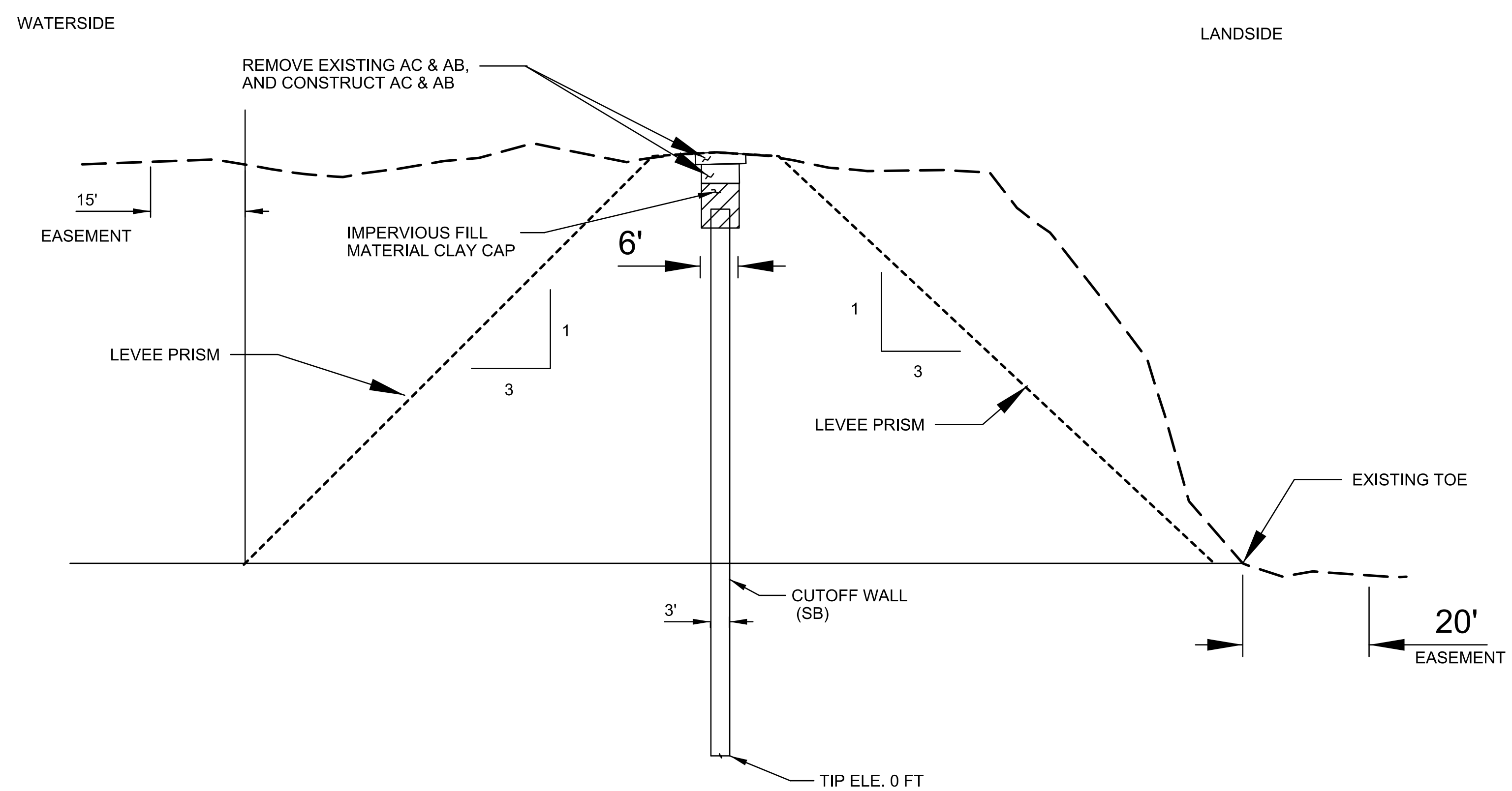
Sheet reference number:

PLATE 19

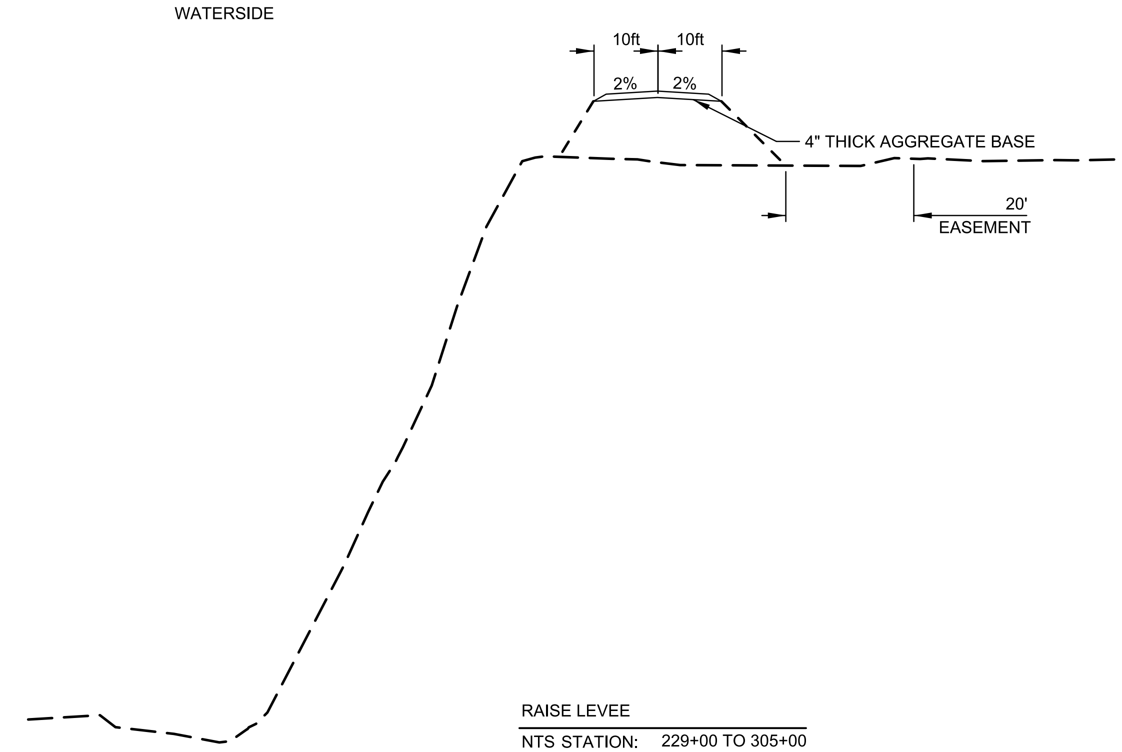
PLOT DATE: 24-OCT-2014 PLOT TIME: 16:10

\\AMETHYST\civcad\WestSacramento\WestSacramentoGRR\CADD\Civil\SacramentoRiverNorthLevee\Sheet\Fil

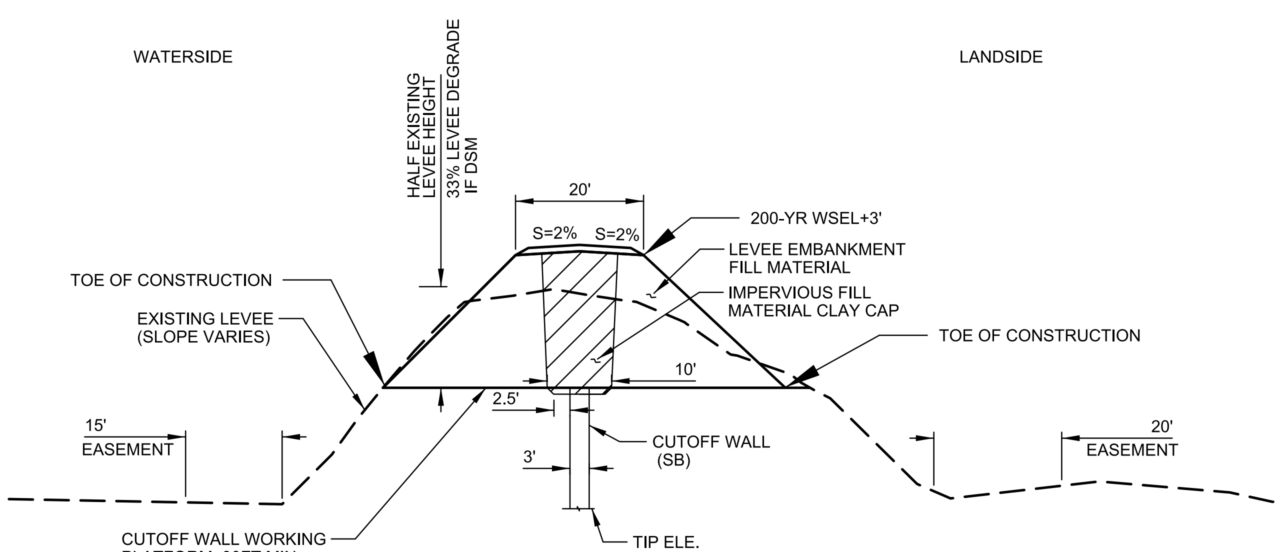
4 3 2 1



LEVEE CUT OFF WALL
NTS STATION: 0+00 TO 11+00

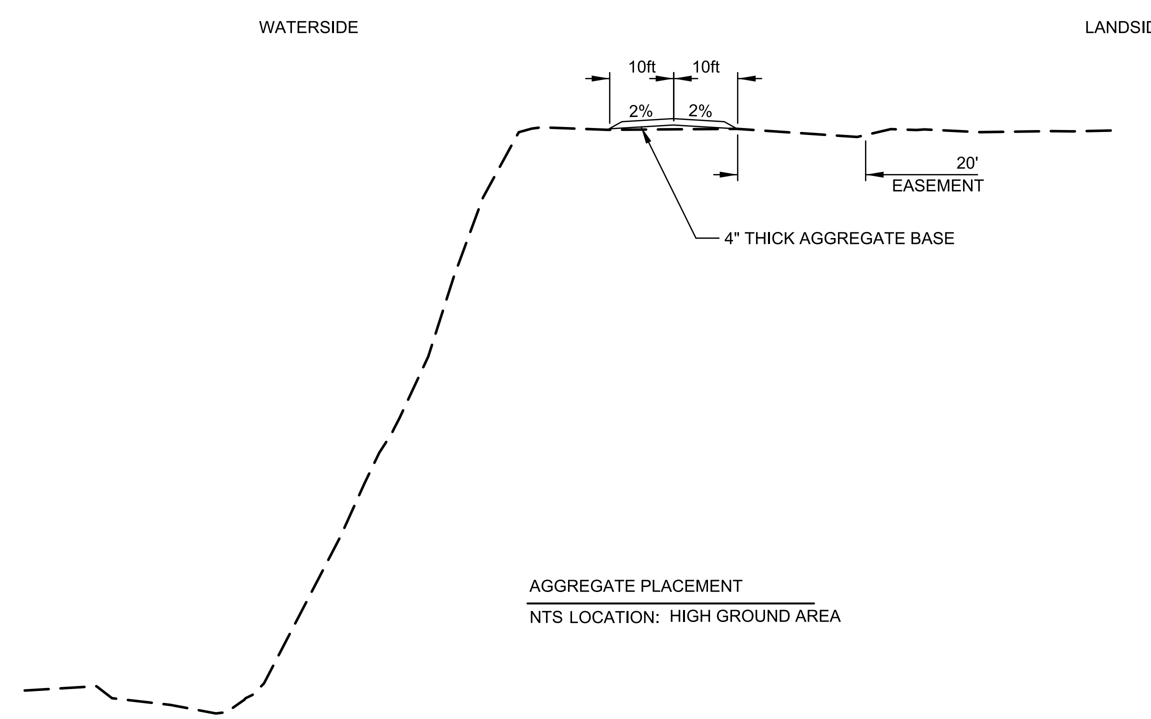


RAISE LEVEE
NTS STATION: 229+00 TO 305+00



TIP ELE. = 0 FROM 11+00 TO 71+70
TIP ELE. = 0 FROM 101+50 TO 140+25
TIP ELE. = -50 FROM 140+25 TO 155+00
TIP ELE. = -80 FROM 155+00 TO 194+50
TIP ELE. = -5 FROM 194+50 TO 199+50
TIP ELE. = -80 FROM 199+50 TO 215+20

LEVEE IMPROVEMENT
NTS TYPICAL



AGGREGATE PLACEMENT
NTS LOCATION: HIGH GROUND AREA

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Sacramento District

Symbol | Description | Date | Approved

Designed by: | Dwn by: | Reviewed by: | Submitted by: CHIEF, CIV ENGR DES SEC A
Date: | Spec No.: | Design file no: | Drawing Code: | File name: | Plot date: | Plot scale:
Rev.

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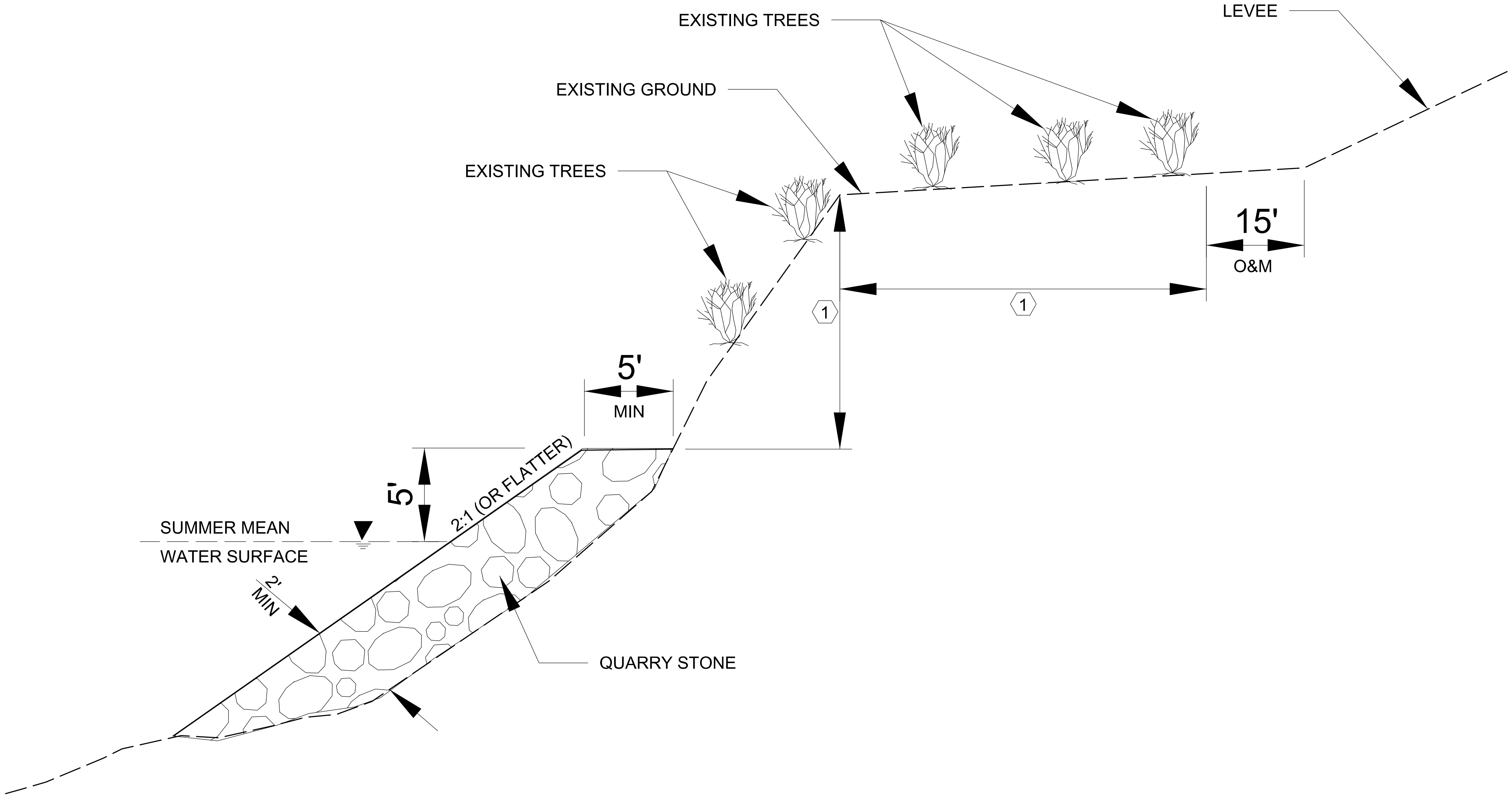
WEST SACRAMENTO COUNTY CA
WEST SACRAMENTO AREA FLOOD CONTROL AGENCY FLOOD RISK REDUCTION PROJECTS
SACRAMENTO RIVER NORTH LEVEE
TYPICAL CROSS SECTIONS

Sheet reference number:
PLATE 20
AM-XX

8.1.2 PLOT DATE: 24-OCT-2014 PLOT TIME: 16:10 \\AMETHYST\civcad\WestSacramento\WestSacramentoGRR\CADD\Civil\SacramentoRiverNorthLevee\Sheet\Fil

RIVERSIDE

LANDSIDE



KEY NOTES:

1 EXISTING TREES AND VEGETATION SHALL REMAIN IN PLACE

LOWER BANK PROTECTION -TYPICAL CROSS SECTION

NOT TO SCALE STA. 71 +00 TO 99 +00
181 +00 TO 296 +00

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WEST SACRAMENTO AREA FLOOD CONTROL
AGENCY FLOOD RISK REDUCTION PROJECTS

SACRAMENTO RIVER NORTH LEVEE
EROSION PROTECTION TYPICAL
CROSS SECTIONS

Sheet reference number:
PLATE 21
AM-XX

PLOT DATE: 20-JUL-2015 PLOT TIME: 13:41 \\amethyst\civcad\WestSacramento\WestSacramentoGRR\CADD\Civil\SacramentoRiverNorthLevee\Sheet Files

PORT SOUTH OVERVIEW MAP

SCALE: 1" =1200'

1200' 600' 0 1200'

1"=1200'

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WEST SACRAMENTO AREA FLOOD CONTROL AGENCY FLOOD RISK REDUCTION PROJECTS

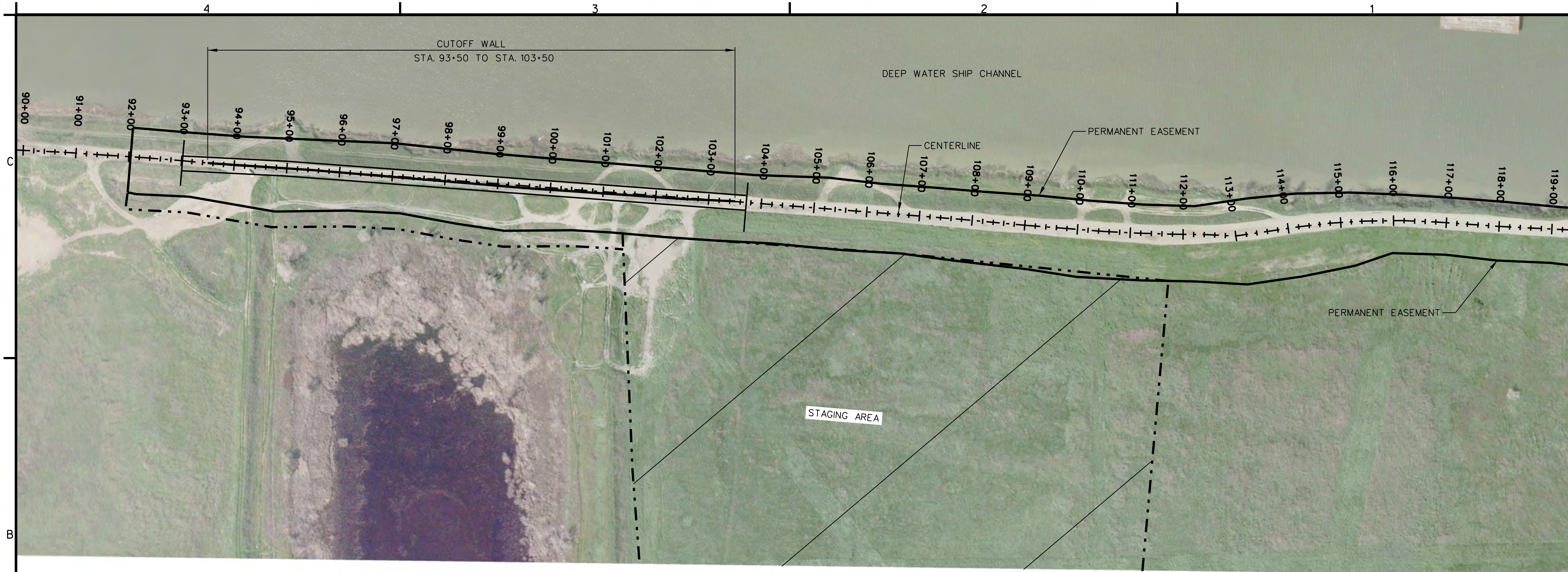
PORT SOUTH LEVEE (ALT. 5)
PORT SOUTH LEVEE OVERVIEW

Sheet reference number:

PLATE 01

AM-XX

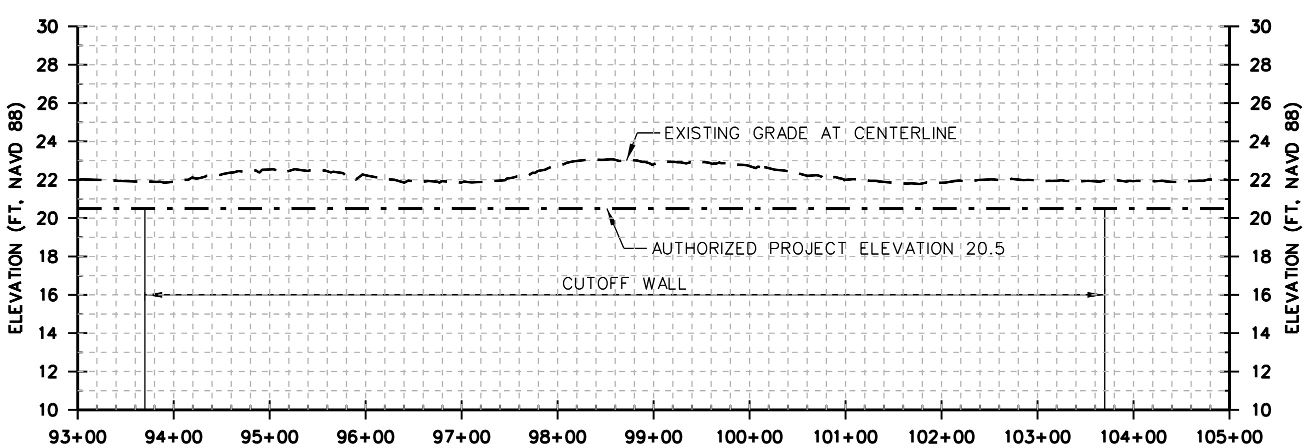
8.1.2 | PLOT DATE: 13-NOV-2015 | PLOT TIME: 16:50 | C:\Users\L2EDDBYL\Desktop\West_Sac_GRR\Port_South\HQ\SheetFiles\C-101PSOV.dgn



PLAN VIEW
SCALE: 1" = 200'

N

200' 100' 0 200'
1"=200'



PORT SOUTH LEVEE PROFILE (ALT. 5)

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Reviewed by: | Drawing Code:
Submitted by: | File name: | Plot date: | Plot scale:
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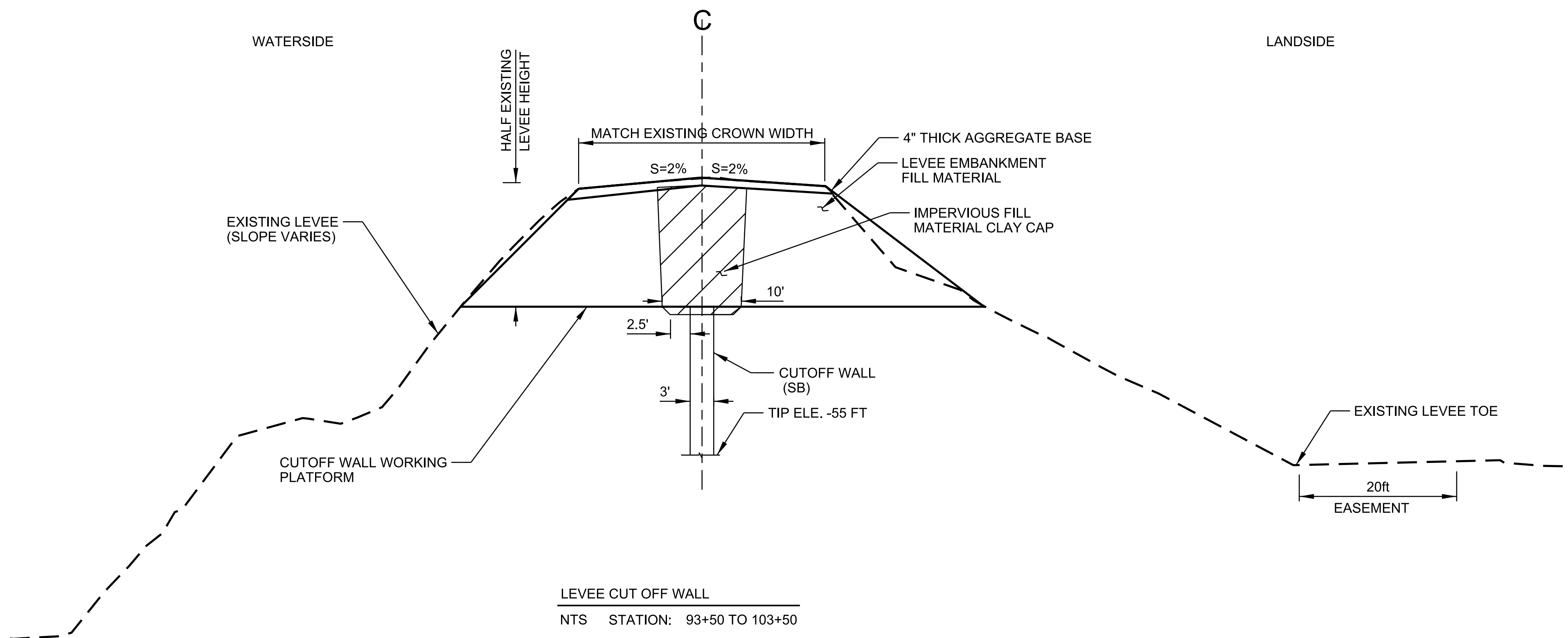
YOLO COUNTY CA

WEST SACRAMENTO AREA FLOOD CONTROL
AGENCY FLOOD RISK REDUCTION PROJECTS

PORT SOUTH LEVEE (ALT. 5)
PLAN AND PROFILE

Sheet reference number:
PLATE 02



LEVEE CUT OFF WALL

NTS STATION: 93+50 TO 103+50

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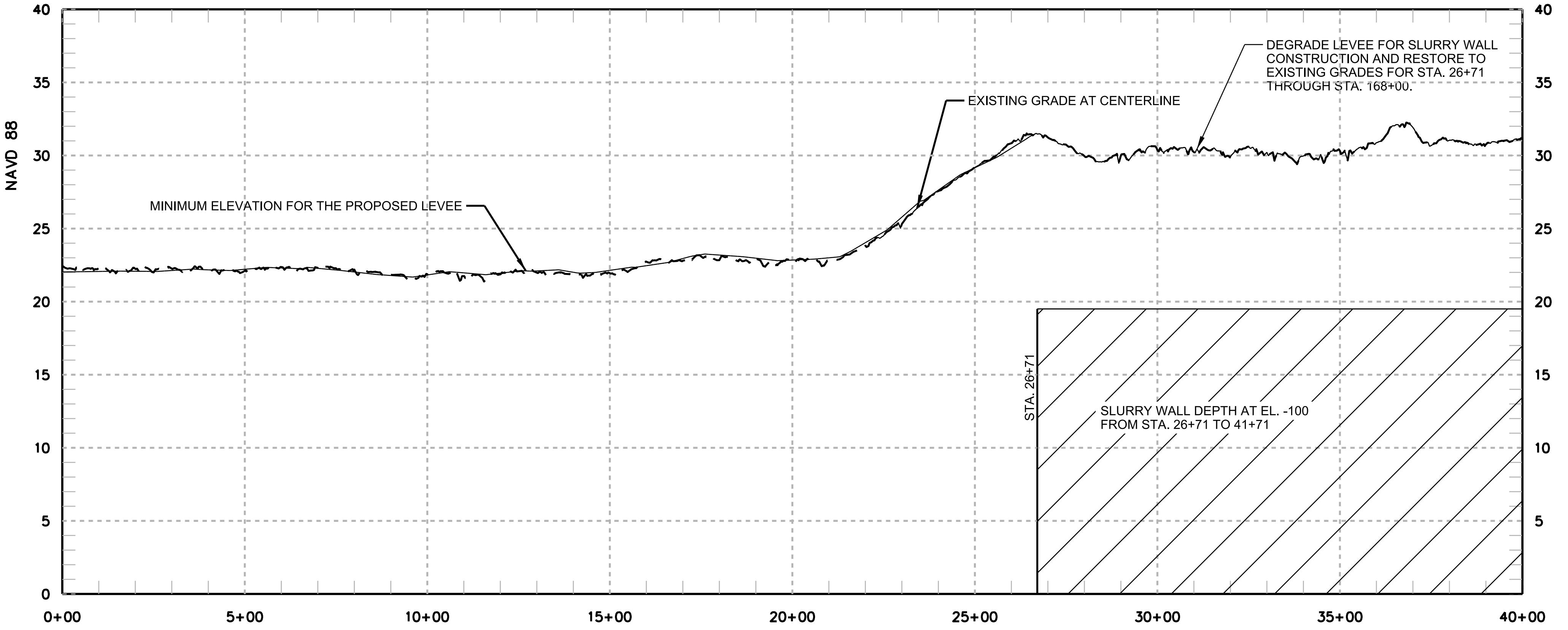
YOLO COUNTY CA

WEST SACRAMENTO AREA FLOOD CONTROL
AGENCY FLOOD RISK REDUCTION PROJECTS

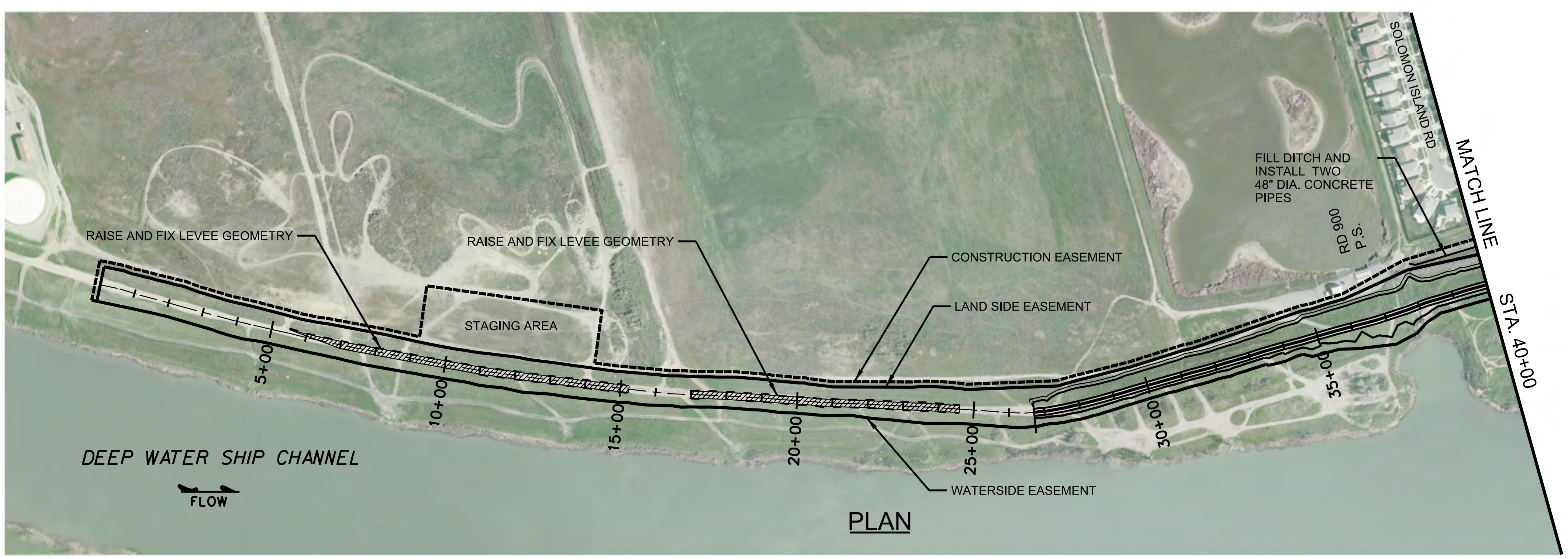
PORT SOUTH LEVEE (ALT. 5)
TYPICAL CROSS SECTIONS

Sheet reference number:
PLATE 10

PLOT DATE: 13-NOV-2015 PLOT TIME: 16:54 C:\Users\L2EDDBYL\Desktop\West_Sac_GRR\Port_South\HQ\SheetFiles\C-301TYP.dgn



PROFILE



PLAN

SCALE:1"=200'

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Date Approved | Description | Symbol

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Dwn by:
Spec No.: SPEC_NO
Reviewed by: REVIEWED_BY
Submitted by: / /PETER VALENTINE
CHIEF, CIV ENGR DES SEC A
Date: DATE_APPROVED
Rev.
Design file no: FILE_NO
Drawing Code: CODE
File name:
Plot date: 09-JUL-2015
Plot scale:

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SACRAMENTO, CALIFORNIA

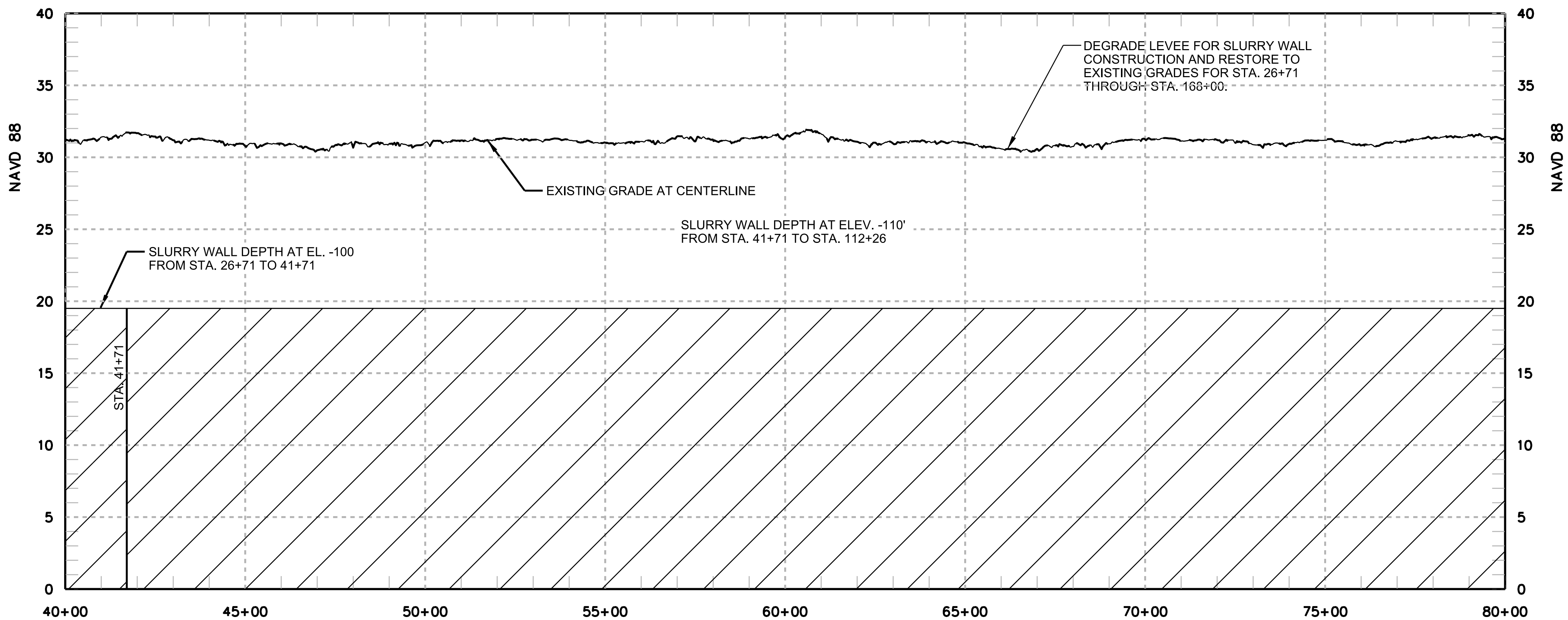
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 'J' STREET
SACRAMENTO, CA 95814-2922

YOLO COUNTY CALIFORNIA
WEST SACRAMENTO PROJECT
GENERAL REEVALUATION REPORT
FLOOD RISK MANAGEMENT PROJECT

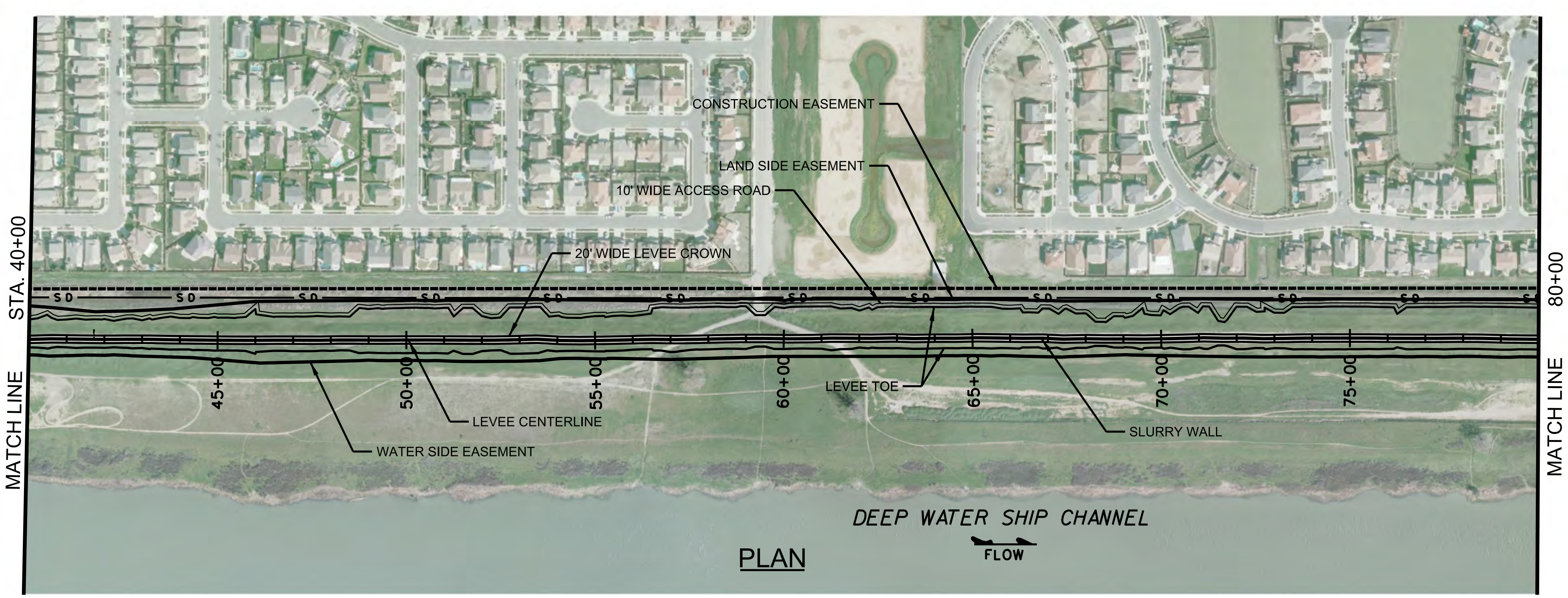
DWSC EAST (ALT. 5)
PLAN AND PROFILE
STA. 0+00 TO STA. 40+00

Sheet reference number:
C-101

8.1.2 PLOT DATE: 09-JUL-2015 PLOT TIME: 13:49 C:\Users\L2EDDBYL\Desktop\West_Sac_GRR\dwsc\sheets\DWSC-C-101PLN.dgn



PROFILE



PLAN

SCALE:1"=200'

0 200' 400'

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SACRAMENTO, CALIFORNIA

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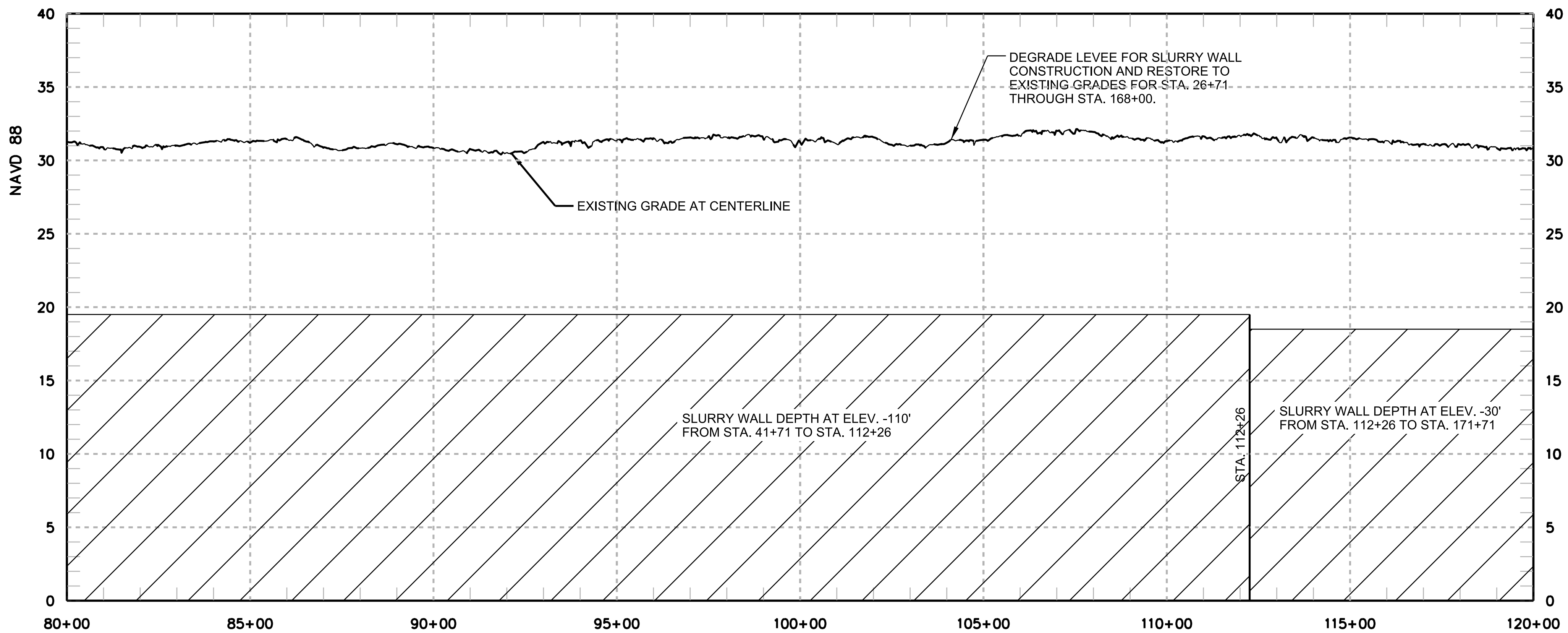
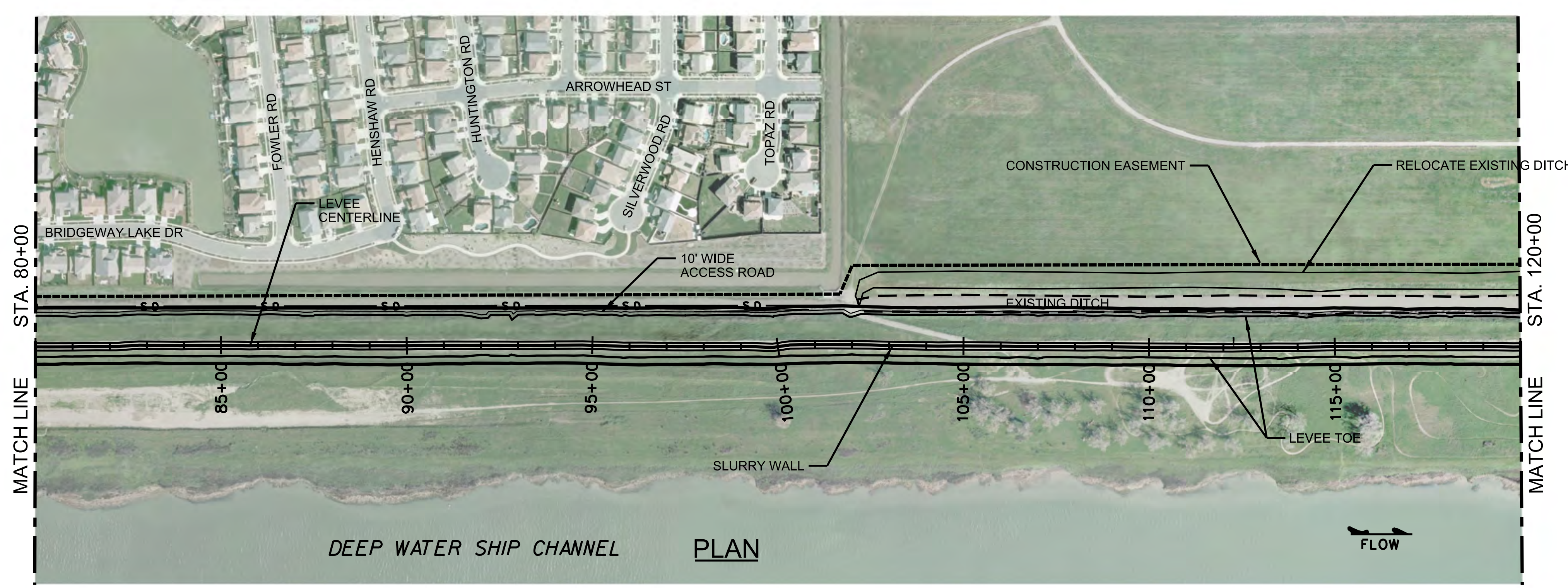
IN-HOUSE DESIGN
1325 'J' STREET
SACRAMENTO, CA 95814-2922

YOLO COUNTY CALIFORNIA
WEST SACRAMENTO PROJECT
GENERAL REEVALUATION REPORT
FLOOD RISK MANAGEMENT PROJECT
DWSC EAST
PLAN AND PROFILE
STA. 40+00 TO STA. 80+00

Sheet reference number:
C-102



PROFILE



PLAN

SCALE:1"=200'

US Army Corps of Engineers
Sacramento District

DEPARTMENT OF THE ARMY
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SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
IN-HOUSE DESIGN
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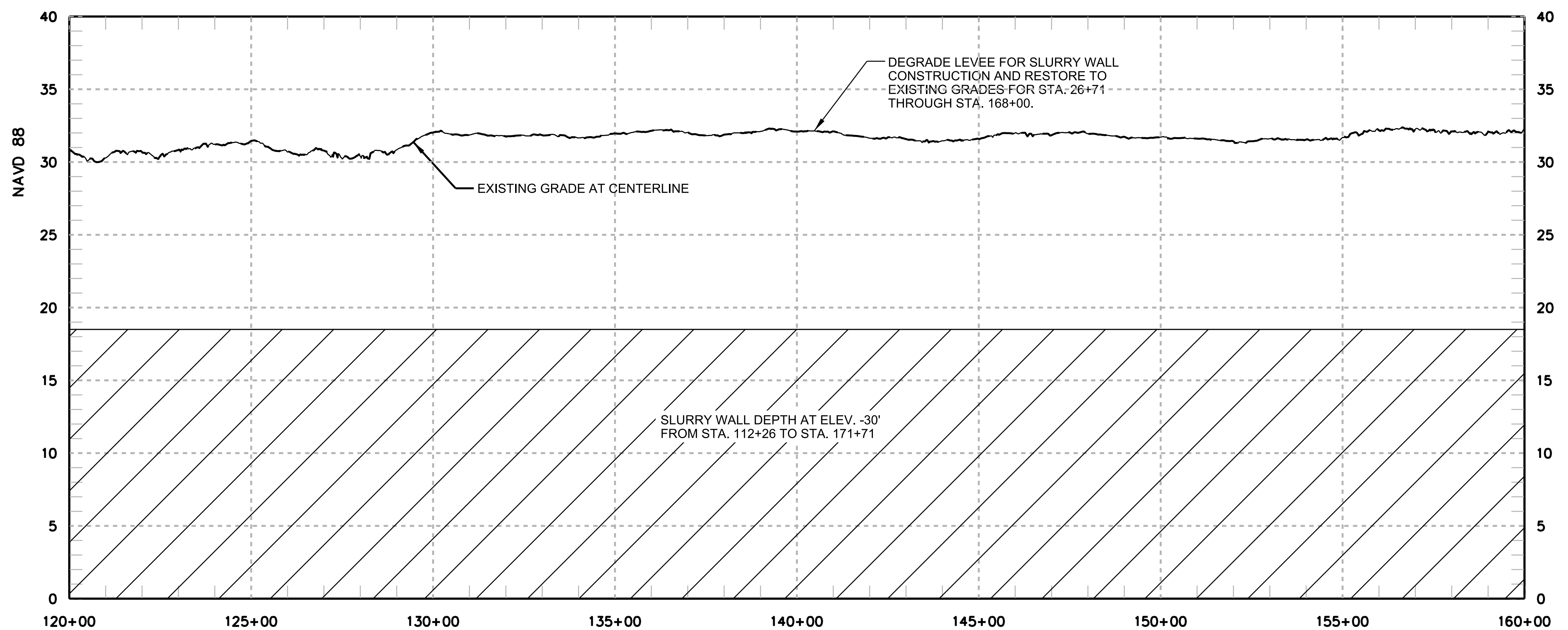
Reviewed by: REVIEWED_BY | Drawing Code: CODE
Submitted by: / PETER VALENTINE, CHIEF, CIV ENGR DES SEC A | File name: | Plot date: 09-JUL-2015 | Plot scale:

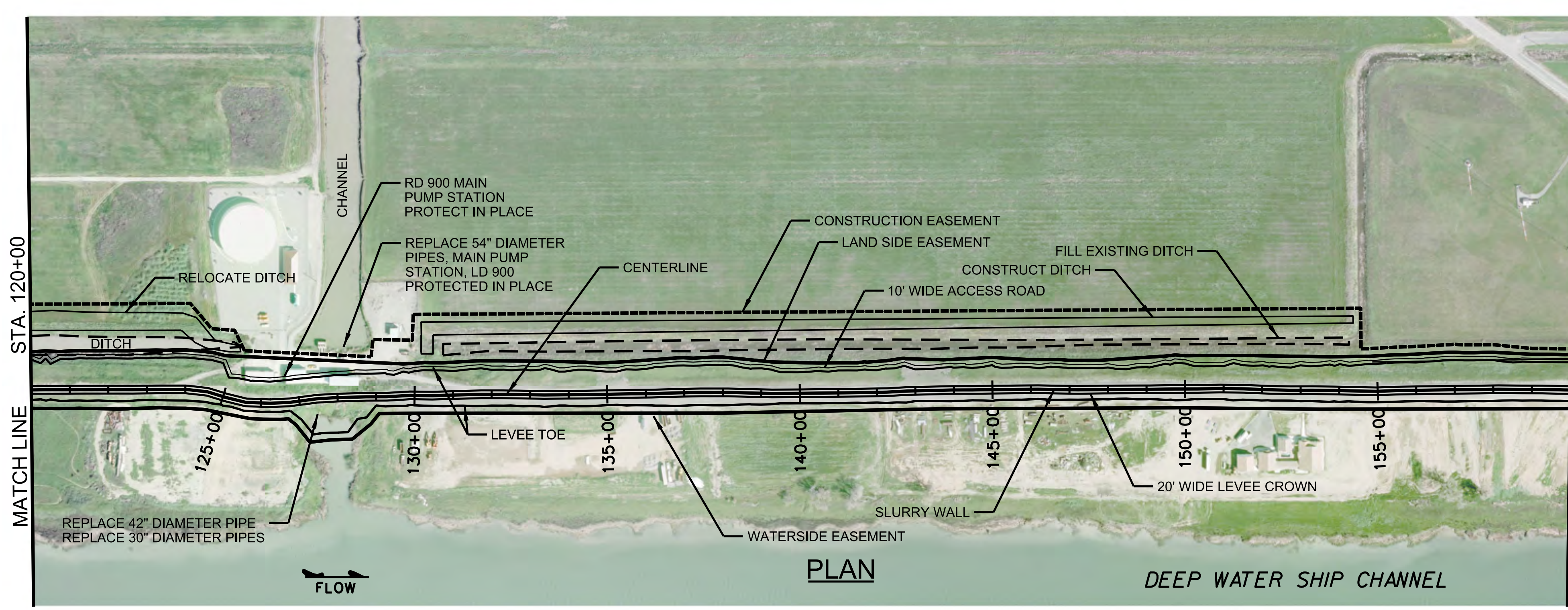
YOLO COUNTY CALIFORNIA
WEST SACRAMENTO PROJECT
GENERAL REEVALUATION REPORT
FLOOD RISK MANAGEMENT PROJECT
DWSC EAST
PLAN AND PROFILE
STA. 115+00 TO STA. 120+00

Sheet reference number:
C-101

PLOT DATE: 09-JUL-2015 PLOT TIME: 13:54 C:\Users\L2EDDBYL\Desktop\West_Sac_GRR\dwsc\sheets\DWSC-C-103PLN.dgn



PROFILE



PLAN

N

0 200' 400'

SCALE:1"=200'

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Dwn by: | Spec No.: SPEC_NO | Design file no: FILE_NO
Reviewed by: REVIEWED_BY | Drawing Code: CODE
Submitted by: / PETER VALENTINE, CHIEF, CIV ENGR DES SEC A | File name: | Plot date: 09-JUL-2015 | Plot scale:

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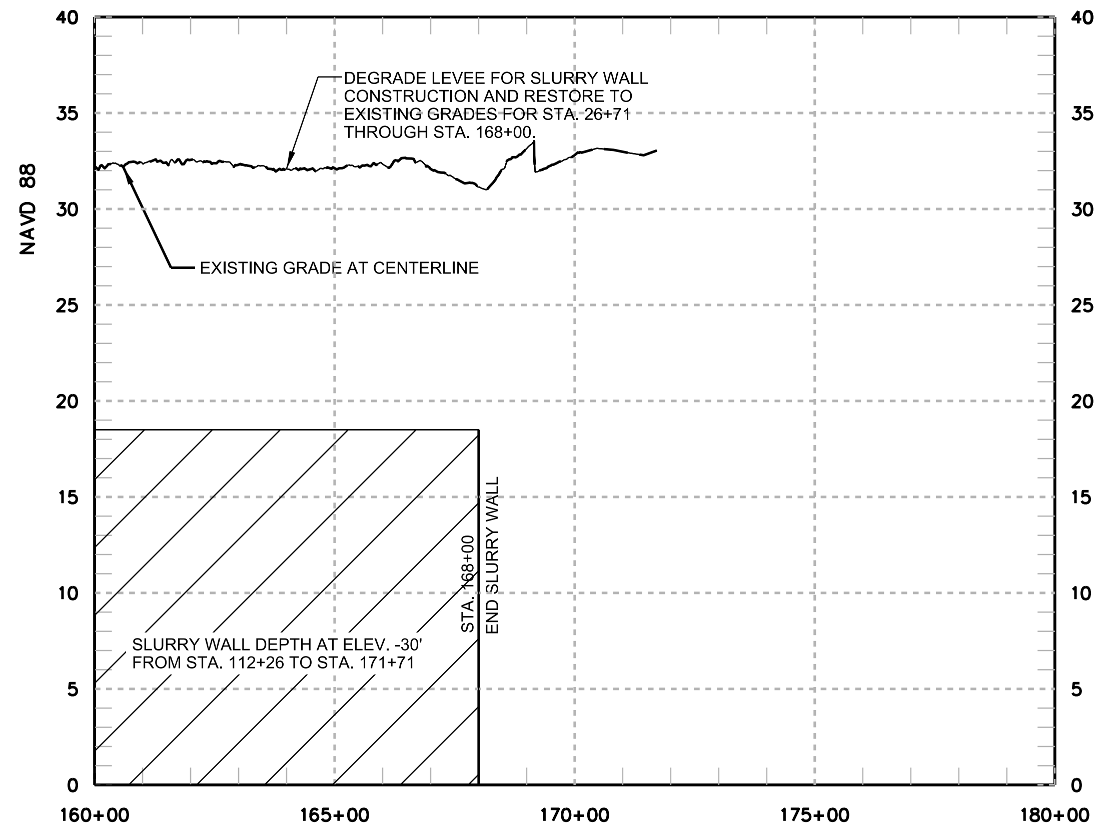
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 'J' STREET
SACRAMENTO, CA 95814-2922

YOLO COUNTY CALIFORNIA
WEST SACRAMENTO PROJECT
GENERAL REEVALUATION REPORT
FLOOD RISK MANAGEMENT PROJECT
DWSC EAST
PLAN AND PROFILE
STA. 120+00 TO STA. 160+00

Sheet reference number:
C-104

8.1.2 | PLOT DATE: 09-JUL-2015 | PLOT TIME: 13:56 | C:\Users\L2EDDBYL\Desktop\West_Sac_GRR\dwsc\sheets\DWSC-C-104PLN.dgn



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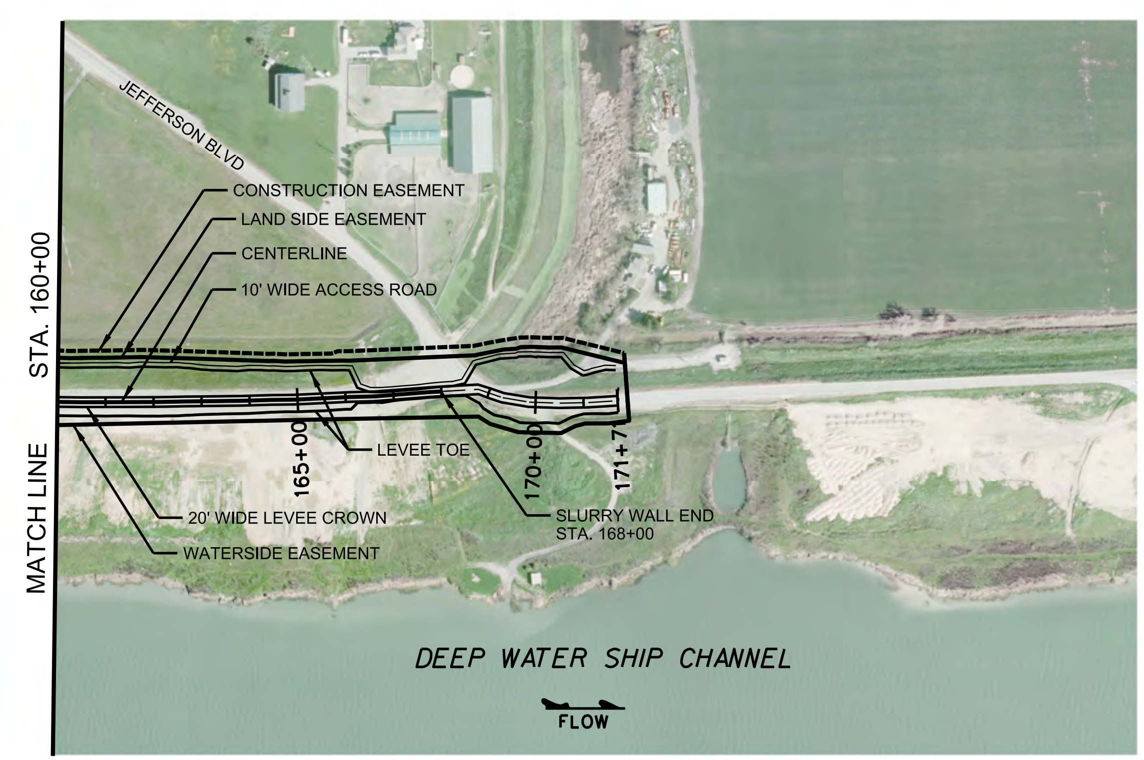

PLAN

N

0 200' 400'

SCALE:1"=200'

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Spec No.: SPEC_NO

Date: DATE_APPROVED | Rev.

