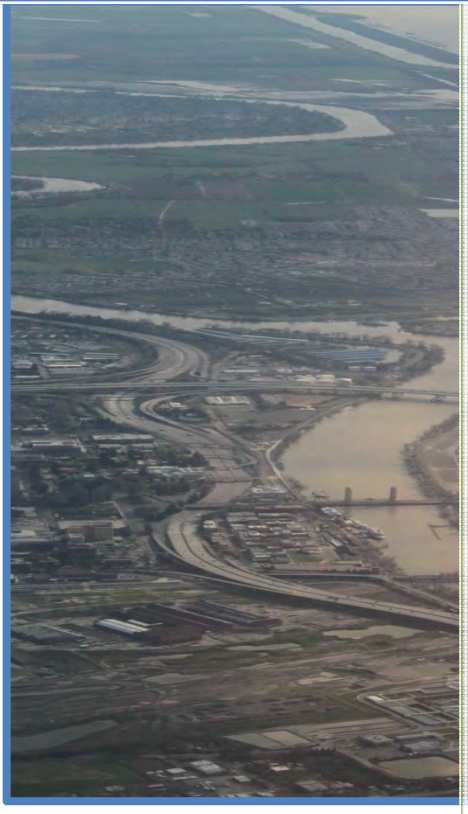
General Reevaluation Report



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

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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

LIST OF FIGURES

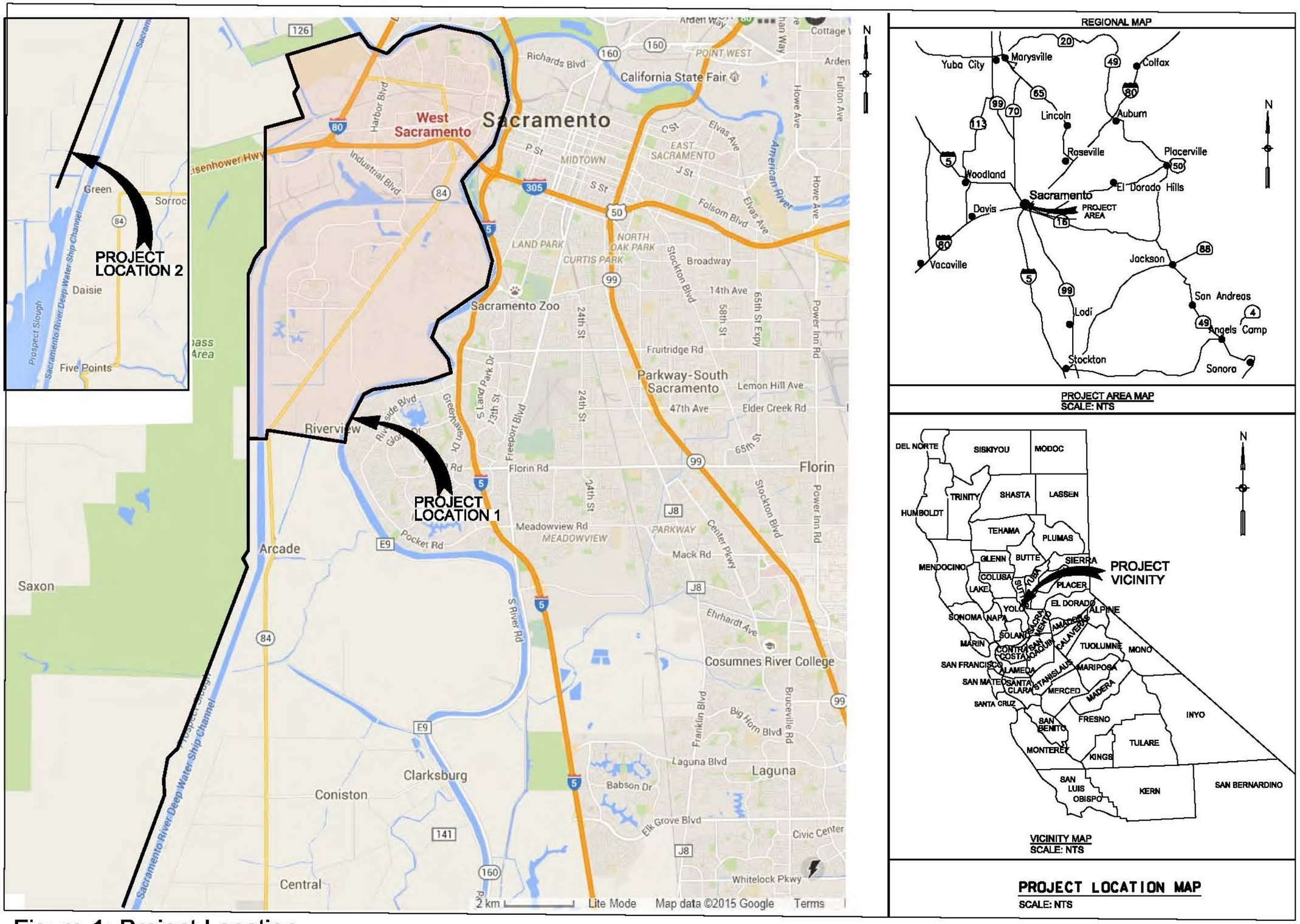
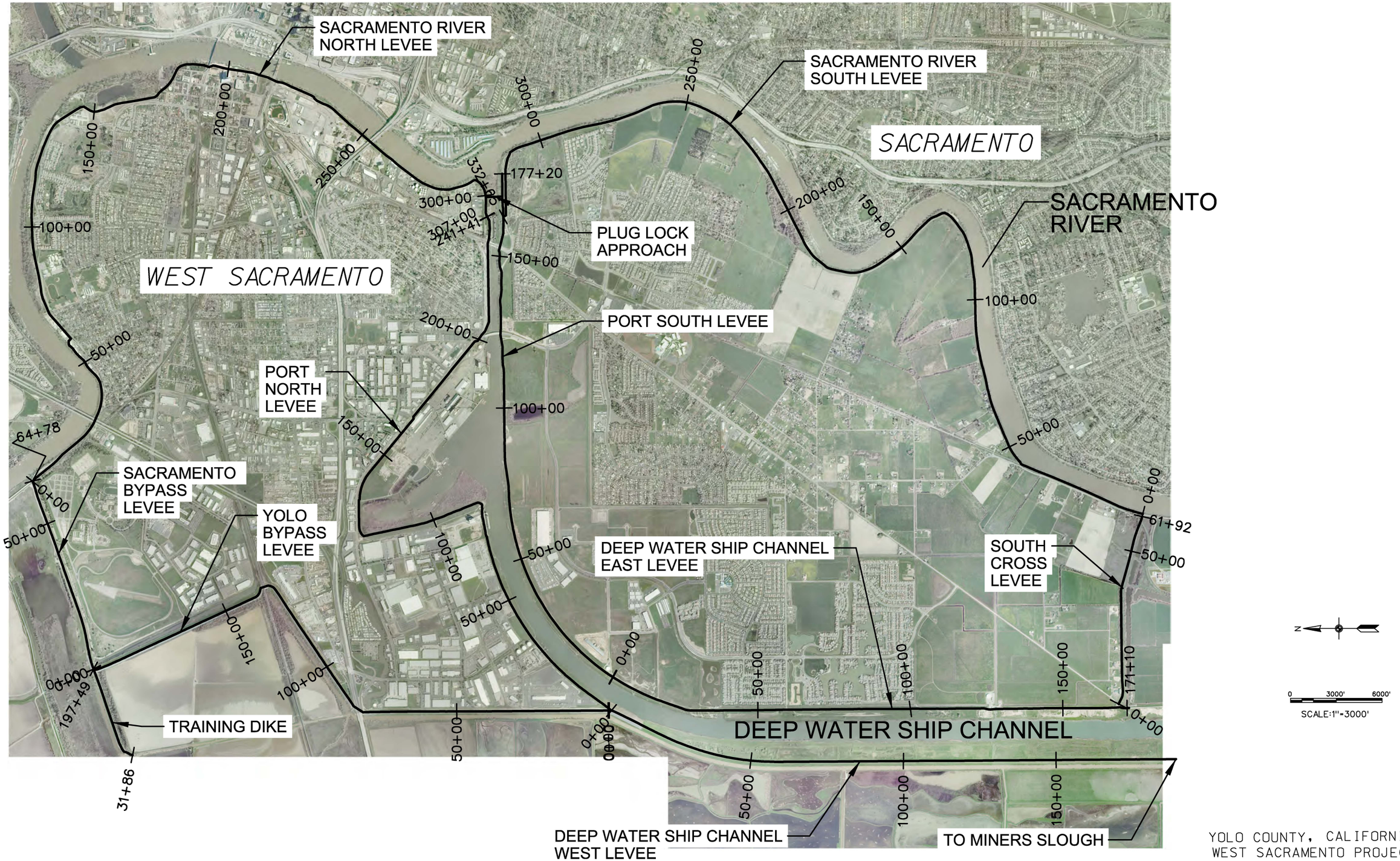


