

Technical Memorandum



To: George Booth - Sacramento County
From: Michael Conant, Kris Van Sant, Katie Laird
cc: Jeffrey Twitchell
Date: March 9, 2021
Re: Cost Estimate Development of Flood Risk Reduction Management Actions
for the Flood Risk Reduction Feasibility Study for Delta Legacy
Communities of West Walnut Grove and Ryde, CA
GEI Project 1800783

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 West Walnut Grove/Ryde 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 Communities of West Walnut Grove and Ryde, CA” (Feasibility Study). As discussed in the Feasibility Study, ten 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 communities of West Walnut Grove and Ryde. This TM is focused on describing how perimeter levee improvements, a ring levee, and all-weather access road/flood fight berm around the community of West Walnut Grove 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) Serious Erosion Site and Address Erosion Sites Identified by the LMA Representatives
- MA 2: Repair and Strengthen-in-Place Sacramento River Right Bank State Plan of Flood Control (SPFC) Levee Adjacent to the communities of West Walnut Grove and Ryde

- MA 3: All-Weather Access Road/Flood Fight Berm for the Community of West Walnut Grove/Clampett Tract
- MA 4: Ring Levee and Federal Emergency Management Agency (FEMA) Certification for the Community of West Walnut Grove/Clampett Tract
- MA 5: Repair and Strengthen-in-Place Steamboat Slough Left Bank SPFC Levee (North of Highway 220)
- MA 6: Repair and Strengthen-in-Place Sacramento River Right Bank SPFC Levee (Between the Confluence with Steamboat Slough and Georgiana Slough)
- MA 7: Repair and Strengthen-in-Place Sacramento River Right Bank SPFC Levee (Between the Confluence with Steamboat Slough and 0.33 miles South of Highway 220)
- MA 8: Repair and Strengthen-in-Place Steamboat Slough Left Bank SPFC Levee (South of Highway 220)
- MA 9: Repair and Strengthen-in-Place Sacramento River Right Bank SPFC Levee (South of Highway 220)
- MA 10: Secure 100-Year FEMA Certification for Sacramento River and Steamboat Slough SPFC Levees North of Highway 220 Paired with a Highway 220 Cross Levee

2. Methodology

The Feasibility Study’s final array of management actions includes a mix of improvements for existing levees around the perimeter of Reclamation District (RD) 3, and non-structural activities. Elements which have costs developed in this TM include:

- Repair and strengthen-in-place levee improvements for the entire study area levee perimeter, based on levee remediations as outlined in the TM Geotechnical Assessment Report – Delta Small Communities Flood Risk Reduction Program – Communities of West Walnut Grove and Ryde. Improvements include:
 - Berms
 - Cutoff walls
 - Rock slope protection (RSP)
- All-weather access road/flood fight berm and ring levee protecting the community of West Walnut Grove
- Cross levee along Highway 220

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 or flood fight berms. 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 Central Valley Flood Protection Plan (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

Construction Activity Description	Unit	Unit Cost
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
CSB 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
Other Construction Costs		

Construction Activity Description	Unit	Unit Cost
Unallocated Items in Construction costs		15.00%-20.00% ¹
Mobilization and Demobilization		5.00%
Other Owner Costs**		
Environmental Documentation and Permitting		10.00%-20.00% ²
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 Improvement Project – IFA Construction Cost Estimate; and

¹ All cost estimates include a 15 percent mark-up for unallocated items in construction costs with the exception of the Highway 220 cross levee which includes a 20 percent mark-up to account for unknown conditions along the highway.

² All cost estimates include a 10 percent mark-up for environmental documentation and permitting with the exception of estimates for RSP which include a 20 percent mark-up due to the more probable disturbance of riparian habitat

- Three Rivers Levee Improvement Authority (TRLIA) levee improvement Segments 1 and 3, bid in 2007, and setback levee Segment 2, bid in 2008.

3. Repair and Strengthen-in-Place Levee Improvements

Repair and strengthen-in-place levee improvements are identified and defined in the Geotechnical Data and Assessment Report – Delta Small Communities Flood Risk Reduction Program – Communities of West Walnut Grove and Ryde TM (Appendix A). Each reach has deficiencies identified as under seepage or through seepage. Each deficient reach can be remediated by either a cutoff wall alternative or berm alternative. A detailed erosion survey/assessment performed by the District engineer (MBK Engineers) as a result of flood damages in 2017 was used to evaluate erosion deficiencies in the study area. The remediations to repair these erosion sites, and the total estimated cost, as provided by MBK Engineers in 2020 is provided in Section 3.3 and further detailed in Appendix A: Geotechnical Data and Assessment Report – Delta Small Communities Flood Risk Reduction Program – Communities of West Walnut Grove/Ryde. No geometric deficiencies were identified in the study area. A description of the repair and strengthen-in-place remediations is included in the following sections and summarized in Table 2.

Table 2: RD 3 Levee Remediation Alternatives

NULE Alignment ID	Reach	Reach Length (feet)	Remediation Alternative 1 Dimensions	Remediation Alternative 2 Dimensions	Vulnerability	
					Underseepage	Through Seepage
SMTS-L	113-A	1,500	N/A	N/A	-	-
SMTS-L	113-B	6,500	30-foot deep cutoff wall	135-foot wide, 11-foot tall combination seepage/stability berm (combo berm)	X	X
SMTS-L	113-C	2,500	20-foot deep cutoff wall	15-foot tall, 15-foot wide stability berm	-	X
SMTS-L	113-D	12,500	30-foot deep cutoff wall	130-foot wide, 14-foot tall combo berm	X	X
SMTS-L	113-E	5,500	45-foot deep cutoff wall	130-foot wide, 13-foot tall combo berm	X	X
SMTS-L	113-F	3,500	20-foot deep cutoff wall	15-foot tall, 15-foot wide stability berm	-	X
SMTS-L	113-G	9,500	90-foot deep cutoff wall	95-foot wide, 11-foot tall combo berm	X	X
SMTS-L	113-H	8,500	25-foot deep cutoff wall	85-foot wide, 8.5-foot tall combo berm	X	X
SMTS-L	113-I	6,000	15-foot deep cutoff wall	10-foot tall, 15-foot wide stability berm	-	X
SMTS-L	113-J	4,100	35-foot deep cutoff wall	80-foot wide, 9-foot tall combo berm	X	X
SACR-R	384-A	37,300	80-foot deep cutoff wall	85-foot wide, 7-foot tall combo berm	X	X
SACR-R	384-B	5,000	15-foot deep cutoff wall	7-foot tall, 15-foot wide stability berm	-	X

NULE Alignment ID	Reach	Reach Length (feet)	Remediation Alternative 1 Dimensions	Remediation Alternative 2 Dimensions	Vulnerability	
					Underseepage	Through Seepage
SACR-R	384-C	3,000	115-foot deep cutoff wall	80-foot wide, 7-foot tall combo berm	X	X
SACR-R	384-D	3,000	15-foot deep cutoff wall	8-foot tall, 15-foot wide stability berm	-	X
SACR-R	384-E	12,000	25-foot deep cutoff wall	7-foot tall, 15-foot wide stability berm	X	X
SACR-R	384-F	16,500	15-foot deep cutoff wall	7-foot tall, 15-foot wide stability berm	-	X
SACR-R	384-G	9,000	35-foot deep cutoff wall	80-foot wide, 8-foot tall combo berm	X	X
SACR-R	384-H	5,800	15-foot deep cutoff wall	9-foot tall, 15-foot wide stability berm	-	X
Total Perimeter Levee System of Grand Island		151,700 (28.8 miles)				

