Community of Yolo
Small Community Flood Risk Reduction Feasibility Study

Appendix B Yolo Geotechnical Assessment

Draft April 2019

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Acronyms and Abbreviations

CVFPP	Central Valley Flood Protection Plan
cfs	cubic feet per second
CPT	Cone Penetration Test
DWR	California Department of Water Resources
GAR	Geotechnical Assessment Report
Hchy	late Holocene channel deposits

Hfy	late Holocene fan deposits
LM	Levee Mile
NULE	Non-Urban Levee Evaluation
Rdc	Historic distributary channel deposits
Rob	Historic overbank deposits
SPFC	State Plan of Flood Control
ULE	Urban Levee Evaluation
URS	URS Corporation
USACE	United States Army Corps of Engineers
WSE	water surface elevation

B.1 Introduction

B.1.1 Purpose

The purpose of this appendix is to describe the geotechnical assessment for the levee repair structural alternatives identified in the Community of Yolo Small Community Flood Risk Reduction Feasibility Study (Feasibility Study). As discussed in the Feasibility Study, six structural alternatives were initially evaluated and screened down to a final array of three alternatives identified as (1) Restore Left Bank of Cache Creek to United States Army Corps of Engineers (USACE) 1957 Design Profile; (2) Levee Improvements for Left Bank of Cache Creek to Pass 100-year Flow; and (3) Restore Left Bank of Cache Creek to USACE 1957 Design Profile and Levee Improvements to pass 100-year Flow. These structural alternatives focus on repairs and improvements to 2,550 feet (approximately 0.5-mile) of Cache Creek left bank levee adjacent to the community of Yolo. This geotechnical assessment considered the existing conditions of this levee extent. An understanding of the existing levee and foundation conditions is essential to identify conceptual remedial levee improvements and facilitate comparative cost assessment for the final array of structural alternatives considered in this Feasibility Study.

B.1.2 Background

The town of Yolo is located approximately 5 miles northwest of the City of Woodland, California. As shown in Figure 1, the community is situated along County Road 99W and the Union Pacific Railroad, south of County Road 17 and Washington Street, west of Cache Creek and County Road 98, and north of County Road 97B and Interstate 5. The community is protected from high water in Cache Creek by the Cache Creek left bank levee, a State Plan of Flood Control (SPFC) levee. Even though the study area for the Feasibility Study encompasses a large area outside the community of Yolo, the Feasibility Study and therefore this geotechnical evaluation focused primarily on the flood risk reduction efforts for the community of Yolo.

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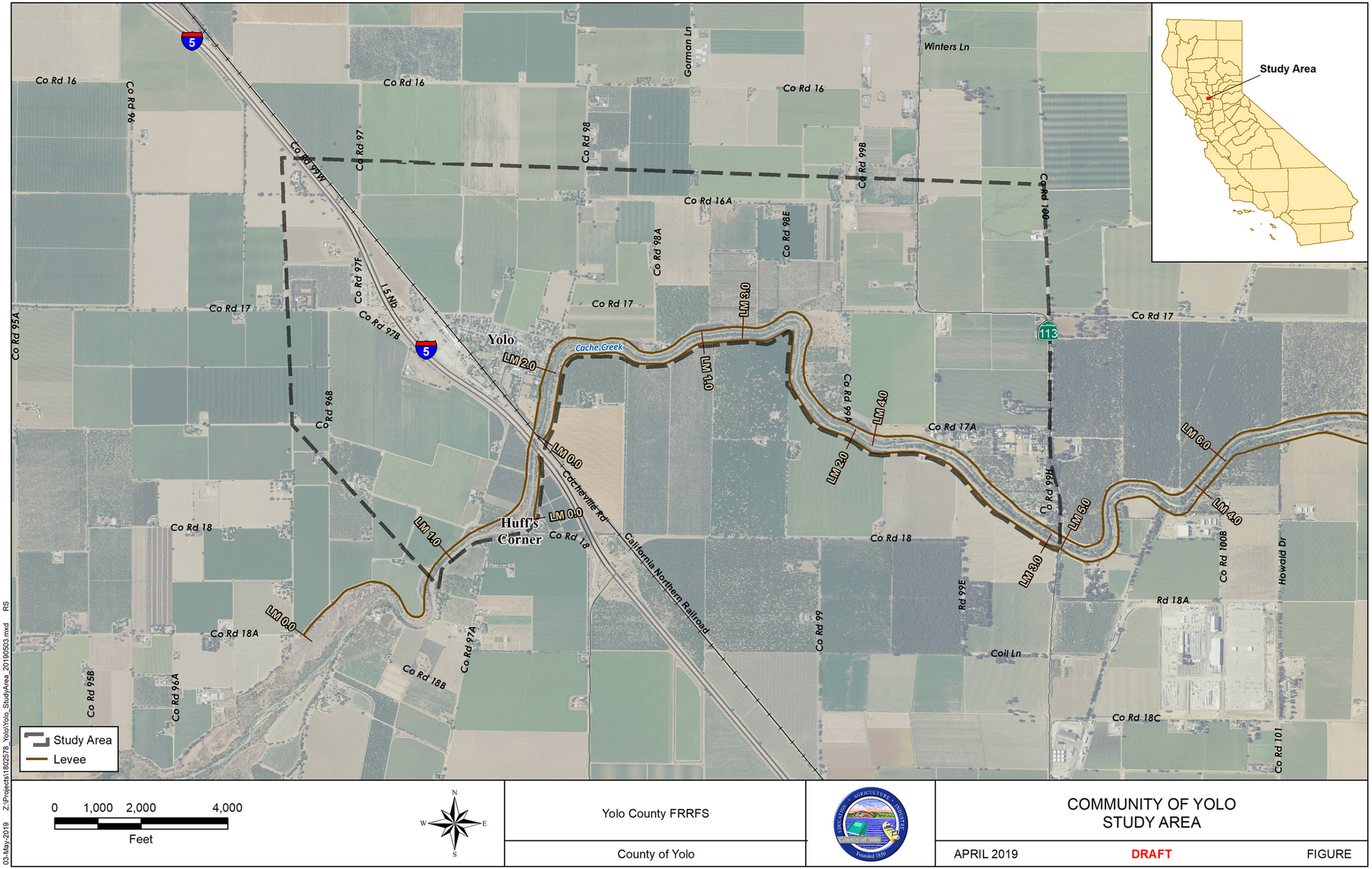