Design file no: FILE_NO

Drawing Code: CODE

File name:
Plot date: 09-JUL-2015
Plot scale:

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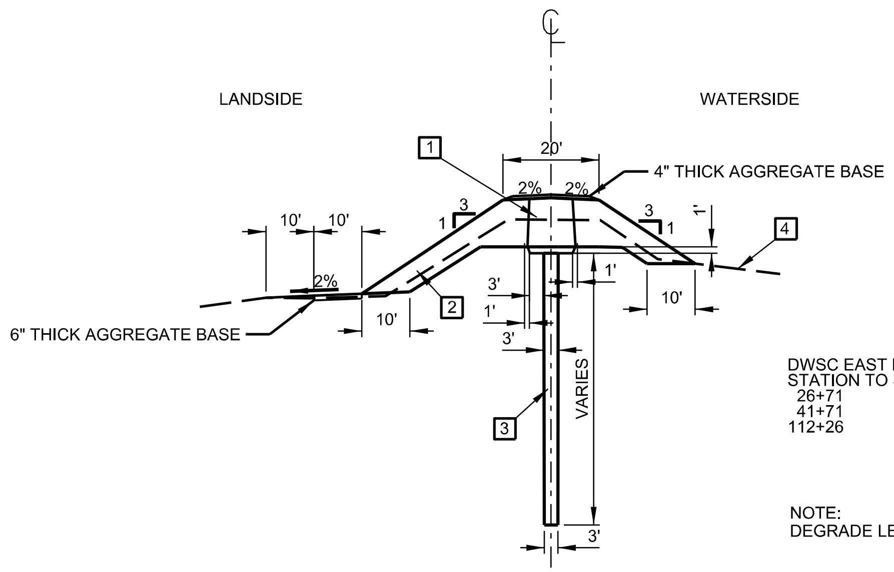
1325 'J' STREET
SACRAMENTO, CA 95814-2922

YOLO COUNTY CALIFORNIA
WEST SACRAMENTO PROJECT
GENERAL REEVALUATION REPORT
FLOOD RISK MANAGEMENT PROJECT
DWSC EAST
PLAN AND PROFILE
STA. 160+00 TO STA. 169+25

Sheet reference number:
C-105



DWSC EAST LEVEE STATION	TO STATION	SLURRY WALL BOTTOM EL.
26+71	41+71	-100
41+71	112+26	-110
112+26	168+00	-30

NOTE:
DEGRADE LEVEE 1/2 HEIGHT

LEVEE IMPROVEMENTS WITH SLURRY WALL

NTS

1 IMPERVIOUS FILL
2 COMPACTED FILL
3 SLURRY WALL
4 EXISTING GROUND

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Dwn by: | Spec No.: SPEC_NO | Design file no: FILE_NO
Reviewed by: REVIEWED_BY | Drawing Code: CODE
Submitted by: / PETER VALENTINE CHIEF, CIV ENGR DES SEC A | File name: | Plot date: 10-JUL-2015 | Plot scale:

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YOLO COUNTY CALIFORNIA
WEST SACRAMENTO PROJECT
GENERAL REEVALUATION REPORT
FLOOD RISK MANAGEMENT PROJECT
DEEP WATER SHIP CHANNEL
EAST BANK
TYPICAL SECTION

Sheet reference number:
C-301

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Date:	Spec No.:		
Rev.	Design file no:	Drawing Code:	File name: Plot date: Plot scale:

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WEST SACRAMENTO COUNTY CA

WEST SACRAMENTO AREA FLOOD CONTROL
AGENCY FLOOD RISK REDUCTION PROJECTS

SOUTH CROSS LEVEE OVERVIEW

Sheet reference number:

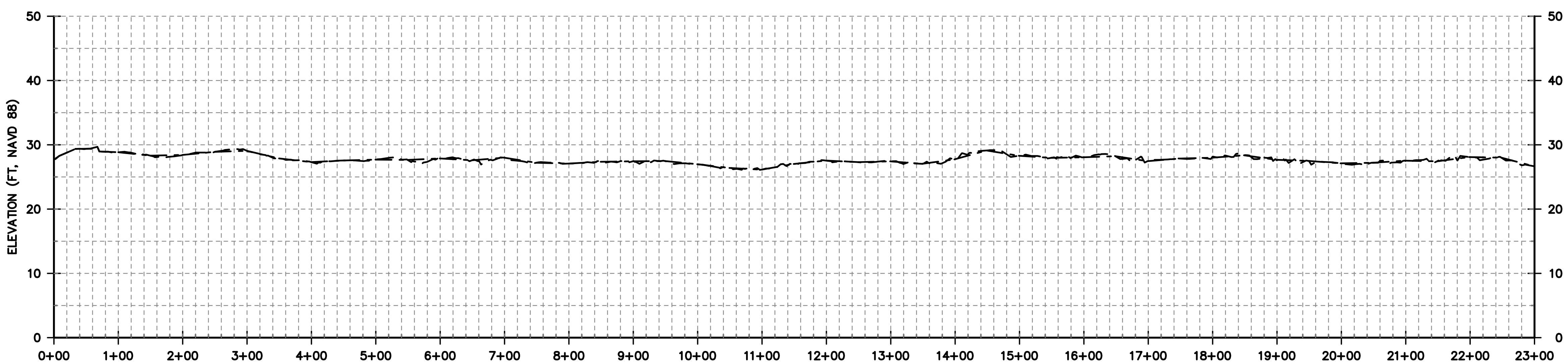
PLATE 01

NOTE:
THE EXISTING FENCE INSIDE THE LEVEE FOOTPRINT WILL BE REMOVED.

SOUTH CROSS LEVEE PLAN VIEW

200' 100' 0 200'

1"=200'



SOUTH CROSS LEVEE (ALT 5)

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SACRAMENTO, CALIFORNIA

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1325 'J' STREET
SACRAMENTO, CA 95814-2922

WEST SACRAMENTO COUNTY CA

WEST SACRAMENTO AREA FLOOD CONTROL
AGENCY FLOOD RISK REDUCTION PROJECTS

SOUTH CROSS LEVEE (ALT 5)
PLAN AND PROFILE

Sheet reference number:

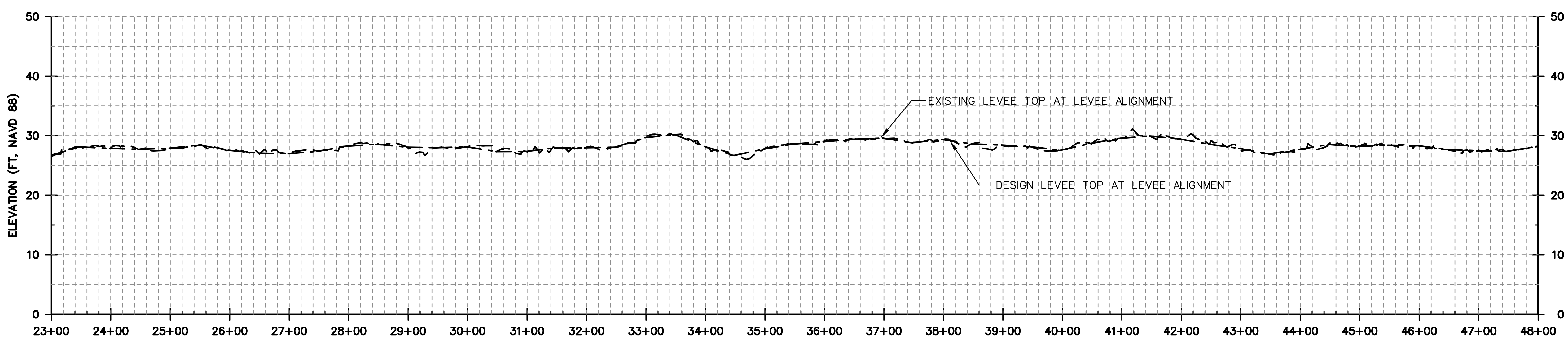
PLATE 02

8.1.2 | PLOT DATE: 20-NOV-2015 | PLOT TIME: 15:11 | C:\Users\L2EDDBYL\Desktop\West_Sac_GRR\South_Cross_Levee\Cad\HQ_10302015\Plate2_P&P.dgn

SOUTH CROSS LEVEE PLAN VIEW

200' 100' 0 200'

1"=200'



SOUTH CROSS LEVEE PROFILE (ALT 5)

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Submitted by: | File name: | Plot date: | Plot scale:
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WEST SACRAMENTO AREA FLOOD CONTROL
AGENCY FLOOD RISK REDUCTION PROJECTS

SOUTH CROSS LEVEE (ALT 5)
PLAN AND PROFILE

Sheet reference number:

PLATE 03

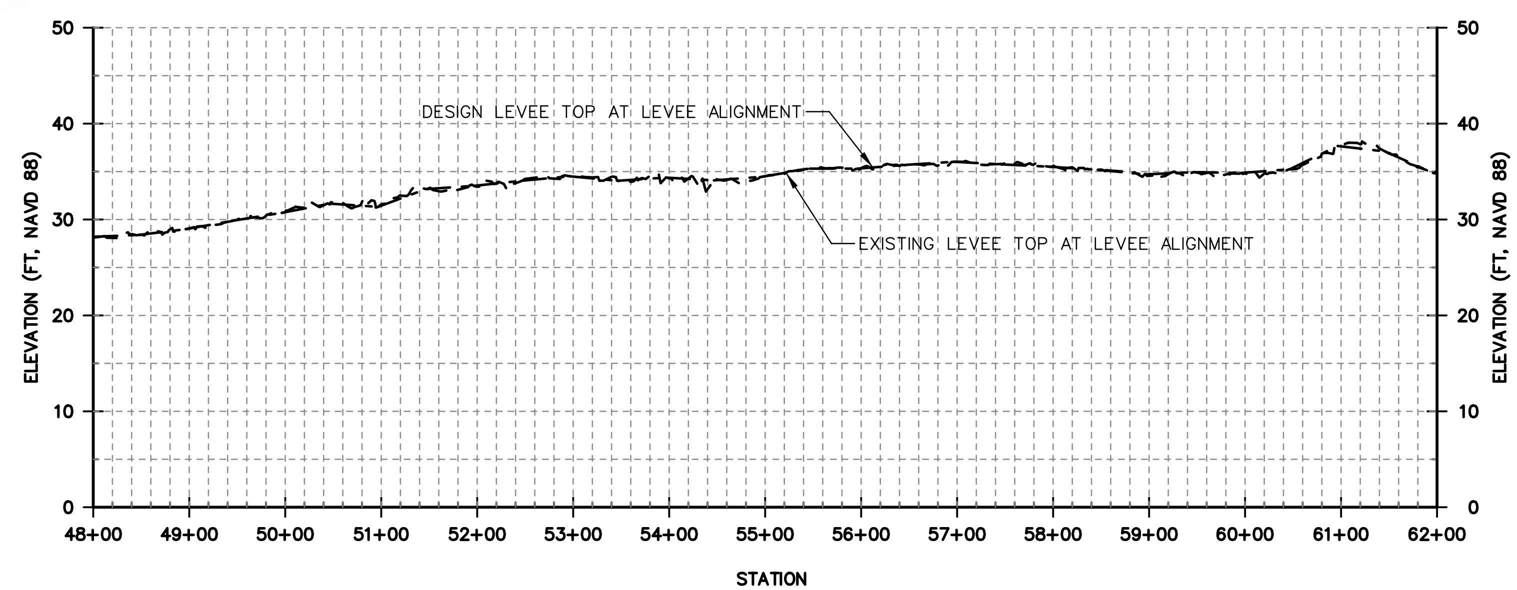
8.1.2

PLOT DATE: 20-NOV-2015 PLOT TIME: 15:12 C:\Users\L2EDDBYL\Desktop\West_Sac_GRR\South_Cross_Levee\Cad\HQ_10302015\Plate3_P&P.dgn

SOUTH CROSS LEVEE PLAN VIEW

200' 100' 0 200'

1"=200'



SOUTH CROSS LEVEE PROFILE (ALT 5)

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Dwn by: | Spec No.: | Design file no:
Reviewed by: | Drawing Code:
Submitted by: CHIEF, CIV ENGR DES SEC A | File name: | Plot date: | Plot scale:

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SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
IN-HOUSE DESIGN
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SACRAMENTO, CA 95814-2922

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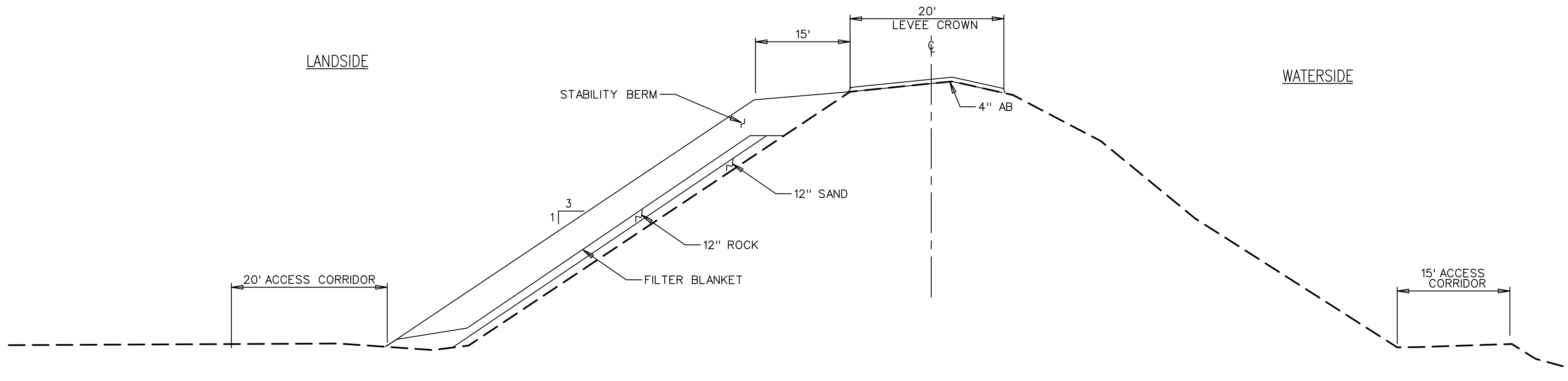
WEST SACRAMENTO AREA FLOOD CONTROL
AGENCY FLOOD RISK REDUCTION PROJECTS

SOUTH CROSS LEVEE (ALT. 5)
PLAN VIEW AND PROFILE

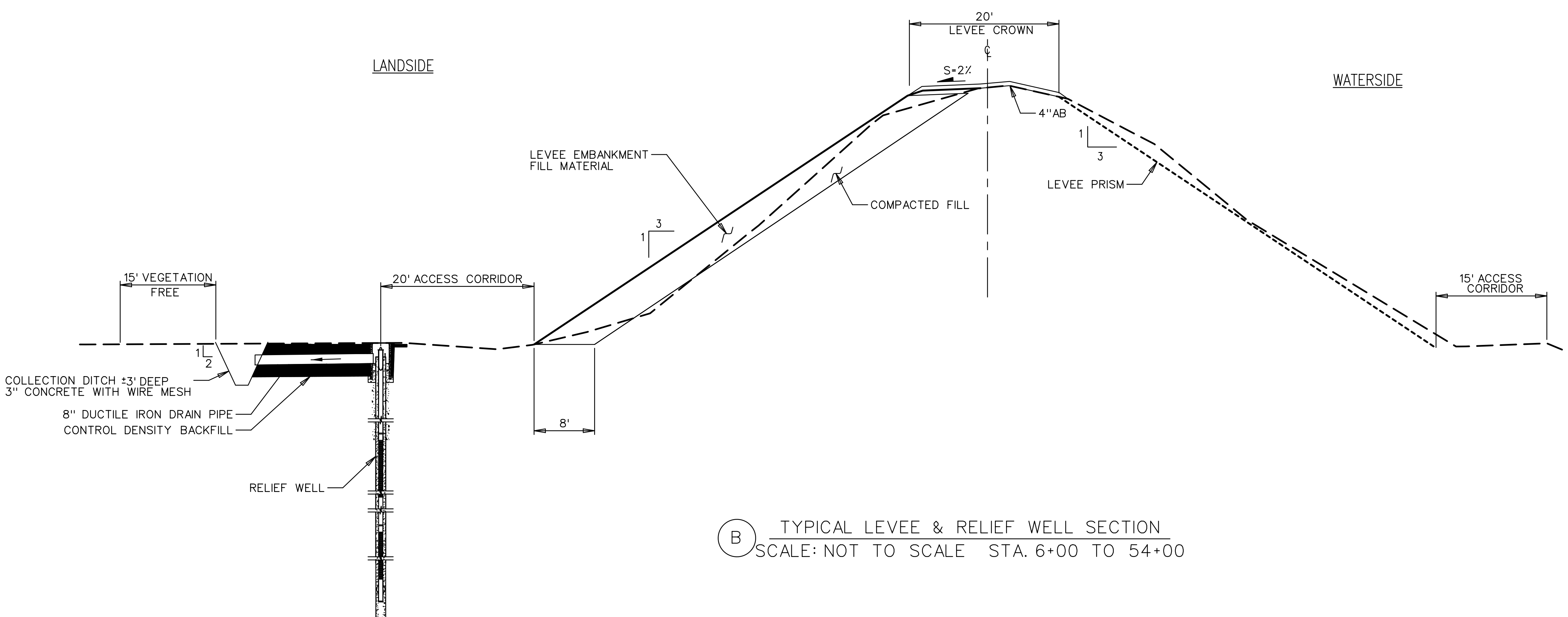
Sheet reference number:

PLATE 04

AM-XX



A TYPICAL STABILITY BERM SECTION
SCALE: NOT TO SCALE, STA. 0+00 TO 6+00
STA. 54+00 TO 62+00



B TYPICAL LEVEE & RELIEF WELL SECTION
SCALE: NOT TO SCALE STA. 6+00 TO 54+00

NOT FOR CONSTRUCTION

PLOT DATE: 20-NOV-2015 PLOT TIME: 15:13 C:\Users\L2EDDBYL\Desktop\West_Sac_GRR\South_Cross_Levee\Cad\HQ_10302015\Plate5_Typ_Sec.dgn

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Symbol	Description	Date	Approved

Designed by: | Date: | Rev.
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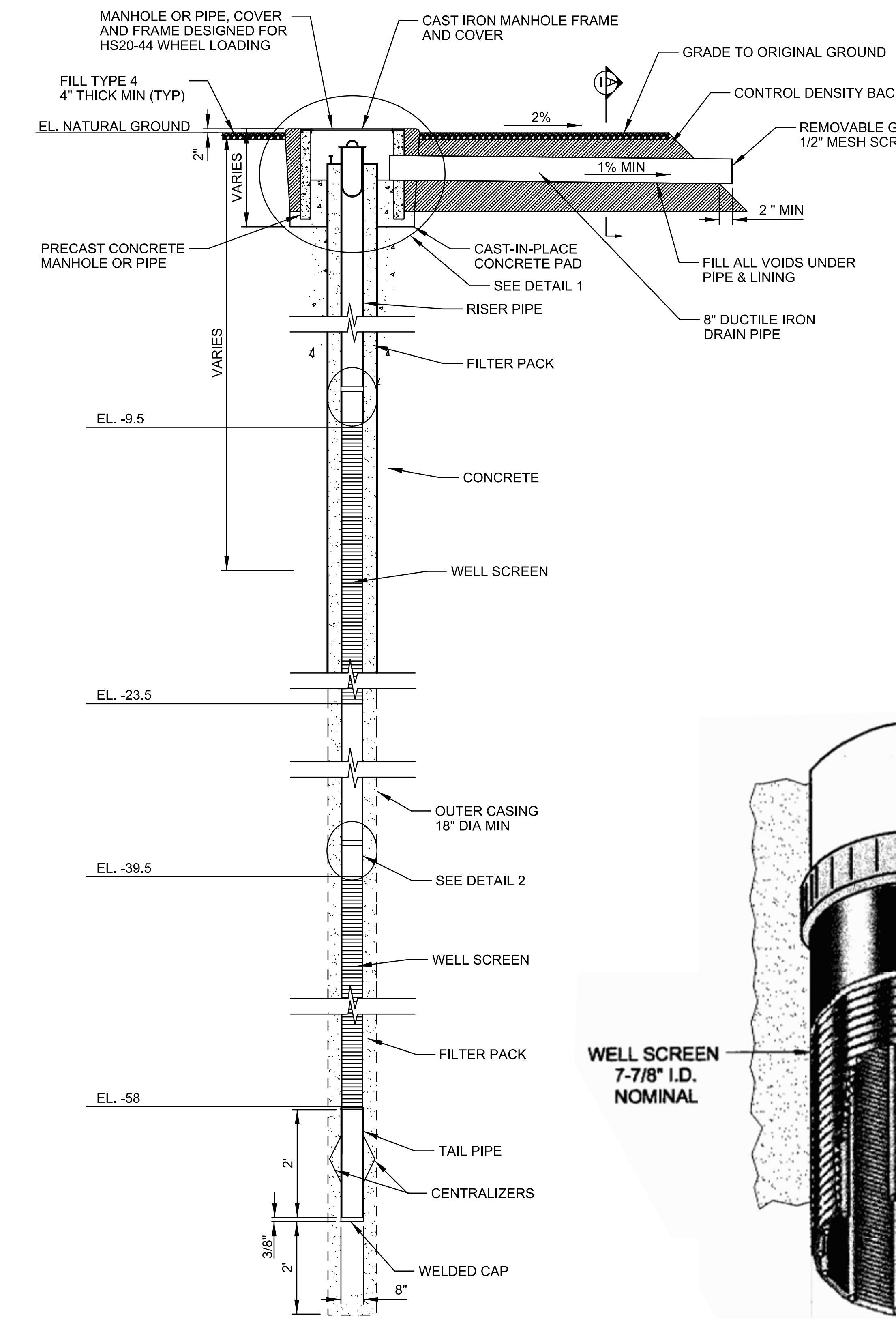
Submitted by: CHIEF, CIV ENGR DES SEC A | File name: Plot date: Plot scale:

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 'J' STREET
SACRAMENTO, CA 95814-2922

WEST SACRAMENTO COUNTY CA
WEST SACRAMENTO AREA FLOOD CONTROL AGENCY FLOOD RISK REDUCTION PROJECTS
SOUTH CROSS LEVEE
TYPICAL STABILITY BERM AND RELIEF WELL DETAILS

Sheet reference number:
PLATE 05
AM-XX



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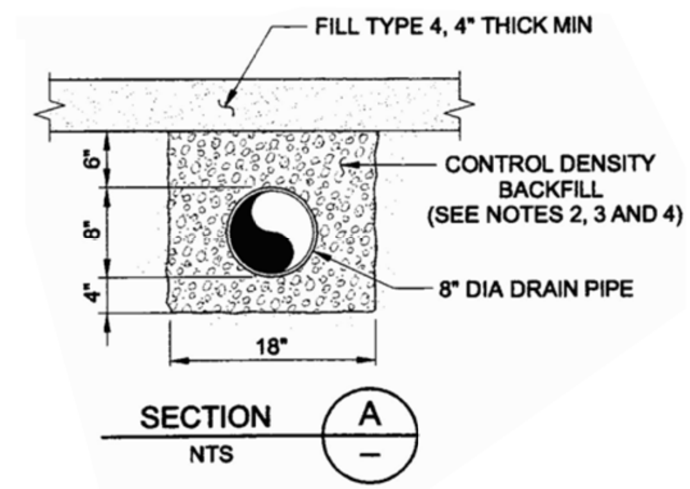

SECTION A
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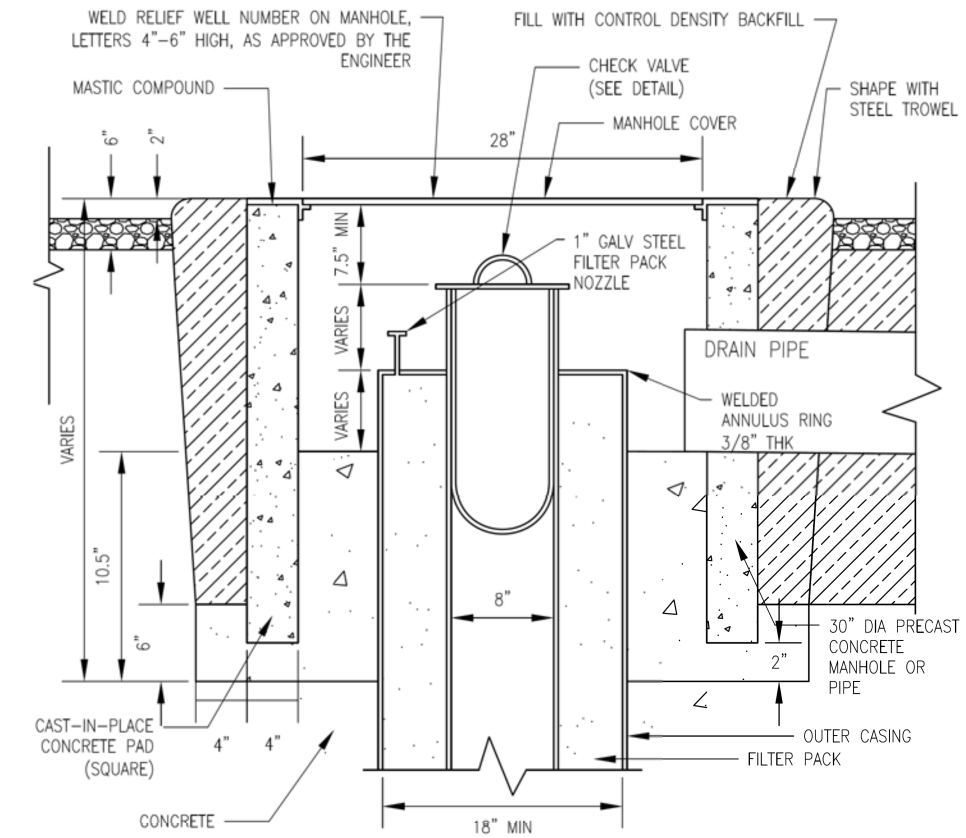

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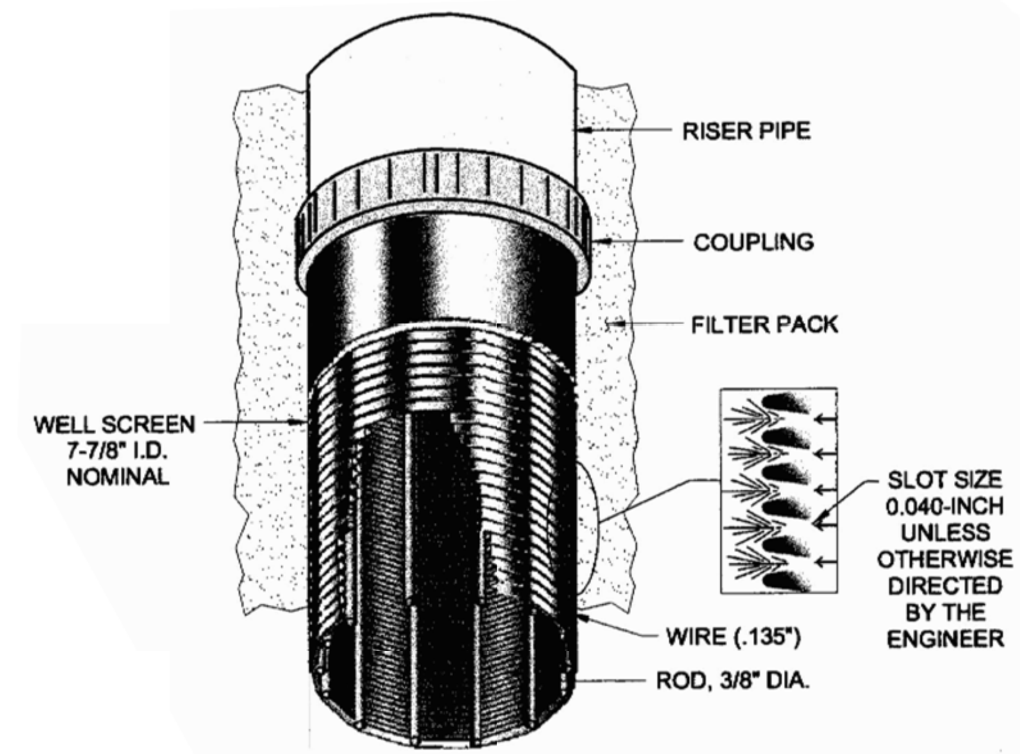

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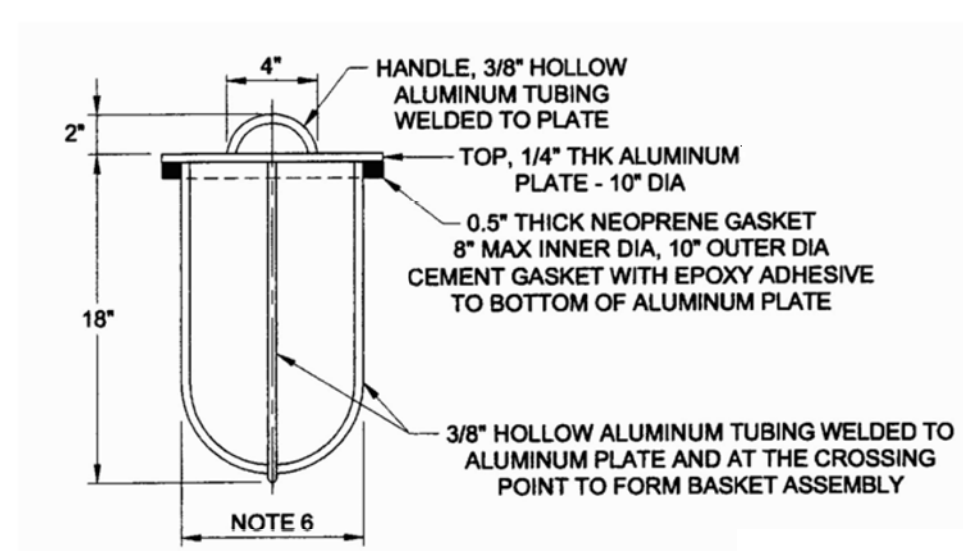

CHECK VALVE DETAIL
NTS

NOT FOR CONSTRUCTION

US Army Corps of Engineers
Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

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RELIEF WELL DETAILS

Sheet reference number:
PLATE 06

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Fill Materials

The embankments shall be constructed of suitable earth materials obtained from the borrow site(s), suitable earthen materials obtained from excavations as prescribed in Section 02222 SITE STRIPPING, EXCAVATION, AND STABILITY BERM REMOVAL, Section 02223 BORROW SITE EXCAVATION, and to the extent shown on the Plans. Materials shall be blended, as necessary, to obtain a blended material suitable for construction.

If earthen materials are encountered that do not meet the gradation requirement, these excavated materials shall not be classified as unsuitable or wasted, but shall be uniformly blended with other suitable borrow in the borrow area until the blended material is suitable to meet the specifications in Paragraph 2.2 TYPES OF FILL MATERIALS. Blending and moisture conditioning shall be in accordance with Section 02222 SITE STRIPPING, EXCAVATION, AND STABILITY BERM REMOVAL and 02223 BORROW SITE EXCAVATION.

If a disagreement between the Contractor and the Agency occurs over the suitability of blended materials the Contractor shall perform laboratory testing prior to placement in the fill area to demonstrate compliance with the Specifications at no additional costs to the Agency. The testing by the Contractor shall comply with Paragraph 3.10 FIELD QUALITY CONTROL. The failure of the Contractor to perform the testing shall not relieve the Contractor from the obligation to provide suitable materials.

The subgrade for roadways, as shown on Plans, shall meet the requirements under Paragraph 2.2.1 SOIL TYPE 1 FILL with a minimum Resistance Value (R) equal to or greater than 50 per CALTRANS requirements.

2.2 TYPES OF FILL MATERIALS

2.2.1 Soil Type 1 Fill (Levee Embankment Fill Material)

Soil Type 1 fill material shall be obtained from the borrow sites provided by the Agency or other required project excavations and is suitable as embankment fill without limitation. The Soil Type 1 material shall consist of low to high plasticity soils classified in accordance with ASTM D 2487 as silt (ML) or clay (CL). Individual test results shall have a minimum of 20 percent passing the No. 200 standard sieve on each individual test. Maximum particle size shall be 2 inches. Soil Type 1 shall have a liquid limit of 50 or less and a plasticity index greater than or equal to 8 and less than or equal to 40.

2.2.2 Soil Type 1A

Soil Type 1A fill material shall be obtained from the borrow sites provided by the Agency or other required project excavations and is suitable as embankment fill without limitation. The Soil Type 1A material shall consist of low to high plasticity soils classified in accordance with ASTM D 2487 as silt (ML) or clay (CL). Individual test results shall have a less than or equal to 12 percent passing the No. 200 standard sieve on each individual test. Maximum particle size shall be 2 inches. Soil Type 1A shall have a liquid limit of 50 or less and a plasticity index less than or equal to 40.

2.2.3 Soil Type 2

Soil Type 2 fill material shall be obtained from the borrow sites provided by the Agency or other required project excavations and is suitable as embankment fill without limitation. The Soil Type 2 material shall consist of low to high plasticity soils classified in accordance with ASTM D 2487 as silt (ML) or clay (CL). Individual test results shall have a less than or equal to 20 percent passing the No. 200 standard sieve on each individual test. Maximum particle size shall be 2 inches. Soil Type 2 shall have a liquid limit of 65 or less and a plasticity index between 8 and 40.

2.2.4 Soil Type 2A

Soil Type 2A fill material shall be obtained from the borrow sites provided by the Agency or other required project excavations and is suitable as embankment fill without limitation. The Soil Type 1 material shall consist of low to high plasticity soils classified in accordance with ASTM D 2487 as silt (ML) or clay (CL). Individual test results shall have a less than or equal to 50 percent passing the No. 200 standard sieve on each individual test. Maximum particle size shall be 2 inches. Soil Type 2A shall have a liquid limit of 75 or less and a plasticity index between 8 and 55.

Type 2A soils shall be lime stabilized.

2.2.5 Type 3 Fill

Type 3 fill shall be obtained from the borrow sites provided by the Agency or other required project excavations and is suitable for use within the seepage berms or as general site fill beyond the limits of the levee. The random fill shall consist of suitable material with a maximum particle size less than 2 inches.

2.2.6 Topsoil

Levee embankment and seepage berm surfaces shall be dressed with topsoil obtained from the stripping operations beneath the levee embankment, seepage berm, and unsuitable organics material obtained from specified project excavations as discussed in Section 02222. Topsoil shall be uniformly blended during placement on the final embankment slope.

2.3 ROCK SLOPE PROTECTION

See Section 02380 STONE, CHANNEL, SHORELINE/COASTAL PROTECTION FOR STRUCTURES

Graded Stone 'C'
3/4-inch crushed rock filter
Clean rock fill

PART 3 EXECUTION

3.1 TOLERANCES

All embankments and backfills shall be constructed to the grades, lines, and cross-sections shown on the Plans. The levee side slopes shall have a tolerance of 0 to 4 inches for final dressing prior to placement of

Real Estate Appendix

General Reevaluation Report

US Army Corps of Engineers®
Sacramento District

CENTRAL VALLEY FLOOD PROTECTION BOARD
STATE OF CALIFORNIA

WSAFCA
West Sacramento Area Flood Control Agency

Real Estate Plan

December 2015

TABLE OF CONTENTS

Real Estate Plan
For
West Sacramento General Revaluation Report Draft Study
Yolo County, California

1. Statement of Purpose

This Real Estate Plan (REP) is intended to support and present the real estate requirements for the West Sacramento Project General Revaluation Report (West Sacramento GRR) located in the eastern Yolo County in the north central region of California's Central Valley. The West Sacramento Project is one of several flood risk management projects authorized within the greater Sacramento River Watershed. It is part of an overall system in place in the Sacramento Valley since the early 1900's known as the Sacramento River Flood Control Project. The initial study for the West Sacramento Project is as follows:

Sacramento River Flood Control System Evaluation Authorization

> The conference report accompanying the Energy and Water Development Appropriation Act of 1987 (Public Law 99-591) included $600,000 in funds over the President's Budget under Operations and Maintenance, General Appropriation, Inspection of Completed Works. Similar language is contained in both the House of Representatives and Senate Version of the Report.

The House of Representative's Report 99-70, states:

> *Inspection of Completed works: Sacramento River Flood Control Project, California.* – The committee has included $600,000 for a comprehensive analysis of the long term integrity of the flood control system for the Sacramento River and its tributaries in collaboration with the State of California. The committee is aware that even before the recent flooding, regional flood control officials felt the need for a thorough survey of the system. While it did serve well in the floods and prevented billions of dollars in damages, under stress it validated concerns that in many places remedial work is necessary as soon as possible, as may be enhanced levels of protection. The Corps is directed to report back to the committee on protection enhancement requirements which it encounters in the review of the project.

The Senate Report, 99-441, states:

> *Inspection of Completed Works, Sacramento River Flood Control Project, CA.* – The Committee is aware of the need for a comprehensive analysis of the integrity of the flood control system for the Sacramento River and its tributaries. Given the importance of this flood protection system, the committee believes that such an analysis is warranted.

In the wake of a 1997 flood, the Corps identified underseepage as an area of greater concern in the design and repair of levees. This resulted in a number of design revisions to the levee repairs in the West Sacramento Project. These design revisions and the associated increase to the total project cost was captured in a supplemental authorization through the Energy and Water Development Appropriation Act of 1999.

The current study area is located in the City of West Sacramento, California comprising the lands within the West Sacramento Area Flood Control Agency's boundaries, which encompass portions of the Sacramento River, the Yolo Bypass, the Sacramento Bypass, and the Sacramento Deep Water Ship Channel (DWSC). The primary objective of the West Sacramento GRR is to determine the extent of Federal interest in reducing the flood risk within the study area in bringing 50 miles of perimeter levees surrounding West Sacramento into compliance with applicable Federal and State standards for levees protecting urban areas. Proposed levee improvements would address levee height deficiencies, levee seepage, erosion, and stability conditions along the West Sacramento Levee area. This REP focuses on the lands, easements, right-of way descriptions and real estate costs for the final construction alternative - the Recommended Plan which is Alternative 5, proposed for Congressional re-authorization due to increased costs. There may be modifications to the project and its plans that occur during the Preconstruction, Engineering and Design (PED) phase, thus changing the final acquisition area(s) and/or administrative and land costs reflected in this REP.

The West Sacramento GRR's Recommended Plan costs, the original authorized project costs from the Feasibility Report completed in 1992, the project costs last presented to Congress in June 2009, and the current Project Cost Estimate from June 2011 are shown in Table 1.

TABLE 1: Project First Cost (Displayed in Thousands)

Construction Item	GRR Recommended Plan	Project as Authorized[1]	Project as Last Presented to Congress[2]	Current Project Cost Estimate[3]
Lands and Damages	286,462	1,880	2,388	2,387
Relocations	21,808	15	128	128
Fish & Wildlife Facilities	18,105	2,400	3,201	3,044
Levees & Floodwalls	1,034,413	10,200	35,370	28,394
Pumping Plants	0	0	0	0
Cultural Resources Preservation	8006	131	0	0
Subtotal	1,360,788	14,626	41,087	33,913
Planning Engineering & Design (PED)	152,655	1,665	9,526	10,690
Construction Management	91,318	1,132	2,007	2,034
Total First Cost	1,612767	17,423	52,620	46,677
Associated Costs	0	0		0
Total Costs	1,769,767	17,423	52,060	46,677

[1] Project Cost from Sacramento Metropolitan Area, California Feasibility Report, February 1992
[2] Project Cost based on Project Cost Estimate from June 2009.
[3] Project Cost based on Project Cost Estimate from June 2011

2. Project Authority

The report for which this REP Appendix has been prepared is a general reevaluation study of the West Sacramento area. Study authorization of this project was provided in Section 209 of the Flood Control Act of 1962, Pub. L. No. 87-874, § 209, 76 Stat. 1173, 1197 (1962). Construction authority and authority to produce a General Reevaluation Report was provided in Section 101(4) of the Water Resources Development Act (WRDA) of 1992, Pub. L. No. 102-580, § 101(4), 106 Stat. 4797, 4801-4802 (1992) (hereinafter WRDA 1992), and revised and supplemented through the Energy and Water Development and Appropriations Act (EWDAA) of 1999, Pub. L. No. 105-245, 112 Stat. 1838, 1840-1841 (1999) (hereinafter EWDAA 1999).

3. Project Description

The project purpose and objective is to provide flood damage reduction to the City of West Sacramento, Yolo County, California. Providing flood damage reduction would reduce loss of life and damage to property in the project area. The objectives being addressed by the project are to reduce flood stages, address through seepage and underseepage of levees, address inadequate levee heights, address erosion, address slope stability, address vegetation issues, increase protection levels of existing levees, and to address operations, maintenance and emergency response access. The location of the study area for the West Sacramento GRR consists of an area that includes almost all of the City of West Sacramento. The study has been divided into two areas, the Northern and Southern Sub-Basins. The Sacramento River Deep Water Ship Channel and Barge Canal divide the northern Sub-Basins from the southern Sub-Basin at the Southport area. The project map is shown in Figure 1.

The project alternatives consist of components and cost estimates of the various reaches which will be described in further detail below.

Northern Sub-basin – The northern sub-basin, representing approximately 6,100 acres, is bounded by the Port North area and the Deep Water Ship Channel (DWSC) to the south, the Sacramento River North Levee to the north and east, the Sacramento Bypass Levee to the north, and the Yolo Bypass Levee to the west. Land in this area varies in elevation from El. 34.0 feet near Raley Field to El. 16.0 to 18.0 feet adjacent to the DWSC. The north bank of the DWSC is generally about El. 19.5 feet. The right bank (looking downstream) of the Sacramento River extends for approximately 5.5 miles of the northern and eastern sides of the basin. The northern reach descriptions are listed below.

Sacramento River North Levee

This reach extends along the right bank of the Sacramento River from its confluence with the Sacramento Bypass downstream approximately 5.5 miles to the entrance of the barge canal. These measures would be: (1) installation of cutoff wall to address seepage and slop stability concerns; and (2) bank protection measures to address erosion concerns.

Yolo Bypass Training Levee

This reach extends for approximately 1.1 miles along the Sacramento Bypass left bank levee from the Sacramento Weir west to the Yolo Bypass Levee. Bank protection is proposed for 3,000 feet to address erosion issues.

Yolo Bypass Levee

This reach extends in a southerly direction along the left bank of the Yolo Bypass approximately 3.8 miles from its intersection with the left bank levee of the Sacramento Bypass to its intersection 21 with the DWSC West Levee. The measure that would be implemented for the Yolo Bypass levee would be: (1) installation of a cutoff wall to address seepage and slope stability concerns.

Southern Sub-Basin

The Southern Sub-Basin encompasses approximately 6,900 acres and varies from El. 18.0 feet to El. 8.0 feet. The area is bounded by the Port South Levee and the DWSC to the north, the Sacramento River South Levee to the east, the South Cross Levee to the south, and the DWSC East Levee to the west. The south bank of the DWSC from Lake Washington to the Sacramento River is generally at El. 19.5 feet. The right bank of the Sacramento River extends for approximately 6.2 miles on the east side of the basin. The southern reach descriptions are listed below.

Port South Levee

This reach encompasses the combination of levees and high ground that exists along the left bank of the barge canal and DWSC from the Sacramento River westward until it meets the DWSC East Levee on the left bank of the DWSC. The measures to address the levee would be: (1) installation of convention open trench clay cap cutoff wall and slurry wall to address seepage concerns.

South Cross Levee

This reach extends for approximately 1.2 miles from the intersection of Jefferson Boulevard and the levee along the left bank of the DWSC to the Sacramento River where it intersects the southern limit of Sacramento River South Levee reach. This levee is the southernmost boundary of the city. The South Cross levee remediation measures would address seepage, slop stability, and erosion concerns. Measures implemented for the South Cross Levee would be: (1) installation of relief wells to address seepage concerns; and (2) a stability berm to address levee stability concerns.

Deep Water Ship Channel Closure Structure

This feature proposes to construct a flood barrier structure within the Sacramento Deep Water Ship Channel (DWSC) and gated overflow weir structure that would prevent flood flows from proceeding north in the ship channel. The gated weir would be constructed along the DWSC West navigation levee and would divert flood flows from the Yolo Bypass into the DWSC. The closure structure would be operated to prevent flood flows from proceeding north and potentially flood the Port of West Sacramento or the City of West Sacramento. While this alternative may provide some degree of flood protection for the city, it would not meet the objective of providing a 200-year level of flood protection because portions of the city would remain susceptible to flooding. In addition, operation of the closure structure and the weir may require reoperation of flood control system components (e.g., the Yolo Bypass or upstream reservoirs). This features only applies to Alternative 3. It is not a feature in Alternatives 1 and 5, and as such is not a part of the Recommended Plan.

Deep Water Ship Channel East Levee
This reach extends along the left bank of the DWSC channel for approximately 2.8 miles in a southerly direction from the high ground making up the western limit of the Port South Levee reach 13 to the intersection of Jefferson Boulevard with the South Cross Levee. The measures implemented for the DWSC east levee would be: (1) installation of slurry walls to address seepage and stability concerns; (2) bank protection to address erosion concerns.

Deep Water Ship Channel West Levee
This reach extends along the left bank of the Yolo Bypass and the right bank of the DWSC approximately 22 miles in a southerly direction from its intersection with the western limit of the Port North Levee to Miners Slough. The measures for the west levee would be: (1) installation of cutoff walls to address seepage and slope stability concerns; and (2) bank protection to address erosion.

Sacramento River South Setback Levee
This reach extends along the right bank of the Sacramento River from the entrance of the barge canal downstream approximately 6.4 miles to the South Cross Levee. The measures that would be implemented would be: (1) construction of a setback levee, adjacent levee, seepage berm, and fix in place to addresss seepage, slop stability, and erosion concerns; (2) installation of cutoff walls, sheet pile walls, jet grouting, and relief wells to address seepage and slope stability concerns; and (3) limited bank protection measures to address erosion concerns on the existing levee and bank protection on the setback levee.

The final array of alternatives considered prior to identification of the Recommended Plan are listed below:

Alternative 1 – Improve Levees - This alternative would include construction of levee improvement measures to address seepage, stability, overtopping and erosion concerns identified for the Sacramento River, South Cross, Deep Water Ship Channel, Port of Sacramento, Yolo Bypass, and Sacramento Bypass Levees. This alternative provided positive net benefits, but other alternatives ranked higher in the benefit to cost analyses.

Alternative 3 – Improve Levees and Deep Water Ship Channel Closure Structure - This alternative would include the levee improvements discussed in Alternative 1 on the Sacramento River, South Cross, Yolo Bypass, and Sacramento Bypass training levees to address identified seepage, stability, erosions and height concerns. Levee repairs on the South Levees and portions of the Deep Water Ship Channel East and West Levees would be replaced by the construction of a closure structure in the Deep Water Ship Channel. This alternative provided positive net benefits, but other alternatives ranked higher in the benefit to cost analyses.

Alternative 5 - Improve Levees and include Sacramento River South Setback Levee
Alternative 5 would include the construction of levee improvements measures to address seepage, stability, erosion and height concerns identified for Sacramento River North, Yolo Bypass, Sacramento Bypass Training Levee, South Cross Levee, Deep Water Ship Channel East and West, and Port South. A setback levee would be constructed along the Sacramento River South reach.

Real Estate Division developed cost estimates which included lands and damages, relocation costs, and federal and non federal acquisition administrative costs for each alternative. The total project costs including real estate costs for each alternative were then analyzed by Economics Section to identify the National Economic Development (NED) Plan, which is the plan that reasonably maximizes the net benefits. Alternative 5 provides the most net benefits and therefore is considered the Recommended Plan. A real estate cost estimate for the Recommended Plan is located in Table 4 Section 12.

