

# Technical Memorandum



**To:** George Booth - Sacramento County  
**From:** Michael Conant, Kris Van Sant, Katie Laird  
**cc:** Jeffrey Twitchell  
**Date:** March 25, 2021  
**Re:** Cost Estimate Development for Flood Risk Reduction Management Actions for the Flood Risk Reduction Feasibility Study for Delta Legacy Community of Hood, CA  
GEI Project 1800776

---

GEI Consultants, Inc. (GEI) is assisting the Sacramento County Department of Water Resources in conducting a feasibility study to evaluate structural and non-structural actions to reduce the risk of flooding to the Hood study area. The feasibility study is being funded under the California Department of Water Resources (DWR) Small Communities Flood Risk Reduction Program. As part of this feasibility study, GEI developed cost estimates for the array of flood risk reduction management actions. This Technical Memorandum (TM) summarizes the development, methodology and results of the cost estimates.

## 1. Introduction and Purpose

The purpose of this appendix is to describe the development of cost estimates for the final array of Flood Risk Reduction Management Actions identified in the “Flood Risk Reduction Feasibility Study for the Delta Legacy Community of Hood, CA” (Feasibility Study). As discussed in the Feasibility Study, nine Management Actions (MA) were evaluated. The Management Actions proposed in the Feasibility Study are combinations of structural and non-structural elements to provide flood risk mitigation to the small community of Hood. This TM is focused on describing how perimeter levee improvements and a proposed cross levee north of the community of Hood have been developed in order to estimate the costs for the Management Actions.

Figures and descriptions of each of the MAs are provided in the Feasibility Study. These MAs are composed of various elements which are covered in this TM, and additional information is included in the Feasibility Study.

- MA 1: Repair DWR Flood System Repair Project (FSRP) Critical and Serious Sites within the Hood Study Area Portion of DWR Maintenance Area (MA) 9
- MA 2: Raise and Repair/Strengthen-in-Place Reclamation District (RD) 744 South Cross Levee
- MA 3: Repair DWR FSRP Critical and Serious Sites North of the Hood Study Area within DWR MA 9
- MA 4: Cross Levee North of Hood paired with Repair and Strengthen-in-Place Existing State Plan of Flood Control (SPFC) and Non-SPFC Levees Adjacent to Hood (2012 Central Valley

Flood Protection Plan [CVFPP] and 2014 Regional Flood Management Plan [RFMP] Configuration)

- MA 5: Cross Levee North of Hood with Community-Preferred Alignment paired with; Repair and Strengthen-in-Place Existing SPFC and non-SPFC Levees Adjacent to Hood
- MA 6: Repair and Strengthen-in-Place DWR MA 9 Sacramento River Left Bank – SPFC Levees in Hood Study Area
- MA 7: Repair and Strengthen-in-Place Non-SPFC Levees/Former Railroad Embankments in the Hood Study Area
- MA 8: Secure 100-Year Federal Emergency Management Agency (FEMA) Certification for Community and Entire Hood Study Area
- MA 9: Repair and Strengthen-in-Place 9.0 miles of DWR MA 9 Sacramento River Left Bank SPFC Levee between Freeport and RD 755

## 2. Methodology

The Feasibility Study’s final array of management actions includes a mix of improvements for existing levees around the perimeter of the study area and beyond, all of which are located within DWR’s MA 9, inclusive of non-structural activities. Elements which have costs developed in this TM include:

- Repair and strengthen-in-place levee improvements for the entire Hood study area levee perimeter, as well as for the entire 9.0 miles of levee located along the left bank of the DWR MA 9 Sacramento River left bank levee between Freeport and RD 755, based on levee remediations as outlined in the Geotechnical Assessment Report – Delta Small Communities Flood Risk Reduction Program – Community of Hood. Improvements include:
  - Berms
  - Cutoff walls
  - Rock slope protection (RSP)
- New cross levee alignments north of Hood

Cost estimates have been prepared using parametric estimates based on preliminary designs for each of the improvements. Cost estimates are intended to be Class 4 (feasibility-study level) according to the Association for the Advancement of Cost Engineering International (AACEI). A Class 4 estimate is prepared based on limited information where the preliminary engineering is from 1 to 15 percent complete. Strategic planning, project screening, alternative scheme analysis, confirmation of economic and/or technical feasibility, and preliminary budget constraints are also considered to proceed with any preferred alternative.

The Class 4 estimate includes allowances for changes due to the level of detail that typically occurs between the feasibility level and the issuance of final design documents. The expected accuracy ranges for a Class 4 estimate are -15 to -30 percent on the low side and +20 to +50 percent on the high side. The costs presented in this technical memo add a 30 percent contingency cost to the Baseline Cost. The cost estimates in this document are considered a planning-level tool.

## **2.1. Cost Development**

A cost estimate was developed for the elements described above by applying unit costs to quantities based upon conceptual designs. Unit costs were established for construction items included within the conceptual designs.

Capital costs consist of:

- Major Construction Item costs (unit costs)
- Other Construction Costs including:
  - Unallocated items in construction costs as a percentage of the Major Construction Item costs (percentage)
  - Mobilization and demobilization of construction equipment as a percentage of the Major Construction Item costs (percentage)
- Other Owner Costs including:
  - Environmental documentation, permitting, and mitigation as a percentage of all construction costs (percentage)
  - Design and engineering costs as a percentage of all construction costs (percentage)
  - Legal costs to implement project as a percentage of all construction costs (percentage)
  - Construction management as a percentage of all construction costs (percentage)
  - Real estate capital outlay and acquisition costs (unit costs)

The sum of the costs presented above is considered the Baseline Cost. The Baseline Cost does not include a contingency and is considered the expected low range of costs. To accommodate the uncertainty of the estimates, and in line with industry standards, an additional estimating contingency of 30 percent has been included on all the above costs.

The following construction activities are included in the cost estimates for the proposed improvements:

- Clearing and grubbing: Clearing all vegetation and debris (trees, shrubs, stumps, major roots, and rubbish) near the ground surface within the remediated levee embankment footprint.
- Stripping: Stripping the original ground surface a minimum of 12 inches within the remediated levee embankment and berm footprint to remove roots and other organic matter. Further investigation will be needed to determine the existing conditions and depth of stripping actually required. This unit cost does not include off-hauling, as material is assumed to be re-used onsite as appropriate.
- Proof compacting: Proof compacting the surface within the extents of the levee footprint including ripping, moisture conditioning and compaction of the existing ground surface prior to placement of select levee fill.

- Levee fill: Select levee fill used for all levee embankment construction including geometry improvements will conform to requirements (CVFPB, 2014). Local sources of select levee fill have not been identified. Therefore, it is assumed that a source within a 30-mile round trip will be utilized for select levee fill. It is assumed that no levee degrade material will be used for select levee fill.
- Drain fill (Geotextile, Filter Sand, Drain Aggregate): Cost includes placement of geotextile, filter sand, and drain aggregate for internal drainage features.
- Berm fill: Berm fill assumed to be locally available due to less stringent material requirements. Compaction of berm fill will be less than that of the select levee fill. Cost includes preparation of the area to receive fill, placement of the fill to the appropriate loose thickness, and compaction of the fill.
- Cutoff Wall: Cutoff wall assumed to be 3 feet wide. Soil-bentonite (SB) or cement-soil bentonite (CSB) cutoff walls will be constructed by standard open-trench methods (i.e., excavator and slurry trench, etc.). Where deeper cutoff walls are needed, the deep-mixing method (DMM) will be used (overlapping auger holes). Depths up to 80 feet assumed to be constructed with traditional open trench method, with costs increasing over 40 ft. Depths greater than 80 feet assumed to be constructed using deep mixing method.
- Inspection trench excavation and backfill: For new levees. An inspection trench along the centerline of the levee with a minimum depth of 6 feet, width of 12 feet, and side slopes of 0.25H:1V or flatter, and backfilled with select levee fill along the length of the setback levee.
- Aggregate Base: A 6-inch-thick, all-weather aggregate base road shall be provided for the levee crown and used as a base layer for asphalt concrete paving. Includes placement and compaction.
- Asphalt Concrete (AC) Removal: Required in sections of levee with existing paved road on the levee crest for cutoff walls which require excavation of existing levee crest. Includes excavation and disposal. Assumes that material is not re-used.
- AC Paving: Used in sections of levee that currently have paved roads and will be reconstructed to existing conditions. 4" thick AC paving. Includes placement, compaction and any road painting.
- Hydroseed: Hydroseeding for erosion protection will occur along both the landside and waterside slopes of the levee as well as the landside and waterside toe access corridors and all disturbed areas impacted by levee construction activities.
- Rock Slope Protection: RSP is placed along the waterside levee slope to prevent additional erosion of the levee. Includes purchase, transportation, and placement of the RSP.