Notes:

- 1) Wall depths and berm widths rounded up to the nearest 5-foot dimension and stability berm heights rounded to the nearest 1-foot dimension.
- 2) Erosion vulnerability was assessed by MBK and the results are included in Appendix A: Geotechnical Data and Assessment Report
- 3) Reach lengths rounded to the nearest 100 feet

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	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				
Units		AC	AC	CY	CY	AC	AC	\$/ AC		
SMTS-L 113-A										
SMTS-L 113-B	Combo	27.5	23.7	61,548	143,638	24.6	39.48	\$47,000	\$7,688,000	\$1,856,000
SMTS-L 113-C	Stability	3.7	3.1	7,015	6,377	3.8	0.32	\$40,000	\$722,000	\$13,000
SMTS-L 113-D	Combo	55.2	45.9	124,008	269,468	46.1	71.05	\$42,600	\$15,126,000	\$3,027,000
SMTS-L 113-E	Combo	23.8	19.9	53,422	118,301	20.2	31.46	\$43,250	\$6,556,000	\$1,361,000
SMTS-L 113-F	Stability	5.2	4.4	10,067	20,206	5.3	1.41	\$36,957	\$1,218,000	\$52,000
SMTS-L 113-G	Combo	31.2	25.9	68,338	154,217	27.4	40.50	\$54,541	\$8,451,000	\$2,209,000
SMTS-L 113-H	Combo	23.3	20.2	50,336	119,575	22.5	33.96	\$63,564	\$6,347,000	\$2,159,000
SMTS-L 113-I	Stability	7.1	5.7	12,820	25,333	7.2	2.75	\$73,400	\$1,552,000	\$202,000
SMTS-L 113-J	Combo	10.8	9.4	23,205	55,254	10.5	8.07	\$71,208	\$2,930,000	\$575,000
SACR-R 384-A	Combo	99.2	85.9	213,272	498,480	96.7	76.61	\$33,835	\$26,768,000	\$2,592,000
SACR-R 384-B	Stability	5.0	3.9	8,539	16,190	5.0	2.63	\$40,500	\$1,026,000	\$106,000
SACR-R 384-C	Combo	7.3	6.6	15,659	37,956	7.5	6.15	\$32,750	\$1,992,000	\$201,000
SACR-R 384-D	Stability	3.2	2.5	5,351	7,750	3.2	1.01	\$58,500	\$604,000	\$59,000
SACR-R 384-E	Stability	12.0	9.2	20,059	33,800	12.1	5.34	\$50,250	\$2,344,000	\$269,000
SACR-R 384-F	Stability	16.5	12.8	28,055	52,036	16.6	8.41	\$79,750	\$3,354,000	\$671,000
SACR-R 384-G	Combo	22.9	20.2	49,100	118,250	22.8	17.93	\$45,500	\$6,227,000	\$816,000
SACR-R 384-H	Stability	6.5	5.2	11,610	23,974	6.5	2.96	\$43,250	\$1,424,000	\$128,000
Totals		361	304	762,404	1,700,804	338	350	-	\$94,329,000	\$16,295,000

Table 4: Berm Reach Cost Summary

Location Description	Berm Type	Length ¹	Stability Berm	Combo Berm	Berm Cost	Residential Structures		Other Structures		Other Construction Costs*	Other Owner Costs**	Construction Contingency***	Right of Way	Reach Total
		(Feet)				#	Cost (\$250k)	#	Cost (\$75k)			30%		
SMTS-L 113-B	Combo	6,500		\$7,688,000	\$7,688,000	2	\$500,000	2	\$150,000	\$5,381,000	\$7,706,000	\$6,233,000	\$1,856,000	\$29,514,000
SMTS-L 113-C	Stability	2,500	\$722,000		\$722,000					\$505,000	\$702,000	\$579,000	\$13,000	\$2,521,000
SMTS-L 113-D	Combo	12,500		\$15,126,000	\$15,126,000	8	\$2,000,000	5	\$375,000	\$10,588,000	\$15,557,000	\$12,381,000	\$3,027,000	\$59,054,000
SMTS-L 113-E	Combo	5,500		\$6,556,000	\$6,556,000	2	\$500,000	4	\$300,000	\$4,589,000	\$6,660,000	\$5,342,000	\$1,361,000	\$25,308,000
SMTS-L 113-F	Stability	3,500	\$1,218,000		\$1,218,000	1	\$250,000	1	\$75,000	\$853,000	\$1,301,000	\$1,012,000	\$52,000	\$4,761,000
SMTS-L 113-G	Combo	9,500		\$8,451,000	\$8,451,000	15	\$3,750,000	8	\$600,000	\$5,916,000	\$9,780,000	\$7,244,000	\$2,209,000	\$37,950,000
SMTS-L 113-H	Combo	8,500		\$6,347,000	\$6,347,000	4	\$1,000,000	4	\$300,000	\$4,443,000	\$6,637,000	\$5,228,000	\$2,159,000	\$26,114,000
SMTS-L 113-I	Stability	6,000	\$1,552,000		\$1,552,000	6	\$1,500,000	5	\$375,000	\$1,086,000	\$2,183,000	\$1,446,000	\$202,000	\$8,344,000
SMTS-L 113-J	Combo	4,100		\$2,930,000	\$2,930,000	1	\$250,000	3	\$225,000	\$2,051,000	\$3,019,000	\$2,400,000	\$575,000	\$11,450,000
SACR-R 384-A	Combo	37,300		\$26,768,000	\$26,768,000	7	\$1,750,000	3	\$225,000	\$18,738,000	\$26,730,000	\$21,671,000	\$2,592,000	\$98,474,000
SACR-R 384-B	Stability	5,000	\$1,026,000		\$1,026,000	6	\$1,500,000	2	\$150,000	\$718,000	\$1,591,000	\$1,001,000	\$106,000	\$6,092,000
SACR-R 384-C	Combo	3,000		\$1,992,000	\$1,992,000					\$1,395,000	\$1,937,000	\$1,597,000	\$201,000	\$7,122,000
SACR-R 384-D	Stability	3,000	\$604,000		\$604,000	1	\$250,000	7	\$525,000	\$423,000	\$866,000	\$568,000	\$59,000	\$3,295,000
SACR-R 384-E	Stability	12,000	\$2,344,000		\$2,344,000	3	\$750,000	4	\$300,000	\$1,641,000	\$2,657,000	\$1,993,000	\$269,000	\$9,954,000
SACR-R 384-F	Stability	16,500	\$3,354,000		\$3,354,000	9	\$2,250,000	8	\$600,000	\$2,348,000	\$4,286,000	\$2,996,000	\$671,000	\$16,505,000
SACR-R 384-G	Combo	9,000		\$6,227,000	\$6,227,000	7	\$1,750,000			\$4,359,000	\$6,683,000	\$5,181,000	\$816,000	\$25,016,000
SACR-R 384-H	Stability	5,800	\$1,424,000		\$1,424,000	1	\$250,000			\$997,000	\$1,474,000	\$1,168,000	\$128,000	\$5,441,000
Repair Type Totals		151,700	\$12,244,000	\$82,084,000	\$94,329,000	73	\$18,250,000	56	\$4,200,000	\$66,031,000	\$99,769,000	\$78,040,000	\$16,295,000	\$376,915,000