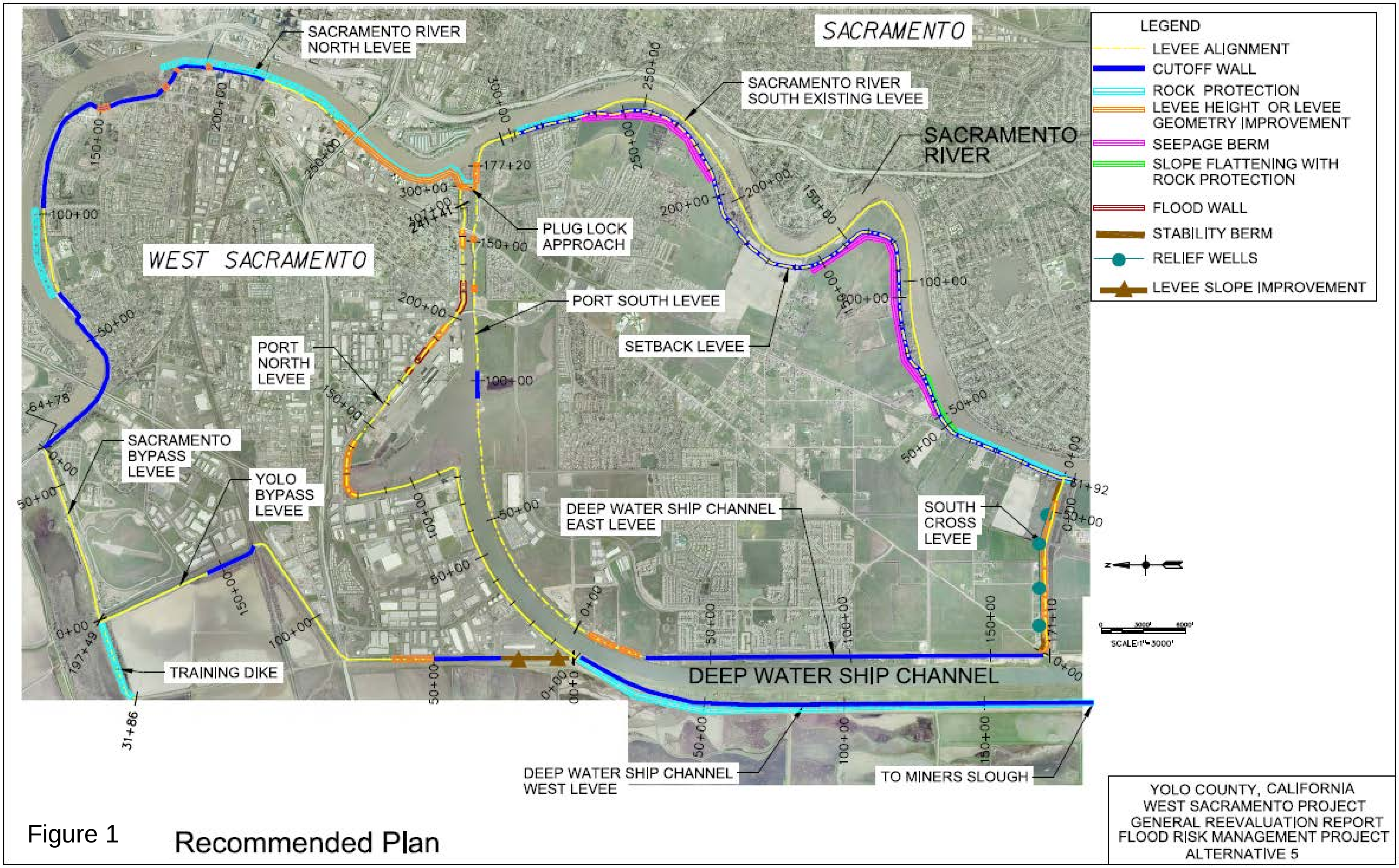


Figure 1 Recommended Plan

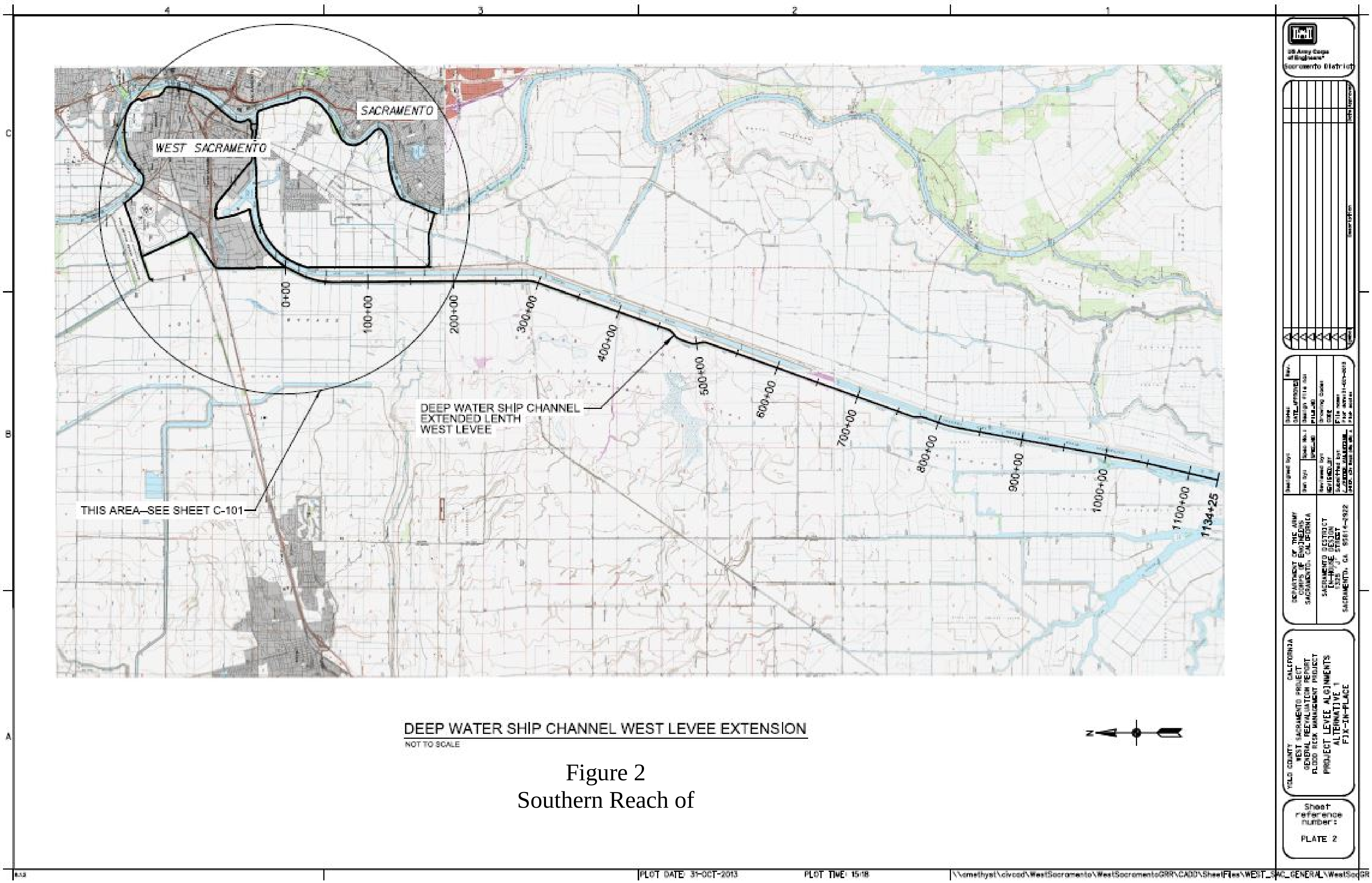


Figure 2
Southern Reach of

4. Description of Lands, Easements, Rights of Way, Relocations and Disposals (LERRDs)

Alternative 5 is the Recommended Plan, and a reach identification system was developed as shown in the Table 2, below.

The real estate cost estimate for the Recommended Plan was developed based on the conventional approach for development of feasibility level design. Cadastral Section has inventoried over 600 parcels that would be impacted by the project. During development of the REP, the real estate cost estimate was developed in accordance with ER 405-1-12 and based upon the footprints delineating project requirements developed by the Sacramento's Engineering Division. The Lands, Easements, Rights of Way, Relocations and Disposal (LERRDs) requirements for the REP include: the acquisition of flood protection levee easements, permanent road easements, temporary work area easements, borrow easements, and mitigation banks. For cost estimating purposes we developed costs for permanent and temporary land easements. The basis for the different types of acquisitions is as follows:

- Flood protection levee easements are required for the construction and operation and maintenance of project levee features. The easements vary in width and are delineated by the toe of existing levee and boundary of the seepage berms (within the project's limit), relocated levee segments and new seepage berms, slurry walls, sheet pile walls, slope flattening, and bank protection.

- 15 foot permanent easements along the landside and waterside edge of the flood protection levee easements, at a minimum, are needed for providing maintenance access to and for flood fighting purposes along the toe of the project features.

- Temporary work area easements are required for acquiring staging areas and haul routes along the length of the project.

- Borrow easements will be required for borrow sites that are not existing commercial sites. Borrow material is presently expected to be sourced from several locations for which easements are required including; newly identified borrow sites within approximately 25 miles of the study area, existing borrow sites identified for the Deep Water Ship Channel dredge disposal area, and the existing levees. Only small amounts will likely be supplied through use of readily available commercial supply.

- Mitigation areas will be acquired in mitigation banks and on site in the new setback levee area to be constructed in the Sacramento River South reach.

- Flowage easements will be required on lands between the new South River South setback levee and the Sacramento River.

TABLE 2: Proposed Design Features of the Recommended Plan Note: F.P.L.E. = Flood Protection Levee Easement, T.W.A.E = Temporary Work Area Easement, P.R.E. = Permanent Road Easement

Reach	Reach Length feet	Feature Length Ft	Improvement	Features	Easement Requirements	Ownerships
Yolo Bypass Levee	19,750	3,860	landside slope	Flatten Landside Slope	36 Acres F.P.L.E, - 11 parcels	6 Privately owned parcels 10 State of CA parcels 6 City of West Sacramento owned parcels
.		2,500	landside slope/seepage	Flatten Landside Slope/ 40' Slurry Wall	36.64 T.W.A.E -11 parcels	
		1,900	Seepage	100' Slurry Wall		
Deep Water Ship Channel West Levee	100,260	9,000	Seepage	85' Slurry Wall	847 Acres F.P.L.E. 47 parcels	8 privately owned parcels 30 City of West Sac parcels 5 State of CA parcels 4 USA parcels
		7,000	Seepage	50' Slurry Wall		
		9,000	Seepage	75' Slurry Wall		
		99,010	Erosion Protection	Bank Protection		
Deep Water Ship Channel East Levee	17,171	1,500	Seepage	120' Slurry Wall, DSM	57 Acres F.P.L.E 50 parcels	31 privately owned parcels R.D 900 owned 12 parcels 15 City of West Sac parcels
		7,055	Seepage	130' Slurry Wall, DSM		
		5,574	Seepage	50' Cut off Wall		

Reach	Reach Length feet	Feature Length Ft	Improvement	Features	Easement Requirements	Ownerships
Port South		1,000	Seepage	70' Cutoff Wall	12.8 Acres F.P.L.E. 25.6 Acres T.W.A.E.	Yolo and Sacramento Port parcel
South Cross Levee	6,400	1,340 5,000 50	Stability/ Seepage,	Stability Berm Embankment Fill Relief Wells /Embankment fill Raise Jefferson Blvd	20 acres T.W.A.E. .18 acres F.P.L.E. 16 parcels	15 private owners parcels 4 Yolo County parcels 1 Rec. District 900 parcel
Sacramento River North Levee	30,700	14,300	Erosion Protection	Bank Protection	186.29 acres Bank Protection Easement. 209 parcels	23 State of CA parcels 46 Yolo County parcels 47 privately owned parcels 2 USA trust parcels 4 Sac and San Joaquin Drainage District parcels
		11,045	Seepage	30' Cut off Wall	187.21 acres T.W.A.E.- 81 parcels	1 RD 900 parcel
		1,470	Seepage	80' Cut off Wall		
		500	Seepage	45' Cut off Wall		
		5,520	Seepage	110' Cut off Wall		
		7,600	Height	Embankment Fill		

Reach	Reach Length feet	Feature Length Ft	Improvement	Features	Easement Requirements	Ownerships
Sacramento River South Levee (Setback Levee)	30,000	7,400	Erosion	Bank Protection	471 acres of fee title and permanent easements. 69 parcels (Some of these lands in setback area will be used for mitigation (42 acres/and + 450 acres borrow) 98.99 acres of T.W.A.E 58 parcels	8 Yolo County parcels 70 private owner parcels 10 State of CA. 4 City of West Sac parcels
		29,320	Seepage	Embankment fill Cut off wall/berm	Stone Protection	1 Sac County parcel
Stone Lock Plug Approach	570	540	Flow Direction	Embankment fill/ Sheet Pile wall/Stone Protection	7.04 acres F.P.L.E rcels, 13.35 acres of T.W.A.E. 4 parcels	1 Yolo County parcel 3 City of West Sac Parcels
Training Dike	3,000	3,000	rosion Protection	Bank Protection	10.81 acres F.P.L.E, 2 parcels, 1.37 acres P.R.E. 3 parcels, 16.01 acres of T.W.A.E. 4 parcels	2 private parcels 2 State of CA parcels

Mitigation Sites

The current plan is to use lands acquired in fee for the construction of the South Levee setback area for project mitigation and to purchase credits from a mitigation bank if the area is insufficient. In terms of Giant Garter Snake Habitat, the mitigation for the 201 acres of upland (temporary impacts) will be done on site after construction through re-seeding of the construction sites. It will not require the purchase of additional acreage. Of the 107 acres for Valley Long Horned Elderberry Beetle, 31 acres will be done onsite in the setback area, the remaining acreage will be purchased at a mitigation bank.

Table 3: Vegetation Impacts in the Study Area

	GGS Upland* **	GGS Aquatic***	Riparian	SRA Habitat ***	Elderberry Shrubs **	Oak Woodland *	Shallow Water **	Wetlands
	North Basin							
Sacramento River North Levee			22 acres (38 if no variance)	10 acres 33,333 LF	42 acres	8 acres	5 acres	5 acres
Yolo Bypass	5 acres	2 acres	2 acres		12 acres			2.5 acres
Sacramento Bypass Training Levee	5 acres		3 acres		1 acres			2.5 acres
	South Basin							
South Cross Levee	4 acres	10 acres	5 acres		8 acres	4 acres		10 acres
Deep Water Ship Channel East Levee	10 acres	10 acres	2 acres		3 acres			10 acres
Port South Levee	2acres	1 acre						1 acre
Deep Water Ship Channel West Levee	20 acres				5 acres			
Sacramento River South Levee **(Alt 5)**	155 acres		4 acres	2 acres 6,666 LF	36 acres	4 acres	9 acres	5 acres
TOTAL (Alt 5)	201 acres	23 acres	38 acres (60 acres- no variance)	12 acres 40,000 LF	193 shrubs (107 acres)	16 acres	14 acres	36 acres

*State Listed **Federal Listed ***State and Federal Listed

Environmental Impacts of and Proposed Mitigation/Compensation for the West Sacramento GRR[1] Alternative 5. Table 4

Habitat Type	Potential Impacts	Duration of Impact	Mitigation/Compensation (Acres/Linear Feet)
GGS Upland and Aquatic	201 Acres	Single Construction Season	201 Acres (5k/ac)
GGS Upland and Aquatic	23 Acres	Permanent	69 Acres (60k/ac)
Riparian	38 Acres	Permanent	38 Acres (55k/ac) 38 Acres (75k/ac)
Shaded Riverine Aquatic Habitat (ESA Fish Species)	40,000 Linear Feet (12 acres)	Single Construction Season (Different Levee Reaches)	12 Acres- 40,000 Linear Feet Self Mitigating with on-site planting[2]
Shallow Water Habitat (ESA Fish Species)	14 Acres	Permanent	14 Acres (55k/ac)
Elderberry Shrubs	193 Shrubs 1,991 Stems (107 Acres)	Permanent	31 Acres (85k/ac) 1,107 credits (69 Acres) (4.5k/credit)
Oak Woodland	16 Acres	Permanent	10 Acres (50k/ac) 22 Acres (75k/ac)
Wetlands	36 Ares	Permanent	72 Acres (130k/ac)
Green Sturgeon	20 Acres	Permanent	Restore acres and conduct monitoring
Total	**448 Acres**		**577 Acres**

Notes:
1 Assumes variance from USACE's vegetation guidance is granted for Sacramento River.

Fish and Wildlife Mitigation Required

Mitigation Bank = $22,982,500
On-Site Mitigation = $23,205,500
Total =$46,188,000

Borrow Sites

It is estimated that a maximum of 9 million cubic yards of borrow material will be needed to construct the project. Because this project is in the preliminary stages of design, detailed studies of borrow needs have not been completed. For the purposes of NEPA/CEQA, a worst case scenario is being evaluated for the volume of borrow material needed. Actual volumes exported from any single borrow site would be adjusted to match demands for fill.

To identify potential locations for borrow material, soil maps and land use maps were obtained for a 25-mile radius surrounding the project area. The criteria used to determine potential locations were based on current land use patterns, soil types from U.S. Soil Conservation Service (SCS), and Corps' criteria for material specifications. These potential borrow locations are shown on the Borrow Site Map (Figure 3). The data from land use maps and SCS has not been field verified, therefore, to ensure that sufficient borrow material would be available for construction the Corps looked at all locations within the 25 miles radius for 20 times the needed material. This would allow for sites that do not meet specifications or are not available for extraction of material.

The excavation limits on the borrow sites would provide a minimum buffer of 50 feet from the edge of the borrow site boundary. From this setback, the slope from existing grade down to the bottom of the excavation would be no steeper than 3H:1V. Excavation depths from the borrow sites would be determined based on available suitable material and local groundwater conditions. The borrow sites would be stripped of top material and excavated to appropriate depths. Once material is extracted, borrow sites would be returned to their existing use whenever possible, or these lands could be used to mitigate for project impacts, if appropriate.

A potential borrow site has been located in the South Setback Levee area. There are 475 acres available for potential borrow. Borrow site real estate costs have been calculated and are shown Table 2.

Disposal Site

Yolo County Central Landfill located in Woodland, California will accept soil and construction/demolition recycling. Soil haul that involves a large amount of soil (greater than 500 cubic yards), will require a Waste Evaluation Form that can be downloaded on line. The least cost areas will be used for disposal sites.

FIGURE 3

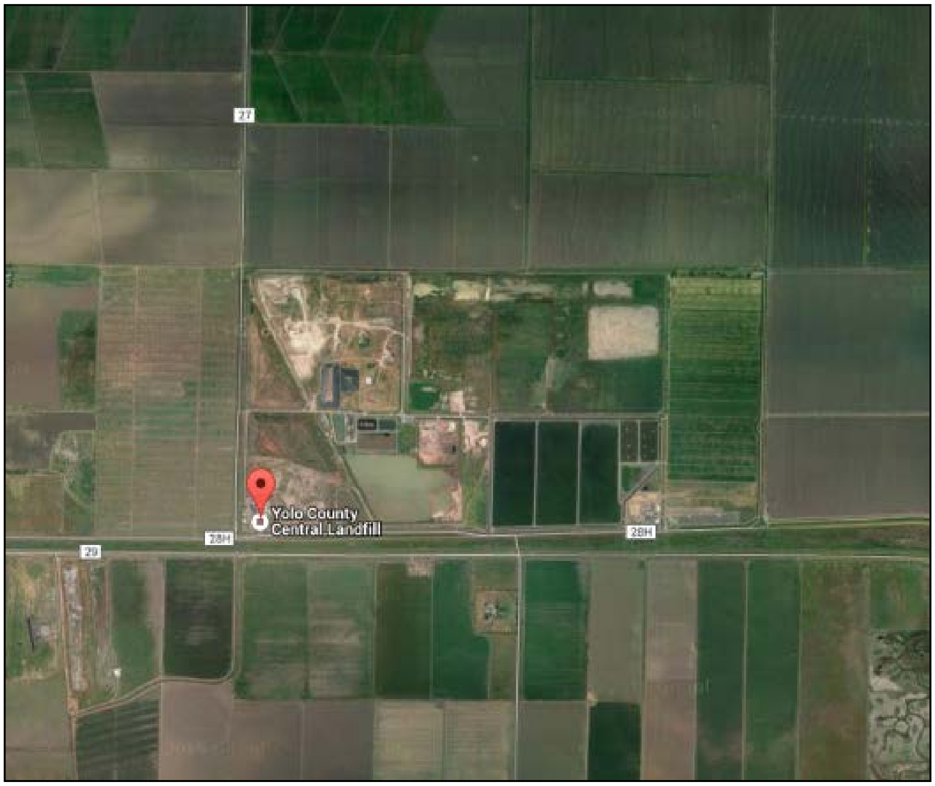
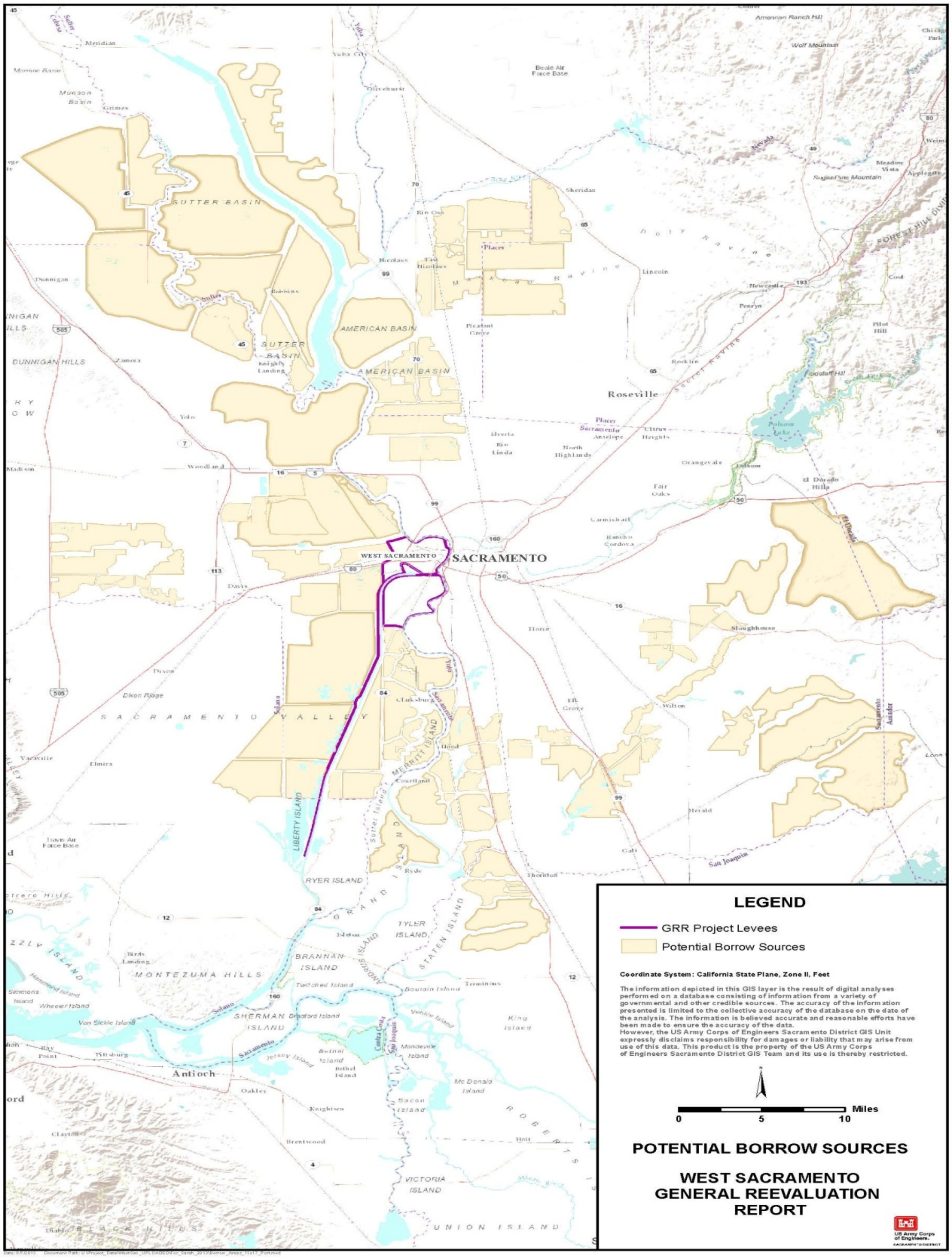


FIGURE 4 - Proposed Borrow and Disposal Sites



Railroad Parcels

There are approximately 7 railroad parcels in the North Levee Reach, 4 of which are owned/operated by Union Pacific and 3 of which are owned/operated by Sierra Northern Railway. There is 1 railroad parcel in the South River Levee reach, owned/operated by Union Pacific Railroad. There are 3 Union Pacific parcels in the Yolo Bypass Reach. The construction areas are working parallel or adjacent to the tracks and existing closure structures in these reaches and will not interfere with active railway activities.

5. LERRDs Owned by the NFS and Crediting

In the event the Recommended Plan is authorized, crediting will follow standard procedures as set out in the model Project Partnership Agreement (PPA). No credit will be afforded to any lands or interests previously acquired and credited for any applicable Federal project. Credit will only be applied to the acreage within the project footprint, namely the lands or corridor required for the recommended Plan of improvements. Lands outside of the project requirements and lands that may be acquired for the sponsor's own purposes would not be creditable LERRDs. Only land deemed necessary that has not been previously cost shared on a project will be credited.

Corps' policy also prescribes that credit will not be afforded for lands purchased with Federal funds or grants where the granting of such credit is not permissible, whether as prescribed by statute, or as determined by the head of the Federal agency and administer such grants or programs. The Federal Emergency Management Agency (FEMA's) floodplain hazard mitigation and elimination grants are examples of such Federal grant programs where credit would not be allocated.

The Non-Federal sponsors own approximately 264 acres of the 527 acres required for project construction and OMRR&R in fee title according the County Assessor's office in the study area which are identified in the tract registers. The parcels owned by the Non Federal Sponsors are assumed sufficient for the estates needed. The City of West Sacramento is reviewing city owned parcels. The City of West Sacramento did provide comments on a spreadsheet regarding ownerships of City owned properties. The State of California, Department of Water Resources has assumed all Sacramento and San Joaquin Drainage District parcels and all RD 900 parcels would be available for flood projects. The coordination with the State owned parcels is ongoing. All restrictions, prior easements, or inconsistent encumbrances are not known at this time. There is relatively low risk to the sponsor owned lands being insufficient for project purposes because 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. The contingency assessment should reduce risk and cause no impact to plan selection. The sponsor owned parcels are located in a table found in the Exhibit E cadastral maps and tract registers. The Non Federal Sponsors have the legal sufficiency to provide the lands required for the project as stated in DWR and WSAFCA Non-Federal Partners Real Estate Acquisition and Capability Assessment they provided to the Corps as shown in Exhibit A.

Sponsor Owned Lands (Approximations)	Permanent Levee Easements	Temporary Easements
City of West Sacramento	120.57 acres	22.29 acres
State of California/RD 900/Sacramento and San Joaquin Drainage District	144 acres	13.9 acres

6. Standard Federal Estates and Non Standard Estates

The following standard estates are anticipated to support project purposes and features. Non-standard estates are not anticipated for the Recommended Plan.

Fee Simple Title

The fee simple title to [the lands described in Exhibit C tract registers], subject however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

Flood Protection Levee Easement (FPLE)

A perpetual and assignable right and easement in the land [described in Exhibit C tract registers] 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.

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.

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, as applicable, for use by the United States and/or the Sponsor, their representatives, agents, and independent contractors as a (work area), haul routes, 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 West Sacramento 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 [parcel number] 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 there from 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 tract register); 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 land described in Exhibit C Tract register) 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.

Flowage Easement

The perpetual right, power, privilege and easement permanently to overflow, flood and submerge (the land described Exhibit C tract register (and to maintain mosquito control) in connection with the operation and maintenance of the project as authorized by the Act of Congress approved ___, and the continuing right to clear and remove and brush, debris and natural obstructions which, in the opinion of the representative of the United States in charge of the project, for use by [the CVFPB and/or the Sacramento and San Joaquin Drainage District], its representatives, agents, and contractors, may be detrimental to the project, together with all right, title and interest in and to the timber, structures and improvements situate on the land [1] (excepting ___, (here identify those structures not designed for human habitation which the United States 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

[1] Any structures existing in areas that will be allowed to remain must be evaluated using the same criteria that would be used to grant permission for a new structure to be placed in the easement, in coordination with the operational office..

without such approval as to the location and method of excavation and/or placement of. landfill; [2] 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 Project in or Partially in the Proposed Project Area

All previous federal projects are described in the main report in section 1.5 of the main General Reevaluation Report. A brief summary is provided below.

Sacramento Urban Area Levee Reconstruction Project
Construction of berms to improve stability and manage seepage at two relatively small sites along the right bank of the Sacramento River near the Lighthouse Marina and approximately six miles of levee along the right bank of the Sacramento River extending from near the Barge Canal entrance downstream to near the South Cross levee. Construction began in November 1990 and was completed in 1992.
Sacramento Metropolitan Area, 1992 and 1999 Authorization (West Sacramento Project)
Raising and installing a slurry wall along 4.7 miles of the east bank of the Yolo Bypass levee from the Sacramento Bypass south to the Navigation Levee. Reconstructing and raising the levee along one mile of the south bank of the Sacramento Bypass, including backfill of a drainage ditch and placing riprap along the levee.

In the 1990's the Corps of Engineers, Sacramento District completed a study to evaluate the existing level of flood protection and increased levels of flood protection in the Sacramento Metropolitan area outside the American River Watershed Investigation. The study area included components of the Sacramento River Flood Control Project, included levees along the Sacramento River, Sacramento Weir, and portions of Yolo and Sacramento Bypass Channels. The Selected Plan consisted of levee raising along the south levee of the Sacramento Bypass and continuing south along the east levee of the Yolo Bypass east levee. Levees were raised along 5,800 LF of the south levee of the Sacramento Bypass and 24,800 LF of the Yolo Bypass East levee.

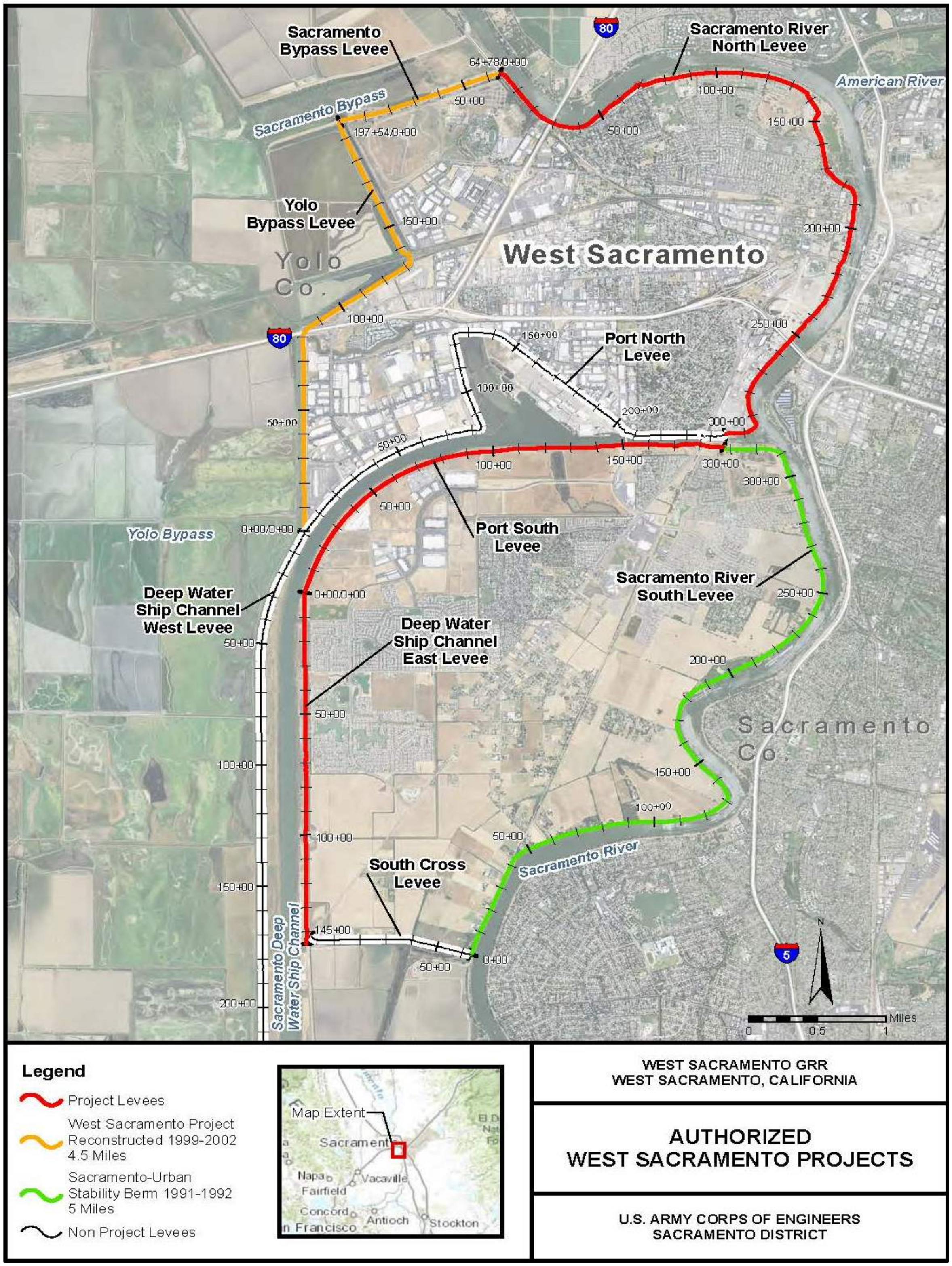
As proposed in the Recommended Plan, levee raising will occur landward along the south side of the Sacramento Bypass and south of the Southern Pacific Railroad (SPRR) on the Yolo Bypass, and waterward between the Sacramento Bypass and the SPRR. Since the levees which were raised as part of the Selected plan were component of existing federal project (Sacramento River Flood Control Project and Sacramento Deep Water Ship Channel), only the additional lands needed for the levee raising proposed in the Recommended Plan have been included in the baseline cost

[2] If sand and gravel or other quarriable material is in the easement area and the excavation thereof will not interfere with the operation of the project, the following clause will be added: "excepting that excavation for the purpose of quarrying (sand) (gravel) (etc.) shall be permitted, subject only to such approval as to the placement of overburden, if any, in connection with such excavation;"

estimate. According to the County Assessor's Office, the existing Yolo Bypass project levees and construction rights of way for the Recommended Plan are owned in fee by Reclamation 537, Reclamation 900, State of California, Sacto and Yolo Port and the Union Pacific Railroad. Based on the foregoing, it is assumed that the non-Federal sponsor and Corps have sufficient rights, obtained in furtherance of prior Federal projects, to accomplish work on the existing levees. Access is already available to all construction areas on the Yolo Bypass Levee Reach and the Sacramento Deep Water Ship Channel, the Sacramento River North Levee Reach, the Sacramento Bypass Reach, Sacramento South Levee Reach, the Port South Levee Reach by virtue of the existing projects.

The following map shows real estate acquisitions that occurred in the past as part of these projects.

Figure 5

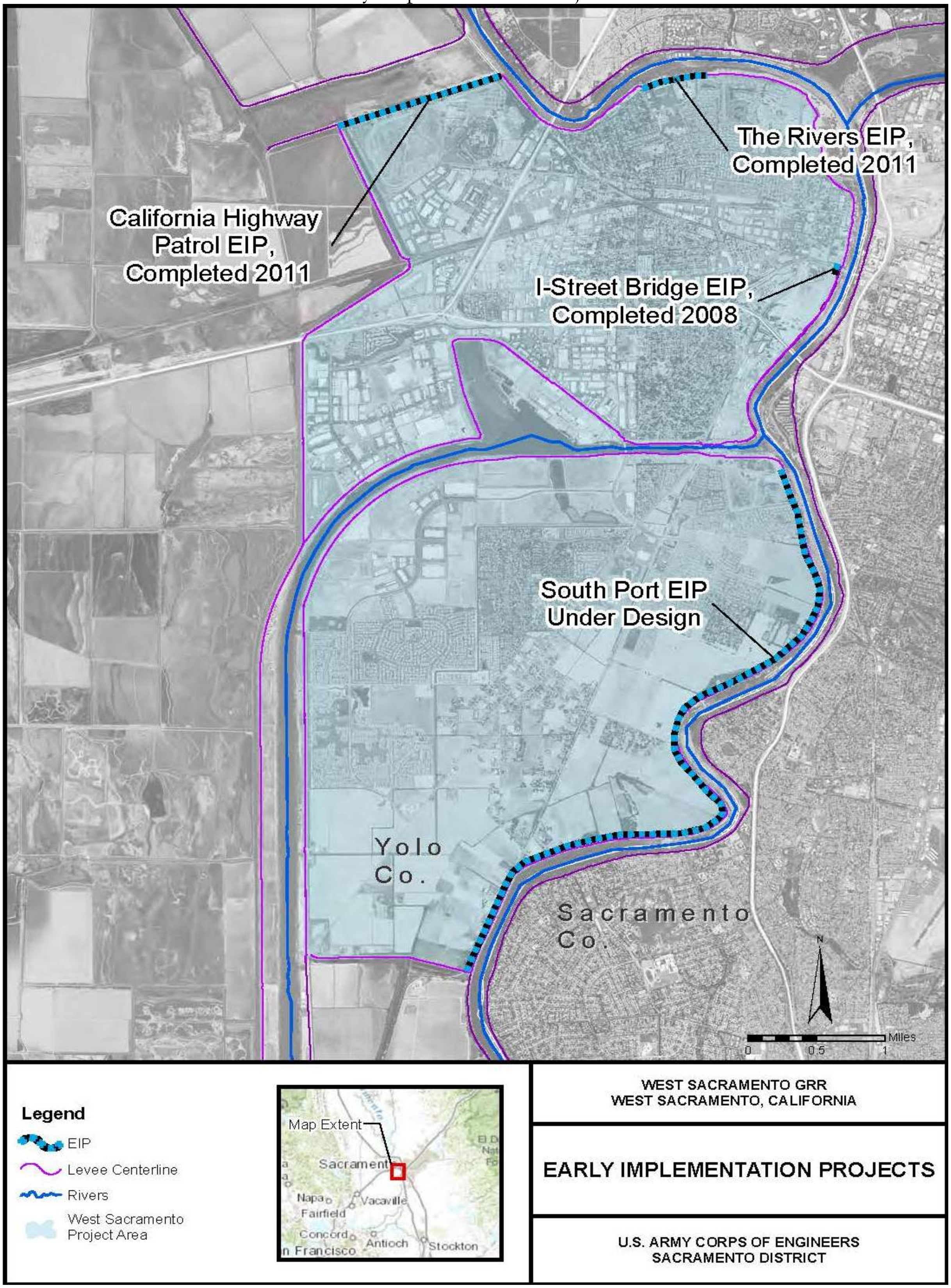

Sacramento Bypass Levee
Sacramento River North Levee
American River
Sacramento Bypass
Yolo Bypass Levee
West Sacramento
Yolo Co.
Port North Levee
Port South Levee
Yolo Bypass
Sacramento River South Levee
Deep Water Ship Channel West Levee
Deep Water Ship Channel East Levee
Sacramento Co.
South Cross Levee
Sacramento River
Sacramento Deep Water Ship Channel
Miles
0
0.5
1
Legend
Project Levees
West Sacramento Project Reconstructed 1999-2002 4.5 Miles
Sacramento-Urban Stability Berm 1991-1992 5 Miles
Non Project Levees
Map Extent
Sacramento
Napa
Vacaville
Fairfield
Concord
Antioch
Stockton
WEST SACRAMENTO GRR
WEST SACRAMENTO, CALIFORNIA
AUTHORIZED
WEST SACRAMENTO PROJECTS
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

West Sacramento Levee Improvement Program. WSAFCA, in cooperation with the California Department of Water Resources and the Central Valley Flood Protection Board, have initiated urgently needed improvements to the Federal Project levees protecting West Sacramento. These improvements address identified deficiencies in the levee system based on recent recognition of seepage problems and levee investigations. A catastrophic failure of the levee system around West Sacramento would imperil the health and safety of approximately 47,000 residents, shut down two of California's important freeways (I-80 and U.S. Highway 50), an important rail link from the San Francisco Bay area to the rest of the country, and cause significant residential, commercial, and industrial property damage. WSAFCA and the State are addressing these challenges by moving aggressively forward with the WSLIP by constructing Early I Implementation Projects (EIP) at what are considered the most vulnerable locations. One EIP site, the I Street Bridge site was completed in 2008. Construction was completed at two other EIP sites, identified as the California Highway Patrol (CHP) and the Rivers sites, in 2011. The Southport EIP site is in construction. In addition to approval to modify a federal levee through Section 408, the I Street Bridge site received approval for credit eligibility for levee modifications pursuant to Section 104 of WRDA of 1986.

The CHP and Rivers EIP sites received approval to modify a federal levee through Section 408. However, due to a change in policy the projects were not approved for credit under Section 104 of WRDA 1986. WSAFCA will seek credit approval through Section 221 of the Flood Control Act of 1970 as amended by Section 2003 of WRDA 2007. The final implementation guidance for Section 221 of the Flood Control Act of 1970 as amended is currently being updated.

The West Sacramento GRR Recommended Plan has adopted the Southport EIP site and the I Street Bridge site form the West Sacramento Levee Improvement Program. Construction of the I Street Bridge site is completed and acquisitions and construction is in progress on the Southport EIP site. The location of these EIP sites is shown on Figure 4.

FIGURE 6 Early Implementation Projects



Sacramento River Bank Protection Project.

Current designs proposed in the Recommended Plan avoid erosion work previously completed in the Sac Bank Project. The erosive forces from flood events on the Sacramento River have weakened the 100 year-old levees. In response to requests from the State of California, Congress authorized the Sacramento River Bank Protection Project in two phases to maintain levee integrity and other flood control facilities associated with the Sacramento River Flood Control Project. Phase I of the Sacramento River Bank Protection Project started in 1960 and was completed in 1975 with the installation of 480,000 lineal feet of rock revetment bank protection. Phase II was authorized by Congress in 1975 and provided for an additional 405,000 lineal feet of bank protection. To date, approximately 390,000 lineal feet of Phase II have been completed with continued construction planned. Expanded authority has been authorized under WRDA 2007 to provide for an additional 80,000 lineal feet of bank protection before the completion of Phase II.

As time goes on and flood seasons pass, an increasing number of sites are requiring some type of maintenance and/or repair work to provide consistent adequate flood control capability. During the 2010 inspection 187 sites were identified as in need of repair. Some of these sites are deemed "critical" and potentially subject to failure during a flood event. While these critical sites are being monitored to provide early warning for emergency response, emergency flood fighting may be required to prevent levee failure and subsequent flooding unless needed repairs are made prior to the next flood event. Funding for repairs does not meet the needs of the system.

Approximately 7 sites along the Sacramento River in the West Sacramento Project area were identified during the 2010 inspection that are considered subject to bank erosion in the form of bed or levee toe scour and wave-wash that threatens the stability of the adjacent levee. Two of the sites are currently being repaired with construction of a setback levee. If for any reason the new bank protection is placed into an existing Sacramento Bank Protection site LER credit will only be considered if the construction footprint is larger (only the area located outside the existing easement) or located in a different location where no easements currently exist.

Sacramento Deepwater Ship Channel

The Sacramento Deepwater Ship Channel is a 43-mile long channel formed by widening and deepening the existing channel from the Suisun Bay to Rio Vista and by excavating a new channel from that point to Lake Washington in West Sacramento. The channel project also includes a triangular harbor and turning basin in Lake Washington and a 1.5 mile shallow-draft barge canal with an 86-foot-wide and 600-foot long navigation lock between the harbor and the Sacramento River.

The channel project was completed in 1963, with the Sacramento-Yolo Port District as the local sponsor. A feasibility report that evaluated the need for a deeper draft channel was completed in 1980. The report recommended enlarging the Suisun Bay and Sacramento River Deep Water Ship Channels from New York Slough to the Port of Sacramento from the existing 30 foot deep channel to 35 feet. Dredging was completed from river mile 41.5 to 35 in April 1991. The presence of utilities in the channel led to the project being stopped. A Limited Reevaluation Report (LRR) was started by the Corps in 2002 to verify the economic and environmental feasibility of continuing the authorized and partially completed deepening project. The draft LRR is currently on hold and the completion date has not been established.

The barge canal and lock, which has a 4-foot lift at normal pool elevation, provides for the transfer of barges between two different water surface elevations. A 135-foot span, single leaf combination highway and railroad bridge crosses the canal at the harbor end of the lock. The bridge and lock were in "caretaker" status under the jurisdiction of the Corps until its transfer to the City of West Sacramento Redevelopment Agency in 2006. The lock is permanently closed except in emergency or special situations; future operation is uncertain. The lock acts as a barrier between the Sacramento River and the DWSC and will be evaluated as part of this General Reevaluation Report.

The Corps already has perpetual easements and right of way for the Deep Water Ship Channel for operations and maintenance purposes on the existing levees, patrol roads, and disposal areas. Proposed construction features in this area include bank protections and slurry walls. The bank protection was not included in the Corp existing easement footprint and was valued as a new easement requirement. New Staging and temporary easements will be needed for the project.

8. Description of any Federally Owned Land Needed for the Project

There are a total of 7 federally owned parcels located in the project area. All parcels are owned by the United States. There are 4 federally owned parcels along the Deep Water Ship Channel West Levee Reach estimated at 69 acres. The federal parcels in the construction area are portions of the ship channel and portions of a drainage canal flowing parallel to the deep water ship channel. There are USA owned parcels utilized by the Corps (Bryte Maintenance Yard) located in the North Levee Reach estimated at 8.25 acres. There are no other federally owned lands in the project area.

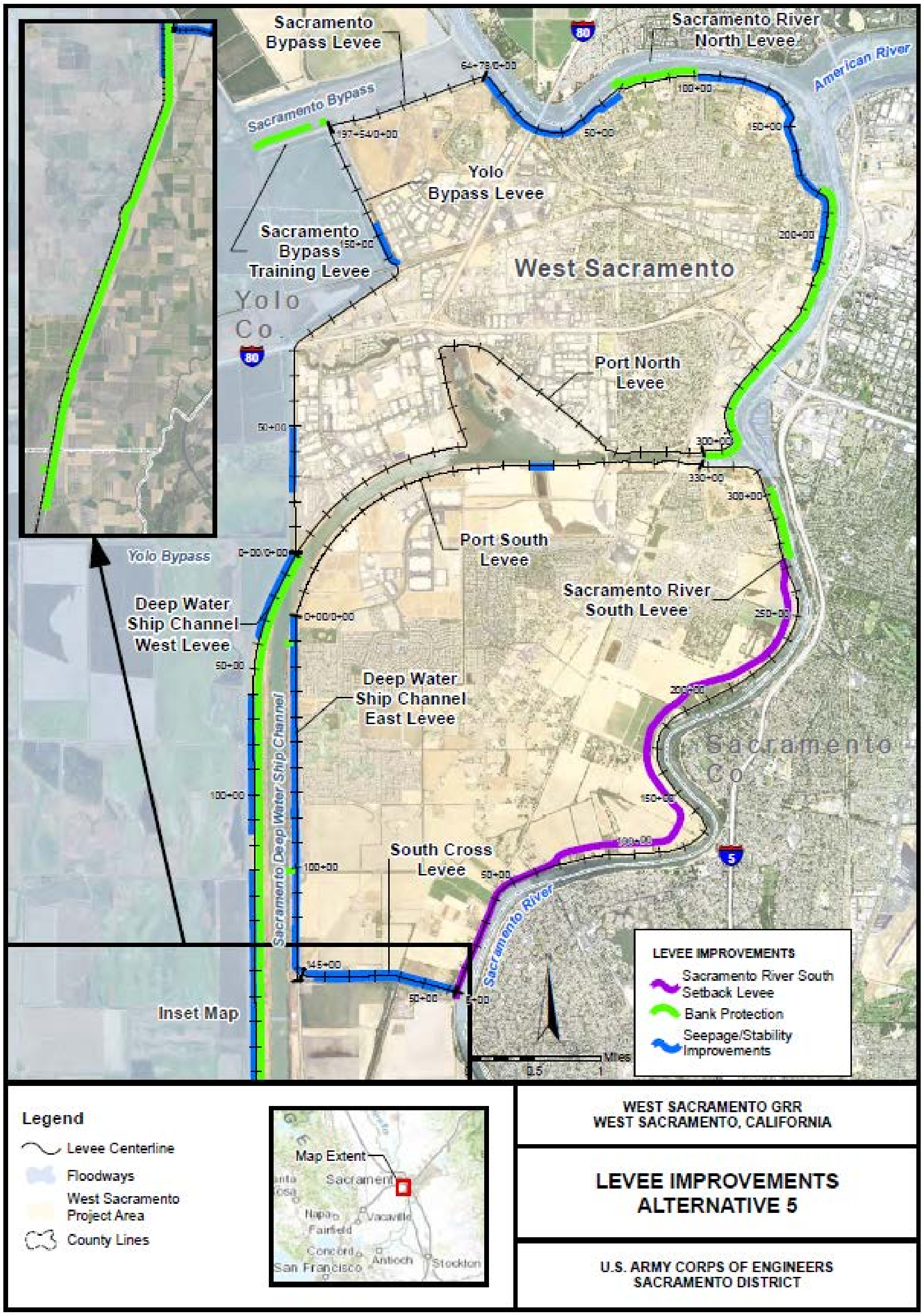
Table 5: Parcels held in Federal Trusts FPLE – Levee Easement, TWAE - Temp Easement

Reach Description	Parcels	Acreage	FPLE	TWAE
Deep Water Ship Channel West	4	353	54.17	0
North Levee Reach (Bryte Yard)	2	8.25	5.75	.104

9. Application of Navigational Servitude to the LERRD's Requirement

The Recommended Plan, a re-evaluated plan of improvement of an authorized flood risk reduction project, includes erosion and bank protection improvements along the Sacramento River (water) side of the levees. Since landside access will likely be unavailable for the placement of rock for bank protection purposes, the navigational servitude will be utilized during project construction to accommodate barges carrying project materials to the project construction site.

10. Project Map FIGURE 7



11. Induced Flooding

Hydraulic Impact Evaluation

Hydraulic impacts of the West Sacramento GRR alternatives were evaluated using the same process the Hydrologic Engineering Center (HEC) developed in evaluating system-wide hydraulic impacts of proposed modifications to the levees of the Sacramento River Flood Control Project (SRFCP). The process utilized risk analysis methods that followed USACE policy as outlined in ER 1105-2-101.

The purpose of this evaluation was to determine if any of the final array of alternatives could cause potential system-wide impacts. Using the model HEC -RAS created for the Sacramento River Flood Control Project (SRFCP) levees, the following three scenarios were created:

- Future without-project baseline condition
- Alternative 1: Fix in place
- Alternative 5: Fix in place with a Sacramento River Setback

Alternative 3 was not analyzed specifically since it includes a portion of Alternative 1 plus a closure structure along the Deep Water Ship Channel. The Deep Water Ship Channel closure structure will not impact the water surface elevations within the SRFCP as it acts a barrier to preventing flow into the Port of Sacramento where the water surface elevation is driven by tidal influences significantly downstream. Alternative 5 includes portions of Alternative 1 with a 4.25 mile setback levee on the Sacramento River south of the Deep Water Ship Channel sector gates. Based on the 408 applicant's model results, there is a slight increase in stage downstream of the setback at the Pocket (0.13 foot and 0.17 foot rise for the 100-year and 200-year, respectively).

Potential impacts are identified from Flood Damage Reduction Analysis (FDA) model results when an increase in the Annual Exceedance Probability (AEP) and a reduction in conditional non-exceedance probability (CNP, also referred to as "assurance") 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 future without project baseline condition:

- There was no significant change in median AEP

- There was no significant change in expected AEP (rounded at three significant figures)

There are small changes in the CNP/assurance, mostly in the thousandths place. For additional information, see the Hydraulics Appendix or The Systems Risk Technical Memorandum (USACE, May 2013). Based on this hydraulic analysis, no anticipated increased flooding of any significance is anticipated from implementation of the Recommend Plan with the exception of the Southport Setback Levee where, by purposeful design, there will be induced flooding in the designated setback area.

As noted above, the Recommended Plan includes a 4.25 mile setback levee on the Sacramento River south of the Deep Water Ship Channel sector gates. This feature is being constructed by the non-Federal sponsors under the authority of Section 408. Hydraulic modeling for this feature was performed by the non-Federal sponsors and reviewed by the Corps as part of the 408 application process, and the modeling results indicate there is a slight increase in stage downstream of the setback at the Pocket (0.13 foot and 0.17 foot rise for the 100-year and 200-year, respectively). Consequently, implementation of the Recommended Plan, with the South Port setback levee, will result in induced flooding of the designated setback area. The acquisition of flowage easements, prohibiting in the placement of habitable structures in the flowage easement area, will be required for project implementation. The costs of these easements are included in the cost estimate of this REP and the GRR.

The non-Federal sponsors presently have flowage easements for occasional flooding over the privately owned lands within the Sacramento and Yolo Bypasses. These easements were acquired in the 1940s and 1950's as part of the SRFCP. Existing flowage easements were reviewed when the prior projects were implemented and it was reported that none of those easements contained limitations on depth, duration or frequency of flooding. With the exception of the Sourth Port setback levee, noted above, Recommended Plan will not induce any significant change in expected AEP.

12. Cost Estimate Summary for Lands and Damages and Relocations

The following table reflects a preliminary estimation of the costs of acquiring the required LERRD's to support the construction, operation and maintenance of the Recommended Plan to assist in the determination of federal interest for the cost benefit analysis. The date of the approved cost estimate was June 2013.

TABLE 6A: COST TABLES Recommended Plan

Features	Cost	Contingency	Total Costs Rounded
Code of Accounts 01	FEDERAL		
Fed RE Admin Account 01	$4,251,250	(5%) $223,750	$4,475,000
Account 01	NON FEDERAL		
Levees, O&M Roads, Staging Areas /Relocation lands and improvements	$52,656,900	Incremental Real Estate Costs 35% Severance Damages 25% $78,985,200	$131,642,000
Non RE Fed Admin	$11,053,250	(5%) $581,750	$11,635,000
PL 91-646 Relocation Assistance Payments	$693,750	(25%) $231,250	$1,025,000
		SUBTOTAL	$148,777,000
Utility Relocation Costs Account 02	$64,020,000	(28%) $17,926,000	(Rounded) $81,946,000
			TOTAL LERRD's $230,723,000

Table 6B

Type of Fish and Wildlife Mitigation 06 Account	Cost
Mitigation Banks	$22,982,500
On Site Mitigation	$15,351,000
Total Mitigation Costs	$38,333,500

13. <u>Relocation Assistance Benefits</u> (as required by the Relocation Assistance and Real Property Acquisition Policies Act, PL 91-646)

The Non-Federal Sponsors must comply with the Uniform Relocation Assistance and Real Properties Acquisition Policies Act of 1970, as amended, 42 U.S.C. 4601, *et seq.* (P.L. 91-646, -the Uniform Act) and provide relocation assistance to residences and businesses within the project area that are "displaced" as defined in the Uniform Act, as a consequence of project implementation. The Non-Federal Sponsors have prepared a draft relocation plan, which the Corps has reviewed.