Figure B-1. Community of Yolo Study Area

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B.2 Existing Levee Information

An important component of comparing structural alternatives considered for flood risk reduction in the Feasibility Study is understanding the improvement needs for the existing levees included in the alternatives. Based on the levee improvements identified, costs can be estimated for comparative assessment of the alternatives. Data collected in existing levee evaluation studies and remediation projects were utilized to evaluate the geotechnical conditions of the existing levees adjacent to the community of Yolo.

B.2.1 Existing Levee Assessment: DWR Non-Urban Levee Evaluation

The California Department of Water Resources (DWR) Non-Urban Levee Evaluation (NULE) project included the levees protecting the community of Yolo. The NULE project was completed in two phases but the Cache Creek left (north) bank levee was only included in NULE Phase 1 which was based on desktop studies and readily available data. No subsurface explorations were completed as a part of the NULE Phase 1 study. Assessment data such as historical reports, site interviews with representatives from local agencies (such as levee maintenance personnel or reclamation district representatives), construction records, levee performance records, and other data provided by relevant agencies was collected and reviewed for the study. Geomorphic studies and topographical surveys were also performed.

The collection of information was used to characterize the existing condition of the non-urban levees in the NULE Geotechnical Assessment Report (GAR). The NULE GAR assessment was performed at a single water surface elevation (WSE). For this area the assessment WSE 1957 design WSE profile. Each segment assessed was assigned a hazard category for four geotechnical failure mechanisms: underseepage, slope stability, through seepage, and erosion. The hazard categories assigned for each of these four failure mechanisms were then evaluated collectively to assign an overall hazard level to each segment.

Phase 1 assessments were discretized based on levee segments (typically, levee maintenance units). The levees protecting the community of Yolo are part of a NULE segment that included 11.7 miles of Cache Creek left bank levee. The NULE GAR assessment found this NULE segment to have a high likelihood of levee failure or need to flood-fight to prevent levee failure at the 1957 design WSE profile for potential vulnerability to underseepage, through seepage, and erosion. The NULE Phase 1 study identified the full 11.7-mile segment length for remediations including, waterside rock slope protection to address erosion and a cutoff wall or seepage-stability combination berm to address underseepage and through seepage. The study also identified approximately 70% of the segment as not providing the required three-feet of freeboard above the 1957 design WSE. In many stretches the levee crest is below the 1957 design WSE.

Since the NULE study assessed a larger segment of the Cache Creek left bank than is the focus of this feasibility study, further assessment was warranted to confirm the existing levee conditions for the levee adjacent to the community of Yolo. The follow sections discuss the levee conditions information available in more detail.

B.2.2 Levee Construction History

The Cache Creek levees upstream of the Cache Creek Settling Basin were originally constructed by USACE in 1943 from the mouth of the Cache Creek Settling Basin to the town of Yolo, providing a flow capacity of 20,000 cubic feet per second (cfs). In 1961, the levees along Cache Creek were enlarged to provide a capacity of 30,000 cfs and extended about 3 miles upstream of the town of Yolo (URS, 2014).

B.2.3 Levee Geometry and Freeboard

Topography is available for the community of Yolo study area from DWR's Central Valley Floodplain Evaluation and Delineation (CVFED) LiDAR collected between October 2008 and February 2009. Based on this CVFED LiDAR, levee heights adjacent to the community of Yolo vary approximately 4.5 to 7.5 feet above the landside levee toe. Higher ground is present along the upstream end of the levee, near the railroad and road embankments that run roughly perpendicular to the levee. The crest width is approximately 11 to 14 feet. The landside levee slopes vary from approximately 2H:1V to 3.6H:1V and the waterside levee slopes vary from approximately 2.4H:1V to 4.3H:1V.

The WSEs considered for the Feasibility Study are the 1957 design WSE profile and 100-year flow WSE. Information on the these WSEs is provided in the Feasibility Study Report.

Comparing the existing levee elevations from CVFED LiDAR to the 1957 design WSE profile, the levees adjacent to the community of Yolo are up to one foot below the 1957 design WSE profile in some locations and short of the required three feet of freeboard by three to four feet throughout the levee extent. Due to these freeboard deficiencies, the levees also do not meet their levee prism requirements as minor tributary for a 12-foot crest width at three feet above the WSE, 3H:1V waterside slopes, and 2H:1V landside slopes.

Comparing the existing levee elevations from CVFED LiDAR to the 100-year flow WSE, the levees adjacent to the community of Yolo are above the 100-year flow WSE but are short of the required three feet of freeboard by approximately 1.5 to 2.8 feet. Due to these freeboard deficiencies, the levees also do not meet their levee prism requirements as minor tributary for a 12-foot crest width at three feet above the WSE, 3H:1V waterside slopes, and 2H:1V landside slopes.