- Right-of-way (ROW) acquisition: ROW quantities are estimated land required to be purchased for the project including for berms, and any temporary roadways to divert traffic. ROW was estimated based on review of aerial photography of existing land use. ROW acquisition only accounts for the required alignment and doesn't include purchase of full parcels.
- Structure removal/relocation: Includes costs for structures which may be required to be removed for the structural levee improvements. Categories split into residential structures and "other" structures which include any non-residential buildings. Structures impacted were estimated based on aerial photography and the proximity to the levee toe. Additional refinement of impacted structures will need to be considered during the project design phase.
- Mobilization and Demobilization: Includes the contractor's mobilization and demobilization of equipment, personnel, field offices, etc. to and from the site in support of the construction.
- Allowance for unlisted, or unanticipated, items: This allowance is not a contingency; rather it is an attempt to acknowledge (and quantify) the "known unknowns" in the project as they relate to work items that have yet to be identified in this early development stage for design, regulatory compliance and construction issues and that will likely increase project costs. Construction items not addressed at the current feasibility level of design include but are not limited to items such as utility relocations and pipe relocations unknown at the time these cost estimates were prepared.
- Environmental documentation and permitting, and environmental compliance monitoring during construction: Includes all studies and report preparation, documentation necessary to complete an Environmental Impact Report or Environmental Impact Statement and any other environmental permits for the project. Does not include any environmental mitigation costs or environmental construction monitoring. Environmental mitigation costs are not presented within the current scope and is depending upon existing conditions.
- Design and engineering costs: Includes investigations, design and engineering of project including surveying, geotechnical investigation, utility investigation and coordination, preparation of plans, specifications and cost estimates along with all other items necessary to complete the design of the project for bidding.
- Legal costs: Includes all Owner legal costs to implement the project.
- Engineering during construction: Includes engineering during construction activities including review of submittals, Requests for Information, bidder questions, changes, etc.
- Construction management: Includes management and oversight of the construction project, including quality assurance inspection and testing.

- Utility relocations: The impact of known utilities to be relocated is considered minimal to the larger scope of the project. Unidentified utility relocations are assumed part of the allowance for unlisted items costs. Costs do not include removal and relocation of any existing structure on the landside of the levee, including but not limited to pump stations, residences, etc. The impact of utility crossings on the stability of the levee foundation, embankments and refinements to associated costs for mitigation and / or relocation of these crossings will need to be considered during the project design phase.

## 2.2. Unit Costs Development

Unit costs were developed by evaluating costs presented in previous cost estimating efforts for levee improvements and bid abstracts from local and regional levee improvement projects mostly from within the greater Sacramento River Flood Control Project (SRFCP) within the CVFPP. Prior to comparison, all unit costs were escalated to July 2020 using the 20-city average from the Engineering News-Record (ENR) Construction Cost Index. Major construction items, their units of measurement, and unit costs are provided in Table 1. All values include materials, labor, placement, and delivery to site.

Other Construction Costs are applied as a percentage of the Major Construction Item costs. Summing the Major Construction Item and Other Construction Costs together presents the Total Construction Cost representing the physical construction components of the work. Other Owner costs are applied as a percentage to the Total Construction Cost and are meant to represent the additional costs to the Owner expected through the construction of a project.

**Table 1: Unit Costs**

<u>Construction Activity Description</u>	<u>Unit</u>	<u>Unit Cost</u>
Clearing and Grubbing	AC	\$8,342.74
Stripping	AC	\$7,490.00
Stripping	CY	\$7.67
Proof Compacting	AC	\$1,382.62
Select Levee Fill (New Levee Construction)	CY	\$26.70
Berm Fill - Misc.	CY	\$16.68
Aggregate Base	CY	\$54.90
Drain Layers (Geotextile, Filter Sand, Drain Aggregate)	CY	\$77.50
AC Paving	SY	\$40.04
AC Removal	SY	\$5.71
SB Cutoff Wall, Open Trench Method (<40')	SF	\$8.93
SB Cutoff Wall, Open Trench Method (>40' and <80')	SF	\$10.29
SB Cutoff Wall (DMM, >78' Depth)	SF	\$41.17
CSB Cutoff Wall, Open Trench Method (<80')	SF	\$32.00
Hydroseeding	AC	\$4,693.00
Rock Slope Protection	CY	\$77.50
<b>Other Construction Costs</b>		
Unallocated Items in Construction costs		15.00%
Mobilization and Demobilization		5.00%
<b>Other Owner Costs</b>		

<b><u>Construction Activity Description</u></b>	<b><u>Unit</u></b>	<b><u>Unit Cost</u></b>
Environmental Documentation and Permitting		10.00%-20.00% <sup>1</sup>
Design and Engineering Costs		15.00%
Legal Costs		2.00%
Engineering during Construction		2.00%
Construction Management		15.00%
Permanent Right-of Way (fee title) - Seasonal Agricultural Field/ Row Crops	AC	\$25,000
Permanent Right-of Way (fee title) - Orchard/ Vineyard	AC	\$40,000
Permanent Right-of Way (fee title) - Commercial/ Industrial	AC	\$240,000
Permanent Right-of Way (fee title) - Residential	AC	\$180,000
Residential structures	Ea	\$250,000
Other structures	Ea	\$75,000

Cost estimates and bid abstracts from the following alphabetically-listed projects were referenced for unit costs comparisons in addition to engineering judgement:

- Bethel Island Municipal Improvement District, Horseshoe Bend Levee Improvement Project, bid 2017;
- Feather River West Levee Project Phase 1, Projects B, C and D, bid in 2013 and 2014;
- Non-Urban Levee Evaluations (NULE) Project Remediation Alternative and Cost Estimates Report (RACER), North NULE Study Area. Prepared by URS for DWR in 2011 (URS, 2011);
- North Area Streams (NAS) Levee Improvement Project, cutoff wall along the waterside toe of the NEMDC East Levee, bid in 2017;
- Sacramento Area Flood Control Agency (SAFCA) Sacramento River East Levee (SREL) Improvement Project – IFA Construction Cost Estimate, currently under construction; and
- Three Rivers Levee Improvement Authority (TRLIA) levee improvement Segments 1 and 3, bid in 2007, and setback levee Segment 2, bid in 2008.

---

<sup>1</sup> All cost estimates include a 10% mark-up for environmental documentation and permitting with the exception of estimates for RSP which include a 20% mark-up due to the more probable disturbance of riparian habitat

### **3. Repair and Strengthen-in-Place Levee Improvements**

Repair and strengthen-in-place levee improvements are identified and defined in the Geotechnical Assessment Report – Delta Small Communities Flood Risk Reduction Program – Community of Hood TM (Appendix A). Each reach has deficiencies identified as under seepage or through seepage, with select reaches also deficient for slope stability and erosion. Each deficient reach can be remediated by either a cutoff wall (vertical) alternative or berm (horizontal) alternative. Erosion concerns are addressed by placement of RSP. Geometric deficiencies were also identified along the northern boundary of the study area for the RD 744 South Cross Levee. A description of the repair and strengthen-in-place remediations is included in the following sections and summarized in Table 2.