¹ Reach lengths rounded to the nearest 100 feet

* Percentages based on the construction subtotal

** Percentages based on construction, structure, other construction cost subtotals

*** Percentages based on construction, structure, other construction cost, other owner cost subtotals

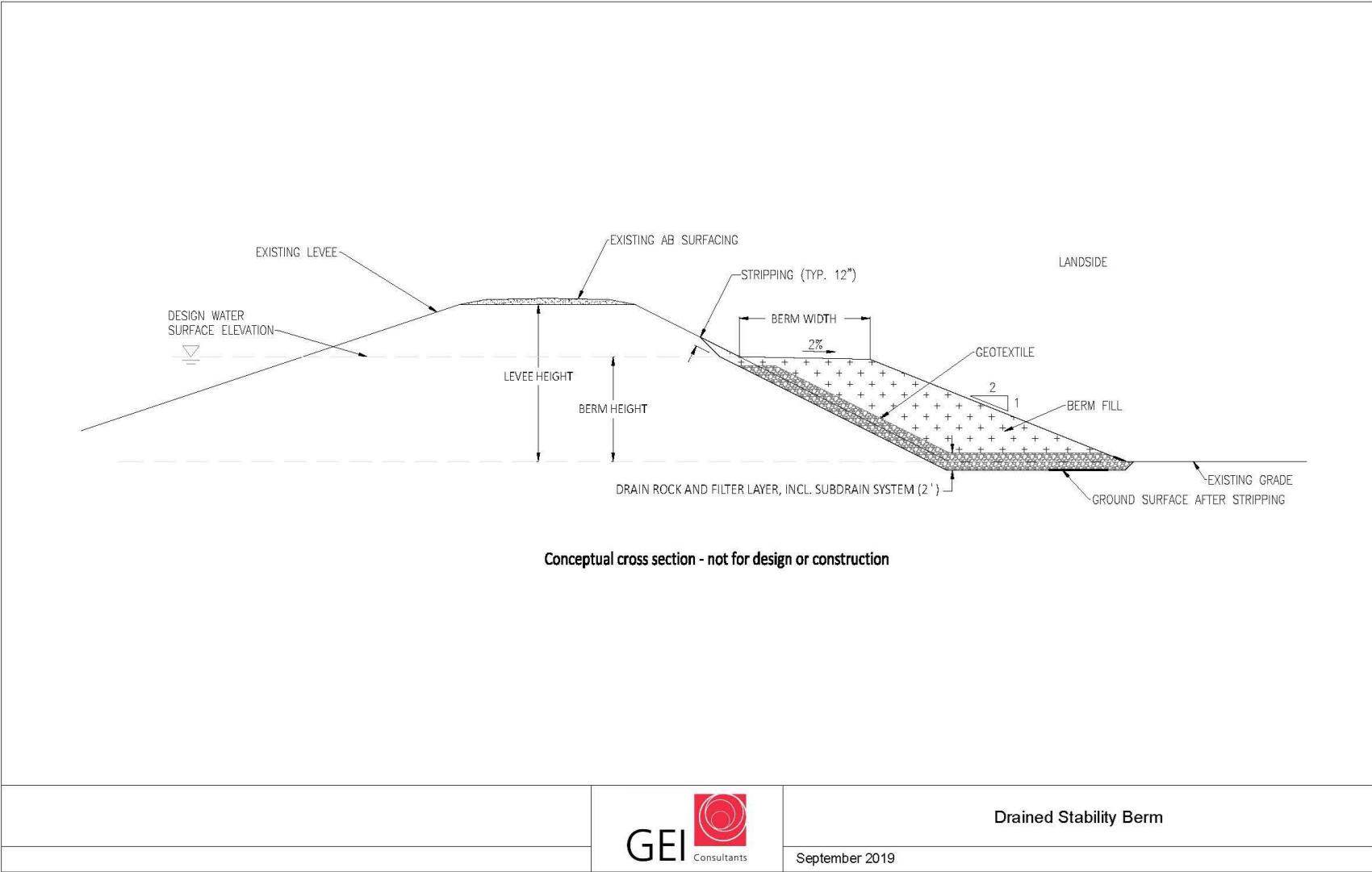
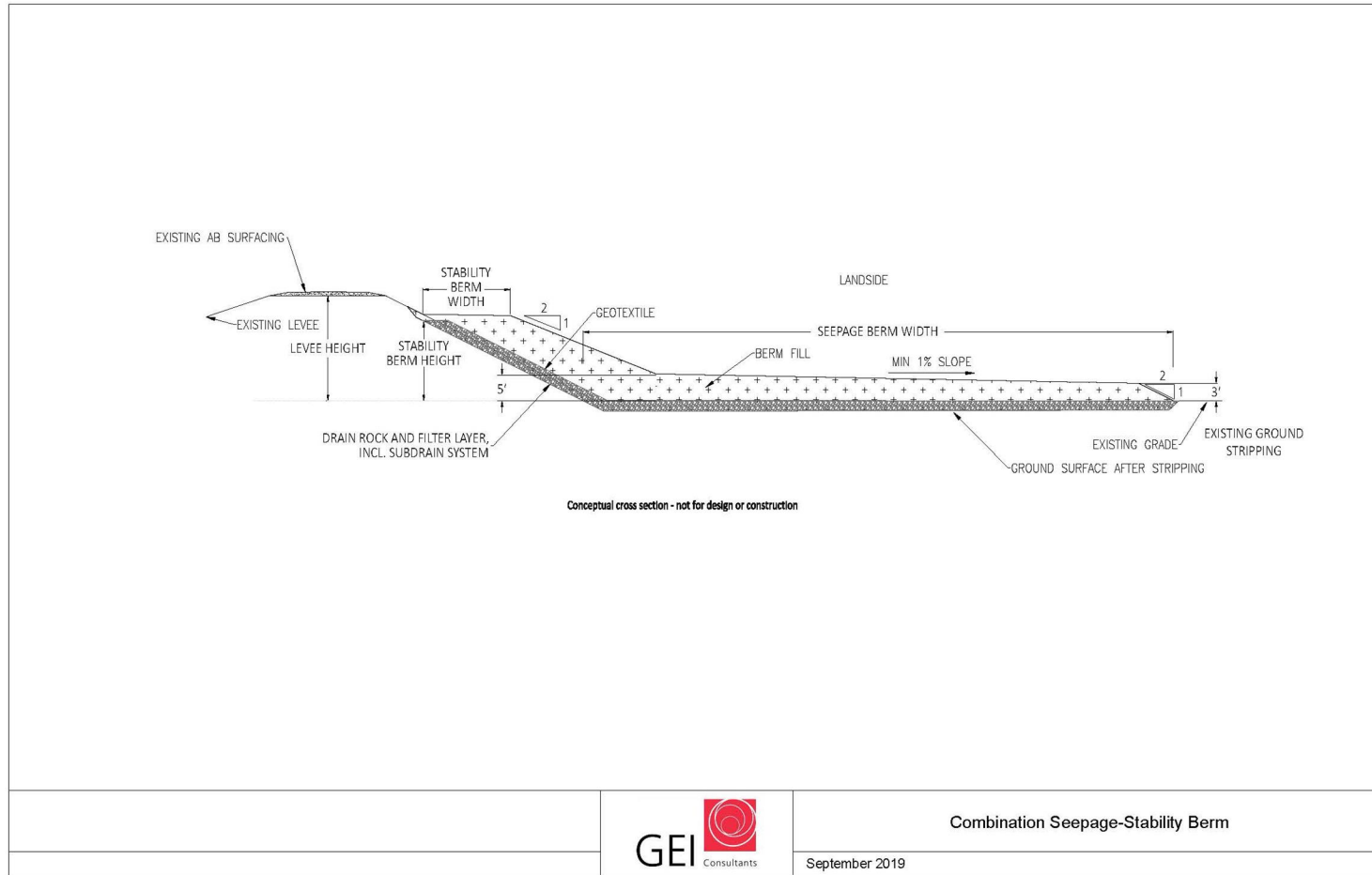