The relocation inventory was created by viewing conceptual designs over aerial photographs. The estimated costs of such potential displacements are required for estimating project costs only and will be refined by the Non-Federal Sponsors when construction designs are completed.

TABLE 7

Reach Station ID	Residence, Business	Total Cost includes 25% contingency
Sacramento River North Levee Temporary Relocations During Construction	11 - 52	$472,500
Sacramento River South Setback Levee	20	$552,500
Total	31	$1,025,000

Availability of Replacement Housing/Business Properties: There is available replacement housing, temporary housing and available land for relocating businesses in West Sacramento.

In the Sacramento River North Reach, there are currently 11 homes that need utilities removed and replaced during the construction of a cut off wall in the levee located near their residences. This will require temporary residential relocations. In addition there are 40 vacant lots that may be developed by the start of construction in this reach. As such, there is the potential for the temporary residential relocations to increase to a total of 52. Costs estimate of $100,000 will be incorporated into total project costs to include this future scenario.

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.

14. <u>Mineral/Timber Activity</u>

There are no active mineral or timber activities in the project construction locations.

15. <u>Non-Federal Sponsor's Ability to Acquire</u>

The State of California Central Valley Flood Protection Board and West Sacramento Area Flood Control Agency have partnered with the Corps on several prior projects and has a full Real Estate staff capable of fulfilling its' responsibilities as a non-Federal sponsor.

The assessment of Non-Federal Sponsor's Real Estate Acquisition Capability has been provided to WSAFCA and is included in Exhibit A.

16. Zoning Anticipated in Lieu of Acquisition

The project 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.

17. Acquisition Schedule

The non-Federal sponsors will be directed to begin real property acquisition for the project only after the Project Partnership Agreement (PPA) is fully executed. Construction is proposed to take approximately 18 years if each reach is constructed sequentially. The construction reaches have been prioritized based on a variety of factors, including the condition of the levee, the potential damages that would occur due to levee failure, and construction feasibility considerations, such as the availability of equipment at any given time. The tentative schedule of construction is shown in below. The durations are for construction activities only, and do not include the time needed for design, right-of-way, utility relocation, etc. A standard risk letter has been sent to the non-Federal sponsors advising of the risks associated with early acquisition of properties before the execution of the PPA or prior to the Government's formal notice to proceed.

Durations of each tasking after the PPA is executed is estimated at 3 to 6 months per construction contract.

REAL ESTATE ACQUISITION SCHEDULE				
Project Name: West Sacramento GRR Contracts	COE Start	COE Finish	NFS Start	NFS Finish
Receipt of preliminary drawings from Engineering/PM	2011	2012		
Receipt of final drawings from Engineering/PM	2015	2020		
Execution of PPA/Finalize Chief's Report	April 21, 2016			
Formal transmittal of final drawings & instruction to acquire LERRDS	2020			
Years for Construction Sequence and Duration South Setback Levee North Levee Yolo Training Dike Yolo Bypass North and South Deep Water Ship Channel East Deep Water Ship Channel West Port South South Cross Levee			Duration 4 years 2 years 75 days 5 years 3 years 3 years 2 years	Ending 2017 2020 2015 2019 2029 2020 2017
Conduct Landowner Meetings			2015	2029
Prepare/review mapping & legal descriptions			2015	2029
Obtain/review title evidence			2015	2029
Obtain/review tract appraisals			2015	2029
Conduct negotiations			2015	2029
Prepare/review condemnations			2015	2029
Perform condemnations			2015	2029
Obtain Possession			2015	2029
Complete/review PL 91-646 benefit assistance			2015	2029
Certify all necessary LERRDS are available for construction			2015	2029
Prepare and submit credit requests			2015	2029
Review/approve or deny credit requests	2015	2030		

18. Description of Facility and Utility Relocations

On January 10, 2013, the Corps issued Real Estate Policy Guidance Letter No. 31--Real Estate Support to Civil Works Planning Paradigm (3x3x3) ("PGL No. 31") establishing additional Corps policy guidance for feasibility-level real estate efforts directed at identifying, defining and estimating the costs of utility/facility relocations resulting from project implementation for planning and budgeting purposes. In qualifying instances, a real estate assessment, in lieu of an attorney's preliminary opinion of compensability, may be prepared and utilized for such purposes (although a final attorney's opinion of compensability will be required for specified relocations prior to execution of the Project Partnership Agreement between the Corps and the non-Federal sponsors.).

The Utility/Facility Inventory table, maps and cost estimates discussed herein and available in Exhibit D sets forth the following information: the utilities/facilities falling within the project area that are presently anticipated to be impacted by the construction, operation and maintenance of the project thus requiring "relocation" (as defined in applicable law and regulations); the District's preliminary efforts to identify owners with compensable interests in the impacted utilities/facilities and eligibility for the provision of a substitute or replacement facility under applicable law and regulations; and identification of the non-Federal sponsors' performance and cost responsibilities in connection with the identified relocations for this cost-shared project.

Consistent with requirements of PGL No. 31, the preparation of a real estate assessment is appropriate for this feasibility study because the estimated total cost to modify all project utility/facility relocations identified in the Utility/Facility Inventory (including the value of any additional lands that may be required for perform the relocations) for the selected plan do not exceed 30 percent of estimated total project costs. Here, total project costs are estimated at 1.6 billion dollars and the utility relocations are estimated at $90,000,000 which is below the 30% threshold.

The real estate assessment discussed herein, and presented in Exhibit D, is based upon the following assumptions to assist in preliminarily analyzing and determining compensability for Study planning and budgeting purposes:

(1) If an impacted utility/facility is likely supported by a permit that has been issued to the utility/facility owner by the underlying property owner, and the terms of the permit include conditional language stating the utility/facility owner must relocate the impacted utility/facility at its own expense at request of the underlying fee or easement owner, the relocation was categorized as a non-compensable relocation, the costs of which are borne by the utility/facility owner and/or the non-Federal sponsor, and not included in the total project cost estimate.

(2) If the owner of the impacted utility/facility likely has an easement or real property interest in the underlying land, and the utility/facility so impacted preliminarily appears to meet the criteria for the provision of a substitute and/or replacement facility under the substitute facilities doctrine, the relocation was categorized as a compensable relocation, the costs of which are borne by the non-Federal sponsor and included in the total project cost estimate.

(3) Impacted utilities/facilities requiring relocation that likely intercept and/or convey drainage blocked by levees or floodwalls from the protected side of the waterway with measures

such as intercepting ditches, ponding areas, pumping plants, gravity outlets, and pressurized conduits, were preliminarily categorized as project features; thus an item of construction to be cost shared and are included in the total project cost estimate. These project features have not been not included in the Utility/Facility Inventory, however, with the exception of costs to increase the size of the facilities to meet special local needs (including betterments), which costs are borne 100% by the non-Federal sponsors and are not included in the total project cost estimate.

Final Attorney's Opinions of Compensability will be completed during the PED Phase and prior to the execution of the Project Partnership Agreement, as well as prior to any notice to proceed to obtain lands and perform relocations by the non-Federal sponsors.

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 assessment of compensability, referencing the data set forth in the Relocation Inventory Table, is as follows:

The following utilities/facilities appear to be non- compensable relocations:

Sacramento River South Reach Item's – 4-8, 10, 12, 14, 15 Sacramento River North Reach – Item 5 (Pipeline), Yolo Bypass Item 2 (water pipe), (DWSC East Reach - Item's 1-7 gas lines and pipelines) (Sacramento River South Reach - Item's – 1, pipeline 3, gas pipe 9, telephone cable 11, water pipe 13, burial phone cable) (Sacramento River North Reach - Item's 1, outfall structure and pipe 3, high pressure gas line 4, septic tank and piping 6-30, pipe lines, storm drains, telephone conduits, water treatment facility, high pressure gas mains, gas tank, water line, water well, electrical conduit, irrigation and portable water main, 20 ft pipe towers, steel pipeline, navigation light, 32-37 Fiber optic cable, waste outfall line, water main, pipeline, gas line, sewage pipeline) (Yolo Bypass Reach Item 1 - Power line across the levee)(DWSC West Reach Item's 1-9 fish passage facility, 4 gas lines, 3 pipelines, outfall structure RD 900).

The following utilities/facilities appear to be compensable relocations:

(Item 8 - DWSC East – 8 power Poles) (Item's 2-4 Port North - sewer lines and utility corridor under barge canal)(Item 1 - Sacramento River South Setback Reach - 143 power poles , Items 2,3,11 – Roads, Item 9 – Cellular Tower and facilities, Item 4,14 Storm drains, Item 13, 5 Gas Main and Gas line, Item 6 – 120' Sewer main, Item 10 – Pump Station #5, (Item's 38, 39 Sacramento River North Reach Items - 37 power poles, 24 light poles) (Item 3 - Yolo Bypass - 2 power poles) (Item's 1-2 -South Cross Levee – Jefferson Road relocations, 10 power poles, ditch, fence, 3 covered structures) (Item 10 - DWSC West - 1 power pole), (Yolo Bypass – road relocations)(Sacramento North reach – road relocations)

The following utilities/facilities may or may not be compensable. There is insufficient information at this time to make a preliminary assessment as to whether the utilities/facilities are compensable relocations. The submission of additional data and further analysis is required:

(Item 9-gas pipelines various owners) (Item 2 Sacramento River North Reach - pipeline cut and replace RD 537) (Item 31- Citizens Utility Co. RD 900 - Pipeline-protect in place (Items 21, 18, Sac

River South Setback Reach – abandon underground electrical and telephone lines)(Item 14 - Sac River South Setback Reach –drainage swales PIP outside construction footprint)(Item 7- Communications Towers and Supporting Facilities PIP)(Deep Water Ship Channel East – ditch removed and rebuilt Station 102 to 125)

TABLE 8 - Code of Accounts 02 Utility/Facility for the Recommended Plan

Reach	Cost
Sacramento River North Levee	$25,110,000
Sacramento River South Setback Levee	$28,092,00
Yolo Training Dike	N/A
Yolo Bypass (North and South)	$205,000
South Cross Levee	$1,098,000
Stone Lock	$100,00
Deep Water Ship Channel East	$7,893,000
Deep Water Ship Channel West	$1,522,000
Sub Total Rounded	$64,020,000
Contingency (28%)	$17,926,000
***Total**	(Rounded) $81,946,000

*Note: Construction Management Costs and PED costs for all construction items are displayed in the MII Cost Engineering Appendix. The Utility Facility Inventory table, maps and costs discussed herein are available in Exhibit D.

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 IMPACTED UTILITIES AND FACILITIES DURING FINAL DESIGNS.

19. Hazardous, Toxic, and Radiological Waste Impacts

A Phase 1 Environmental Site Assessment (ESA) was completed in May 2012 for approximately 50.5 miles of levee system that surround the City of West Sacramento and the Deep-Water Ship Channel to identify recognized environmental conditions involving hazardous, toxic, or radioactive waste (HTRW). Sites that could affect levee construction projects may include those that exhibit the presence or likely presence of any hazardous substances or petroleum products under conditions that indicate an existing release, a past release, or the material threat of a release into structures, the ground, and groundwater or surface waters of the project site.

Environmental Data Resources (EDR) conducted a records search of 71 federal, state, public, and proprietary available databases to identify sites located within a one mile radius of the project area where the presence or likely presence of HTRW has been previously documented. The Phase 1 ESA conducted in May 2012 did not include any sampling or analysis of environmental media. A review of the records search results identified 788 environmental sites including eight sites that have the HTRW concerns with the potential to affect future construction activities and eight sites with HTRW concerns that are not likely to affect future construction activities.

For the West Sacramento GRR, the USACE conducted a second review of previously identified potential HTRW sites in the May 2012 Phase 1 ESA. The USACE utilized updated site information in the EnviroStor and GeoTracker databases maintained by the California Department of Toxic Substance Control (DTSC) and California State Water Resources Control Board (SWRCB) to determine possible impacts that the identified sites may have on future construction activities. Characteristics used to determine potential impacts on construction activities included the suspected mass and volume of contaminants, their mobility within the soil-groundwater-air matrix, and the likelihood of traditional levee remediation measures impacting contaminated media.

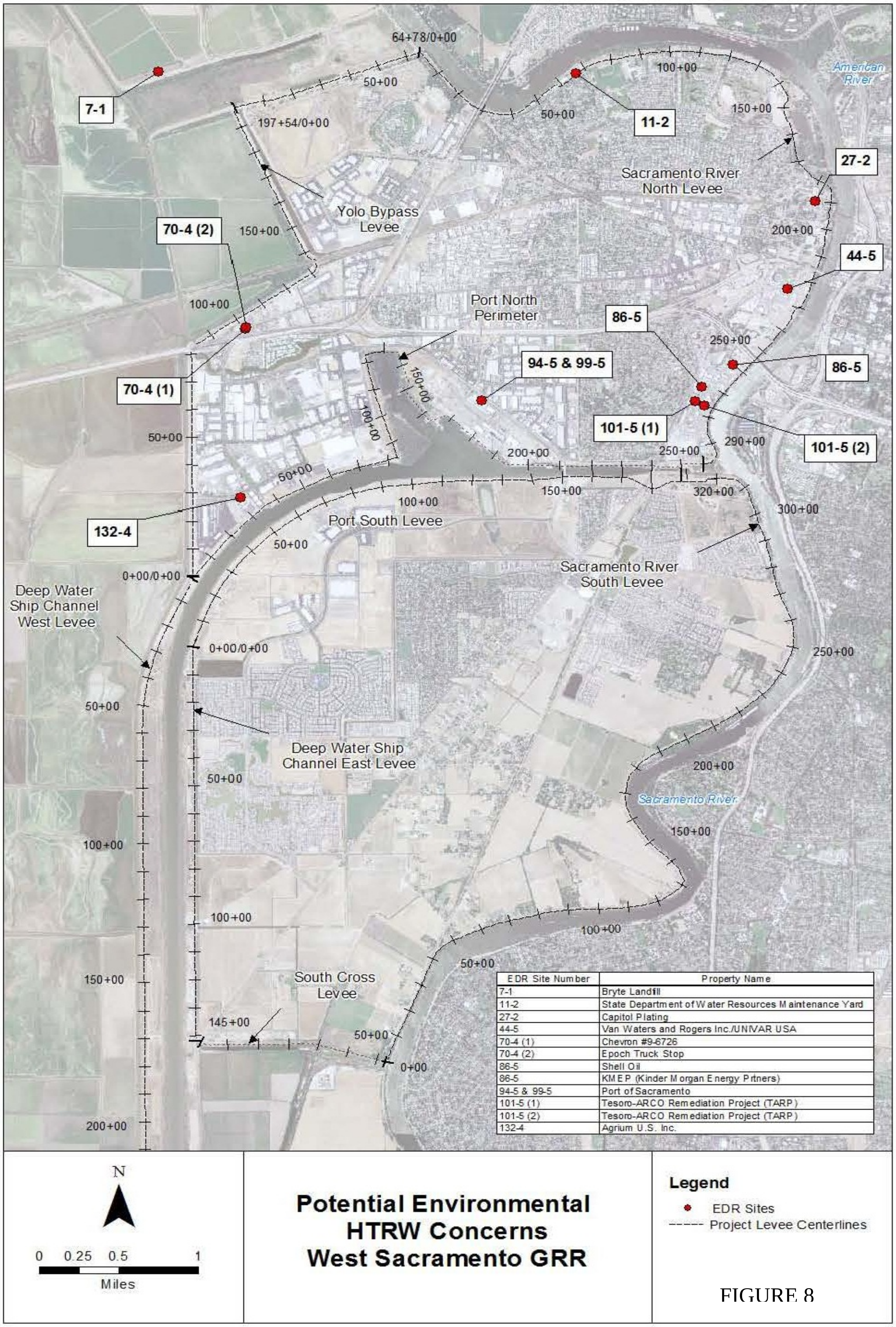
If any evidence of potential HTRW is found during construction, all work would cease, and the USACE and non-Federal sponsor would be notified for further evaluation of the potential contamination. Any unanticipated hazardous materials encountered during construction would be handled according to applicable federal, state, and local regulations. The USACE 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 contaminate in place or relocate the material (ER 1110-2-1150).

TABLE 9

Type 1 Sites – HTRW concerns that may impact future activities						
Site Name	**EDR ID #**	**Distance from Centerline (miles)**	**Closest Levee Reach**	**Stationing Along Closest Reach**	**Address**	**Summary**
State Department of Water Resources Maintenance Yard	11-2	0.00	Sacramento River North Levee	50+00	1450 Riverbank Rd., West Sacramento, CA 95605	Leaky underground storage tank with hydrocarbon plume located under the levee
Capitol Plating	27-2	0.13	Sacramento River North Levee	180+00	319 3rd St., West Sacramento, CA 95605	Heavy metals and chlorinated solvents in the soil around the former facility
Van Waters and Rogers Inc./UNIVAR USA	44-5	0.00	Sacramento River North Levee	220+00	800-850 South River Rd., West Sacramento, CA 95691	Former chemical handling and storage facility with solvent contamination in soil and groundwater
Chevron #9-6726 and Epoch Truck Stop	70-4	0.13	Yolo Bypass	100+00	4790-4800 West Capitol Ave, West Sacramento, CA 95691	Co-mingled fuel plume located beneath to fuel dispensers
Shell Oil, Ramos Environmental, KMEP	86-5	0.13	Sacramento River North Levee	260+00	1509-1570 South River Road, West Sacramento, CA 95691	Previous storage, distribution, and recycling facilities for hydrocarbon compounds. Current soil and groundwater contamination
Port of Sacramento	94-5 & 99-5	0.25	Port North Area	160+00	2895 Industrial Blvd., West Sacramento, CA 95691	Ammonia and Nitrate plume associated with previous fertilizer storage and transport
Tesoro-ARCO Remediation Project (TARP)	101-5	0.13	Sacramento River North Levee	270+00	1700-1701 South River Road, West Sacramento, CA 95691	Large fuel storage and distribution terminal with associated hydrocarbon and VOC plume
Agrium U.S. Inc.	132-4	0.13	Port North Area	35+00	3961 Channel Drive, West Sacramento, CA 95691	Nitrogen contamination of groundwater related to previous storage and production of fertilizers

Type 1 Potential Environmental Concerns



EDR Site Number	Property Name
7-1	Bryte Landfill
11-2	State Department of Water Resources Maintenance Yard
27-2	Capitol Plating
44-5	Van Waters and Rogers Inc./UNIVAR USA
70-4 (1)	Chevron #9-6726
70-4 (2)	Epoch Truck Stop
86-5	Shell Oil
86-5	KMEP (Kinder Morgan Energy Prtners)
94-5 & 99-5	Port of Sacramento
101-5 (1)	Tesoro-ARCO Remediation Project (TARP)
101-5 (2)	Tesoro-ARCO Remediation Project (TARP)
132-4	Agrium U.S. Inc.

FIGURE 8

20. Attitude of Landowners

To date, the results of the outreach program from the public scoping meetings have been very favorable, constructive, and supportive. The tone and substance of the input has been consistent with the voter-approved assessment to fund the local share of the project. The attitude of landowners that have the potential to be temporarily relocated along the South Cross Levee area during construction of the setback levee varied on a case by case basis. Some residents felt public safety issues were important and could see value in relocating and were supportive. Some residents were angry and did not want to relocate. The attitude of landowners along the Sacramento River North Levee reach and the South Cross Levee reach is unknown.

21. Cultural Resource Issues

Preparation and implementation of a Programmatic Agreement, Historic Properties Management Plan, and Historic Properties Treatment Plans has been included in the EIS Cultural Resource Appendix C. Coordination continues with Yocha Dehe Wintun Nation.

EXHIBIT A

ASSESSMENT OF NON-FEDERAL SPONSOR'S REAL ESTATE ACQUISITION CAPABILITY
WEST SACRAMENTO GENERAL REEVALUTION STUDY

SPONSORS: The State of California, Central Valley Flood Protection Board (CVFPB), West Sacramento Flood Control Agency (WSFCA)

I. Legal Authority:

a. Do the sponsors have legal authority to acquire and hold title to real property for project purposes? Yes CVFPB; Yes WSAFCA

b. Do the sponsors have the power of eminent domain for this project? Yes CVFPB; Yes WSAFCA

c. Do the sponsors have "quick-take" authority for this project? Yes CVFPB; Yes WSAFCA

d. Are any of the lands/interests in land required for the project located outside the sponsor's political boundary? No CVFPB; No WSAFCA

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; No WSAFCA

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; Yes WSAFCA

b. If the answer to a. is "yes," has a reasonable plan been developed to provide such training? Yes CVFPB; WSAFCA: Yes

c. Does the sponsor's in-house staff have sufficient real estate acquisition experience to meet its responsibilities for the project? Yes CVFPB; Yes WSAFCA

d. Is the sponsor's project in-house staffing level sufficient considering its other workload, if any, and the project schedule? Yes CVFPB; Yes WSAFCA

e. Can the sponsor obtain contractor support, if required, in a timely fashion? Yes CVFPB; Yes WSAFCA

f. Will the sponsor likely request USACE assistance in acquiring real estate? No CVFPB; No WSAFCA

III. Other Project Variables:

a. Will the sponsor's staff be located within reasonable proximity to the project site? Yes

CVFPB; Yes WSAFCA

b. Has the sponsor approved the project real estate schedule/milestones? Yes CVFPB; WSAFCA Response: No, the approval occurs during the preconstruction, engineering and design phase.

IV. Overall Assessment:

a. Has the sponsor performed satisfactorily on other USACE projects? Yes CVFPB; WSAFCA

b. With regard to this project, the sponsor is anticipated to be: The State of California, Central Valley Flood Protection Board and the West Sacramento Flood Control Agency

V. Coordination:

a. Has this assessment been coordinated with the sponsor? Yes CVFPB; Yes WSAFCA

b. Does the sponsor concur with this assessment? Yes CVFPB; Yes WSAFCA

Prepared by:

Laurie Parker
____
Laurie Parker
Realty Specialist
Acquisition Branch

Date _12/02/2015____

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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SUBJECT: Real Estate Policy Guidance Letter No. 31-Real Estate Support to Civil Works Planning Paradigm (3x3x3)

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)

December 2015

West Sacramento General Reevaluation Report

US Army Corps of Engineers ®
Sacramento District

Central Valley Flood Protection Board

WSAFCA
West Sacramento Area Flood Control Agency

Final Report Documentation

Economic Appendix

Cover Photo: Sacramento River, West Sacramento, and Yolo Bypass, March 2011

Photo courtesy of Chris Austin.

WEST SACRAMENTO PROJECT, CALIFORNIA
GENERAL REEVALUATION REPORT

Final Report Documentation

Economic Appendix

U.S. Army Corps of Engineers
Sacramento District

December 2015

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1 - INTRODUCTION

1.1 PURPOSE AND SCOPE

This Appendix documents the economic analysis performed for the West Sacramento General Reevaluation Report (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 two previously authorized projects (the Joint Federal Project (JFP), and the Folsom Dam Raise) are in place and functional.
- Describe the residual flood risk, which is the remaining flood risk once improvements are completed, associated with each alternative.
- Summarize the results of the net benefit and benefit-to-cost analyses for each alternative.
- Identify the National Economic Development (NED) Plan, which is the alternative that reasonably maximizes net benefits.

1.2 BACKGROUND

Surrounded by water during the winter months, the city of West Sacramento depends on levees for the safety of its residents (Figure 1 below). In 2002, the U.S. Army Corps of Engineers (Corps) completed levee improvements authorized through the *West Sacramento Project* that were intended to protect the city from a flood having greater than a 1% chance of occurring in any given year. Unfortunately, these levee improvements, recommended as part of *the Sacramento Metropolitan Area, California, General Reevaluation Report (*February 1992), did not consider the under seepage deficiencies facing many of the levees which protect the city. Although the levee improvements authorized for construction were redesigned to address under seepage, the levees not included in the authorization and which also protect the city were not reevaluated to determine whether they were adequate to withstand the design flood event. Further, the geotechnical engineering and risk analysis standards being applied to urban levees in the post-Katrina environment have raised additional doubt regarding the actual level of protection afforded to the city by the existing flood protection infrastructure.

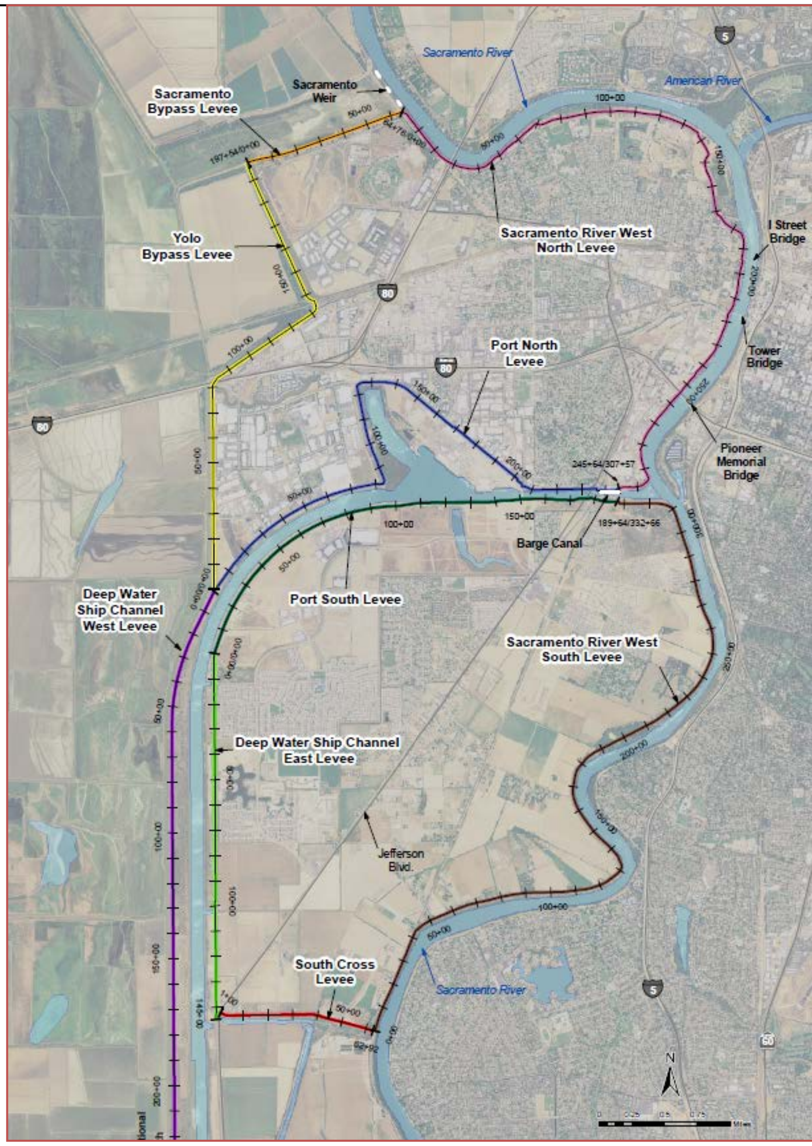


Figure 1: Levees Surrounding the City of West Sacramento

As a result, the West Sacramento Area Flood Control Agency (WSAFCA) has initiated a thorough, State and locally-funded review of its flood risk management system. Based on the current Federal standards, multiple deficiencies have been found in the Federal levee system that protects the city, with the predominant dangers being seepage, stability, and erosion. Recognizing the need for more work, the city has moved proactively to address this challenge, with city residents recently voting to assess a tax on themselves for up to $40 million of the needed funds. The city is seeking additional assistance and funding from private, state, and Federal agencies to implement the levee improvements necessary to reduce the flood risk facing their community.

1.3 STUDY AREA

Sacramento Watershed

The West Sacramento study area is part of the larger Sacramento River watershed, which is composed of 26,300 square miles in the northern half of California's Central Valley. The watershed is approximately

240 miles long and up to 150 miles wide bounded by the Sierra Nevada on the east, the Coastal Range on the west, the Cascade and Trinity Mountains in the north, and the Delta in the south. Major tributaries of the Sacramento River include the Feather and American Rivers (Figure 2).

The Sacramento River watershed typically receives the greatest runoff as a result of winter and spring rainfall. A majority of the Sacramento River is perched, meaning the river channel is at a higher elevation than the adjacent lower lying basins. This effect is amplified as flows combine with tides near the bottom of the watershed to strongly influence flood water levels in the Delta. This often causes backwater effects on the Sacramento River and its tributaries in and near the Delta.

Between Lake Shasta and Red Bluff, the Sacramento River is relatively narrow and entrenched, with little floodplain and a narrow riparian corridor. Shasta Dam regulates most of the flood flows entering the reach. From Red Bluff to Chico Landing, the river is relatively free to erode and deposit bank material as it meanders within its floodplain. This reach does not have major levees or other flood management facilities and includes the most extensive riparian habitat of any reach of river. Downstream from Chico Landing, a system of levees, weirs, bypasses, and natural overbank areas convey flow to the Delta. The Sutter Bypass and finally the Yolo Bypass carry the bulk of flood flows to the Delta.

Riparian forests in the Sacramento River watershed are considerably smaller than they were historically, but still support a variety of wildlife. The vegetation includes Valley oak riparian, Great Valley cottonwood riparian, Great Valley mixed riparian elderberry savanna, oak woodland, freshwater marsh, seasonal wetlands, grasslands, and agricultural lands. Ecosystem functions, such as periodic inundation of habitat along the river, have also been reduced from the historical condition, resulting in a reduction of ecosystem diversity and productivity.

In the early 1900s, the Federal and State governments began construction of system-wide flood management facilities, including levees, weirs, and bypass channels. This included constructing new facilities and reconstructing existing private facilities to meet the Federal engineering standards that existed at the time. The effort focused on protecting lives and property by increasing the conveyance of flood waters through the system. The design goal of the facilities was to aid navigation and flush sediment remaining from the hydraulic mining conducted late in the 19th century. These conveyance facilities improved flood protection and navigation and allowed continued agricultural and urban development. They also constrained the river to specific alignments, significantly reducing channel meandering and further isolating the rivers from their historic floodplain.

The Corps constructed new levees or reconstructed private levees in order to complete the Sacramento River Flood Control Project. This project, authorized by the Flood Control Act of 1917, encompasses approximately 1,100 miles of levee along the Sacramento River and its primary tributaries from Collinsville in the Sacramento and San Joaquin River Delta upstream to Ord Ferry in Glenn County. The non-Federal partner for this flood control system is the Central Valley Flood Protection Board (formerly the Reclamation Board), which accepted the responsibility to operate and maintain the system under authority granted in the Flood Control Act of 1944. In accordance with State law, most of these responsibilities have been delegated to local levee and reclamation districts.

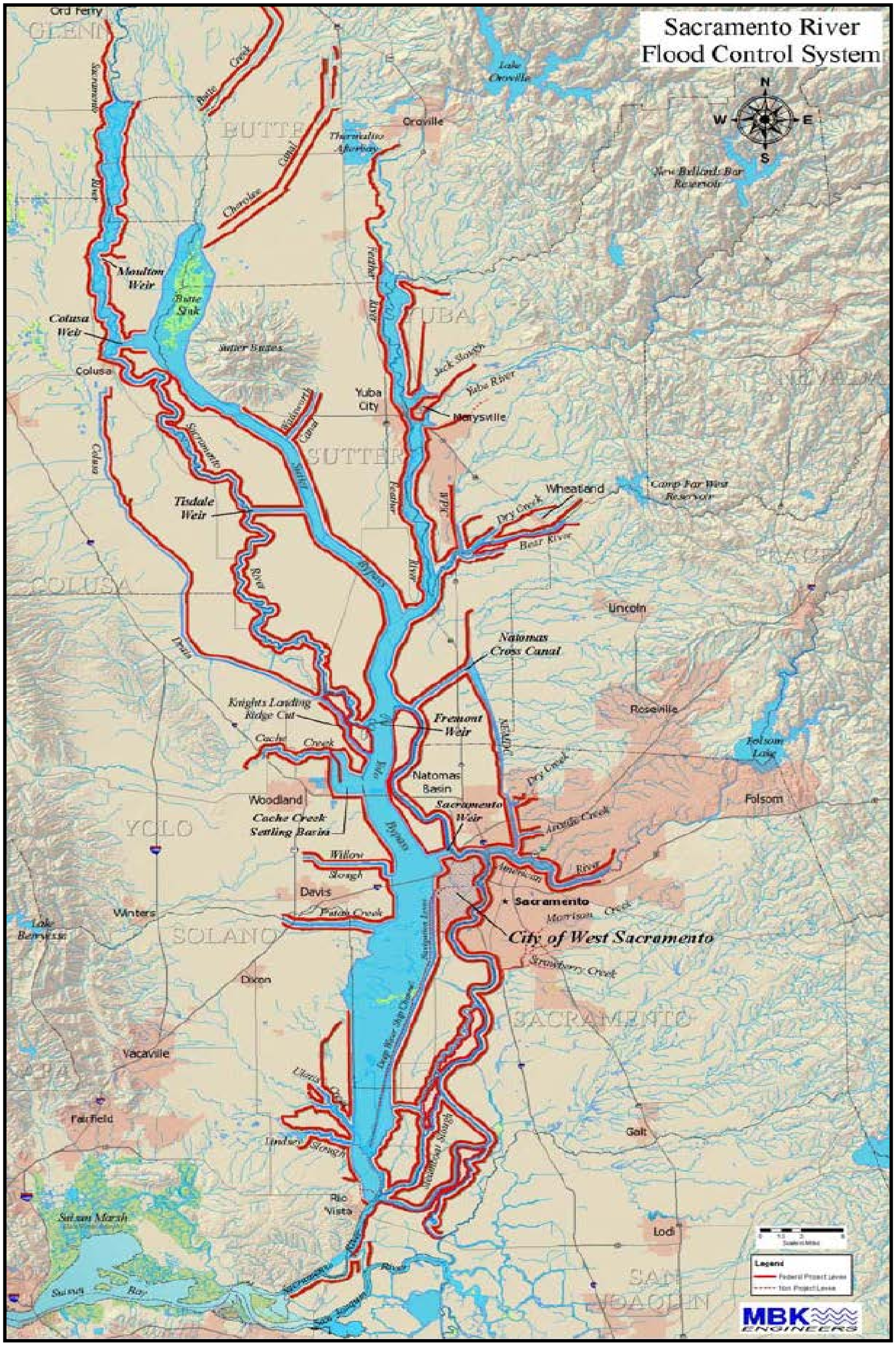


Figure 2: Study Area

West Sacramento Study Area

The study area is located in eastern Yolo County in the north central region of California's Central Valley (See Figure 2). The study area corresponds approximately with the city limit of West Sacramento, which is composed of an estimated 13,000 acres of mixed-use land and an estimated population of 44,000 residents. The city of West Sacramento is located directly across the Sacramento River from the city of Sacramento, the state's capital.

The study area is almost completely bound by floodways and levees, making it vulnerable to multiple sources of flood risk. These sources include the Yolo Bypass to the west, the Sacramento Bypass to the north, and the Sacramento River to the east. Further, the City is bifurcated by the Sacramento River Deep Water Ship Channel (DWSC) and Barge Canal. The associated levee system currently protecting the study area includes nearly 50 miles of levees in Reclamation District (RD) 900, RD 537, Maintenance Area 4, and along the DWSC and Barge Canal. The sub-basins and the levee reaches within each sub-basin include:

Northern Sub-Basin – The northern sub-basin, representing approximately 6,100 acres, is bounded by the Port North Levee and the DWSC to the south, the Sacramento River West-North Levee to the north and east, the Sacramento Bypass Levee to the north, and the Yolo Bypass Levee to the west. Land in this area varies in elevation from 34.0 feet near Raley Field to 16.0 to 18.0 feet adjacent to the DWSC. The north bank of the DWSC is generally at about elevation 19.5 feet. This area is traversed by the right bank of the Sacramento River from river mile (RM) 63.0 to RM 57.5.

- **Sacramento River West-North Levee** extends for approximately 5.5 miles along the Sacramento River right bank levee from the Sacramento Bypass south to the confluence of the Barge Canal and the Sacramento River.
- **Sacramento Bypass Levee** extends for approximately 1.1 miles along the Sacramento Bypass left bank levee from the Sacramento Weir west to the Yolo Bypass Levee.
- **Yolo Bypass Levee** extends for approximately 3.7 miles along the Yolo Bypass levee left bank from the confluence of the Sacramento Bypass and the Yolo Bypass south to the Navigation Levee (DWSC West).
- **Port North Levee** extends for approximately 4.9 miles along the DWSC right bank levee from the Barge Canal west to the bend in the Navigation Levee.

Southern Sub-Basin – The southern sub-basin encompasses approximately 6,900 acres and varies from elevation 18.0 feet to elevation 8.0 feet. The area is bounded by the Port South Levee and the DWSC to the north, the Sacramento River West-South Levee to the east, the South Cross Levee to the south, and the DWSC East Levee to the west. The south bank of the DWSC from Lake Washington to the Sacramento River is generally at elevation 19.5 feet. The right bank of the Sacramento River extends from RM 57.7 to RM 51.5.

- **Port South Levee** extends for approximately 4 miles along the DWSC left bank levee from the Barge Canal west past the bend in the DWSC.
- **DWSC West** extends for approximately 21.4 miles along the DWSC right bank levee from the bend in the DWSC at the intersection of Port North Levee and Yolo Bypass Levee south to Miners Slough.

- **DWSC East** extends for approximately 2.8 miles along the DWSC left bank levee from the end of Port South Levee south to South Cross Levee.
- **Sacramento River West South Levee** extends approximately 5.9 miles along the Sacramento River right bank levee from the confluence of the Barge Canal and the Sacramento River south to the South Cross Levee.
- **South Cross Levee** extends along the South Cross levee for approximately 1.2 miles from Jefferson Boulevard to the Sacramento River where it intersects the southern end of Sacramento River West-South Levee.

A majority of the levees within the study area are part of the Sacramento River Flood Control Project. The few exceptions are the Port North and Port South Levees, the DWSC West levee and the South Cross Levee. The Port North, Port South, and DWSC West levees were constructed as part of the Port of Sacramento. The South Cross Levee is a private levee. Although the DWSC West levee was constructed as part of the navigation project supporting the Port of Sacramento, this levee provides significant flood benefits to portions of both the northern and southern sub-basins. During the 200-year flood event, the water surface elevation in the Yolo Bypass is more than 12-feet higher than the water surface elevation in the DWSC at the northern limit of the DWSC West levee. This difference in water surface elevation is still greater than 10-feet between these two water courses downstream near the South Cross Levee. Based on these differences in water surface elevation, a failure of the DWSC West levee within this reach would result in higher flood damages within the study area for a 200-year flood event.

1.4 SUMMARY OF PRIOR REPORTS ASSOCIATED WITH WEST SACRAMENTO

The list below provides a summary of prior reports associated with the West Sacramento study area.

- **Sacramento River Flood Control Project: Sacramento Urban Area Levee Reconstruction, Basis of Design—USACE (November 1989)**

  The Corps completed a basis of design (BOD) to present the results of engineering studies and investigations prior to preparing plans and specification for remedial construction of select levees in the cities of Sacramento and West Sacramento. The BOD includes discussion of previous studies, geology of the region, discussion of subsurface characteristics, design considerations, alternative comparison and cost estimates.

- **Sacramento Metropolitan Area, California, Feasibility Report and Environmental Impact Statement/Environmental Impact Report—USACE (February 1992)**

  The Corps developed a feasibility report to assess the need for additional flood protection, to identify potential alternatives to increase flood protection and to determine Federal interest on the alternatives. The Corps study determined that there was a need for additional flood protection and then provided several potential alternatives which would provide varying levels of flood protection. The selected alternative recommended raising the south bank of the Sacramento Bypass and the east bank of the Yolo Bypass from the Sacramento Bypass south to the Navigation Levee.

- **West Sacramento Project, West Sacramento, California: Design Memorandum and Environmental Assessment/Initial Study – USACE (May 1995)**
  The Corps prepared a design memorandum for the flood protection improvements recommended in the Sacramento Metropolitan Area, California, Feasibility Report and Environmental Impact Statement/Environmental Impact Report authorized by Congress in 1992. The memorandum addressed necessary revisions to this feasibility report which had assumed that a flood control only dam near Auburn would be constructed. The memorandum presented and described the process for construction and mitigation as well as associated costs.

- **Sacramento River Bank Protection Project, California - USACE (On-Going)**

  Authorized by the Flood Control Act of 1960, the Sacramento River Bank Protection Project (SRBPP) is a continuing construction project that maintains the existing levee and flood control facilities of the Sacramento River Flood Control Project (SRFCP). The SRBPP provides a continuing long-range program of bank stabilization and erosion control to maintain the integrity of the SRFCP through bank protection and setback levees. As the authority for Phase II draws to a close, the Corps is initiating a GRR to study alternative means to preserve the integrity of the SRFCP. The SRBPP has historically repaired erosion sites in the West Sacramento area.

- **Sacramento and San Joaquin River Basins, California, Comprehensive Study (Interim Report) - USACE (December 2002)**

  Following the floods that occurred in January 1997, the Corps and the State of California Reclamation Board (currently known as the Central Valley Flood Protection Board) prepared an Interim Report along with Technical Study Documentation which documented the existing flood management system and potential modifications to it for flood risk management and ecosystem restoration along the Sacramento and San Joaquin Rivers. This report also reflects that the public's safety and economic prosperity should not conflict with conserving natural systems. This report goes into more detail on developing a comprehensive and effective plan for flood risk management, how the system functions, and how it can be improved. The major undertaking of the study was developing the necessary analytical tools to evaluate how changes to the system affected the performance of the system as a whole with respect to reducing flood damages, protecting public safety, and restoring degraded ecosystems. The study laid the groundwork for future potential modifications to the system for the purpose of reducing flood damages and restoring affected ecosystems.

1.5 FUTURE WITHOUT-PROJECT CONDITION

For this current GRR effort, the future without-project condition assumes that previously authorized projects, including the Joint Federal Project (JFP) and Folsom Dam Raise, are in place and functional. The future without-project condition also assumes that the Sacramento Bypass levee improvements (i.e., CHP Academy) are also completed. System-wide risk reduction was estimated by comparing the economic outputs of each alternative evaluated to the future without-project condition.

1.6 ORGANIZATION AND CONTENT

This report is organized around four main chapters. The contents of each chapter are summarized in Figure 3 below.

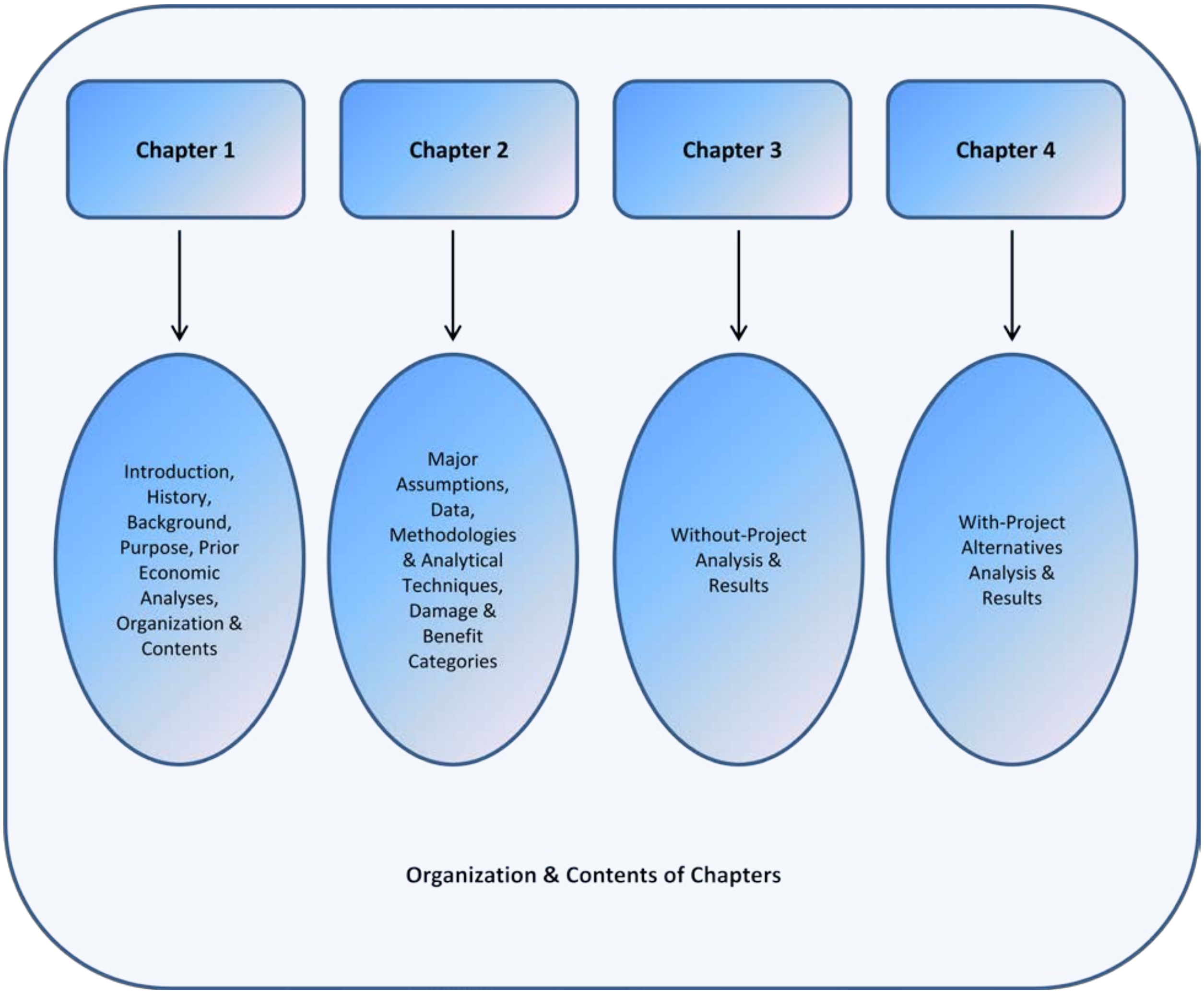


Figure 3: Organization and Contents

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 Sections 2.1 through 4.10 of this document are based on an October 2014 price level; annualized benefits and costs were computed using a 50-year period of analysis and a federal discount rate of 3.375%. Values presented in Sections 4.11 and beyond are based on an October 2015 price level, current FY16 federal discount rate of 3.125% and a 50-year period of analysis. For all sections, annualized values are presented in thousands ($1,000s) of dollars unless otherwise noted.

2.3 MAIN ASSUMPTIONS

Several main assumptions were relied upon in order to reasonably and efficiently study the problem (i.e., flooding) and its potential solutions (i.e., flood risk management alternatives), and then ultimately reach a conclusion as efficiently and as resource-effectively as possible. The analysis assumes that:

- The Joint Federal Project (JFP) and Folsom Dam Raise are in place and functional; this assumption is reflected in the hydrologic (inflow-outflow operations at Folsom Dam used in the hydraulic analysis), 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
- The with-project operations at Folsom Dam assume a target release of 160,000 cfs for the 200-year event

- 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
- Future development (mostly in the South Basin) was not included in the inventory and therefore without-project damages or with-project benefits associated with new structures (built after 2008) were not claimed
- For the alternatives analysis, the engineering performance (and by extension the damages, residual damages, and benefits) associated with index points 5 and 6 on the Sacramento River for Alternative 5 are the same as those for Alternative 1 since it is believed that there is minimal difference in hydraulics between Alternative 1 (improve levee on Sacramento River – South) and Alternative 5 (set back levee on Sacramento River – South); refinements to the hydraulic modeling may be completed for future analyses.

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 v.1.2.5) software. 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, hydraulic 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 the plan formulation process, 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, 0.1, 0.04, 0.02, 0.01, 0.005, and 0.002 exceedance probability 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 they resembled a HEC-RAS water surface profile (WSP) output file and could be imported into the HEC-FDA program. 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 as opposed to in-channel water surface elevations.

2.4.3 Computing Stage-Damage Curves in HEC-FDA

Each formatted WSP is composed of every grid cell containing a structure and the water surface elevations associated with each grid cell per 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. 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 sometimes used 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 the 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 could be flooded from a levee breach occurring at different locations but with 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 specifics source of flooding within the study area. The same index points were used for both the without-project and with-project analyses. Section 2.6 below describes in more detail the index points used and their locations.

2.5 ECONOMIC IMPACT AREAS (EIA)

The study area was divided into two sub-economic impact areas (EIA) primarily to facilitate the economic modeling and economic data collection. These sub-areas allow for the direct computation and reporting of consequences that result from flooding from a specific source under both the without-project and with-project conditions. The two sub-EIAs are:

- West Sacramento – North Basin
- West Sacramento – South Basin

Since the North and South Basins are considered hydraulically linked and both areas would experience flooding and therefore damages from a levee breach that occurred at any of the eight index points (see

Section 2.6 below for a discussion regarding index points), damages/benefits are reported for the two areas combined and not by sub-basin. Figure 4 shows the two sub-EIAs.

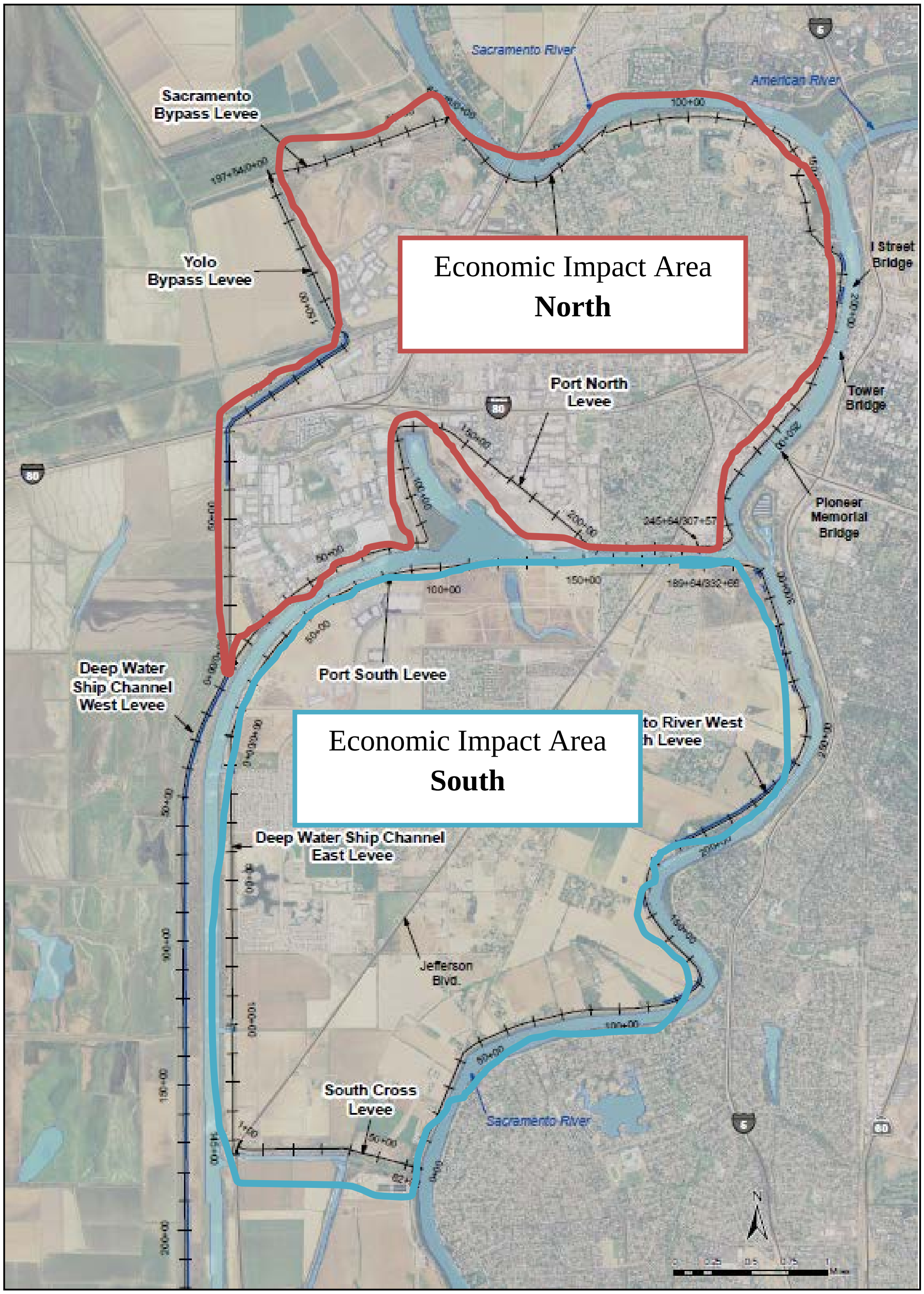


Figure 4: Economic Impact Areas (EIA)

2.6 HYDRAULIC REACHES & REPRESENTATIVE INDEX POINTS

Chapter 1 (Section 1.3) briefly noted that West Sacramento is at risk of flooding from multiple sources. For example, the North Basin sub-EIA could be potentially flooded from either the Yolo Bypass or the Sacramento River. 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.

The project delivery team (PDT) selected eight hydraulic/geotechnical reaches, with each containing one index point, for which to generate engineering data for use in the economic modeling. These index points were selected to aid in a more accurate description of residual flood risk in the study area. The eight index points used in the economic analysis are shown in Figure 5 and listed below.