**Table 2: Hood Study Area Levee Remediation Alternatives**

NULE Alignment ID	NULE Segment/Reach	Reach Length (ft.)	Remediation Alternative 1 Cutoff Wall Dimensions and RSP	Remediation Alternative 2 Berm Dimensions and RSP	Vulnerability				Freeboard (% Deficient)
					Under-seepage	Through Seepage	Slope Stability	Erosion	
SACR-L	106-A	13,100	80 ft. deep cutoff wall	80 ft. wide, 9 ft. tall combination seepage/stability berm (combo berm)	X	X	-	-	-
HNCL	North CL (RD 744 South Cross Levee)	500	50 ft. deep cutoff wall 1 ft. levee raise	85 ft. wide, 16 ft. tall combo berm 1 ft. levee raise	X	X	-	-	100%
		800	50 ft. deep cutoff wall 2.5 ft. levee raise	85 ft. wide, 16 ft. tall combo berm 2.5 ft. levee raise	X	X	-	-	100%
HDERR	East RR-A (Northeast)	4,500	15 ft. deep cutoff wall RSP: 105 ft. wide RSP (4,500 ft.)	12 ft. tall, 15 ft. wide drained stability berm RSP: 105 ft. wide RSP (4,500 ft.)	-	X	-	X	-
HDERR	East RR-B (East)	4,500	60 ft. deep cutoff wall 140 ft. wide RSP (3,500 ft.)	140 ft. wide 19 ft. tall combo berm 140 ft. wide RSP (3,500 ft.)	X	X	X	X*	-
HDERR	East RR-C (Southeast)	4,100	-	-	-	-	-	-	-
HDSRR	South RR-A (South of Hood)	3,400	15 ft. deep cutoff wall 105 ft. wide RSP (3,000 ft.)	13 ft. tall, 15 ft. wide drained stability berm 105 ft. wide RSP (3,000 ft.)	-	X	X	X*	-
Total Perimeter Levee System of Hood Study Area		30,900 (5.85 miles)							

Notes:

- 1) \* Only affects a portion of the reach
- 2) Wall depths and berm widths rounded up to the nearest 5 ft. dimension and stability berm heights rounded to the nearest 1 ft. dimension.
- 3) Reach lengths rounded to the nearest 100 ft.

### **3.1. Levee Improvement Berms**

As shown in Table 2, berm remediations for a given reach can include a stability berm or a combo berm which incorporates elements of a stability and seepage berm. Typical drained stability berm and combo berm details are shown in Figures 1-2, respectively. A summary of the construction activities for each reach is provided in Table 3. A summary of the total cost estimate for the berm alternatives is provided in Table 4.

**Table 3: Levee Improvement Berm Base Construction Quantities**

Location Description	Berm Type	Clearing and Grubbing	Ground Stripping	Drain Layers	Berm Fill	Hydroseeding	Geometry Repair	Right of Way		Total Base Construction Estimate	ROW Acquisition
								AC	\$/ AC		
Cost per unit		\$ 8,342.74	\$ 7,489.52	\$ 77.50	\$ 16.68	\$ 4,692.56	\$ 26.70				
Units		AC	AC	CY	CY	AC	CY	AC	\$/ AC		
SACR-L 106-A	Combo	34.0	29.9	73,097	177,883	33.7		49.9	\$64,050	\$9,297,000	\$3,194,000
HNCL North CL (RD 744 South Cross Levee)	Combo	1.4	1.4	3,078	9,757	1.6	861	2.2	\$40,000	\$454,000	\$87,000
HNCL North CL (RD 744 South Cross Levee)	Combo	2.3	2.2	4,925	15,612	2.6	3,444	3.5	\$40,000	\$782,000	\$139,000
HDERR East RR-A	Stability	5.9	4.9	11,155	27,792	5.9		2.6	\$31,700	\$1,442,000	\$82,000
HDERR East RR-B	Combo	19.4	18.9	43,875	130,683	20.7		30.5	\$25,000	\$5,981,000	\$764,000
HDSRR South RR-A	Stability	4.8	4.0	9,230	29,142	4.7		2.6	\$80,800	\$1,293,000	\$208,000
<b>Totals</b>		<b>73</b>	<b>66</b>	<b>155,860</b>	<b>422,670</b>	<b>75</b>	<b>4,306</b>	<b>73</b>	<b>-</b>	<b>\$19,249,000</b>	<b>\$4,474,000</b>

