

**Knights Landing
Small Community Flood Risk Reduction
Feasibility Study**

**Appendix C Cost Estimate Development
for Final Array Structural Alternatives**

July 2019

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Acronyms and Abbreviations

AACEI	Association for the Advancement of Cost Engineering International
BWFS	Basin-Wide Feasibility Study
CVFPB	Central Valley Flood Protection Board
CVFPP	Central Valley Flood Protection Plan
CVFMP	Central Valley Flood Management Planning
DWR	California Department of Water Resources
CVP	Central Valley Project
DSM	Deep-Soil-Mixing
DWSE	Design Water Surface Elevation
ft	feet
HTOL	hydraulic top of levee
NULE	Non-Urban Levee Evaluation
ROW	Right-of-Way
pcf	pounds per cubic foot
USACE	United States Army Corps of Engineers
WSE	water surface elevation

C.1 Introduction

C.1.1 Purpose

The purpose of this appendix is to describe the development of cost estimates for the final array of structural alternatives identified in the Knights Landing Small Community Flood Risk Reduction Feasibility Study (Feasibility Study). As discussed in the Feasibility Study, thirteen different structural alternatives were initially evaluated and screened down to a final array of six alternatives identified as Alternatives 1, 3, 6, 11, 12, and 13. The alternatives proposed in the Feasibility Study are intended to provide 100-year level of flood protection to the community of Knights Landing. These alternatives propose structural improvements including fixes to existing levees and construction of new cross levees. These alternatives are included in Figure 1 through Figure 6. The costs included in this appendix are intended to provide a consistent basis for comparing the relative costs of the different alternatives.

C.2 Methodology

The Knights Landing Feasibility Study's final array of alternatives includes a mix of cross-levees and improvements for existing levees, including levees around the perimeter of Knights Landing and improvements to three "Mid-valley sites" originally identified by the United States Army Corp of Engineers (USACE) in 1989. Due to the different level of information available for each of these elements, slightly different methodologies were utilized to most effectively use the available information. These methodologies are outlined in the following sections.

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 establish a Baseline Cost for the lower range and add a 30 percent contingency cost to the Baseline Cost for the higher range. Therefore, the cost range for the cost estimates presented in this Appendix falls within the range for a Class 4 estimate. The cost estimates in this document are considered a planning-level tool.