Figure 1: Project Location



YOLO COUNTY, CALIFORNIA
WEST SACRAMENTO PROJECT
GENERAL REEVALUATION REPORT
FLOOD RISK MANAGEMENT PROJECT

PROJECT LEVEE ALIGNMENTS

FIGURE 2 THE EXISTING LEVEES

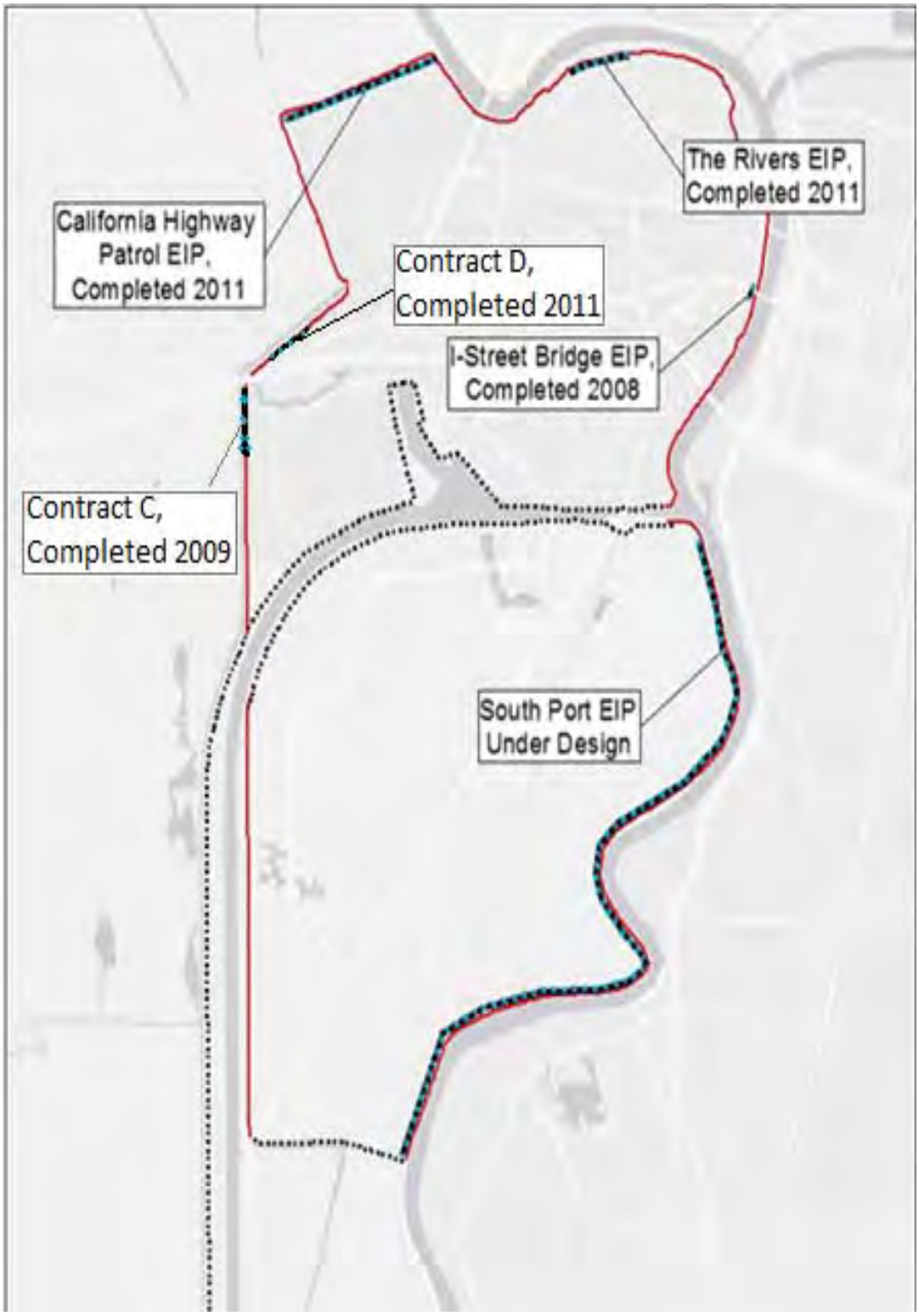


Figure 3: Early Implementation Project Locations

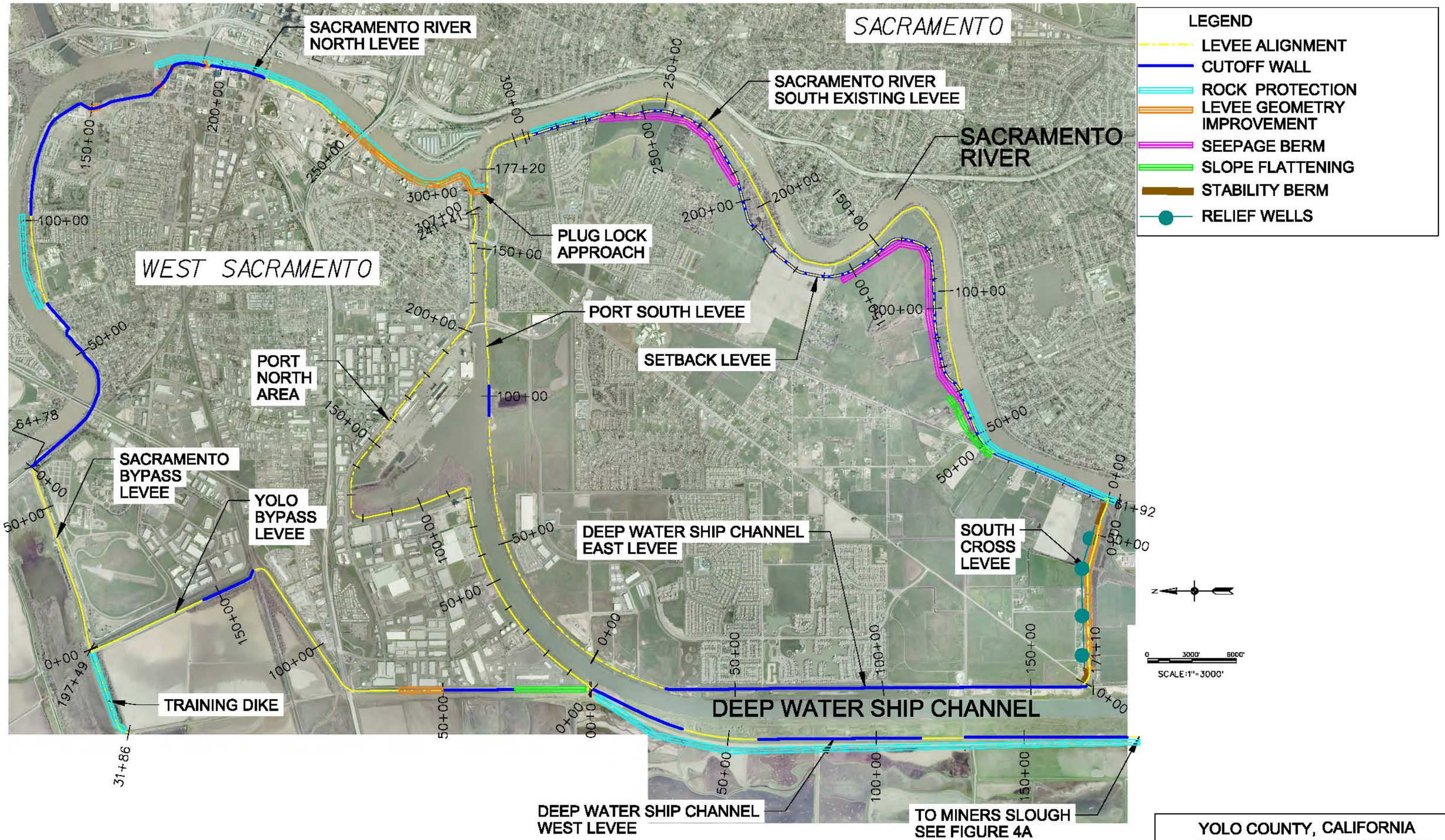
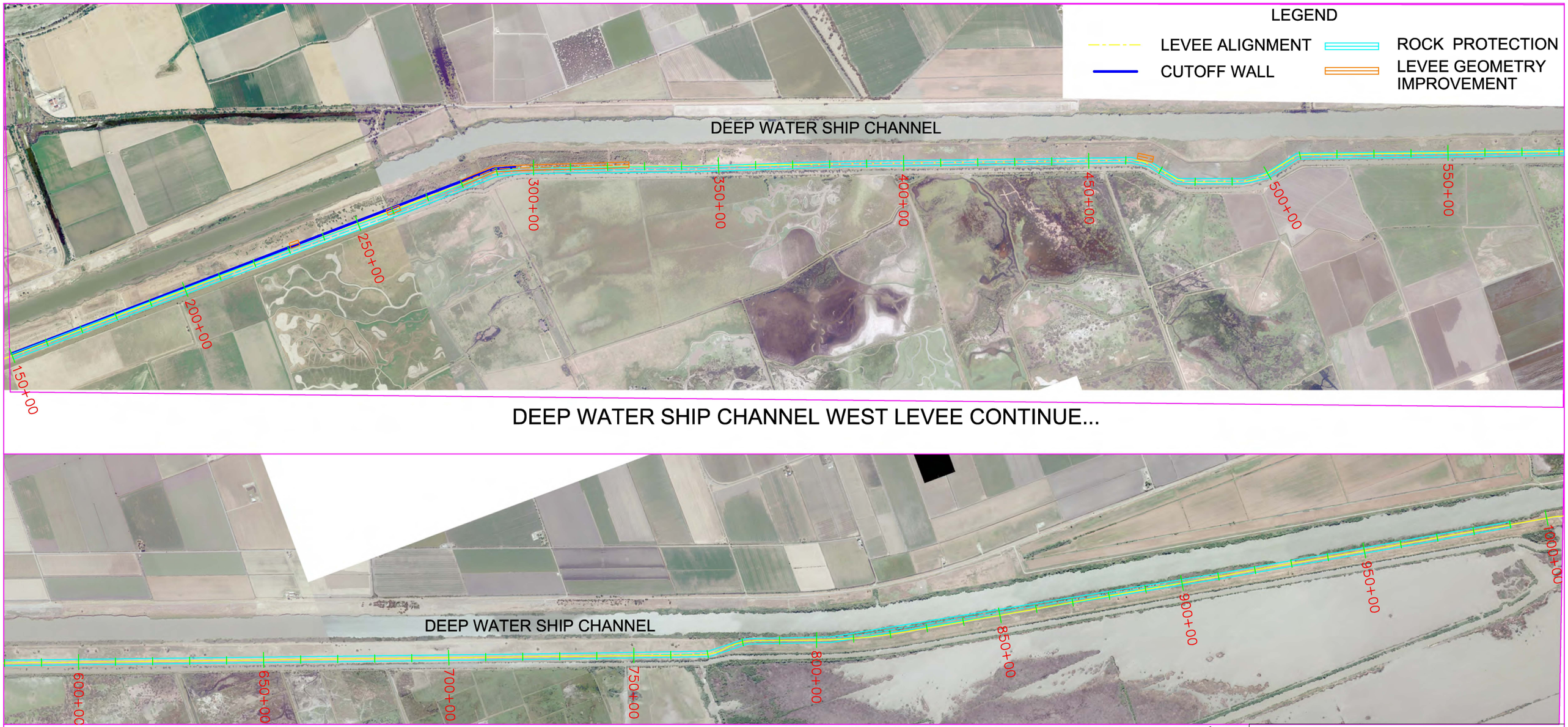