- Index Point 1, Sacramento River, River Mile (RM) 61.7
- Index Point 2, Sacramento River, RM 60.2
- Index Point 3, Yolo Bypass, RM 43.1
- Index Point 4, Sacramento Bypass, RM 1.6
- Index Point 5, Sacramento River, RM 56.7
- Index Point 6, Sacramento River, RM 53.1
- Index Point 7, Deep Water Ship Channel (DWSC), RM 41.2
- Index Point 8, DWSC, RM 43.5

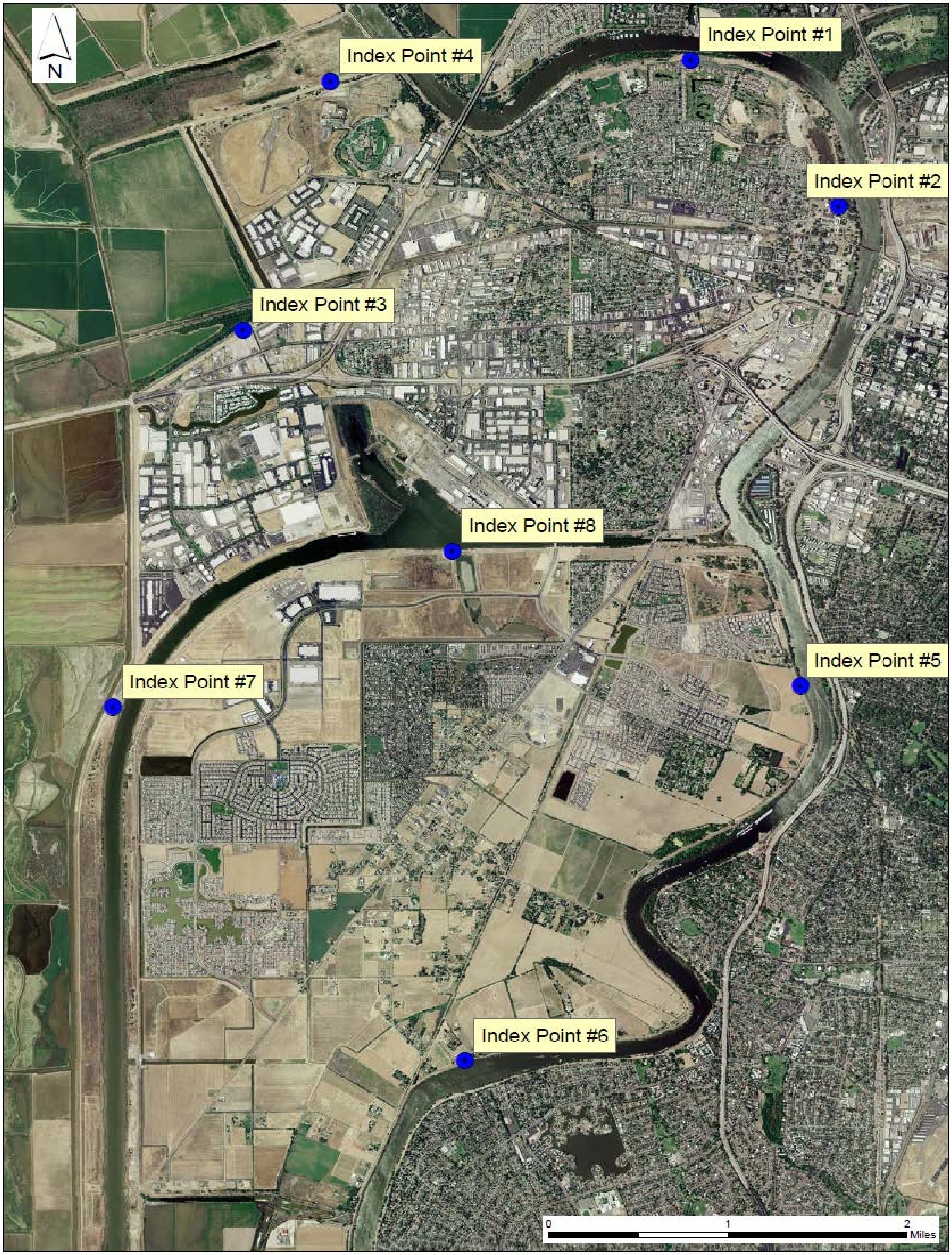


Figure 5: Index Points Used in the Economic Analysis

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

A base geographic information system (GIS) inventory with parcel attribute data for Yolo County was provided by the non-federal partner. Building attribute data were used to determine land use and valuation of structures and contents. Several field visits were taken to collect the base inventory data using standard USACE practices. The data collected included number of stories, foundation heights, building use (commercial, industrial, public, residential), 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).

Structure counts for the four main building categories are listed in Table 1 below, and represent those structures falling within the 500-year floodplain. There are close to 14,000 structures at risk of flooding.

Table 1: Number of Structures by Category in 0.2% Exceedance Probability Floodplain

DAMAGE CATEGORY/BUILDING TYPE	STRUCTURE COUNT
COMMERCIAL	365
INDUSTRIAL	424
PUBLIC	98
RESIDENTIAL	12,951
TOTAL	**13,838**

Figure 6 below shows the land-use types in the West Sacramento study area. The purple shaded area at the southern extent of the study area indicates agricultural land. A quantitative agricultural crop damage analysis was not completed for this study due to the relatively small amount of agricultural acreage in the study area. Additionally, when factoring in the chance of flooding by month (flooding is more likely to occur during the November to April time frame) in conjunction with the planting season for the various crops grown in the study area (mostly April to October), crop damages are expected to be minimal and an extremely small percentage (<1%) of the total damages.

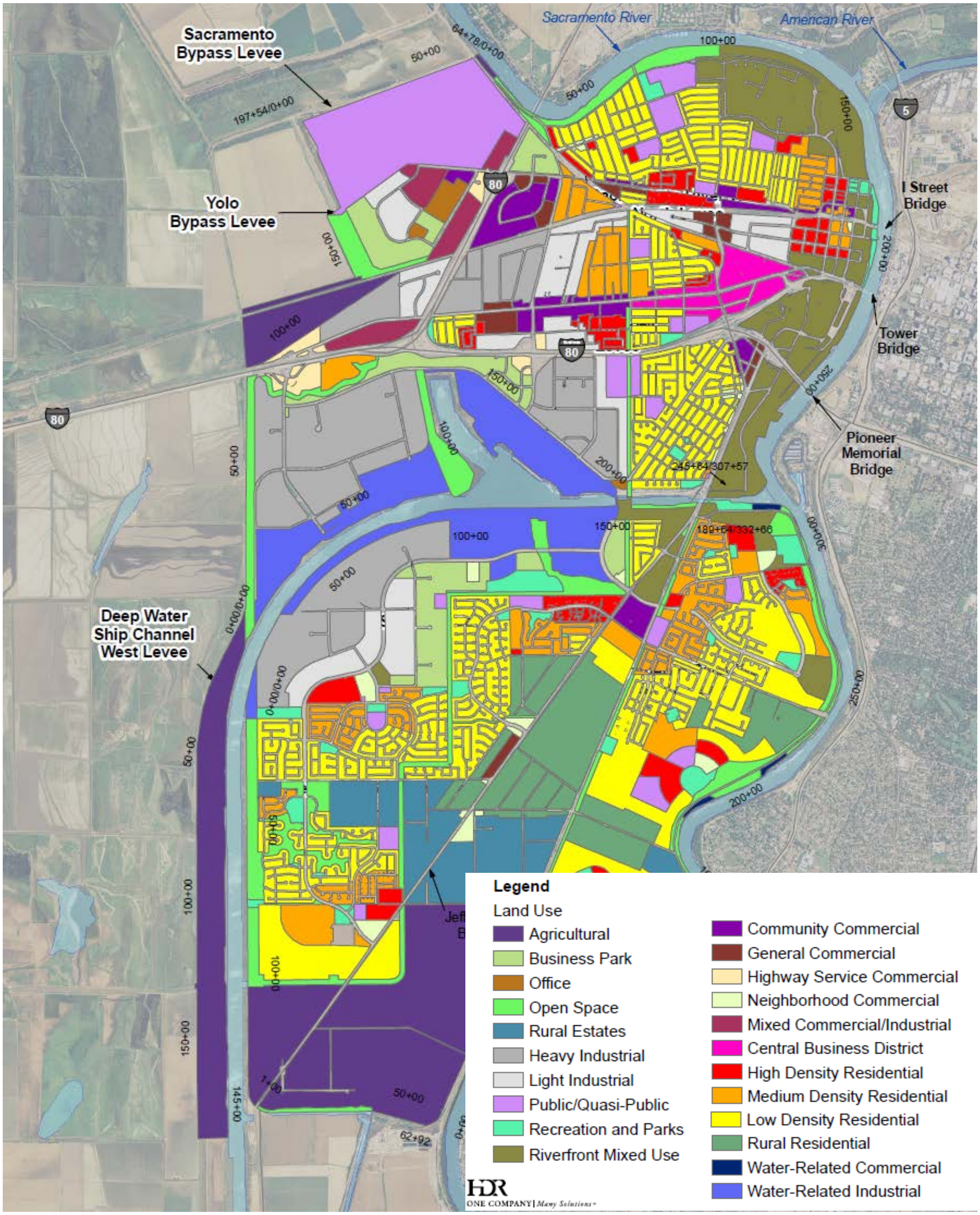


Figure 6: Land Use in West Sacramento

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 Value

Depreciated replacement value of structures were estimated based on 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.

For structures, the value of property at risk was estimated based on depreciated replacement values. The USACE flood risk management projects require that structures be valued using replacement costs minus depreciation. These values may differ from assessed values, sales or market values, reproduction costs or values determined by income capitalization. Depreciated replacement cost does not include land values. Depreciated replacement values were calculated using the formula,

Depreciated Replacement Value = (Square Footage of Structure)*(Cost per Square Foot)*(Remaining Value)

Remaining value is simply 100% minus the estimated depreciation (in percent).

2.7.2.2 Content Value

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 other USACE studies.

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 American River Watershed, Folsom Dam Raise and Modification Economic Reevaluation Report (ERR). Although the values and curves were developed specifically for structures in the American River Watershed study area, the results of the expert elicitation were extended to the West Sacramento study area in light of its proximity to Sacramento and the similarity of its structure types/construction types to those in Sacramento. 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.

Table 2 displays the value of damageable property for structures, contents, and combined. Estimated value of damageable property is over $4.8 billion.

Table 2: Value of Damageable Property - Structures and Contents

CATEGORY	TOTAL VALUE OF DAMAGEABLE PROPERTY (OCTOBER 2014 PRICE LEVEL, IN $1,000)		
	STRUCTURES	CONTENTS	TOTAL
COMMERCIAL	417,080	292,125	709,205
INDUSTRIAL	715,069	572,876	1,287,945
PUBLIC	163,949	73,894	237,843
RESIDENTIAL	1,741,359	870,680	2,612,039
TOTAL	**3,037,457**	**1,809,575**	**4,847,032**

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 depth of flooding data (per grid cell) from the FLO-2D modeling. Parcels/structures were then tied to a specific grid cell in which the parcel was located.

Foundation heights for each structure were estimated during numerous field visits. First-floor elevations were computed in HEC-FDA using the foundation height and an assumed ground elevation of zero feet. During the field inventory, first floor estimations 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 having a foundation height of 0.5 foot to 1.0 foot; structures on raised foundations may have foundation heights greater than 1.5 feet.

Using the ground elevation and foundation height data from the economic structure inventory in conjunction with the depth of flooding (in feet) data from the WSP, depths of flooding above the first floor of each structure for each exceedance probability event were computed within HEC-FDA. As explained previously, depths of flooding 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 exceedance probability events and were imported into the HEC-FDA model in the form of a water surface profile.

2.7.4 Automobiles

Damages to automobiles were developed based on a function of average value, number of vehicles, depth of flooding, and depth-percent damages loss. Values were determined for average used cars ($7,988 and updated to current price of $8,549) based on information from the U.S. Department of Transportation, Bureau of Transportation Statistics. The number of cars per residential unit (1.93) 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. It was assumed that, based on short evacuation time[1], about 50% of residential-based vehicles would be removed from the flood area

[1] The 50% assumption (percentage of autos moved out of the floodplain) used for automobiles was made based on the potential short warning time, the large number of people who live in the area, the relatively small number of major routes (highways) for evacuation, and EGM 09-04 which recommends a removal rate of 50.6% for areas where the warning time is less than 6 hours.

prior to a flood event. Table 3 below shows the estimated value of automobiles at risk of flooding in the study area.

Table 3: Value of Automobiles Potentially at Risk of Flooding

CATEGORY	VALUE OF DAMAGEABLE PROPERTY (OCTOBER 2014 PRICE LEVEL, IN $1,000S)
AUTOMOBILES	148,910

2.7.5 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. Since flood inundation in the area is deep and durations are long (exceeding three days), these curves were based on prior American River Watershed Studies (Natomas Basin) and the 1997 Morganza Study, areas where flooding is also deep and of long duration. 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 but used for this study.

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 West Sacramento GRR HEC-FDA models.

2.7.6 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 were based on data from 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 $8,549. 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. 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.

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 West Sacramento GRR HEC-FDA models. A summary of the uncertainty values by category is displayed in Table 4 below.

Table 4: Uncertainty Parameters Used in HEC-FDA Analysis

USE CATEGORY	UNCERTAINTY IN VALUE (INPUT TO HEC-FDA), IN PERCENT	
	STRUCTURE SD/MEAN	CONTENT SD/MEAN
Residential (SFR & MFR)	17	--
Mobile Homes	14	--
Office 2-Story	15	14
Office 1-Story	15	16
Retail	13	18
Retail-Furniture	13	20
Auto Dealerships	12	16
Hotel	11	3
Food Stores	11	27
Restaurants	15	3
Restaurants-Fast Food	12	13
Medical	12	46
Shopping Centers	10	23
Large Grocery Stores	11	4
Service (Auto)	15	4
Warehouse	15	31
Light Industry	16	19
Heavy Industry	13	31
Government	14	16
Schools	12	33
Religious	12	40
Recreation	13	13
Automobiles	15	N/A

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 Hydrology, Hydraulics, and Geotechnical Appendices.

2.8.1 Hydrologic Engineering Data Used in HEC-FDA

Hydrologic data is used in the HEC-FDA modeling. This includes the equivalent record length for each index point (1-8) and frequency-discharge curves for index point 2, 3, 4, 5, 6, and 7. For index points 1 and 8, only frequency-stage (and not frequency-discharge curves) were provided due to the difficulty in modeling discharges along these reaches. (The hydrologic data was provided to the Hydraulic Design Section for use in channel modeling using HEC-RAS program; frequency-stage curves were then developed and provided to the Economics and Risk Analysis Section by the SPK Hydraulic Design Section for use in the HEC-FDA models.) The hydrologic data and curves used in the economic analysis can be found in the West Sacramento GRR HEC-FDA models.

2.8.2 Hydraulic Engineering Data Used in HEC-FDA

The HEC-RAS model was used to determine stages in the channel, to model levee breakout locations, and to develop breakout hydrographs; the FLO-2D model was used 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 Hydraulics Appendix.

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 six index points (Index Points 2-7)
- Exceedance probability-stage curves with uncertainty for the without-project and with-project conditions for two index points (Index Points 1 and 8)
- Suites of floodplains for each index point; these were formatted from FLO-2D water surface elevation data for direct import into HEC-FDA

The hydraulic data and curves used in the economic analysis can be found in the West Sacramento GRR HEC-FDA models.

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, eight 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. Details about the development of the geotechnical fragility curves can be found in the

Geotechnical Appendix. The geotechnical data and curves used in the economic analysis can be found in the West Sacramento GRR HEC-FDA models.

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 equivalent record lengths. 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 stages (in-channel) was captured in the hydraulic rating curves, which were entered into HEC-FDA.

All of the data used to describe the uncertainty in the main engineering relationships can be found in the West Sacramento GRR HEC-FDA models.

3 - WITHOUT-PROJECT ANALYSIS & RESULTS

3.1 FUTURE WITHOUT-PROJECT CONDITION

Expected annual damages (EAD) and engineering project performance results for the without-project condition, which assumes that the Joint Federal Project (JFP), the Folsom Dam Raise Project, and the levee improvements along the Sacramento Bypass (CHP Academy) 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.

It is estimated that there are approximately 3,900 acres of developable land that is currently being used for agriculture in the southern portion of the study area. Future without project population growth and development were considered in terms of residual risk and EO 11988 (wise use of floodplains), but were not included in the economic damage analysis, as it would have little impact on project benefits and would not change NED identification, the recommended plan or economic feasibility of a given alternative. In addition, Sec 308 of WRDA 1990 (33 USC 2318) precludes USACE from justifying projects based on future development.

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. Table 5 displays key characteristics of flooding associated with specific annual chance exceedance events for the West Sacramento study area; characteristics are broken out by north and south basins. The flooding characteristics of a particular area for a particular exceedance probability event may differ depending on the assumed levee breach location (reach/index point). For example, the inundation extent and depth of flooding from a levee breach at Index Point 8 on the Deep Water Ship Channel will differ from the extent and depth from a breach at Index Point 3 on the Yolo Bypass. In general, flooding from any of the sources of risk (i.e., Sacramento River, Sacramento Bypass, Yolo Bypass, and Deep Water Ship Channel) 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 to derive a total number of structures at risk (Table 5 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). Estimates of the total number of structures at risk from flooding in each basin were presented in Chapter 2.

Table 5: Flooding Characteristics – West Sacramento Study Area

REACH/INDEX POINT	AVERAGE DEPTH OF FLOODING ABOVE 1ST FLOOR BY INDICATED ANNUAL CHANCE EXCEEDANCE (ACE) EVENT (IN FEET)			ESTIMATE OF NUMBER OF STRUCTURES INUNDATED BY INDICATED ANNUAL CHANCE EXCEEDANCE (ACE) EVENT		
	0.04	**0.01**	**0.002**	**0.04**	**0.01**	**0.002**
1 NORTH	4.7	7.7	11.3	6,499	6,635	6,669
1 SOUTH	4.4	12.5	15.8	6,577	7,095	7,096
2 NORTH	5.3	9.1	12.0	6,564	6,659	6,673
2 SOUTH	6.6	14.1	16.4	6,862	7,095	7,096
3 NORTH	10.1	12.0	13.5	6,661	6,668	6,679
3 SOUTH	15.9	17.4	18.5	7,096	7,100	7,100
4 NORTH	8.1	11.8	13.7	6,645	6,667	6,677
4 SOUTH	13.0	16.4	17.8	7,095	7,096	7,100
5 NORTH	6.9	9.9	10.9	6,580	6,652	6,669
5 SOUTH	13.4	16.4	17.4	7,095	7,100	7,100
6 NORTH	1.8	7.0	8.9	3,812	6,617	6,654
6 SOUTH	9.3	13.8	15.6	7,082	7,095	7,096
7 NORTH	2.3	7.0	9.4	5,233	6,617	6,654
7 SOUTH	8.2	13.6	15.9	7,068	7,095	7,096
8 NORTH	0	0	3.0	0	0	6,012
8 SOUTH	0	0	2.5	0	0	5,976

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 6 below shows the damages that may occur for a range of events within the West Sacramento study area; damages are displayed for each index point. These damage values include automobiles, structures, and contents.

Table 6: Annual Chance Exceedance (ACE) Event Damages by Index Point

INDEX POINT/REACH	ACE EVENT DAMAGES (IN $1,000s, OCTOBER 2014 PRICE LEVEL)						
	50%	10%	4%	2%	1%	0.5%	0.2%
1	1,049,353	1,459,581	2,319,027	2,632,441	3,310,743	3,555,300	3,671,358
2	1,170,516	2,237,508	2,586,092	2,806,084	3,476,503	3,566,494	3,651,863
3	1,512,554	3,332,540	3,683,960	3,759,996	3,832,358	3,879,293	3,930,207
4	113,112	2,745,007	3,442,365	3,631,110	3,781,351	3,843,305	3,913,954
5	1,288,525	3,201,613	3,351,915	3,446,528	3,666,467	3,691,719	3,748,872
6	904,898	1,327,493	2,198,564	2,751,113	3,380,761	3,518,455	3,583,804
7	0	512,497	2,137,749	2,733,231	3,150,867	3,308,739	3,396,251
8	0	0	0	0	0	271,874	1,795,585

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 of proposed FRM alternatives. (Expected annual damages, under existing without-project conditions, were estimated for each damage category and all impact areas. Note that without-project EAD is used as the metric in this analysis and not without-project *equivalent* annual damage. Equivalent annual damage reflects the damage value associated with the without-project condition over the period of analysis and under *changing* hydrology, hydraulic, and economic conditions in the study area. Essentially, equivalent annual damages are expected annual damages that have been converted to a single present worth value and then amortized over the analysis period using an appropriate discount rate. For purposes of this analysis, the study area is assumed to be fully built out, which implies future conditions are the same as existing conditions; therefore expected annual damages are equal to equivalent annual damages.)

Table 7 displays the EAD results for each index point and by major damage category. Since the economic incremental analysis is being performed from a system-wide/basin perspective, the EAD results for Index Point 3 on the Yolo Bypass (highlighted in Table 3) was used as the starting point without-project damages for which to measure with-project outputs; the greatest risk to West Sacramento, in terms of consequences, is associated with a breach at Index Point 3. Expected annual damages associated with a levee breach along the Yolo Bypass are estimated to be approximately $297 million.

Table 7: Expected Annual Damages (EAD) by Index Point

INDEX POINT	WITHOUT-PROJECT EXPECTED ANNUAL DAMAGES (EAD) (IN $1,000s, OCTOBER 2014 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS)					
	AUTO	COM	IND	PUB	RES	TOTAL
1	3,785	17,691	35,872	5,198	35,030	**97,578**
2	1,180	4,057	7,996	1,301	14,187	**28,719**
3	12,071	42,491	85,205	13,221	143,591	**296,579**
4	10	39	73	13	127	**262**
5	3,072	9,834	20,048	3,074	38,060	**74,089**
6	2,638	7,210	14,359	1,996	33,522	**59,725**
7	7,299	20,115	42,184	6,135	96,238	**171,971**
8	457	2,062	3,995	540	4,292	**11,346**

3.3.3 Annual Exceedance Probability (AEP) by Index Point

Annual exceedance probability (AEP) is a statistic used to describe the chance of flooding in any given year within a consequence 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.

Table 8 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 consequence area. Each area is considered to be protected by a system of levees, and flooding to the area could potentially occur from various sources. For example, in West Sacramento, flooding can occur from the Sacramento River, Sacramento Bypass, Yolo Bypass, or Deep Water Ship Channel; further, the risk of flooding along either water source varies depending on the location along the source. In this respect, the AEP values listed in Table 8 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 8: Annual Exceedance Probability (AEP) Results by Index Point

INDEX POINT	SOURCE	AEP	1/AEP
1	Sacramento River	0.055	1 in 18
2	Sacramento River	0.008	1 in 119
3	Yolo Bypass	0.089	1 in 11
4	Sacramento Bypass	0.000	N/A
5	Sacramento River	0.024	1 in 42
6	Sacramento River	0.041	1 in 25
7	DWSC	0.123	1 in 8
8	DWSC	0.012	1 in 83

3.3.4 Long-Term Risk by Index Point

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 9 displays the without-project long-term risk results for each index point.

Table 9: Long-Term Risk Results by Index Point

INDEX POINT	SOURCE	LONG-TERM RISK (%)		
		10 YEARS	30 YEARS	50 YEARS
1	Sacramento River	43	82	94
2	Sacramento River	8	22	35
3	Yolo Bypass	61	94	99
4	Sacramento Bypass	0	0	0
5	Sacramento River	21	51	70
6	Sacramento River	34	72	88
7	DWSC	75	98	100
8	DWSC	12	31	46

3.3.5 Assurance

Assurance, previously referred to 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 under the without-project condition are listed in Table 10 below. Taking Index Point 3 as an example, the information indicates that there is a 72% chance of passing the 10% flow event, but only a 23% chance of passing the 1% flow event.

Table 10: Assurance Results by Index Point

INDEX POINT	SOURCE	ASSURANCE (%)					
		10%	4%	2%	1%	0.4%	0.2%
1	Sac River	94	84	80	75	49	24
2	Sac River	100	93	91	88	65	31
3	Yolo BP	72	39	31	23	13	9
4	Sac BP	100	100	100	100	100	100
5	Sac River	96	89	87	85	72	65
6	Sac River	93	91	91	90	89	86
7	DWSC	53	22	17	12	9	9
8	DWSC	100	89	82	70	47	28

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 the West Sacramento basin by accounting for the multiple sources of flooding in the 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. However, this is not the case for the West Sacramento study area since flood risk in the basin/consequence area comes from more than one source. Under this scenario, benefits were computed first at each index point (source), and then estimated for the whole basin by comparing the risk at each index point and using the highest EAD/residual EAD. Table 11 below summarizes the method used to estimate benefits for the West Sacramento basin.

Table 11: Method of Benefit Calculation by Basin

BASIN	INDEX POINT	METHOD USED TO ESTIMATE BENEFITS
West Sacramento North and South Basins	1 (Sacramento River)	Compare risk at multiple index points and use highest EAD/residual EAD to estimate benefits
	2 (Sacramento River)	
	3 (Yolo Bypass)	
	4 (Sacramento Bypass)	
	5 (Sacramento River)	
	6 (Sacramento River)	
	7 (DWSC)	
	8 (DWSC)	

4.2 DESCRIPTION OF ALTERNATIVES

Summary descriptions of each alternative are presented below:

- **Alternative 1 –** This alternative improves levees in place. The FRM features of this alternative are summarized in Table 12 by reach.

Table 12: Alternative 1 FRM Features

Levee Reach	Seepage Measures	Stability Measures	Overtopping Measures	Erosion Protection Measures
NORTH BASIN				
Sacramento River North	Cutoff Wall	Cutoff Wall	Levee Raise	Bank Protection
Port North	---	---	---	---
Yolo Bypass	Cutoff Wall	Cutoff Wall	---	---
Sacramento Bypass Training Levee	---	---	---	Bank Protection
SOUTH BASIN				
Sacramento River South	Cutoff Wall, Seepage Berm	Cutoff Wall	---	Bank Protection
South Cross	Relief Wells	Stability Berm	Levee Raise	---
Deep Water Ship Channel East	Cutoff Wall	Cutoff Wall	Levee Raise	---
Deep Water Ship Channel West	Cutoff Wall	Cutoff Wall	Levee Raise	Bank Protection
Port South	Cutoff Wall	Cutoff Wall	Levee Raise	---

- **Alternative 3 –** Alternative 3, just like Alternative 1, improves levees in place. The FRM features of this alternative mirror those of Alternative 1, except this alternative also includes a control structure on the DWSC near the area where the South Cross Levee ties into the east levee of the DWSC. Table 13 summarizes the features of Alternative 3.

Table 13: Alternative 3 FRM Features

Levee Reach	Seepage Measures	Stability Measures	Overtopping Measures	Erosion Protection Measures
NORTH BASIN				
Sacramento River North	Cutoff Wall	Cutoff Wall	Levee Raise	Bank Protection
Port North	Closure Structure	Closure Structure	Closure Structure	Closure Structure
Yolo Bypass	Cutoff Wall	Cutoff Wall	---	---
Sacramento Bypass Training Levee	---	---	---	Bank Protection
SOUTH BASIN				
Sacramento River South	Cutoff Wall, Seepage Berm	Cutoff Wall	---	Bank Protection
South Cross	Relief Wells	Stability Berm	Levee Raise	---
Deep Water Ship Channel East	Cutoff Wall	Cutoff Wall	Levee Raise	---
Deep Water Ship Channel West	Cutoff Wall, Closure Structure	Cutoff Wall, Closure Structure	Levee Raise, Closure Structure	Bank Protection
Port South	Closure Structure	Closure Structure	Closure Structure	Closure Structure

- **Alternative 5 –** This alternative includes essentially the same features as Alternative 1, except a setback levee along the Sacramento River south reach replaces improving levees in place. Table 14 below summarizes the features of Alternative 5 by reach.

Table 14: Alternative 5 FRM Features

Levee Reach	Seepage Measures	Stability Measures	Overtopping Measures	Erosion Protection Measures
NORTH BASIN				
Sacramento River North	Cutoff Wall	Cutoff Wall	Levee raise	Bank Protection
Port North	---	---	---	---
Yolo Bypass	Cutoff Wall	Cutoff Wall	---	---
Sacramento Bypass Training Levee	---	---	---	Bank Protection
SOUTH BASIN				
Sacramento River South	Setback Levee, Cutoff Wall, Seepage Berm,	Setback Levee, Cutoff Wall, Seepage Berm	---	Setback Levee, Bank Protection
South Cross	Stability Berm, Relief Wells	---	Levee Raise	---
Deep Water Ship Channel East	Cutoff Wall	Cutoff Wall	Levee Raise	Bank Protection
Deep Water Ship Channel West	Cutoff Wall	Cutoff Wall	Levee Raise	---
Port South	Cutoff Wall	Cutoff Wall	Levee Raise	---

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 location. The benefits shown for each alternative in each table are the damages reduced at a respective index point/breach location, and represent the benefits to the 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.

For example, in Table 15, the benefits of Alternative 1 (with levee raises) are approximately $70 million. All of these benefits could be claimed if improvements to the Sacramento River (right 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 other water sources. Since there is still flood risk from other sources, the full $70 million in benefits cannot be claimed for the entire basin. (In the next section, the benefits for the basin as a whole are estimated by considering all sources of flood risk.)

Tables 15 through 22 display both the without-project and with-project data per index point. The first set is associated with outputs derived from improvements, except for any levee raises, made under Alternatives 1, 3, and 5, which for most index points are the same across each alternative; the second set is associated with outputs derived from improvements made under Alternatives 1, 3, and 5, which do include proposed levee raises; and the third set is associated with outputs derived from Alternative 3's control structure, whose impacts are measured at Index Point 8. It should be noted that at some index locations (IP 3 and IP 6) levee raises do not provide any additional benefit.

Table 15: Without-Project EAD and With-Project Residual EAD (IP1, right bank Sacramento River)

DAMAGE CATEGORY	INDEX POINT 1 – WEST SACRAMENTO BASIN (IN $1,000s, OCTOBER 2014 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS)						
	WITHOUT EAD	ALTERNATIVES 1/3/5 (NO LEVEE RAISES)		ALTERNATIVES 1/3/5 (WITH LEVEE RAISES)		ALTERNATIVE 3 CONTROL STRUCTURE	
		RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS
Autos	3,785	1,099	2,686	726	3,059	N/A	N/A
Commercial	17,691	5,102	12,589	2,613	15,078	N/A	N/A
Industrial	35,872	10,215	25,657	5,115	30,757	N/A	N/A
Public	5,198	1,525	3,673	833	4,365	N/A	N/A
Residential	35,030	10,834	24,196	8,884	26,146	N/A	N/A
TOTAL IP	**97,576**	**28,775**	**68,801**	**18,171**	**79,405**	N/A	N/A

Table 16: Without-Project EAD and With-Project Residual EAD (IP2, right bank Sacramento River)

DAMAGE CATEGORY	INDEX POINT 2 – WEST SACRAMENTO BASIN (IN $1,000s, OCTOBER 2014 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS)						
	WITHOUT EAD	ALTERNATIVES 1/3/5 (NO LEVEE RAISES)		ALTERNATIVES 1/3/5 (WITH LEVEE RAISES)		ALTERNATIVE 3 CONTROL STRUCTURE	
		RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS
Autos	1,180	499	681	411	769	N/A	N/A
Commercial	4,057	1,762	2,295	1,441	2,616	N/A	N/A
Industrial	7,996	3,441	4,555	2,824	5,172	N/A	N/A
Public	1,301	567	734	464	837	N/A	N/A
Residential	14,187	6,100	8,087	4,988	9,199	N/A	N/A
TOTAL IP	**28,721**	**12,369**	**16,352**	**10,128**	**18,593**	N/A	N/A

Table 17: Without-Project EAD and With-Project Residual EAD (IP3, left bank Yolo Bypass)

DAMAGE CATEGORY	INDEX POINT 3 – WEST SACRAMENTO BASIN (IN $1,000s, OCTOBER 2014 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS)						
	WITHOUT EAD	ALTERNATIVES 1/3/5 (NO LEVEE RAISES)		ALTERNATIVE 1/3/5 (WITH LEVEE RAISES)		ALTERNATIVE 3 CONTROL STRUCTURE	
		RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS
Autos	12,071	1,316	10,755	1,316	10,755	N/A	N/A
Commercial	42,491	4,453	38,038	4,453	38,038	N/A	N/A
Industrial	85,205	8,956	76,249	8,956	76,249	N/A	N/A
Public	13,221	1,405	11,816	1,405	11,816	N/A	N/A
Residential	143,591	16,179	127,412	16,179	127,412	N/A	N/A
TOTAL IP	**296,579**	**32,309**	**264,270**	**32,309**	**264,270**	N/A	N/A

Table 18: Without-Project EAD and With-Project Residual EAD (IP4, left bank Sacramento Bypass)

DAMAGE CATEGORY	INDEX POINT 4 – WEST SACRAMENTO BASIN (IN $1,000s, OCTOBER 2014 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS)						
	WITHOUT EAD	ALTERNATIVES 1/3/5 (NO LEVEE RAISES)		ALTERNATIVES 1/3/5 (WITH LEVEE RAISES)		ALTERNATIVE 3 CONTROL STRUCTURE	
		RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS
Autos	10	0	10	N/A	N/A	N/A	N/A
Commercial	39	0	39	N/A	N/A	N/A	N/A
Industrial	73	0	73	N/A	N/A	N/A	N/A
Public	13	0	13	N/A	N/A	N/A	N/A
Residential	127	0	127	N/A	N/A	N/A	N/A
TOTAL IP	**262**	**0**	**262**	N/A	N/A	N/A	N/A

Table 19: Without-Project EAD and With-Project Residual EAD (IP5, right bank Sacramento River)

DAMAGE CATEGORY	INDEX POINT 5 – WEST SACRAMENTO BASIN (IN $1,000s, OCTOBER 2014 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS)						
	WITHOUT EAD	ALTERNATIVES 1/3/5 (NO LEVEE RAISES)		ALTERNATIVES 1/3/5 (WITH LEVEE RAISES)		ALTERNATIVE 3 CONTROL STRUCTURE	
		RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS
Autos	3,072	153	2,919	N/A	N/A	N/A	N/A
Commercial	9,834	516	9,318	N/A	N/A	N/A	N/A
Industrial	20,050	1,034	19,016	N/A	N/A	N/A	N/A
Public	3,074	163	2,911	N/A	N/A	N/A	N/A
Residential	38,060	1,906	36,154	N/A	N/A	N/A	N/A
TOTAL IP	**74,089**	**3,772**	**70,318**	N/A	N/A	N/A	N/A

Table 20: Without-Project EAD and With-Project Residual EAD (IP6, right bank Sacramento River)

DAMAGE CATEGORY	INDEX POINT 6 – WEST SACRAMENTO BASIN (IN $1,000s, OCTOBER 2014 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS)						
	WITHOUT EAD	ALTERNATIVES 1/3/5 (NO LEVEE RAISES)		ALTERNATIVES 1/3/5 (WITH LEVEE RAISES)		ALTERNATIVE 3 CONTROL STRUCTURE	
		RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS
Autos	2,638	457	2,181	457	2,181	N/A	N/A
Commercial	7,210	1,396	5,814	1,396	5,814	N/A	N/A
Industrial	14,359	2,786	11,573	2,786	11,573	N/A	N/A
Public	1,996	391	1,605	391	1,605	N/A	N/A
Residential	33,522	5,680	27,842	5,680	27,842	N/A	N/A
TOTAL IP	**59,725**	**10,710**	**49,015**	**10,710**	**49,015**	N/A	N/A

Table 21: Without-Project EAD and With-Project Residual EAD (IP7, right bank DWSC)

DAMAGE CATEGORY	INDEX POINT 7 – WEST SACRAMENTO BASIN (IN $1,000s, OCTOBER 2014 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS)						
	WITHOUT EAD	ALTERNATIVES 1/3/5 (NO LEVEE RAISES)		ALTERNATIVES 1/3/5 (WITH LEVEE RAISES)		ALTERNATIVE 3 CONTROL STRUCTURE	
		RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS
Autos	7,299	706	6,593	433	6,866	N/A	N/A
Commercial	20,115	1,866	18,249	1,472	18,723	N/A	N/A
Industrial	42,184	3,887	38,297	3,024	39,160	N/A	N/A
Public	6,135	573	5,562	461	5,674	N/A	N/A
Residential	96,238	9,589	86,649	5,245	90,993	N/A	N/A
TOTAL IP	**171,971**	**16,621**	**155,350**	**10,635**	**161,416**	N/A	N/A

Table 22: Without-Project EAD and With-Project Residual EAD (IP8, left bank DWSC)

DAMAGE CATEGORY	INDEX POINT 8 – WEST SACRAMENTO BASIN (IN $1,000s, OCTOBER 2014 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS)						
	WITHOUT EAD	ALTERNATIVES 1/5 (NO LEVEE RAISES)		ALTERNATIVES 1/5 (WITH LEVEE RAISES)		ALTERNATIVE 3 CONTROL STRUCTURE	
		RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS
Autos	457	447	10	N/A	N/A	0	457
Commercial	2,062	1,957	105	N/A	N/A	0	2,062
Industrial	3,995	3,865	130	N/A	N/A	0	3,995
Public	540	513	27	N/A	N/A	0	540
Residential	4,292	4,231	61	N/A	N/A	0	4,292
TOTAL IP	**11,346**	**11,013**	**333**	N/A	N/A	**0**	**11,346**

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 23: Range of Benefits at IP1 (In $1000s, October 2014 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	97,576	--	--	--	--	--
Alts. 1/3/5 (no raises)	97,576	28,775	68,801	52,025	66,849	78,256
Alts. 1/3/5 (with raises)	97,576	18,171	79,405	66,111	78,205	88,799

Table 24: Range of Benefits at IP2 (In $1000s, October 2014 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	28,721	--	--	--	--	--
Alts. 1/3/5 (no raises)	28,721	12,369	16,352	9,510	12,734	20,270
Alts.1/3/5 (with raises)	28,721	10,128	18,593	10,785	15,977	23,388

Table 25: Range of Benefits at IP3 (In $1000s, October 2014 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	296,579	--	--	--	--	--
Alts. 1/3/5 (no raises)	296,579	32,309	264,270	179,842	245,576	326,757
Alt. 1/3/5 (with raises)	296,579	32,309	264,270	179,842	245,576	326,757

Table 26: Range of Benefits at IP4 (In $1000s, October 2014 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	262	--	--	--	--	--
Alts. 1/3/5	262	0	262	262	262	262

Table 27: Range of Benefits at IP5 (In $1000s, October 2014 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	74,089	--	--	--	--	--
Alts. 1/3/5	74,089	3,772	70,318	46,574	67,634	90,014

Table 28: Range of Benefits at IP6 (In $1000s, October 2014 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	59,725	--	--	--	--	--
Alts. 1/3/5 (no raises)	59,725	10,710	49,015	30,703	38,938	57,650
Alts. 1/3/5 (with raises)	59,725	10,710	49,015	30,703	38,938	57,650

Table 29: Range of Benefits at IP7 (In $1000s, October 2014 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	171,971	--	--	--	--	--
Alts. 1/3/5 (no raises)	171,971	16,621	155,350	89,481	147,943	209,237
Alts. 1/3/5 (with raises)	171,971	10,635	161,416	94,302	153,674	215,992

Table 30: Range of Benefits at IP8 (In $1000s, October 2014 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	11,346	--	--	--	--	--
Alts. 1/5	11,346	11,013	333	60	229	528
Alt. 3	11,346	0	11,346	2,191	5,402	12,744

4.5 WITH-PROJECT RESULTS: BENEFITS BY BASIN AND ALTERNATIVE

Table 31 below displays the benefits of each alternative from the perspective of looking at the West Sacramento area as one complete FRM system. The benefit values in these tables reflect improvements made to each source of flood risk within the basin. For example, FRM improvements are implemented to reduce flood risk associated with the Yolo Bypass, the Sacramento River, and the DWSC. This table reflects benefits that would be realized in the basin (i.e., in a single consequence area) by thinking of the flood problem from a broader system perspective rather than from just individual, isolated (index points/reaches) sources of flood risk.

As the results in Table 31 indicate, when looking at the West Sacramento basin (north and south) as one system, the benefits of each alternative are essentially the same. The rationale for this outcome is that under each alternative, all improvements are assumed to be made. Making this assumption results in the same residual flood risk (remaining risk) under each alternative (again, when looking at the West Sacramento area as a whole); this residual risk is associated with the “weakest link” in the system after all improvements are made, which under each alternative turns out to be Index Point 3 on the Yolo Bypass. The residual EAD at this location is approximately $32 million.

Table 31: Average Annual Benefits by Alternative (In $1,000s, October 2014 Price Level, 50-Year Period of Analysis)

BASIN	WITHOUT-PROJECT EAD	WITH-PROJECT EAD	AVERAGE ANNUAL BENEFITS
ALTERNATIVE 1/5 (NO LEVEE RAISES)	296,579	32,309 (residual EAD from IP 3)	264,270
ALTERNATIVE 1/5 (WITH LEVEE RAISES)	296,579	32,309 (residual EAD from IP 3)	264,270
ALTERNATIVE 3 (NO LEVEE RAISES)	296,579	32,309 (residual EAD from IP 3)	264,270
ALTERNATIVE 3 (WITH LEVEE RAISES)	296,579	32,309 (residual EAD from IP 3)	264,270

If looked at from a single index point/reach perspective, residual risk in terms of consequences and chance of flooding differs across index points/reaches. This can be seen in Tables 16 to 23 above for consequences and Tables 32 to 34 (in the next section) for chance of flooding.

4.6 WITH-PROJECT PERFORMANCE RESULTS: AEP, LONG-TERM RISK, & ASSURANCE

Tables 32 to 34 present the performance statistics under both without-project and with-project conditions for each index point 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, at Index Point 3 on the Yolo Bypass, without-project AEP is about 1 in 11. With improvements, flood risk as estimated at IP3 is reduced to about a 1 in 111 for all Alternatives.

The long-term risk statistics indicate that the chance of flooding over specified time periods is also reduced. For example, at IP3 the chance of flooding over a 10-year and 30-year period improves significantly with a project in place, going from a 61% and 94% chance for a 10-year and 30-year period without a project, respectively, to a 9% and 24% chance with a project in place.

The assurance results describe the chance a specified flow event would be contained within the channels of a water source (at a specific index point location). For example, for IP3 the chance of containing the 1% flow event under the without-project condition is about 23%. With improvements made to the Yolo Bypass, the chance of containing the 1% flow event increases to about 93% (all alternatives).

Table 32: Without-Project and With-Project Conditions

INDEX POINT	ANNUAL EXCEEDANCE PROBABILITY (AEP)[1]				
	WITHOUT	ALTS. 1 and 5 (NO LEVEE RAISES)	ALTS. 1 and 5 (WITH LEVEE RAISES)	ALT. 3 (NO LEVEE RAISES)	ALT. 3 (WITH LEVEE RAISES)
1	0.055	0.006	0.006	0.006	0.006
2	0.008	0.004	0.003	0.004	0.003
3	0.089	0.009	0.009	0.009	0.009
4	0.000	0.000	0.000	0.000	0.000
5	0.024	0.001	0.001	0.001	0.001
6	0.041	0.003	0.003	0.003	0.003
7	0.129	0.011	0.003	0.011	0.003
8	0.012	0.007	0.007	0.000	0.000

[1]Engineering performance results at index points 5 and 6 on the Sacramento River were assumed the same for Alternatives 1 and 5.

Table 33: Long-Term Risk -- Without-Project and With-Project Conditions

INDEX POINT	LONG-TERM RISK[1]									
	WITHOUT		ALTS. 1 AND 5 (NO LEVEE RAISES)		ALTS. 1 AND 5 (WITH LEVEE RAISES)		ALT. 3 (NO LEVEE RAISES)		ALT. 3 (WITH LEVEE RAISES)	
	10 Years	30 Years	10 Years	30 Years	10 Years	30 Years	10 Years	30 Years	10 Years	30 Years
1	43	82	5	15	5	15	5	15	5	15
2	8	22	4	10	3	9	4	10	3	9
3	61	94	9	24	9	24	9	24	9	24
4	0	0	0	0	0	0	0	0	0	0
5	21	51	1	3	1	3	1	3	1	3
6	34	72	3	10	3	10	3	10	3	10
7	75	98	3	9	3	9	3	9	3	9
8	12	31	7	20	7	20	0	0	0	0

[1]Engineering performance results at index points 5 and 6 on the Sacramento River were assumed the same for Alternatives 1 and 5.

Table 34: Assurance -- Without-Project and With-Project Conditions

INDEX POINT	ASSURANCE[1]														
	WITHOUT			ALTS. 1 AND 5 (NO LEVEE RAISES)			ALTS. 1 AND 5 (WITH LEVEE RAISES)			ALT. 3 (NO LEVEE RAISES)			ALT. 3 (WITH LEVEE RAISES)		
	4%	1%	.2%	4%	1%	.2%	4%	1%	.2%	4%	1%	.2%	4%	1%	.2%
1	84	75	24	97	96	28	97	96	28	97	96	28	97	96	28
2	93	88	31	98	97	48	98	97	63	98	97	48	98	97	63
3	39	23	9	93	93	92	93	93	92	93	93	92	93	93	92
4	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
5	89	85	65	99	98	97	99	98	97	99	98	97	99	98	97
6	91	90	86	98	98	97	98	98	97	98	98	97	98	98	97
7	22	12	9	96	93	90	96	93	90	96	93	90	96	93	90
8	89	70	28	96	79	33	96	79	33	99	99	99	99	99	99

[1]Engineering performance results at index points 5 and 6 on the Sacramento River were assumed the same for Alternatives 1 and 5.

4.7 SCREENING-LEVEL COST ESTIMATES: BY ALTERNATIVE & SOURCE OF FLOOD RISK

Preliminary, screening-level cost estimates were used for the alternatives carried forward into the Final Array. The costs were broken out by stream/reach/feature for this economic analysis and are summarized in Tables 35 to 37 below.

Table 35: Alternative 1 – Costs

REACH IMPROVEMENTS	RISK SOURCE THAT IMPROVEMENTS PROTECT AGAINST	ALTERNATIVE 1 (IN $1,000s, OCTOBER 2014 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS, 3.375% DISCOUNT RATE)			
		Project Costs	Average Annual Costs	O&M Costs	Total Average Annual Costs
Sacramento Bypass Training Dike	Sacramento Bypass	7,932	331	N/A	331
Yolo Bypass	Yolo Bypass	18,611	777	N/A	777
DWSC West - Yolo Bypass to DWSC Structure	Yolo Bypass	N/A	N/A	N/A	N/A
DWSC West – Yolo Bypass to DWSC Structure South 18 miles	Yolo Bypass	405,097	16,883	N/A	16,883
DWSC East	Yolo Bypass	114,608	4,777	N/A	4,777
DWSC East - Structure to South Levee	Yolo Bypass	N/A	N/A	N/A	N/A
Port North Levee	Sacramento River	N/A	N/A	N/A	N/A
Port South Levee	Sacramento River	25,719	1,072	N/A	1,072
Sacramento River North Levee - IMPROVE LEVEES	Sacramento River	573,269	23,892	N/A	23,892
Sacramento River South Levee - IMPROVE LEVEES	Sacramento River	558,301	23,268	N/A	23,268
Sacramento River South Levee – SET BACK LEVEES	Sacramento River	N/A	N/A	N/A	N/A
Stone Lock	Sacramento River	39,271	1,637	N/A	1,637
South Cross Levee	Yolo Bypass	68,524	2,856	N/A	2,856
DWSC Structure	Yolo Bypass	N/A	N/A	N/A	N/A
Total	**--**	**1,811,332**	**75,491**	**106**	**75,597**

Table 36: Alternative 3 - Costs

REACH IMPROVEMENTS	RISK SOURCE THAT IMPROVEMENTS PROTECT AGAINST	ALTERNATIVE 3 (IN $1,000s, OCTOBER 2014 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS, 3.375% DISCOUNT RATE)			
		Project Costs	Average Annual Costs	O&M Costs	Total Average Annual Costs
Sacramento Bypass Training Dike	Sacramento Bypass	8,815	367	N/A	367
Yolo Bypass	Yolo Bypass	21,063	886	N/A	879
DWSC West - Yolo Bypass to DWSC Structure	Yolo Bypass	91,990	3,834	N/A	3,834
DWSC West – Yolo Bypass to DWSC Structure South 18 miles	Yolo Bypass	N/A	N/A	N/A	N/A
DWSC East	Yolo Bypass	N/A	N/A	N/A	N/A
DWSC East - Structure to South Levee	Yolo Bypass	38,338	1,598	N/A	1,598
Port North Levee	Sacramento River	N/A	N/A	N/A	N/A
Port South Levee	Sacramento River	N/A	N/A	N/A	N/A
Sacramento River North Levee – IMPROVE LEVEES	Sacramento River	636,282	26,518	N/A	26,518
Sacramento River South Levee – IMPROVE LEVEES	Sacramento River	629,037	26,216	N/A	26,216
Sacramento River South Levee – SET BACK LEVEES	Sacramento River	N/A	N/A	N/A	N/A
Stone Lock	Sacramento River	44,313	1,847	N/A	1,847
South Cross Levee	Yolo Bypass	77,054	3,211	N/A	3,211
DWSC Structure	Yolo Bypass	519,429	21,648	N/A	21,648
Total	**--**	**2,066,321**	**86,118**	**1,306**	**87,424**

Table 37: Alternative 5 - Costs

REACH IMPROVEMENTS	RISK SOURCE THAT MPROVEMENTS PROTECT AGAINST	ALTERNATIVE 5 (IN $1,000s, OCTOBER 2014 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS, 3.375% DISCOUNT RATE)			
		Project Costs	Average Annual Costs	O&M Costs	Total Average Annual Costs
Sacramento Bypass Training Dike	Sacramento Bypass	7,932	331	N/A	331
Yolo Bypass	Yolo Bypass	18,611	776	N/A	776
DWSC West - Yolo Bypass to DWSC Structure	Yolo Bypass	N/A	N/A	N/A	N/A
DWSC West – Yolo Bypass to DWSC Structure South 18 miles	Yolo Bypass	405,097	16,883	N/A	16,883
DWSC East	Yolo Bypass	114,608	4,777	N/A	4,777
DWSC East - Structure to South Levee	Yolo Bypass	N/A	N/A	N/A	N/A
Port North Levee	Sacramento River	N/A	N/A	N/A	N/A
Port South Levee	Sacramento River	25,719	1,072	N/A	1,072
Sacramento River North Levee - IMPROVE LEVEES	Sacramento River	573,269	23,892	N/A	23,892
Sacramento River South Levee - IMPROVE LEVEES	Sacramento River	N/A	N/A	N/A	N/A
Sacramento River South Levee – SET BACK LEVEES	Sacramento River	516,317	21,519	N/A	21,519
Stone Lock	Sacramento River	39,271	1,637	N/A	1,637
South Cross Levee	Yolo Bypass	68,524	2,856	N/A	2,856
DWSC Structure	Yolo Bypass	N/A	N/A	N/A	N/A
Total	**--**	**1,769,348**	**73,741**	**106**	**73,847**

In addition to project first costs, interest during construction (IDC), which is an economic cost, was also factored into the net benefit/BCR analyses. For the Final Array of Alternatives, a gross assumption was made in regard to the construction period (number of years) used to calculate IDC. It was assumed that approximately $100 million dollars would be spent each year until the project was complete. Based on this assumption, the construction period for Alternative 1 is estimated to be 18 years; the construction period for Alternative 3 is estimated to be 21 years; and the construction period for Alternative 5 is estimated to be 17 years. Total NED costs, which include IDC, are shown in Table 38 for each alternative. It should be noted again that the analysis displayed in Table 38 are based on the price level and discount rate that prevailed at the time of the analysis.

Table 38: NED Costs by Alternative with IDC

Alternative	Costs (IN $1,000s, OCTOBER 2014 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS, 3.375% DISCOUNT RATE)					
	Project Costs	IDC	Total Costs	Average Annual Costs (AAC)	O&M Costs	Total AAC
Alt 1	1,811,332	788,930	2,600,262	108,371	106	108,477
Alt 3	2,066,321	985,796	3,052,116	127,203	1,306	128,509
Alt 5	1,769,348	703,002	2,472,350	103,040	106	103,146

4.8 NET BENEFIT AND BENEFIT-TO-COST ANALYSES: FROM SINGLE FRM FEATURE/REACH/INDEX POINT PERSPECTIVE

When evaluating the feasibility of a specific FRM feature, the costs and benefits of the feature can be compared to one another within a narrowly-defined perspective that addresses the flood risk reduction associated with building only that single FRM feature. This narrow perspective assumes that the benefits (i.e., damage reduction in a consequence area) of a particular feature are fully realized because there are no other sources of risk to be concerned with; that is, once this particular feature is built, the area's flood risk is reduced so significantly that no other measures are necessary.

In reality, the West Sacramento consequence area is vulnerable to multiple sources of flood risk. So while the area may benefit from making improvements to just one source of risk, the area does not realize full benefits until other FRM features are built since the area would still be vulnerable from other sources of risk. In this context, consequence areas having multiple sources of risk must rely on various FRM improvements located in various geographic locations and implemented over a period of time (phases) that work together. Analyzing a consequence area as one unit having multiple sources of flood risk underlies the rationale for performing incremental net benefit/BCR analyses. An incremental analysis allows for the demonstration, in a logical manner, of the incremental risk reduction that is achieved in the area of concern as various FRM components come on line through to the point at which the entire FRM system is finally addressed. Table 39 displays the FRM features, the sources of risk that the features protect against, and the index point used in the incremental benefit/cost analysis.

The incremental analysis is presented in Section 4.9.

Table 39: FRM Features, Sources of Risk, and Index Points Used in the Economic Analysis

Feature	Source of Risk FRM Feature Protects Against	Associated IP Used to Estimate Net Benefits Provided by Feature
Yolo Bypass	Yolo Bypass	IP3
DWSC West - Yolo Bypass to DWSC Structure	Yolo Bypass	IP7
DWSC West - DWSC Structure South 18 miles	Yolo Bypass	IP7
DWSC East	Yolo Bypass/DWSC	IP7, IP8
DWSC East - Structure to South Levee	Yolo Bypass/DWSC	IP7, IP8
Port North Levee	Yolo Bypass/DWSC	IP7, IP8
Port South Levee	Yolo Bypass/DWSC	IP7, IP8
Sacramento River North Levee - IMPROVE LEVEES	Sacramento River	IP1, IP2
Sacramento River South Levee - IMPROVE LEVEES	Sacramento River	IP5, IP6
Sacramento River South Levee – SET BACK LEVEES	Sacramento River	IP5, IP6
South Cross Levee	Yolo Bypass	IP7
DWSC Structure	Yolo Bypass	IP7, IP8

4.9 INCREMENTAL NET BENEFIT AND BENENFIT-TO-COST ANALYSES: FROM A BASIN-WIDE PERSPECTIVE BASED ON MAJOR SOURCE OF FLOOD RISK AND FRM MEASURE

Incremental net benefit/benefit-to-cost analyses were performed using the major sources of flood risk as the incremental unit. The cost information presented in Tables 35 to 37 was used to perform the analyses, which are presented in Table 40 below.