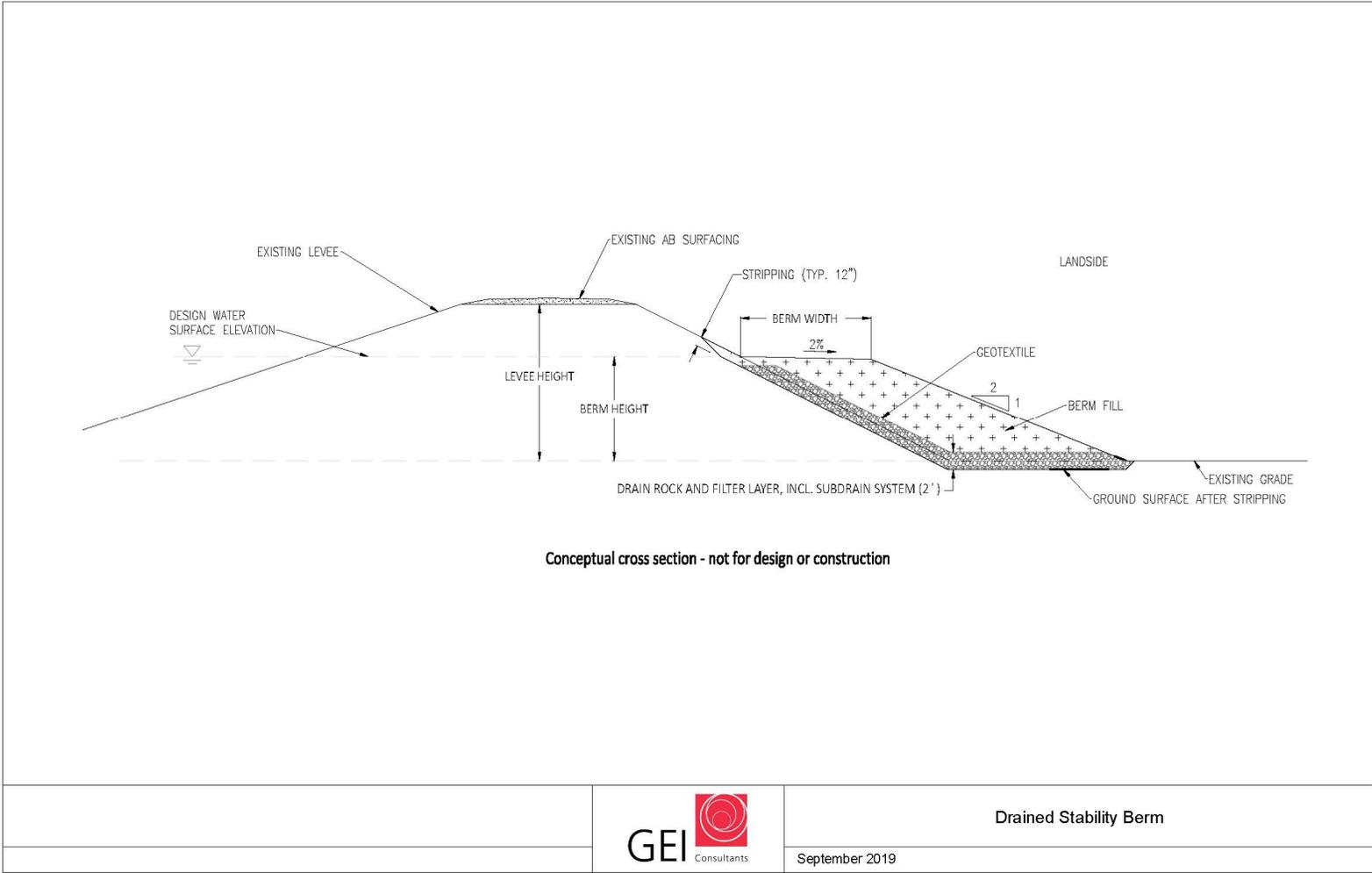
**Table 4: Berm Reach Cost Summary**

Location Description	Stability Berm	Combo Berm	Berm Base Cost	Residential Structures		Other Structures		Other Construction Costs*	Other Owner Costs**	Construction Contingency***	Right of Way	Reach Total
				#	Cost (\$250k)	#	Cost (\$75k)			30%		
SACR-L 106-A		\$9,297,000	\$9,297,000	3	\$750,000	4	\$300,000	\$3,719,000	\$10,280,000	\$6,989,000	\$3,194,000	\$34,529,000
HNCL North CL (RD 744 South Cross Levee)		\$454,000	\$454,000					\$182,000	\$480,000	\$335,000	\$87,000	\$1,538,000
HNCL North CL (RD 744 South Cross Levee)		\$782,000	\$782,000					\$313,000	\$826,000	\$576,000	\$139,000	\$2,636,000
HDERR East RR-A	\$1,442,000		\$1,442,000					\$577,000	\$1,523,000	\$1,063,000	\$82,000	\$4,687,000
HDERR East RR-B		\$5,981,000	\$5,981,000					\$2,392,000	\$6,316,000	\$4,407,000	\$764,000	\$19,860,000
HDSRR South RR-A	\$1,293,000		\$1,293,000	15	\$3,750,000	1	\$75,000	\$517,000	\$3,048,000	\$1,457,000	\$208,000	\$10,348,000
<b>Repair Type Totals</b>	<b>\$2,735,000</b>	<b>\$16,514,000</b>	<b>\$19,249,000</b>	<b>18</b>	<b>\$4,500,000</b>	<b>5</b>	<b>\$375,000</b>	<b>\$7,700,000</b>	<b>\$22,473,000</b>	<b>\$14,827,000</b>	<b>\$4,474,000</b>	<b>\$73,598,000</b>

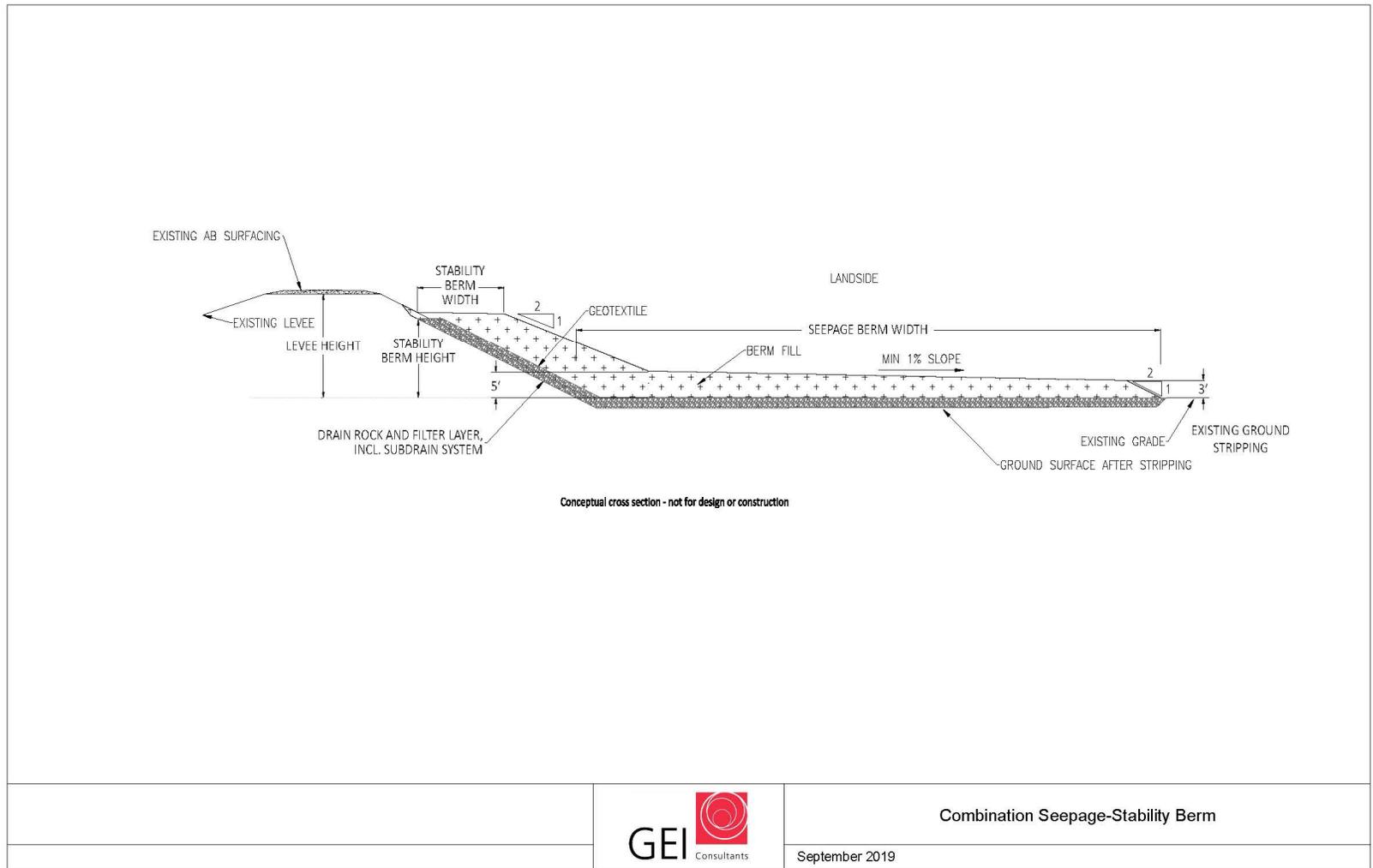
\* Percentages based on the construction subtotal (see Table 1)

\*\* Percentages based on construction, structure, other construction cost subtotals (see Table 1)

\*\*\* 30% of the construction, structure, other construction cost, other owner cost subtotals



**Figure 1: Drained Stability Berm Conceptual Schematic**



**Figure 2: Combination Seepage and Stability Berm Conceptual Schematic**

### **3.2. Levee Improvement Cutoff Walls**

As shown in Table 2, cutoff wall remediations for a given reach vary in depth depending on if through seepage is a concern, and the subsurface conditions. All reaches underlying paved roads assume 1/3 of the levee height is removed to form a suitable working surface for installation of the cutoff walls. Standard practice is to assume 1/2 levee degrade, but due to the wide existing levee prisms it was assumed 1/3 degrade would be permissible, and possibly less. The Geotechnical Assessment Report assumed 1/2 levee degrade in development of the cutoff wall depths, and the difference between these degrade heights were added to the cutoff wall depth. Levee reaches that are not underlying paved roads assume 1/2 levee degrade.

The construction of a cutoff wall along reach 106 (Sacramento River) would result in disruption of traffic along Highway 160 and Hood Franklin Road. Contingencies were included in the estimate for construction of a temporary roadway off the existing levee crown during construction of the cutoff wall. No alignments for this temporary roadway were developed, and additional work is needed during design.

A typical cutoff wall is shown in Figure 3. A summary of the construction activities for each reach is provided in Table 5. A summary of the total cost estimate for the cutoff wall alternatives is provided in Table 6.

**Table 5: Levee Improvement Cutoff Wall Base Construction Quantities**

Location Description	Wall Depth	Degrade Volume	Remove AC	Disposal Volume	Wall Area	Wall Cost/sq. ft	Levee Rebuild	Temporary Roadway				Aggregate Base Levee Crown	New Roadway AC	Hydro-seeding	Right of Way		Total Base Construction Estimate	ROW Acquisition
								Clear & Grub	Proof Compaction	AB	AC				AC	\$/ AC		
Cost per unit		\$6.9	\$5.7	\$10.0	varies	varies	\$26.7	\$8,342.7	\$1,382.6	\$54.9	\$40.0	\$54.9	\$40.0	\$4,692.6				
Units		CY	SY	CY	Sq ft		CY	AC	AC	CY	SY	CY	SY	AC	AC	\$/ AC		
SACR-L 106-A	80 ft	115,234	43,510	115,234	1,044,240	\$32.00	105,024	86.5	86.5	7,252	43,510	6,043	43,510	3.8	10.5	\$64,050	\$43,485,000	\$672,000
HNCL North CL	50 ft	10,420		10,420	25,000	\$10.29	10,415	0.0	0.0	0	0	231	0	0.5	0.0	\$0	\$726,000	\$0
HNCL North CL	50 ft	16,673		16,673	40,000	\$10.29	19,295	0.0	0.0	0	0	370	0	0.8	0.0	\$0	\$1,232,000	\$0
HDERR East RR-A	15 ft	59,075		59,075	67,500	\$8.93	60,492	0.0	0.0	0	0	2,083	0	1.9	0.0	\$0	\$3,337,000	\$0
HDERR East RR-B	60 ft	74,702		74,702	270,000	\$10.29	79,494	0.0	0.0	0	0	2,083	0	2.2	0.0	\$0	\$6,286,000	\$0
HDSRR South RR-A	15 ft	54,255		54,255	51,315	\$8.93	50,929	0.0	0.0	0	0	1,584	0	1.7	0.0	\$0	\$2,828,000	\$0
<b>Totals</b>		<b>330,359</b>	<b>43,510</b>	<b>330,359</b>	<b>1,498,055</b>	<b>--</b>	<b>325,648</b>	<b>87</b>	<b>87</b>	<b>7,252</b>	<b>43,510</b>	<b>12,395</b>	<b>43,510</b>	<b>11</b>	<b>10</b>	<b>--</b>	<b>\$57,895,000</b>	<b>\$672,000</b>