FIGURE 4 - Recommended Plan

YOLO COUNTY, CALIFORNIA
WEST SACRAMENTO PROJECT
GENERAL REEVALUATION REPORT
FLOOD RISK MANAGEMENT PROJECT
ALTERNATIVE 5



YOLO COUNTY, CALIFORNIA
WEST SACRAMENTO PROJECT
GENERAL REEVALUATION REPORT
FLOOD RISK MANAGEMENT PROJECT
ALTERNATIVE 5

FIGURE 4A - Recommended Plan

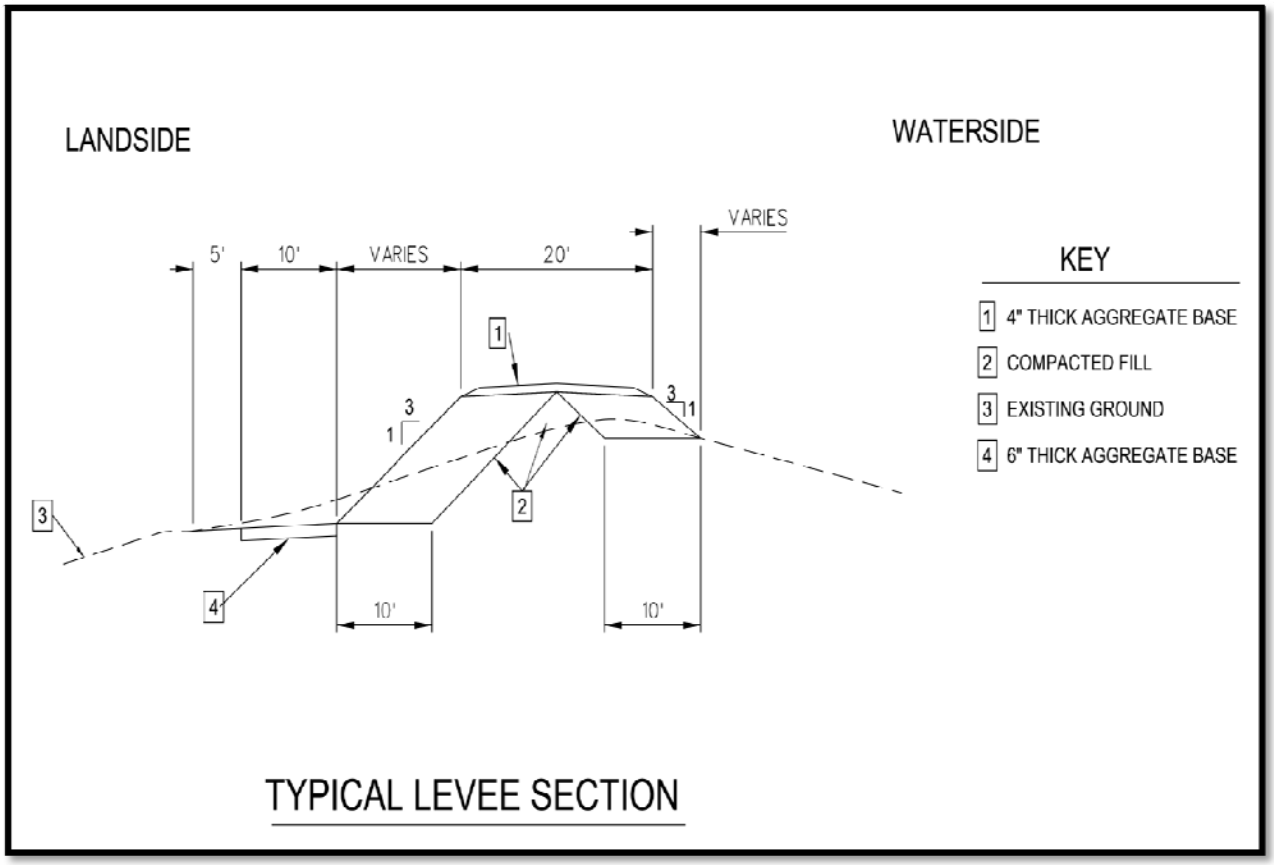


Figure 5: Typical Embankment Fill