Addressing in tandem all sources of flood risk as part of an overall system is necessary in order to significantly reduce risk to the city of West Sacramento. Since the city is surrounded by levees, until all sources of risk are addressed West Sacramento would still face a relatively significant chance of flooding and incur catastrophic consequences (damages and possible loss of life) should flooding to the area take place. Table 40 shows how an alternative can be broken down into increments in order to attribute benefits to specific features of an alternative and to show how each feature of the West Sacramento FRM system works as one unit – with each feature progressively reducing residual risk to the area as they come on line. The analyses presented in Table 42 are intended to show how parts of the system work together, how residual risk is incrementally reduced as weak links in the system are strengthened, and how the alternatives differ from one another in terms of incremental net benefits.

Table 40: Incremental Net Benefit and Benefit-to-Cost Analyses for Alternatives 1, 3, and 5 (Values in $1,000s, October 2014 Price Level, 50-Year Period of Analysis, 3.375% 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: Improve Levees									
0 -- No Action	296,579	0	0	0	0	0	0	N/A	N/A
1 – Yolo Bypass, Sac Bypass Training Dike	171,971	124,608	124,608	2,078	2,078	122,530	122,530	60	60
2 - DWSC-W, DWSC-E, Port North, Port South, South Cross Levee	97,576	74,395	199,003	43,832	45,910	30,563	153,093	1.7	4.3
3 - Sac River North, Stone Lock, Sac River South IMPROVE LEVEES	32,309	65,267	264,270	62,461	108,371	2,806	155,899	1.0	2.4
Total			**264,270**	**108,371**	**108,371**	**155,899**	**155,899**		**2.4**
Alternative 3: Improve Levees + Control Structure									
0 -- No Action	296,579	0	0	0	0	0	0	N/A	N/A
1 – Yolo Bypass, Sac Bypass Training Dike	171,971	124,608	124,608	2,500	2,500	122,108	122,108	50	50
2 - DWSC-W limited, DWSC-E limited, South Cross Levee, DWSC Control Structure	97,576	74,395	199,003	54,401	56,901	19,994	142,102	1.4	3.5
3 - Sac River North, Stone Lock, Sac River South IMPROVE LEVEES	32,309	65,267	264,270	70,302	127,203	(5,035)	137,067	0.9	2.1
Total			**264,270**	**127,203**	**127,203**	**137,067**	**137,067**		**2.1**
Alternative 5: Improve Levees; Set Back Levee on Sacramento River (South)									
0 -- No Action	296,579	0	0	0	0	0	0	N/A	N/A
1 – Yolo Bypass, Sac Bypass Training Dike	171,971	124,608	124,608	2,010	2,010	122,598	122,598	62	62
2 - DWSC-W, DWSC-E, Port North, Port South, South Cross Levee	97,576	74,395	199,003	42,401	44,411	31,994	154,592	1.8	4.5
3 - Sac River North, Stone Lock, Sac River South SET BACK LEVEES	32,309	65,267	264,270	58,629	103,040	6,638	161,230	1.1	2.6
Total			**264,270**	**103,040**	**103,040**	**161,230**	**161,230**		**2.6**

The reaches were grouped into increments and the increments, as displayed in Table 40, were determined by assessing the without-project and with-project HEC-FDA AEP and EAD results. Walking through the increments, Table 40 shows that the first one, under all alternatives, would be to improve the Yolo Bypass levees since the economic HEC-FDA modeling indicates that this is the weakest point of the system in terms of the chance and consequences of flooding. Following the Yolo Bypass levee improvements, the next increment would be to either address the DWSC levee/South Cross Levee/Port improvements that provide protection against inundation water originating from the Yolo Bypass (Alternatives 1 and 5) or constructing the DWSC control structure (Alternative 3) that would also protect against inundation water originating from the Yolo Bypass. Once these improvements are made, the final increment would be to address the levees along the Sacramento River (all alternatives).

4.10 IDENTIFICATION OF NATIONAL ECONOMIC DEVELOPMENT (NED) PLAN

Based on the analysis presented above, all alternatives provide positive net benefits. Alternative 5 provides the most net benefits ($161 million) and therefore would be considered the NED Plan. The net benefit analysis for each alternative is summarized in Table 41 below; the net benefit curve is shown in Figure 7. Whichever alternative is recommended, additional refinements would have to be completed during future phases of this study in order to more fully optimize the return on investment (i.e., net benefits).

Table 41: Net Benefit and Benefit-to-Cost Analyses by Alternative (Values in $1,000s, October 2014 Price Level, 50-Year Period of Analysis, 3.375% Discount Rate)

Alternative	Average Annual Benefits	Average Annual Costs (AAC)	Annual O&M Costs	Total AAC	Net Benefits	Benefit-to-Cost Ratio (BCR)
Alt. 1 IMPROVE LEVEES	264,270	108,371	106	108,477	155,793	2.4
Alt. 3 IMPROVE LEVEES + Control Structure	264,270	127,203	1,306	128,509	135,761	2.1
Alt. 5 IMPROVE LEVEES + Set Back Levee on Sac River South	264,270	103,040	106	103,146	161,124	2.6

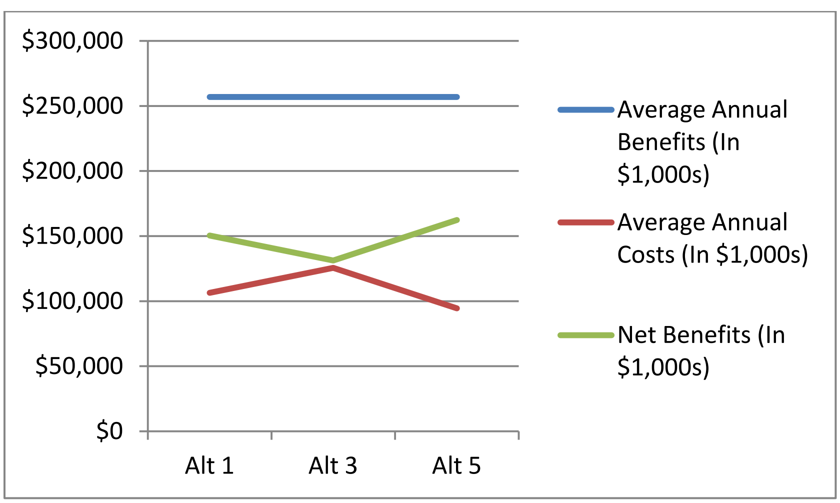


Figure 7: Net Benefit Curve (Green)

4.11 REFINEMENTS TO WITHOUT-PROJECT EAD, BENEFITS, COSTS, AND NET BENEFITS

In May of 2014 Alternative 5 was presented as the Tentatively Selected Plan (TSP) at the TSP Milestone Conference. This plan was then carried forward and presented as the Recommended Plan at the Agency Decision Milestone (ADM), which was held in May of 2015.

Comments and recommendations received during reviews leading up to and following the ADM initiated several refinements to the economic analysis. These include: 1) establishing a future without-project EAD value that accounts for a reduction in floodplain occupancy due to repetitive damages 2) estimating benefits of the Recommended Plan based on an assumption of reduced floodplain occupancy due to repetitive damages and 3) incorporating emergency cost-related damages and benefits into the economic analysis. The following sections explicitly address these topics.

From this point forward in this document, prices are updated to October 2015 levels[2] and discount rates have been updated to reflect the FY16 rate of 3.125%.

4.11.1 Without-Project EAD and Expected Benefits of the Recommended Plan (Alternative 5) – Assumption of Reduced Floodplain Occupancy Due to Repetitive Damages

When an area is flooded the value of damageable property in that area is likely to decrease, as some residents decide not to rebuild after a flood event. Residents that stay may not be able to rebuild completely, before the next flood occurs. As a result, the value of damageable property in the floodplain is reduced, at least temporarily, following each flood event. The reduction in damageable property value in the floodplain is an increasing function of the frequency and depth of flooding - more frequent or severe flooding leads to a more rapid decrease in damageable property value.

The HEC-FDA software is a USACE certified program and is used throughout the Corps to estimate future without-project damages and with-project benefits. Its primary limitation lies in its inability to account for the likelihood of reduced floodplain occupancy and therefore reduced value of damageable property following a flood event, without the user manually adjusting the data. By not taking into account the potential for reduced floodplain occupancy, the HEC-FDA damage and benefit estimates, especially for those areas that may be prone to frequent flooding and large consequences (damages), such as the West Sacramento area, may be overstated.

Since flooding under without-project conditions in the West Sacramento are relatively frequent (annual exceedance probability of 9%) and consequences are relative high (about $297 million), the project delivery team (PDT), with support from the vertical team, determined that an adjustment to the without-project equivalent annual damage (EAD) estimate should be made using HEC-FDA and the same primary assumptions from the Natomas @Risk Model (N@RM), which was approved for use in the Natomas Post Authorization Change Report (PACR) in 2010. An adjustment to future without-project EAD allows for a more accurate estimate of the benefits of the Recommended Plan (Alternative 5).

The N@RM model is an Excel-based @Risk model that used annual exceedence probabilities (AEPs) to infer the frequency of flooding over the period of analysis. Following each flood event during the period

[2] Equal to October 2014 levels because price indices remained flat year over year.

of analysis, a portion of the overall property value is removed from the floodplain, a process which accounts for the impact of repetitive damages on estimates of EAD.
The West Sacramento GRR PDT used the primary assumptions from the N@RM model[3] to adjust the West Sacramento without-project EAD using HEC-FDA. These assumptions stated that no more than 80 percent of the floodplain inhabitants would choose to re-build after one flood[4], and no more than 80 percent of those remaining would re-build again after another flood event. Accordingly it is assumed that approximately forty percent of those flooded more than once choose to relocate outside the consequence area. (Alternatives to relocation, such as raising houses, are not a viable option in West Sacramento due to the high depths of flooding.)

Given the without-project AEP of nine percent, the likelihood of the occurrence of multiple flood events during any given 20-year period is high. To reflect the decrease in the value of damageable property in the study area over twenty years and two flood events, the stage-damage curves for each damage category computed in HEC-FDA under the without-project condition were copied to the most likely future without-project condition and adjusted to reflect a forty percent decrease in damages at every stage. Equivalent annual damages at the current discount rate of 3.375% were then calculated and is estimated to be approximately $219 million, which is a 26 percent reduction from the unadjusted without-project EAD of $297 million. The decrease in without-project EAD indicates that average annual benefits of the Recommended Plan (Alternative 5) would decrease from approximately $264 million to about $187 million (29% reduction). Table 42 below displays the adjusted average annual benefits of the Recommended Plan.

Table 42: Adjusted Damages and Benefits of Recommended Plan (Values in $1000s, October 2015 Price Level, 50-Year Period of Analysis)

RECOMMENDED PLAN (ALTERNATIVE 5)		
Adjusted Without-Project EAD	**With-Project Residual EAD**	**Average Annual Benefits**
219,152	32,309	186,843

4.11.2 Damages and Benefits Associated with Emergency Cost Loss Categories

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 West Sacramento 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

[3] While N@RM was developed and approved for use in the Natomas basin, flooding patterns in the West Sacramento basin are similar to those in Natomas, which is just a few miles away. Both study areas are surrounded by water on all sides resulting in deep flooding from multiple sources including the Sacramento and American Rivers. Both basins can also be viewed as "systems" from the standpoint that all flood sources surrounding the basin result in similar flooding characteristics affecting the entire study area.
[4] Eighty percent rebuild assumption based on empirical evidence of rebuilding in New Orleans post Hurricane Katrina. Flooding in Natomas and West Sacramento would be deep flooding similar to what was experienced during Hurricane Katrina.

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 5 – the Recommended Plan) associated with clean-up and TERHA costs are summarized in Table 43.

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 West Sacramento 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.

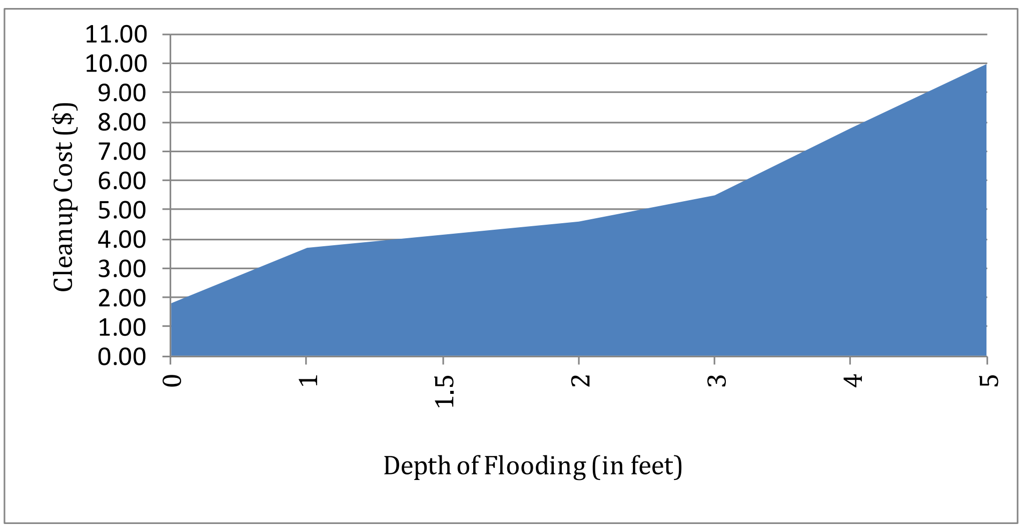


Figure 8: West Sacramento GRR, Dollar-Per-Square Foot Clean-Up Costs as a Function of Depth of Flooding

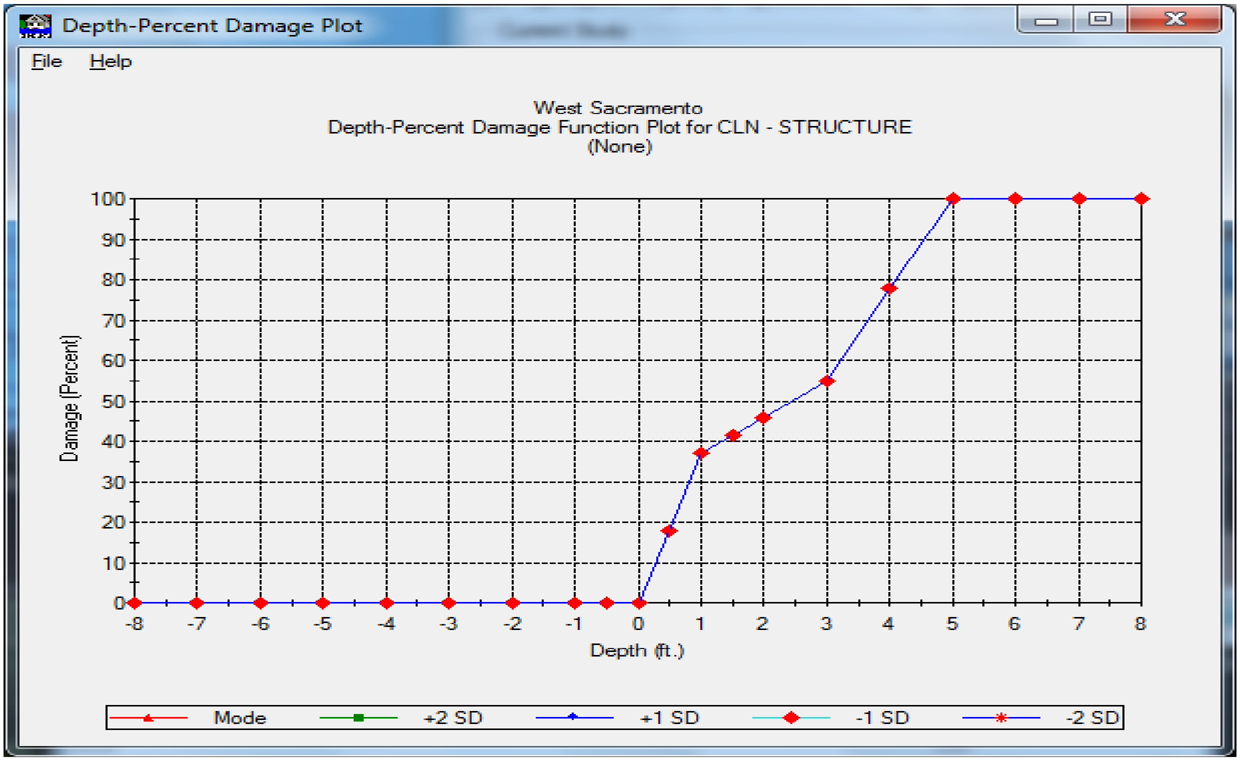


Figure 9: West Sacramento GRR, Depth-Percent Damage Curve for Clean-Up Costs Used in HEC-FDA Analysis

Temporary Evacuation, Relocation, and Housing Assistance Costs (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.

Costs 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. (Rents for West Sacramento were not used since the city would be flooded and people would be evacuating the area.) 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.

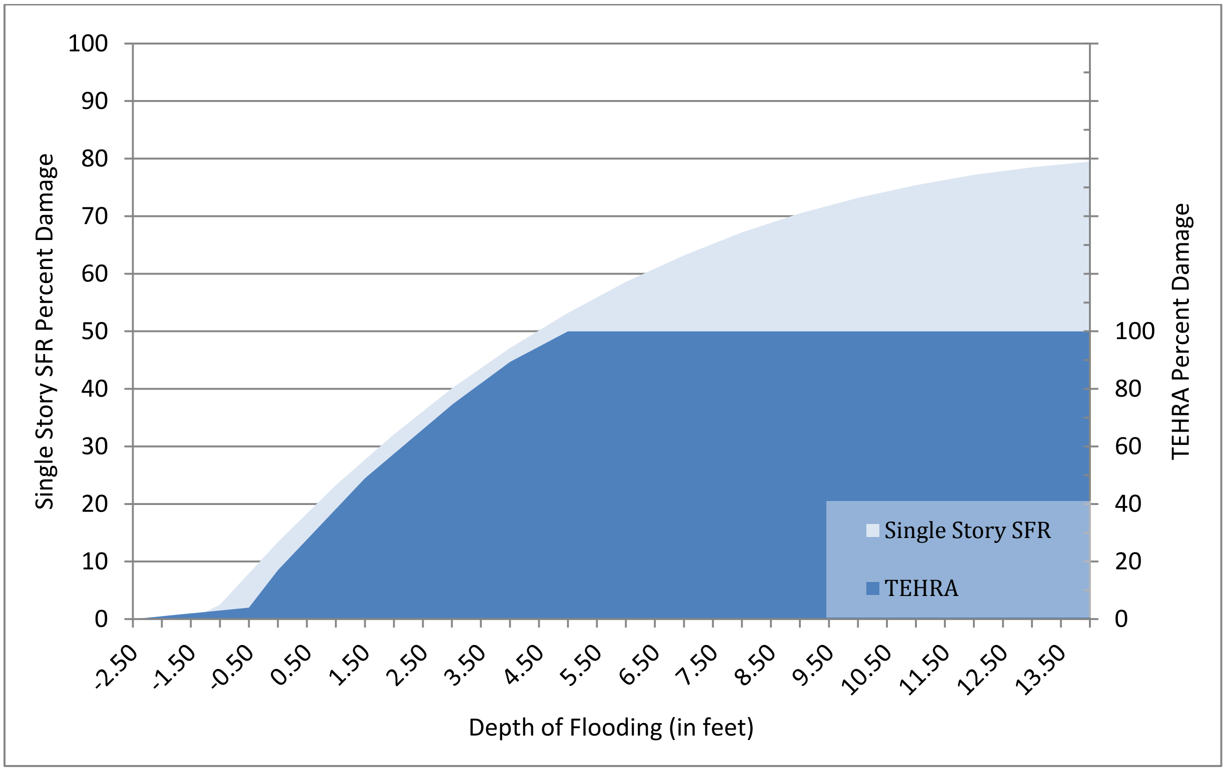


Figure 10: West Sacramento GRR, Depth-Percent Damage Curve for TERHA Overlaid onto Depth-Percent Damage Curve for One-Story Residential

Expected Annual Damages (EAD) and Benefits: Expected annual damages (EAD) under the without-project condition and expected annual benefits under the with-project conditions were computed using HEC-FDA. Damages and benefits were computed using the engineering data from Index Point 3 (Yolo Bypass), 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. It is also important to note that EAD for emergency cost losses was computed using the same reduced floodplain occupancy/property value assumptions that were used to adjust without-project EAD for structures and contents (Section 4.11.1).

Table 43 below displays the results of the HEC-FDA analysis. Expected annual damages associated with clean-up activities are estimated to be approximately $19.9 million; EAD associated with TERHA is estimated to be approximately $7.8 million. Total EAD for both emergency cost categories combined is estimated to be around $27.7 million. The Recommended Plan (Alternative 5) reduces the frequency of flooding to West Sacramento and therefore prevents a significant amount of emergency-related costs from being incurred. Under the Recommended Plan, EAD would be reduced by nearly 86%, or to about $4 million. Therefore the average annual benefits are approximately $23.7 million. The prevention of clean-up and TEHRA costs comprise about 11% of total benefits for the West Sacramento area.

Table 43: Expected Annual Damages and Benefits – West Sacramento Clean-Up and TERHA Costs (In $1,000s, October 2015 Price Level)

Category	Without-Project EAD			With-Project Residual EAD Recommended Plan (Alternative 5)			Average Annual Benefits
	North Basin	South Basin	Total	North Basin	South Basin	Total	
Clean-UP	14,306	5,596	19,902	2,009	865	2,874	17,028
TERHA	4,980	2,852	7,832	705	428	1,133	6,699
Total	**19,286**	**8,448**	**27,734**	**2,714**	**1,293**	**4,007**	**23,727**

4.11.3 Refined Cost Estimate for the Recommended Plan (Alternative 5)

The cost estimate for the Recommended Plan was refined and certified by the Cost Center of Expertise (MCX) following the Agency Decision Milestone (ADM). Table 44 below summarizes the updated cost estimate. IDC is not included in Table 44, but it is included in the Final Net Benefits and BCR shown in Table 45. Note that the Port North Levee reach improvement was removed from the plan during the final analysis as it did not have incremental benefits.

Table 44: Refined cost estimate for the Recommended Plan (Alternative 5)

REACH IMPROVEMENTS	RISK SOURCE THAT MPROVEMENTS PROTECT AGAINST	ALTERNATIVE 5 (IN $1,000s, OCTOBER 2015 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS, 3.125% DISCOUNT RATE)			
		Project Costs[1]	Average Annual Costs	O&M Costs	Total Average Annual Costs[2]
Sacramento Bypass Training Dike	Sacramento Bypass	7,868	313	N/A	1,444
Yolo Bypass	Yolo Bypass	28,745	1,144	N/A	1,296
DWSC West - Yolo Bypass to DWSC Structure	Yolo Bypass	N/A	N/A	N/A	N/A
DWSC West – Yolo Bypass to DWSC Structure South 18 miles	Yolo Bypass	311,234	12,385	N/A	13,834
DWSC East	Yolo Bypass	123,467	4,913	N/A	5,490
DWSC East - Structure to South Levee	Yolo Bypass	N/A	N/A	N/A	N/A
Port North Levee	Sacramento River	N/A	N/A	N/A	N/A
Port South Levee	Sacramento River	8,222	327	N/A	1,061
Sacramento River North Levee - IMPROVE LEVEES	Sacramento River	278,289	11,074	N/A	11,651
Sacramento River South Levee - IMPROVE LEVEES	Sacramento River	N/A	N/A	N/A	N/A
Sacramento River South Levee – SET BACK LEVEES	Sacramento River	364,386	14,500	N/A	16,457
Stone Lock	Sacramento River	31,463	1,252	N/A	1,371
South Cross Levee	Yolo Bypass	29,215	1,163	N/A	2,573
DWSC Structure	Yolo Bypass	N/A	N/A	N/A	N/A
Total	**--**	**1,182,889**	**47,071**	**106**	**47,177**

[1]Costs associated with cultural resource preservation ($7.639M) excluded from economic analysis as per USACE policy
[2]Does not include Interest During Construction (IDC). IDC is included in the Final Net Benefits and BCR shown below in Table 45

4.11.4 Final Updated Net Benefit/BCR Analyses for the Recommended Plan (Alternative 5)

Table 45 shows the updated net benefit/BCR analyses for the Recommended Plan (Alternative 5).The values in this table reflect the adjusted without-project EAD and benefits of the Recommended Plan (summarized in Section 4.11.1), the inclusion of benefits associated with the prevention of emergency cost losses (summarized in Section 4.11.2), and the updated cost estimate of the Recommended Plan (summarized in Section 4.11.3).

Net benefits of the Recommended Plan are approximately $146 million. The benefit-cost ratio (BCR) for the Recommended Plan is 3.2-to-1.

Table 45: Final Net Benefits and Benefit-to-Cost Ratio – Recommended Plan (Alternative 5) (Dollar Values in $1,000s, October 2015 Price Level, 50-Year Period of Analysis, 3.125% Discount Rate)

Recommended Plan (Alternative 5)	
Without-Project (EAD) Damages and With-Project Benefits	
Structures/Contents/Autos	219,152
Emergency Costs	27,734
Total	**246,886**
With-Project Residual EAD	
Structures/Contents/Autos	32,309
Emergency Costs	4,007
Total	**36,316**
Average Annual Benefits (AAB)	
Structures/Contents/Autos	186,843
Emergency Costs	23,727
Total AAB	**210,570**
Costs	
Total First Costs[1]	1,182,889
Interest During Construction	442,752
Total Costs	1,625,641
Average Annual Costs	64,689
OMRRR Costs	106
Total Average Annual Costs	**64,795**
Net Benefit and BCR Analyses	
Net Benefits	**145,775**
Benefit-to-Cost Ratio (BCR)	**3.2**

[1] Costs associated with cultural resource preservation ($7.639M) excluded from economic analysis as per USACE policy

West Sacramento GRR
Attachments to Economic Appendix

Attachment 1 - Supporting Data (Floodplain Plates, HEC-FDA Input Data)

Attachment 2 – Certified Cost Estimates

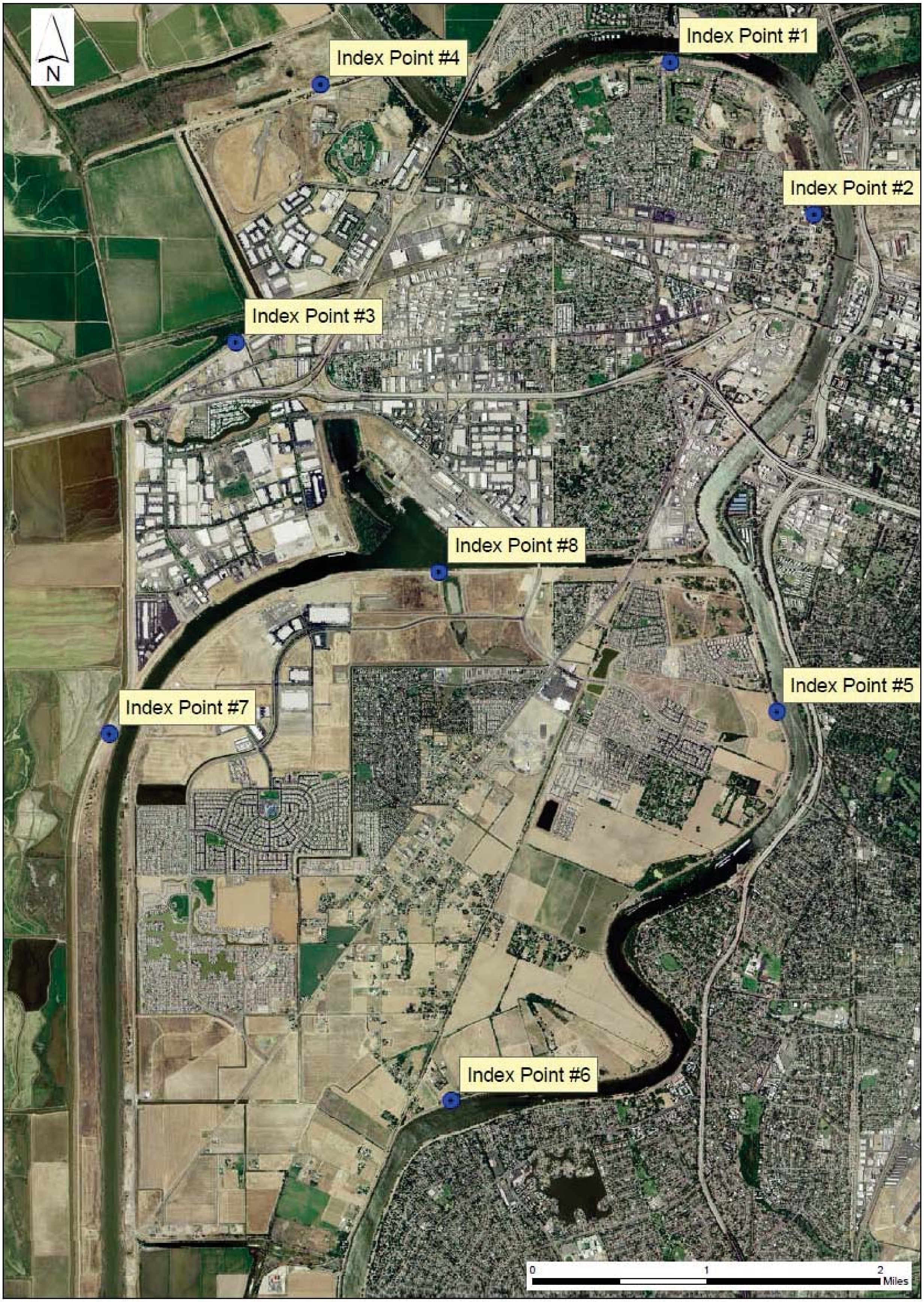
Attachment 3 - Other Social Effects (OSE) Analysis & Regional Economic Development (RED) Analysis

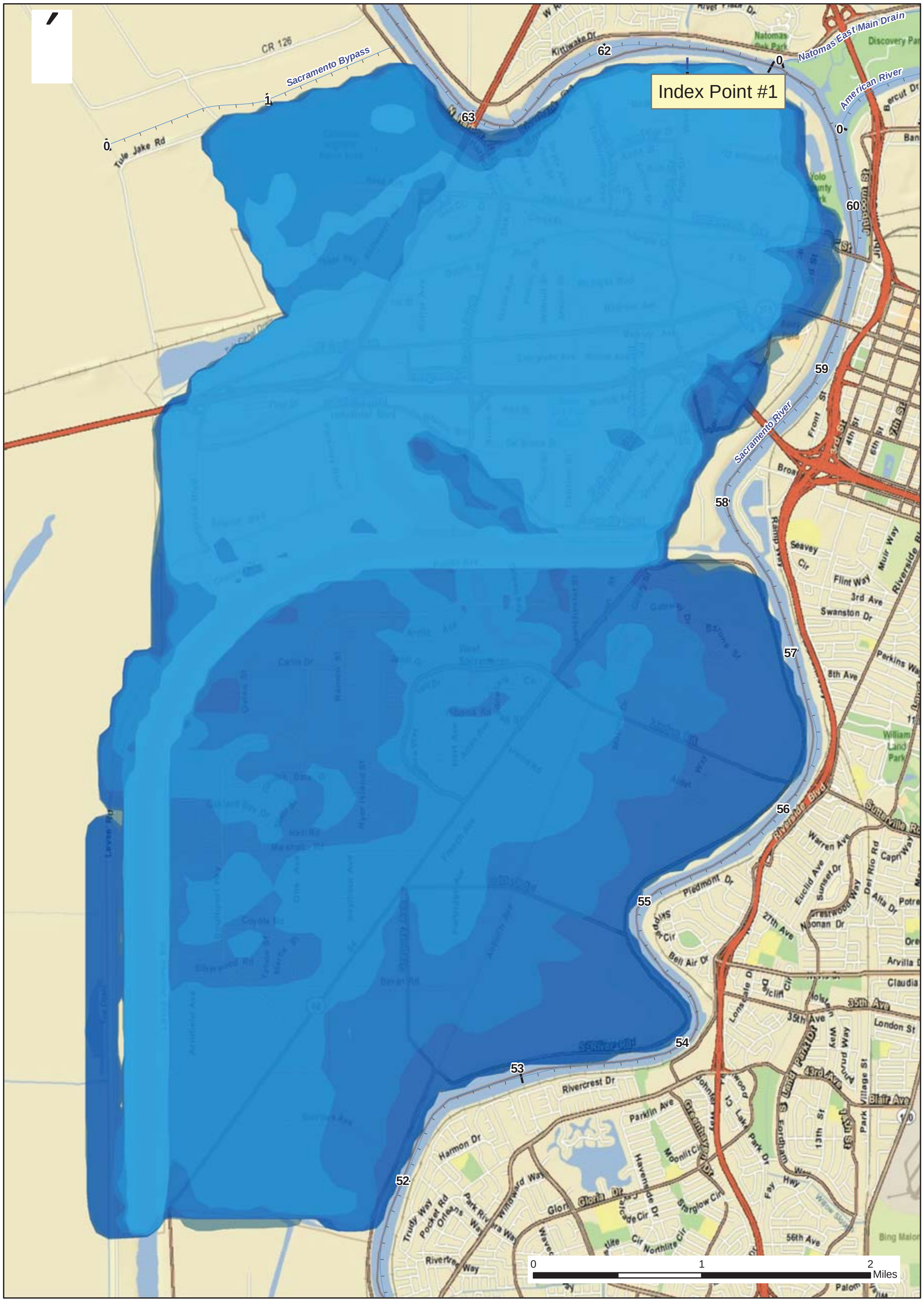
West Sacramento GRR
Economic Appendix

Attachment:

Engineering Supporting Data

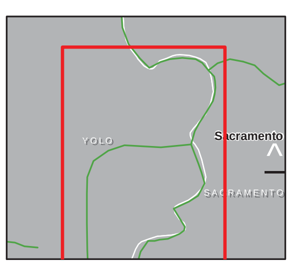
ENCLOSURE 1
FLOODPLAINS





Legend

2-yr Sac Break IP 1	100-yr Sac Break IP 1
10-yr Sac Break IP 1	200-yr Sac Break IP 1
25-yr Sac Break IP 1	500-yr Sac Break IP 1
50-yr Sac Break IP 1	

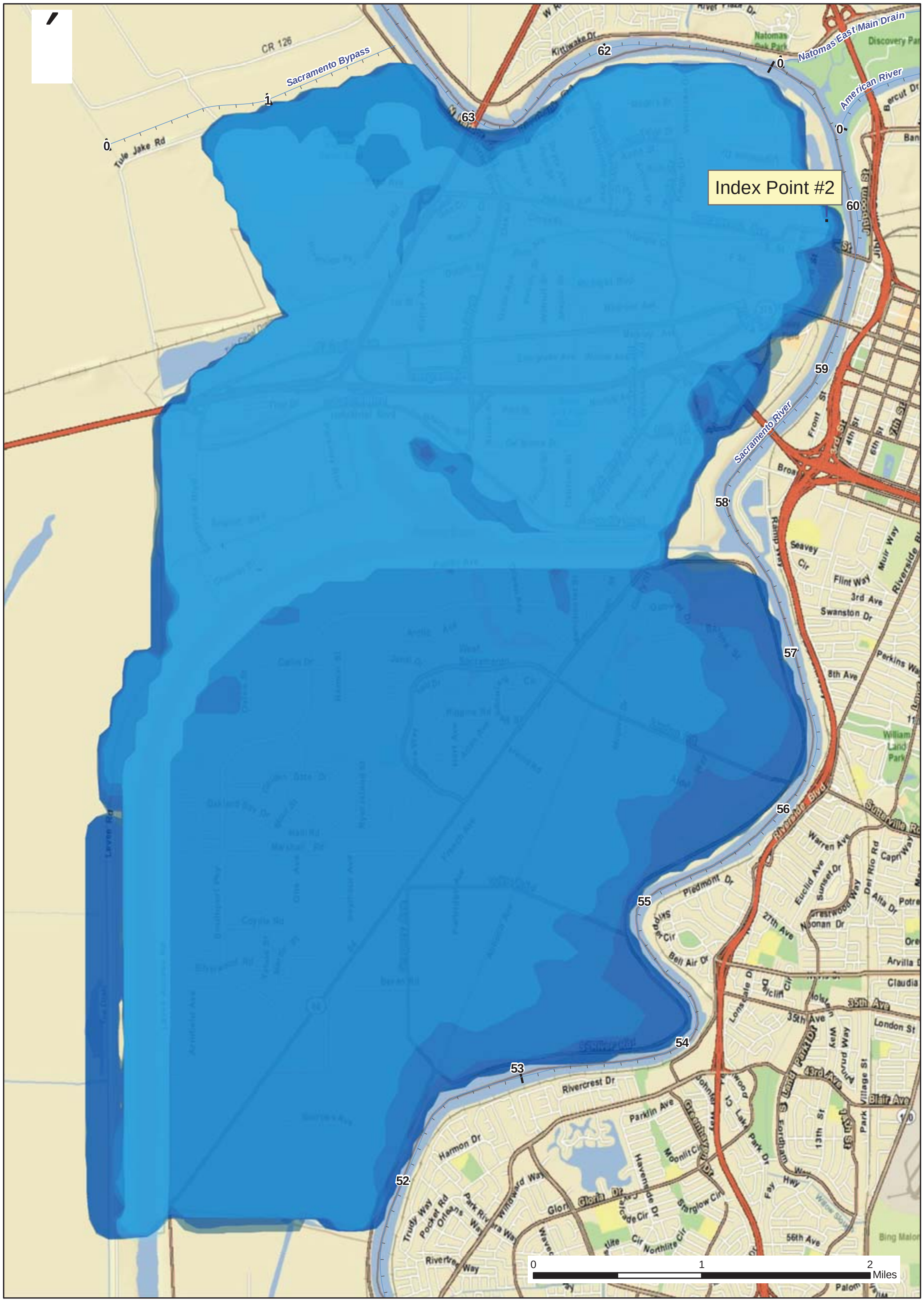


West Sacramento GRR
Yolo, Solano Counties, California

2-Yr Thru 500-yr Floodplains
Index Point 1
Sacramento River RM 61

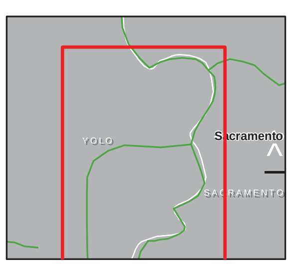
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

FEB 2011 Prepared by J.S.M and J.J.S. PLATE 1



Legend

2-yr Sac Break IP 2	100-Yr Sac Break IP 2
10-Yr Sac Break IP 2	200-Yr Sac Break IP 2
25-Yr Sac Break IP 2	500-Yr Sac Break IP 2
50-Yr Sac Break IP 2	



West Sacramento GRR
Yolo, Solano Counties, California

2-Yr Thru 500-yr Floodplains
Index Point 2
Sacramento River RM 60

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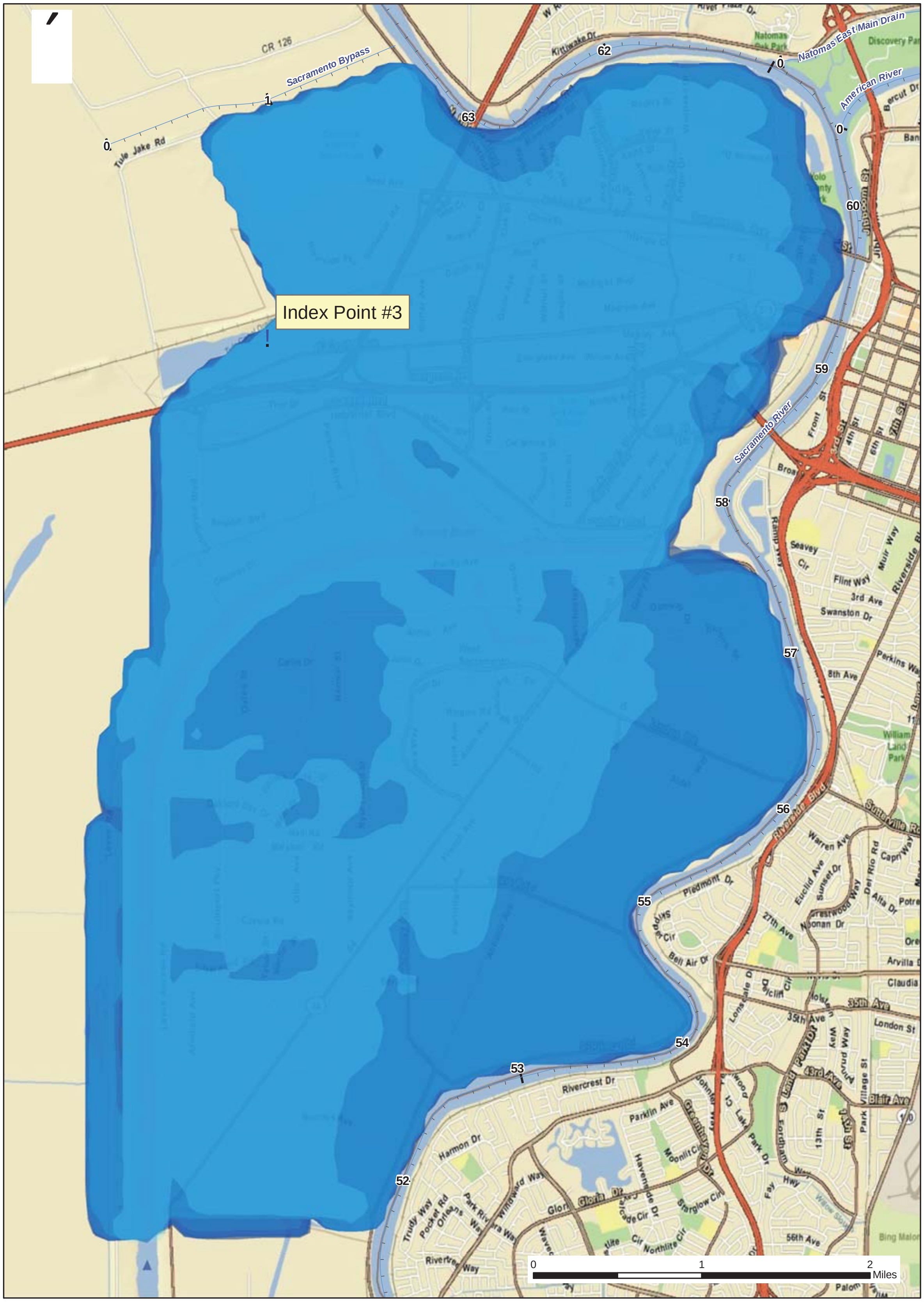
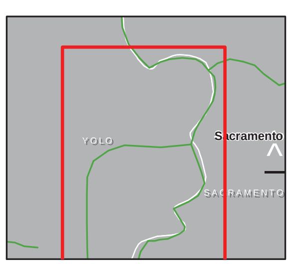
SACRAMENTO DISTRICT

FEB 2011 Prepared by J.S.M and J.J.S. PLATE 1



Legend

2-Yr Yolo Break IP 3	100-Yr Yolo Break IP 3
10-Yr Yolo Break IP 3	200-Yr Yolo Break IP 3
25-Yr Yolo Break IP 3	500-Yr Yolo Break IP 3
50-Yr Yolo Break IP 3	



West Sacramento GRR
Yolo, Solano Counties, California

2-Yr Thru 500-yr Floodplains
Index Point 3
Yolo Bypass RM 42.6

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SACRAMENTO DISTRICT

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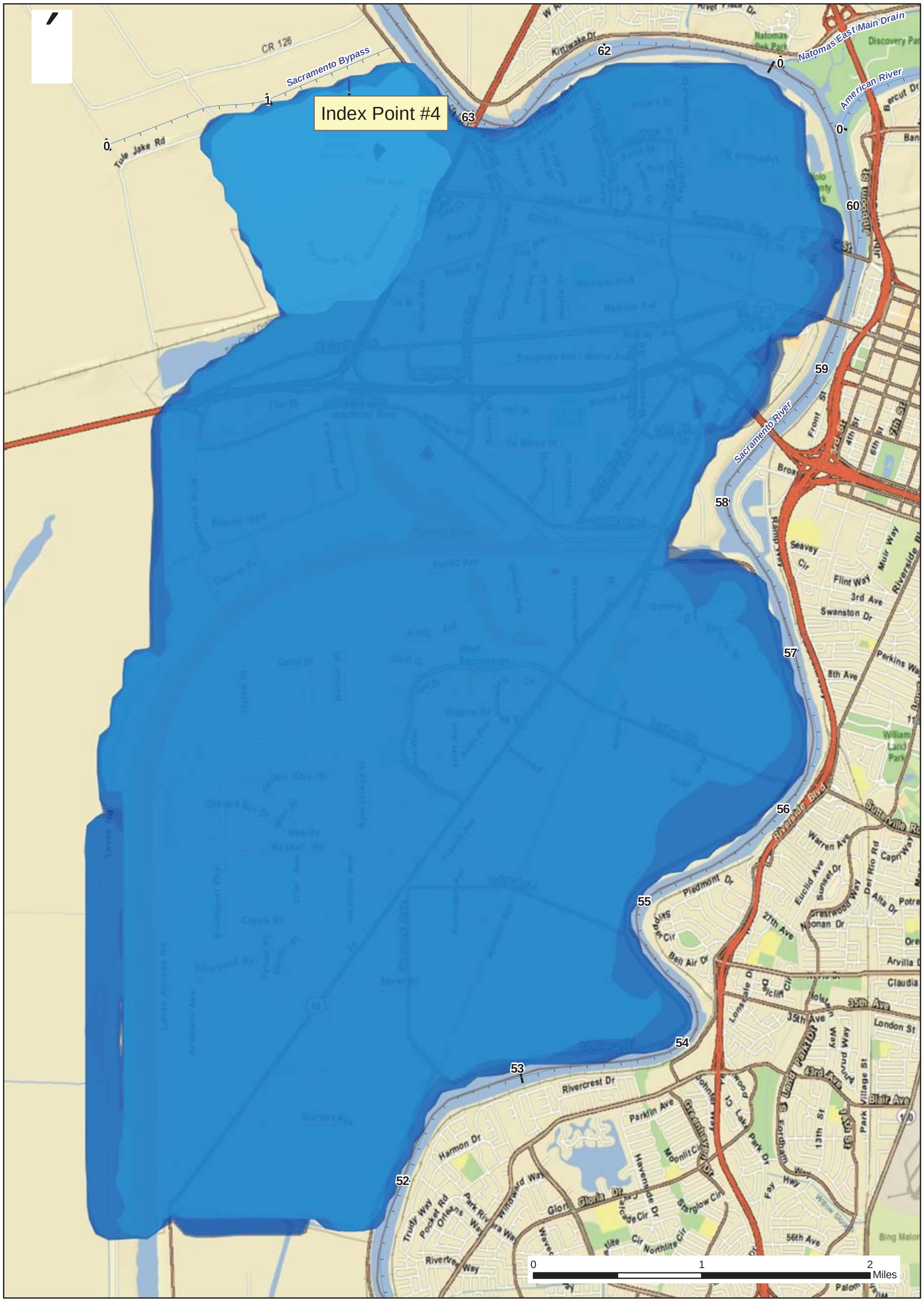
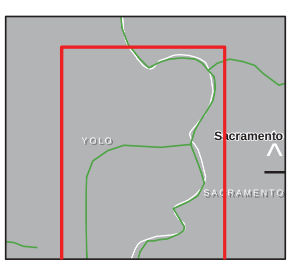


Legend

2-Yr Sac Byp Break IP 4	100-Yr Sac Byp Break IP 4
10-Yr Sac Byp Break IP 4	200-Yr Sac Byp Break IP 4
25-Yr Sac Byp Break IP 4	500-Yr Sac Byp Break IP 4
50-Yr Sac Byp Break IP 4	



West Sacramento GRR
Yolo, Solano Counties, California

2-Yr Thru 500-yr Floodplains
Index Point 4
Sacramento Bypass RM 1.49

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SACRAMENTO DISTRICT

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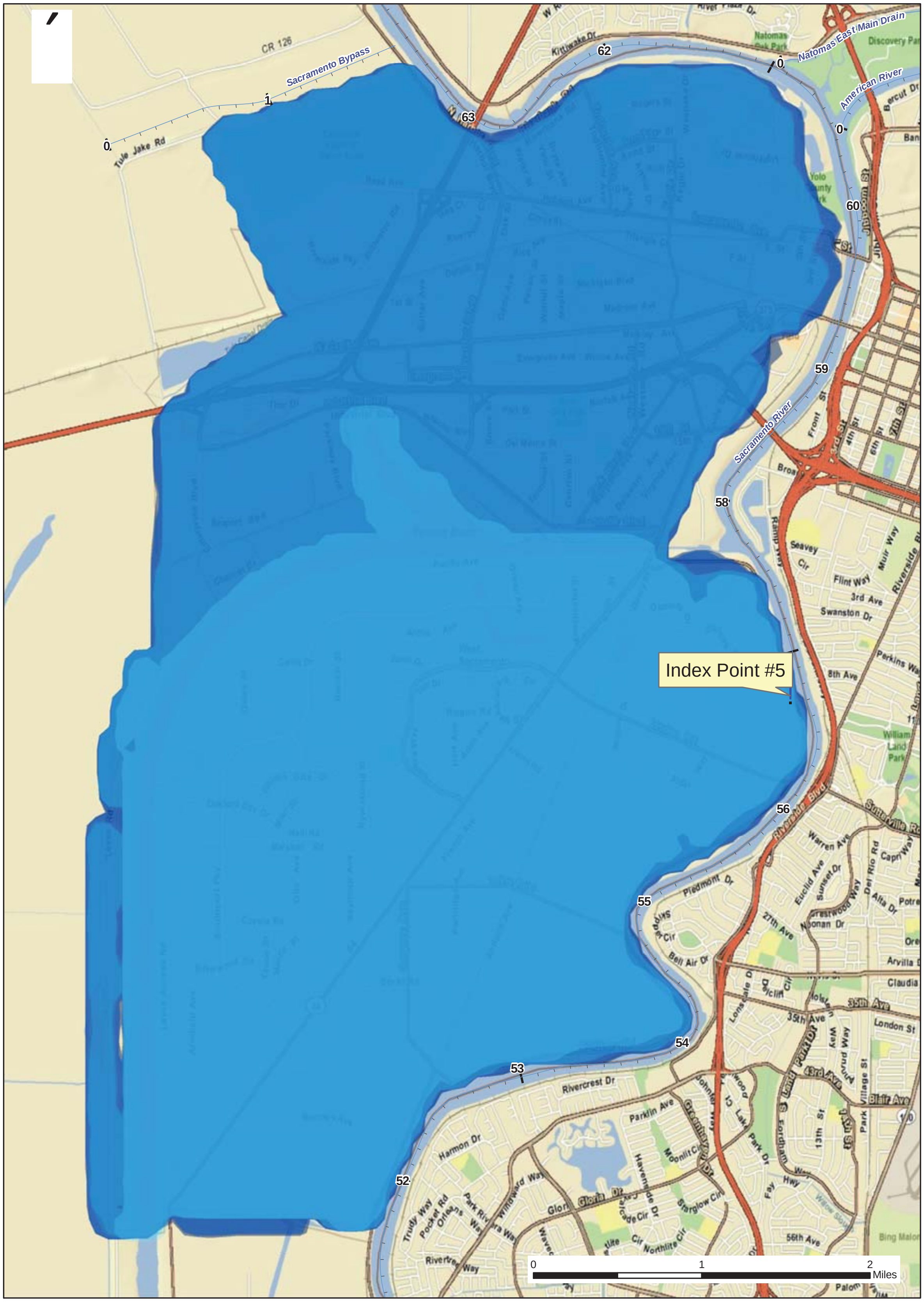
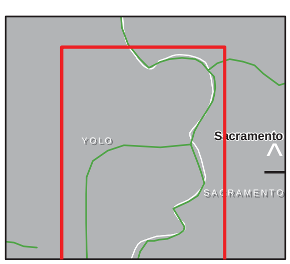


Legend

2-yr Sac Break IP 5	100-yr Sac Break IP 5
10-yr Sac Break IP 5	200-yr Sac Break IP 5
25-yr Sac Break IP 5	500-yr Sac Break IP 5
50-yr Sac Break IP 5	



West Sacramento GRR
Yolo, Solano Counties, California

2-Yr Thru 500-yr Floodplains
Index Point 5
Sacramento River RM 56.75

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

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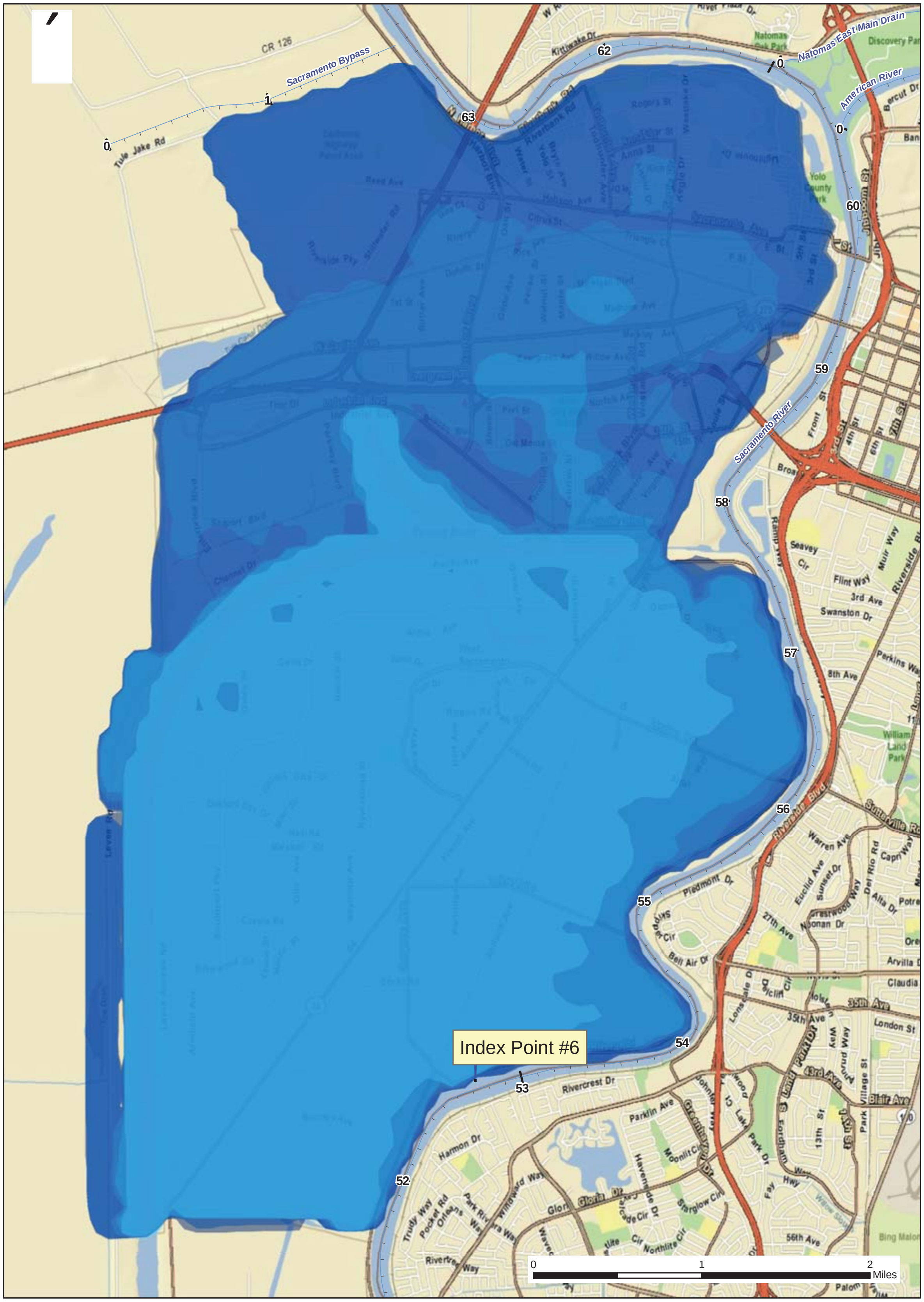
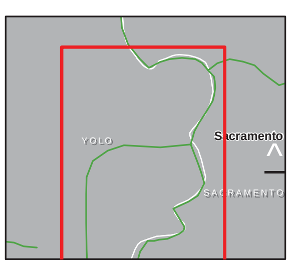