**Table 6: Cutoff Wall Reach Cost Summary**

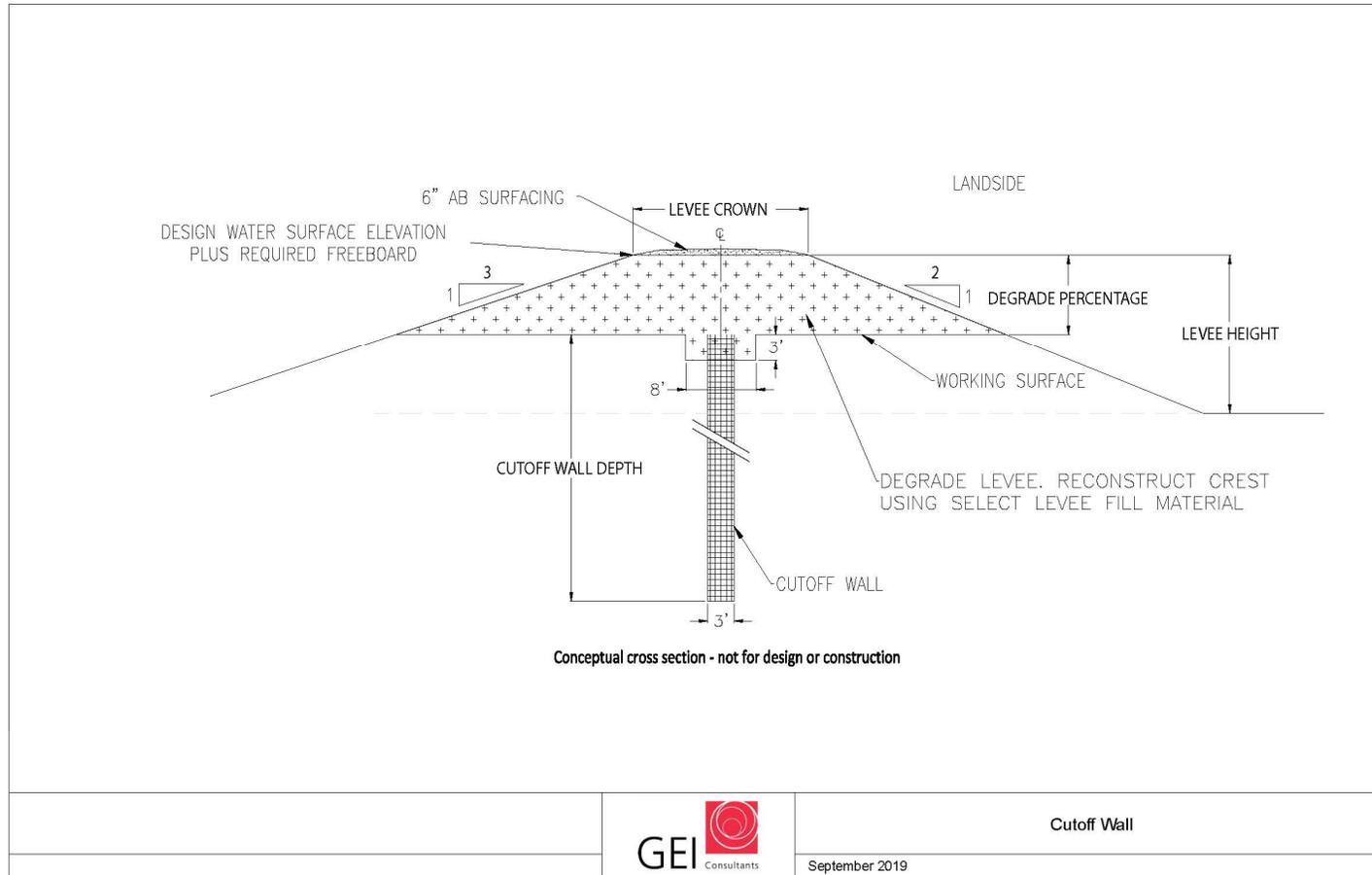
Location Description	Stationing		Length <sup>1</sup> (Feet)	Cutoff Wall	Other Construction Costs*	Other Owner Costs**	Construction Contingency***	Right of Way	Location Total
	From	To							
SACR-L 106-A	3107+39	3237+92	13,100	\$43,485,000	\$8,697,000	\$22,960,000	\$22,543,000	\$672,000	\$98,357,000
HNCL North CL		5+00	500	\$726,000	\$145,000	\$383,000	\$376,000		\$1,631,000
HNCL North CL	5+00	13+00	800	\$1,232,000	\$246,000	\$651,000	\$639,000		\$2,768,000
HDERR East RR-A		45+00	4,500	\$3,337,000	\$667,000	\$1,762,000	\$1,730,000		\$7,497,000
HDERR East RR-B	45+00	90+00	4,500	\$6,286,000	\$1,257,000	\$3,319,000	\$3,259,000		\$14,122,000
HDSRR South RR-A		34+21	3,400	\$2,828,000	\$566,000	\$1,493,000	\$1,466,000		\$6,352,000
			<b>Repair Type Totals</b>	<b>\$57,895,000</b>	<b>\$11,579,000</b>	<b>\$30,568,000</b>	<b>\$30,013,000</b>	<b>\$672,000</b>	<b>\$130,726,000</b>

<sup>1</sup> Reach lengths rounded to the nearest 100 feet

\* Percentages based on the construction subtotal (see Table 1)

\*\* Percentages based on construction, structure, other construction cost subtotals (see Table 1)

\*\*\* 30% of the construction, structure, other construction cost, other owner cost subtotals



**Figure 3: Cutoff Wall Conceptual Schematic**

### **3.3. Rock Slope Protection Improvements**

To address existing erosion concerns RSP involves placement of rip-rap along the waterside slope of the levee. Erosion concerns have been identified for repair along reaches East RR-A, East RR-B, and South RR-A. These concerns are assumed to require 2 ft. thick RSP along the entire waterside slope. The extents along this reach will need to be refined in future designs.

A conceptual cross section for the proposed RSP is provided in Figure 4. A summary of the construction activities for each reach is provided in Table 7. A summary of the total RSP cost estimate is provided in Table 8.