Figure 1: Drained Stability Berm Conceptual Schematic



Combination Seepage-Stability Berm

September 2019

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 assume 25 percent of the levee height is removed to form a suitable working surface for installation of the cutoff walls. The construction of a cutoff wall along reach 113 (Steamboat Slough) and 384 (Sacramento River) would result in disruption of traffic along Highway 160 and Grand Island 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/sqft	Levee Rebuild	Temporary Roadway				Aggregate Base Levee Crown	New Roadway AC	Hydroseeding	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	\$7.7	\$7.7	\$109.8	\$40.0	\$82.3	\$40.0	\$4,467.0				
Units		CY	SY	CY	Sq ft		CY	AC	AC	CY	SY	CY	SY	AC	AC	\$/ AC		
SMTS-L 113-A	0 ft	0	0	0	0	\$0.00	0	0.0	0.0	0	0	0	0	0.0	0.0	\$0	\$0	\$0
SMTS-L 113-B	30 ft	92,727	17,333	92,727	202,865	\$32.00	93,568	35.7	35.7	2,889	17,333	2,407	17,333	2.8	4.3	\$47,000	\$12,504,000	\$203,000
SMTS-L 113-C	20 ft	54,513	6,667	54,513	53,713	\$32.00	62,413	13.7	13.7	1,111	6,667	926	6,667	1.8	1.7	\$40,000	\$5,058,000	\$67,000
SMTS-L 113-D	30 ft	205,040	33,333	205,040	389,438	\$32.00	172,956	68.7	68.7	5,556	33,333	4,630	33,333	6.9	8.3	\$42,600	\$24,295,000	\$355,000
SMTS-L 113-E	45 ft	82,503	14,667	82,503	253,853	\$32.00	84,905	30.2	30.2	2,444	14,667	2,037	14,667	2.2	3.7	\$43,250	\$13,431,000	\$158,000
SMTS-L 113-F	20 ft	51,464	9,333	51,464	74,235	\$32.00	53,199	19.2	19.2	1,556	9,333	1,296	9,333	2.3	2.3	\$36,957	\$5,718,000	\$86,000
SMTS-L 113-G	90 ft	109,886	25,333	109,886	864,928	\$41.17	97,753	52.2	52.2	4,222	25,333	3,519	25,333	3.9	6.3	\$54,541	\$42,924,000	\$345,000
SMTS-L 113-H	25 ft	87,359	22,667	87,359	220,448	\$32.00	73,230	46.7	46.7	3,778	22,667	3,148	22,667	2.5	5.7	\$63,564	\$13,028,000	\$360,000
SMTS-L 113-I	15 ft	55,691	16,000	55,691	95,280	\$32.00	47,478	33.0	33.0	2,667	16,000	2,222	16,000	1.7	4.0	\$73,400	\$7,052,000	\$293,000
SMTS-L 113-J	35 ft	34,806	11,040	34,806	148,543	\$32.00	31,163	22.7	22.7	1,840	11,040	1,533	11,040	1.4	2.8	\$71,208	\$7,413,000	\$196,000
SACR-R 384-A	80 ft	442,237	99,544	442,237	2,986,320	\$32.00	364,219	205.0	205.0	16,591	99,544	13,826	99,544	12.3	24.9	\$33,835	\$123,926,000	\$841,000
SACR-R 384-B	15 ft	59,407	16,667	59,407	79,675	\$32.00	46,941	33.1	33.1	2,222	16,667	1,852	16,667	1.4	4.0	\$40,500	\$6,587,000	\$163,000
SACR-R 384-C	115 ft	37,411	10,000	37,411	347,640	\$41.17	27,437	19.9	19.9	1,333	10,000	1,111	10,000	0.7	2.4	\$32,750	\$16,745,000	\$79,000
SACR-R 384-D	15 ft	31,985	10,000	31,985	47,640	\$32.00	26,118	19.9	19.9	1,333	10,000	1,111	10,000	0.7	2.4	\$58,500	\$3,830,000	\$141,000
SACR-R 384-E	25 ft	129,048	40,000	129,048	310,560	\$32.00	104,408	79.5	79.5	5,333	40,000	4,444	40,000	3.3	9.6	\$50,250	\$19,179,000	\$485,000
SACR-R 384-F	15 ft	176,584	55,000	176,584	261,113	\$32.00	137,259	109.4	109.4	7,333	55,000	6,111	55,000	4.4	13.3	\$79,750	\$20,879,000	\$1,057,000
SACR-R 384-G	35 ft	97,420	30,000	97,420	322,920	\$32.00	76,300	59.7	59.7	4,000	30,000	3,333	30,000	2.3	7.2	\$45,500	\$17,221,000	\$329,000
SACR-R 384-H	15 ft	69,243	19,303	69,243	91,961	\$32.00	52,823	38.4	38.4	2,574	19,303	2,145	19,303	1.4	4.7	\$43,250	\$7,585,000	\$201,000
Totals		1,817,323	436,887	1,817,323	6,751,129	-	1,552,169	887	887	66,782	436,887	55,652	436,887	52	108	-	\$347,375,000	\$5,359,000