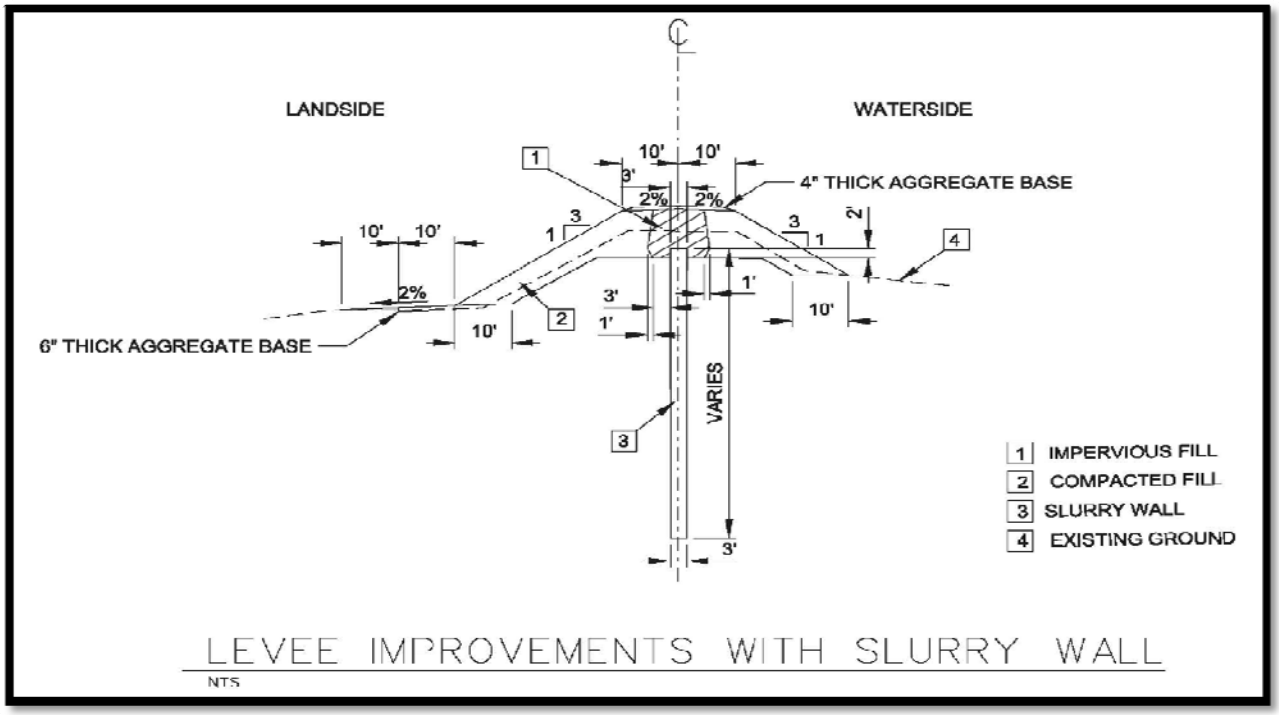


Figure 6: Levee Improvements with Cutoff Wall

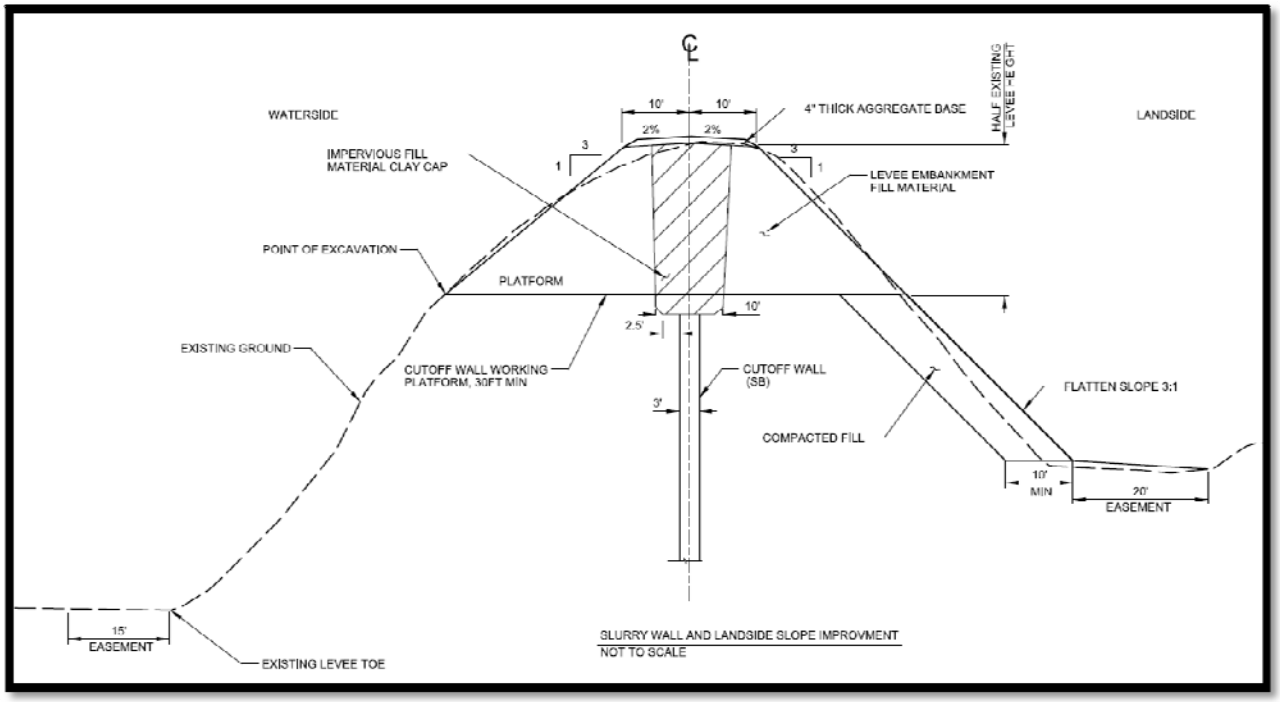


Figure 7: Cutoff Wall and Landside Slope Improvement

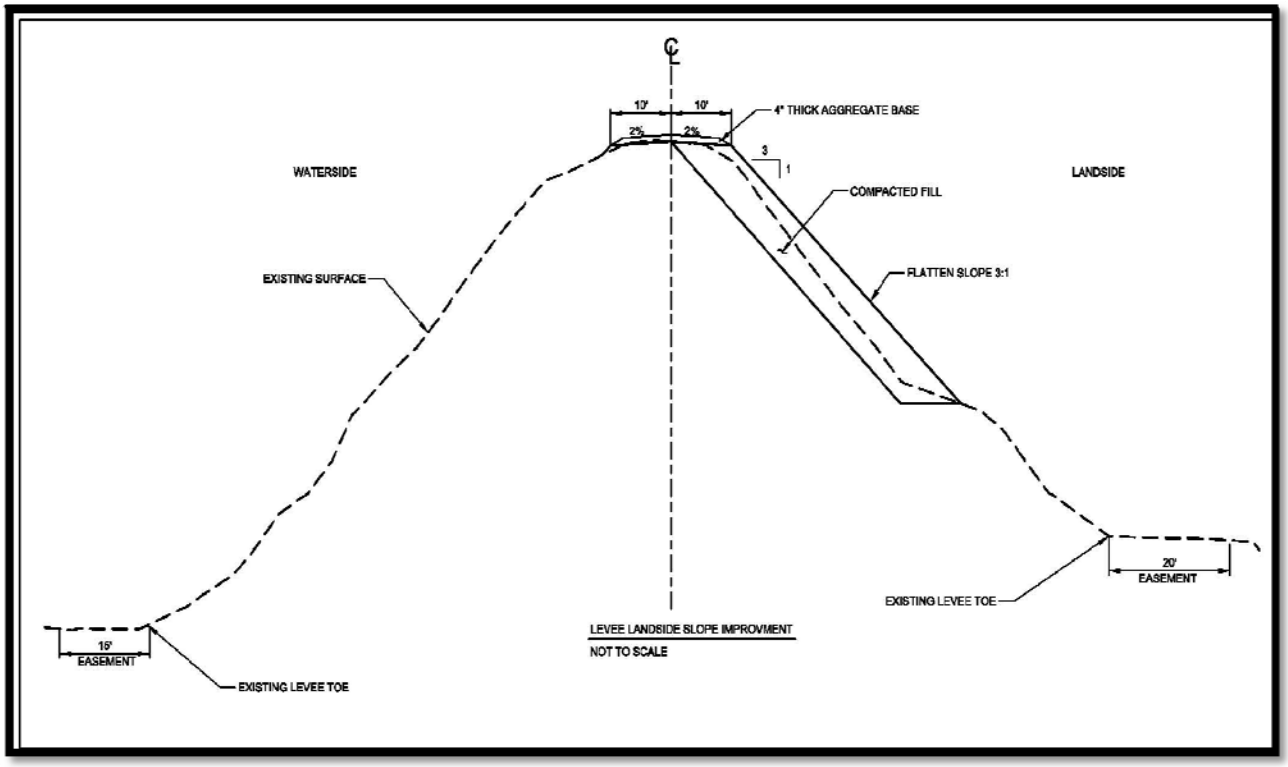


Figure 8: Levee Landside Slope Improvement

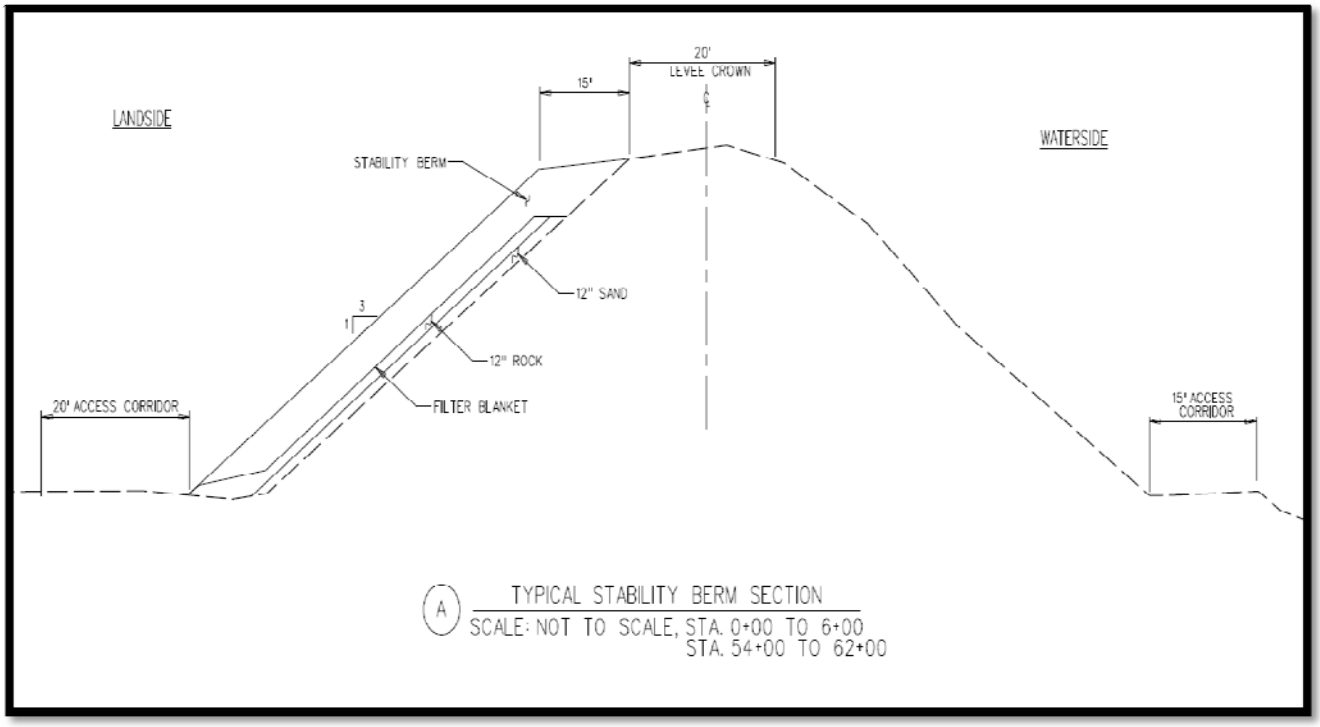


Figure 9: Embankment Fill and Stability Berm

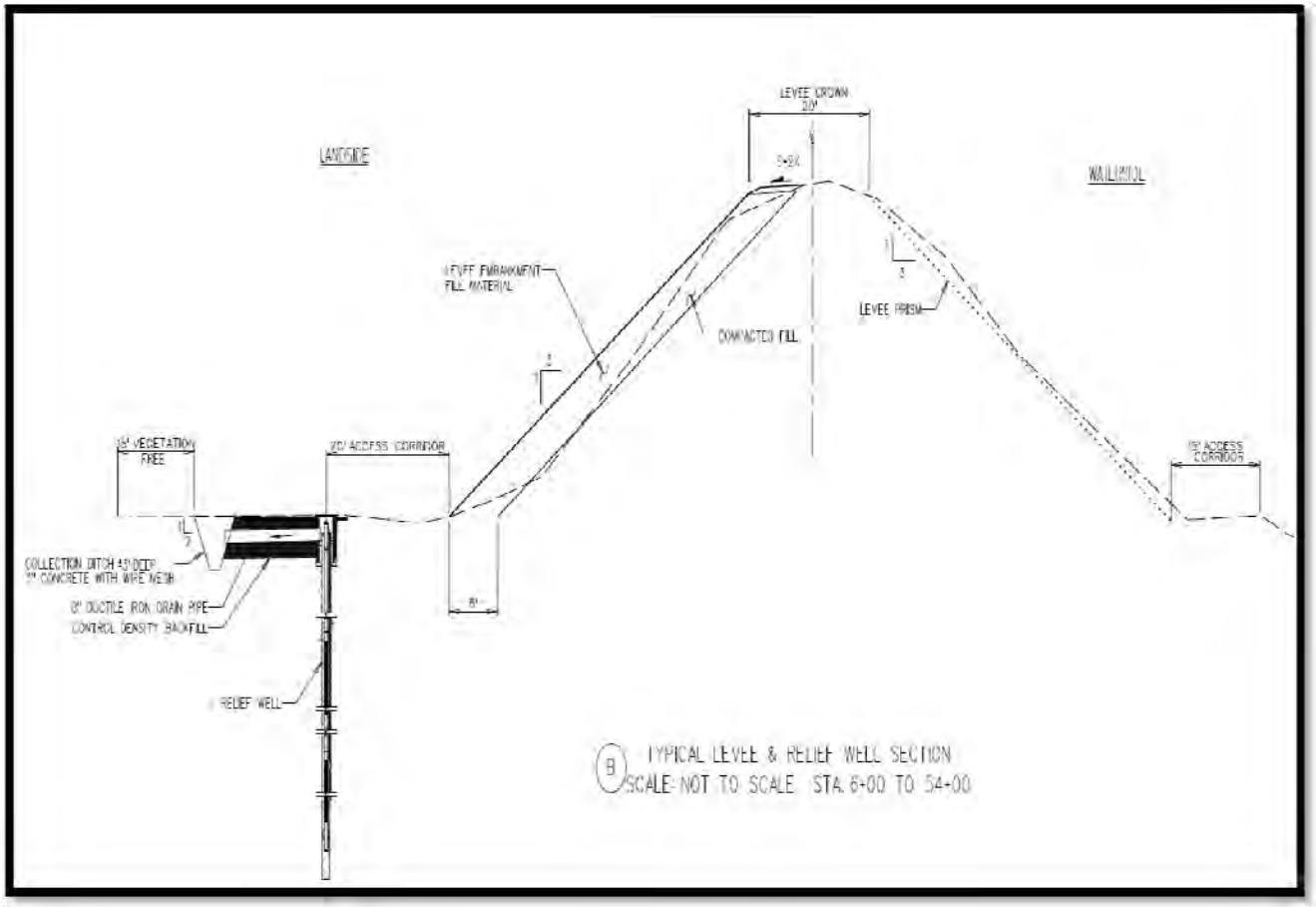