**Table 7: RSP Base Construction Quantities Cost Summary**

Location Description	Stationing		Length <sup>1</sup> (Feet)	Levee Height H	Levee Crest ft	Ex WS Slope X:1	Repair Length W	Rock Slope Protection CY
	From	To						
SACR-L 106-A	3107+39	3237+92	13,100	16 ft	33 ft	2.2 :1		-
HNCL North CL		5+00	500	17 ft	39 ft	5.0 :1		-
HNCL North CL	5+00	13+00	800	17 ft	39 ft	5.0 :1		-
HDERR East RR-A		45+00	4,500	17 ft	23 ft	1.9 :1	105 ft	35,000
HDERR East RR-B	45+00	90+00	4,500	23 ft	20 ft	1.6 :1	140 ft	46,667
HDERR East RR-C	90+00	131+25	4,100	17 ft	33 ft	1.9 :1		-
HDSRR South RR-A		34+21	3,400	18 ft	31 ft	2.2 :1	105 ft	26,608
							Quantity Total	108,274
							Unit Costs	\$77.50
							<b>Total Base Cost</b>	<b>\$8,391,000</b>

<sup>1</sup> Reach lengths rounded to the nearest 100 feet

**Table 8: RSP Reach Cost Summary**

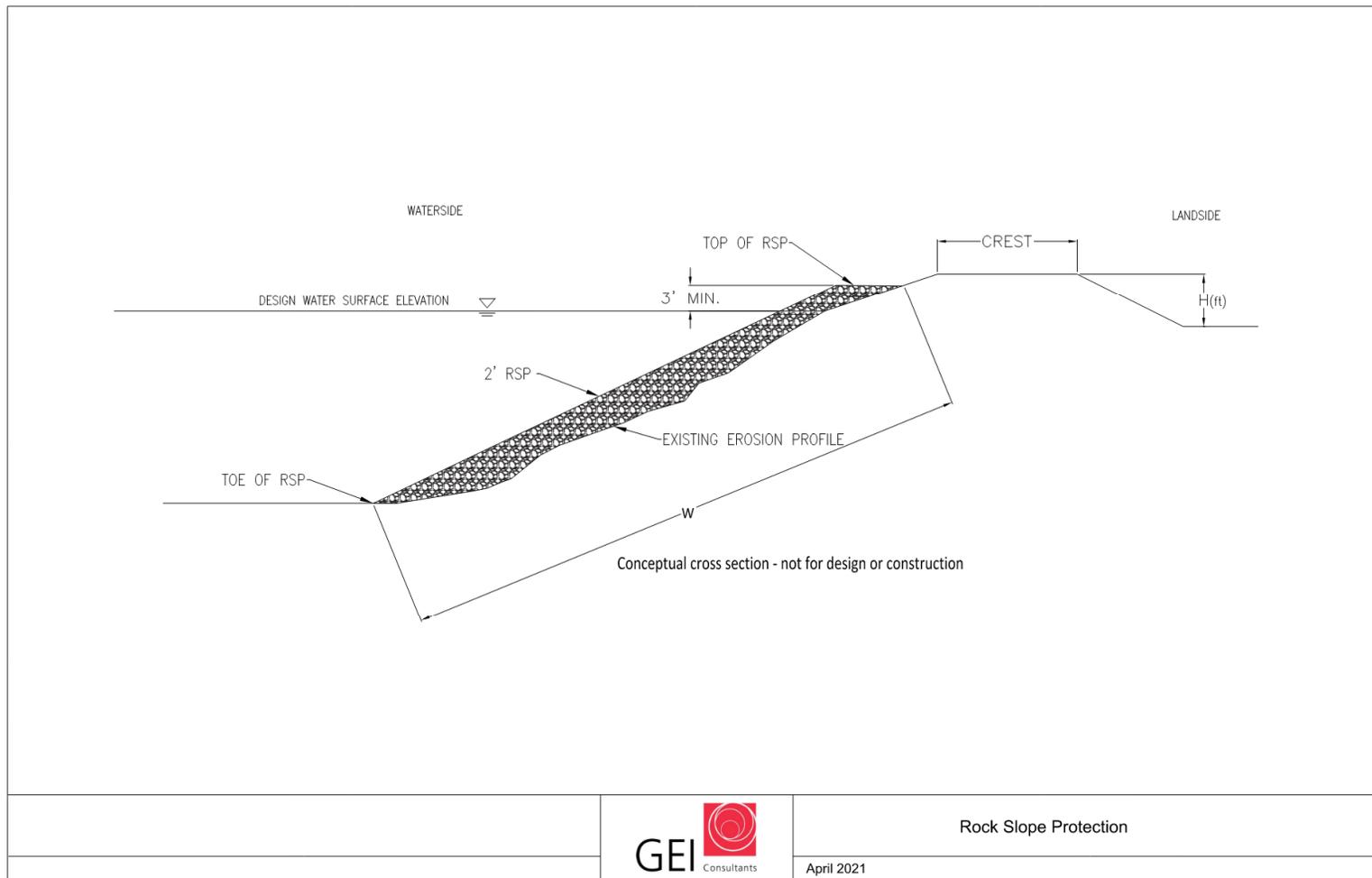
Location Description	Stationing		Length <sup>1</sup> (Feet)	Rock Slope Protection	Other Construction Costs*	Other Owner Costs**	Construction Contingency***	Location Total
	From	To						
SACR-L 106-A	3107+39	3237+92	13,100				30%	
HNCL North CL		5+00	500					
HNCL North CL	5+00	13+00	800					
HDERR East RR-A		45+00	4,500	\$2,713,000	\$543,000	\$1,758,000	\$1,504,000	\$6,517,000
HDERR East RR-B	45+00	90+00	4,500	\$3,617,000	\$723,000	\$2,344,000	\$2,006,000	\$8,689,000
HDERR East RR-C	90+00	131+25	4,100					
HDSRR South RR-A		34+21	3,400	\$2,062,000	\$412,000	\$1,336,000	\$1,143,000	\$4,954,000
			<b>Repair Type Totals</b>	<b>\$8,391,000</b>	<b>\$1,678,000</b>	<b>\$5,438,000</b>	<b>\$4,652,000</b>	<b>\$20,159,000</b>

<sup>1</sup> Reach lengths rounded to the nearest 100 feet

\* Percentages based on the construction subtotal (see Table 1)

\*\* Percentages based on construction, structure, other construction cost subtotals (see Table 1)

\*\*\* 30% of the construction, structure, other construction cost, other owner cost subtotals



Rock Slope Protection

April 2021

**Figure 4: RSP Conceptual Cross Section**

#### 4. Hood Community Cross Levee – 2012 CVFPP and 2014 RFMP Alignment

A 0.70-mile-long cross levee north of Hood, as identified in the 2012 CVFPP and 2014 RFMP, is considered in conjunction with levee repairs and improvements west and south of Hood to secure 100-year FEMA certification for the community of Hood. The dimensions for the cross levee are summarized in Table 9. Utilizing these dimensions, construction quantities were calculated based on the existing ground elevations along the proposed cross levee alignment and were summed to calculate the quantities for each activity. The unit costs identified in Table 1 were then applied to the construction quantities to determine the estimated cost for the proposed cross levee. The cost summary for the proposed cross levee is summarized in Table 10. The estimated range of costs to secure FEMA accreditation for this cross levee system, which includes repairing and strengthening the levees to the west and south of Hood, is summarized in Table 11.

**Table 9. Cross Levee Dimensions**

Crown Width	Landside Slope	Waterside Slope	Crest Elevation	Average Levee Height
20 ft.	3:1	3:1	28 ft. NAVD 88	18.4 ft.

**Table 10: 2012 CVFPP and 2014 RFMP Cross Levee Cost Summary**

**Hood Southern Alignment Cross Levee Cost Estimate**

**Cost Summary (July 2020 Costs)**

Levee length = 3,676 ft, Crest Elevation @ 28.0, Average levee height = 18.4 ft, Crown width = 20 ft

<u>Item</u>	<u>Unit</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Cost</u>
<b>New Cross Levee</b>				
<i>Clearing and Grubbing</i>	AC	13.3	\$8,342.74	\$111,000
<i>Stripping</i>	CY	17,386	\$7.67	\$133,000
<i>Proof Compacting</i>	AC	13.3	\$1,382.62	\$18,000
<i>Inspection Trench - Excavation</i>	CY	14,400	\$6.86	\$99,000
<i>Levee Embankment - Select Levee Fill</i>	CY	218,092	\$26.70	\$5,824,000
<i>Aggregate Base (Crown + LS Maint Rd)</i>	CY	1,600	\$54.90	\$88,000
<i>Hydroseeding</i>	AC	12.1	\$4,692.56	\$57,000
<b>Major Construction Items Subtotal =</b>				<b>\$6,330,000</b>
<b>Other Construction Costs* (see Table 1)</b>				
Unallocated Items in Construction Costs			15%	\$950,000
Mobilization and Demobilization			5%	\$317,000
<b>Other Construction Costs Subtotal =</b>				<b>\$1,270,000</b>
<b>Construction Total =</b>				<b>\$7,600,000</b>
<b>Other Owner Costs** (see Table 1)</b>				
Environmental Documentation and Permitting			10%	\$760,000
Design and Engineering Costs			15%	\$1,140,000
Legal Costs			2%	\$152,000
Engineering during Construction			2%	\$152,000
Construction Management			15%	\$1,140,000
<b>Other Owner Costs Subtotal =</b>				<b>\$3,340,000</b>
<b>Right-of-Way</b>				
<i>Permanent Right-of-Way (fee Title)- Agricultural</i>	AC	13.3	\$40,000.00	\$530,231
<b>Total Project Baseline Cost =</b>				<b>\$11,470,000</b>
<b>Contingency*** 30%</b>				<b>\$3,441,000</b>
<b>Expected Project Cost =</b>				<b>\$14,910,000</b>