Table 6: Cutoff Wall Reach Cost Summary

Location Description	Stationing		Length ¹ (Feet)	Cutoff Wall	Other Construction Costs*	Other Owner Costs**	Construction Contingency***	Right of Way	Reach Total
	From	To					30%		
SMTS-L 113-A	1000+00	1015+00	1,500						
SMTS-L 113-B	1015+00	1080+00	6,500	\$12,504,000	\$2,501,000	\$6,602,000	\$6,482,000	\$203,000	\$28,292,000
SMTS-L 113-C	1080+00	1105+00	2,500	\$5,058,000	\$1,012,000	\$2,671,000	\$2,622,000	\$67,000	\$11,430,000
SMTS-L 113-D	1105+00	1230+00	12,500	\$24,295,000	\$4,859,000	\$12,828,000	\$12,595,000	\$355,000	\$54,932,000
SMTS-L 113-E	1230+00	1285+00	5,500	\$13,431,000	\$2,686,000	\$7,091,000	\$6,962,000	\$158,000	\$30,328,000
SMTS-L 113-F	1285+00	1320+00	3,500	\$5,718,000	\$1,144,000	\$3,019,000	\$2,964,000	\$86,000	\$12,931,000
SMTS-L 113-G	1320+00	1415+00	9,500	\$42,924,000	\$8,585,000	\$22,664,000	\$22,252,000	\$345,000	\$96,770,000
SMTS-L 113-H	1415+00	1500+00	8,500	\$13,028,000	\$2,606,000	\$6,879,000	\$6,754,000	\$360,000	\$29,627,000
SMTS-L 113-I	1500+00	1560+00	6,000	\$7,052,000	\$1,410,000	\$3,723,000	\$3,656,000	\$293,000	\$16,134,000
SMTS-L 113-J	1560+00	1601+40	4,100	\$7,413,000	\$1,483,000	\$3,914,000	\$3,843,000	\$196,000	\$16,849,000
SACR-R 384-A	1841+71	2215+00	37,300	\$123,926,000	\$24,785,000	\$65,433,000	\$64,243,000	\$841,000	\$279,228,000
SACR-R 384-B	2215+00	2265+00	5,000	\$6,587,000	\$1,317,000	\$3,478,000	\$3,415,000	\$163,000	\$14,960,000
SACR-R 384-C	2265+00	2295+00	3,000	\$16,745,000	\$3,349,000	\$8,841,000	\$8,681,000	\$79,000	\$37,695,000
SACR-R 384-D	2295+00	2325+00	3,000	\$3,830,000	\$766,000	\$2,022,000	\$1,985,000	\$141,000	\$8,744,000
SACR-R 384-E	2325+00	2445+00	12,000	\$19,179,000	\$3,836,000	\$10,127,000	\$9,943,000	\$485,000	\$43,570,000
SACR-R 384-F	2445+00	2610+00	16,500	\$20,879,000	\$4,176,000	\$11,024,000	\$10,824,000	\$1,057,000	\$47,960,000
SACR-R 384-G	2610+00	2700+00	9,000	\$17,221,000	\$3,444,000	\$9,093,000	\$8,927,000	\$329,000	\$39,014,000
SACR-R 384-H	2700+00	2757+91	5,800	\$7,585,000	\$1,517,000	\$4,005,000	\$3,932,000	\$201,000	\$17,240,000
Repair Type Totals			151,700	\$347,375,000	\$69,476,000	\$183,414,000	\$180,080,000	\$5,359,000	\$785,704,000

¹ Reach lengths rounded to the nearest 100 feet

* Percentages based on the construction subtotal

** Percentages based on construction, structure, other construction cost subtotals

*** Percentages based on construction, structure, other construction cost, other owner cost subtotals

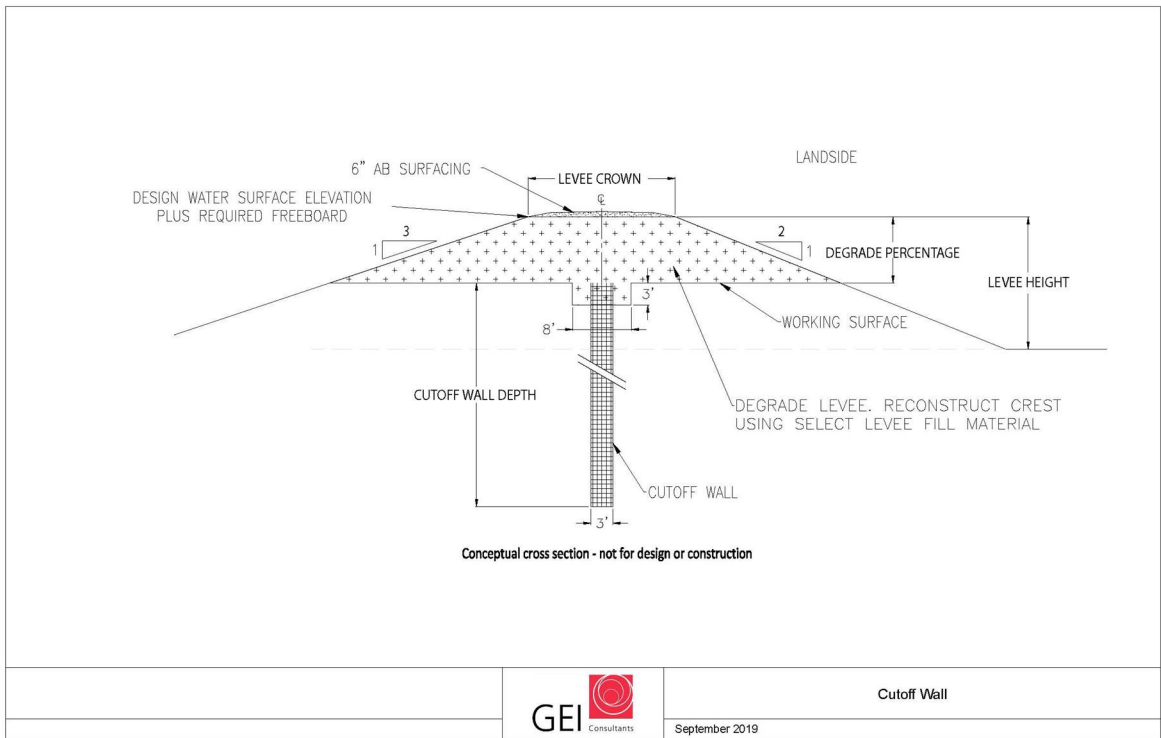


Figure 3: Cutoff Wall Conceptual Schematic

3.3. Rock Slope Protection Improvements

To address existing erosion concerns RSP involves placement of rip-rap along the waterside slope of the levee. Along reaches 113 and 384, specific sites have been identified for repair by the District engineer (MBK Engineers), including a quantity estimate for the repairs. These sites are assumed to require 2-foot thick RSP along the entire waterside slope. The extents along this reach will need to be refined in future designs.

Past estimates to repair erosion sites on RD 3 in 2019 were used to develop a base cost estimate to repair all known erosion sites identified by MBK Engineers in RD 3. Other construction costs, other owner costs, and construction contingency was added to this base cost to develop a total cost estimate to repair all known erosion sites. A summary of the total cost estimate is provided in Table 7.