Legend

- 2-Yr Sac Break IP 6
- 10-Yr Sac Break IP 6
- 25-Yr Sac Break IP 6
- 50-Yr Sac Break IP 6
- 100-Yr Sac Break IP 6
- 200-Yr Sac Break IP 6
- 500-Yr Sac Break IP 6



West Sacramento GRR
Yolo, Solano Counties, California

2-Yr Thru 500-yr Floodplains
Index Point 6
Sacramento River RM 52.7

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

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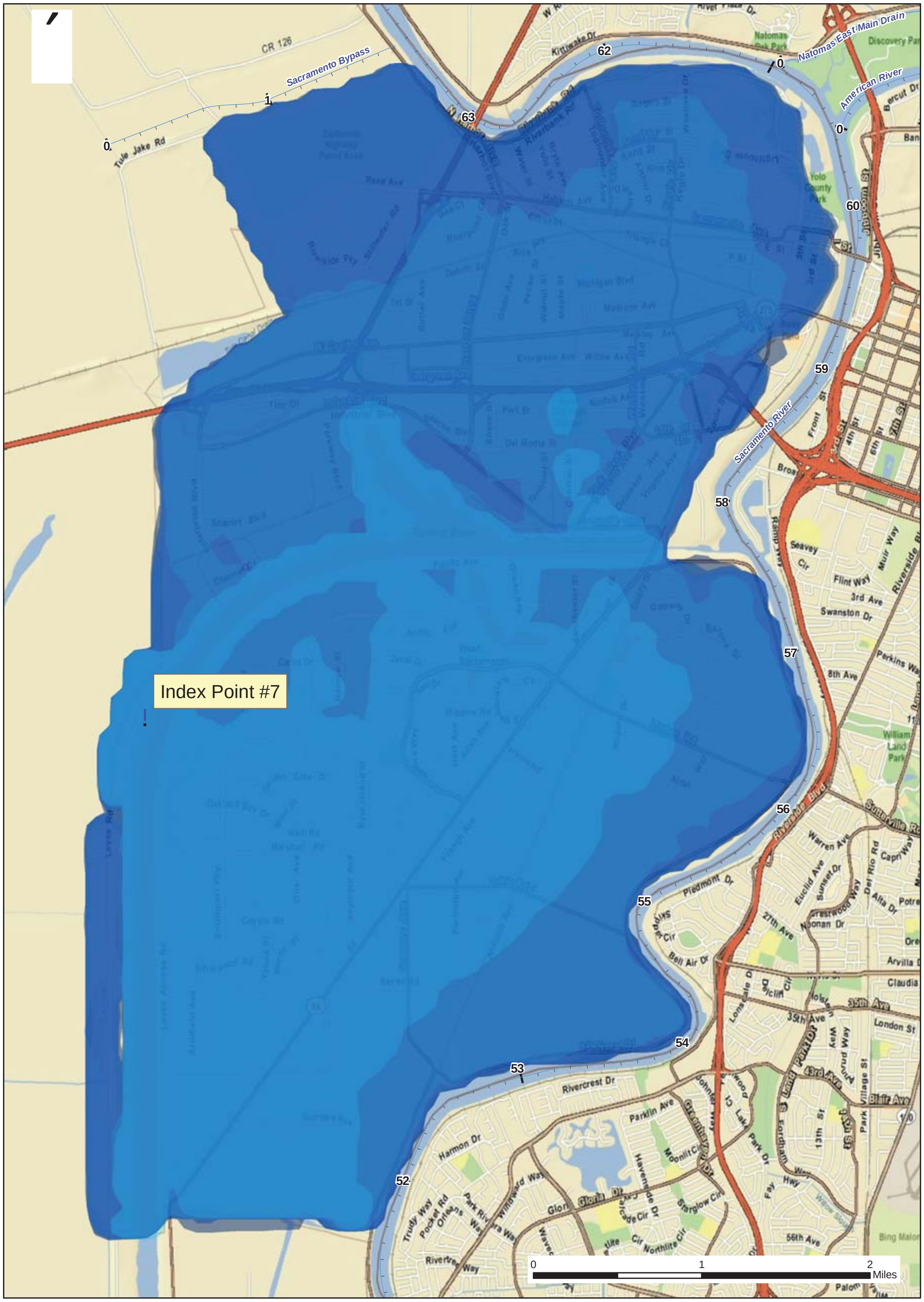
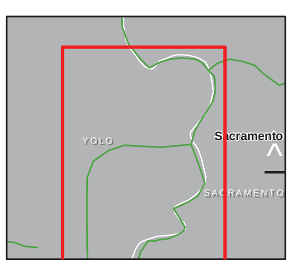


Legend

- 10-Yr Yolo Break IP 7
- 25 Yr Yolo Break IP 7
- 50-Yr Yolo Break IP 7
- 100-yr Yolo Break IP 7
- 200-Yr Yolo Break IP 7
- 500-Yr Yolo Break IP 7

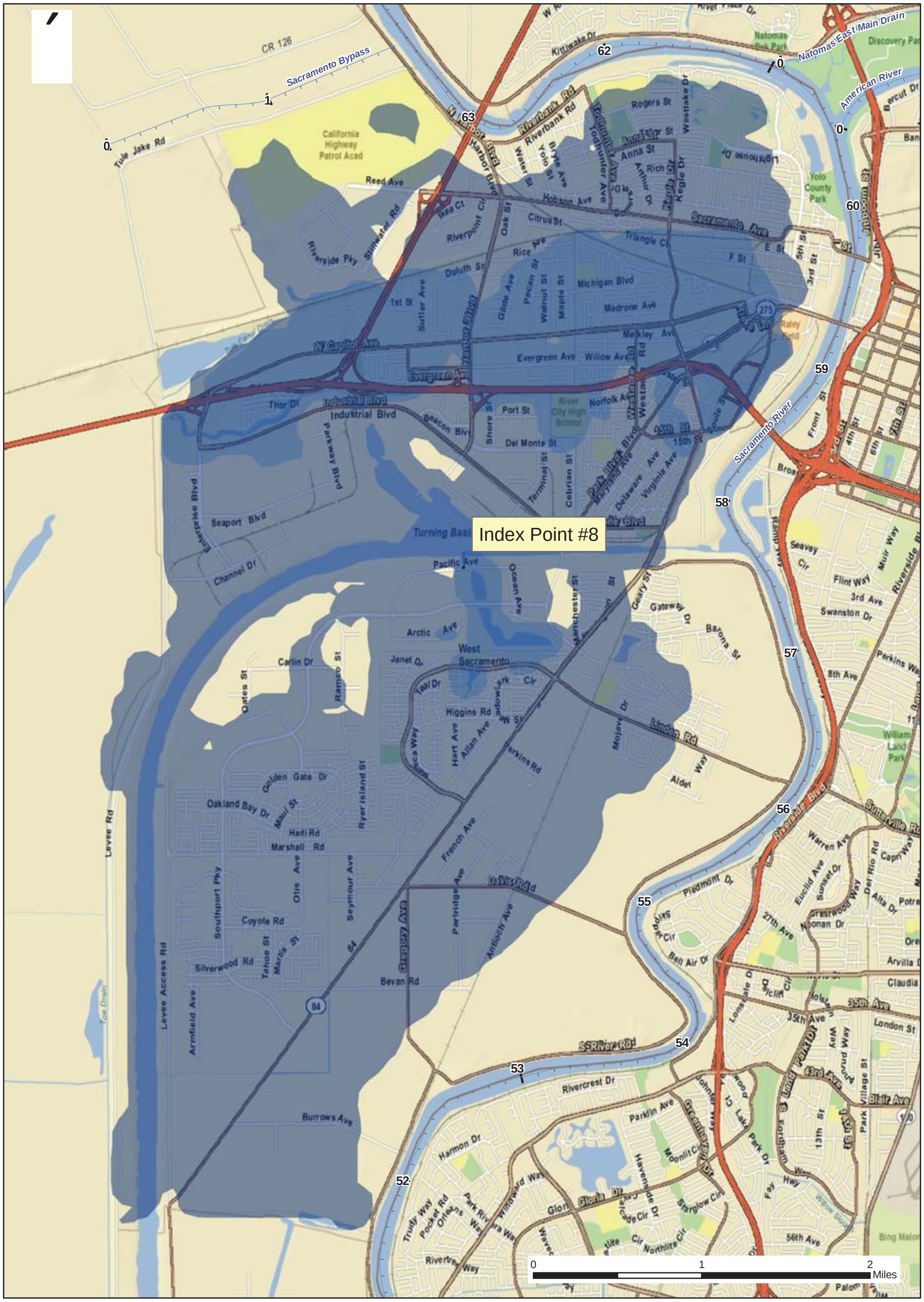


West Sacramento GRR
Yolo, Solano Counties, California

2-Yr Thru 500-yr Floodplains
Index Point 7
Yolo Bypass RM 40.95

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

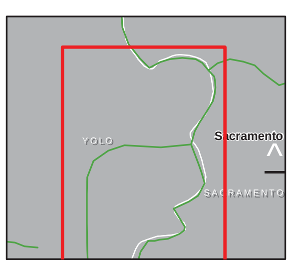
FEB 2011 Prepared by J.S.M and J.J.S. PLATE 1



Legend

500-Yr Sac DWSC Break IP 8

200-Yr Sac DWSC Break IP 8



West Sacramento GRR
Yolo, Solano Counties, California

2-Yr Thru 500-yr Floodplains
Index Point 8
Sacramento DWSC RM 43.75

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

FEB 2011 Prepared by J.S.M and J.J.S. PLATE 1

West Sacramento Without Project Condition Risk Inputs ("n"YRSAC_NA3_3)

IP:1 Sac Riv, RM 61.4986 (Model TOL = 43.2')				
Without Project				
Frequency	**Inflow**	**Adjusted Outflow**	**Q Total (Model)**	**Stage NAVD '88**
1yr = .999	N/A	N/A		27.00
2yr = .5	N/A	N/A	66936.3	29.63
10yr = .1	N/A	N/A	26073.52	30.78
25yr = .04	N/A	N/A	-1223.5	33.49
50yr = .02	N/A	N/A	792.87	34.03
100yr = .01	N/A	N/A	4573.9	34.71
200yr = .005	N/A	N/A	-16234.2	36.17
500yr = .002	N/A	N/A	-71592.7	38.20
Equivalent Record Length = 71				

LEVEE PERFORMANCE CURVE	
NAVD 88 Elevation	**Pr(f)**
26	0
29	0.039
32	0.077
35	0.239
38	0.536
41	0.953

IP:4 Sac Bypass, RM 1.49 (Model TOL =36.82')				
Without Project				
Frequency	**Inflow**	**Adjusted Outflow**	**Q Total (Model)**	**Stage NAVD '88**
1yr = .999	141500	0		20.65
2yr = .5	197300	0	100	21.61
10yr = .1	328800	35858	65841	28.59
25yr = .04	448700	76374	107329	31.87
50yr = .02	475700	101301	111202	32.52
100yr = .01	545800	117399	115011	33.28
200yr = .005	635700	156687	138930	34.69
500yr = .002	911400	180775	183293	36.41
Equivalent Record Length = 71				

LEVEE PERFORMANCE CURVE	
NAVD 88 Elevation	**Pr(f)**
21.97	0
29.97	0
35.97	0
37.97	0.012
39.97	0.042
42.37	0.459

IP:7 Yolo Bypass, RM 40.95 (Model TOL = 32.83)				
Without Project				
Frequency	**Inflow**	**Adjusted Outflow**	**Q Total (Model)**	**Stage NAVD '88**
1yr = .999	139200	0		20.43
2yr = .5	200100	107259	105596	21.11
10yr = .1	343600	272803	297133	26.44
25yr = .04	458700	410491	443123	29.21
50yr = .02	492200	483135	482828	29.96
100yr = .01	552000	552770	534892	30.85
200yr = .005	646600	631168	602885	31.89
500yr = .002	928700	692678	673392	32.92
Equivalent Record Length = 72				

LEVE PERFORM CURV
NAVD 88 Elevation
9.5
15.5
19.5
24.5
29.5
34.5

IP:2 Sac R, RM 59.9979 (Model TOL = 42.4 ')				
Without Project				
Frequency	**Inflow**	**Adjusted Outflow**	**Q Total (Model)**	**Stage NAVD '88**
1yr = .999	166900	80000		26.38
2yr = .5	224300	91314	94639	29.23
10yr = .1	359600	98397	101171	30.55
25yr = .04	525300	103479	115649	33.3
50yr = .02	551700	113351	118221	33.85
100yr = .01	666700	121560	121799	34.54
200yr = .005	939900	143491	131092	36.02
500yr = .002	1133400	180634	158047	38.12
Equivalent Record Length = 73				

LEVEE PERFORMANCE CURVE	
NAVD 88 Elevation	**Pr(f)**
28	0
32	0.039
34	0.077
36	0.183
38	0.437
40	0.922

IP:5 Sac Riv, RM 56.75 (Model TOL = 41.74)				
Without Project				
Frequency	**Inflow**	**Adjusted Outflow**	**Q Total (Model)**	**Stage NAVD '88**
1yr = .999	166900	80000		24.52
2yr = .5	224300	91306	94631	27.82
10yr = .1	359600	98329	100694	29.13
25yr = .04	525300	103421	115584	31.84
50yr = .02	551700	113323	118179	32.42
100yr = .01	666700	121448	121792	33.09
200yr = .005	939900	135024	130652	34.54
500yr = .002	1133400	146336	148644	36.51
Equivalent Record Length = 73				

LEVEE PERFORMANCE CURVE	
NAVD 88 Elevation	**Pr(f)**
19.63	0
27.63	0.024
30.63	0.034
34.63	0.223
38.63	0.493
40.63	0.687

IP:8 Sac DWSC, RM 43.412 (MODEL TOL = 22)				
Without Project				
Frequency	**Inflow**	**Adjusted Outflow**	**Q Total (Model)**	**Stage NAVD '88**
1yr = .999	N/A	N/A	N/A	7.37
2yr = .5	N/A	N/A	N/A	7.68
10yr = .1	N/A	N/A	N/A	12.97
25yr = .04	N/A	N/A	N/A	17.7
50yr = .02	N/A	N/A	N/A	18.64
100yr = .01	N/A	N/A	N/A	19.78
200yr = .005	N/A	N/A	N/A	20.87
500yr = .002	N/A	N/A	N/A	22.27
Equivalent Record Length = 73				

LEVE PERFORM CURV
NAVD 88 Elevation
13
14
16
18
20
21.67

IP:3 Yolo Bypass, RM 42.62 (Model TOL = 34.9')				
Without Project				
Frequency	**Inflow**	**Adjusted Outflow**	**Q Total (Model)**	**Stage NAVD '88**
1yr = .999	139200	0		20.67
2yr = .5	200100	107711	105994	21.38
10yr = .1	343600	273031	297332	26.86
25yr = .04	458700	410938	443816	29.74
50yr = .02	492200	483545	483412	30.50
100yr = .01	552000	553424	535272	31.41
200yr = .005	646600	631918	603455	32.55
500yr = .002	928700	693250	673943	33.65
Equivalent Record Length = 72				

LEVEE PERFORMANCE CURVE	
NAVD 88 Elevation	**Pr(f)**
8.12	0
14.12	0
20.12	0.01
26.12	0.169
32.12	0.891
38.12	0.999

IP:6 Sac Riv, RM 52.7474 (Model TOL = 40.03)				
Without Project				
Frequency	**Inflow**	**Adjusted Outflow**	**Q Total (Model)**	**Stage NAVD '88**
1yr = .999	166900	80000		22.94
2yr = .5	224300	91303	94628	26.23
10yr = .1	359600	98255	100688	27.53
25yr = .04	525300	103394	115489	30.19
50yr = .02	551700	113302	118158	30.77
100yr = .01	666700	121342	121789	31.44
200yr = .005	939900	135009	130614	32.85
500yr = .002	1133400	145927	148530	34.62
Equivalent Record Length = 73				

LEVEE PERFORMANCE CURVE	
NAVD 88 Elevation	**Pr(f)**
19.02	0
23.02	0.02
27.02	0.04
35.02	0.165
37.02	0.273
39.02	0.425

West Sacramento Alternative 1: Fix In Place Risk Inputs ("n"YR_SAC_W-PRJ_Raised_Levees)

West Sacramento Alternative 3: Fix Levees and DWSC Closure Structure In Place Risk Inputs ("n"YR_SAC_W-PRJ_Raised_Levees)

IP:1 Sac Riv, RM 61.4986 (Model TOL = 43.2') — Alternative 1 & 3

Frequency	Inflow	Adjusted Outflow	Q Total (Model)	Stage NAVD '88
1yr = .999	N/A	N/A		27.00
2yr = .5	N/A	N/A	66903.02	29.63
10yr = .1	N/A	N/A	26077.77	30.78
25yr = .04	N/A	N/A	-1222.78	33.48
50yr = .02	N/A	N/A	803.9	34.03
100yr = .01	N/A	N/A	4574.56	34.71
200yr = .005	N/A	N/A	-28105	36.54
500yr = .002	N/A	N/A	-99340	39.04
Equivalent Record Length = 71				

LEVEE PERFORMANCE CURVE

NAVD 88 Elevation	Pr(f)
26	
29	
32	
35	
38	
41	

IP:4 Sac Bypass, RM 1.49 (Model TOL =36.82') — Alternative 1 & 3

Frequency	Inflow	Adjusted Outflow	Q Total (Model)	Stage NAVD '88
1yr = .999	141500	0		20.65
2yr = .5	197300	0	100	21.61
10yr = .1	328800	35858	65843	28.59
25yr = .04	448700	76374	107318	31.87
50yr = .02	475700	101301	111170	32.51
100yr = .01	545800	117399	115016	33.28
200yr = .005	635700	156687	148940	34.98
500yr = .002	911400	180775	206912	37.00
Equivalent Record Length = 71				

LEVEE PERFORMANCE CURVE

NAVD 88 Elevation	Pr(f)
22	
29	
36	
38	
40	
42.4	

IP:7 Yolo Bypass, RM 40.95 (Model TOL = 32.83) — Alternative 1 & 3

Frequency	Inflow	Adjusted Outflow	Q Total (Model)	Stage NAVD '88
1yr = .999	139200	0		20.43
2yr = .5	200100	107259	105590	21.11
10yr = .1	343600	272803	297134	26.44
25yr = .04	458700	410491	442953	29.21
50yr = .02	492200	483135	482620	29.96
100yr = .01	552000	552770	534852	30.85
200yr = .005	646600	631168	610023	31.99
500yr = .002	928700	692678	687476	33.13
Equivalent Record Length = 72				

LEVEE PERFORMANCE CURVE

NAVD 88 Elevation	Pr(f)
10	
15	
20	
25	
30	
34.5	

IP:2 Sac R, RM 59.9979 (Model TOL = 42.4 ') — Alternative 1 & 3

Frequency	Inflow	Adjusted Outflow	Q Total (Model)	Stage NAVD '88
1yr = .999	166900	80000		26.38
2yr = .5	224300	91314	94610	29.22
10yr = .1	359600	98397	101171	30.55
25yr = .04	525300	103479	115657	33.29
50yr = .02	551700	113351	118223	33.85
100yr = .01	666700	121560	121798	34.54
200yr = .005	939900	143491	134255	36.40
500yr = .002	1133400	180634	179092	39.03
Equivalent Record Length = 73				

LEVEE PERFORMANCE CURVE

NAVD 88 Elevation	Pr(f)
28	
32	
34	
36	
38	
40	

IP:5 Sac Riv, RM 56.75 (Model TOL = 41.74) — Alternative 1 & 3

Frequency	Inflow	Adjusted Outflow	Q Total (Model)	Stage NAVD '88
1yr = .999	166900	80000		24.52
2yr = .5	224300	91306	94603	27.82
10yr = .1	359600	98329	100694	29.13
25yr = .04	525300	103421	115596	31.84
50yr = .02	551700	113323	118180	32.41
100yr = .01	666700	121448	121791	33.09
200yr = .005	939900	135024	133374	34.92
500yr = .002	1133400	146336	159123	37.29
Equivalent Record Length = 73				

LEVEE PERFORMANCE CURVE

NAVD 88 Elevation	Pr(f)
19	
27	
31	
35	
39	
41	

IP:8 Sac DWSC, RM 43.412 (MODEL TOL = 22) — Alternative 1 & 3

Frequency	Inflow	Adjusted Outflow	Q Total (Model)	Stage NAVD '88
1yr = .999	N/A	N/A	N/A	7.37
2yr = .5	N/A	N/A	N/A	7.68
10yr = .1	N/A	N/A	N/A	12.97
25yr = .04	N/A	N/A	N/A	17.72
50yr = .02	N/A	N/A	N/A	18.64
100yr = .01	N/A	N/A	N/A	19.78
200yr = .005	N/A	N/A	N/A	20.91
500yr = .002	N/A	N/A	N/A	22.66
Equivalent Record Length = 73				

LEVEE PERFORMANCE CURVE

NAVD 88 Elevation	Pr(f)
13	
14	
16	
18	
20	
21.7	

IP:3 Yolo Bypass, RM 42.62 (Model TOL = 34.9') — Alternative 1 & 3

Frequency	Inflow	Adjusted Outflow	Q Total (Model)	Stage NAVD '88
1yr = .999	139200	0		20.67
2yr = .5	200100	107711	106012	21.38
10yr = .1	343600	273031	297332	26.86
25yr = .04	458700	410938	443711	29.73
50yr = .02	492200	483545	483253	30.50
100yr = .01	552000	553424	535233	31.41
200yr = .005	646600	631918	610692	32.66
500yr = .002	928700	693250	688445	33.88
Equivalent Record Length = 72				

LEVEE PERFORMANCE CURVE

NAVD 88 Elevation	Pr(f)
8	
14	
20	
26	
32	
38	

IP:6 Sac Riv, RM 52.7474 (Model TOL = 40.03) — Alternative 1 & 3

Frequency	Inflow	Adjusted Outflow	Q Total (Model)	Stage NAVD '88
1yr = .999	166900	80000		22.94
2yr = .5	224300	91303	94600	26.23
10yr = .1	359600	98255	100688	27.53
25yr = .04	525300	103394	115493	30.19
50yr = .02	551700	113302	118153	30.76
100yr = .01	666700	121342	121789	31.44
200yr = .005	939900	135009	133257	33.20
500yr = .002	1133400	145927	159087	35.23
Equivalent Record Length = 73				

LEVEE PERFORMANCE CURVE

NAVD 88 Elevation	Pr(f)
19	
23	
27	
35	
37	
39	

NOTE 1: Stage and flow data (2yr to 500yr) were obtained from RAS results - Without-Project "n"YR_SAC_NA3_3

NOTE 2: (Values in Red) Stage and flow data for 1yr and 2yr (along Sacramento and American Rivers) was obtained from gage data and rating curves. The stage was determined by taking the difference in water surface elvations from the gage and index point and adding or subtracting (depending if the gage is upstream or downstream of the index point) from the 1yr and 2yr stage at the gage station. The flow was determined by interpolation of the rating curve (since the stage was already determined). See Rating Curve Tab. NEMDC, RM 1 is considered American River here.

NOTE 3: Stage data for 2yr NEMDC (except RM 1) is obtained from RAS results- With-Project, Selected Levee Raise (SLR). The 1yr stage is land-side levee toe at location of index point. See NEMDC Toe Elev Tab.

NOTE 4: Reaches B, C, and I require flow and stage data. All other Natomas reaches only require stages (stage-frequency curves will be used)

NOTE 5: Data for Non Natomas (blue) reaches should be checked and updated as necessary.

NOTE 6: Values for 1yr and 2yr, Sac River 79.0022 taken from WO-PRJ_Risk_Inputs.xls.

NOTE 7: Standard Deviation taken from SD_Data.xls

NOTE 8: For the NEMDC, RM 1 (1yr and 2yr) the flow was increased to account for flow with the NEMDC. Flow in the American is for the 2-yr and 10-yr events is 10 times that of the NEMDC, so this value was used to derive the additional flow in the NEMDC. (Rating for the stages generated for the American portion only). Because flow ends up greater than the inflow, outflow was set equal to inflow.

30,110
10,415

NOTE 9: Inflow taken from Inflows.xls.

NOTE 10: Values in blue extrapolated using process as in West Report (B-5). Original value for 70.2464 was 93721 for the 500-yr event and had to be adjusted for FDA.

NOTE 11: Values in green are greater than stage from dominant centering and therefore were adjusted. Must be a difference of at least greater .05 ft to make adjustment.

Other Notes

Need to extrapolate above top of levee?
Sensitivities - ERL, Standard Deviations (Flow & Stage), SD sig digits, Extrapolated Values, 1yr & 2yr on NEMDC

Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

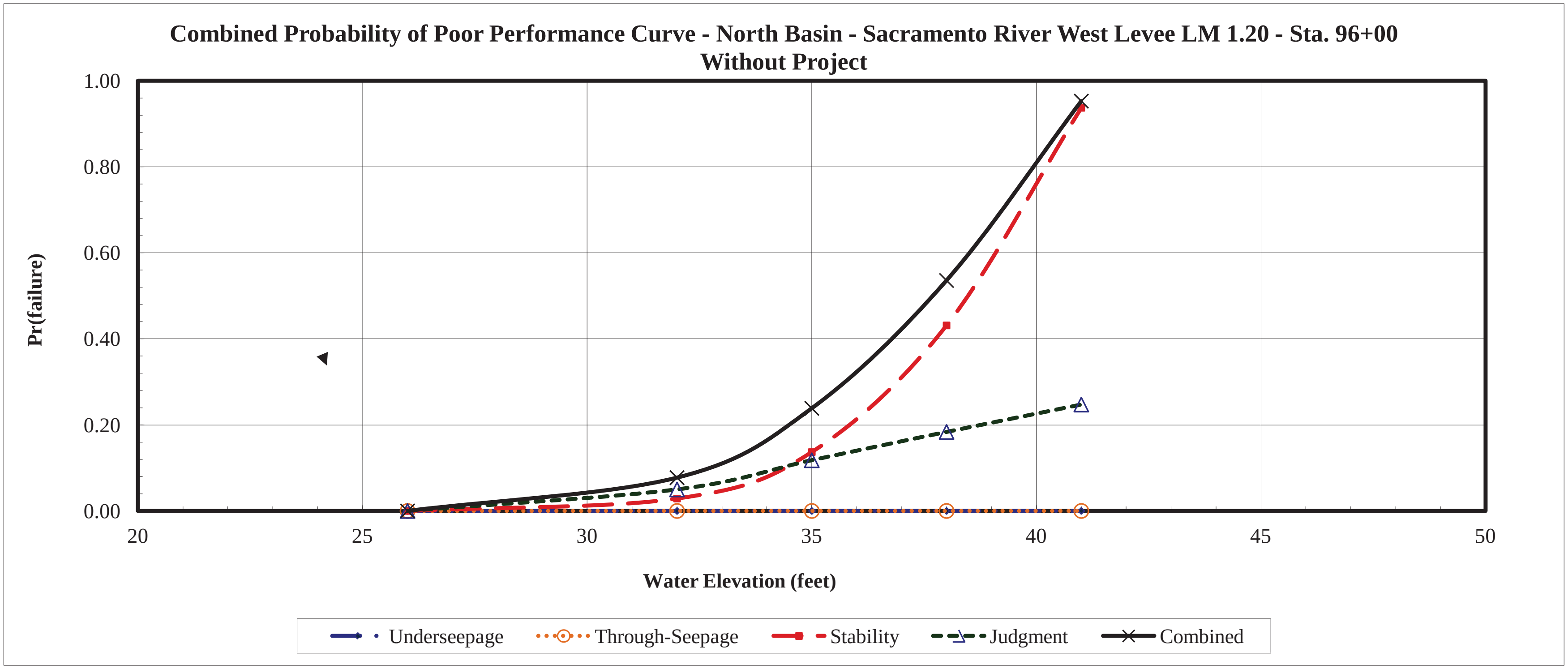
Project: West Sacramento GRR
Study Area: Sacramento River
River Section: North Basin - Sacramento River W

Levee Mile: 1.20 - Sta. 96+0(
River Mile: 61.67
Analysis Case: Without Project

Crest Elev.: 41.00
L/S Toe Elev.: 26.00
W/S Toe Elev.: 28.20

Analysis By: A. Deus
Checked By: M. Kynett
Date: 4/22/2013

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
26.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
32.00	0.0000	1.0000	0.0000	1.0000	0.0288	0.9712	0.0500	0.9500	0.0773	0.9227
35.00	0.0000	1.0000	0.0000	1.0000	0.1369	0.8631	0.1179	0.8821	0.2386	0.7614
38.00	0.0000	1.0000	0.0000	1.0000	0.4313	0.5687	0.1837	0.8163	0.5358	0.4642
41.00	0.0001	0.9999	0.0000	1.0000	0.9372	0.0628	0.2473	0.7527	0.9528	0.0472



Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

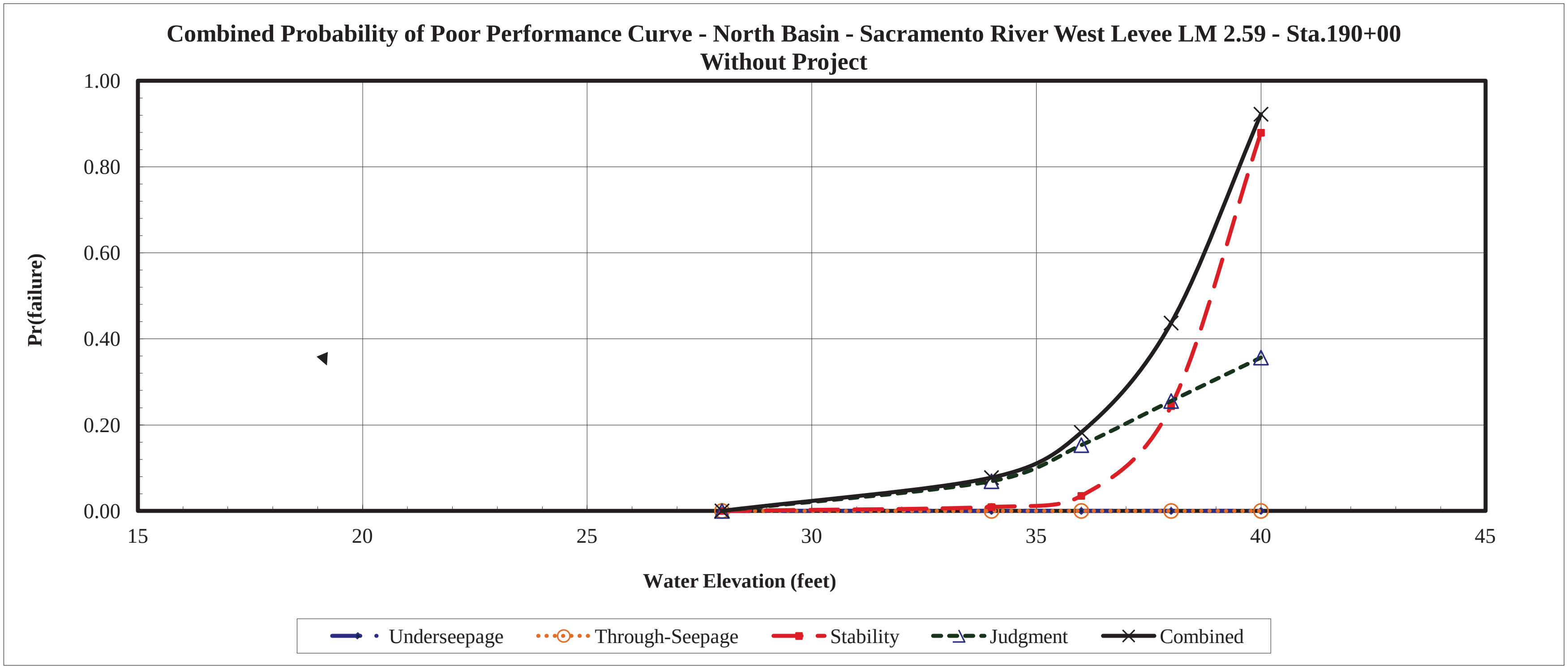
Project: West Sacramento GRR
Study Area: Sacramento River
River Section: North Basin - Sacramento River W

Levee Mile: 2.59 - Sta.190+0
River Mile: 60.20
Analysis Case: Without Project

Crest Elev.: 40.00
L/S Toe Elev.: 28.00
W/S Toe Elev.: 28.00

Analysis By: A. Deus
Checked By: M. Kynett
Date: 4/23/2013

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
28.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
34.00	0.0000	1.0000	0.0000	1.0000	0.0090	0.9910	0.0690	0.9310	0.0774	0.9226
36.00	0.0000	1.0000	0.0000	1.0000	0.0349	0.9651	0.1529	0.8471	0.1825	0.8175
38.00	0.0000	1.0000	0.0000	1.0000	0.2436	0.7564	0.2555	0.7445	0.4368	0.5632
40.00	0.0000	1.0000	0.0000	1.0000	0.8793	0.1207	0.3564	0.6436	0.9223	0.0777



Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

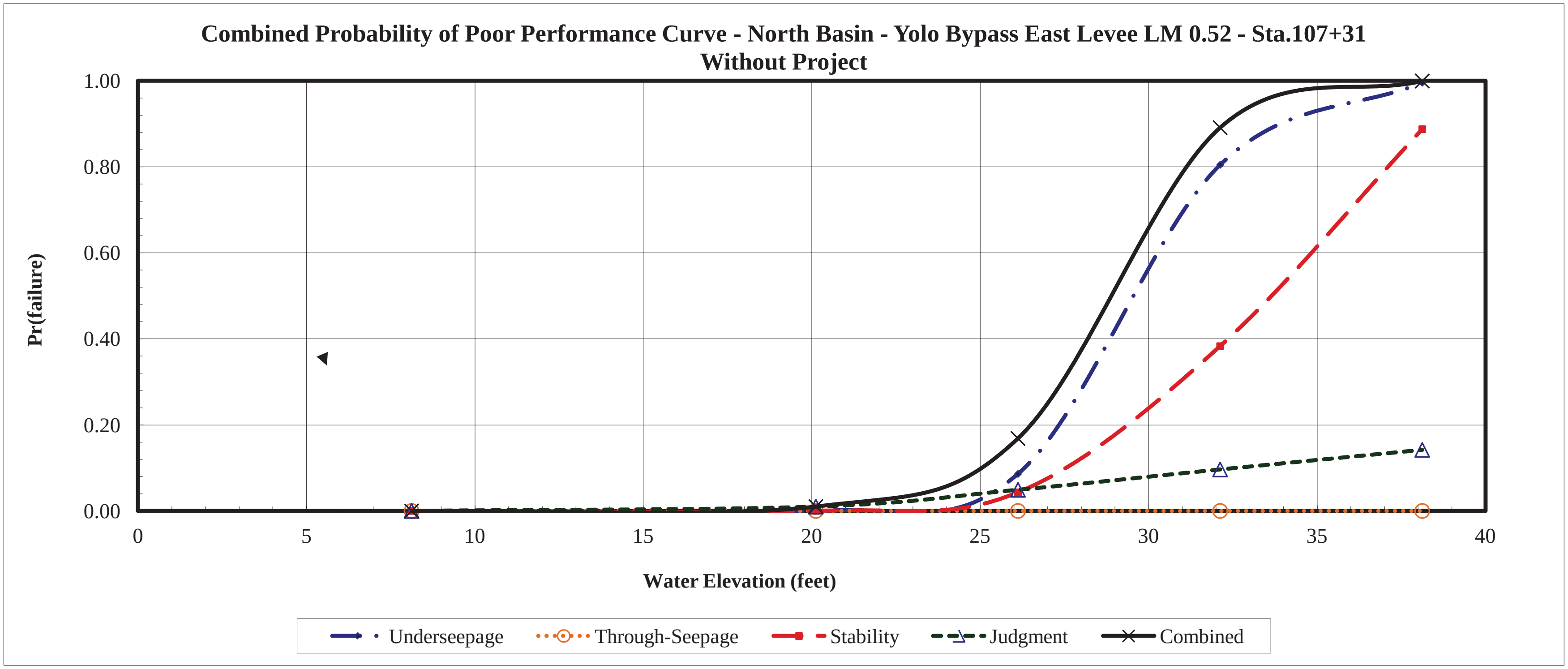
Project: West Sacramento GRR
Study Area: Yolo Bypass
River Section: North Basin - Yolo Bypass East L

Levee Mile: 0.52 - Sta.107+3
River Mile: 43.10
Analysis Case: Without Project

Crest Elev.: 38.12
L/S Toe Elev.: 8.12
W/S Toe Elev.: 8.12

Analysis By: A. Deus
Checked By: M. Kynett
Date: 4/23/2013

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
8.12	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
20.12	0.0000	1.0000	0.0000	1.0000	0.0001	0.9999	0.0100	0.9900	0.0101	0.9899
26.12	0.0861	0.9139	0.0000	1.0000	0.0433	0.9567	0.0491	0.9509	0.1686	0.8314
32.12	0.8046	0.1954	0.0000	1.0000	0.3832	0.6168	0.0964	0.9036	0.8911	0.1089
38.12	0.9957	0.0043	0.0000	1.0000	0.8876	0.1124	0.1419	0.8581	0.9996	0.0004



Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

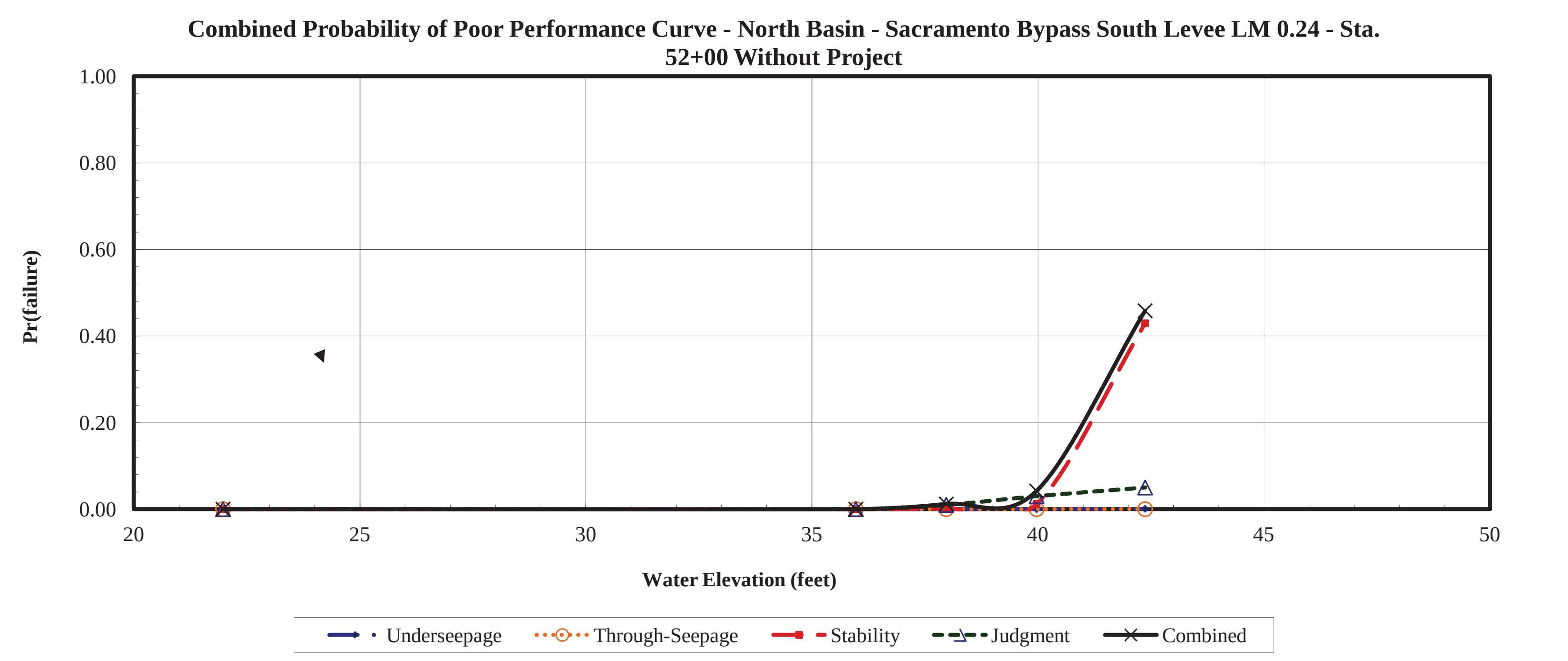
Project: West Sacramento GRR
Study Area: Sacramento Bypass
River Section: North Basin - Sacramento Bypass

Levee Mile: 0.24 - Sta. 52+0(
River Mile: 1.60
Analysis Case: Without Project

Crest Elev.: 42.37
L/S Toe Elev.: 21.97
W/S Toe Elev.: 22.17

Analysis By: A. Deus
Checked By: M. Kynett
Date: 4/22/2013

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
21.97	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
35.97	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
37.97	0.0000	1.0000	0.0000	1.0000	0.0018	0.9982	0.0100	0.9900	0.0119	0.9881
39.97	0.0003	0.9997	0.0000	1.0000	0.0122	0.9878	0.0300	0.9700	0.0421	0.9579
42.37	0.0010	0.9990	0.0000	1.0000	0.4294	0.5706	0.0500	0.9500	0.4585	0.5415



Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

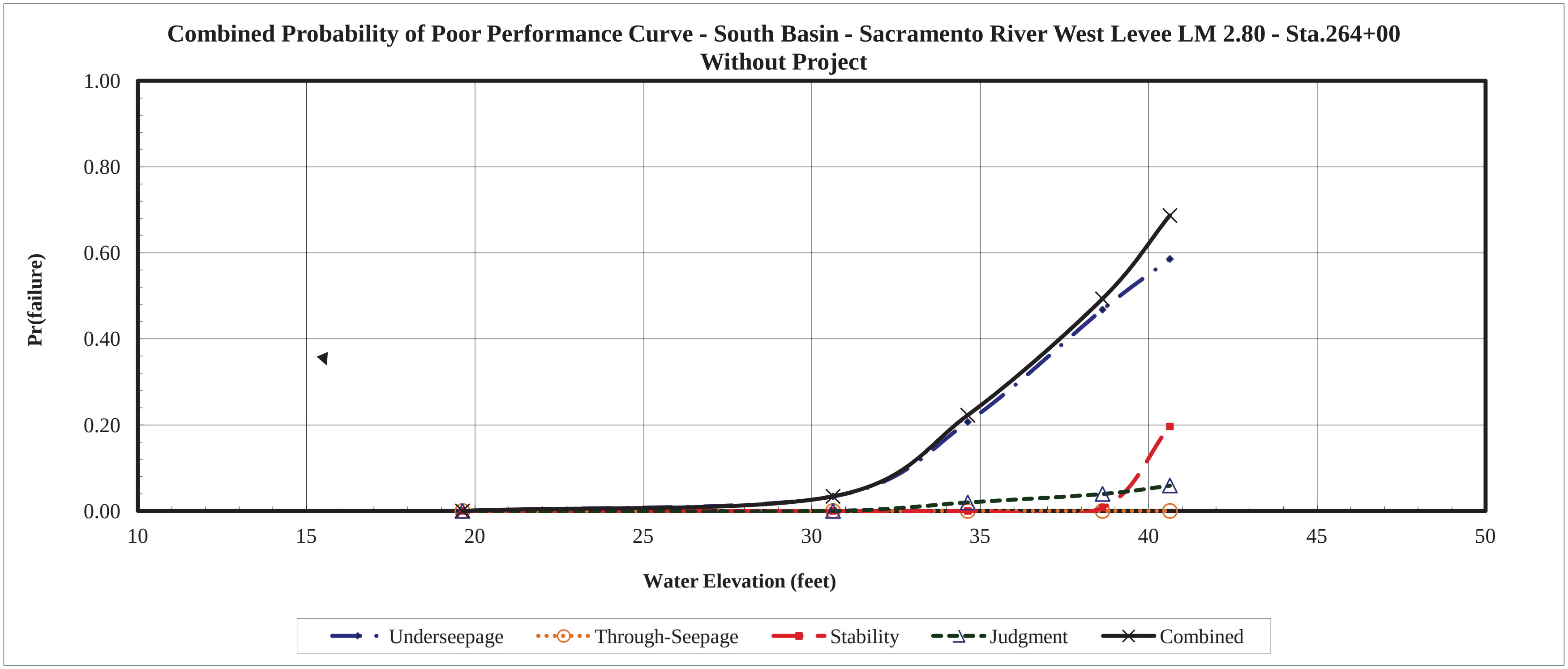
Project: West Sacramento GRR
Study Area: Sacramento River
River Section: South Basin - Sacramento River W

Levee Mile: 2.80 - Sta.264+0
River Mile: 56.74
Analysis Case: Without Project

Crest Elev.: 40.63
L/S Toe Elev.: 19.63
W/S Toe Elev.: 19.63

Analysis By: A. Deus
Checked By: M. Kynett
Date: 4/24/2013

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
19.63	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
30.63	0.0339	0.9661	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0339	0.9661
34.63	0.2069	0.7931	0.0000	1.0000	0.0000	1.0000	0.0199	0.9801	0.2227	0.7773
38.63	0.4680	0.5320	0.0000	1.0000	0.0079	0.9921	0.0396	0.9604	0.4931	0.5069
40.63	0.5859	0.4141	0.0000	1.0000	0.1965	0.8035	0.0591	0.9409	0.6869	0.3131



Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

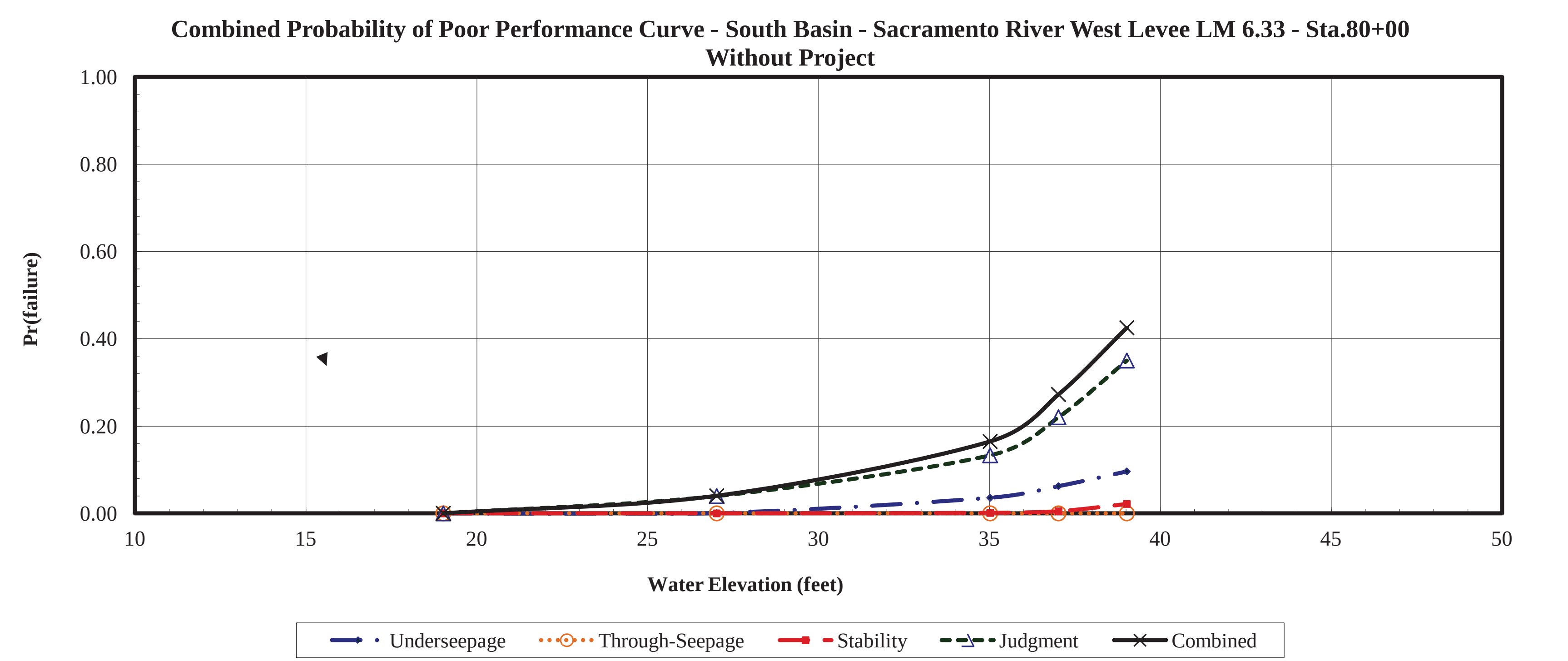
Project: West Sacramento GRR
Study Area: Sacramento River
River Section: South Basin - Sacramento River W

Levee Mile: 6.33 - Sta.80+00
River Mile: 53.08
Analysis Case: Without Project

Crest Elev.: 39.02
L/S Toe Elev.: 19.02
W/S Toe Elev.: 19.02

Analysis By: A. Deus
Checked By: M. Kynett
Date: 4/24/2013

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
19.02	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
27.02	0.0007	0.9993	0.0000	1.0000	0.0000	1.0000	0.0396	0.9604	0.0403	0.9597
35.02	0.0358	0.9642	0.0000	1.0000	0.0010	0.9990	0.1330	0.8670	0.1648	0.8352
37.02	0.0625	0.9375	0.0000	1.0000	0.0047	0.9953	0.2203	0.7797	0.2725	0.7275
39.02	0.0962	0.9038	0.0000	1.0000	0.0216	0.9784	0.3502	0.6498	0.4254	0.5746



Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

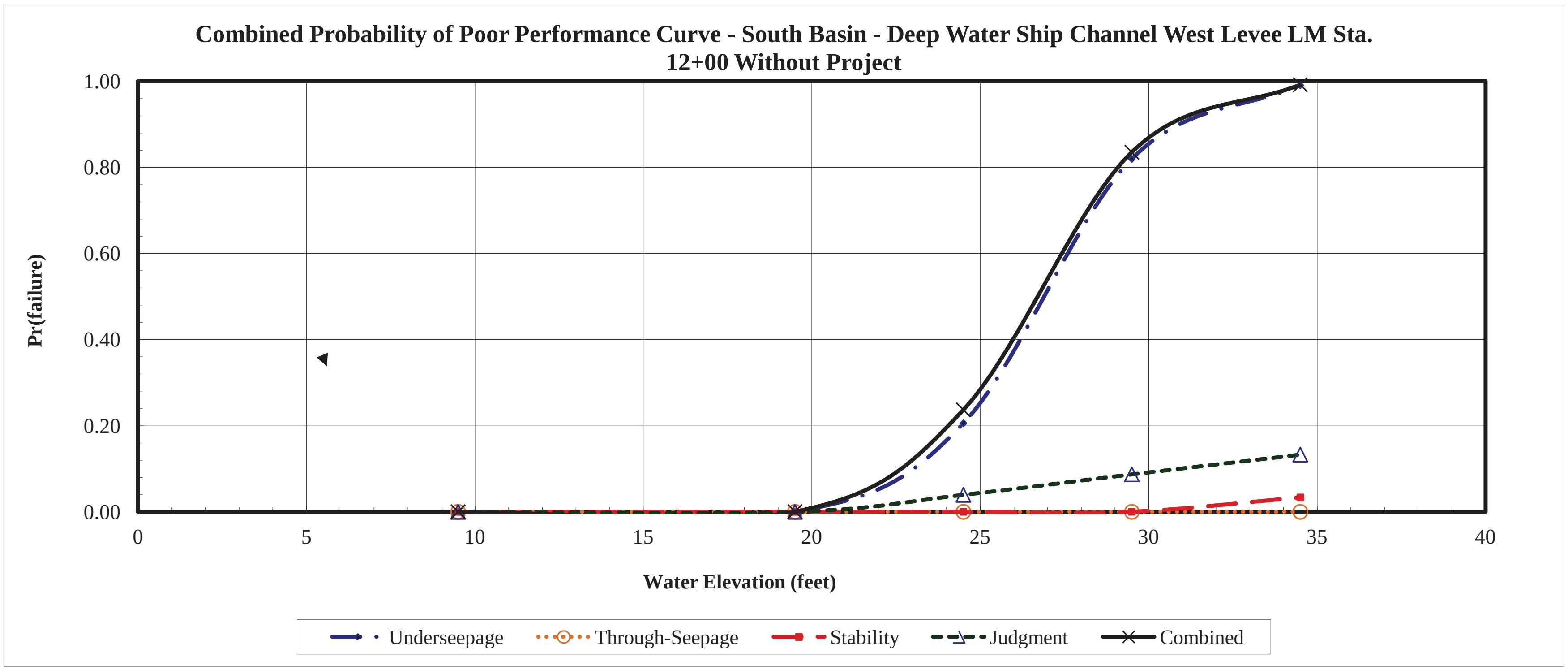
Project: West Sacramento GRR
Study Area: Deep Water Ship Channel
River Section: South Basin - Deep Water Ship Cl