Figure 10: Embankment Fill & Relief Well

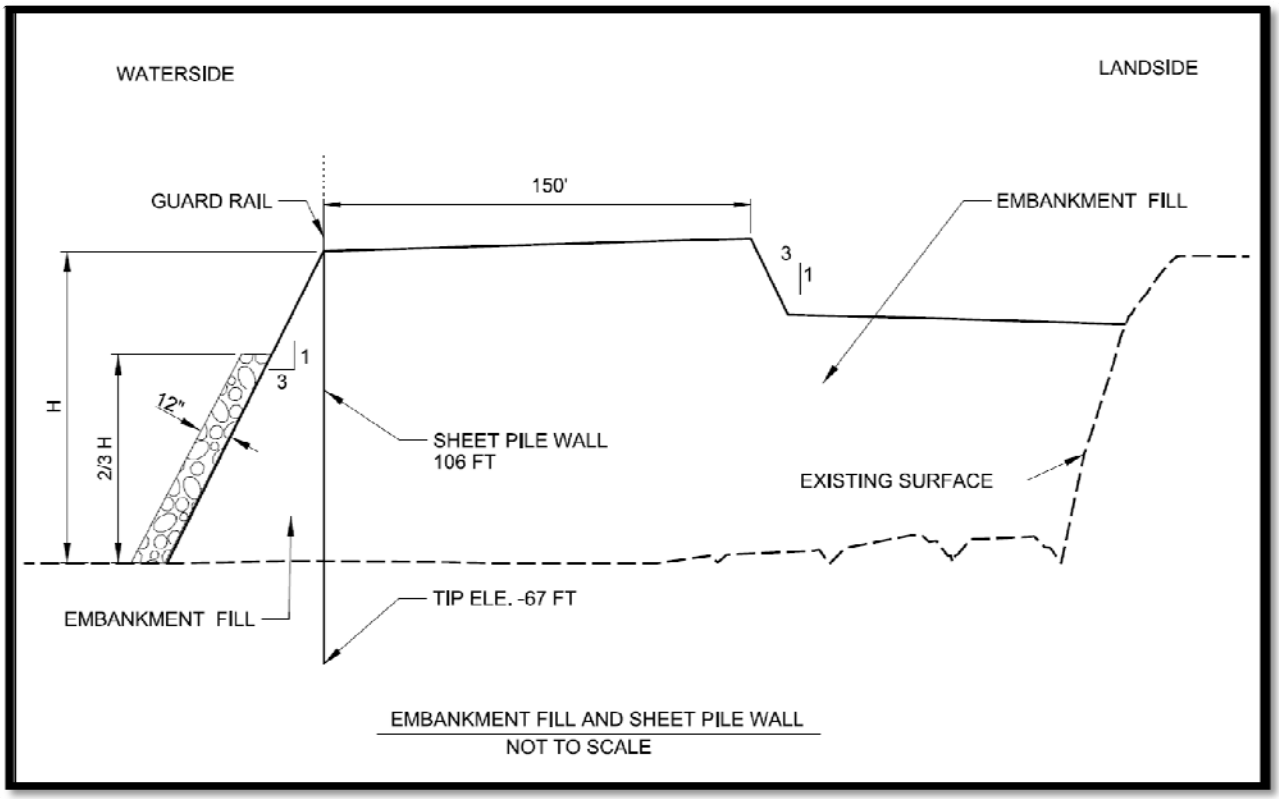


Figure 11: Embankment Fill and Sheet Pile Wall

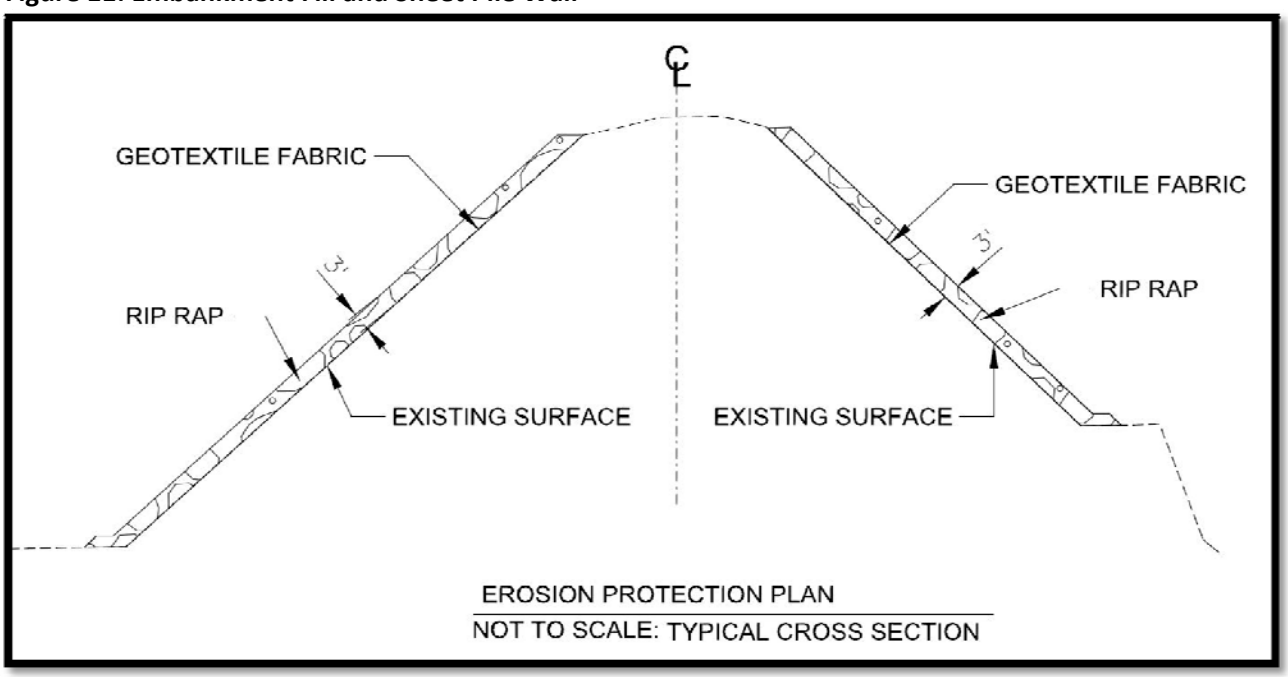


Figure 12: Erosion Protection Plan

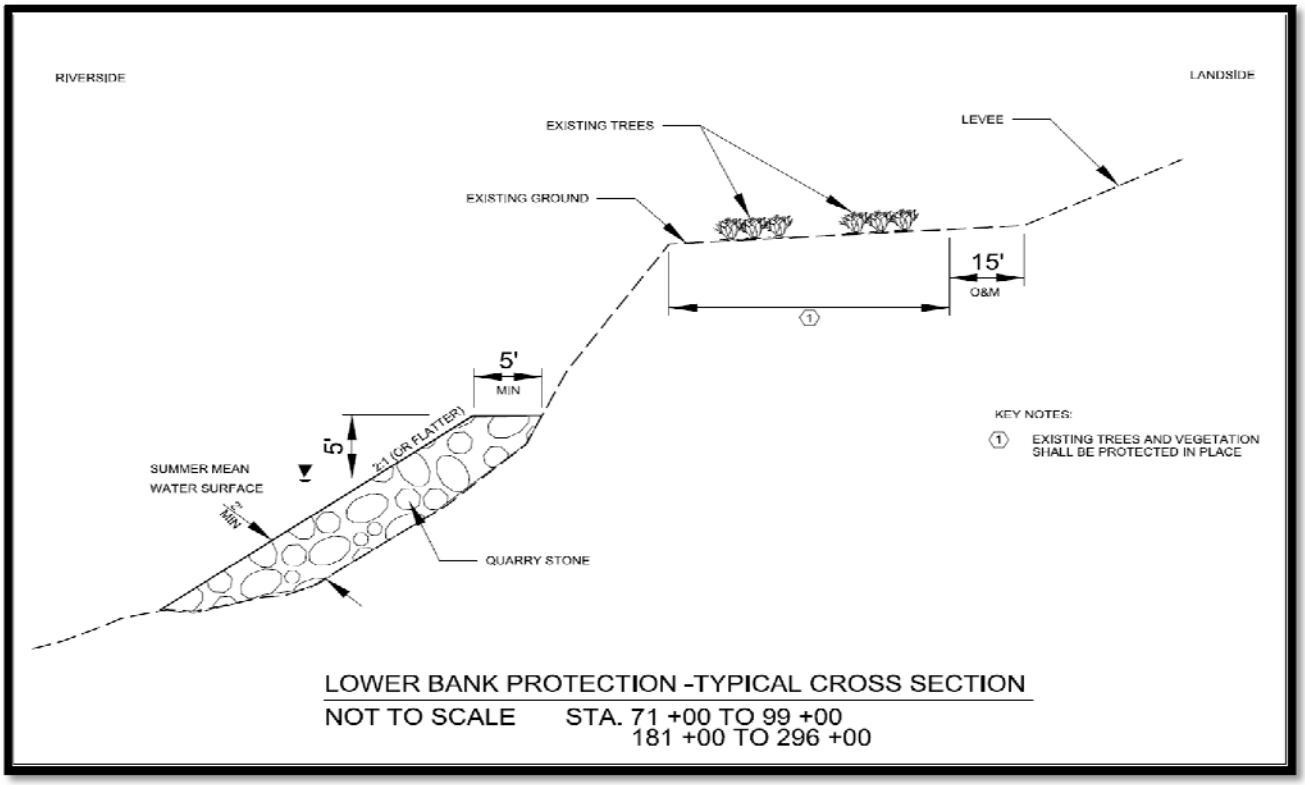


Figure 13: Bank Erosion Protection

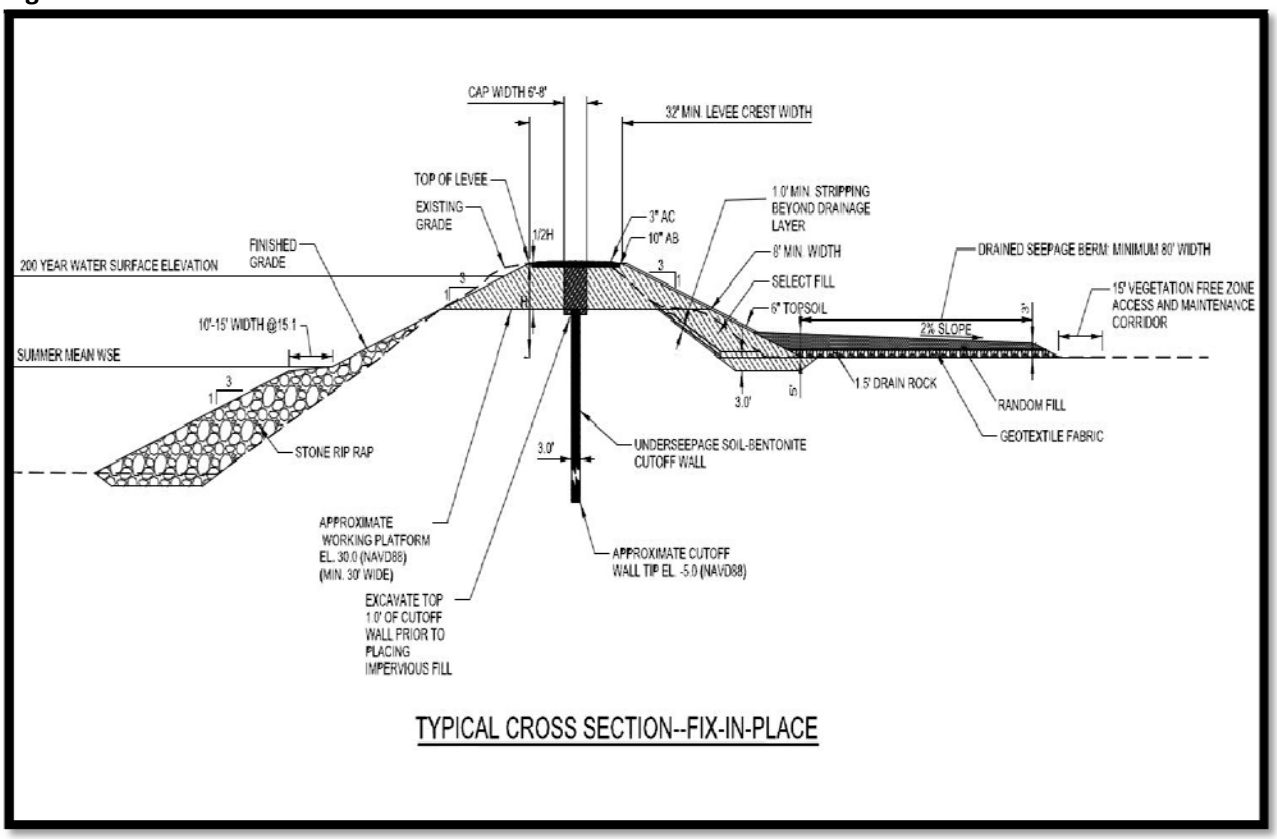
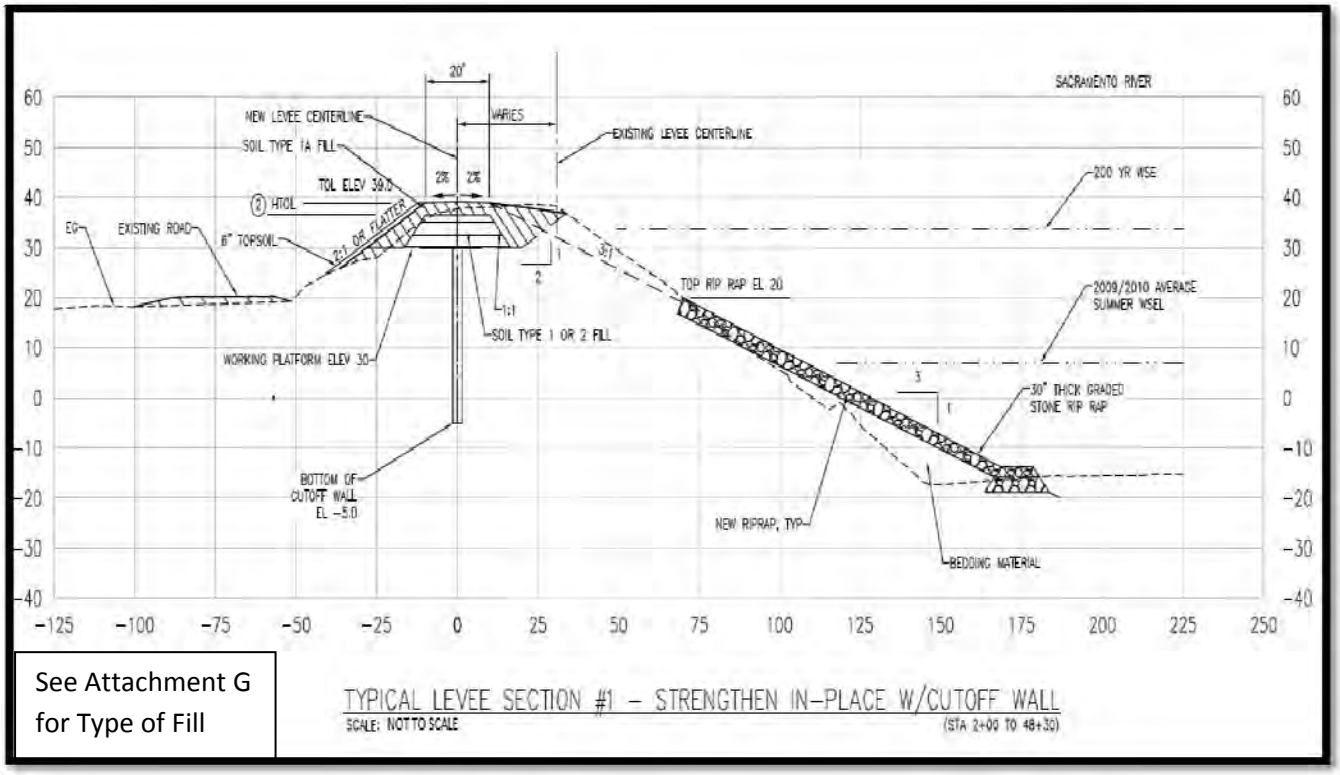
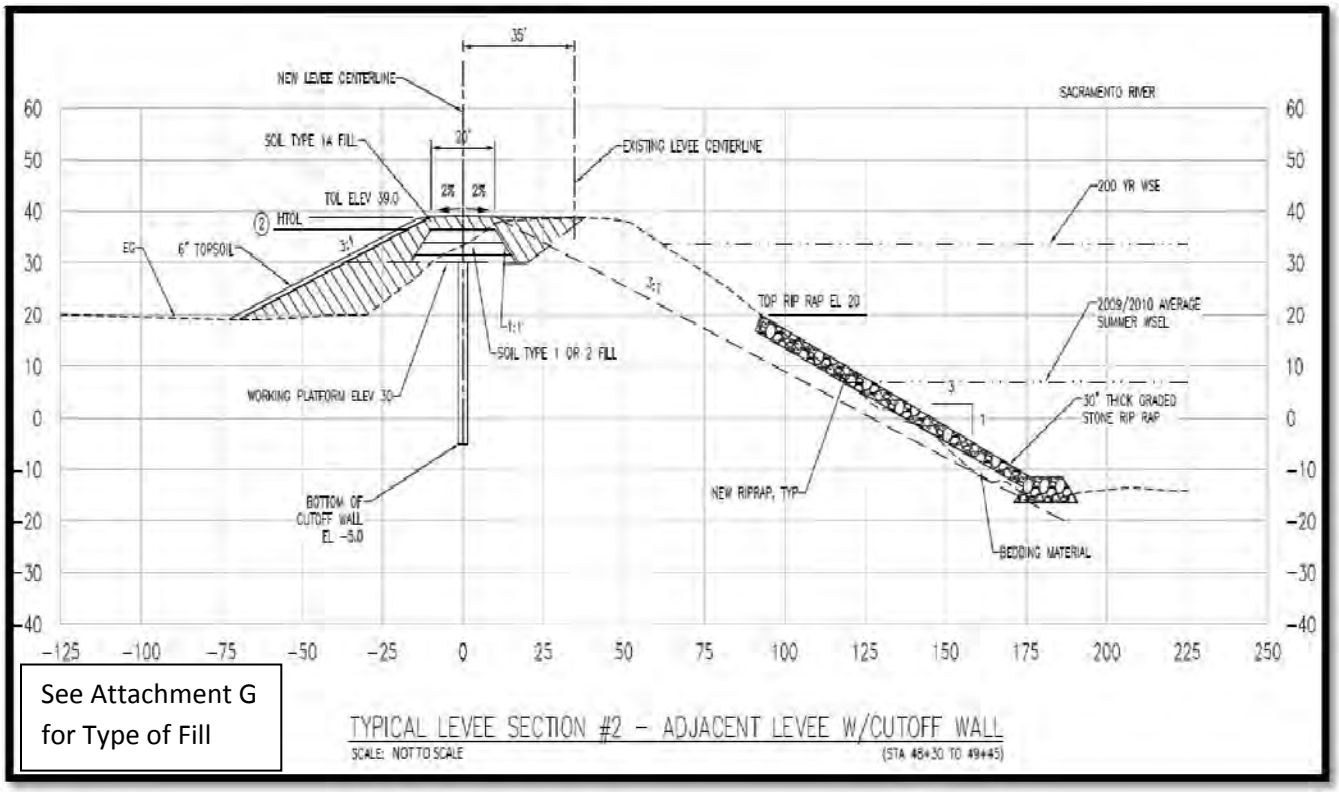