\*Other Construction Costs are a percentage of the Major Construction Items Subtotal

\*\* Other Owner Costs are a percentage of the Construction Total

\*\*\* Contingency is a percentage of Construction Total and Total Other Owners Costs

**Table 11: Estimated Range of Costs for Construction of a Cross Levee System per the 2012 CVFPP and 2014 RFMP Including FEMA Certification (Management Action 4)**

<b>Cost Component</b>	<b>Estimated Cost</b>
1. Construction of a Cross Levee Identified in 2012 CVFPP and 2014 RFMP	\$14,910,000
2. Repair and Strengthen-in-Place MA 9 Levee Immediately Fronting the Community of Hood	\$3,492,000 - \$9,946,000
3. Repair and Strengthen-in-Place Railroad Embankment South of Hood (including RSP)	\$10,696,000 - \$14,692,000
4. FEMA Certification (5 percent of items 1-3 above)	\$1,655,000 - \$1,778,000
<b>Total for Management Action 4</b>	<b>\$34,749,000 - \$37,330,000</b>

**5. Hood Community Cross Levee – Community-Preferred Alignment**

A 0.70-mile-long cross levee north of Hood, located approximately 0.25 miles further north of the community of Hood than the cross levee identified by the 2012 CVFPP and 2014 RFMP and as preferred by local interests and landowners, is proposed in conjunction with levee repairs and improvements west and south of Hood to secure 100-year FEMA certification for the community of Hood. The dimensions for the cross levee are nearly identical, but slightly higher compared to that proposed by the 2012 CVFPP and 2014 RFMP and are summarized in Table 9 above. Utilizing these dimensions, construction quantities were calculated based on the existing ground elevations along the proposed cross levee alignment and were summed to calculate the quantities for each activity. The unit costs identified in Table 1 were then applied to the construction quantities to determine the estimated cost for the proposed cross levee. The cost summary for the proposed cross levee is summarized in Table 12. The estimated range of costs to secure FEMA accreditation for this cross levee system, which includes repairing and strengthening the levees to the west and south of Hood, is summarized in Table 13.

## Table 12. Community-Preferred Cross Levee Alignment Cost Summary

### Hood Northern Alignment Cross Levee Cost Estimate Cost Summary (July 2020 Costs)

Levee length = 3,603 ft, Crest Elevation @ 28.0, Average levee height = 19.6 ft, Crown width = 20 ft

<u>Item</u>	<u>Unit</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Cost</u>
<b>New Cross Levee</b>				
<i>Clearing and Grubbing</i>	AC	14	\$8,342.74	\$113,000
<i>Stripping</i>	CY	18,034	\$7.67	\$138,000
<i>Proof Compacting</i>	AC	14	\$1,382.62	\$19,000
<i>Inspection Trench - Excavation</i>	CY	14,012	\$6.86	\$96,000
<i>Levee Embankment - Select Levee Fill</i>	CY	241,001	\$26.70	\$6,435,000
<i>Aggregate Base (Crown + LS Maint Rd)</i>	CY	1,557	\$54.90	\$85,000
<i>Hydroseeding</i>	AC	12	\$4,692.56	\$59,000
<b>Major Construction Items Subtotal =</b>				<b>\$6,945,000</b>
<b>Other Construction Costs* (see Table 1)</b>				
Unallocated Items in Construction Costs			15%	\$1,042,000
Mobilization and Demobilization			5%	\$347,000
<b>Other Construction Costs Subtotal =</b>				<b>\$1,390,000</b>
<b>Construction Total =</b>				<b>\$8,335,000</b>
<b>Other Owner Costs** (see Table 1)</b>				
Environmental Documentation and Permitting			10%	\$834,000
Design and Engineering Costs			15%	\$1,250,000
Legal Costs			2%	\$167,000
Engineering during Construction			2%	\$167,000
Construction Management			15%	\$1,250,000
<b>Other Owner Costs Subtotal =</b>				<b>\$3,670,000</b>
<b>Right-of-Way</b>				
<i>Permanent Right-of-Way (fee Title)- Agricultural</i>	AC	13.6	\$40,000.00	\$544,000
<b>Total Project Baseline Cost =</b>				<b>\$12,545,000</b>
<b>Contingency*** 30%</b>				<b>\$3,764,000</b>
<b>Expected Project Cost =</b>				<b>\$16,310,000</b>

\*Other Construction Costs are a percentage of the Major Construction Items Subtotal

\*\* Other Owner Costs are a percentage of the Construction Total

\*\*\* Contingency is a percentage of Construction Total and Other Owners Costs

**Table 13: Estimated Range of Costs for Construction of a Hood Cross Levee System with Community-Preferred Alignment Including FEMA Certification (Management Action 5)**

<b>Cost Component</b>	<b>Estimated Cost</b>
1. Construction of a New Cross Levee with Community-Preferred Alignment	\$16,310,000
2. Repair and Strengthen-in-Place Levee Immediately Fronting the Community of Hood	\$5,587,000 - \$15,914,000
3. Repair and Strengthen-in-Place Railroad Embankment South of Hood (including RSP)	\$10,696,000 - \$14,692,000
4. FEMA Certification (5 percent of items 1-3 above)	\$1,829,000 - \$2,146,000
<b>Total for Management Action 5</b>	<b>\$38,419,000 - \$45,066,000</b>

**6. Cost Summary of Perimeter Levee System Improvements including FEMA Accreditation for Entire Hood Study Area (Management Actions 2, 6, 7, and 8)**

Table 14 below provides a range of capital cost estimates by levee reach using the remediation alternatives identified in Table 2. These estimates are used as the basis to develop the range of costs for each of the repair and strengthen-in-place structural elements as summarized in Table 16.

**Table 14: Repair/Strengthen-in-Place Cost Estimates by Levee Reach for Hood Study Area**

Management Action	Levee Segment Location	Reach	Start Station	End Station	Length (ft) <sup>1</sup>	Remediation Alternative 1	Remediation Alternative 1 Cost Estimate	Remediation Alternative 2	Remediation Alternative 2 Cost Estimate
MA 6	Left Bank Sacramento River	106-A	3107+39	3237+92	13,100	80 ft. deep cutoff wall	\$98,357,000	80 ft. wide, 9 ft. tall combination seepage and stability berm	\$34,529,000
MA 2	RD 744 South Cross Levee	North CL	0+00	5+00	500	50 ft. deep cutoff wall 1 ft. levee raise	\$1,631,000	85 ft. wide, 16 ft. tall combination seepage and stability berm 1 ft. levee raise	\$1,538,000
			5+00	13+00	800	50 ft. deep cutoff wall 2.5 ft. levee raise	\$2,768,000	85 ft. wide, 16 ft. tall combination seepage and stability berm 2.5 ft. levee raise	\$2,636,000
MA 7	Hood East Railroad Embankment	East RR-A	0+00	45+00	4,500	15 ft. deep cutoff wall 105-ft. wide RSP (4,500 ft.)	\$14,013,000	12 ft. tall, 15 ft. wide drained stability berm 105-ft. wide RSP (4,500 ft.)	\$11,204,000
		East RR-B	45+00	90+00	4,500	60 ft. deep cutoff wall 140 ft. wide RSP (3,500 ft.) 1.0 ft. levee raise	\$20,880,000	140 ft. wide, 19 ft. tall combination seepage and stability berm 140 ft. wide RSP (3,500 ft.) 1.0 ft. levee raise	\$26,618,000
		East RR-C	90+00	131+25	4,100	-	\$0	-	\$0
	Hood South Railroad Embankment	South RR-A	0+00	34+21	3,400	15 ft. deep cutoff wall 105 ft. wide RSP (3,000 ft.)	\$10,696,000	13 ft. tall, 15. ft wide drained stability berm 105 ft. wide RSP (3,000 ft.)	\$14,692,000
MA 8	Totals for Entire Levee Perimeter System of Hood Study Area				30,900 ft. 5.85 mi.		\$148,345,000 (\$25M/mile)		\$91,217,000 (\$16M/mile)
	FEMA Accreditation @ 5% of Perimeter Levee Repair and Strengthen in Place				5.85 mi..		\$7,417,000		\$4,575,000
	Total Cost Summary for FEMA accreditation of Entire Hood Study Area				5.85 mi.		\$155,762,000 (\$27M/mile)		\$96,066,000 (\$16M/mile)