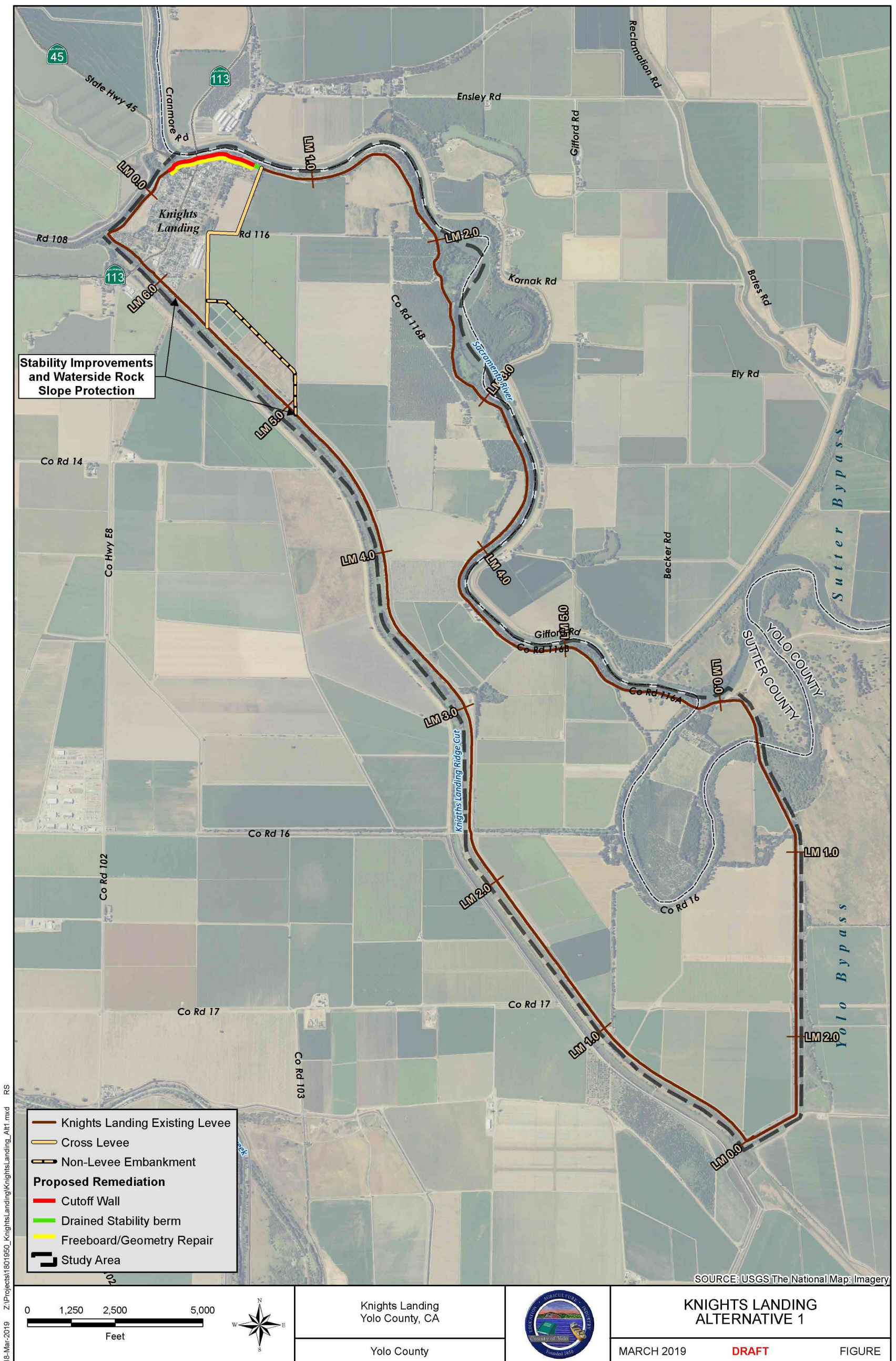


Figure 1: Alternative 1 with Potential Remediation for Levee Improvements

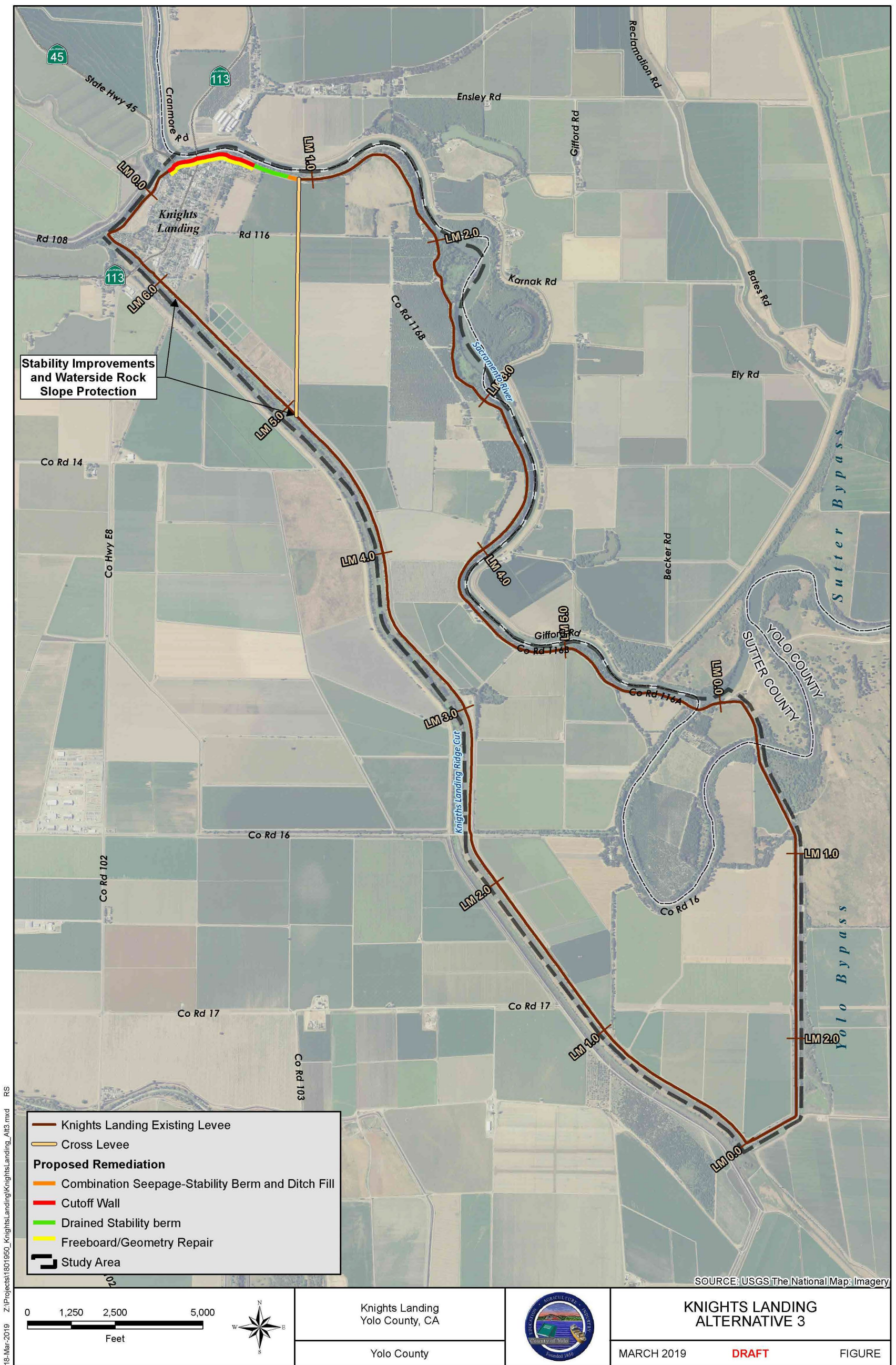
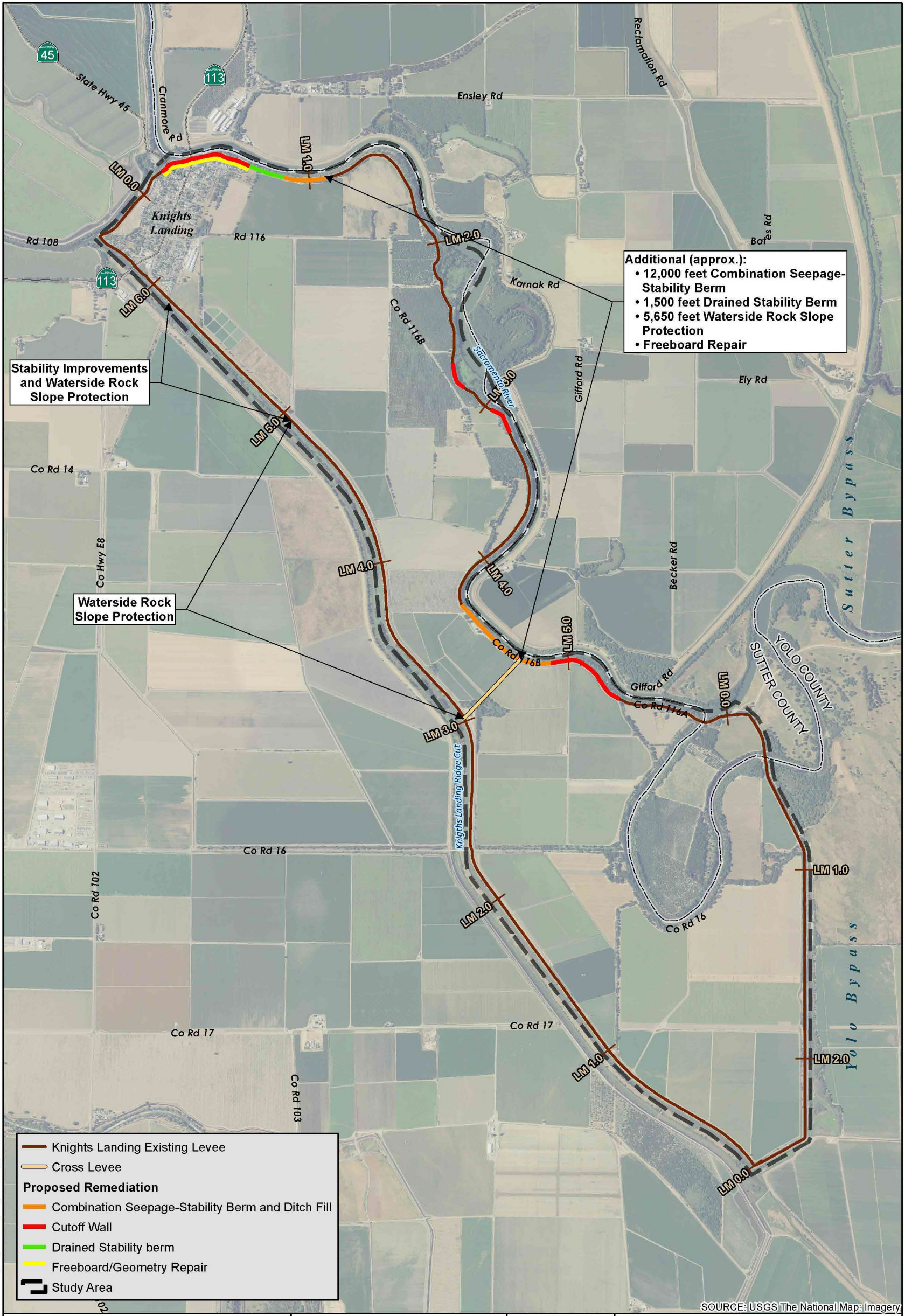


Figure 2: Alternative 3 with Potential Remediation for Levee Improvements

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<p>0 1,250 2,500 5,000</p> <p>Feet</p>	<p>Knights Landing Yolo County, CA</p> <p>Yolo County</p>	<p>KNIGHTS LANDING ALTERNATIVE 6</p> <p>MARCH 2019 DRAFT FIGURE</p>
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Figure 3: Alternative 6 with Potential Remediation for Levee Improvements