Table 7: RSP Cost Summary for Erosion Repairs

Cost Component	Estimated Cost
Base Rock Slope Protection Cost (provided by MBK Engineers in 2020)	\$500,000
Other Construction Costs*	\$100,000
Unallocated Items in Construction Costs (15%)	\$75,000
Mobilization and Demobilization	\$25,000
Other Owner Costs**	\$324,000
Environmental Documentation and Permitting (20%)	\$120,000
Design and Engineering Costs (15%)	\$90,000
Legal Costs (2%)	\$12,000
Engineering during Construction (2%)	\$12,000
Construction Management (15%)	\$90,000
Construction Contingency*** (30%)	\$277,200
Total	\$1,201,000

* Percentages based on the construction subtotal

** Percentages based on construction, structure, other construction cost subtotals

*** Percentages based on construction, structure, other construction cost, other owner cost subtotals

4. All-Weather Access Road/Flood Fight Berm and Ring Levee

Construction of an all-weather access road/flood fight berm or ring levee would prevent floodwaters originating upstream or downstream within the RD 3 basin from entering the community of West Walnut Grove, allowing additional time for evacuation. A ring levee is a permanent flood control structure and would be higher in height than an all-weather access road/flood fight berm, but slightly lower in height than the existing levees adjacent to the Sacramento River. An all-weather access road and flood fight berm is essentially a slightly elevated all-weather roadway to accommodate the temporary placement of interlocking Muscle Wall during flood fight conditions. The noted access road would accommodate the temporary flood fight installation of a 4 to 8 ft.-high Muscle Wall. The access road/flood fight berm would follow a similar, but shorter alignment as the ring levee. The dimensions for the ring levee and flood fight berm are summarized in Table 8 below. The height of the flood fight berm varies based on the existing ground elevation and the height of muscle wall to be installed. With the installation of the muscle wall, the effective elevation of the berm plus wall is at 14 feet NAVD88. Additional refinement of the flood fight berm is needed including an assessment of the time needed to deploy the Muscle Wall in inclement weather and development of an Emergency Action Plan.

The cost estimates for the ring levee and flood fight berm are included in Table 9 and Table 10.

Table 8: Ring Levee and Flood Fight Berm Dimensions

	Ring Levee	Flood Fight Berm
Crown Width	20 ft.	20 ft.
Landside Slope	3:1	3:1
Waterside Slope	3:1	3:1
Crest Elevation	14 ft. NAVD88	Varies from 3 to 11 ft. based on muscle wall height

Table 9: Ring Levee Cost Summary

**WWG/ Ryde Current Alignment Ring Levee Cost Estimate
Cost Summary (July 2020 Costs)**

Levee length = 7,560 ft, Crest Elevation @ 14.0, Average levee height = 9.5 ft, Crest Width 20 ft.

<u>Item</u>	<u>Unit</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Cost</u>
New Cross Levee				
<i>Clearing and Grubbing</i>	AC	18.1	\$8,342.74	\$151,000
<i>Stripping</i>	CY	21,073	\$7.67	\$162,000
<i>Proof Compacting</i>	AC	18.1	\$1,382.62	\$25,000
<i>Inspection Trench - Excavation</i>	CY	29,440	\$6.86	\$202,000
<i>Levee Embankment - Select Levee Fill</i>	CY	191,545	\$26.70	\$5,115,000
<i>Aggregate Base (Crown + LS Maint Rd)</i>	CY	3,271	\$54.90	\$180,000
<i>Hydroseeding</i>	AC	15.3	\$4,692.56	\$72,000
Major Construction Items Subtotal =				\$5,910,000
Other Construction Costs*				
Unallocated Items in Construction Costs			15%	\$887,000
Mobilization and Demobilization			10%	\$591,000
Other Construction Costs Subtotal =				\$1,480,000
Construction Total =				\$7,390,000
Other Owner Costs**				
Environmental Documentation and Permitting			10%	\$739,000
Design and Engineering Costs			15%	\$1,109,000
Legal Costs			2%	\$148,000
Engineering during Construction			2%	\$148,000
Construction Management			15%	\$1,109,000
Other Owner Costs Subtotal =				\$3,250,000
Right-of-Way				
<i>Permanent Right-of-Way (fee Title)- Orchard</i>	AC	8.3	\$40,000.00	\$331,000
Total Project Baseline Cost =				\$10,970,000
Contingency*** 30%				\$3,291,000
Expected Project Cost =				\$14,260,000

*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 10: All-Weather Access Road/Flood Fight Berm Cost Summary

**WWG/Clampett Tract Alignment Flood Fight Berm Cost Estimate
Cost Summary (July 2020 Costs)**

Levee length = 7,581 ft, Crest Elevation @ 14.0, Average berm height = 3.4 ft., Crest Width = 20 Ft.

<u>Item</u>	<u>Unit</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Cost</u>
New Cross Levee				
<i>Clearing and Grubbing</i>	AC	10.3	\$8,342.74	\$85,976
<i>Stripping</i>	CY	8,536	\$7.67	\$65,451
<i>Proof Compacting</i>	AC	10.3	\$1,382.62	\$14,249
<i>Inspection Trench - Excavation</i>	CY	29,124	\$6.86	\$199,851
<i>Levee Embankment - Select Levee Fill</i>	CY	60,291	\$26.70	\$1,609,965
<i>Aggregate Base (Crown + LS Maint Rd)</i>	CY	3,236	\$54.90	\$177,645
<i>Hydroseeding</i>	AC	7.1	\$4,692.56	\$33,167
Major Construction Items Subtotal =				\$2,190,000
Other Construction Costs*				
Unallocated Items in Construction Costs			15%	\$328,500
Mobilization and Demobilization			10%	\$219,000
Other Construction Costs Subtotal =				\$550,000
Construction Total =				\$2,740,000
Other Owner Costs**				
Environmental Documentation and Permitting			10%	\$274,000
Design and Engineering Costs			15%	\$411,000
Legal Costs			2%	\$54,800
Engineering during Construction			2%	\$54,800
Construction Management			15%	\$411,000
Other Owner Costs Subtotal =				\$1,210,000
Right-of-Way				
<i>Permanent Right-of-Way (fee Title)- Orchard</i>	AC	4.8	\$40,000.00	\$193,010
Total Project Baseline Cost =				\$4,140,000
Contingency*** 30%				\$1,242,000
Expected Project Cost =				\$5,380,000

*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

5. Highway 220 Cross Levee

A 2.7-mile-long cross levee along the portion of Highway 220 which bisects Grand Island is proposed in conjunction with levee repairs and improvements north of Highway 220 along the Sacramento River and Steamboat Slough to secure 100-year FEMA certification for the

communities of West Walnut Grove and Ryde. The dimensions for the cross levee are summarized in Table 11 below. Utilizing these dimensions, construction quantities were calculated based on the existing ground elevations along Highway 220 and 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 Highway 220 cross levee. The cost summary for the Highway 220 cross levee is summarized in Table 12.

Table 11. Cross Levee Dimensions

Crown Width with Hwy 220	Landside Slope	Waterside Slope	Crest Elevation
30 ft.	3:1	3:1	14 ft. NAVD 88

Table 12: Highway 220 Cross Levee Cost Summary**WWG/Ryde Highway 220 Alignment Cross Levee Cost Estimate
Cost Summary (July 2020 Costs)**

Levee length = 14,159 ft, Crest Elevation @ 14.0, Average levee height = 11.4 ft, Crest width = 30 ft.