Figure 14: Typical Cross Section Fix-in-Place



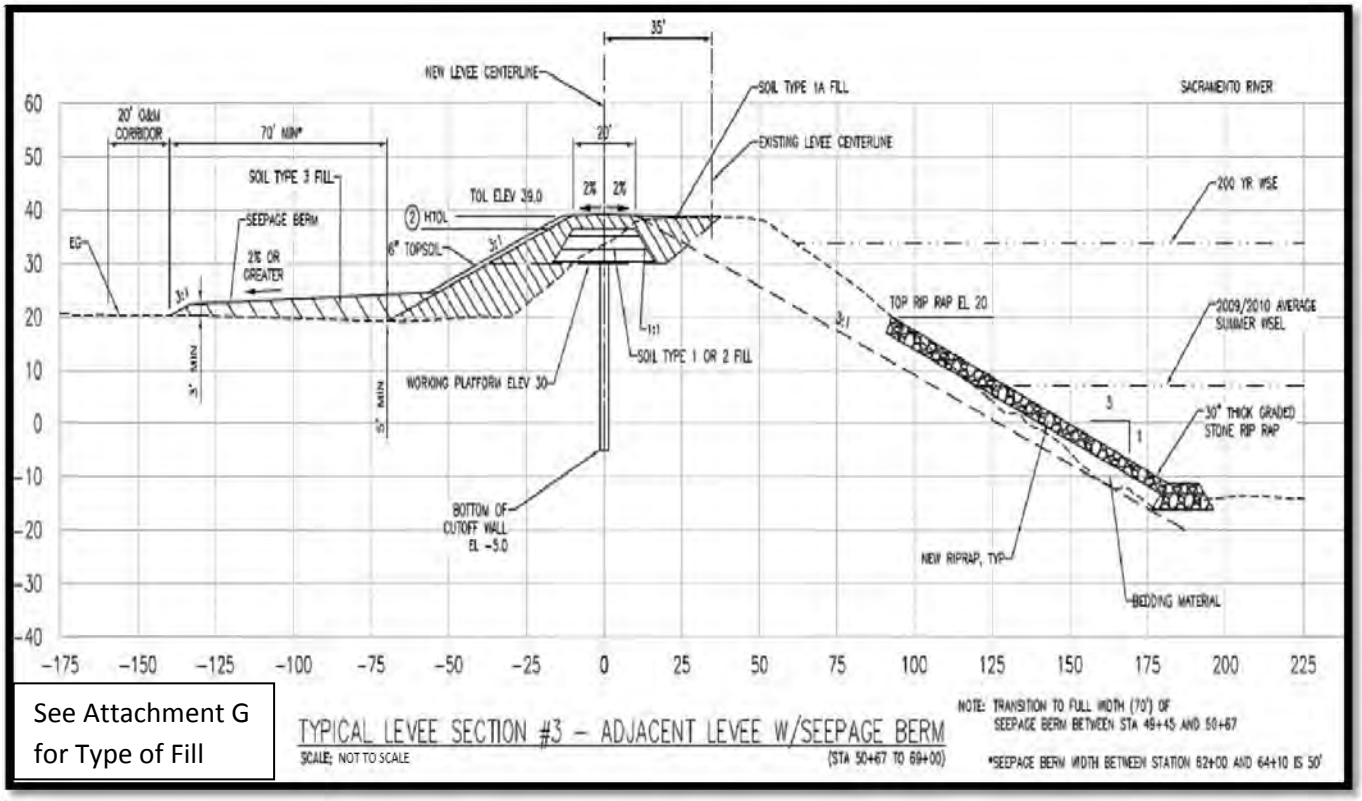
See Attachment G for Type of Fill

Figure 15: Typical Cross Section Strengthen In-Place with Cutoff wall



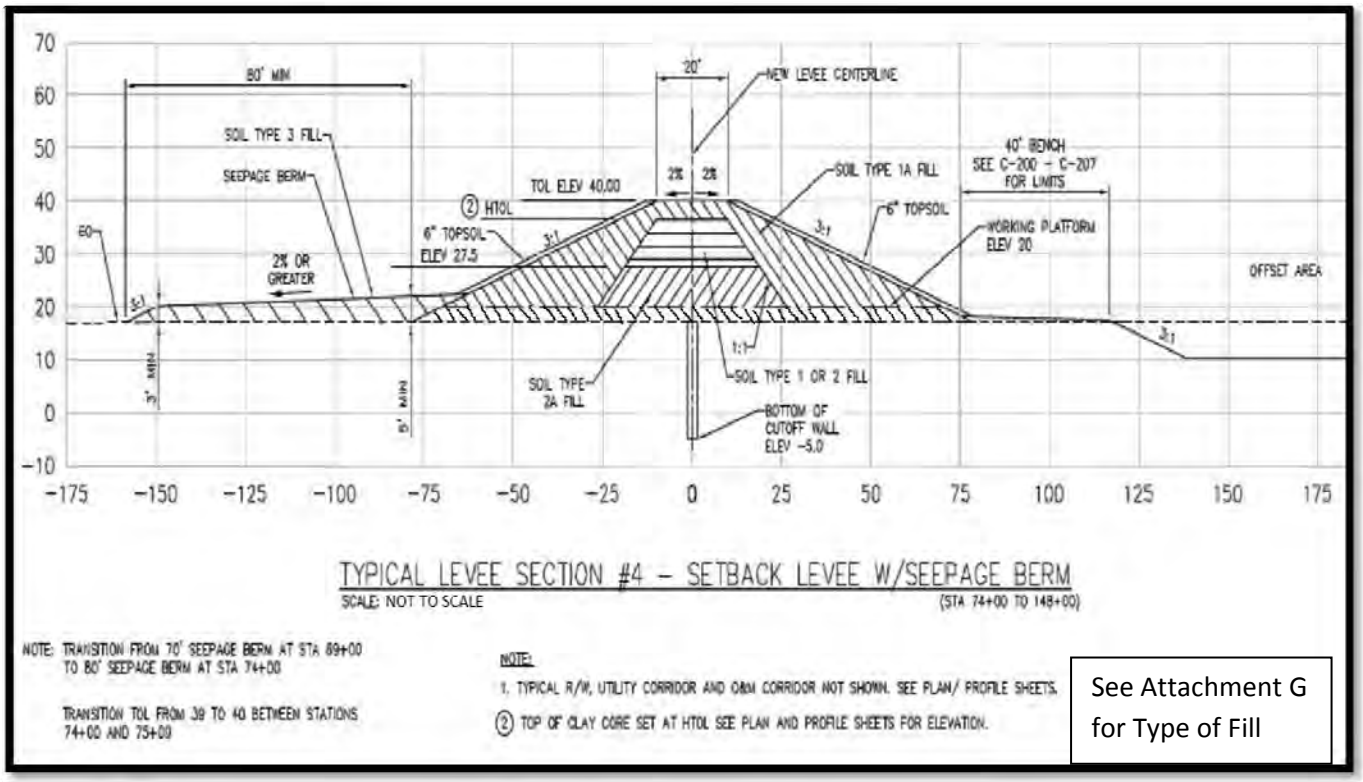
See Attachment G for Type of Fill

Figure 16: Typical Cross Section – Adjacent Levee with Cutoff Wall



See Attachment G for Type of Fill

Figure 17: Adjacent Levee with Seepage Berm



See Attachment G for Type of Fill

Figure 18: Setback Levee with Seepage Berm