Levee Mile: Sta. 12+00
River Mile: 41.21
Analysis Case: Without Project

Crest Elev.: 34.50
L/S Toe Elev.: 9.50
W/S Toe Elev.: 9.50

Analysis By: A. Deus
Checked By: M. Kynett
Date: 4/26/2013

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
9.50	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
19.50	0.0005	0.9995	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0005	0.9995
24.50	0.2057	0.7943	0.0000	1.0000	0.0000	1.0000	0.0394	0.9606	0.2370	0.7630
29.50	0.8196	0.1804	0.0000	1.0000	0.0001	0.9999	0.0870	0.9130	0.8353	0.1647
34.50	0.9907	0.0093	0.0000	1.0000	0.0335	0.9665	0.1330	0.8670	0.9922	0.0078



Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

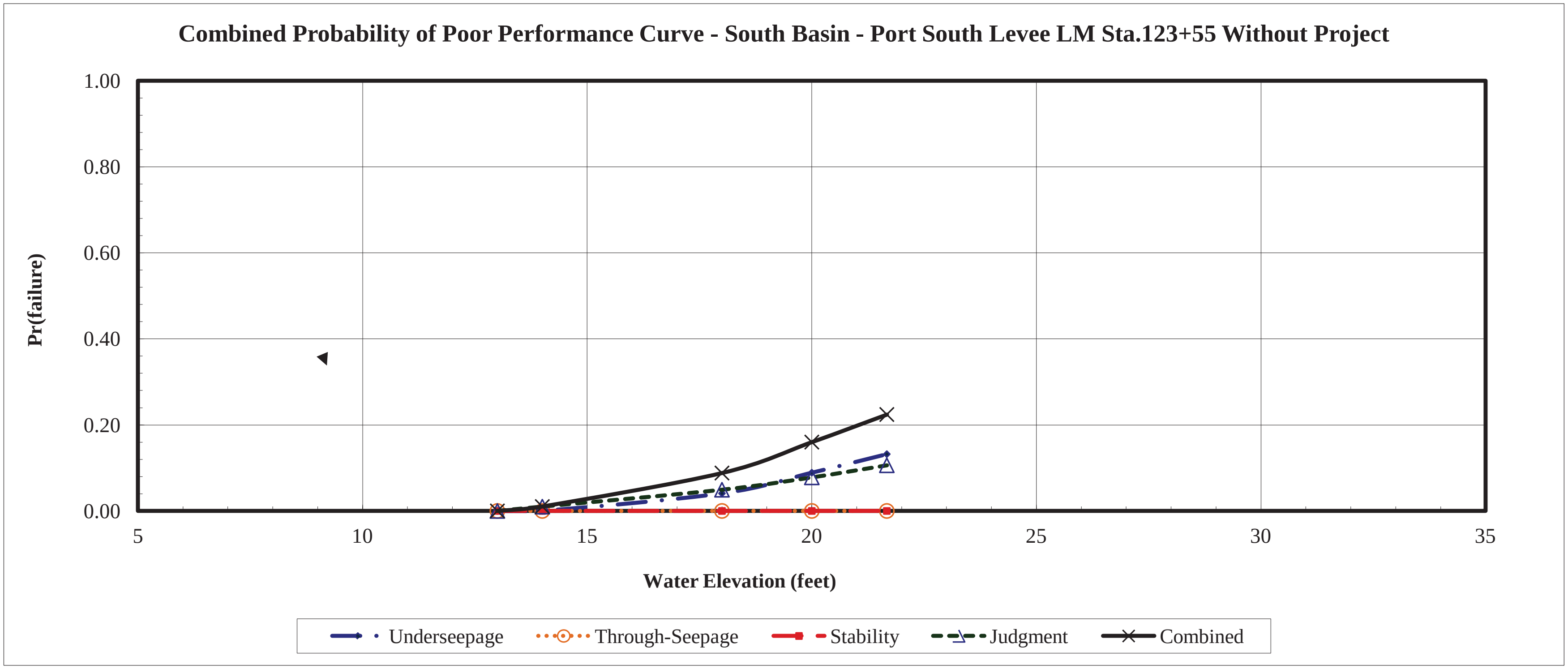
Project: West Sacramento GRR
Study Area: Deep Water Ship Channel
River Section: South Basin - Port South Levee

Levee Mile: Sta.123+55
River Mile: 43.45
Analysis Case: Without Project

Crest Elev.: 21.67
L/S Toe Elev.: 13.00
W/S Toe Elev.: 13.00

Analysis By: A. Deus
Checked By: M. Kynett
Date: 4/24/2013

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
13.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
14.00	0.0002	0.9998	0.0000	1.0000	0.0000	1.0000	0.0100	0.9900	0.0102	0.9898
18.00	0.0409	0.9591	0.0000	1.0000	0.0000	1.0000	0.0493	0.9507	0.0882	0.9118
20.00	0.0890	0.9110	0.0000	1.0000	0.0000	1.0000	0.0780	0.9220	0.1601	0.8399
21.67	0.1322	0.8678	0.0000	1.0000	0.0000	1.0000	0.1061	0.8939	0.2243	0.7757



With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

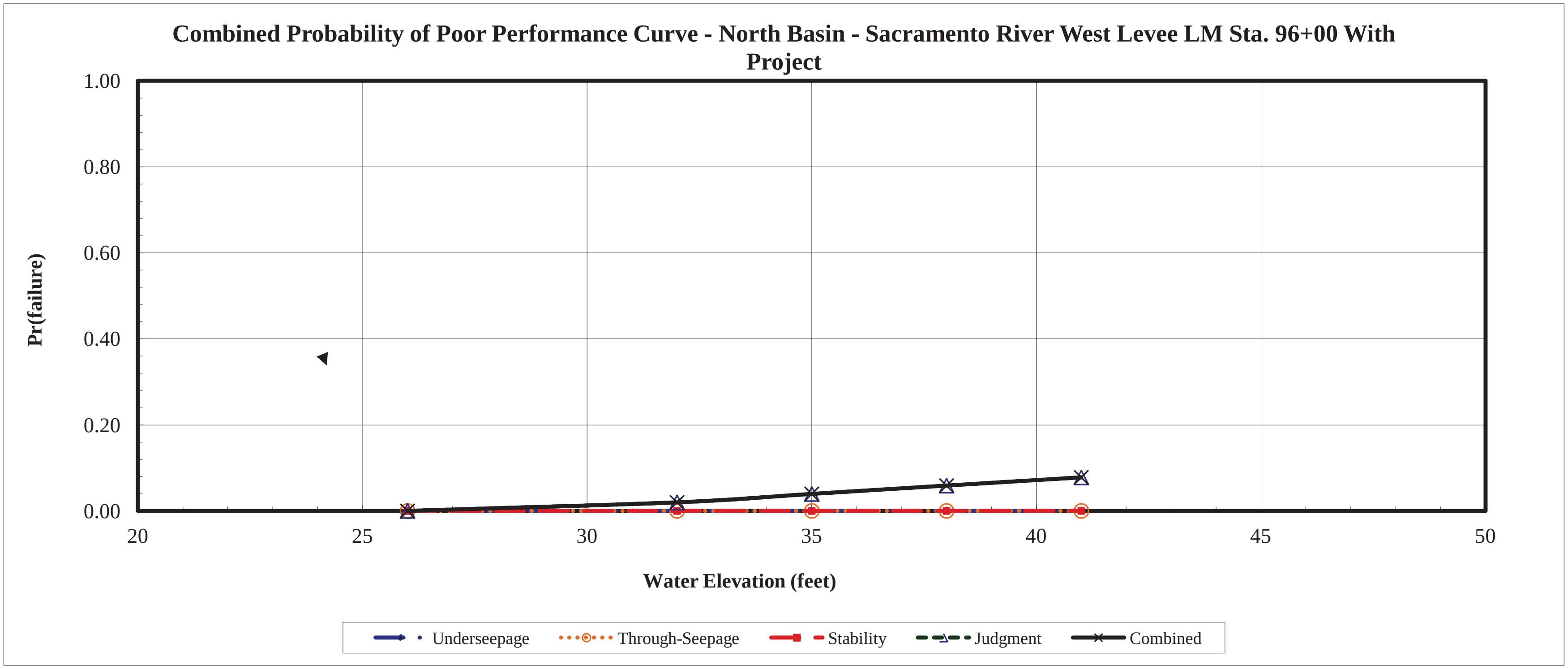
Project: West Sacramento GRR
Study Area: Sacramento River
River Section: North Basin - Sacramento River W

Levee Mile: Sta. 96+00
River Mile: 61.67
Analysis Case: With Project

Crest Elev.: 41.00
L/S Toe Elev.: 26.00
W/S Toe Elev.: 28.20

Analysis By: A. Deus
Checked By: M. Kynett
Date: 4/22/2013

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
26.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
32.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0199	0.9801	0.0199	0.9801
35.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0395	0.9605	0.0395	0.9605
38.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0588	0.9412	0.0588	0.9412
41.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0779	0.9221	0.0779	0.9221



With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

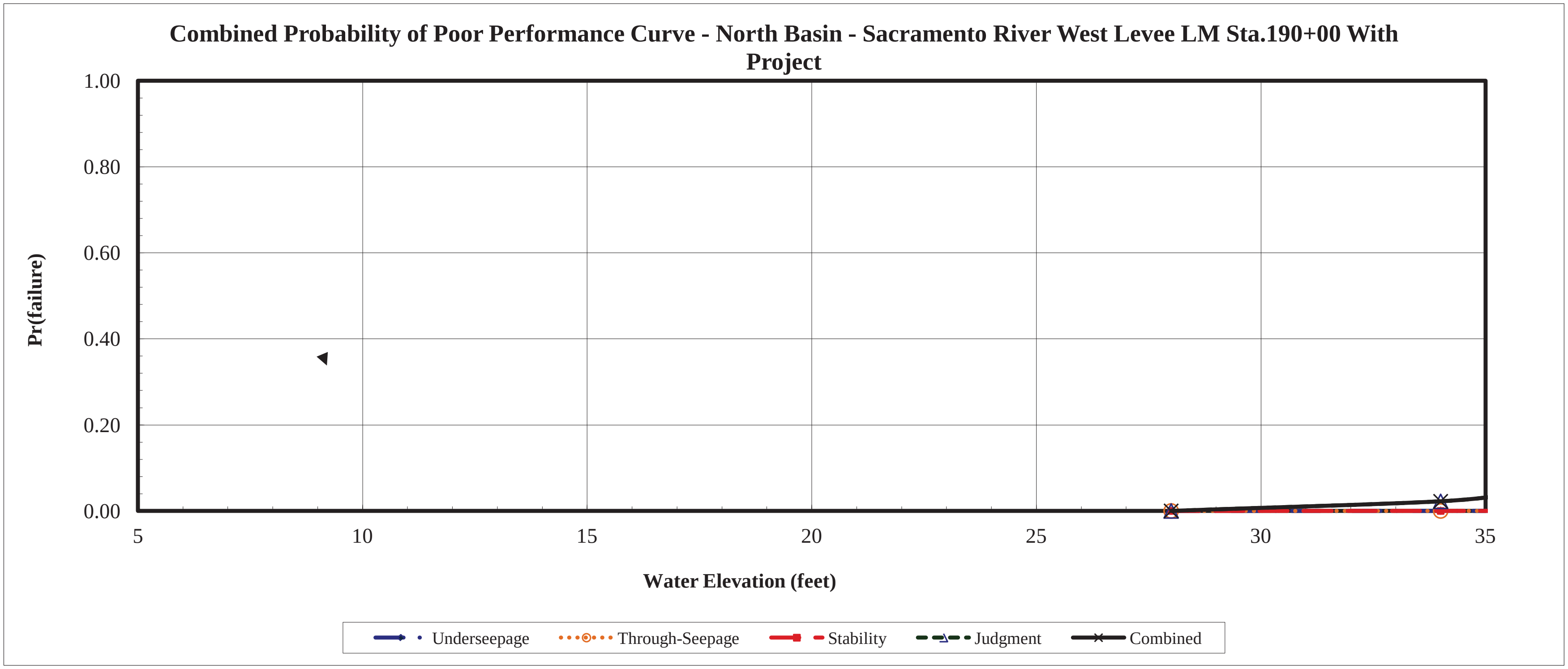
Project: West Sacramento GRR
Study Area: Sacramento River
River Section: North Basin - Sacramento River W

Levee Mile: Sta.190+00
River Mile: 60.20
Analysis Case: With Project

Crest Elev.: 40.00
L/S Toe Elev.: 28.00
W/S Toe Elev.: 28.00

Analysis By: A. Deus
Checked By: M. Kynett
Date: 4/23/2013

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
28.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
34.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0223	0.9777	0.0223	0.9777
36.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0443	0.9557	0.0443	0.9557
38.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0659	0.9341	0.0659	0.9341
40.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0871	0.9129	0.0871	0.9129



With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

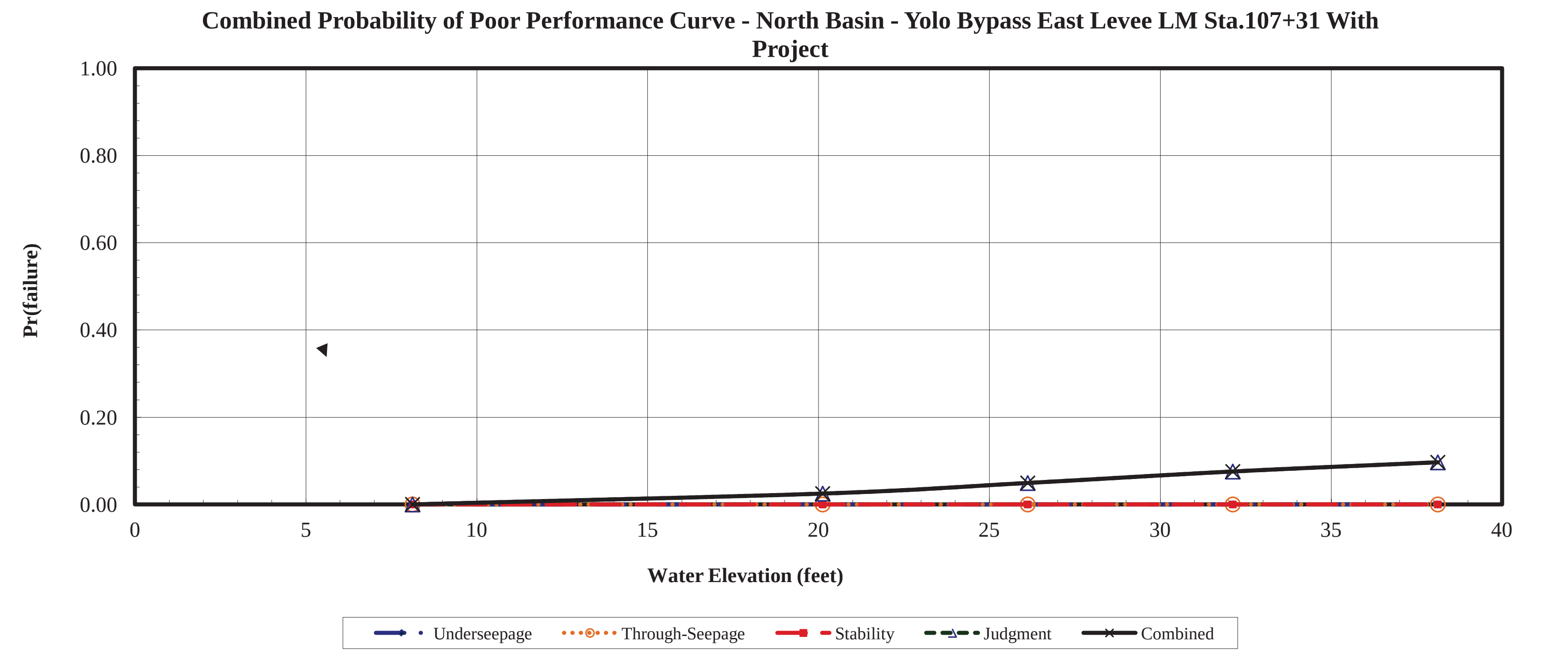
Project: West Sacramento GRR
Study Area: Yolo Bypass
River Section: North Basin - Yolo Bypass East L

Levee Mile: Sta.107+31
River Mile: 43.10
Analysis Case: With Project

Crest Elev.: 38.12
L/S Toe Elev.: 8.12
W/S Toe Elev.: 8.12

Analysis By: A. Deus
Checked By: M. Kynett
Date: 4/23/2013

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
8.12	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
20.12	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0248	0.9752	0.0248	0.9752
26.12	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0491	0.9509	0.0491	0.9509
32.12	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0754	0.9246	0.0754	0.9246
38.12	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0965	0.9035	0.0965	0.9035



With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

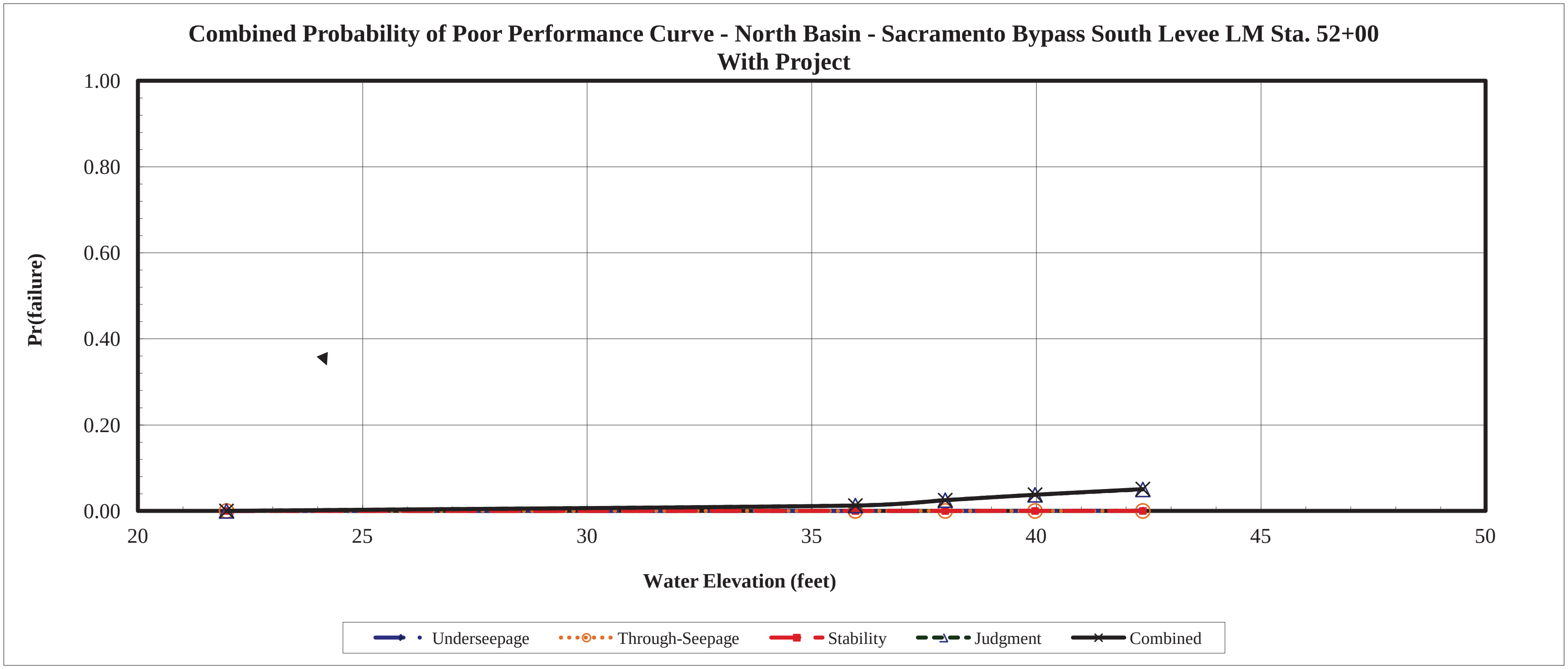
Project: West Sacramento GRR
Study Area: Sacramento Bypass
River Section: North Basin - Sacramento Bypass

Levee Mile: Sta. 52+00
River Mile: 1.60
Analysis Case: With Project

Crest Elev.: 42.37
L/S Toe Elev.: 21.97
W/S Toe Elev.: 22.17

Analysis By: A. Deus
Checked By: M. Kynett
Date: 4/22/2013

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
21.97	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
35.97	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0125	0.9875	0.0125	0.9875
37.97	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0250	0.9750	0.0250	0.9750
39.97	0.0003	0.9997	0.0000	1.0000	0.0000	1.0000	0.0375	0.9625	0.0377	0.9623
42.37	0.0010	0.9990	0.0000	1.0000	0.0000	1.0000	0.0500	0.9500	0.0509	0.9491



With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

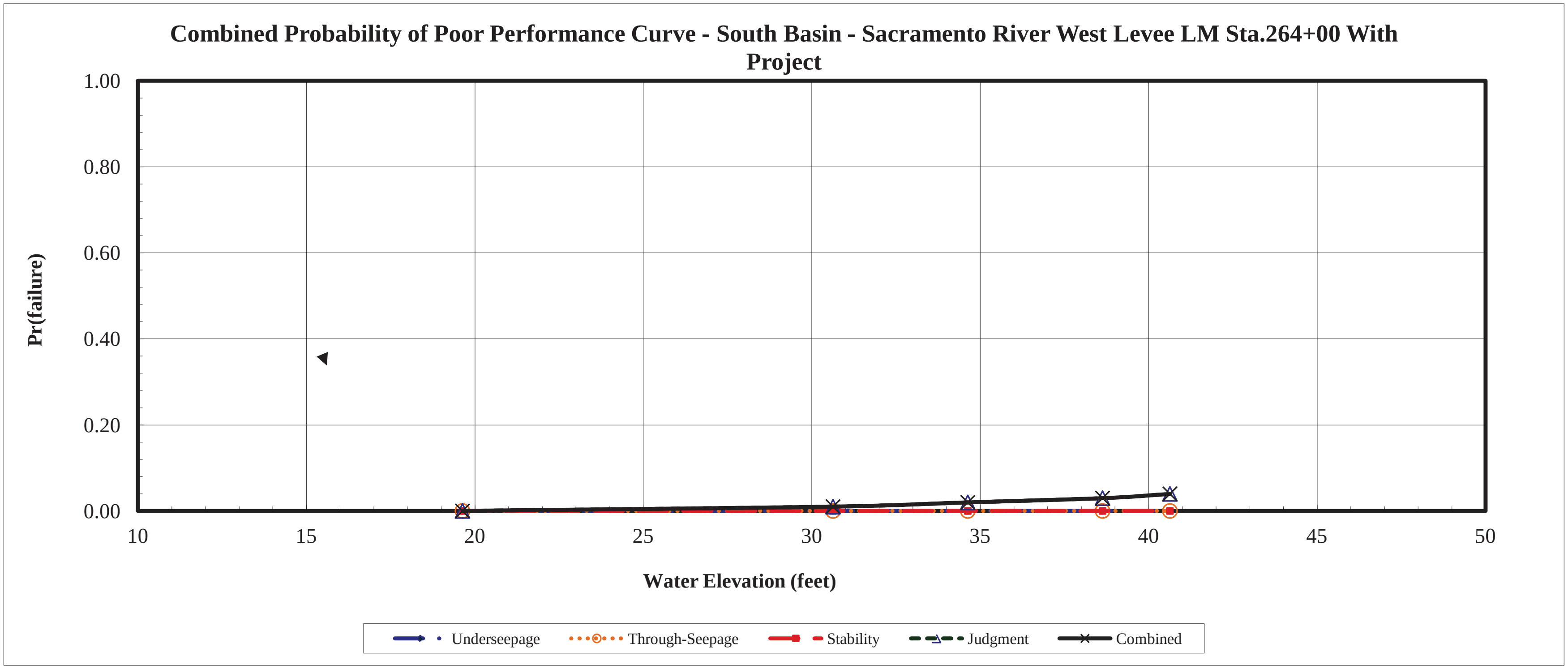
Project: West Sacramento GRR
Study Area: Sacramento River
River Section: South Basin - Sacramento River W

Levee Mile: Sta.264+00
River Mile: 56.74
Analysis Case: With Project

Crest Elev.: 40.63
L/S Toe Elev.: 19.63
W/S Toe Elev.: 19.63

Analysis By: A. Deus
Checked By: M. Kynett
Date: 4/25/2013

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
19.63	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
30.63	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0100	0.9900	0.0100	0.9900
34.63	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0199	0.9801	0.0199	0.9801
38.63	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0298	0.9702	0.0298	0.9702
40.63	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0397	0.9603	0.0397	0.9603



With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

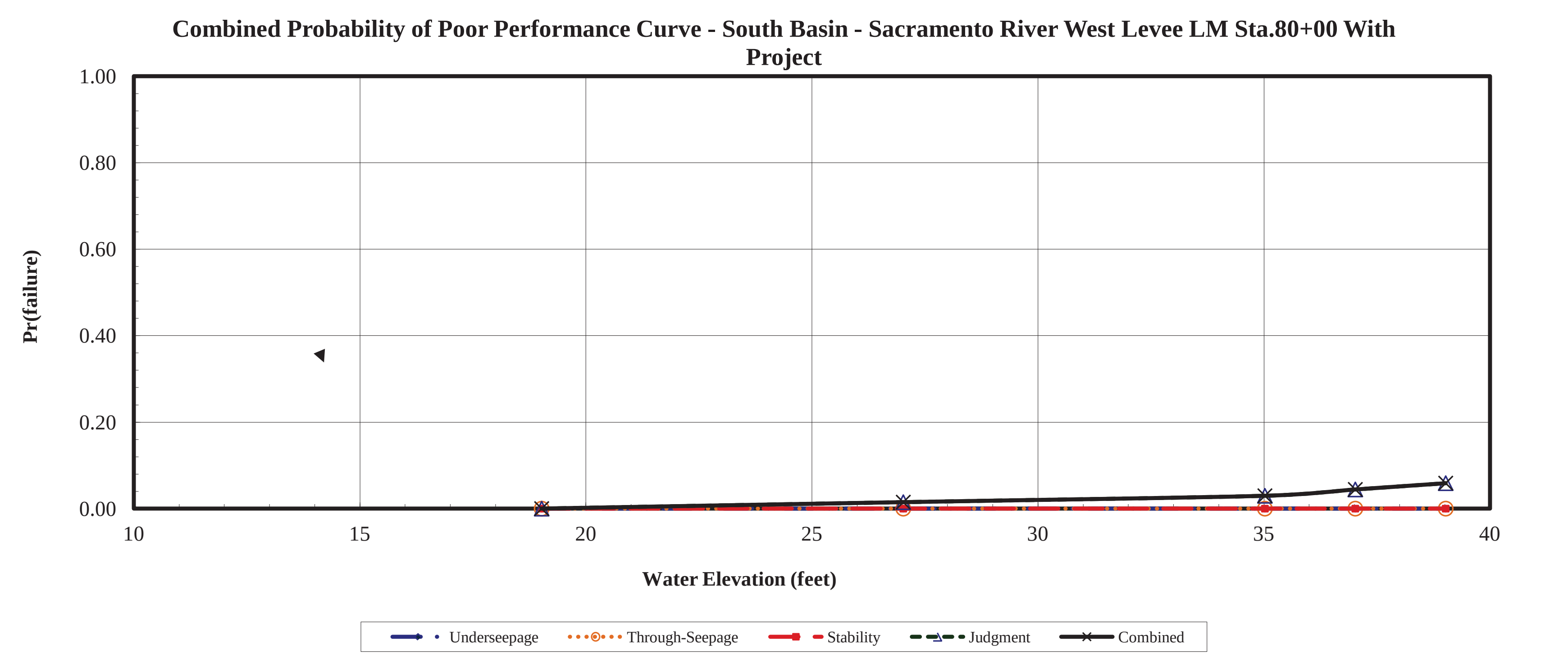
Project: West Sacramento GRR
Study Area: Sacramento River
River Section: South Basin - Sacramento River W

Levee Mile: Sta.80+00
River Mile: 53.08
Analysis Case: With Project

Crest Elev.: 39.02
L/S Toe Elev.: 19.02
W/S Toe Elev.: 19.02

Analysis By: A. Deus
Checked By: M. Kynett
Date: 4/25/2013

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
19.02	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
27.02	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0149	0.9851	0.0149	0.9851
35.02	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0297	0.9703	0.0297	0.9703
37.02	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0444	0.9556	0.0444	0.9556
39.02	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0589	0.9411	0.0589	0.9411



With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

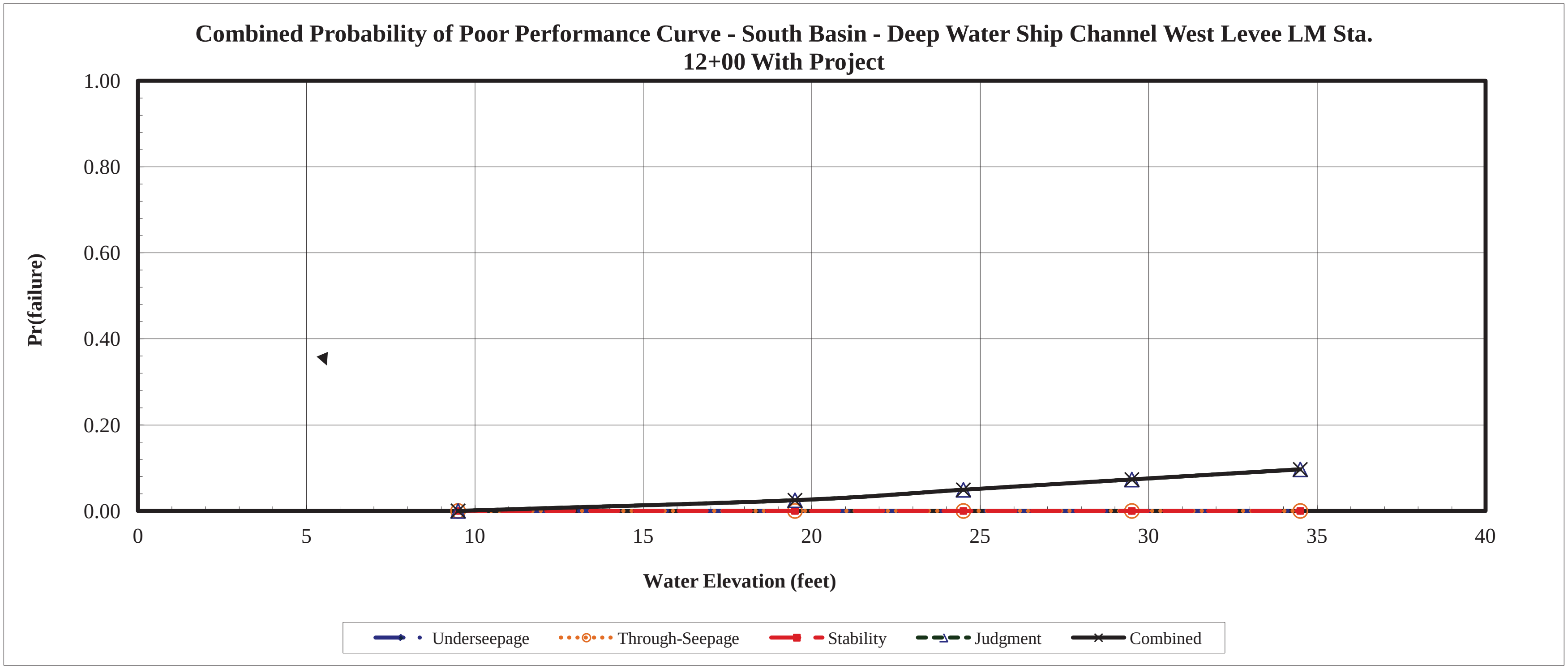
Project: West Sacramento GRR
Study Area: Deep Water Ship Channel
River Section: South Basin - Deep Water Ship Cl

Levee Mile: Sta. 12+00
River Mile: 41.21
Analysis Case: With Project

Crest Elev.: 34.50
L/S Toe Elev.: 9.50
W/S Toe Elev.: 9.50

Analysis By: A. Deus
Checked By: M. Kynett
Date: 4/26/2013

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
9.50	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
19.50	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0248	0.9752	0.0248	0.9752
24.50	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0491	0.9509	0.0491	0.9509
29.50	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0730	0.9270	0.0730	0.9270
34.50	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0965	0.9035	0.0965	0.9035



With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

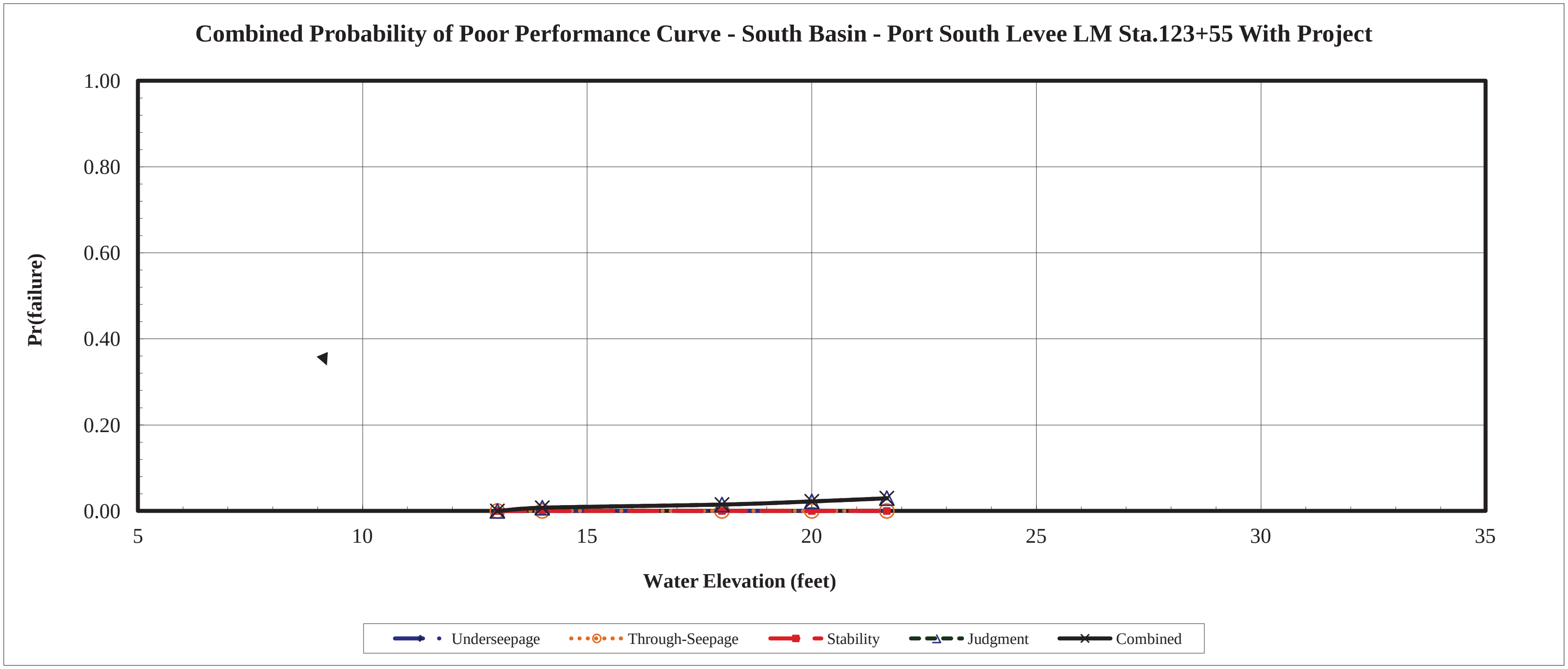
Project: West Sacramento GRR
Study Area: Deep Water Ship Channel
River Section: South Basin - Port South Levee

Levee Mile: Sta.123+55
River Mile: 43.45
Analysis Case: With Project

Crest Elev.: 21.67
L/S Toe Elev.: 13.00
W/S Toe Elev.: 13.00

Analysis By: A. Deus
Checked By: M. Kynett
Date: 4/24/2013

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
13.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
14.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0075	0.9925	0.0075	0.9925
18.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0150	0.9851	0.0150	0.9851
20.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0224	0.9776	0.0224	0.9776
21.67	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0298	0.9702	0.0298	0.9702



West Sacramento GRR
Economic Appendix

Attachment:

Certified Cost Estimate

WALLA WALLA COST ENGINEERING MANDATORY CENTER OF EXPERTISE

COST AGENCY TECHNICAL REVIEW

CERTIFICATION STATEMENT

SPK - PN 320653
West Sacramento GRR Project
West Sacramento, CA

The West Sacramento GRR Project, 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 cost:

FY2016 Costs: $1,190,528,000 (Cost ATR Certified)
Fully Funded Costs: $1,378,911,000

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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DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=USA, cn=JACOBS.MICHAEL.PIERRE.1160569537
Date: 2015.12.03 11:45:35 -08'00'

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

PROJECT: West Sacramento GRR

ALTERNATE #5

Alternate #1 with Set Back @ SRS

DISTRICT: SPK Sacramento PREPARED: 12/1/2015

PROJECT N(P2 #320653

POC: CHIEF, COST ENGINEERING, Jeremiah Frost

LOCATION: West Sacramento, CA Class 3 Estimate

This Estimate reflects the scope and schedule in 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	CE determined	$37,017	$10,365	28%	$47,382	0.0%	$37,017	$10,365	$47,382	$0	$47,382	13.0%	$41,817	$11,709	$53,526
06	FISH & WILDLIFE FACILITIES		$36,084	$10,104	28%	$46,188	0.0%	$36,084	$10,104	$46,188	$0	$46,188	16.0%	$41,845	$11,717	$53,562
11	LEVEES & FLOODWALLS		$413,408	$115,754	28%	$529,162	0.0%	$413,408	$115,754	$529,162	$0	$529,162	16.0%	$479,459	$134,249	$613,708
16	BANK STABILIZATION		$129,696	$36,315	28%	$166,011	0.0%	$129,696	$36,315	$166,011	$0	$166,011	17.0%	$151,752	$42,491	$194,243
02	RELOCATIONS	RE / Eng Supplied	$27,003	$7,561	28%	$34,564	0.0%	$27,003	$7,561	$34,564	$0	$34,564	9.6%	$29,586	$8,284	$37,870
	CONSTRUCTION ESTIMATE TOTALS:		$643,208	$180,098		$823,306	0.0%	$643,208	$180,098	$823,306	$0	$823,306	15.7%	$744,460	$208,449	$952,909
01	LANDS AND DAMAGES		$110,205	$38,572	35%	$148,777	0.0%	$110,205	$38,572	$148,777	$0	$148,777	4.4%	$115,054	$40,269	$155,323
30	PLANNING, ENGINEERING & DESIGN		$106,804	$29,905	28%	$136,709	0.0%	$106,804	$29,905	$136,709	$0	$136,709	18.5%	$126,553	$35,435	$161,988
31	CONSTRUCTION MANAGEMENT		$57,888	$16,209	28%	$74,097	0.0%	$57,888	$16,209	$74,097	$0	$74,097	35.9%	$78,683	$22,031	$100,714
18	CULTURAL RESOURCE PRESERVATION		$ 5,968	$ 1,671	28%	$7,639	0.0%	$ 5,968	$ 1,671	$7,639	$0	$7,639	4.4%	$ 6,232	$ 1,745	$7,977
	PROJECT COST TOTALS:		$924,073	$266,455	29%	$1,190,528		$924,073	$266,455	**$1,190,528**	$0	**$1,190,528**	15.8%	$1,070,983	$307,929	$1,378,911

CHIEF, COST ENGINEERING, Jeremiah Frost

PROJECT MANAGER, Bryon Lake

CHIEF, REAL ESTATE, Stan Wallen (Acting)

CHIEF, ENGINEERING, Rick Poeppelman

ESTIMATED FEDERAL COST:	65%	**$896,292**
ESTIMATED NON-FEDERAL COST:	35%	**$482,619**
ESTIMATED TOTAL PROJECT COST:		**$1,378,911**

West Sacramento GRR
Economic Appendix

Attachment:

Regional Economic Development (RED)/Other Social Effects (OSE) Analyses

ATTACHMENT
WEST SACRAMENTO 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 West Sacramento GRR. (The EQ assessment is described in the main planning document.)

B. OTHER SOCIAL EFFECTS (OSE)

<u>Purpose and Methodology</u>

The OSE assessment is intended to provide a portrait of the social landscape of the West Sacramento 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)

Early History of the West Sacramento Area

The surrounding land and water provided abundant natural resources to the Patwin Indians, who were the first inhabitants of the area at around 500 AD. European settlers began arriving in the 1800's, and established the first permanent settlement in 1844. In 1849 the Town of Washington (which is now the Broderick area of West Sacramento) was established. During the early years, the area supported successful fishing, farming, and dairy industries. Over time the area continued to grow, prosper, and develop; from 1900 to 1920, the population in the area doubled from about 1,398 to about 2,638. In 1963, the Port of Sacramento opened to deep sea traffic with the completion of the Deep Water Ship Channel.

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 West Sacramento study area is home to more than 48,000 people. The area has seen tremendous growth over the last 10 to 15 years as an influx of people have come from across the region to take advantage of the relatively affordable home prices as well as the many amenities available nearby. Between 2000 and 2010, the area has seen a population increase of about 54%, many of whom represent various races and ethnicities, bringing extraordinary diversity to the area. Also, based on the 2010 Census, the people that have settled in West Sacramento over the past decade have more formal education, with a quarter of the residents holding at least a bachelor's degree (compared to only about 10% in 2000). Finally, the median household income in the area has increased significantly from 2000 ($31,718) to 2010 ($54,179), indicating an increase level of economic activity for the area and the region. In comparison, the median household income for California as a whole stayed about the same between 2000 and 2010.

Key demographics are presented in Table 1 below.

Table 1: Basic Social Characteristic of West Sacramento Study Area - 2000 and 2010 Census Data

Social Statistic	West Sacramento			California		
	2000	2010	% Δ	2000	2010	% Δ
Population	31,615	48,744	+54%	33,871,648	37,253,956	+10%
Age						
Median	34	33.6	-1.2%	33.3	35.2	+5.7%
% >65	12.7%	9.5%	-25%	10.6%	11.4%	+7.5%
% <18	29.8%	26.7%	-10.4%	27.3%	25.0%	-8.4%
Race & Ethnicity						
Asian	7.2%	10.5%	+46%	10.9%	12.8%	+17.4%
Black	2.6%	4.8%	+85%	6.7%	5.8%	-13.4%
Hispanic	30%	31.4%	+4.7%	32.4%	37.6%	+16%
White	54.6%	36.8%	-33%	46.7%	40.1%	-14.1%
Other	5.6%	16.5%	+195%	4.3%	3.7%	+86%
Education						
% HS Graduates	69.9%	81.2%	+16.2%	81%	80.8%	-0.2%
% College Graduates	9.8%	23.5%	+39.8%	30.5%	30.2%	-0.9%
Income and Poverty						
% Unemployed	5.4%	12.2%	+126%	4.3%	7.1%	+65%
Median Household Income	$31,718	$54,179	+71%	$61,400	$61,632	0%
% Below Poverty	22.3%	18.8%	-15.7%	15.3%	14.4%	-5.9%
Housing						
% Own	54.5%	58.7%	+7.7%	56%	55.9%	0%
% Rent	45.5%	41.3%	-9.2%	44%	44.1%	0%
Quality of Life						
Avg. Household Size	2.75	2.78	-1.1%	2.98	3.45	+16%
Language Other than English Spoken at Home	38.4%	37.4%	-2.6%	43.5%	43.2%	-0.7%
Mean Travel Time to Work (in minutes)	21.2	22.7	+7.1%	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 West Sacramento 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 – West Sacramento 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 community is in very close proximity to the state Capitol and the significant amount of political resources available there.
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 51.2% of the work force while men make up 48.8%; the median earnings for women in the area is $34,046, which is just 83% of the median earnings 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. About 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 and for the state as a whole; the percentage of residents younger than 18 (26.7%) is slightly higher than the stage statistic (25%).
Employment Loss	The potential loss of employment following a disaster exacerbates the number of unemployed workers in a community, contributing to a slower	The latest Census indicates that the current unemployment rate in the area may be significantly higher than the state's. A flood event

	recovery from the disaster.	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 average quality homes. Medium density neighborhoods are typical. There is not a significant percentage of prestige homes; there is not a significant percentage of mobile homes.
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.	The West Sacramento community is 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, Sacramento, Folsom, Elk Grove, Dixon, and 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 fairly high (greater than 40%), but is still lower 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, and gardening) may similarly suffer, as disposable income fades and the	The number of people that live in the area and work in resource extraction occupations is fairly low the 2010 Census indicates that around 300 people work in the farming, fishing, and forestry occupations.

	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 quarter 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.	West 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 54%. 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 West Sacramento would have access to nearby medical facilities in the cities of Davis, Woodland, Sacramento, Elk Grove, Folsom, El Dorado Hills, Roseville, Rocklin, Dixon, and others

<u>Life Safety Evaluation</u>

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 West Sacramento 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 (Alternative 5) condition. A comparison of potential fatalities under each condition is displayed in Table 3 below.

Table 3: Statistical Life Loss Estimates

Levee Segment	Estimated Life Loss					
	Without-Project (Assumes Breach Prior to Overtopping)			Alternative 5 (Assumes No Breach Until Overtopping)		
	Day	Night	Weighted	Day	Night	Weighted
Sacramento River – North Levee	124	90	106	41	30	35
Sacramento River – South Levee	124	90	106	41	30	35
Yolo Bypass – North of DWSC	124	90	106	41	30	35

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. These include:

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 (Alternative 5) 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 5
Population at Risk (People)	48,000	0
Critical Infrastructure (Facilities)	76	41
Evacuation Routes (Number of Routes)	0	11
Wise Use of Floodplains (Acres)	0	3,896

Population at Risk: The population at risk of flooding from a 1% ACE flood event is about 48,000 for the without-project condition. Most of this population would be removed from the 1% ACE floodplain under Alternative 5. 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 West Sacramento community actually has a lower percentage (9.5%) of seniors over 65 as compared to the senior population of the state of California (11.4%).

Critical Infrastructure: A significant amount of critical infrastructure is located within the West Sacramento 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. Alternative 5 removes a significant proportion of the critical infrastructure from the floodplain.

Evacuation Routes: The City of West Sacramento's evacuation maps were last updated in 2009. In their plan they have identified flood stage actions, public notification procedures, temporary shelters for children and special needs adults, and an evacuation checklist. The City has provided maps detailing evacuation routes and temporary shelter locations. The City of West Sacramento distributes quarterly news letters to its residents to keep them informed of all current emergency information.

Flood preparedness is a common topic in local media. The local emergency management offices often send out information about what to do in preparation for an emergency. The City of West Sacramento's public website provides emergency preparedness information, emergency evacuation procedures, and links to the appropriate County, State and Federal agencies responsible for emergency preparedness.

There are several evacuation routes out of the city of West Sacramento. Interstate 80, three lanes in each direction, can be taken either east (to Sacramento) or west (towards Davis). Business 80/State Highway 50, which are four lanes in each direction, can be taken east (to Sacramento). The I Street and Tower Bridges (one and two lanes in each direction, respectively) can be taken east (to Sacramento). North Harbor Boulevard, one lane in each direction, can be taken northwest across the Sacramento Weir to the area north of the Sacramento Bypass. Jefferson Boulevard or South River Road, both one lane in each direction, can be taken south to the area south of the cross levee. In total, there are 16 assigned lanes going out of West Sacramento, which is a large number compared to other locations in the Central Valley of California.

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.

<u>Without-Project and With-Project Comparison</u>

An assessment of the beneficial and adverse effects associated with the without-project condition and the tentatively selected plan (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 Alternative 5.

Table 6: Effects of Alternatives

	Without-Project	**Alternative 5**
Alternative Description		
	No project is constructed by the Federal government	Improvements to the Yolo Bypass (east levee), DWSC (west levee), Sacramento River (north and south levees), South Cross Levee, and port (north and south levees) 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 48,000 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 48,000 West Sacramento residents
Loss of Life	Potential loss of life: 106	Potential loss of life: 35
Critical Infrastructure	76 critical infrastructure at risk	41 critical infrastructure at risk
Evacuation Routes	No evacuation routes available if flood event occurs	11 evacuation routes available in the event of a flood
Wise Use of Floodplains	0 available acres	About 3,900 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 West 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.

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 Alternative 5 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 West Sacramento 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 Alternative 5. 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 the Recommended Plan (Alternative 5) is $1,041,751,000 (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.

Table 9 is based on the average annual regional expenditures that are expected over the construction period. The construction period for the Recommended Plan is assumed to be 17 years. Over that period, a total of about $1.04 billion is anticipated to be spent in the West Sacramento study area in order to build the Recommended Plan. The average construction expenditure is $61 million, which is the anticipated amount ($1.04 billion) divided by the number of years of construction (17).

Table 9: Inputs Assumptions, Sacramento/Arden/Arcade/Roseville, CA MSA (October 2015 Price Level)

Category	Spending	Spending Amount	Local Percentage Capture		
		Recommended Plan	Local	State	National
Aggregate Materials	10%	102,092,000	70	77	97
Other Materials	1%	12,501,000	99	100	100
Equipment	35%	364,613,000	69	99	100
Construction Labor	54%	562,546,000	100	100	100
Total	100%	1,041,751,000	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 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 Table 9, all of the construction labor is expected to occur within the Sacramento/Arden/Arcade/Roseville MSA; 69% of the equipment is expected to be provided from within the study area and 99% from within the state of California.

Table 10 summarizes the overall economic impacts for this analysis. The USACE is planning to expend approximately $1.04 billion on the project. Of this total project expenditure, approximately $899 million will be captured within the regional impact area. 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 10.

Table 10: Summary of Economic Impacts, Sacramento/Arden/Arcade/Roseville, CA MSA (October 2015 Price Level)

Total Spending		Recommended Plan		
		Regional	State	National
		$1,041,751,000	$1,041,751,000	$1,041,751,000
Direct Impact	**Output**	$899,314,000	$1,014,708,000	$1,038,015,000
	Jobs	13,650	14,050	14,200
	Labor Income	$656,282,000	$687,520,000	$697,667,000
	GRP	$725,860,000	$806,738,000	$819,668,000
Total Impact	**Output**	$1,652,888,000	$2,041,037,000	$2,740,896,000
	Jobs	18,930	21,020	24,800
	Labor Income	$913,345,000	$1,040,775,000	$1,267,865,000
	GRP	$1,199,787,000	$1,419,026,000	$1,807,941,000

Table 11: Economic Impacts – Regional Level, Sacramento/Arden/Arcade/Roseville, CA MSA (October 2015 Price Level)

Industry Sector		Recommended Plan			
		Sales	Jobs	Labor Income	GRP
Direct Effects	Mining and quarrying sand, gravel, clay, & ceramic and refractory minerals	$39,826,000	290	$14,753,000	$19,145,000
	Wholesale trade businesses	$1,106,000	6	$422,000	$836,000
	Transport by rail	$2,398,000	7	$814,000	$1,325,000
	Transport by water	$449,000	1	$91,000	$202,000
	Transport by truck	$28,183,000	220	$12,552,000	$15,178,000
	Construction of other new nonresidential structures	$12,391,000	70	$4,995,000	$6,308,000
	Commercial & industrial machinery & equipment rental/leasing	$252,407,000	810	$60,110,000	$137,067,000
	Labor	$562,546,000	12,260	$562,546,000	$562,546,000
Total Direct Effects		$899,314,000	13,650	$656,282,000	$742,607,000
Secondary Effects		$753,574,000	5,270	$257,063,000	$457,180,000
Total Effects		**$1,652,888,000**	**18,930**	**$913,345,000**	**$1,199,787,000**

Table 12: Economic Impacts – State Level, Sacramento/Arden/Arcade/Roseville, CA MSA (October 2015 Price Level)

Industry Sector		Recommended Plan			
		Sales	Jobs	Labor Income	GRP
Direct Effects	Mining and quarrying sand, gravel, clay, & ceramic and refractory minerals	$39,826,000	290	$14,753,000	$19,145,000
	Wholesale trade businesses	$1,531,000	8	$609,000	$1,167,000
	Transport by rail	$2,398,000	7	$814,000	$1,325,000
	Transport by water	$794,000	2	$161,000	$356,000
	Transport by truck	$34,458,000	270	$15,393,000	$18,595,000
	Construction of other new nonresidential structures	$12,501,000	70	$5,040,000	$6,365,000
	Commercial & industrial machinery & equipment rental/leasing	$360,654,000	1,160	$88,205,000	$197,239,000
	Labor	$562,546,000	12,260	$562,546,000	$562,546,000
Total Direct Effects		$1,014,708,000	14,050	$687,520,000	$806,738,000
Secondary Effects		$1,026,329,000	6,970	$353,255,000	$612,288,000
Total Effects		**$2,041,037,000**	**21,020**	**$1,040,775,000**	**$1,419,026,000**

Table 13: Economic Impacts – National Level, Sacramento/Arden/Arcade/Roseville, CA MSA (October 2015 Price Level)

Industry Sector		Alternative 5			
		Sales	Jobs	Labor Income	GRP
Direct Effects	Mining and quarrying sand, gravel, clay, & ceramic and refractory minerals	$56,669,000	410	$22,511,000	$28,539,000
	Wholesale trade businesses	$1,552,000	9	$618,000	$1,183,000
	Transport by rail	$2,969,000	8	$1,008,000	$1,641,000
	Transport by water	$1,149,000	3	$234,000	$516,000
	Transport by truck	$36,548,000	280	$16,341,000	$19,734,000
	Construction of other new nonresidential structures	$12,501,000	70	$5,040,000	$6,365,000
	Commercial & industrial machinery & equipment rental/leasing	$364,080,000	1,170	$89,369,000	$199,144,000
	Labor	$562,546,000	12,260	$562,546,000	$562,546,000
Total Direct Effects		$1,038,015,000	14,200	$697,667,000	$819,668,000
Secondary Effects		$1,702,881,000	10,600	$570,198,000	$988,273,000
Total Effects		**$2,740,896,000**	**24,800**	**$1,267,865,000**	**$1,807,941,000**

The creation of jobs in the study area is important to note. In 2010, the unemployment rate in the study area (12.4%) 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.