<sup>1</sup> Reach lengths rounded to the nearest 100 feet

The estimated range of costs to secure 100-year FEMA certification for the entire study area are summarized below in Table 15. The cost of securing 100-year FEMA certification for the entire study area, inclusive of the community of Hood, is the summation of all the costs associated with:

- (1) Repairing and strengthening the entirety of the perimeter levees (SPFC and non-SPFC levees) to current FEMA standards
- (2) Addressing any reaches that contain an immediate freeboard issue (RD 744 south cross levee) or long-term settlement issues (unknown)
- (3) Correcting all encroachments (closures, pipelines, and structures) within and/or adjacent to the entirety of the perimeter levee system that pose a threat to the structural and/or operational integrity of the levee system pursuant to 44 CFR §65.10

- (4) Conducting the applicable interior drainage studies and operational plans
- (5) Updating applicable operation and maintenance plans following all repairs and improvements and modifications to ensure the entirety of the perimeter levee system is operated and maintained by RDs 551 and 755 in accordance with FEMA, U.S. Army Corps of Engineers, and Central Valley Flood Protection Board standards.

For cost estimating purposes, FEMA certification items (2) through (5) noted herein are estimated at 5 percent of item (1) herein associated with repairing and strengthening the entirety of the perimeter levee system.

**Table 15: Estimated Range of Costs for 100-Year FEMA Certification for the Community of Hood and Entire Study Area**

<b>Cost Component</b>	<b>Estimated Cost</b>
<b>Remediation and Improvement Alternative 1 (Cutoff Walls) Implemented for Entire Perimeter Levee System of Hood Study Area (5.85 miles)</b>	
1. Repair and Strengthen-in-Place Repairs to the Entire Perimeter Levee System: Remediation Alternative 1 (Cutoff Walls and RSP)	\$148,345,000
2. FEMA Certification (5 percent of item 1 above)	\$7,417,000
<b>Total</b>	\$155,762,000 (\$27M/mile)
<b>Remediation and Improvement Alternative 2 (Berms) Implemented for Entire Perimeter Levee System of Hood Study Area (5.85 miles)</b>	
1. Repair and Strengthen-in-Place Repairs to the Entire Perimeter Levee System: Remediation Alternative 2 (Berms and RSP)	\$91,492,000
2. FEMA Certification (5 percent of item 1 above)	\$4,575,000
<b>Total</b>	\$96,066,000 (\$16M/mile)

**7. Cost Summary of All Management Actions (1-9) Including Multi-Objective Improvements to Sacramento River North Delta Conveyance Corridor (Management Action 9)**

A summary of capital costs for Management Actions 1-9 is provided in Table 16 below.

**Table 16: Estimated Range of Costs for Management Actions 1-9 including FEMA Certification for the Community of Hood**

Hood Management Action	Cutoff Walls	Berms	Cross Levee	RSP	FEMA Certification	Total
1: Repair DWR FSRP Critical and Serious Sites within the Hood Study Area	\$0	\$7,740,000	--	\$0	--	\$7,740,000
2: Raise and Repair/Strengthen-in-Place RD 744 South Cross Levee	\$4,399,000	\$4,174,000	--	\$0	--	\$4,174,000 -\$4,399,000
3: Repair DWR FSRP Critical and Serious Sites North of the Hood Study Area	\$0	\$5,920,000	--	\$0	--	\$5,920,000
4: Cross Levee North of Hood paired with Repair and Strengthen-in-Place Existing SPFC and Non-SPFC Levees adjacent to Hood (2012 CVFPP and 2014 RFMP Configuration)	\$16,298,000	\$13,840,000	\$14,910,000	\$4,344,000	\$1,655,000 -\$1,778,000	\$34,749,000 -\$37,330,000
5: Cross Levee North of Hood with Community-Preferred Alignment paired with Repair and Strengthen-in-Place Existing SPFC and Non-SPFC Levees adjacent to Hood	\$22,266,000	\$15,935,000	\$16,310,000	\$4,344,000	\$1,829,000 -\$2,146,000	\$38,419,000 -\$45,066,000
6: Repair and Strengthen-in-Place DWR MA 9 Sacramento River Left Bank SPFC Levee in Hood Study Area (2.5 miles)	\$98,357,000	\$34,529,000	--	\$0	--	\$34,529,000 - \$98,357,000
<b>Total Cost per Mile for Management Action 6</b>						\$14M-\$39M
7: Repair and Strengthen-in-Place Non-SPFC Levees/Former Railroad Embankments in Hood Study Area (3.35 miles)	\$32,369,000	\$39,069,000	--	\$17,619,000	--	\$49,988,000 - \$56,688,000
<b>Total Cost per Mile for Management Action 7</b>						\$15M-\$17M
8: Secure 100-Year FEMA Certification for Community and Entire Hood Study Area (5.85 miles)	\$130,726,000	\$73,598,000	--	\$17,619,000	\$4,561,000 -\$7,417,000	\$95,778,000 -\$155,762,000
<b>Total Cost per Mile for Management Action 8</b>						\$16M-\$27M
9: Repair and Strengthen-in-Place 9.0 miles of DWR MA 9 Sacramento River Left Bank SPFC Levee between Freeport and RD 755	\$358,072,000	\$125,704,000	--	\$0	--	\$125,704,000 -\$358,072,000
<b>Total Cost per Mile for Management Action 9</b>						\$14M-\$40M

\*Management Action 9 – Repair and Strengthen 9.0 miles of DWR MA 9 Sacramento River Left Bank SPFC Levee Between Freeport and RD 755 is considered a Multi-Objective Component to the Sacramento River North Delta Conveyance Corridor

## 8. References

- California Department of Water Resources: BWFS Sacramento Basin Appendix D, Yolo Bypass Cost Estimates. January 2016.
- Central Valley Flood Protection Board. 2014. Barclays Official California Code of Regulations, Title 23. Waters, Division 1 Central Valley Flood Protection Board. July 2014.
- URS Corporation. 2011a. *Geotechnical Assessment Report, North NULE Project Study Area*. Non-Urban Levee Evaluations Project. Prepared by URS for Department of Water Resources (DWR) Division of Flood Management. April.
- URS Corporation. 2011b. *Remedial Alternatives and Cost Estimating Report (RACER), North NULE Study Area*. Non-Urban Levee Evaluations Project. Prepared by URS for Department of Water Resources (DWR) Division of Flood Management. August.
- URS Corporation. 2012. *Geotechnical Data Report, North NULE Project Study Area*. Non-Urban Levee Evaluations Project. Prepared by URS for DWR Division of Flood Management. November.
- URS Corporation. 2014a. *Geotechnical Overview Report Volume 1, Existing Conditions, Knights Landing Study Area, Segments 162 and 217*. Non-Urban Levee Evaluations Project. Prepared by URS for DWR Division of Flood Management. January.
- URS Corporation. 2014b. *Geotechnical Overview Report Volume 2, Remedial Alternatives, Knights Landing Study Area, Segments 162 and 217*. Non-Urban Levee Evaluations Project. Prepared by URS for DWR Division of Flood Management. September.
- URS Corporation. 2015. *Geotechnical Data Report Addendum, Knights Landing Study Area*. Non-Urban Levee Evaluations Project. Prepared by URS for DWR Division of Flood Management. April.