B.2.4 Past Levee Performance

The Cache Creek left bank levee near the community of Yolo has experienced reoccurring erosion, numerous boils, and overtopping during past high-water events. Past performance records indicate that erosion has occurred along both the levee slopes and the channel bank. Cache Creek is considered incised near the community of Yolo with deep and steep waterside slopes. Based on past performance, DWR's Flood System Repair Project (FSRP) identified critical and serious past levee performance problem sites along non-urban SPFC levees. Along the Cache Creek left bank levee, the FSRP identified 4 critical erosion sites, including one less than 0.5 miles east of the Yolo community, at approximately LM 2.56. DWR has since constructed a setback levee to address erosion in this location.

Boils have been observed upstream and downstream of Yolo and records report them on the landside slope of the levee and beyond the levee toe, indicating the occurrence of both underseepage and levee through seepage. In several cases, boils have been documented to have had sand bag rings put around them until the flow from the boil stabilized. Some of the levee through seepage occurrences have been attributed to rodent holes/burrows. The Cache creek levees have also experienced overtopping and near overtopping both upstream and downstream of the community.

B.2.5 Geomorphic Setting

The Cache Creek left bank levee was included in the geomorphologic mapping of the DWR Urban Levee Evaluation (ULE) project's Woodland Study Area. An excerpt of this mapping is shown in Figure B-2. As seen in the figure, the levee adjacent to the community of Yolo and much of the upstream and downstream Cache Creek left bank levee is mapped predominantly over late Holocene fan deposits (Hfy). Hfy deposits are typically coarse-grained in nature, since they are deposited under high energy environments and likely consist of poorly sorted sand, silt, and clay deposited by distributary channels on the alluvial fan. The technical memorandum prepared for the geomorphic assessment states, "fan deposits often exhibit prominent natural levees revealed by the topographic contours that form long, sinuous ridges following distributary fan channels. Relatively coarser sediments are expected to underlie portions of the fan surface between these levees and distributary channels (URS, 2013)." A late Holocene channel deposit (Hchy) is mapped beneath the levee and the community approximately halfway through Yolo and likely to be composed of well sorted sands, trace fine gravel, silt, and lesser clay. A historic distributary channel deposit (Rdc) is also mapped just upstream of Yolo. Approximately 0.2 miles upstream from the edge of the community an area of historical overbank deposits (Rob) are mapped. The Rob deposits likely consist of sand, silt, and clay deposited during high-stage water flow overtopping the channel banks. The location mapped is consistent with a location of reported past overtopping.

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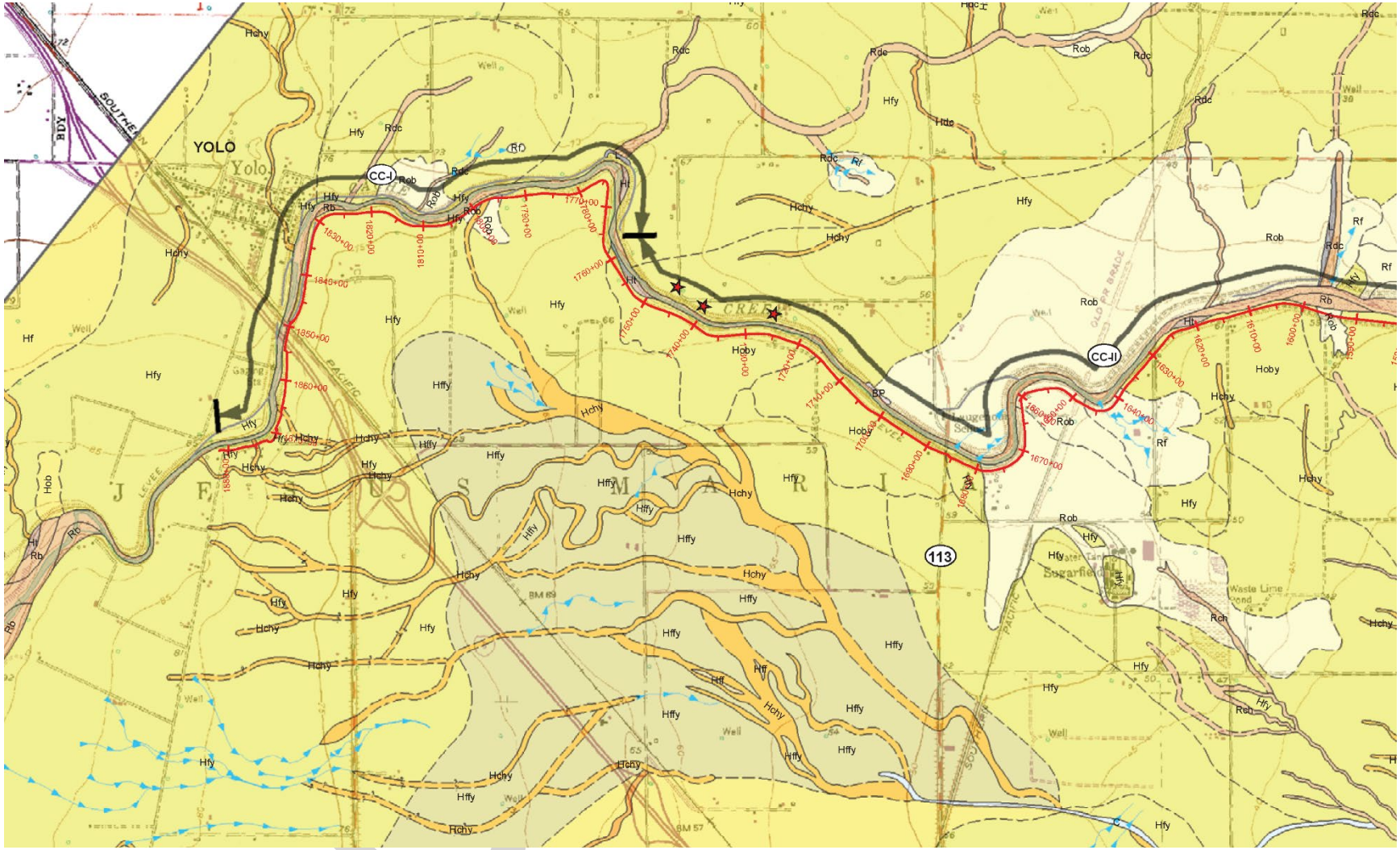