<u>Item</u>	<u>Unit</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Cost</u>
New Cross Levee				
<i>Clearing and Grubbing</i>	AC	41.2	\$8,342.74	\$344,000
<i>Stripping</i>	CY	50,920	\$7.67	\$390,000
<i>Proof Compacting</i>	AC	41.2	\$1,382.62	\$57,000
<i>Inspection Trench - Excavation</i>	CY	56,000	\$6.86	\$384,000
<i>Levee Embankment - Select Levee Fill</i>	CY	492,975	\$26.70	\$13,164,000
<i>Aggregate Base (Crown + LS Maint Rd)</i>	CY	6,222	\$54.90	\$342,000
<i>Hydroseeding</i>	AC	32.7	\$4,692.56	\$154,000
<i>Roadway</i>	SY	31,000	\$45.75	\$1,418,000
Major Construction Items Subtotal =				\$16,250,000
Other Construction Costs*				
Unallocated Items in Construction Costs			20%	\$3,250,000
Mobilization and Demobilization			5%	\$812,500
Other Construction Costs Subtotal =				\$4,060,000
Construction Total =				\$20,310,000
Other Owner Costs**				
Environmental Documentation and Permitting			10%	\$2,031,000
Design and Engineering Costs			15%	\$3,046,500
Legal Costs			2%	\$406,200
Engineering during Construction			2%	\$406,200
Construction Management			15%	\$3,046,500
Other Owner Costs Subtotal =				\$8,940,000
Right-of-Way				
<i>Permanent Right-of-Way (fee Title)- Agricultural</i>	AC	10.7	\$25,000.00	\$267,696
Total Project Baseline Cost =				\$29,520,000
Contingency 30%				\$8,856,000
Expected Project Cost =				\$38,380,000

* 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

6. Summary and Range of Costs to Repair and Strengthen-in-Place SPFC Levee Segments

Table 13 provides a range of capital cost estimates by levee reach (excluding erosion) 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 13: Repair/Strengthen-in-Place Cost Estimates by Levee Reach for West Walnut Grove/Ryde Study Area, Excluding Erosion Repairs

SPFC Levee Segment Location	Reach	Start Station	End Station	Length (ft) ¹	Remediation Alternative 1	Remediation Alternative 1 Cost Estimate	Remediation Alternative 2	Remediation Alternative 2 Cost Estimate
Steamboat Slough, south of Highway 220	113-A	1000+00	1015+00	1,500	--	--	--	--
	113-B	1015+00	1080+00	6,500	30 ft. deep cutoff wall	\$28,292,000	135 ft. wide, 11 ft. tall combination seepage and stability berm	\$29,514,000
	113-C	1080+00	1105+00	2,500	20 ft. deep cutoff wall	\$11,430,000	15 ft. tall, 15 ft. wide stability berm	\$2,521,000
	113-D	1105+00	1230+00	12,500	30 ft. deep cutoff wall	\$54,932,000	130 ft. wide, 14 ft. tall combination seepage and stability berm	\$59,054,000
	113-E	1230+00	1285+00	5,500	45 ft. deep cutoff wall	\$30,328,000	130 ft. wide, 13 ft. tall combination seepage and stability berm	\$25,308,000
Steamboat Slough, north of Highway 220	113-F	1285+00	1320+00	3,500	20 ft. deep cutoff wall	\$12,931,000	15 ft. tall, 15 ft. wide stability berm	\$4,761,000
	113-G	1320+00	1415+00	9,500	90 ft. deep cutoff wall	\$96,770,000	95 ft. wide, 11 ft. tall combination seepage and stability berm	\$37,950,000
	113-H	1415+00	1500+00	8,500	25 ft. deep cutoff wall	\$29,627,000	85 ft. wide, 8.5 ft. tall combination seepage and stability berm	\$26,114,000
	113-I	1500+00	1560+00	6,000	15 ft. deep cutoff wall	\$16,134,000	10 ft. tall, 15 ft. wide stability berm	\$8,344,000
	113-J	1560+00	1601+40	4,100	35 ft. deep cutoff wall	\$16,849,000	80 ft. wide, 9 ft. tall combination seepage and stability berm	\$11,450,000
Totals for Steamboat Slough Levees				60,100 ft., 11.4 Mi.		\$297,293,000 (\$26M/mile)		\$205,016,000 (\$18M/mile)
Right Bank of the Sacramento River, south of Highway 220	384-A	1841+71	2215+00	37,300	80 ft. deep cutoff wall	\$279,228,000	85 ft. wide, 7 ft. tall combination seepage and stability berm	\$98,474,000
	384-B	2215+00	2265+00	5,000	15 ft. deep cutoff wall	\$14,960,000	7 ft. tall, 15 ft. wide stability berm	\$6,092,000
	384-C	2265+00	2295+00	3,000	115 ft. deep cutoff wall	\$37,695,000	80 ft. wide, 7 ft. tall combination seepage and stability berm	\$7,122,000
	384-D	2295+00	2325+00	3,000	15 ft. deep cutoff wall	\$8,744,000	8 ft. tall, 15 ft. wide stability berm	\$3,295,000

SPFC Levee Segment Location	Reach	Start Station	End Station	Length (ft) ¹	Remediation Alternative 1	Remediation Alternative 1 Cost Estimate	Remediation Alternative 2	Remediation Alternative 2 Cost Estimate
Right Bank of the Sacramento River, north of Highway 220	384-E	2325+00	2445+00	12,000	25 ft. deep cutoff wall	\$43,570,000	7 ft. tall, 15 ft. wide stability berm	\$9,954,000
	384-F	2445+00	2610+00	16,500	15 ft. deep cutoff wall	\$47,960,000	7 ft. tall, 15 ft. wide stability berm	\$16,505,000
	384-G	2610+00	2700+00	9,000	35 ft. deep cutoff wall	\$39,014,000	80 ft. wide, 8 ft. tall combination seepage and stability berm	\$25,016,000
	384-H	2700+00	2757+91	5,800	15 ft. deep cutoff wall	\$17,240,000	9 ft. tall, 15 ft. wide stability berm	\$5,441,000
Totals for Sacramento River Levees				91,600 ft., 17.4 Mi		\$488,411,000 (\$28M/mile)		\$171,899,000 (\$10M/mile)
Totals for Grand Island Perimeter Levee System	Perimeter Levees North of Hwy 220			14.2	Cutoff walls	\$320,095,000	Seepage/Stability Berms	\$145,535,000
	Perimeter Levees South of Hwy 220			14.6	Cutoff Walls	\$465,609,000	Seepage/Stability Berms	\$231,380,000
	Entire Perimeter Levee System of Grand Island			28.8	Cutoff Walls	\$785,704,000	Seepage/Stability Berms	\$376,915,000

¹ Reach lengths rounded to the nearest 100 feet

7. Range of Costs to Repair and Strengthen-in-Place SPFC Levees to Obtain FEMA Certification for Portion of Grand Island North of Highway 220, including West Walnut Grove/Clampett Tract and Portions of Ryde

The estimated range of costs to secure 100-year FEMA certification for the community of West Walnut Grove/Clampett Tract and the portion of Grand Island north of Highway 220 are summarized below in Table 14. The cost of securing 100-year FEMA certification for the northerly half of Grand Island, inclusive of the community of West Walnut Grove/Clampett Tract, is the summation of all the costs associated with:

- 1) Repairing and strengthening the west bank of the Sacramento River levee north of Highway 220 to current FEMA standards
- 2) Repairing and strengthening the left bank of the Steamboat Slough levee north of Highway 220 to current FEMA standards
- 3) Addressing erosion sites identified by LMA representatives
- 4) Constructing a new cross levee along Highway 220
- 5) Addressing any reaches that contain an immediate freeboard issue (none) or long-term settlement issues (unknown)

- 6) 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
- 7) Conducting the applicable interior drainage studies and operational plans
- 8) Updating applicable operation and maintenance plans following all repairs and improvements and modifications to ensure the segment of levee along the west bank of the Sacramento River is operated and maintained by RD 3 in accordance with FEMA, U.S. Army Corps of Engineers, and Central Valley Flood Protection Board standards

For cost estimating purposes, FEMA certification items (5) through (8) noted herein are estimated at 5 percent of the total combined cost of items (1) through (4) herein associated with repairing and strengthening the segments of levee north of Highway 220, addressing erosion sites identified by LMA representatives, and constructing a new cross levee along Highway 220.