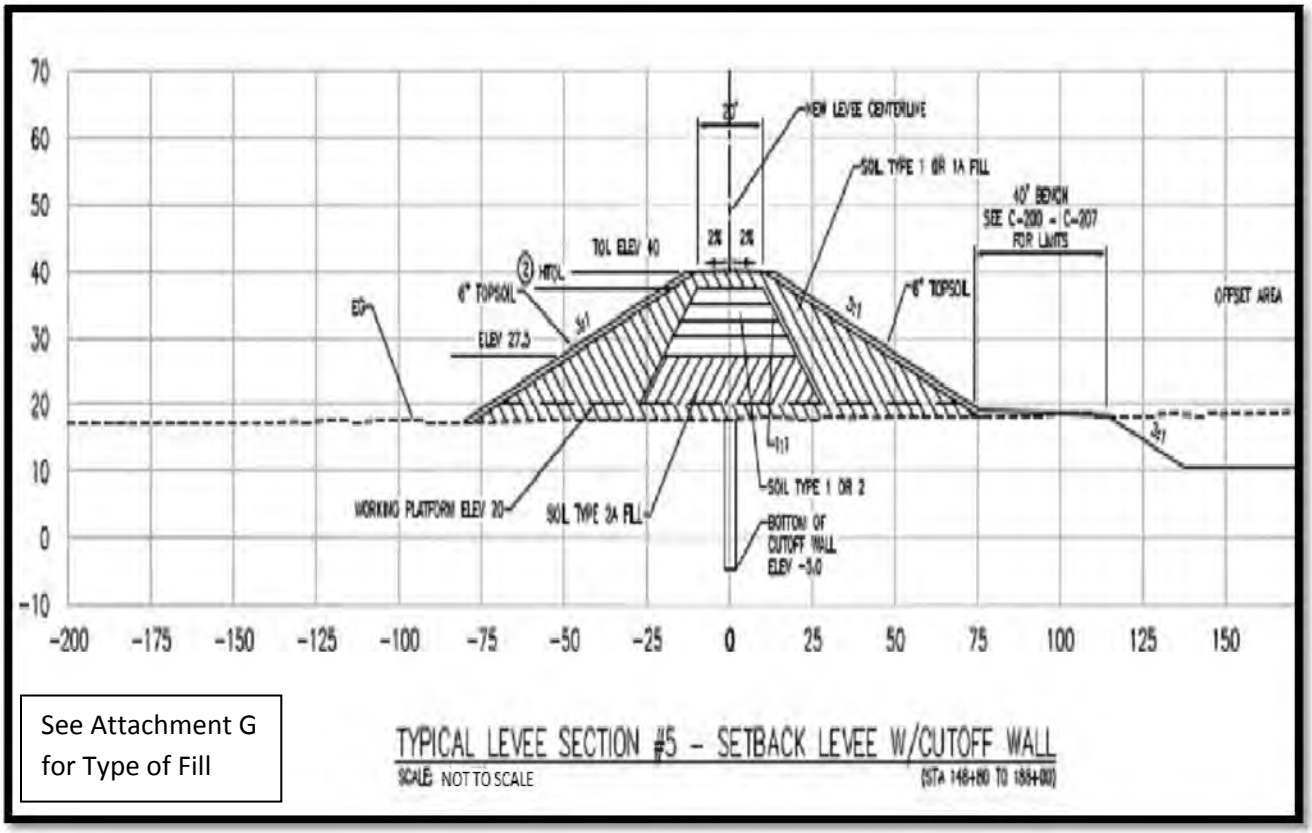


Figure 19: Setback Levee with Cutoff Wall

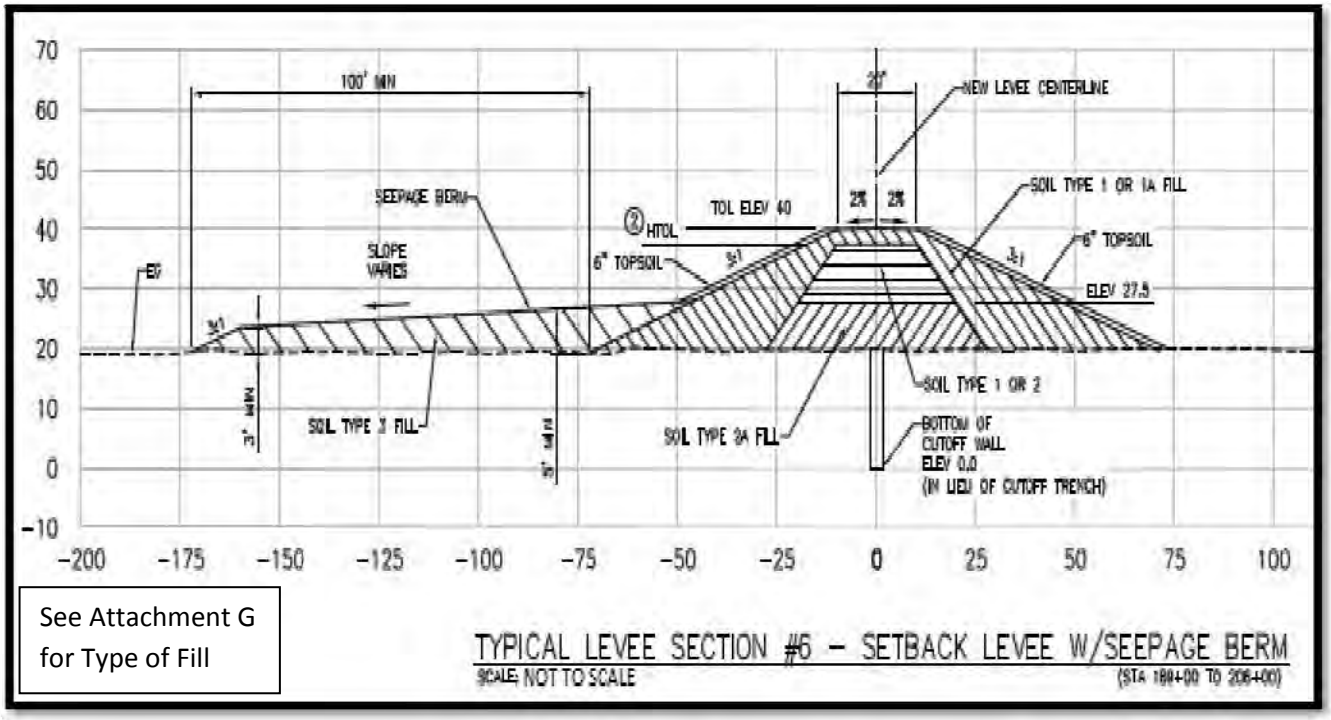


Figure 20: Setback Levee with Seepage Berm

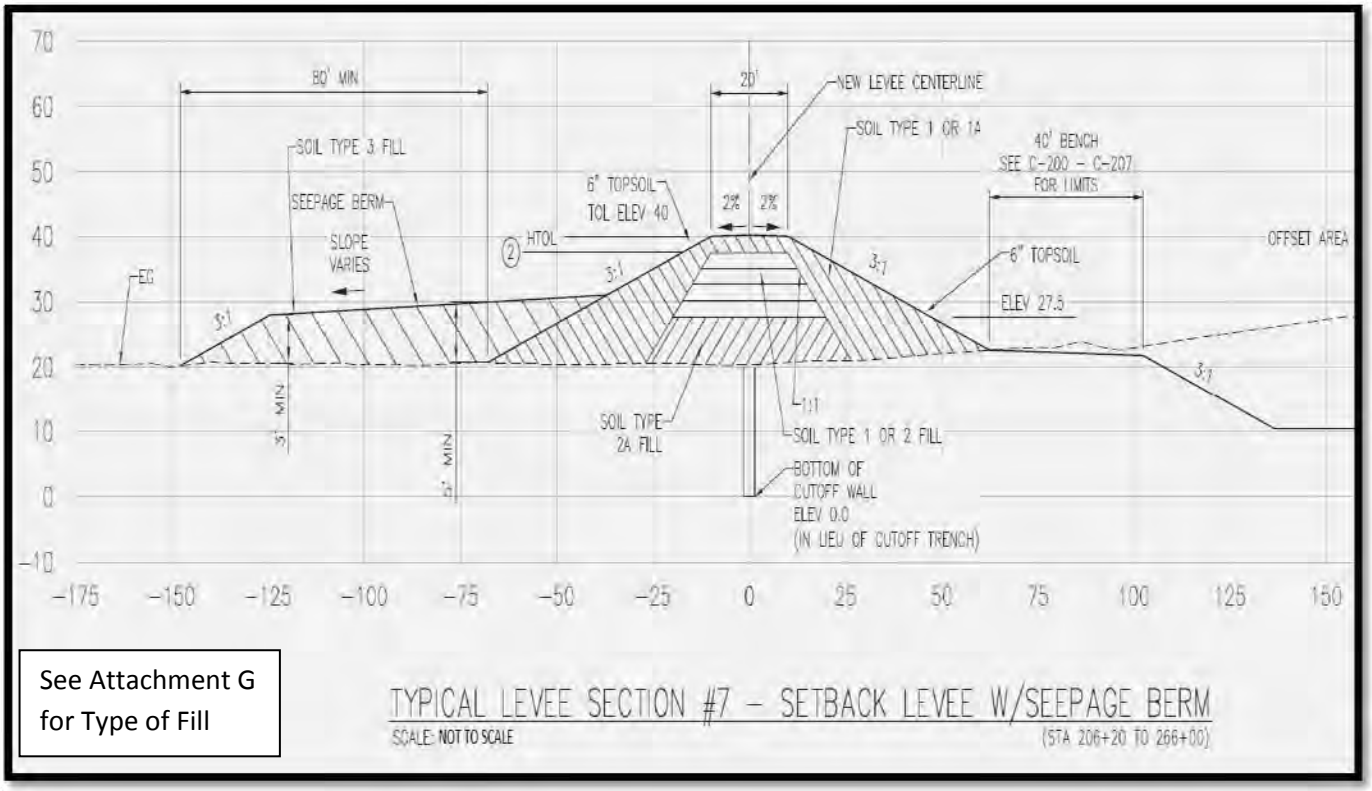


Figure 21: Setback Levee with Seepage Berm

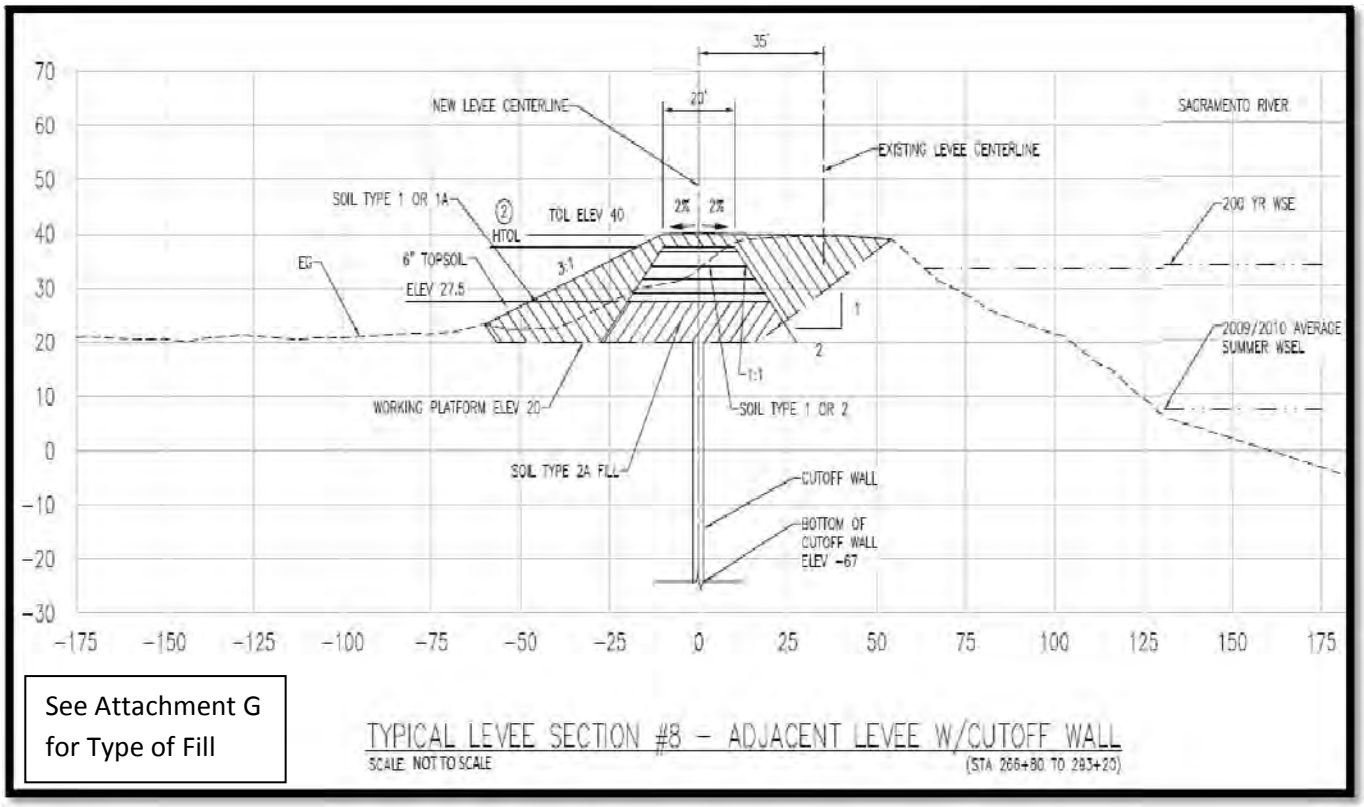
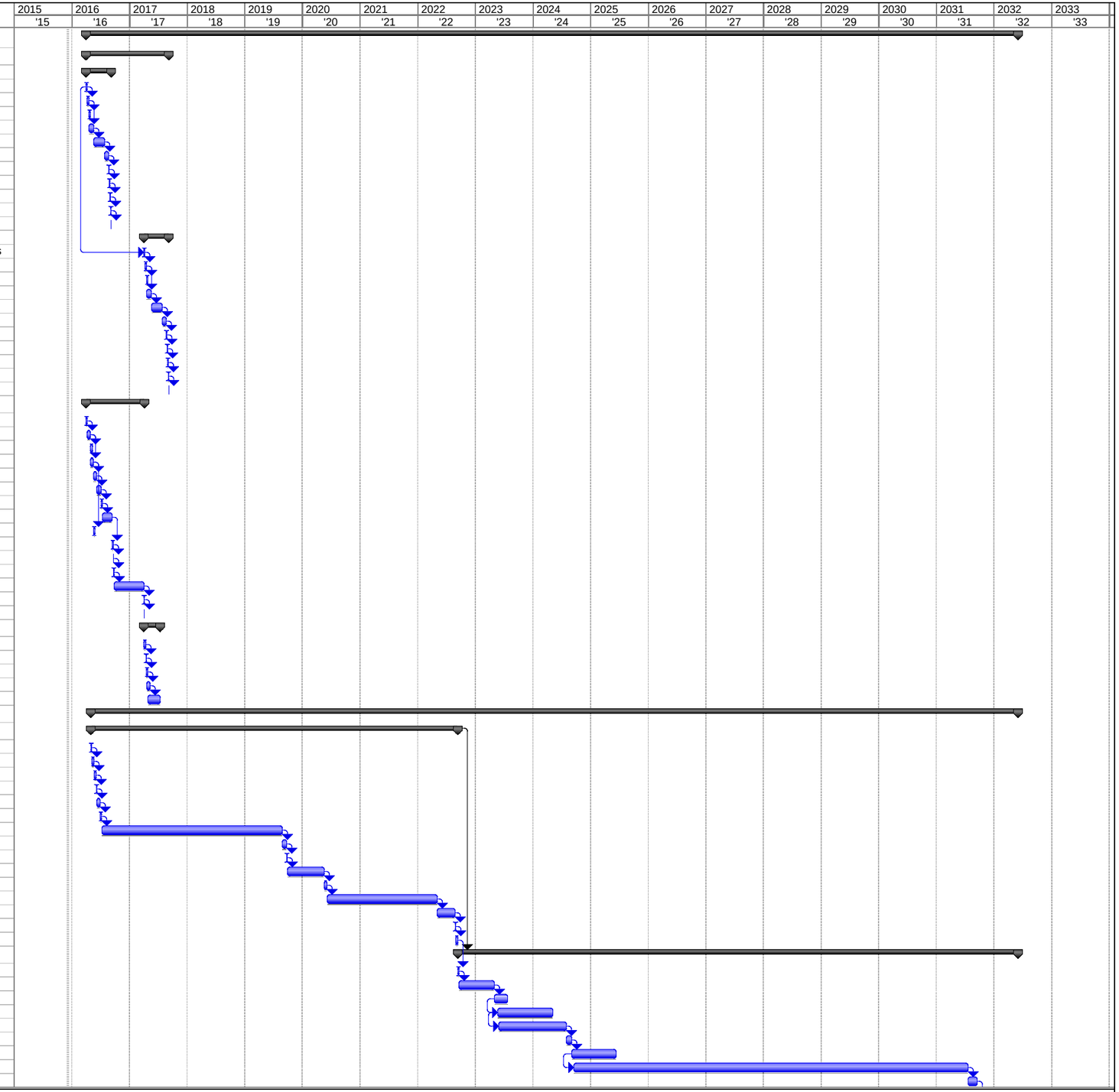


Figure 22: Adjacent Levee with Cutoff Wall

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