Figure B-2. ULE Geomorphology for Cache Creek near the Community of Yolo

Source: Excerpt from Plate 1 from the Technical Memorandum on Surficial Geologic Map and Geomorphic Assessment, California Department of Water Resources Urban Levees Project, Woodland Stud Area, Yolo County, California presented in the URS Supplemental Geotechnical Data Report, Woodland Study Area (URS, 2013)

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B.2.6 Existing Subsurface Explorations

Existing subsurface exploration data in the vicinity of the community of Yolo were identified and reviewed from available documents. There are no subsurface exploration explorations along levee directly adjacent to the community of Yolo but available nearby data includes recent DWR explorations for erosion repair sites, explorations from the Caltrans bridge database, as well as a few 1958 explorations from USACE levee improvement work. Figure B-3 shows the approximate locations of all of the explorations identified along the Cache Creek left bank between levee mile (LM) 1.0 and LM 3.3.

Under the Sacramento River Bank Protection Project, DWR has evaluated and repaired 7 identified critical erosion sites along the Cache Creek north bank with small setback levees. The working was been done under a State Emergency Erosion Repair Project and a Cache Creek Levee Setback Project and included sites at the following locations:

- LM 0.8
- LM 1.1
- LM 2.5
- LM 2.8
- LM 3.4
- LM 3.9
- LM 4.2

At each erosion project location subsurface exploration was completed by the DWR Division of Engineering Project Geology section. The explorations from the three sites closest to the community of Yolo, (LM 1.1, LM 2.5, and LM 2.8) were reviewed in detailed. The subsurface explorations at these three sites included borings, Cone Penetration Tests (CPTs), test pits, and small trench excavations. The explorations are shown in Figure B-3 and their subsurface stratigraphy summarized in Table B-1. Table B-1 also includes summary of index test results available.

The Caltrans bridge database included 1950s and 1960s records for the Interstate 5 bridges just upstream of the community of Yolo. Additionally, a set of explorations completed in 2000 by Taber Consultants was included in the database, for County Road 99W bridge, adjacent to the upstream end of the community of Yolo. From these available records, six explorations were identified near or along the east bank of Cache Creek. The explorations are shown in Figure B-3 and their subsurface stratigraphy is summarized in Table B-1.

USACE levee improvement drawings from1960 include 19 borings completed in 1958 along the left and right banks of Cache Creek between the Yolo Bypass and high ground. Borings ranged in depth from 24 to 35 feet drilled from the existing levee crown or waterside or landside areas. Closest to the community of Yolo, four of these 1958 explorations are located approximately between LM 2.8 and LM 3.3. The explorations are shown in Figure B-3 and their subsurface stratigraphy is summarized in Table B-1.

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Figure B-2. Existing Subsurface Explorations near the Community of Yolo

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Table B-1. Summary of Existing Subsurface Explorations near the Community of Yolo

Locations and subsurface stratigraphy are based on available information. USCS classifications may be interpreted from the available information.

Exploration ID	Approximate Levee Mile	Approximate Location	Approximate Ground Surface Elevation (ft, NAVD88)	Total Depth (ft)	Exploration Type	Approximate Depths (ft)		Soil Type	% Fines	% Sand	% Gravel	Liquid Limit	Plastic Limit	Moisure Content (%)	Notes
						Top	Bottom								
CRS2-1	1.10	Setback Foundation	85	82.5	Boring	0	20	CL	97	3	0	41	19	--	DWR Erosion Repair Project 2005 Boring
									96	4	0	38	16	--	
									89	11	0	37	16	--	
						20	35	ML	96	4	0	49	17	--	
						35	63.5	CL	84	16	0	38	20	--	
									96	4	0	36	16	--	
									55	45	0	26	10	--	
						63.5	73.5	SM	31	69	0	22	3	--	
						73.5	82.5	CL	90	10	0	39	22	--	
CRTP2-1	1.10	Between original levee and setback levee	84	3.7	Test Pit	0	3.7	CL	57	43	0	29	12	--	DWR Erosion Repair Project 2005 Test Pit
									50	50	0	25	9	--	
									72	28	0	31	12	11	
									95	5	0	45	22	22	
CRTP2-2	1.13	Between original levee and setback levee	84	4.3	Test Pit	0	4.3	CL to CL-ML	59	41	0	27	9	--	DWR Erosion Repair Project 2005 Test Pit
									52	48	0	26	7	--	
									55	45	0	28	11	12	
									96	4	0	43	21	23	
CRS2-2	1.14	Setback levee Foundation	83	52.5	Boring	0	40	CL	89	11	0	44	23	--	DWR Erosion Repair Project 2005 Boring
									98	2	0	46	'22	--	
									83	17	0	33	13	--	
									98	2	0	--	--	--	
									96	4	0	47	26	--	
									90	10	0	41	21	--	
						40	52.5	CH	85	15	0	--	--	--	
CRT2-1	1.14	Setback Levee Foundation	82	12.7	Trench	0	12.7	CL to ML	89	11	0	39	19	17	DWR Erosion Repair Project 2005 Trench
									91	9	0	42	20	--	
									95	5	0	44	22	18	
									98	2	0	45	23	--	
CRTP2-3	1.15	Between original levee and setback levee	83	4.5	Test Pit	0	4.5	CL	71	28	1	34	15	--	DWR Erosion Repair Project 2005 Test Pit
									94	6	0	43	21	19	
									97	3	0	42	21	15	
CRS2-3	1.22	Levee Crown	89	52.5	Boring	0	5.5	CL/ML	--	--	--	--	--	--	DWR Erosion Repair Project 2005 Boring
						5.5	52.5	CL	90	10	0	39	18	--	
									89	11	0	39	17	--	
									79	21	0	--	--	--	
									83	17	0	36	17	--	
									96	4	0	47	26	--	
									96	4	0	44	22	--	
									94	6	0	41	23	--	