Table 14: Estimated Range of Costs for 100-Year FEMA Certification for the Portion of Grand Island North of Highway 220

Cost Component	Estimated Cost
Remediation and Improvement Alternative 1 (Cutoff Walls) Implemented for Repair of Levees North of Highway 220 (14.2 miles)	
1. Repair and Strengthen-in-Place Sacramento River Right Bank SPFC Levee North of Highway 220: Remediation Alternative 1 (Cutoff Walls)	\$153,632,000
2. Repair and Strengthen-in-Place Steamboat Slough Left Bank Levee North of Highway 220: Remediation Alternative 1 (Cutoff Walls)	\$172,311,000
3. Construct a New Cross Levee Along Highway 220	\$38,380,000
4. Address Remaining Erosion Sites Identified by LMA Representatives and by the FSRP	\$4,520,000
5. FEMA Certification (5 percent of items 1-4 above)	\$18,442,000
Total	\$387,285,000

Cost Component	Estimated Cost
Remediation and Improvement Alternative 2 (Berms) Implemented for Repair of Levees North of Highway 220 (14.2 miles)	
1. Repair and Strengthen-in-Place Sacramento River Right Bank SPFC Levee North of Highway 220: Remediation Alternative 2 (Berms)	\$59,120,000
2. Repair and Strengthen-in-Place Steamboat Slough Left Bank SPFC Levee North of Highway 220: Remediation Alternative 2 (Berms)	\$88,619,000
3. Construct a New Cross Levee along Highway 220	\$38,380,000
4. Address Remaining Erosion Sites Identified by LMA Representatives and by the FSRP	\$4,520,000
5. FEMA Certification (5 percent of items 1-4 above)	\$9,532,000
Total	\$200,171,000

8. Range of Costs for Construction and FEMA Certification of Ring Levee System for West Walnut Grove/Clampett Tract

The estimated cost to construct the ring levee described in Section 4 and to secure FEMA accreditation for the community of West Walnut Grove includes cost components for construction of the ring levee, repairing and strengthening-in-place the levee immediately fronting the community of West Walnut Grove, and FEMA certification. These cost components and the total estimated cost for this element is summarized in Table 15 below. A range of costs is provided, as the strengthen-in-place repairs to the levee fronting the community of West Walnut Grove can be remediated through a cutoff wall or a stability berm, which results in a range of costs for this repair and strengthen-in-place element. However it is expected that a cutoff wall would be implemented along this segment of levee to reduce physical impacts associated with a stability berm that would displace structures within the community that are located on and/or directly adjacent to the landward toe of the existing levee system. Note that the estimated costs to repair and strengthen the levee fronting the community of West Walnut Grove includes an additional 300 ft. on either end to accommodate the transition of the ring levee. Additionally, to attain FEMA accreditation, erosion site 8 identified by the LMA representatives will likely need to be addressed in addition to the repairs and strengthening in place of the levee fronting the community and

construction of the new ring levee. These costs have not been included in the range of costs below.

Table 15: Estimated Range of Costs for Construction of a Ring Levee and FEMA Certification for the Community of West Walnut Grove – Clampett Tract

Cost Component	Estimated Cost
1. Construction of a Ring Levee	\$14,260,000
2. Repair and Strengthen-in-Place Sacramento River Right Bank SPFC Levee Immediately Fronting the Community of West Walnut Grove	\$7,427,000 - \$21,553,000
3. FEMA Certification (5 percent of items 1-2 above)	\$1,084,000 - \$1,791,000
Total	\$22,771,000 - \$37,604,000

9. Cost Summary of Management Actions for Walnut Grove/Ryde Study Area

A summary of capital costs for Management Actions 1-10 is provided in Table 16 below. A range of costs has been provided since levees can be remediated through a cutoff wall or a stability berm.

Table 16: Estimated Range of Costs for Management Actions 1-10 Including FEMA Certifications for the Community of West Walnut Grove and the Portion of Grand Island North of Highway 220

Management Action	Cutoff walls	Berms	Ring Levee or All-Weather Access Road/Flood Fight Berm	RSP/Rock Revetment	FEMA Certification	Total \$M
1: Repair DWR FSRP Site(s) and Address Erosion Sites Identified by the LMA Representatives	\$0	\$0	\$0	\$4,520,000	\$0	\$5M
2: Repair and Strengthen-in-Place Sacramento River Right Bank Levee Adjacent to West Walnut Grove and Ryde	\$28,551,000	\$9,893,000	\$0	\$0	\$0	\$10M-\$29M
3: All-Weather Access Road/Flood Fight Berm for the Community of West Walnut Grove/Clampett Tract	\$0	\$0	\$5,380,000	\$0	\$0	\$5M
4: Ring Levee and FEMA Certification for the Community of West Walnut Grove/Clampett Tract	\$21,553,000	\$7,427,000	\$14,260,000	\$0	\$1,084,000-\$1,791,000	\$23M-\$38M
5: Repair and Strengthen-in-Place Steamboat Slough Left Bank SPFC Levee (north of Highway 220 – 6.0 miles)	\$172,311,000	\$88,619,000	\$0	\$0	\$0	\$89M-\$172M
Total Cost per Mile for Management Action 5						\$15M-\$29M
6: Repair and Strengthen-in-Place Sacramento River Right Bank SPFC Levee (between the confluence with Steamboat Slough and Georgiana Slough – 5.9 miles)	\$104,214,000	\$46,962,000	\$0	\$0	\$0	\$47M-\$104M
Total Cost per Mile for Management Action 6						\$8M-\$18M
7: Repair and Strengthen-in-Place Sacramento River Right Bank SPFC Levee (north of Highway 220 – 8.2 miles)	\$153,632,000	\$59,120,000	\$0	\$0	\$0	\$59M-\$154M
Total Cost per Mile for Management Action 7						\$7M-\$19M
8: Repair and Strengthen-in-Place Steamboat Slough Left Bank SPFC Levee (south of Highway 220 – 5.4 miles)	\$124,982,000	\$116,397,000	\$0	\$0	\$0	\$116M-\$125M
Total Cost per Mile for Management Action 8						\$22M-\$23M
9: Repair and Strengthen-in-Place Sacramento River Right Bank SPFC Levee (south of Highway 220 – 9.15 miles)	\$334,847,000	\$112,805,000	\$0	\$0	\$0	\$113M-\$335M
Total Cost per Mile for Management Action 9						\$12M-\$37M
10: Secure 100-Year FEMA Certification for Sacramento River and Steamboat Slough SPFC Levees North of Highway 220 Paired with a Highway 220 Cross Levee	\$325,943,000	\$147,739,000	\$38,380,000	\$4,520,000	\$9,532,000 -\$18,442,000	\$200M -\$387M

10. 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.
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- 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.