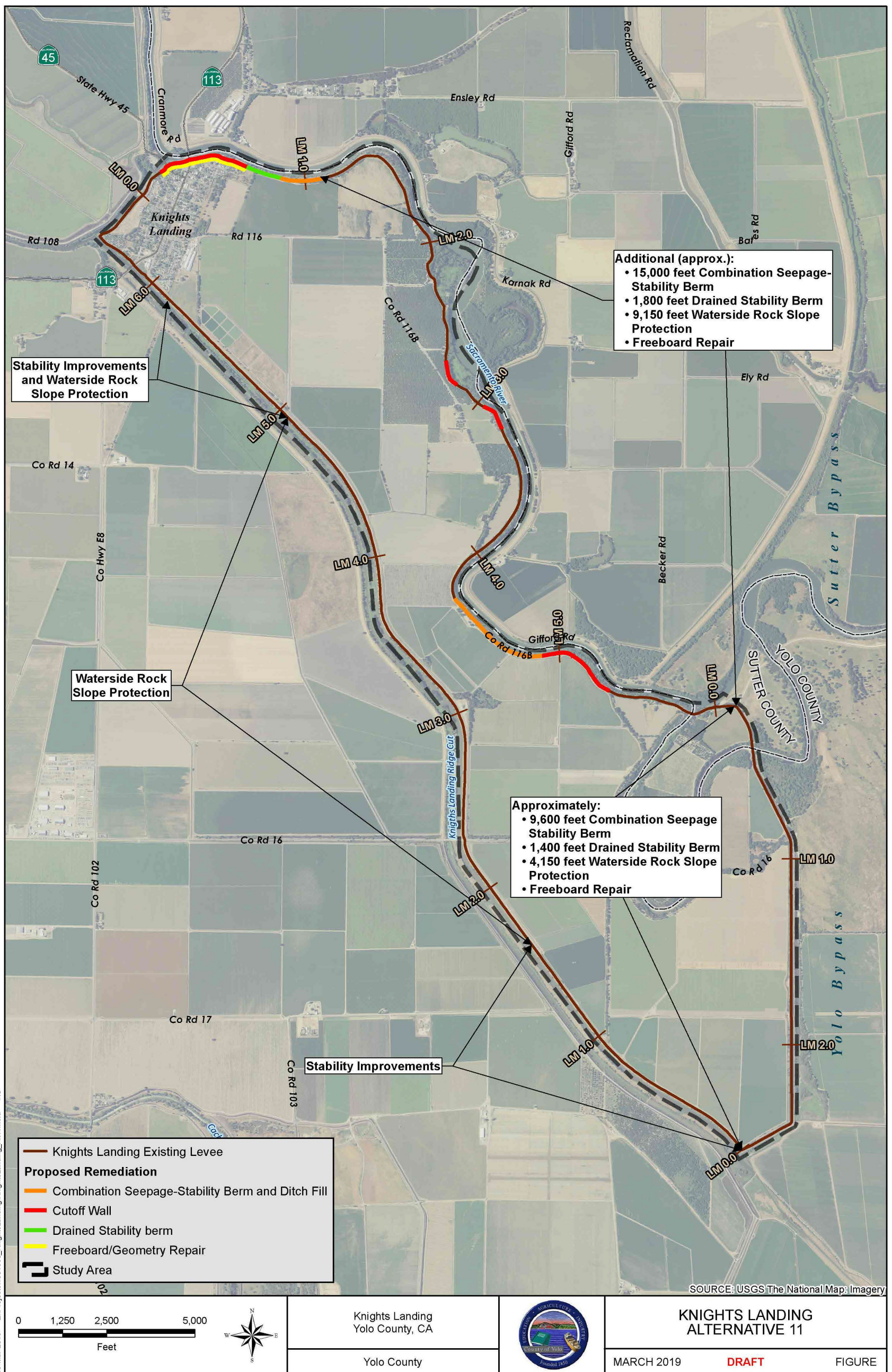


Figure 4: Alternative 11 with Potential Remediation for Levee Improvements

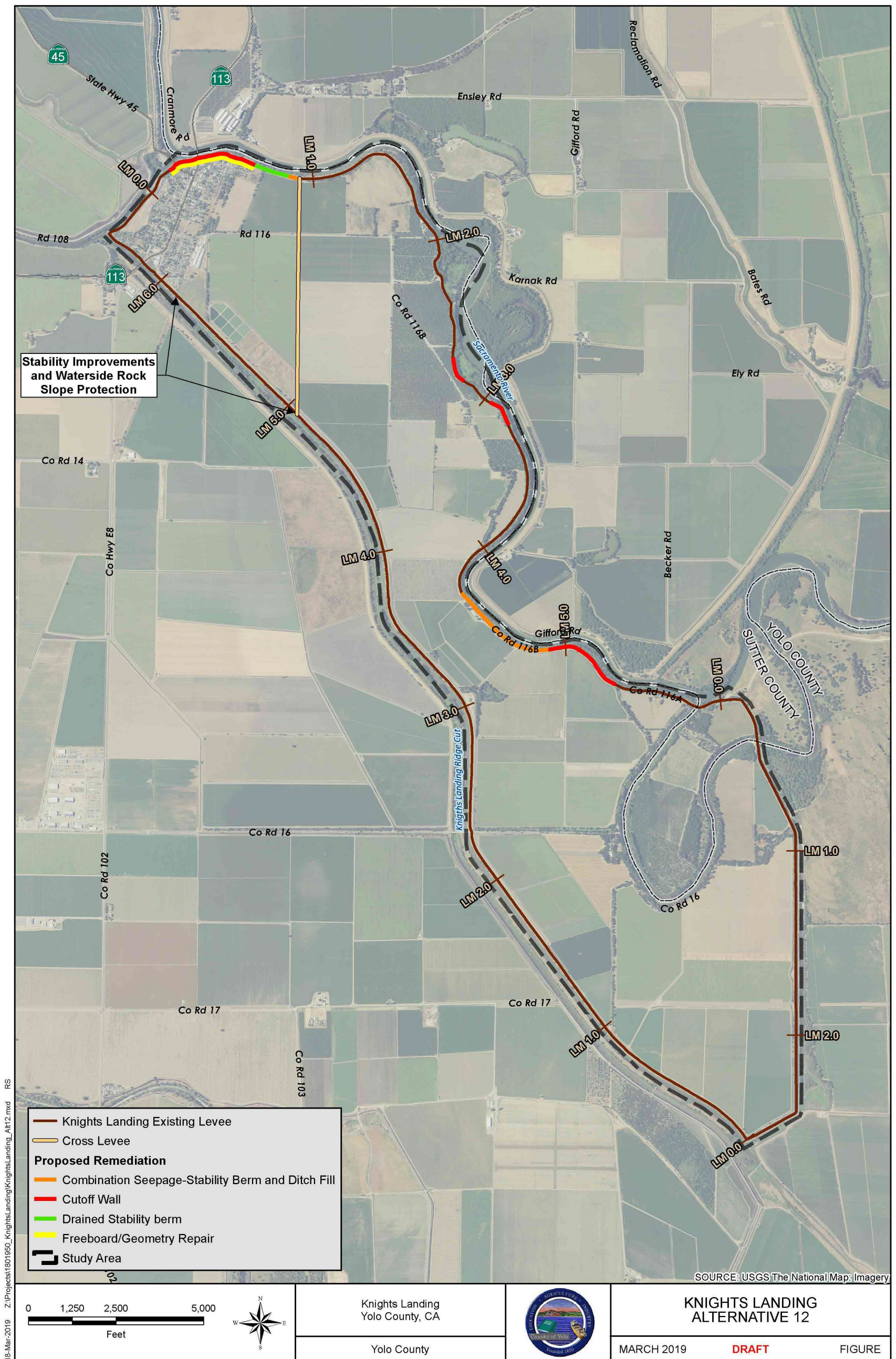
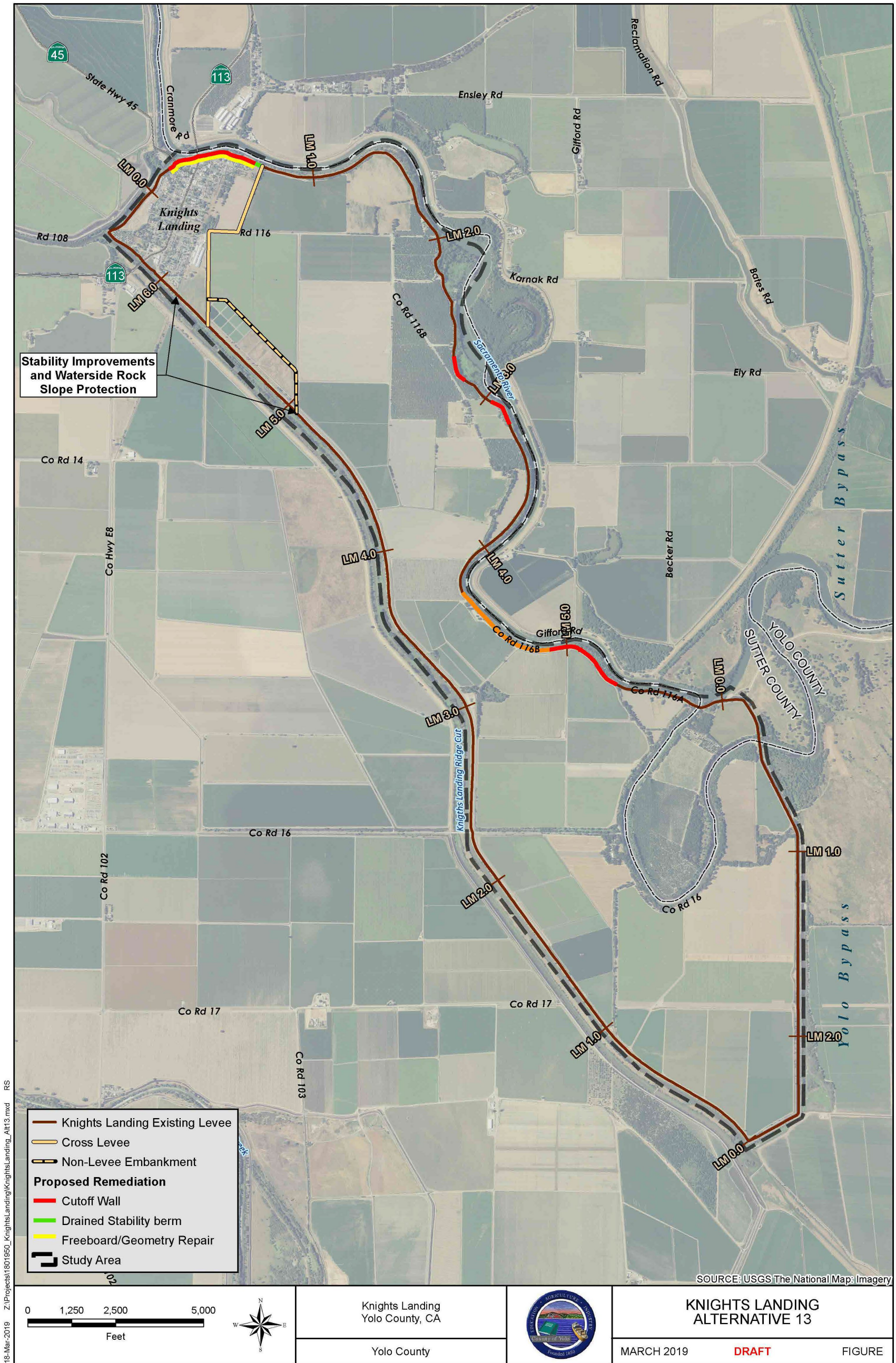


Figure 5: Alternative 12 with Potential Remediation for Levee Improvements



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Figure 6: Alternative 13 with Potential Remediation for Levee Improvements

C.3 Cross-Levees

Interior cross-levees are included as an element in Alternatives 1, 3, 6, 12, and 13.

Alternatives 1 and 13 share the same cross-levee alignment. The cross-levee runs north from the Knights Landing Ridgecut south levee immediately west of the existing waste treatment spreading ponds for 2,650 feet (ft). The levee then continues east for 750 ft parallel to the alignment of Rd 116. The levee then runs 2,030 ft north-east along the western alignment of the Castle Properties parcel. The total levee length is 5,430 ft. This alternative also includes a 4,400 ft embankment to protect the Knights Landing treatment ponds along Knights Landing Ridgecut. For purposes of this feasibility study it is assumed that the cross-levee will be run adjacent to existing infrastructure such as Road (Rd) 116 to minimize impacts.

Alternatives 3 and 12 share the same cross-levee alignment. The cross-levee runs north from the Knights Landing Ridgecut south levee immediately east of the existing waste treatment spreading ponds for 6,840 ft before tying into the Sacramento River Levees. For purposes of this feasibility study it is assumed that the cross-levee will run adjacent to existing infrastructure such as Rd 116 to minimize impacts.

The cross-levee for Alternative 6 runs north-east from the Knights Landing Ridgecut south levee for 2,200 ft to the Sacramento River levee.

C.3.1 Cost Development

A cost estimate was developed for each of the cross-levee alignments 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 to provide a cost estimate range.

The following construction activities are included in the cost estimates for the proposed cross-levees:

- Clearing and grubbing: Clearing all vegetation and debris above the ground surface from 25 feet beyond the waterside and landside toe.
- Stripping: Stripping the original ground surface a minimum of 12 inches within the levee footprint.
- Proof compacting: Proof compacting the surface within the extents of the levee footprint prior to the placement of select levee fill.
- Inspection trench excavation and backfill: An inspection trench centered under the future waterside hinge 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.
- Select 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.
- Seepage 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.
- Aggregate Base: A 6-inch-thick, all-weather aggregate base road shall be provided for the levee crown (20 feet wide) and a 4-inch-thick landside access road (12 feet wide) within the provided toe access corridor.
- 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.
- Utility relocation: There is an existing overhead 12kV power line that runs along Rd 116 that will be impacted by Alternatives 1, 3, and 12. There may be other unidentified utilities impacted by the levee construction. It is assumed that these unidentified utility relocations are part of the unallocated construction costs.

- Pump station: There are existing irrigation ditches that will be impacted by the alignment of Alternatives 1, 3, and 12. This item would account for installation of a new pump, supporting structure, and penetration through the levee to ensure continued agricultural operations.
- Unallocated items in construction costs: Items include utility relocations, pipe relocations, and all other unknown site conditions at the time these cost estimates were prepared.
- Mobilization and demobilization: Includes activation of contractor's physical equipment, labor to the construction site, and the cleanup and removal of resources from the construction site.
- Environmental documentation, permitting, and mitigation: Includes all studies and report preparation necessary to complete an EIR/EIS. Also includes any mitigation activities that may be required for completion of the project.
- Design and engineering costs: Costs include 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: Broken out of permitting and cost items. Includes all Owner legal costs to implement the project.
- Engineering during construction: Cost includes engineering during construction activities including review of submittals, RFIs, bidder questions, changes, etc.
- Construction management: Cost includes management and oversight, including inspection and testing of the construction efforts.
- Right-of-way (ROW) acquisition: ROW quantities are based on GIS mapping of setback configurations and the area between the setback levee alignments and the existing levee alignments. Cross-levee areas were evaluated through an aerial photography review to determine the type of land being acquired. ROW would be purchased for the levee footprint and a 25-foot toe-access-corridor on the land and waterside.

C.3.2 Unit Costs Development

Unit costs are based primarily on the Central Valley Flood Protection Plan, Sacramento Basin-Wide Feasibility Study (BWFS), Appendix 1-D: Yolo Bypass Cost Estimates. All unit costs were escalated from June 2014 to December 2018 using the 20 cities average from the *Engineering News-Record* Construction Cost Index, which resulted in an escalation factor of 1.14. Major construction items, their units of measurement, cost, and a description of the selected unit costs are identified in Table 1. All values include materials, labor, placement, and delivery to site. Any values different from what was used in the BWFS are indicated in the description.

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: Cross-Levee Unit Costs

Construction Activity Description	Unit	Unit Cost	Notes
Clearing and Grubbing	AC	\$6,458.09	
Stripping	CY	\$9.97	
Proof Compacting	AC	\$1,382.62	
Select Levee Fill (New Levee Construction)	CY	\$25.00	Cost is based on estimates from recent projects along Knights Landing Ridgecut.
Aggregate Base	CY	\$90.41	
Electrical Overhead Line Relocation (12 kV)	LF	\$59.26	
Hydroseeding	AC	\$3,871	
Drain Layers (Geotextile, Filter Sand, Drain Aggregate)	CY	\$77.50	
Seepage Berm Fill	CY	\$6.32	
Pump Station/Culvert crossing	EA	\$570,667	Cost includes the demolition of the pump station, installation of a new pump, supporting structure, and penetration through the levee.
Road 116 ramp over cross-levee	EA	\$350,000	Estimated based on 18' height levee at 10% grade, and the above unit costs.
Other Construction Costs*			
Unallocated Items in Construction costs		15.0%	
Mobilization and Demobilization		5.0%	
Other Owner Costs**			
Environmental Documentation and Permitting		20.0%	Not included in BWFS; BWFS identifies specific environmental improvements instead of a percentage of construction costs.
Design and Engineering Costs		15.00%	
Legal Costs		2.00%	
Engineering during Construction		2.00%	
Construction Management		15.00%	
Real Estate Capital Outlay and Acquisition Costs			
Permanent Right-of-Way (Fee Title)-Agricultural	AC	\$35,000	Estimate for the agricultural area around Knights Landing. Cost is only for ROW acquisition and doesn't include purchase of full parcels.

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

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

C.3.3 Levee Design

Levee prism geometry was assumed to meet the updated minimum non-urban levee dimensions currently under review by the *Central Valley Flood Protection Board*, identified in Table 2 below. These standards are also consistent with the Sacramento District USACE Geotechnical Levee Practice (2008) guidance.

The proposed levees in Alternative 1 protecting the Knights Landing treatment ponds are not constructed to the same standards as the cross-levee protecting the community of Knights Landing as they do not protect lives in the event of a levee breach. The levee dimensions for these levees are identified in Table 3.

Levee heights vary between locations and levee crown elevations were established to meet freeboard requirements (three feet) above the 100-year water surface elevation (WSE). WSE was developed through 2-D modeling of the Knights Landing basin with each of the cross-levee alignments taken into account. Additional information on the hydraulic analysis can be found in Appendix A. The designs WSE for each of the cross-levee alignments are listed in Table 4.

Table 2: Cross-Levee Minimum Geometry Dimensions

Crown Width	12'
Landside Slope	3:1
Waterside Slope	3:1
Freeboard	3'
Levee Patrol Road Width	10'

Table 3: Treatment Pond Levee Geometry Dimensions

Crown Width	12'
Landside Slope	2:1
Waterside Slope	2:1
Freeboard	1.5'
Levee Patrol Road Width	10'

Table 4: Cross-Levee 100-Year WSE

Alternative	Design WSE (NAVD 88)	Levee Elevation (NAVD 88)
1	42.5	45.5
3 & 12	41.8	44.8
6	41.5	44.5

Existing ground surface elevations along the cross-levee alignments were calculated using topography developed from the Department of Water Resources, Central Valley Floodplain Evaluation and Delineation Program. An average ground surface elevation was calculated every 100 ft for Alternatives 1, 3, 12, and 13 and every 50 ft for Alternative 6. The profile of existing ground elevations along each alignment is shown in Figure 7. Levee heights vary depending on the alternative. Levee heights for Alternative 1 average 15.5 ft tall and range from 12 ft to 17 ft. Levee heights for Alternatives 3 and 12 average 18.9 ft and range from 15 to 21 ft. Levee heights for Alternative 6 average 17.4 ft and range from 15 ft to 24 ft. Table 5 shows the minimum, average, and maximum heights of the cross-levee for Alternatives 1, 3, 6, 12, and 13.

Table 5: Minimum, Average and Maximum Height of Cross-Levees

Alternative	Minimum (ft)	Average (ft)	Maximum (ft)
1 & 13	12	15.5	17
3 & 12	15	18.9	21
6	15	17.4	24

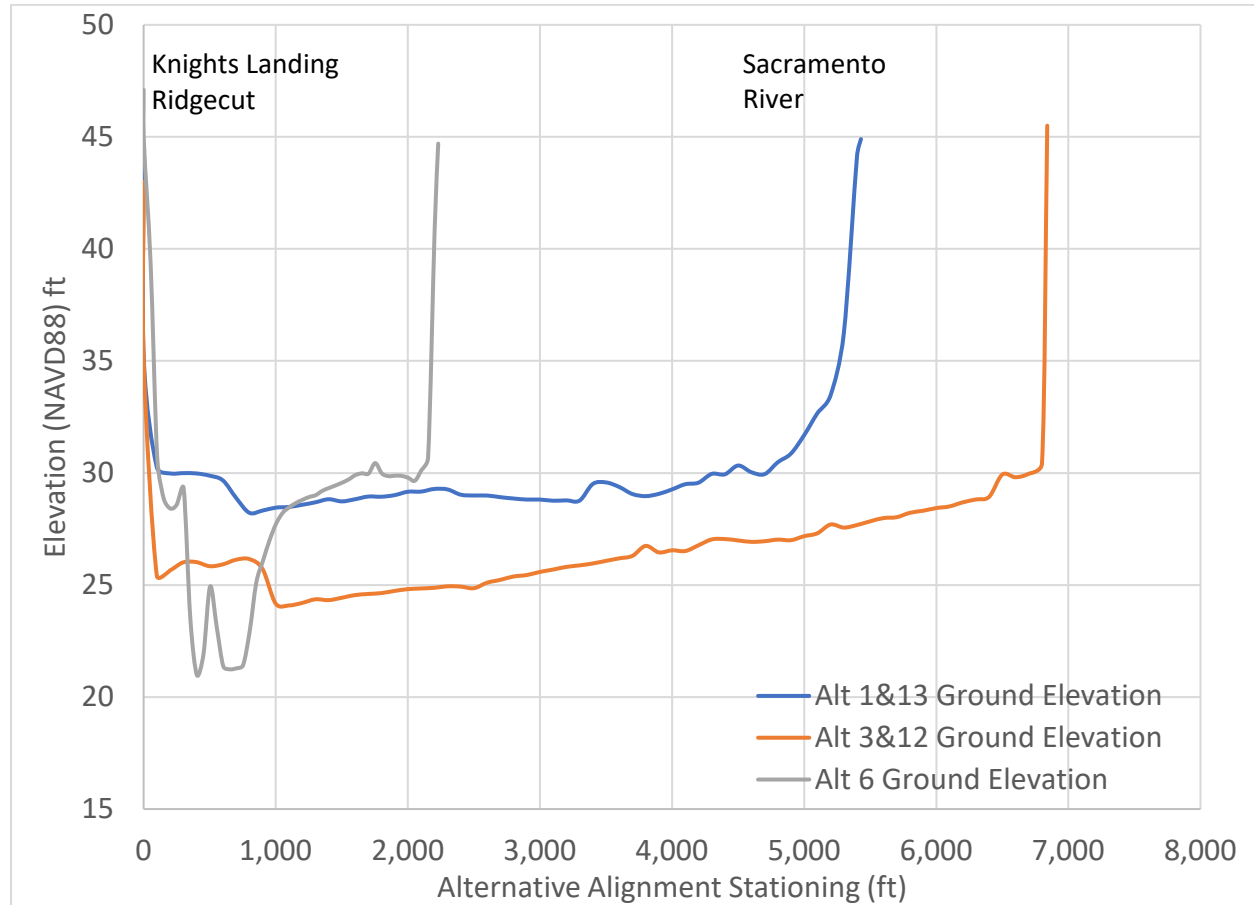


Figure 7: Cross-Levee Alignment Existing Ground Elevations

The levee elevations at the Ridgecut levee and the Sacramento River levee tie-in to the cross levees were reviewed for differences in elevation due to being on different ends of the basin. Table 6 shows the levee elevations at each of the tie-in locations for each of the cross-levee alternatives. Alternatives 1, 13, 3, and 12 have one or more tie-in elevations where the existing levee is lower than the cross-levee design elevation. During construction, the cross-levee crown would extend across the crown width of the existing levee and a small ramp would be constructed within the existing levee crown to allow access over the slightly higher elevation. This is not taken into account in this analysis due to the relatively small volumes required but should be taken into account in further design efforts.

Table 6: Levee Tie-In Elevations for Alternatives

Location	Levee Elevation (NAVD 88)		
	1 & 13	3 & 12	6
Sacramento Levee	44.9	45.5	47.1

Ridgecut Levee	44.1	43	44.7
Design Levee Elevation	45.5	44.8	44.5

C.3.4 Cross-Levee Seepage Berms

Potential seepage remediations were analyzed by reviewing geotechnical borings along the Alternative 3 alignment. The bottom of the aquifer was not found within 65 feet of the ground surface, and so it was assumed that a drained seepage berm would be a more viable option for the cross levees. Utilizing guidance from NULE for seepage berms, a design of five times the levee height, two-foot drain layer, and between three and five feet of berm fill were assumed for the cross-levees. No site-specific information was available for Alternatives 1 and 6 so it is assumed that a seepage berm is required along the entire length. Based on investigations along alignment 3 and 12 it was determined that a seepage berm would be required along the northern 3,300 ft of cross-levee. The seepage berm requirements are summarized in Table 7.

Table 7: Seepage Berm Dimensions

	Width of seepage berm (ft)	Length of levee with berm (ft)
Alternative 1 & 13	75	5,430
Alternative 3 & 12	95	3,340
Alternative 6	90	2,203

C.3.5 Cross-Levee Cost Summary

Utilizing the standard levee design, construction quantities were calculated based on the existing ground elevations for each of the segments and were summed up 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 each alternative. Cost summaries for each of the cross-levee alternatives are included in Table 8 through Table 10.

Table 8: Alternatives 1 & 13 Cost Summary

Cost Basis Summary (Dec 2018 Costs)

Alternatives 1 & 13

Setback levee length = 5,430 ft, Average levee height = 15.5 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	19	\$6,458.09	\$125,908
<i>Stripping</i>	CY	21,400	\$9.97	\$213,435
<i>Proof Compacting</i>	AC	13	\$1,382.62	\$18,340
<i>Inspection Trench - Excavation</i>	CY	21,716	\$6.46	\$140,244
<i>Levee Embankment - Select Levee Fill</i>	CY	232,590	\$25.00	\$5,814,761
<i>Aggregate Base (Crown + LS Maint Rd)</i>	CY	2,212	\$90.41	\$199,977
<i>Hydroseeding</i>	AC	19	\$3,871.35	\$72,151
Seepage Berm				
<i>Clearing and Grubbing</i>	AC	9	\$6,458.09	\$60,378
<i>Stripping (1')</i>	CY	15,083	\$9.97	\$150,434
<i>Drain Layer (2' thick)</i>	CY	30,167	\$77.50	\$2,337,827
<i>Berm Fill</i>	CY	60,333	\$6.32	\$381,181
<i>Aggregate Base (12', 6" deep)</i>	CY	1,207	\$90.41	\$109,099
<i>Hydroseeding</i>	AC	9	\$3,871.35	\$36,194
New WTP Embankment				
<i>Clearing and Grubbing</i>	AC	11	\$6,458.09	\$71,639
<i>Stripping</i>	CY	13,823	\$9.97	\$137,859
<i>Proof Compacting</i>	AC	9	\$1,382.62	\$11,846
<i>Inspection Trench - Excavation</i>	CY	17,600	\$6.46	\$113,662
<i>Levee Embankment - Select Levee Fill</i>	CY	175,369	\$25.00	\$4,384,213
<i>Aggregate Base (Crown + LS Maint Rd)</i>	CY	1,793	\$90.41	\$162,074
<i>Hydroseeding</i>	AC	11	\$3,871.35	\$41,613
Utilities				
<i>12kv Utility Raise/Relocation</i>	LF	380	\$59.26	\$22,520
Other Items				
<i>Pump Stations</i>	EA	1	\$570,667	\$570,667
<i>Raise Road 116</i>	EA	1	\$350,000	\$350,000
Major Construction Items Subtotal =				\$15,530,000
Other Construction Costs*				
Unallocated Items in Construction Costs			15%	\$2,329,500
Mobilization and Demobilization			5%	\$776,500
Other Construction Costs Subtotal =				\$3,110,000
Construction Total =				\$18,640,000
Other Owner Costs**				
Environmental Documentation and Permitting			20%	\$3,728,000
Design and Engineering Costs			15%	\$2,796,000
Legal Costs			2%	\$372,800

Engineering during Construction			2%	\$372,800	
Construction Management			15%	\$2,796,000	
Other Owner Costs Subtotal =				\$10,070,000	
Right-of-Way					
<i>Permanent Right-of-Way (Fee Title)- Agricultural</i>	AC	40	\$35,000.00	\$1,397,840	
Total Project Baseline Cost =				\$30,110,000	
Expected Project Cost Accuracy Range is 0%/30%					
Expected Project Cost Range =			\$30,110,000	to	\$39,140,000

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

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

Table 9: Alternatives 3 & 12 Cost Summary

**Cost Basis Summary (Dec 2018 Costs)
Alternatives 3 & 12**

Setback levee length = 6,840 ft, Average levee height = 18.9 ft

<u>Item</u>	<u>Unit</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Cost</u>
New Levee				
Clearing and Grubbing	AC	28	\$6,458.09	\$178,258
Stripping	CY	31,867	\$9.97	\$317,826
Proof Compacting	AC	20	\$1,382.62	\$27,310
Inspection Trench - Excavation	CY	27,356	\$6.46	\$176,667
Levee Embankment - Select Levee Fill	CY	392,807	\$25.00	\$9,820,172
Aggregate Base (Crown + LS Maint Rd)	CY	2,786	\$90.41	\$251,915
Hydroseeding	AC	27	\$3,871.35	\$103,306
Seepage Berm				
Clearing and Grubbing	AC	7	\$6,458.09	\$47,042
Stripping (1')	CY	11,752	\$9.97	\$117,208
Drain Layer (2' thick)	CY	23,504	\$77.50	\$1,821,468
Berm Fill	CY	47,007	\$6.32	\$296,989
Aggregate Base (12', 6" deep)	CY	742	\$90.41	\$67,107
Hydroseeding	AC	7	\$3,871.35	\$28,200
Utilities				
12kv Utility Raise/Relocation	LF	380	\$59.26	\$22,520
Other Items				
Pump Stations	EA	1	\$570,667.16	\$570,667
Raise Road 116	EA	1	\$350,000.00	\$350,000
Major Construction Items Subtotal =				\$14,200,000
Other Construction Costs*				
Unallocated Items in Construction Costs			15.00%	\$2,130,000
Mobilization and Demobilization			5.00%	\$710,000
Other Construction Costs Subtotal =				\$2,840,000
Construction Total =				\$17,040,000
Other Owner Costs**				
Environmental Documentation and Permitting			20.00%	\$3,408,000
Design and Engineering Costs			15.00%	\$2,556,000
Legal Costs			2.00%	\$340,800
Engineering during Construction			2.00%	\$340,800
Construction Management			15.00%	\$2,556,000
Other Owner Costs Subtotal =				\$9,200,000
Right-of-Way				
Permanent Right-of-Way (Fee Title)- Agricultural	AC	35	\$35,000.00	\$1,221,029
Total Project Baseline Cost =				\$27,460,000
Expected Project Cost Accuracy Range is 0%/30%				
Expected Project Cost Range =		\$27,460,000	to	\$35,700,000

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

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

Table 10: Alternative 6 Cost Summary

Cost Basis Summary (Dec 2018 Costs)

Alternative 6

Setback levee length = 2,203 ft, Average levee height = 17.4 ft

<u>Item</u>	<u>Unit</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Cost</u>
New Levee				
Clearing and Grubbing	AC	8	\$6,458.09	\$54,402
Stripping	CY	9,511	\$9.97	\$94,857
Proof Compacting	AC	6	\$1,382.62	\$8,151
Inspection Trench - Excavation	CY	8,812	\$6.46	\$56,909
Levee Embankment - Select Levee Fill	CY	113,843	\$25.00	\$2,846,086
Aggregate Base (Crown + LS Maint Rd)	CY	898	\$90.41	\$81,148
Hydroseeding	AC	8	\$3,871.35	\$31,370
Seepage Berm				
Clearing and Grubbing	AC	5	\$6,458.09	\$29,395
Stripping (1')	CY	7,343	\$9.97	\$73,239
Drain Layer (2' thick)	CY	14,687	\$77.50	\$1,138,173
Berm Fill	CY	29,373	\$6.32	\$185,578
Aggregate Base (12', 6" deep)	CY	490	\$90.41	\$44,262
Hydroseeding	AC	5	\$3,871.35	\$17,621
Utilities				
12kv Utility Raise/Relocation	LF	0	\$59.26	\$0
Other Items				
Pump Stations	EA	0	\$570,667	\$0
Raise Road 116	EA	0	\$350,000	\$0
Major Construction Items Subtotal =				\$4,660,000
Other Construction Costs*				
Unallocated Items in Construction Costs			15%	\$699,000
Mobilization and Demobilization			5%	\$233,000
Other Construction Costs Subtotal =				\$930,000
Construction Total =				\$5,590,000
Other Owner Costs**				
Environmental Documentation and Permitting			20%	\$1,118,000.00
Design and Engineering Costs			15%	\$838,500
Legal Costs			2%	\$111,800
Engineering during Construction			2%	\$111,800
Construction Management			15%	\$838,500
Other Owner Costs Subtotal =				\$3,020,000
Right-of-Way				
Permanent Right-of-Way (Fee Title)-Agricultural	AC	13.0	\$35,000	\$454,142
Total Project Baseline Cost =				\$9,060,000
Expected Project Cost Accuracy Range is 0%/30%				
Expected Project Cost Range =		\$9,060,000	to	\$11,780,000

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

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

C.4 Levee Improvements for Existing Levees

The methodology utilized to estimate the costs to address existing issues on the outer levees protecting Knights Landing is outlined in Appendix B. The approach used to estimate the costs for fix-in-place improvements using information from the Non-Urban Levee Evaluation is not repeated in this Appendix, but the summary tables are included for completeness of the cost estimates.

Table 11: Other Levee Improvement Cost Summary

Knights Landing Fix-In-Place Cost Estimates

Cost Basis Summary (Dec 2018 Costs)

2/26/2019 DRAFT

Alt.	NULE Phase 2 Study Extents ¹			Additional Levee Extents - NULE Phase 1 Study Only ²			Fix-In-Place Total
	NULE GOR Reaches in Alternative ³	Remediations Include	Total Fix-In-Place Repair Cost ⁴	Length not included in NULE Phase 2 Extents	Remediations Include	Total Fix-In-Place Repair Cost ^{4, 5}	
1	C, D, E, F, portion (240 ft) of B	Drained Stability Berm, Cutoff Wall, and Freeboard Repair	\$9,840,000	4,825 ft of Knights Landing Ridge Cut Left Bank	Drained Stability Berm and Erosion Repair	\$12,480,000	\$22,300,000
3	B, C, D, E, F, portion (290 ft) of A	Combination Seepage-Stability Berm, Ditch Fill, Drained Stability Berm, Cutoff Wall, and Freeboard Repair	\$11,890,000	4,825 ft of Knights Landing Ridge Cut Left Bank	Drained Stability Berm, Combination Seepage-Stability Berm, Erosion Repair, and Freeboard/Geometry Repair	\$12,480,000	\$24,400,000
6	A, B, C, D, E, F	Combination Seepage-Stability Berm, Ditch Fill, Drained Stability Berm, Cutoff Wall, and Freeboard Repair	\$16,580,000	14,415 ft of Knights Landing Ridge Cut Left Bank 18,840 ft of Sacramento River Right Bank	Drained Stability Berm, Combination Seepage-Stability Berm, Erosion Repair, and Freeboard/Geometry Repair	\$79,160,000	\$95,700,000
11	A, B, C, D, E, F	Combination Seepage-Stability Berm, Ditch Fill, Drained Stability Berm, Cutoff Wall, and Freeboard Repair	\$16,580,000	30,515 ft of Knights Landing Ridge Cut Left Bank 25,875 ft of Sacramento River Right Bank 13,805 ft along Yolo Bypass Right Bank	Drained Stability Berm, Combination Seepage-Stability Berm, Erosion Repair, and Freeboard/Geometry Repair	\$156,150,000	\$172,700,000
12	B, C, D, E, F, portion (290 ft) of B	Combination Seepage-Stability Berm, Ditch Fill, Drained Stability Berm, Cutoff Wall, and Freeboard Repair	\$11,890,000	4,825 ft of Knights Landing Ridge Cut Left Bank	Drained Stability Berm, Combination Seepage-Stability Berm, Erosion Repair, and Freeboard/Geometry Repair	\$12,480,000	\$24,400,000

Notes:

Cost estimates include fix-in-place remediation costs for freeboard, geometry, erosion, and seepage and stability repairs as identified in the cited studies. Freeboard repair estimates approximately updated for 100-year WSE profile prepared by MBK. For Knights Landing Ridge Cut no freeboard deficiencies for 100-year WSE. For the Sacramento River levee and Yolo Bypass levee approximately twice the length deficient for 100-year WSE compared to 55/57 Design WSE used by NULE.

1 - For NULE Phase 2 Study Extents, fix-in-place costs based on conceptual remedial alternatives and cost estimates presented in the DWR Geotechnical Overview (GOR) Volume 2, Remedial Alternatives, Knights Landing Study Area, September 2014.

2 - For additional levee extents where only NULE Phase 1 Study completed (not Phase 2 or a Mid-Valley Site included in Alternative), fix-in-place costs based on conceptual remedial alternatives and cost estimates presented in the DWR Remedial Alternatives and Cost Estimates Report (RACER), North NULE Study Area, August 2011. Exception: For stability repair on the Knights Landing Ridge Cut repairs similar in design and costs to the improvements recently constructed by the Knights Landing Drainage District were assumed.

3 - NULE Phase 2 GOR includes no remediations for Reach D, no contribution to Fix-In-Place repair costs.

4 - Estimates are escalated to 2018 dollars using the 20 cities average from the Engineering News-Record Construction Cost Index. Rounded to the nearest \$10,000.

5 - For Knights Landing Ridge Cut, costs for Drained Stability Berm identified by the NULE Phase 1 effort removed along the extents where the Knights Landing Drainage District recently constructed a spoils berm along with landside slope flattening and ditch relocation (where applicable).

6 - Mid-Valley Site cost estimate utilizes approximation of USACE designs and BWFS assumptions for unit costs. Site 11 replaces a 110' cut off wall from USACE with a seepage berm.

C.5 Mid-Valley Sites Levee Improvements

As discussed in the Feasibility Study, USACE performed a geotechnical study to determine the potential geotechnical recommendations for levee repairs in the Sacramento Valley, which included three sites along the Sacramento River, southeast of Knights Landing. Although USACE completed a detailed geotechnical alternatives analysis and developed final design drawings, the cost estimates for these repairs were not made available for the purposes of this Feasibility Study. To develop a cost estimate for these repair sites, unit cost assumptions used in the cross-levee cost estimate were utilized as applicable.

C.5.1 Cost Development

Similar to the methodology for the cross-levees, a cost estimate was developed for each of the Mid-Valley sites by applying unit costs to quantities based upon conceptual designs. Unit costs were established for construction items included within the conceptual designs. Capital costs are the same as the cross-levee estimate. To accommodate the uncertainty of the estimates, and in line with industry standards, an additional estimating contingency of 30 percent has been included to provide a cost estimate range.

Construction activities include many of the same activities as the cross-levee estimate, but also include the following activities:

- Remove existing AB: Cost includes removal and disposal of AB surfacing.
- Remove existing AC: Cost includes removal and disposal of AC.
- Levee Excavation: Mass excavation is assumed to be performed in bulk by large soil moving equipment (e.g. dozers, scrapers, loaders, etc.). Cost includes excavation of material and does not include disposal.
- Soil Bentonite Cutoff Wall <40ft: Cost includes excavation, preparation of slurry, placement, and curing efforts for cutoff wall.
- Rebuild Levee Geometry: Placement is limited due to access issues; therefore, the cost is higher per unit than cross-levee construction. Cost includes import of material, preparation of the area to receive fill, placement of the fill to the appropriate loose thickness, and compaction of the fill.
- AC Paving: Cost includes the placement and compaction of AC with an assumed finished thickness of 4 inches.

C.5.2 Unit Costs Development

Unit costs development for the Mid-Valley Sites follows the same methodology as that used in the cross-levees. Unit costs not included in the cross-levee section or that differ from those previously used are included in Table 12.

Table 12: Mid-Valley Site Unit Costs

Construction Activity Description	Unit	Unit Cost	Notes
Remove existing AB	CY	\$3.42	
Remove existing AC	SY	\$5.71	
Levee Excavation	CY	\$6.46	
SB Cutoff Wall <40ft	SF	\$6.85	
Rebuild Levee Geometry	CY	\$32.29	
AC Paving	SY	\$40.04	

C.5.3 Levee Improvement Design

The USACE recommended repair from the 2012 design document for sites 9, 10, and 11 includes a cutoff wall at each site. Site 9, 10, and the southern 3,157 feet of site 11 all have relatively shallow clay layers for the cutoff wall to tie into, but the northern 2,400 feet of site 11 does not have an applicable clay layer to tie into. The USACE recommended repair for this location includes a 110 foot “hanging” cutoff wall which does not tie into a clay layer. The typical cutoff wall design is included in Figure 8.

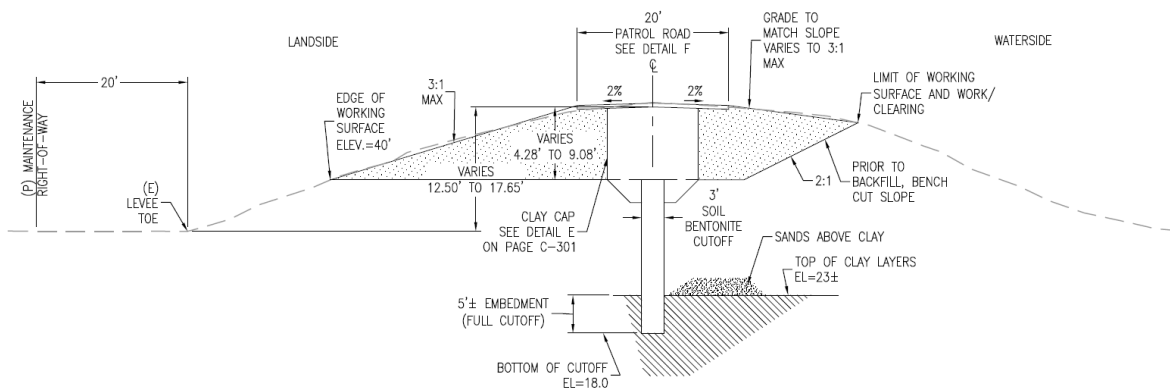


Figure 8: Typical USACE Cutoff Wall Cross-Section Mid-Valley Sites

The 2012 USACE geotechnical study of the Mid-Valley Sites also designed seepage berms to address existing seepage problems. A typical cross-section is shown in Figure 9. Due to the high costs of cutoff walls deeper than 80 feet, it was decided that a seepage berm would be included as an option for Mid-Valley Site 11 for the portion that includes deep cutoff walls.

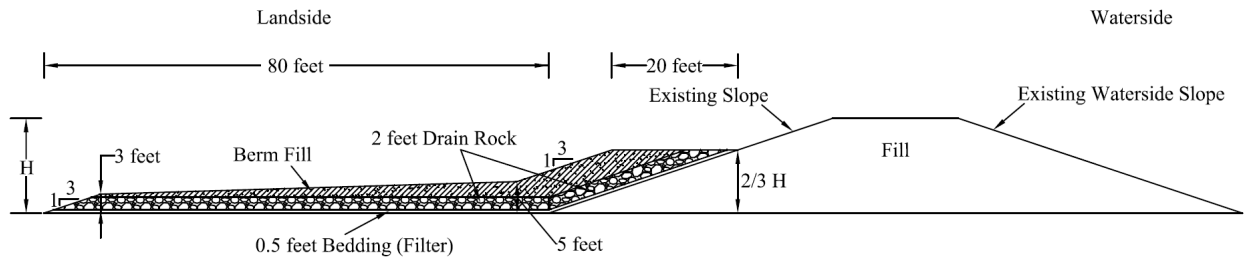


Figure 9: Typical USACE Seepage Berm Cross-Section Mid-Valley Sites

Table 13 provides the summary of Mid-Valley Sites 9, 10, and 11 cost estimates.

C.5.4 Mid-Valley Sites Cost Summary

Utilizing the standard levee design, construction quantities were calculated based on the existing ground elevations for each of the segments and were summed up 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 each alternative. Cost summaries for each of the cross-levee alternatives are included in Tables 8 through Table 10.

Table 13: Mid-Valley Site Cost Summary

Cost Basis Summary (Dec 2018 Costs)

3/14/2019

<u>Construction Item</u>	<u>Unit</u>	<u>Unit Cost</u>	<u>Site 9</u>		<u>Site 10</u>		<u>Site 11</u>	
			<u>Quantity</u>	<u>Cost</u>	<u>Quantity</u>	<u>Cost</u>	<u>Quantity</u>	<u>Cost</u>
Levee Repair								
Remove Existing AB	CY	\$3.42	294	\$1,006	325	\$1,113	1,704	\$5,833
Remove Existing AC	SY	\$5.71					4,600	\$26,251
Levee Excavation	CY	\$6.46	8,434	\$54,468	6,865	\$44,333	19,817	\$127,978
Inspection Trench - Excavation	CY	\$6.46	1,057	\$6,828	1,171	\$7,560	3,067	\$19,805
Backfill Trench	CY	\$32.29	1,057	\$34,143	1,171	\$37,803	3,067	\$99,027
SB Cutoff Wall <40ft	SF	\$6.85	17,446	\$119,470	16,682	\$114,238	43,700	\$299,258
Seepage Berm								\$1,766,937
Clay Cap	CY	\$32.29	0	\$0	0	\$0	0	\$0
Rebuild Levee Geometry	CY	\$32.29	8,434	\$272,349	6,865	\$221,671	19,817	\$639,911
Aggregate Base	CY	\$90.41	470	\$42,488	520	\$47,042	2,215	\$200,249
AC Paving	SY	\$40.04					4,600	\$184,185
Hydroseeding	AC	\$3,871	1.3	\$4,925	1.2	\$4,695	3.1	\$11,938
Major Construction Items								
Subtotal =				\$540,000		\$480,000		\$3,380,000
Other Construction Costs**								
Unallocated Items in Construction Costs		15%		\$81,000		\$72,000		\$507,000
Mobilization and Demobilization		5%		\$27,000		\$24,000		\$169,000
Other Construction Costs								
Subtotal =				\$108,000		\$96,000		\$676,000
Construction Total =				\$648,000		\$576,000		\$4,056,000
Other Owner Costs***								
Environmental Documentation and Permitting		35%		\$226,800		\$201,600		\$1,419,600
Design and Engineering Costs		15%		\$97,200		\$86,400		\$608,400
Legal Costs		2%		\$12,960		\$11,520		\$81,120
Engineering during Construction		2%		\$12,960		\$11,520		\$81,120
Construction Management		15%		\$97,200		\$86,400		\$608,400
Other Owner Costs Subtotal =				\$447,120		\$397,440		\$2,798,640
Right-of-Way								
<i>Permanent Right-of-Way (Fee Title)- Agricultural</i>	AC	\$35,000	0.4	\$12,743	0.4	\$14,109	7.0	\$244,831
Total Site Baseline Cost =				\$1,100,000		\$1,000,000		\$7,100,000
Contingency of 30%								
Expected Project Cost =				\$1,400,000		\$1,300,000		\$9,200,000

NOTES:

Design for sites 9 & 10 estimated based on USACE design in SRFCP Mid-Valley Area Phase III Area 3, Sites 9, 10, & 11: 11/28/12

Site 11 estimated based on above reference for shallow cutoff wall. Site 11 design had very deep cutoff walls (110'). Estimate for this area used seepage berm identified in Appendix B - Geotechnical Design Report.

All unit costs are consistent with the cross-levee cost estimates.

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

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

C.6 Cost Summary

Cost estimates for the elements for each of the Alternatives are summarized in Table 14. Each of the estimates includes a 30% contingency. The estimates for the 6 Alternatives range between \$60.1 million to \$220.4 million.

Table 14: Knights Landing Capital Cost Summary

**Knights Landing Small Community Flood Risk Reduction Alternatives Cost Estimate
Cost Basis Summary (Dec 2018 Costs)**

Alternative	NULE Phase 2 Study Extents ¹	Additional Levee Extents - NULE Phase 1 Study Only ²	USACE Mid-Valley Sites 9,10,11 ³	Fix-In-Place Total	Cross Levee Estimate ⁴	Total Feasibility-level Estimate
1	\$9,800,000	\$12,500,000	\$0	\$22,300,000	\$39,140,000	\$61,440,000
3	\$11,900,000	\$12,500,000	\$0	\$24,400,000	\$35,700,000	\$60,100,000
6	\$16,600,000	\$79,200,000	\$11,900,000	\$107,700,000	\$11,780,000	\$119,480,000
11	\$16,600,000	\$156,200,000	\$11,900,000	\$184,700,000	\$35,700,000	\$220,400,000
12	\$11,900,000	\$12,500,000	\$11,900,000	\$36,300,000	\$35,700,000	\$72,000,000
13	\$9,800,000	\$12,500,000	\$11,900,000	\$34,200,000	\$39,140,000	\$73,340,000

Notes:

All estimates include a 30% contingency on the baseline cost estimates

All estimates are escalated to 2018 dollars using the 20 cities average from the Engineering News-Record Construction Cost Index. Rounded to the nearest \$100,000.

1 - Fix-in-place costs based on conceptual remedial alternatives and cost estimates presented in the DWR Geotechnical Overview (GOR) Volume 2, Remedial Alternatives, Knights Landing Study Area, September 2014. Freeboard repair estimates removed for Knights Landing Ridge Cut as no freeboard deficiencies identified for the 100-year WSE.

2 - Levee extents where only NULE Phase 1 Study completed (not Phase 2 or a Mid-Valley Site included in Alternative), fix-in-place costs based on conceptual remedial alternatives and cost estimates presented in the DWR Remedial Alternatives and Cost Estimates Report (RACER), North NULE Study Area, August 2011. Freeboard repair estimates approximately updated for 100-year WSE profile prepared by MBK. For Segment 217 (Ridge Cut) no freeboard deficiencies for 100-year WSE. For Segments 162 (Sacramento River Levee) and 172 (Yolo Bypass) approximately twice the length deficient for 100-year WSE compared to 55/57 Design WSE used by NULE. Additionally, for Knights Landing Ridge Cut, costs for Drained Stability Berm identified by the NULE Phase 1 effort removed along the extents where the Knights Landing Drainage District recently constructed a spoils berm along with landside slope flattening and ditch relocation (where applicable).

3 - MVS utilizes approximation of USACE designs and BWFS assumptions for unit costs. Site 11 replaces a 110' cut off wall from USACE with a seepage berm.

4 - includes an estimate for seepage berms

C.7 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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- USACE. 1995. *Design Memorandum, Sacramento River Flood Control Project, California, Mid-Valley Area, Phase III. Volume I of II*. August.