Table B-1. Continued

Exploration ID	Approximate Levee Mile	Approximate Location	Approximate Ground Surface Elevation (ft, NAVD88)	Total Depth (ft)	Exploration Type	Approximate Depths (ft)		Soil Type	% Fines	% Sand	% Gravel	Liquid Limit	Plastic Limit	Moisure Content (%)	Notes
						Top	Bottom								
D-105	1.64	Bridge Abutment	91.5	42	Boring	0	3	CL	86	14	0	--	--	23	Caltrans boring prior to May 1966. Souce elevation assumed to be NGVD29, adjusted to NAVD88
						3	17	ML-CL	72 67 70	28 33 30	0 0 0	--	--	12 14 17	
						17	31	CL	94 91 76 88	6 9 23 22	0 0 1 0	--	--	24 22 -- 18	
						31	42	SM and GP-GM	18 8	57 42	25 50	--	--	7 3	
B-1	1.64	Waterside Bank	81.0	85	Boring	0	13	SM	--	--	--	--	--	--	March 1965 Caltrans Bridge Boring. Souce elevation assumed to be NGVD29, adjusted to NAVD88
						13	34	CL-ML	--	--	--	--	--	--	
						34	39	SP and GP	--	--	--	--	--	--	
						39	59	CL-ML	--	--	--	--	--	--	
						59	65	SM	--	--	--	--	--	--	
						65	85	SP and GP	--	--	--	--	--	--	
TH-2A	1.66	Waterside Bank	76.9	45	Boring	0	9	SM	--	--	--	--	--	--	December 1952 Caltrans Bridge Boring. Souce elevation assumed to be NGVD29, adjusted to NAVD88
						9	19	SP	--	--	--	--	--	--	
						19	23	SC	--	--	--	--	--	--	
						23	27	CL	--	--	--	--	--	--	
						27	34	CL-ML	--	--	--	--	--	--	
						34	40	ML-CL	--	--	--	--	--	--	
						40	45	ML	--	--	--	--	--	--	
TH-1	1.67	Waterside Bank	56.0	19	Boring	0	3	GP and SP	--	--	--	--	--	--	- June 1951 Caltrans Bridge Boring. - Start elevation well below landside toe elevation, therefore cannot evaluate blanket thickness. - Souce elevation assumed to be NGVD29, adjusted to NAVD88
						3	19	CL	--	--	--	--	--	--	
B-3	1.70	Channel	55.0	153.5	Boring	0	22	CL	--	--	--	--	--	--	December 2000 Caltrans Bridge Boring. Start elevation well below landside toe elevation, therefore cannot evaluate blanket thickness.
						22	32	CL	--	--	--	--	--	--	
						32	37	SC	--	--	--	--	--	--	
						37	77	SP to GP	--	--	--	--	--	--	
						77	111	CL	--	--	--	--	--	--	
						111	121.5	SP-SC	--	--	--	--	--	--	
						121.5	145.5	CL-ML							
						145.5	153.5	SP	--	--	--	--	--	--	
CPT-1	1.71	Bridge Abutment	91.0	80	CPT	0	48	CL to ML	--	--	--	--	--	--	October 2000 Caltrans Bridge CPT.
						48	55.5	SM to SP	--	--	--	--	--	--	
						55.5	60	CL to ML	--	--	--	--	--	--	
						60	65.5	SM to SP	--	--	--	--	--	--	
						65.5	77	CL to ML	--	--	--	--	--	--	
						77	80	SM to SP	--	--	--	--	--	--	

Table B-1. Continued

Exploration ID	Approximate Levee Mile	Approximate Location	Approximate Ground Surface Elevation (ft, NAVD88)	Total Depth (ft)	Exploration Type	Approximate Depths (ft)		Soil Type	% Fines	% Sand	% Gravel	Liquid Limit	Plastic Limit	Moisure Content (%)	Notes
						Top	Bottom								
CRS3-1	2.41	Levee Crown	83	51.5	Boring	0	6	CL	82	18	0	--	--	--	DWR Erosion Repair Project 2005 Boring
						6	10	ML	--	--	--	--	--	--	
						10	15	SC	44	56	0	26	8	--	
						15	17	CL	51	49	0	28	8	--	
						17	19.5	GP	--	--	--	--	--	--	
						19.5	24.5	SM	25	75	0	--	--	--	
						24.5	35	CL	86 57	14 43	0 0	-- 25	-- 9	-- --	
						35	51.5	CH	88 93 91 85	12 7 9 15	0 0 0 0	-- -- -- --	-- -- -- --	-- -- -- --	
CRTP3-1	2.46	Between original levee and setback levee	74	11.5	Test Pit	0	1.5	CL	80 67	20 33	0 0	38 31	19 13	-- 9	DWR Erosion Repair Project 2005 Test Pit
						1.5	3.3	SM-SC and CL	-- 84	-- 16	-- 0	-- 34	-- 12	-- 9	
						3.3	7.8	ML	--	--	--	--	--	--	
						7.8	9.3	SP	--	--	--	--	--	--	
						9.3	10.2	ML	--	--	--	--	--	--	
						10.2	10.7	GP and SP	--	--	--	--	--	--	
						10.7	11.5	ML	--	--	--	--	--	--	
CRT3-1	2.47	Setback Levee Foundation	74	13.8	Trench	0	1.8	CL	78	22	0	36	17	--	DWR Erosion Repair Project 2005 Trench
						1.8	3.5	ML	--	--	--	--	--	--	
						3.5	6.2	CL	84	16	0	34	13	--	
						6.2	7.6	SM	18	82	0	--	NP	--	
						7.6	8.1	GP	2	42	55	--	NP	--	
						8.1	11.8	SM/SC to CL	69	30	1	30	11	15	
						11.8	13.8	CL	81	19	0	38	18	15	
CRTP3-2	2.48	Between original levee and setback levee	74	10	Test Pit	0	1.9	CL	74 83	26 17	0 0	34 39	16 18	-- 12	DWR Erosion Repair Project 2005 Test Pit
						1.9	7.5	CL to ML	92	8	0	38	16	12	
						7.5	7.9	SM	--	--	--	--	--	--	
						7.9	8.3	ML	--	--	--	--	--	--	
						8.3	9	GP and SP	--	--	--	--	--	--	
						9	10	SM	--	--	--	--	--	--	
CRTP3-5	2.49	Setback Levee Foundation	74	12.5	Test Pit	0	2	CL	--	--	--	--	--	--	DWR Erosion Repair Project 2005 Test Pit
						2	8	ML-CL	--	--	--	--	--	--	
						8	9	SP-SM	--	--	--	--	--	--	
						9	11.8	ML	--	--	--	--	--	--	
						11.8	12.5	CL	--	--	--	--	--	--	

Table B-1. Continued

Exploration ID	Approximate Levee Mile	Approximate Location	Approximate Ground Surface Elevation (ft, NAVD88)	Total Depth (ft)	Exploration Type	Approximate Depths (ft)		Soil Type	% Fines	% Sand	% Gravel	Liquid Limit	Plastic Limit	Moisure Content (%)	Notes
						Top	Bottom								
CRS3-2	2.50	Between original levee and setback levee	82	60	Boring	0	20	CL	67	33	0	34	16	--	DWR Erosion Repair Project 2005 Boring
									84	16	0	34	13	--	
									91	9	0	36	13	--	
						20	25	CH	95	5	0	60	35	--	
						25	44.5	CL	89	11	0	43	23	--	
									92	8	0	43	23	--	
									97	3	0	51	31	--	
									79	21	0	42	25	--	
						44.5	50	SC	12	57	31	30	16	--	
						50	55	SP-SM	6	67	27	20	1	--	
						55	60	SW-SM	7	65	25	21	2	--	
CRTP3-3	2.50	Between original levee and setback levee	77	11	Test Pit	0	5	CL	85	15	0				DWR Erosion Repair Project 2005 Test Pit
									62	38	0				
									88	12	0				
						5	9	ML	--	--	--	--	--	--	
						9	10.5	SP	--	--	--	--	--	--	
						10.5	11	GP	--	--	--	--	--	--	
CRTP3-4	2.53	Between original levee and setback levee	77	12.5	Test Pit	0	2.6	CL	82	18	0	35	15	--	DWR Erosion Repair Project 2005 Test Pit
									85	15	0	37	16	7	
						2.6	3.5	SM and ML	--	--	--	--	--	--	
						3.5	10	SM to CL	77	23	0	33	13	9	
						10	11	SP	--	--	--	--	--	--	
						11	12.5	GP	--	--	--	--	--	--	
CRS3-3	2.56	Levee Crown	77	50	Boring	0	5.5	CL	69	31	0	31	15	--	DWR Erosion Repair Project 2005 Boring Gravel increasing a bottom of boring, last 8.5 feet not sampled.
						5.5	13	CL	77	23	0	34	15	--	
						13	20	SC-SM	42	58	0	28	7	--	
						20	41	CL	72	28	0	34	17	--	
									95	5	0	48	28	--	
						41	50	CL/GC	58	26	16	34	14	--	
DH-2.8L-1	2.76	Levee Crown	77	60	Boring	0	6	ML	--	--	--	--	--	--	DWR Erosion Repair Project 2010 Boring
						6	17.5	CL	55	45	0	29	12	--	
									60	40	0	30	12	--	
						17.5	20.5	SW	--	--	--	--	--	--	
						20.5	49	CL	88	12	0	39	17	--	
									95	5	0	48	26	--	
									80	20	0	39	21	--	
						49	52	SC	15	73	12	27	8	--	
						52	60	GP	--	--	--	--	--	--	

Table B-1. Continued

Exploration ID	Approximate Levee Mile	Approximate Location	Approximate Ground Surface Elevation (ft, NAVD88)	Total Depth (ft)	Exploration Type	Approximate Depths (ft)		Soil Type	% Fines	% Sand	% Gravel	Liquid Limit	Plastic Limit	Moisure Content (%)	Notes
						Top	Bottom								
2F-8-4	2.84	Levee Crown	83.3	30	Boring	0	3	ML	72	28	0	--	NP	8	1958 USACE exploration
						3	7.5	SM	50	50	0	--	NP	12	
						7.5	22	ML	63 53 96 79	37 47 4 21	0 0 0 0	--	All NP	17 12 35 29	Ground surface elevation based on log elevation and datum conversions. Higher than current ground surface, assumed to be due to settlement.
						22	25	CL	80	20	0	41	18	28	
						25	27.5	ML	65	35	0	--	NP	19	
						27.5	30	CL	85 85	15 15	0 0	34 36	12 15	26 27	Souce elevation assumed to be NGVD29, adjusted to NAVD88
DH-2.8L-2	2.85	Between original levee and setback levee	70	61	Boring	0	12.5	CL	53 50 57 58	47 50 43 42	0 0 0 0	27 26 28 29	9 9 11 11	--	DWR Erosion Repair Project 2010 Boring
						12.5	13	SP	--	--	--	--	--	--	
						13.5	51	CL to CH	88 93 86	12 7 14	0 0 0	43 46 36	21 26 15	--	
						51	54.4	SC	--	--	--	--	--	--	
						54.4	57	SP-SM	9	70	21	--	NP	--	
						57	61	GP	--	--	--	--	--	--	
CPT-2.8L-1	2.85	Between original levee and setback levee	70	60	CPT	0	13	SM to ML	--	--	--	--	--	--	DWR Erosion Repair Project 2010 CPT
						13	43.5	CL to ML	--	--	--	--	--	--	
						43.5	58.5	SP	--	--	--	--	--	--	
						58.5	60	CL to ML	--	--	--	--	--	--	
T-2.8L-1	2.85	Between original levee and setback levee	76	14.5	Trench	0	1	CL	71	29	0	31	12	10	DWR Erosion Repair Project 2010 Trench
						1	3.5	SC	49	51	0	26	8	6	
						3.5	5	SM	20	80	0	--	NP	4	
						5	9	CL	56	44	0	28	10	7	
						9	9.75	GP-GM	--	--	--	--	--	--	
						9.75	14.5	CL	89 66	11 34	0 0	36 31	14 12	28 17	
CPT-2.8L-5	2.85	Setback Levee Foundation	69	30.3	CPT	0	3	CL to ML	--	--	--	--	--	--	DWR Erosion Repair Project 2011 CPT Elevation estimated from 2008/2009 CVFED LiDAR
						3	3.5	SP	--	--	--	--	--	--	
						3.5	14	CL to ML	--	--	--	--	--	--	
						14	14.5	SP	--	--	--	--	--	--	
						14.5	30.3	CL to ML	--	--	--	--	--	--	
CPT-2.8L-4	2.85	Setback Levee Landside Toe	69	30.3	CPT	0	2	CL to ML	--	--	--	--	--	--	DWR Erosion Repair Project 2011 CPT Elevation estimated from 2008/2009 CVFED LiDAR
						2	2.5	SP	--	--	--	--	--	--	
						2.5	30.3	CL to ML	--	--	--	--	--	--	

Table B-1. Continued

Exploration ID	Approximate Levee Mile	Approximate Location	Approximate Ground Surface Elevation (ft, NAVD88)	Total Depth (ft)	Exploration Type	Approximate Depths (ft)		Soil Type	% Fines	% Sand	% Gravel	Liquid Limit	Plastic Limit	Moisure Content (%)	Notes
						Top	Bottom								
2F-8-5	2.87	Levee Crown	82.5	30	Boring	0	8	ML	63	37	0	--	NP	10	1958 USACE exploration Ground surface elevation based on log elevation and datum conversions. Higher than current ground surface, assumed to be due to settlement.
									61	39	0	--	NP	18	
						8	13	SM	41	59	0	--	NP	11	
						13	30	CL	76	24	0	31	11	23	
									96	4	0	35	11	33	
									81	19	0	40	19	26	
									71	29	0	30	12	20	
									90	10	0	37	13	28	
									90	10	0	44	20	26	
2F-8-6	2.88	Levee Crown	82.9	30	Boring	0	28	ML	58	42	0	--	all NP	7	1958 USACE exploration Ground surface elevation based on log elevation and datum conversions. Higher than current ground surface, assumed to be due to settlement.
									65	35	0			18	
									83	17	0			21	
									70	30	0			20	
									95	5	0			32	
									90	10	0			35	
									68	32	0			18	
						28	30	CL	90	10	0	36	15	28	
CPT-2.8L-2	2.91	Between original levee and setback levee	70	60	CPT	0	49.5	CL to ML	--	--	--	--	--	--	DWR Erosion Repair Project 2010 CPT
						49.5	58	SP	--	--	--	--	--	--	
						58	60	CL to ML	--	--	--	--	--	--	
DH-2.8L-3	2.93	Levee Crown	76	60	Boring	0	6	CL	--	--	--	--	--	--	DWR Erosion Repair Project 2010 Boring
						6	8	GP	--	--	--	--	--	--	
						8	13	SC	37	40	23	30	11	--	
						13	19.3	CL	53	33	14	38	19	--	
						19.3	20.2	SC	--	--	--	--	--	--	
						20.2	60	CL to CH	85	15	0	39	18	--	
									92	8	0	40	16	--	
									96	4	0	49	28	--	
									75	25	0	37	20	--	
2F-8-7	3.27	Waterside	75.4	27.5	Boring	0	7	SP	4	96	0	--	NP	4	1958 USACE exploration Ground surface elevation based on log elevation and datum conversions. Higher than current ground surface, assumed to be due to settlement.
									5	95	0	--	NP	3	
						7	8	SM	18	82	0	--	NP	8	
						8	10.5	SP	5	95	0	--	NP	3	
						10.5	24	SM	35	65	0			9	
									44	56	0	--	All NP	10	
									18	58	24			12	
						24	26.5	SP	4	62	34	26	10	4	
						26.5	27.5	CL	77	23	0	37	19	11	

As shown in Figure B-3, the available explorations generally fall into five areas, the explorations in each of these areas are discussed further below.

Upstream of the community of Yolo there are seven 2005 subsurface explorations available from DWR's State Emergency Erosion Repair Project site at LM 1.1. The explorations included three borings which were completed to depths of approximately 50 to 80 feet, three test pits from 3.7 to 5.5 feet deep, and a small trench excavation to 12.7 feet deep. One of the borings went through the levee crown and logged the embankment as containing clay and silt. All of the explorations found the foundation to be predominately composed of clay and silt materials. The deepest boring encountered a 10-foot thick silty sand layer beginning at a depth of 63.5 feet below the landside ground surface.

Near LM 1.7, slightly upstream of the community of Yolo, there are six bridge relate subsurface explorations. The explorations included 5 borings and one CPT and range in depth from 19 feet to 153.5 feet. A mix of fine-grained (silt and clay) and coarse-grained (sand and gravel) material was encountered in all of the explorations. Two of the borings identified a sandy shallow foundation with no fine-grained blanket at the surface. The sandy material in these borings went to depths of up to 23 feet below the ground surface. Where present, the fined-grained blanket appeared to be approximately 24 to 41 feet thick. Records reviewed did not include information on bridge abutment construction and if any treatment or improvement was made to the embankment or shallow foundation in these locations that would create different subsurface conditions at these locations than elsewhere along the nearby Cache Creek left bank levee. The two borings that identified a sandy shallow subsurface were from 1951 and 1952, prior to the Interstate 5 construction in 1956.

Downstream from community of Yolo there are nine 2005 subsurface explorations available from DWR's State Emergency Erosion Repair Project site at LM 2.5. The explorations included three borings which were completed to depths of 50 to 60 feet, five test pits to 10 to 12.5 feet deep, and a small trench excavation to 13.8 feet deep. Two of the borings went through the levee crown and identified the embankment to be composed of lean clay. A fine-grained blanket was identified in foundation all of the explorations. In most locations, the blanket thickness ranged from approximately 7 feet to 14 feet thick, but in one location the blanket thickness was up to approximately 44 feet thick. Zones of sand and often gravel were encountered below the blanket in all explorations that extended past the bottom of the blanket layer. The deepest exploration terminated in sand at 60 feet below the landside ground surface.

Further downstream of the community of Yolo there are eight 2010 and 2011 subsurface explorations available from DWR's Cache Creek Levee Setback Project site at LM 2.8. Additionally, in this area there are three 1958 USACE explorations. In total, the 11 explorations in this area included 6 borings and 4 CPTs to depths of approximately 30 to 60 feet and one small trench excavation to 14.5 feet deep. Two of the explorations encountered coarse-grained materials (sand and/or gravel) in the shallow foundation, with no fine-grained blanket above them. One of the CPT also identified a potentially sandy surface layer. The thickness of the surficial sands ranged from 5 feet to 13 feet. Two other CPTs identified likely sandy lenses in the upper 5 feet of the blanket. The remaining explorations generally identified a fine-grained blanket approximately 11 feet up to almost 50 feet thick. Two of the deeper borings, encountered

sand underlain by gravels at the bottom of the explorations, as deep as about 60 feet below the ground surface.

The last exploration, one of the 1958 USACE explorations, is further downstream at approximately LM 3.27. This exploration encountered surficial sands to a depth of 26.5 feet. The boring terminated at 27.5 feet and encountered clay in its final foot.

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B.3 Levee Improvement Conclusions

The goal of this geotechnical assessment was to identify conceptual remedial levee improvements for the levee adjacent to the community of Yolo to facilitate the costs assessment for the final array of structural alternatives considered in the Feasibility Study. Considerations included potential repairs for erosion, freeboard, and underseepage, through seepage, and landside slope stability.

Performance history indicates erosion has been a consistent problem along this stretch of levee and repair is recommended. To address erosion the Feasibility Study will consider placement of rock slope protection along the waterside of the levee and the channel bank slope.

As summarized in Section B.2.3, freeboard repairs are needed for both the 1957 design WSE profile and the 100-year flow WSE. To meet 1957 design WSE profile freeboard requirements, the levees adjacent to the community of Yolo would need to be raised approximately 0 to 4 feet. To meet 100-year flow WSE profile freeboard requirements, the levees adjacent to the community of Yolo would need to be raised approximately 0 to 2.8 feet. Freeboard repairs would also address levee prism (geometry) requirements.

Review of underseepage, through seepage, and stability remediation needs were based on available subsurface information and the past performance of the levees near the community of Yolo. Past performance of the levees near Yolo includes records of through and underseepage There were not records of past landside slope instability in the area. Explorations through the levee generally found a fine-grained levee embankment composed of clay and silt. Animal burrows are suspected to be contributing to the past through seepage problems. Available explorations identified generally variable foundation conditions. Surficial sand layers up to 26.5 feet thick provide concern for shallow underseepage. There is also concern for deeper underseepage, with locations of thin fine-grained blankets and deeper sand and gravel units. The bottom depth of some of the encountered pervious zones is not known based on the available exploration information as some borings, up to 60 feet deep, ended in sand or gravels. Therefore, to address underseepage and through seepage, a cutoff wall is recommended. A cutoff wall is the most practical remedy for this project site as there is not adequate space at the landside levee toe for a seepage berm solution. Based on the unknown depth of the underlying aquifer, a cutoff wall to a depth of 80 feet (the limit of conventional open trench wall construction) will be assumed for this Feasibility Study.

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B.4 References

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