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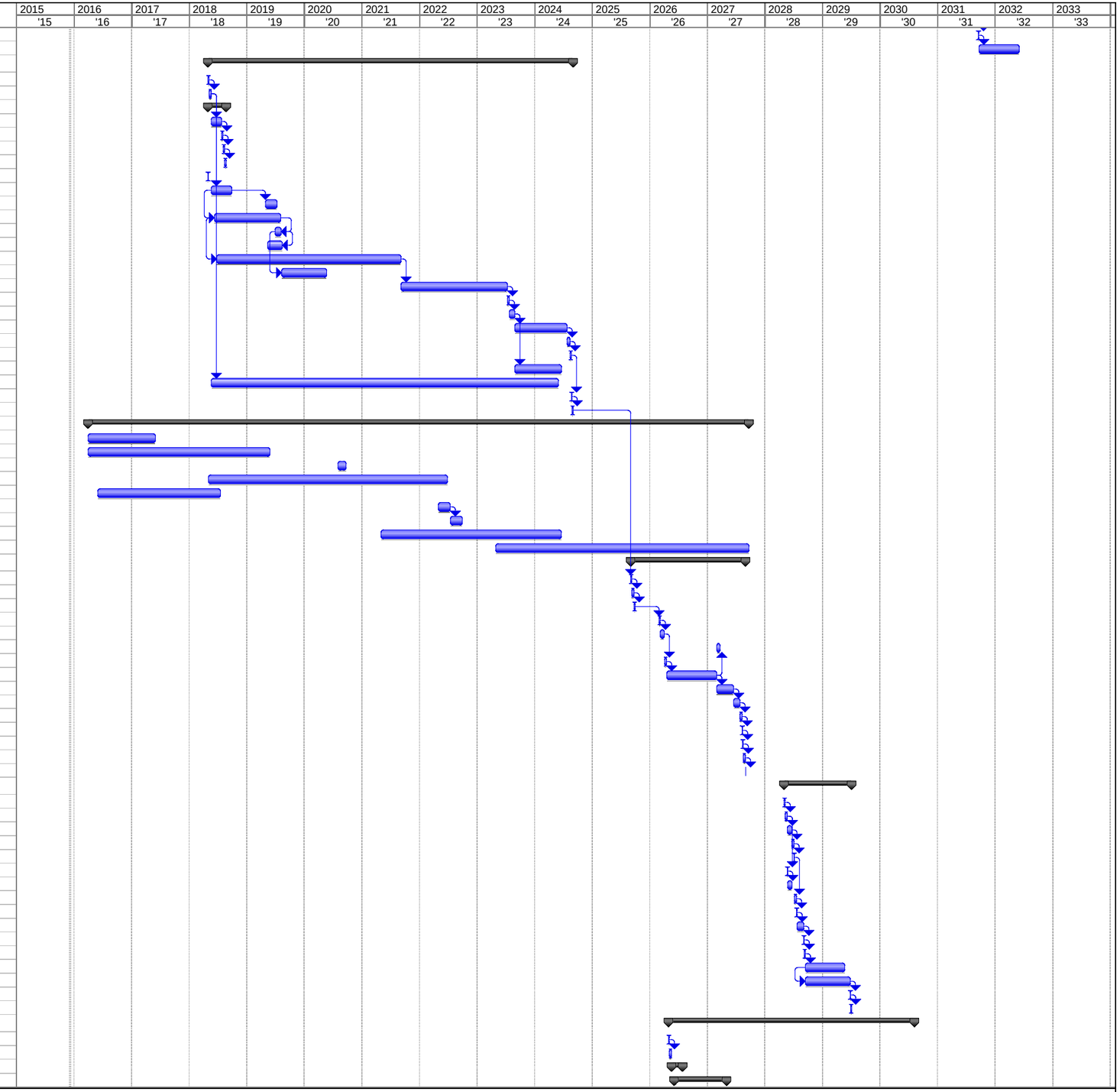
Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone

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**	



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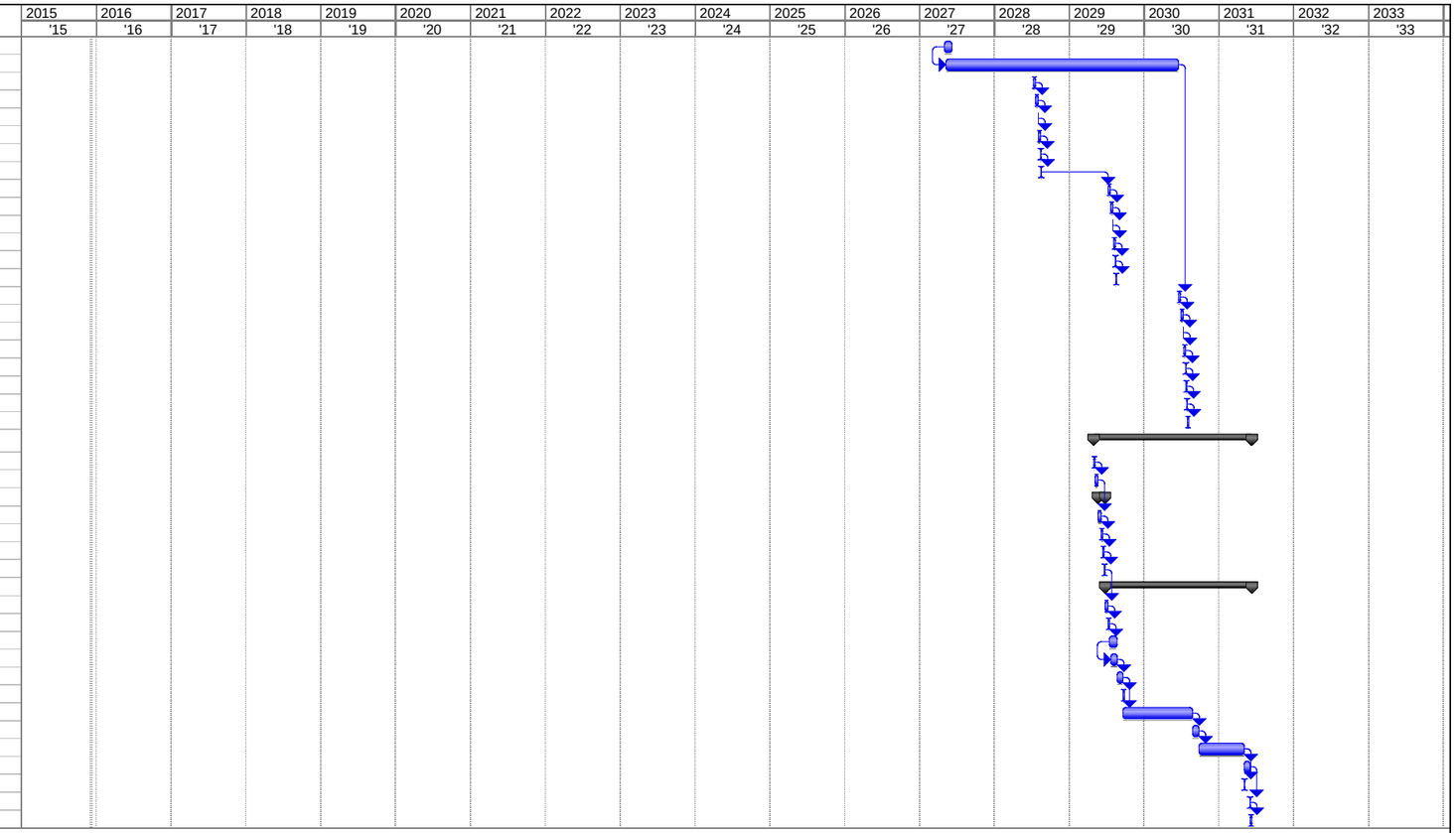
Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

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



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Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone