SUTTER BASIN PILOT FEASIBILITY FINAL REPORT—FINAL ENVIRONMENTAL IMPACT REPORT/SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT APPENDICES

COMMUNICATION

FROM

THE ASSISTANT SECRETARY OF THE ARMY, CIVIL WORKS, THE DEPARTMENT OF DEFENSE

TRANSMITTING

A FINAL ENVIRONMENTAL IMPACT REPORT ON THE SUTTER BASIN PROJECT IN SUTTER AND BUTTE COUNTIES, CALIFORNIA

PART 2 OF 2

NOVEMBER 12, 2014.—Referred to the Committee on Transportation and Infrastructure and ordered to be printed

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AUTHENTICATED
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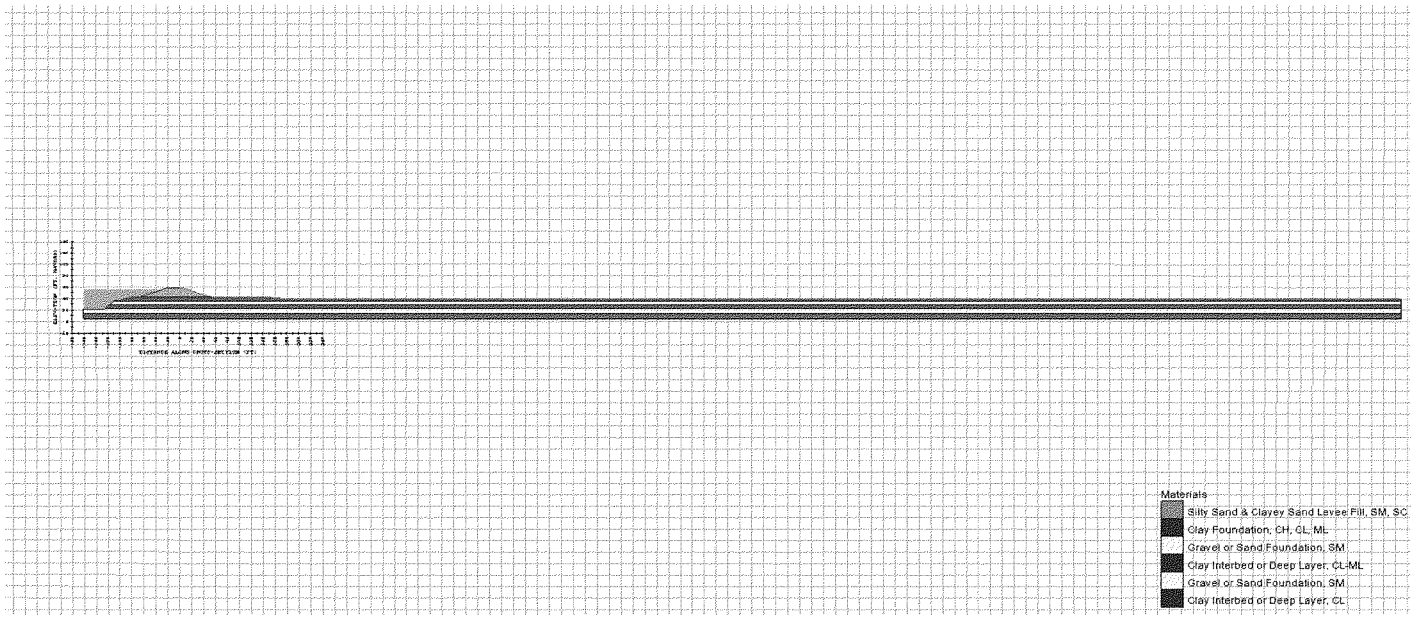
DETERMINISTIC ANALYSIS



Seepage and Slope Stability Parameters								
Model Layer No.	Model Layer Name	K_H (ft/day)	K_V (ft/day)	K_H/K_V	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Silty Sand & Clayey Sand Levee Fill, SM, SC	1.40	0.35	4	125	10	32
2	Clay Foundation, CH, CL, ML	0.028	0.028	1	115	100	28
3	Gravel or Sand Foundation, SM	2,800	0.710	4	125	0	34
4	Clay Interbed or Deep Layer, CL-ML	0.03	0.01	4	115	100	28
5	Gravel or Sand Foundation, SM	2.80	0.71	4	125	0	34
6	Clay Interbed or Deep Layer, CL	0.03	0.01	4	115	100	28

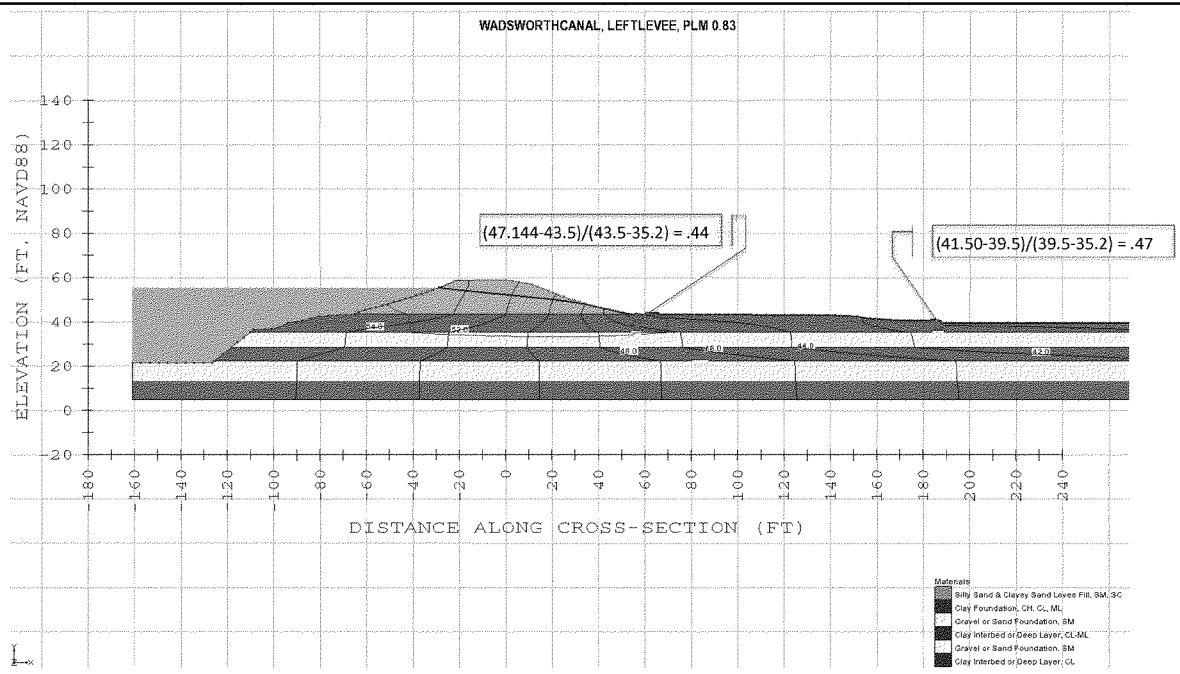
NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WSEWWC_001B
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 55.5 ft.

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SUTTER BASIN CALIFORNIA

GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
WADSWORTH CANAL, LEFT LEVEE, LM0.83
COMPLETE SUBSURFACE MODEL

28-Jun-2012 | SCALE: AS SHOWN | SHEET 1 of 3



Seepage and Slope Stability Parameters							
Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	φ'
1	Silty Sand & Clayey Sand Levee Fill, SM, SC	1.40	0.35	4	125	10	32
2	Clay Foundation, CH, CL, ML	0.028	0.028	1	115	100	28
3	Gravel or Sand Foundation, SM	2.800	0.710	4	125	0	34
4	Clay Interbed or Deep Layer, CL-ML	0.03	0.01	4	115	100	28
5	Gravel or Sand Foundation, SM	2.80	0.71	4	125	0	34
6	Clay Interbed or Deep Layer, CL	0.03	0.01	4	115	100	28

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WSEWWC_0018
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 55.5 ft.

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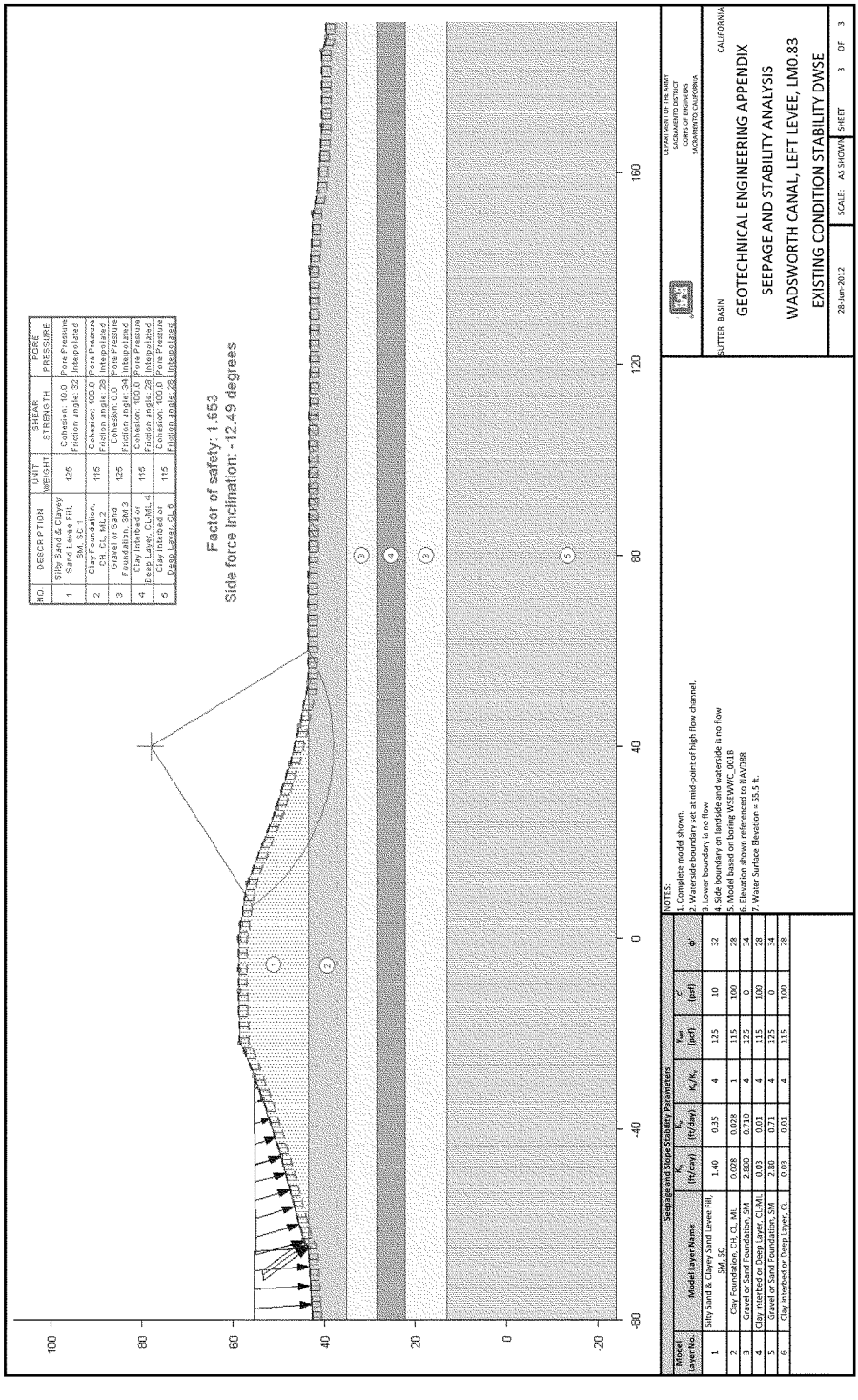
SUTTER BASIN CALIFORNIA

GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
WADSWORTH CANAL, LEFT LEVEE, LM0.83
EXISTING CONDITION SEEPAGE DWSE

28-Jun-2012 | SCALE: AS SHOWN | SHEET 2 OF 3



Model Layer No.	Seepage and Slope Stability Parameters: Model Layer Name	k_h (ft/day)	k_v (ft/day)	k_h/k_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Silty Sand & Clayey Sand Levee Fill, SM, SC	1.40	0.35	4	125	10	32
2	Clay Foundation, CH, CL, ML	0.028	0.028	1	115	100	28
3	Gravel or Sand Foundation, SM	2.800	0.710	4	125	0	34
4	Clay Interbed or Deep Layer, CL-ML	0.03	0.01	4	115	100	28
5	Gravel or Sand Foundation, SM	2.80	0.71	4	125	0	34
6	Clay Interbed or Deep Layer, CL	0.03	0.01	4	115	100	28

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow.
4. Side boundary on landside and waterside is no flow.
5. Model based on boring WSEWWC_0018.
6. Elevation shown referenced to NAVD88.
7. Water Surface Elevation = 55.5 ft.

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SACRAMENTO, CALIFORNIA

SUTTER BASIN — CALIFORNIA

GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
WADSWORTH CANAL, LEFT LEVEE, LM0.83
EXISTING CONDITION STABILITY DWSE

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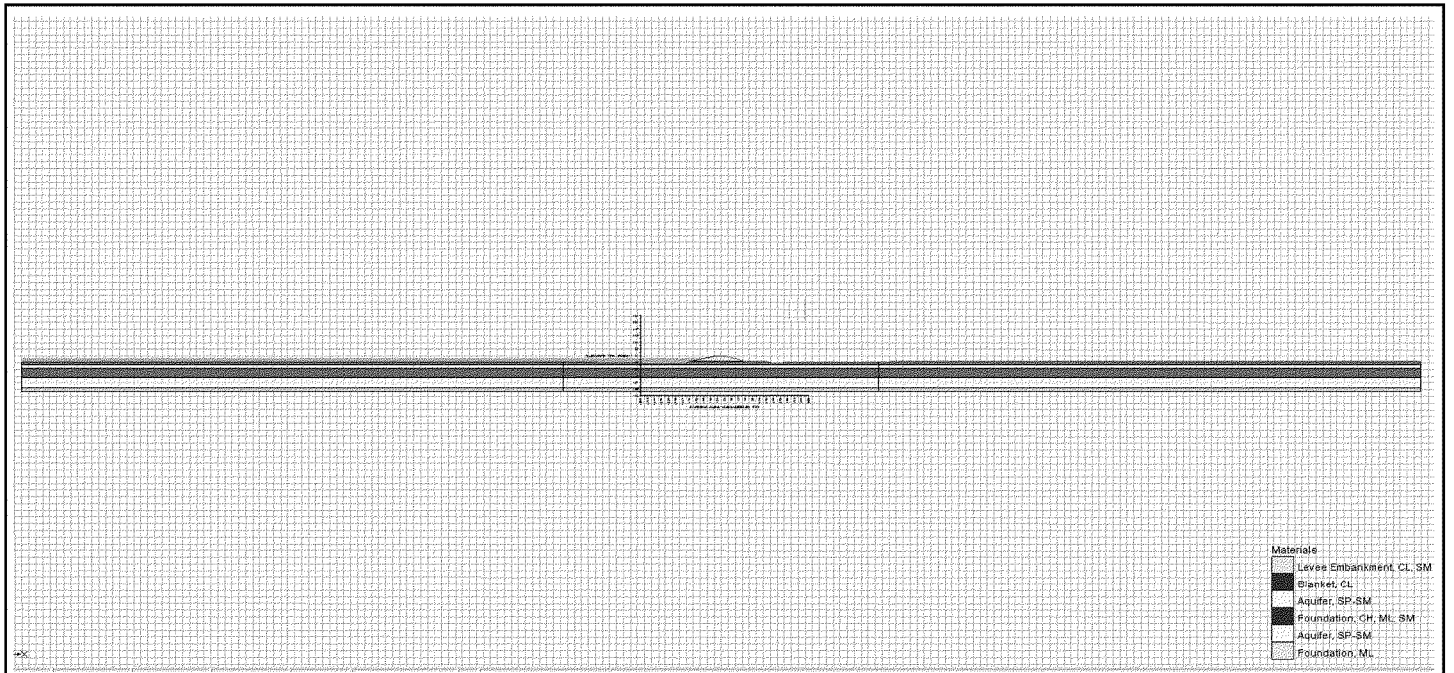

Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, CL, SM	0.57	0.14	4	115	50	28
2	Blanket, CL	0.028	0.007	4	115	100	28
3	Aquifer, SP-SM	14.000	1.400	10	125	0	32
4	Foundation, CH, ML, SM	0.57	0.14	4	120	100	28
5	Aquifer, SP-SM	14.00	1.40	10	125	0	32
6	Foundation, ML	0.57	0.14	4	120	10	28

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side bounidary on landside and waterside is no flow
5. Model based on boring WSESBP_017B
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 53.29 ft.

DEPARTMENT OF THE ARMY
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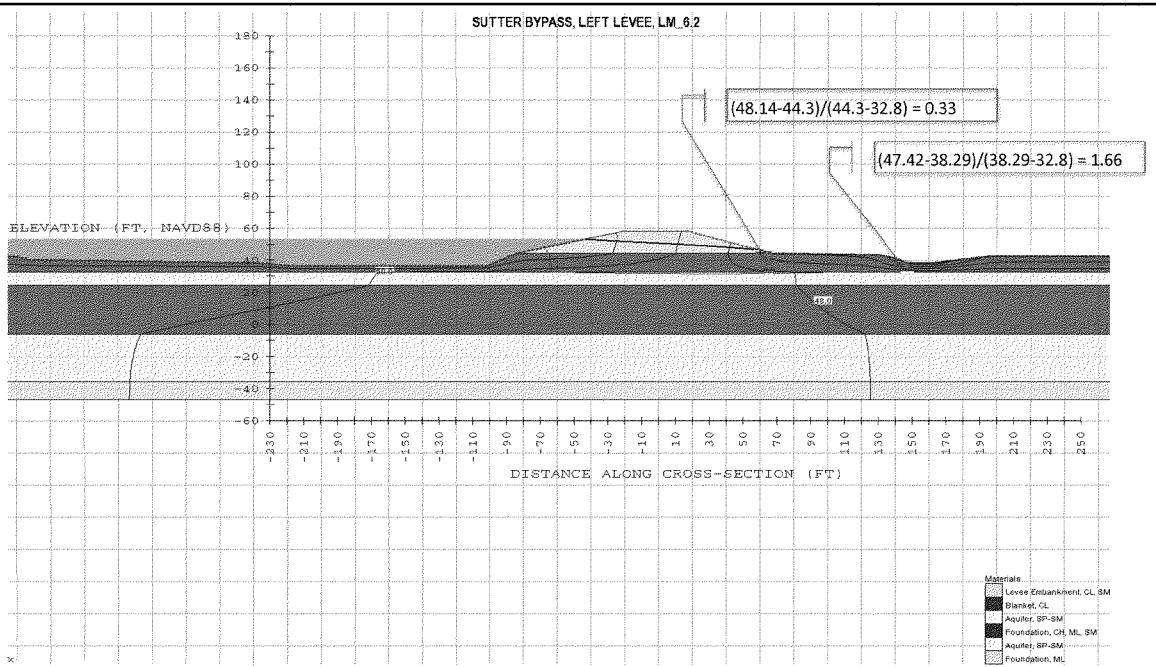
SACRAMENTO, CALIFORNIA

SUTTER BASIN — CALIFORNIA

GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
SUTTER BYPASS, LM_6.2, STATION 823+27
COMPLETE SUBSURFACE MODEL

28-Jun-2012 | SCALE: AS SHOWN | SHEET 1 of 3



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, CL, SM	0.57	0.14	4	115	50	28
2	Blanket, CL	0.028	0.007	4	115	100	28
3	Aquifer, SP-SM	14.000	1.400	10	125	0	32
4	Foundation, CH, ML, SM	0.57	0.14	4	120	100	28
5	Aquifer, SP-SM	14.00	1.40	10	125	0	32
6	Foundation, ML	0.57	0.14	4	120	10	28

NOTES:
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SUTTER BASIN — CALIFORNIA

GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
SUTTER BYPASS, LM_6.2, STATION 823+27
EXISTING CONDITION SEEPAGE DWSE

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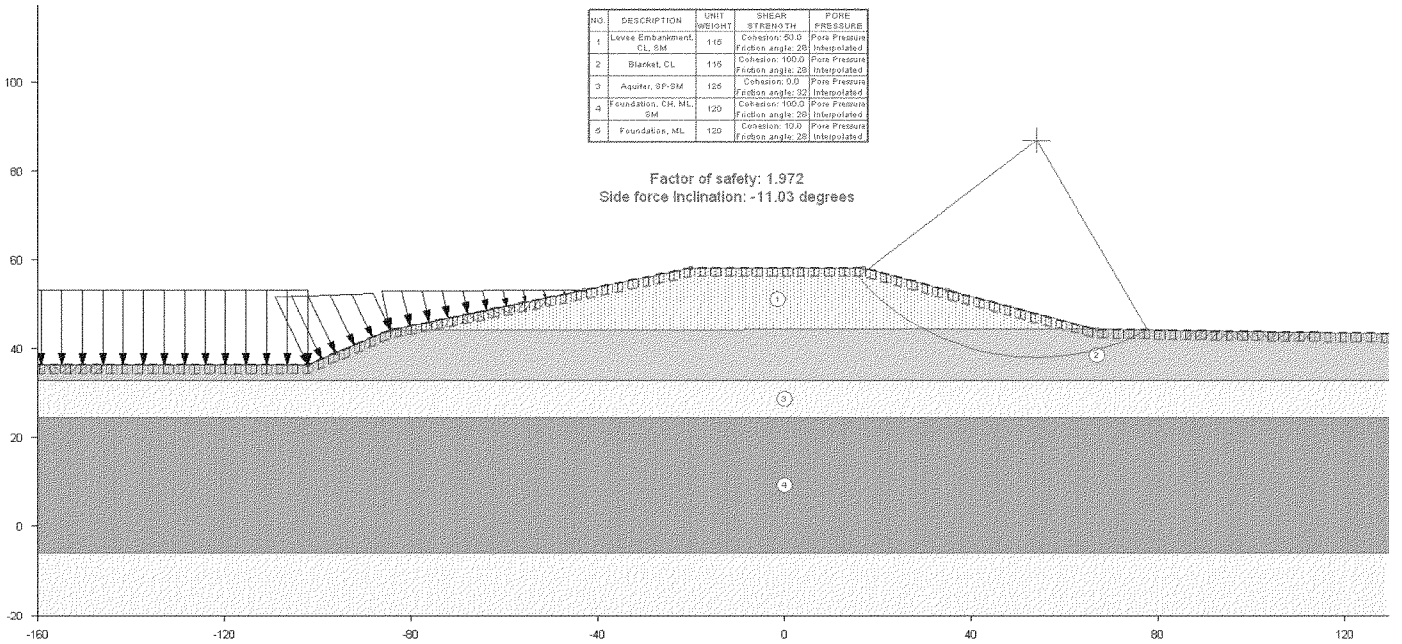
NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Levee Embankment, CL, SM	115	Cohesion: 50.0 Friction angle: 28	Pore Pressure Interpolated
2	Blanket, CL	115	Cohesion: 100.0 Friction angle: 28	Pore Pressure Interpolated
3	Aquifer, SP-SM	125	Cohesion: 0.0 Friction angle: 32	Pore Pressure Interpolated
4	Foundation, CH, ML, SM	120	Cohesion: 100.0 Friction angle: 28	Pore Pressure Interpolated
5	Foundation, ML	120	Cohesion: 10.0 Friction angle: 28	Pore Pressure Interpolated



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, CL, SM	0.57	0.14	4	115	50	28
2	Blanket, CL	0.028	0.007	4	115	100	28
3	Aquifer, SP-SM	14.000	1.400	10	125	0	32
4	Foundation, CH, ML, SM	0.57	0.14	4	120	100	28
5	Aquifer, SP-SM	14.00	1.40	10	125	0	32
6	Foundation, ML	0.57	0.14	4	120	10	28

NOTES:
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4. Side boundary on landside and waterside is no flow
5. Model based on boring WSESBP_017B
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 53.29 ft.

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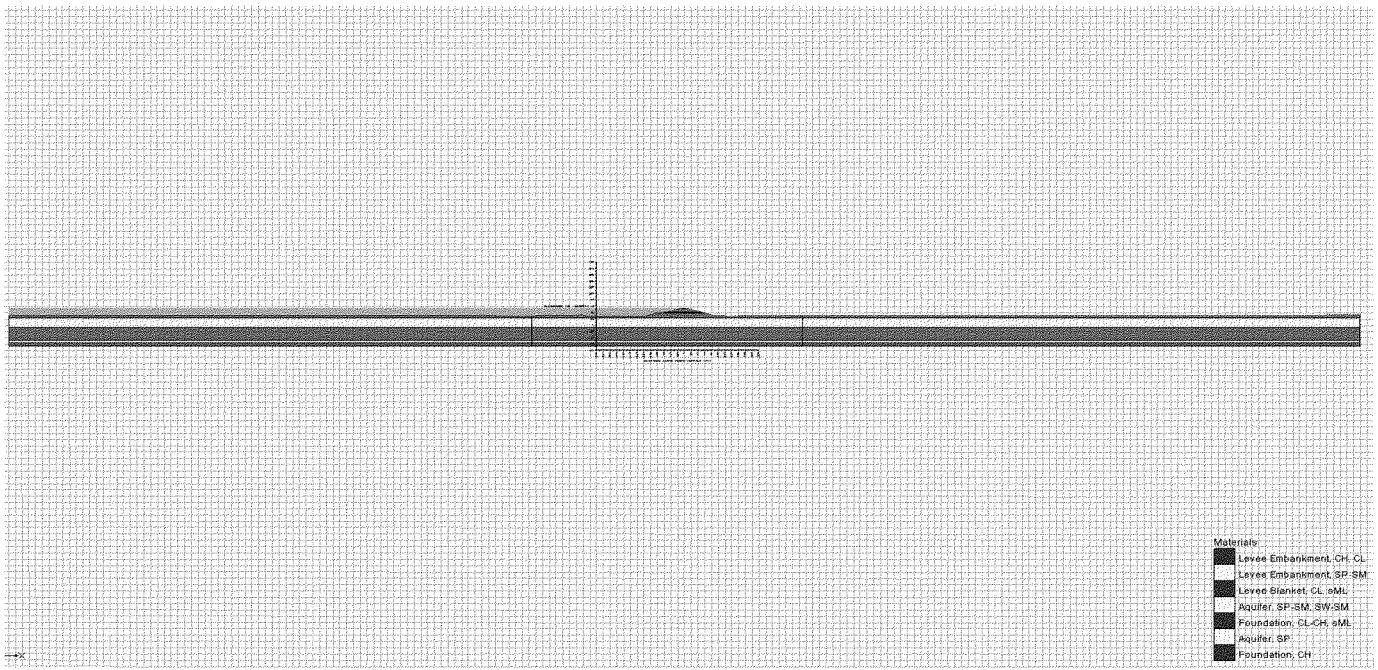
SUTTER BASIN — CALIFORNIA

GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
SUTTER BYPASS, LM_6.2, STATION 823+27
EXISTING CONDITION STABILITY DWSE

28-Jun-2012 | SCALE: AS SHOWN | SHEET 3 OF 3



Seepage and Slope Stability Parameters								
Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, (ML)s	0.57	0.14	4	115	10	28
2	Levee Embankment, CL, (CL)s	0.028	0.007	4	115	150	27
3	Blanket, CL, (CL)s	0.028	0.007	4	115	150	27
4	Aquifer, SP-SM	14.00	1.40	10	125	0	34
5	Foundation, (ML)s	0.57	0.14	4	120	10	28
6	Aquifer, SP-SM	14.00	1.40	10	125	0	34

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WSESBP_005B
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 54.1 ft.

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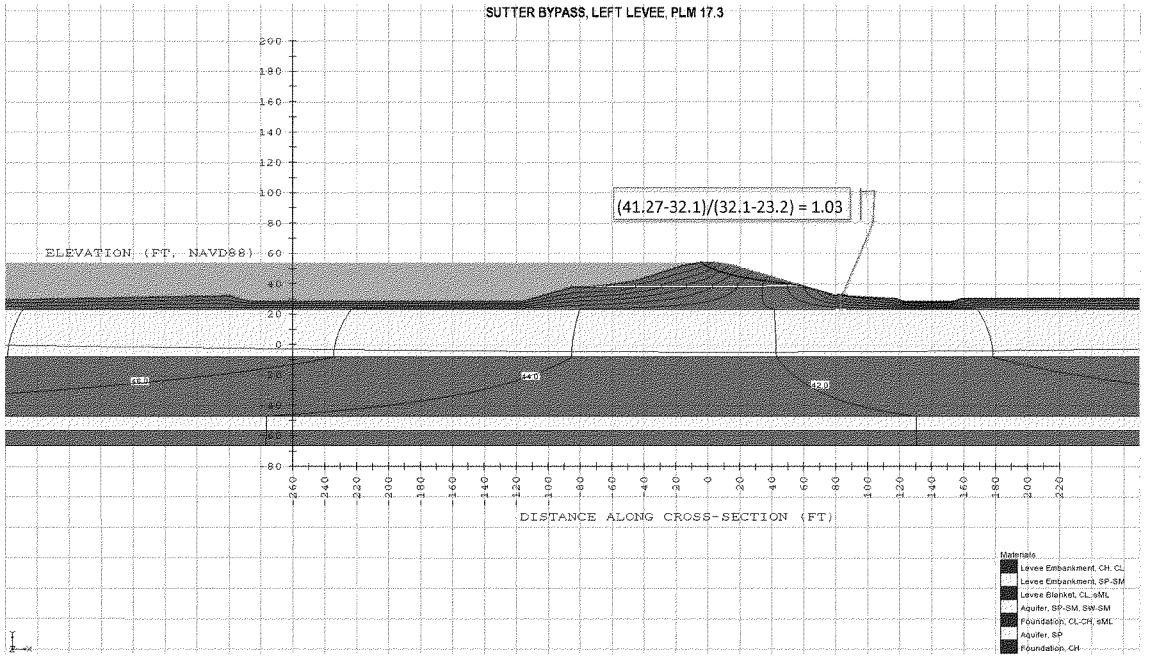
SUTTER BASIN — CALIFORNIA

GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
SUTTER BYPASS, LM_17.3 STATION 293+00
COMPLETE SUBSURFACE MODEL

28-Jun-2012 | SCALE: AS SHOWN | SHEET 1 of 3



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, (ML)s	0.57	0.14	4	115	10	28
2	Levee Embankment, CL, (CL)s	0.028	0.007	4	115	150	27
3	Blanket, CL, (CL)s	0.028	0.007	4	115	150	27
4	Aquifer, SP-SM	14.00	1.40	10	125	0	34
5	Foundation, (ML)s	0.57	0.14	4	120	10	28
6	Aquifer, SP-SM	14.00	1.40	10	125	0	34

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WSESBP_005B
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 54.1 ft.

DEPARTMENT OF THE ARMY
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SACRAMENTO, CALIFORNIA

SUTTER BASIN — CALIFORNIA

GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
SUTTER BYPASS, LM_17.3 STATION 293+00
EXISTING CONDITION SEEPAGE DWSE

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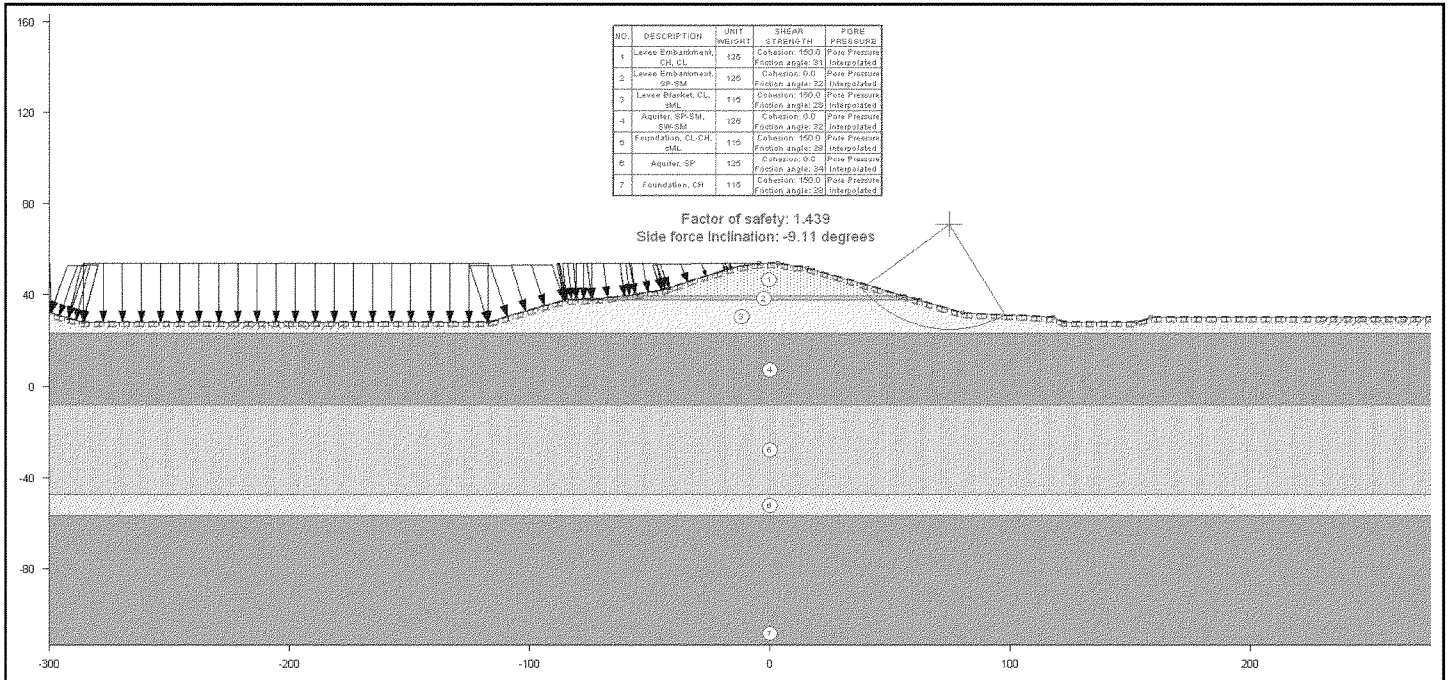

Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{wet} (pcf)	C' (psf)	ϕ'
1	Levee Embankment, (ML)s	0.57	0.14	4	115	10	28
2	Levee Embankment, CL, (CL)s	0.028	0.007	4	115	150	27
3	Blanket, CL, (CL)s	0.028	0.007	4	115	150	27
4	Aquifer, SP-SM	14.00	1.40	10	125	0	34
5	Foundation, (ML)s	0.57	0.14	4	120	10	28
6	Aquifer, SP-SM	14.00	1.40	10	125	0	34

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WSESBP_0058
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 54.1 ft.

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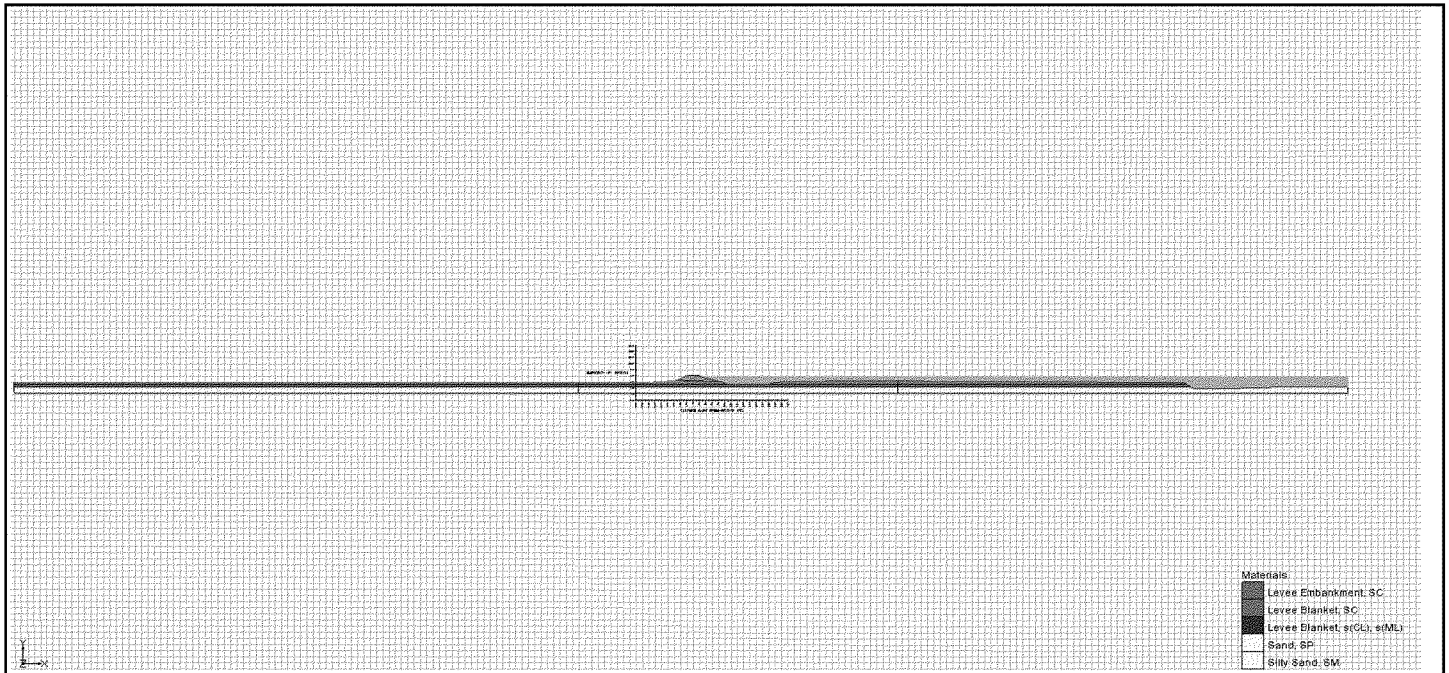
SACRAMENTO, CALIFORNIA

SUTTER BASIN — CALIFORNIA

GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
SUTTER BYPASS, LM_17.3 STATION 293+00
EXISTING CONDITION STABILITY DWSE

28-Jun-2012 | SCALE: AS SHOWN | SHEET 3 OF 3



Seepage and Slope Stability Parameters								
Model Layer No.	Model Layer Name	K_x (ft/day)	K_y (ft/day)	K_x/K_y	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, SC	0.28	0.07	4	115.00	10.00	27.00
2	Blanket, SC	0.28	0.07	4	115.00	10.00	27.00
3	Blanket, s(ML), s(CL)	0.57	0.14	4	120.00	10.00	28.00
4	Aquifer, SP	28.00	2.80	10	125.00	0.00	34.00
5	Aquifer, SM	28.00	2.80	10	125.00	0.00	32.00

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on borings WM0003_002B, 2F-91-7, 5F-73-CD10 (1957 boring)
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 59 ft.

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
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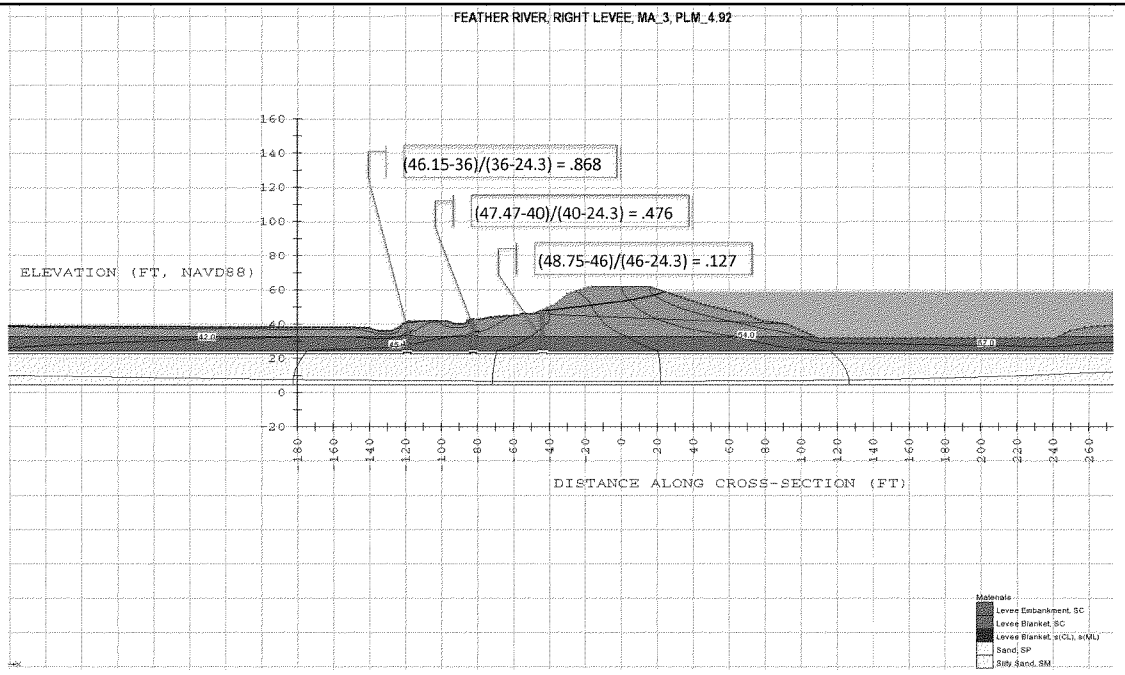
SACRAMENTO, CALIFORNIA

SUTTER BASIN CALIFORNIA

GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
FEATHER RIVER, LM_4.92, STATION 262+00
COMPLETE SUBSURFACE MODEL

28-Jun-2012 | SCALE: AS SHOWN | SHEET 1 of 3



Seepage and Slope Stability Parameters							
Model Layer No.	Model Layer Name	K_h, (ft/day)	K_v (ft/day)	K_h/K_v	γ_{tot} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, SC	0.28	0.07	4	115.00	10.00	27.00
2	Blanket, SC	0.28	0.07	4	115.00	10.00	27.00
3	Blanket, s(ML), s(CL)	0.57	0.14	4	120.00	10.00	28.00
4	Aquifer, SP	28.00	2.80	10	125.00	0.00	34.00
5	Aquifer, SM	28.00	2.80	10	125.00	0.00	32.00

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on borings WM0003_002B, 2F-91-7, SF-73-CD10 (1957 boring)
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 59 ft.

DEPARTMENT OF THE ARMY
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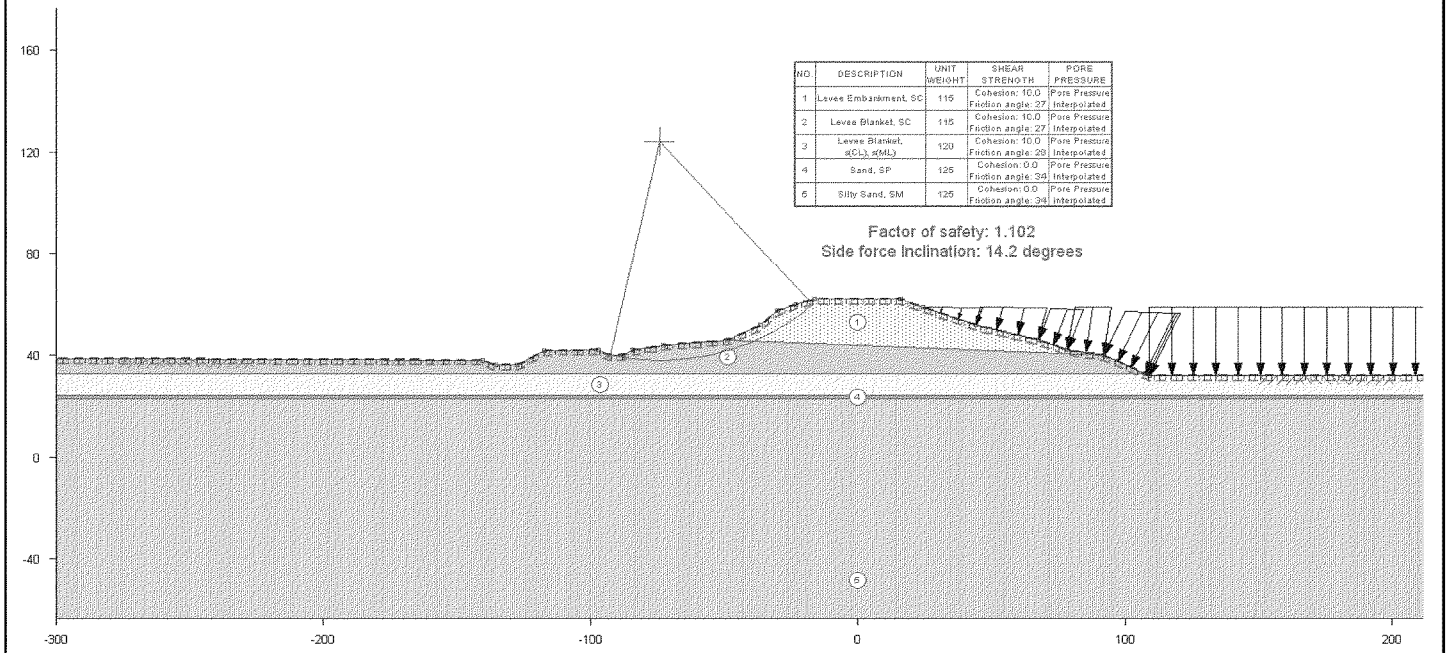
SACRAMENTO, CALIFORNIA

SUTTER BASIN — CALIFORNIA

GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
FEATHER RIVER, LM_4.92, STATION 262+00
EXISTING CONDITION SEEPAGE DWSE

28-Jun-2012	SCALE: AS SHOWN	SHEET 2 OF 3



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, SC	0.28	0.07	4	115.00	10.00	27.00
2	Blanket, SC	0.28	0.07	4	115.00	10.00	27.00
3	Blanket, s(ML), s(CL)	0.57	0.14	4	120.00	10.00	28.00
4	Aquifer, SP	28.00	2.80	10	125.00	0.00	34.00
5	Aquifer, SM	28.00	2.80	10	125.00	0.00	32.00

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on borings WM0003_0028, 2F-91-7, SF-73-CD10 (1957 boring)
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 59 ft.

DEPARTMENT OF THE ARMY
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SACRAMENTO, CALIFORNIA

SUTTER BASIN — CALIFORNIA

GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
FEATHER RIVER, LM_4.92, STATION 262+00
EXISTING CONDITION STABILITY DWSE

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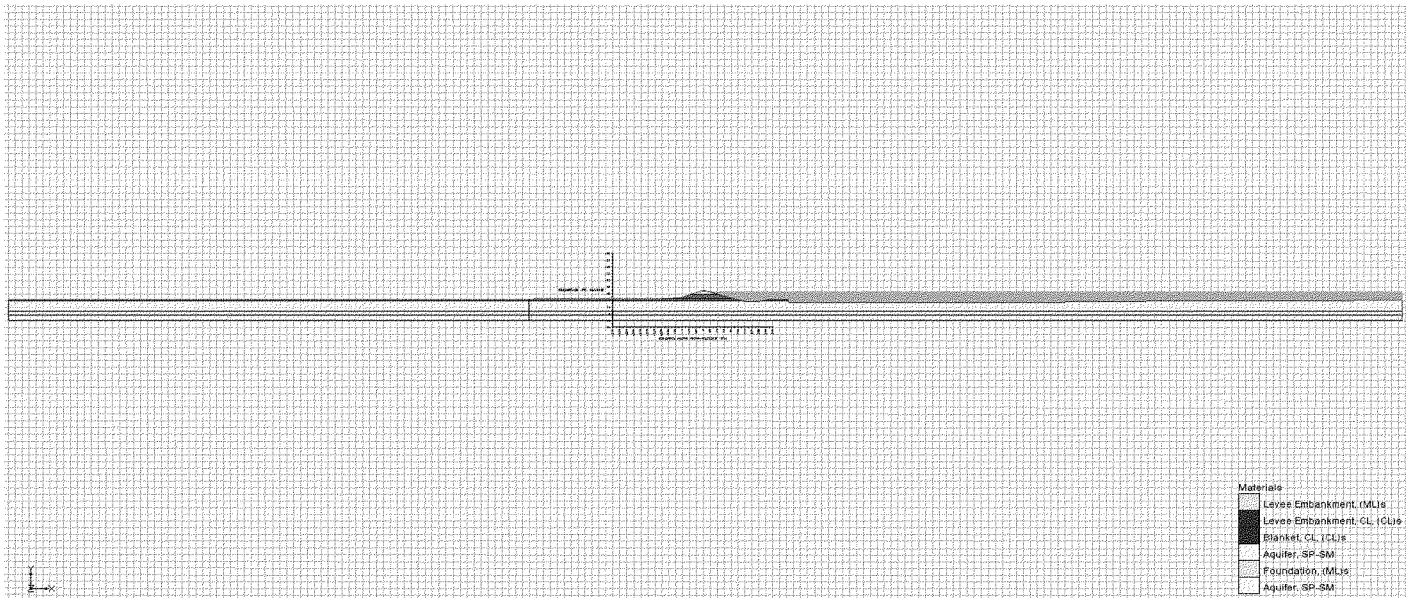

Seepage and Slope Stability Parameters							
Model Layer No.	Model Layer Name	K_x (ft/day)	K_y (ft/day)	K_x/K_y	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, (ML)s	0.57	0.14	4	115	10	28
2	Levee Embankment, CL, (CL)s	0.028	0.007	4	115	200	28
3	Blanket, CL, (CL)s	0.028	0.007	4	115	200	28
4	Aquifer, SP-SM	14.00	1.40	10	125	0	34
5	Foundation, (ML)s	0.57	0.14	4	120	10	28
6	Aquifer, SP-SM	14.00	1.40	10	125	0	34

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WL0001_088B, WL0001_007S
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 68 ft.

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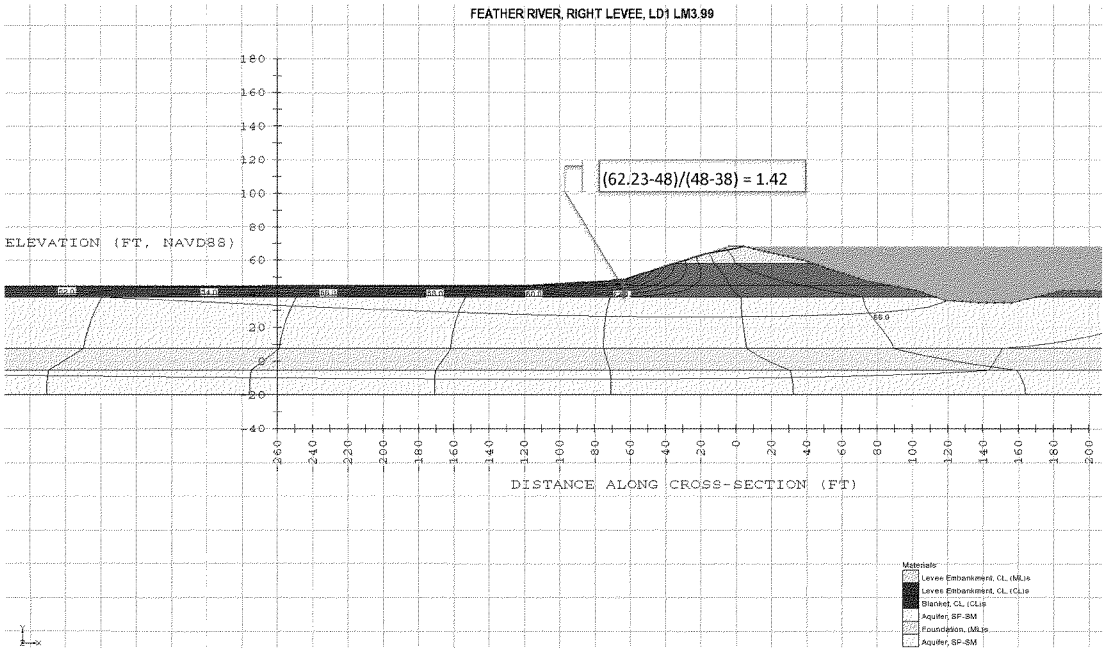
GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
FEATHER RIVER LM_3.99, STA 540+00
COMPLETE SUBSURFACE MODEL

28-Jun-2012 | SCALE: AS SHOWN | SHEET 1 of 3



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, (ML)s	0.57	0.14	4	115	10	28
2	Levee Embankment, CL, (CL)s	0.028	0.007	4	115	200	28
3	Blanket, CL, (CL)s	0.028	0.007	4	115	200	28
4	Aquifer, SP-SM	14.00	1.40	10	125	0	34
5	Foundation, (ML)s	0.57	0.14	4	120	10	28
6	Aquifer, SP-SM	14.00	1.40	10	125	0	34

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WL0001_088B, WL0001_007S
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 68 ft.

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SACRAMENTO DISTRICT
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SACRAMENTO, CALIFORNIA

SUTTER BASIN — CALIFORNIA

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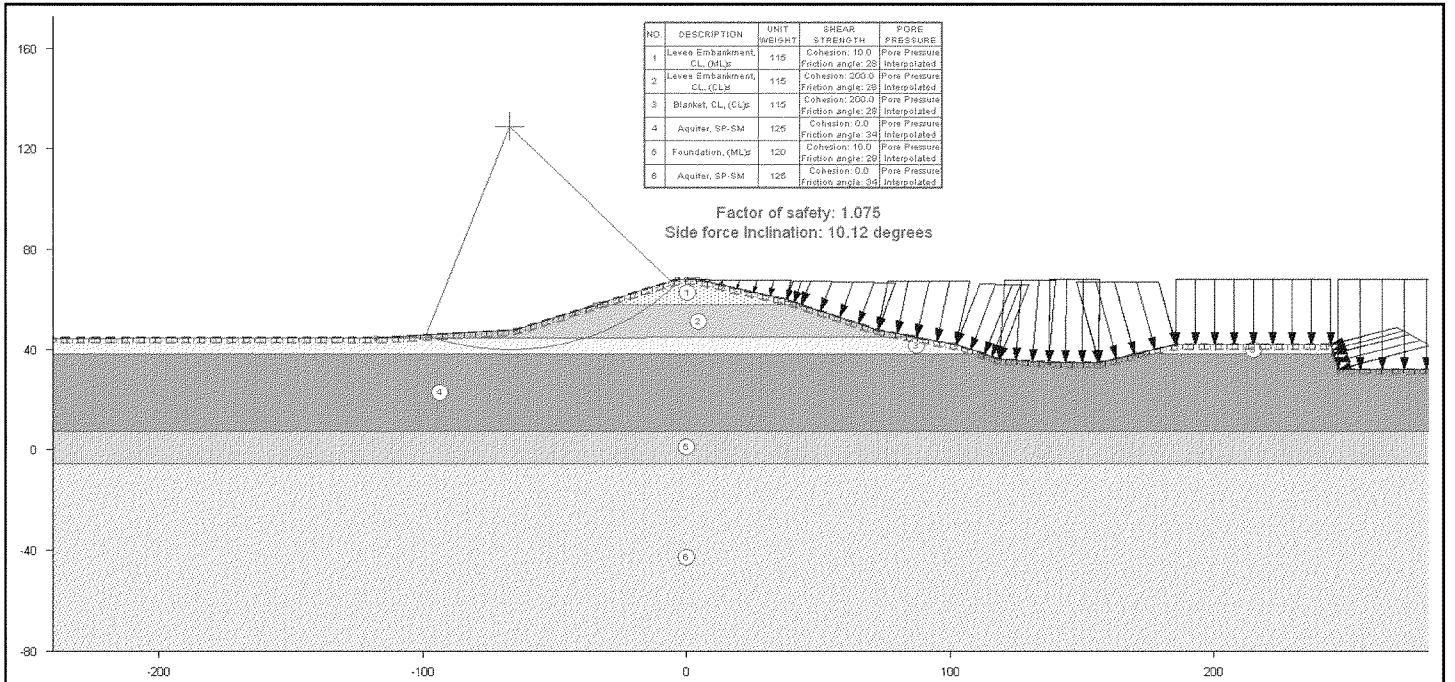
SEEPAGE AND STABILITY ANALYSIS
FEATHER RIVER LM_3.99, STA 540+00
EXISTING CONDITION SEEPAGE DWSE

28-Jun-2012 | SCALE: AS SHOWN | SHEET 2 OF 3



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{wet} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, (ML)s	0.57	0.14	4	115	10	28
2	Levee Embankment, CL, (CL)s	0.028	0.007	4	115	200	28
3	Blanket, CL, (CL)s	0.028	0.007	4	115	200	28
4	Aquifer, SP-SM	14.00	1.40	10	125	0	34
5	Foundation, (ML)s	0.57	0.14	4	120	10	28
6	Aquifer, SP-SM	14.00	1.40	10	125	0	34

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WL0001_088B, WL0001_0075
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 68 ft.

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CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

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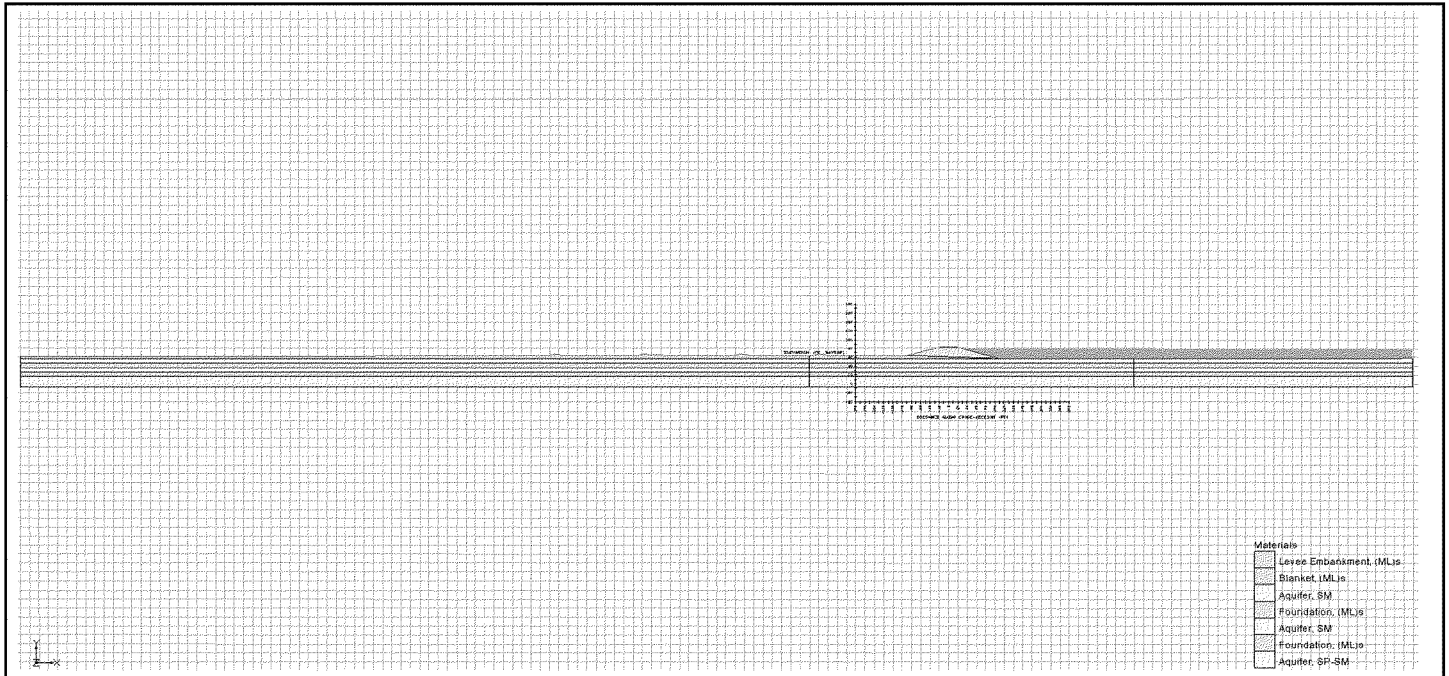
GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
FEATHER RIVER LM_3.99, STA 540+00
EXISTING CONDITION STABILITY DWSE

28-Jun-2012 | SCALE: AS SHOWN | SHEET 3 OF 3



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, (ML)s	0.57	0.14	4	115	50	28
2	Blanket, (ML)s	0.570	0.140	4	115	50	28
3	Aquifer, SM	2.800	0.710	4	125	0	32
4	Foundation, (ML)s	0.57	0.14	4	120	50	28
5	Aquifer, SM	2.80	0.71	4	125	0	32
6	Foundation, (ML)s	0.57	0.14	4	120	50	28
7	Aquifer, SP-SM	14	1.4	10	125	0	34

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring 2F-07-05 & 2F-07-06
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 79.6 ft.

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SACRAMENTO, CALIFORNIA

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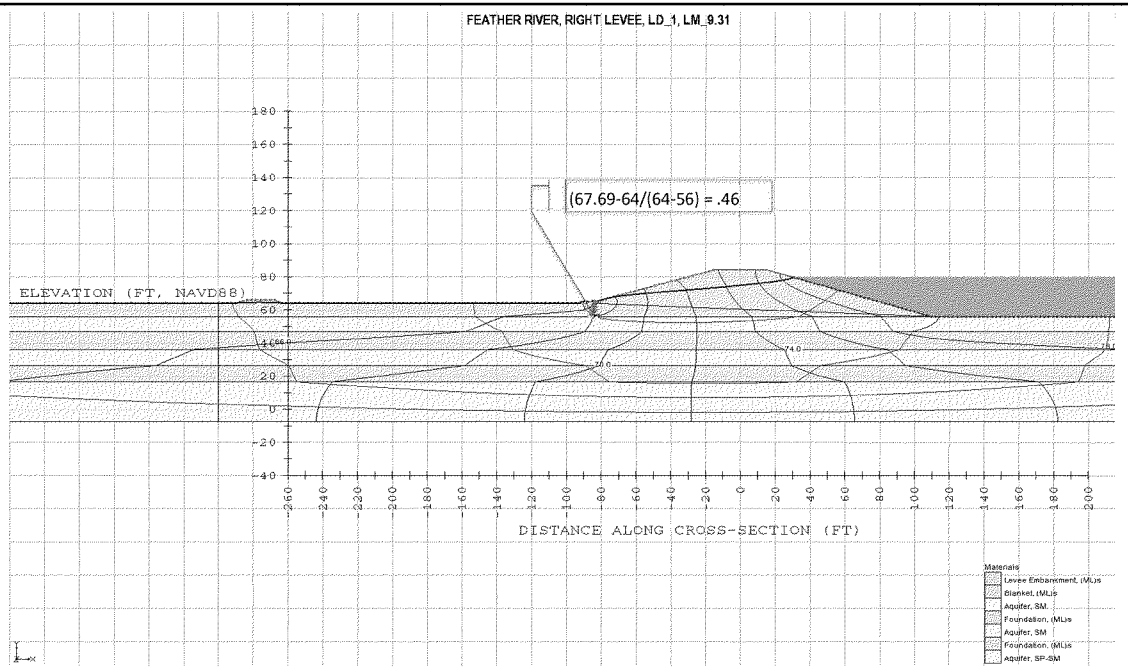
GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
FEATHER RIVER, LM_9.31, STA 1108+86
COMPLETE SUBSURFACE MODEL

28-Jun-2012 | SCALE: AS SHOWN | SHEET 1 of 3



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{wet} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, (ML)s	0.57	0.14	4	115	50	28
2	Blanket, (ML)s	0.570	0.140	4	115	50	28
3	Aquifer, SM	2.800	0.710	4	125	0	32
4	Foundation, (ML)s	0.57	0.14	4	120	50	28
5	Aquifer, SM	2.80	0.71	4	125	0	32
6	Foundation, (ML)s	0.57	0.14	4	120	50	28
7	Aquifer, SP-SM	14	1.4	10	125	0	34

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring 2F-07-05 & 2F-07-06
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 79.6 ft.

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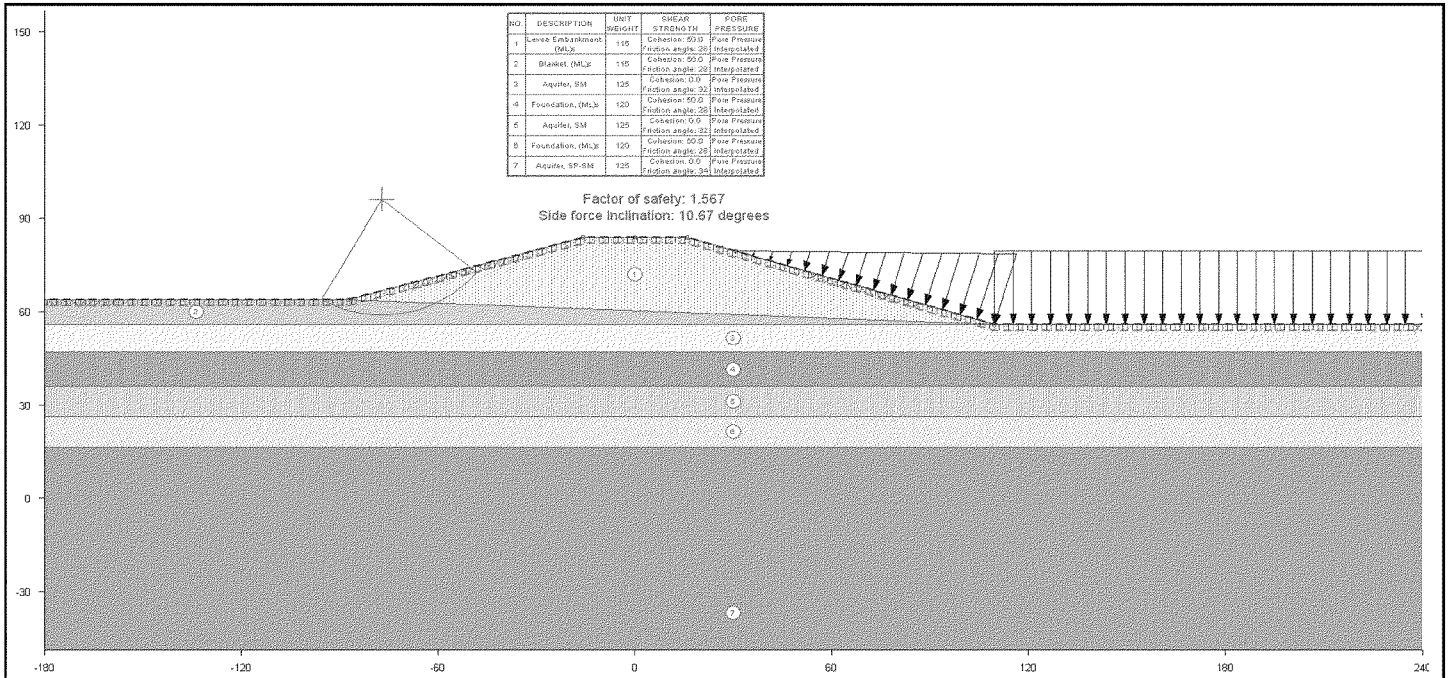
GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
FEATHER RIVER, LM_9.31, STA 1108+86
EXISTING CONDITION SEEPAGE DWSE

28-Jun-2012 | SCALE: AS SHOWN | SHEET 2 OF 3



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{wet} (pcf)	C' (psf)	ϕ'
1	Levee Embankment, (ML)s	0.57	0.14	4	115	50	28
2	Blanket, (ML)s	0.570	0.140	4	115	50	28
3	Aquifer, SM	2.800	0.710	4	125	0	32
4	Foundation, (ML)s	0.57	0.14	4	120	50	28
5	Aquifer, SM	2.80	0.71	4	125	0	32
6	Foundation, (ML)s	0.57	0.14	4	120	50	28
7	Aquifer, SP-SM	14	1.4	10	125	0	34

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring 2F-07-05 & 2F-07-06
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 79.6 ft.

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SACRAMENTO DISTRICT
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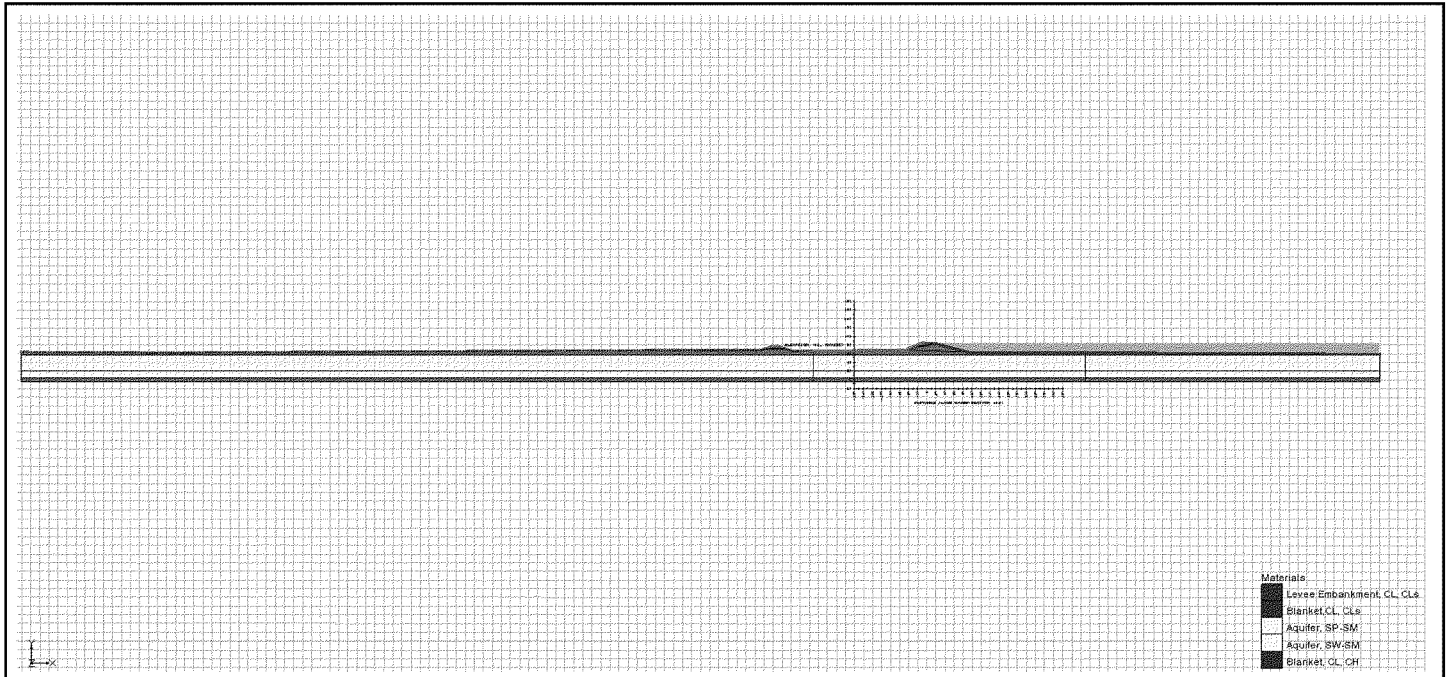
GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
FEATHER RIVER, LM_9.31, STA 1108+86
EXISTING CONDITION STABILITY DWSE

28-Jun-2012 | SCALE: AS SHOWN | SHEET 3 OF 3



Seepage and Slope Stability Parameters							
Model Layer No.	Model Layer Name	K_H (ft/day)	K_V (ft/day)	K_H/K_V	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment CL CLs	0.028	0.007	4	115.00	150	28.00
2	Blanket CL CLs	0.028	0.007	4	115.00	150	28.00
3	Aquifer SP-SM	14.00	1.40	10	125.00	0	34.00
4	Aquifer SW-SM	14.00	1.40	10	125.00	0	34.00
5	Blanket CL CH	0.028	0.007	4	115.00	150	28.00

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WL0009_001S, WL0009_007A
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 84 ft.

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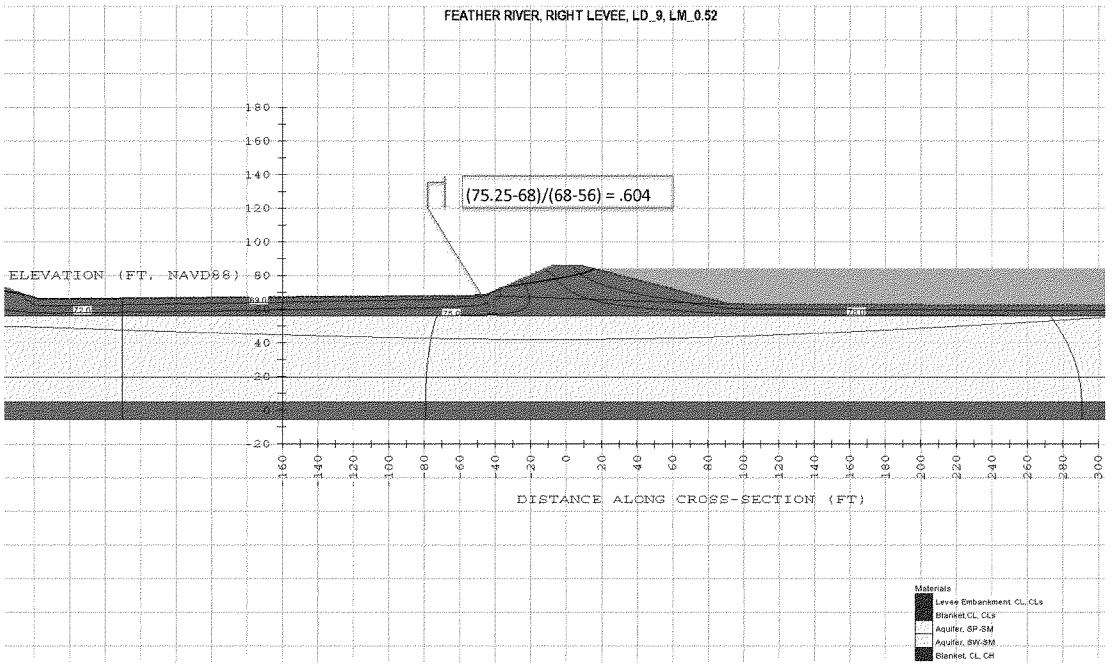
GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
FEATHER RIVER, LM_9, STATION 1138+68
COMPLETE SUBSURFACE MODEL

28-Jun-2012 | SCALE: AS SHOWN | SHEET 1 of 3



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	φ'
1	Levee Embankment CL CLs	0.028	0.007	4	115.00	150	28.00
2	Blanket CL CLs	0.028	0.007	4	115.00	150	28.00
3	Aquifer SP-SM	14.00	1.40	10	125.00	0	34.00
4	Aquifer SW-SM	14.00	1.40	10	125.00	0	34.00
5	Blanket CL CH	0.028	0.007	4	115.00	150	28.00

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WL0009_001S, WL0009_007A
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 84 ft.

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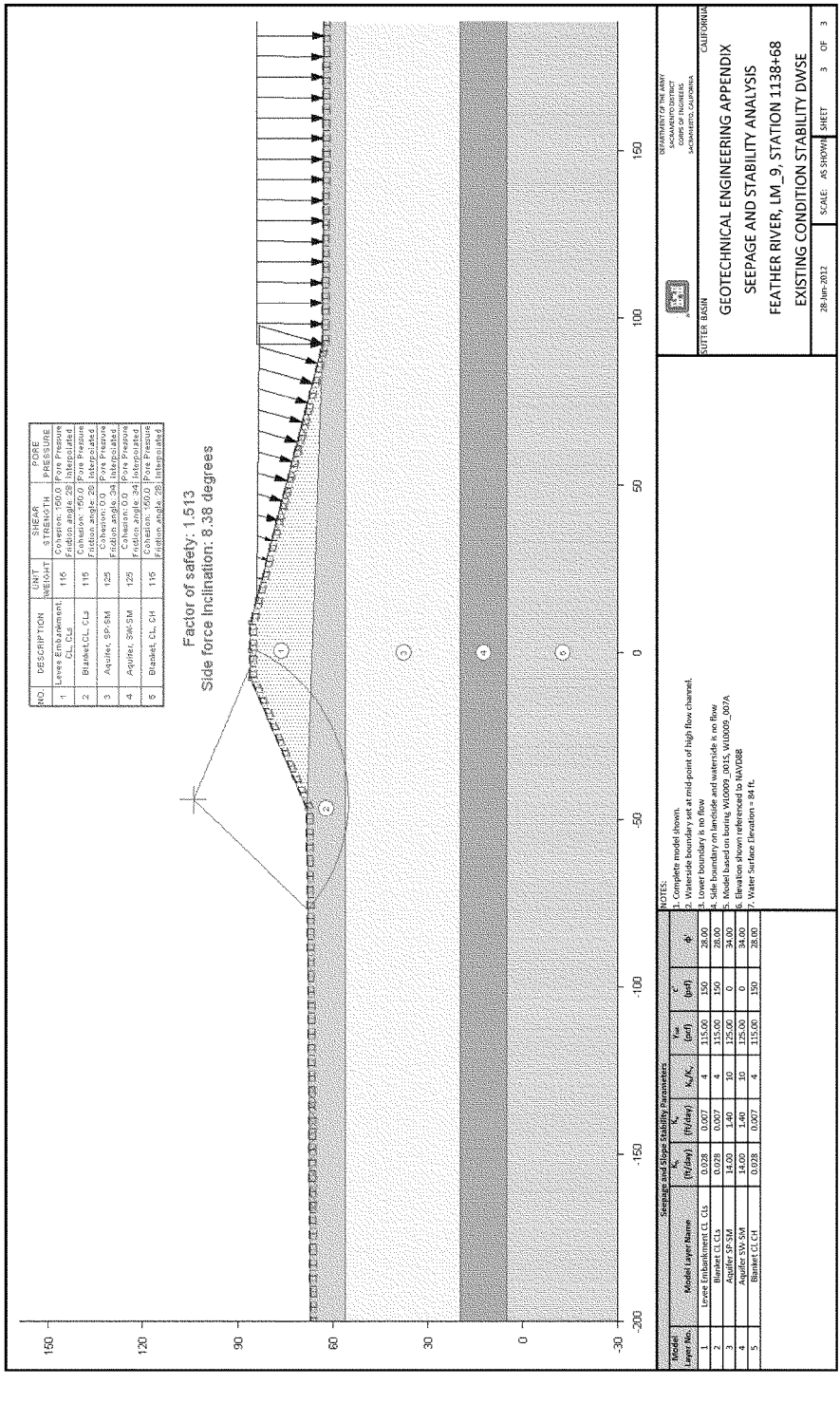
SEEPAGE AND STABILITY ANALYSIS
FEATHER RIVER, LM_9, STATION 1138+68
EXISTING CONDITION SEEPAGE DWSE

28-Jun-2012 | SCALE: AS SHOWN | SHEET 2 OF 3


NO.
DESCRIPTION
UNIT WEIGHT
SHEAR STRENGTH
PORE PRESSURE
1
Levee Embankment CL, CLs
115
Cohesion=160.0 Friction angle=28 Interpolated
Cohesion=160.0 Friction angle=28 Interpolated
2
Blanket,CL, CLs
115
Cohesion=160.0 Friction angle=28 Interpolated
Cohesion=160.0 Friction angle=28 Interpolated
3
Aquifer, SP-SM
125
Cohesion:0.0 Friction angle: 34 Interpolated
Cohesion:0.0 Friction angle: 34 Interpolated
4
Aquifer, SW-SM
125
Cohesion:0.0 Friction angle: 34 Interpolated
Cohesion:0.0 Friction angle: 34 Interpolated
5
Blanket, CL, CH
115
Cohesion=160.0 Friction angle=28 Interpolated
Cohesion=160.0 Friction angle=28 Interpolated
Factor of safety: 1.513
Side force Inclination: 8.38 degrees
150
120
90
60
30
0
-30
-200
-150
-100
-50
0
50
100
150
Model Layer No.
Seepage and Slope Stability Parameters
Model Layer Name
K_h (ft/day)
K_v (ft/day)
K_h/K_v
γ_{sat} (pcf)
c' (psf)
ϕ'
1
Levee Embankment CL, CLs
0.028
0.007
4
115.00
150
28.00
2
Blanket CL, CLs
0.028
0.007
4
115.00
150
28.00
3
Aquifer SP-SM
14.00
1.40
10
125.00
0
34.00
4
Aquifer SW-SM
14.00
1.40
10
125.00
0
34.00
5
Blanket CL,CH
0.028
0.007
4
115.00
150
28.80
NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring W10009_0015, W10009_007A
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 84 ft.
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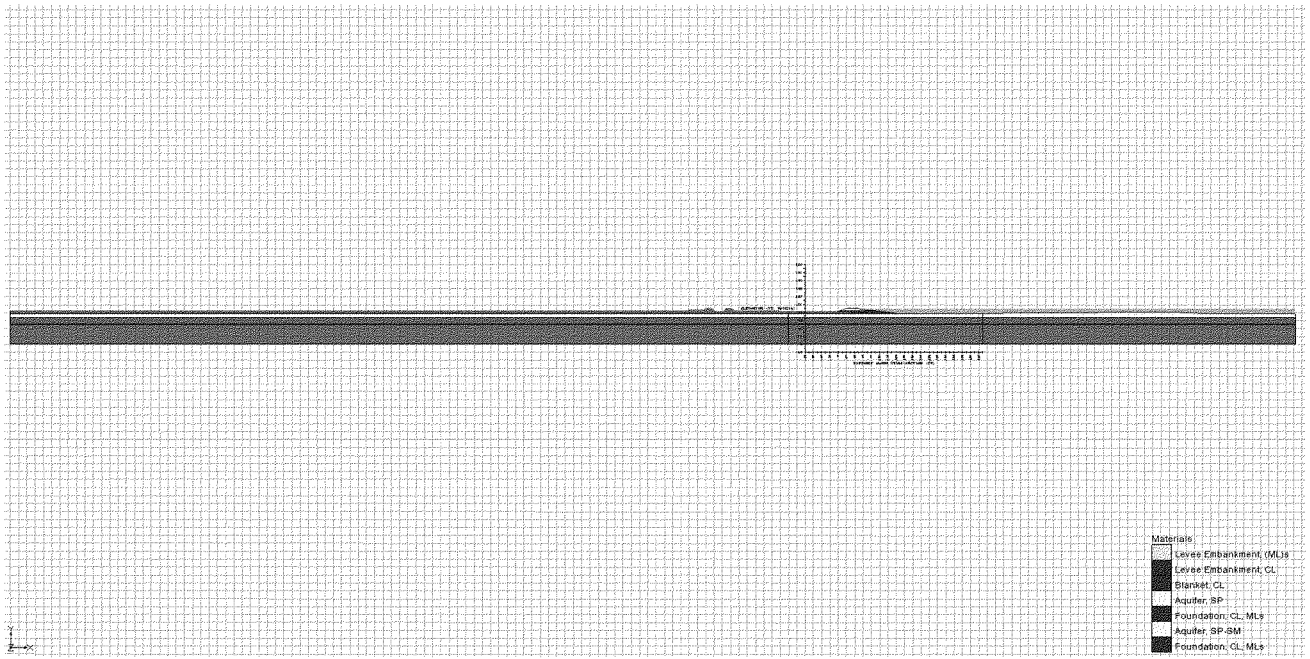
SACRAMENTO, CALIFORNIA
SUTTER BASIN
CALIFORNIA
GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
FEATHER RIVER, LM_9, STATION 1138+68
EXISTING CONDITION STABILITY DWSE
28-Jan-2012
SCALE: AS SHOWN
SHEET
3
OF
3



Seepage and Slope Stability Parameters								
Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, (ML)s	0.57	0.14	4	115	10	28
2	Levee Embankment, CL	0.028	0.007	4	115	150	28
3	Blanket, CL	0.028	0.007	4	115	150	28
4	Aquifer, SP	28.00	2.80	10	125	0	34
5	Foundation, CL, MLs	0.57	0.14	4	120	150	29
6	Aquifer, SP-SM	14.00	1.40	10	125	0	32
7	Foundation, CL, MLs	0.57	0.14	4	120	150	28

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WM0016_011B
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 88.79 ft.

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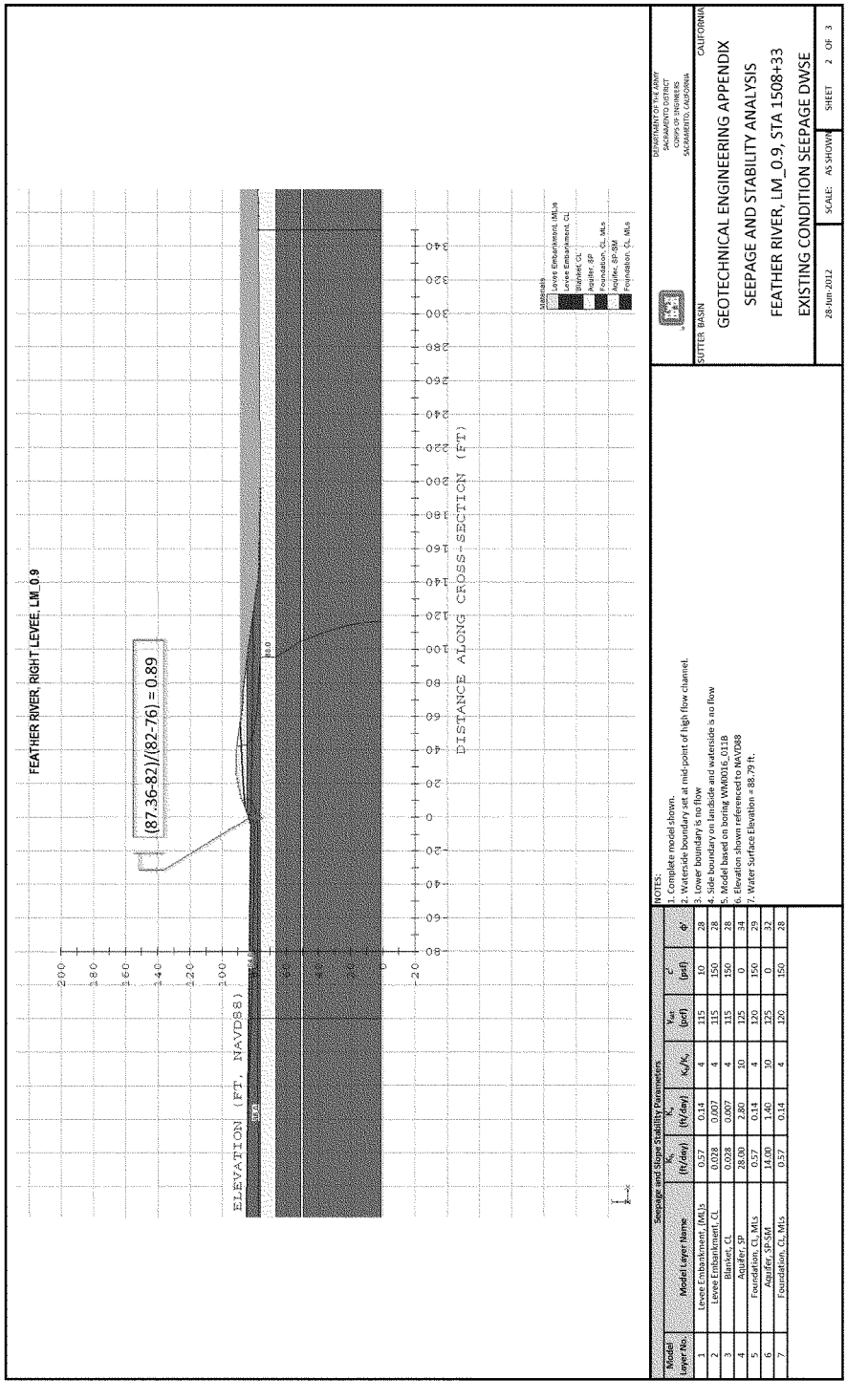
GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
FEATHER RIVER, LM_0.9, STA 1508+33
COMPLETE SUBSURFACE MODEL

28-Jun-2012 | SCALE: AS SHOWN | SHEET 1 of 3



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	k_h (ft/day)	k_v (ft/day)	k_h/k_v	γ_{wet} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, (ML)s	0.57	0.14	4	115	10	28
2	Levee Embankment, CL	0.028	0.007	4	115	150	28
3	Blanket, CL	0.028	0.007	4	115	150	28
4	Aquifer, SP	28.00	2.80	10	125	0	34
5	Foundation, CL, MLs	0.57	0.14	4	120	150	29
6	Aquifer, SP-SM	14.00	1.40	10	125	0	32
7	Foundation, CL, MLs	0.57	0.14	4	120	150	28

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WM0016_012B
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 88.79 ft.

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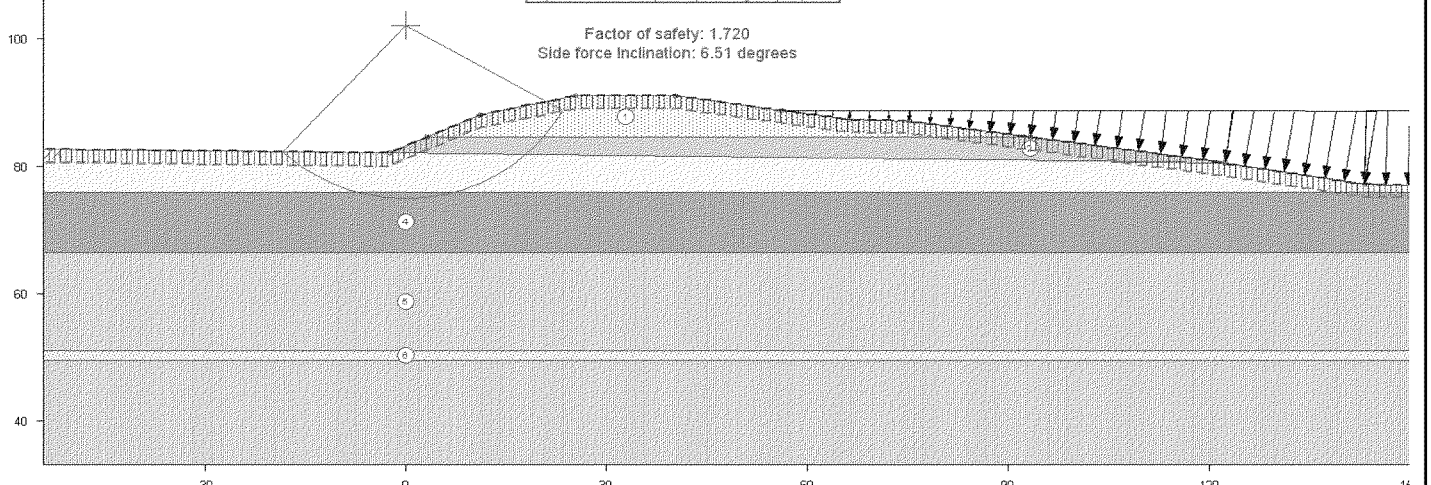
FEATHER RIVER, LM_0.9, STA 1508+33
EXISTING CONDITION SEEPAGE DWSE

28 Jun 2012 | SCALE: AS SHOWN | SHEET 2 OF 3

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Levee Embankment, (ML)s	115	Cohesion: 10.0 Friction angle: 28	Pore Pressure Interpolated
2	Levee Embankment, CL	115	Cohesion: 150.0 Friction angle: 28	Pore Pressure Interpolated
3	Blanket, CL	115	Cohesion: 150.0 Friction angle: 28	Pore Pressure Interpolated
4	Aquifer, SP	125	Cohesion: 0.0 Friction angle: 34	Pore Pressure Interpolated
5	Foundation, CL, ML	120	Cohesion: 150.0 Friction angle: 29	Pore Pressure Interpolated
6	Aquifer, SP-SM	125	Cohesion: 0.0 Friction angle: 32	Pore Pressure Interpolated



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, (ML)s	0.57	0.14	4	115	10	28
2	Levee Embankment, CL	0.028	0.007	4	115	150	28
3	Blanket, CL	0.028	0.007	4	115	150	28
4	Aquifer, SP	28.00	2.80	10	125	0	34
5	Foundation, CL, MLs	0.57	0.14	4	120	150	29
6	Aquifer, SP-SM	14.00	1.40	10	125	0	32
7	Foundation, CL, MLs	0.57	0.14	4	120	150	28

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WM0016_011B
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 88.79 ft.

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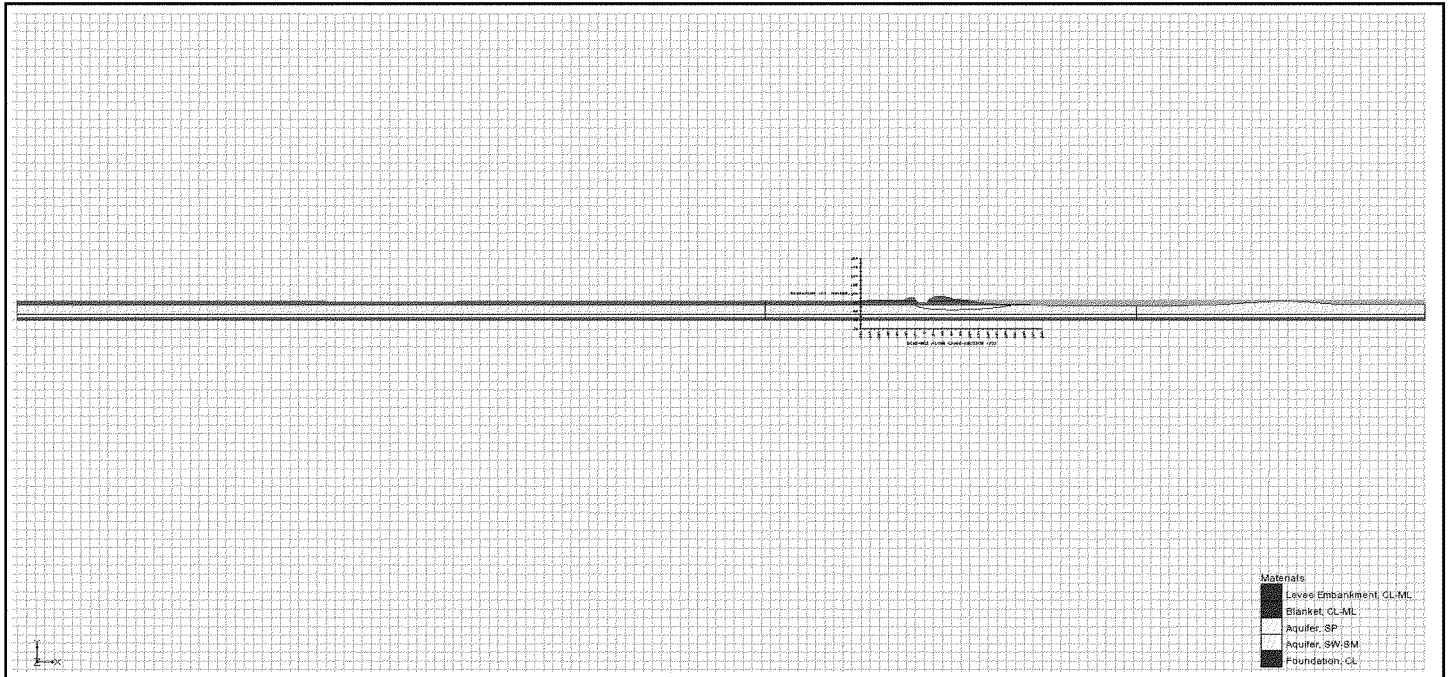
SEEPAGE AND STABILITY ANALYSIS
FEATHER RIVER, LM_0.9, STA 1508+33
EXISTING CONDITION STABILITY DWSE

28-Jun-2012 | SCALE: AS SHOWN | SHEET 3 OF 3



Seepage and Slope Stability Parameters								
Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, CL-ML	0.57	0.14	4	115.00	50.00	28.00
2	Blanket, CL-ML	0.570	0.140	4	115.00	50.00	28.00
3	Aquifer, SW-SM	14.00	1.40	10	125.00	0.00	32.00
4	Aquifer, SP	28.000	2.8	10	125.00	0.00	34.00
5	Aquifer, SW-SM	14.00	1.40	10	125.00	0.00	32.00
6	Foundation, CL	0.03	0.007	4	120.00	100.00	28.00

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WM0016_019S, WM0016-020B
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 87.4 ft.

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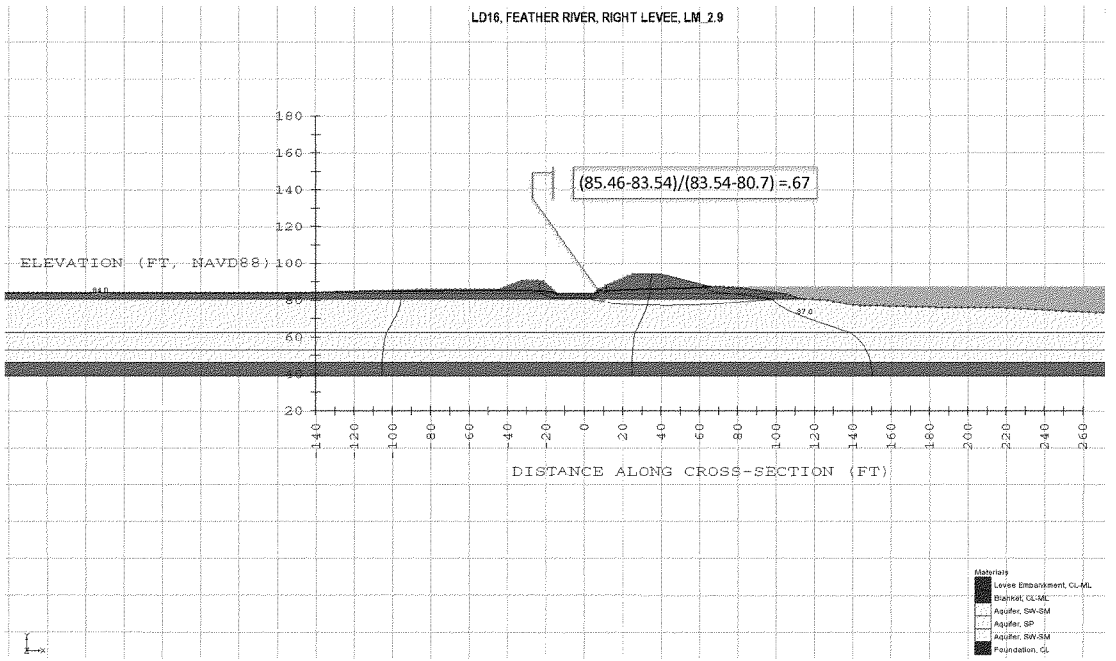
GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
FEATHER RIVER STATION 1615+62
COMPLETE SUBSURFACE MODEL

28-Jun-2012	SCALE: AS SHOWN	SHEET 1 of 3



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, CL-ML	0.57	0.14	4	115.00	50.00	28.00
2	Blanket, CL-ML	0.570	0.140	4	115.00	50.00	28.00
3	Aquifer, SW-SM	14.00	1.40	10	125.00	0.00	32.00
4	Aquifer, SP	28.000	2.8	10	125.00	0.00	34.00
5	Aquifer, SW-SM	14.00	1.40	10	125.00	0.00	32.00
6	Foundation, CL	0.03	0.007	4	120.00	100.00	28.00

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WM0016_0195, WM0016-020B
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 87.4 ft.

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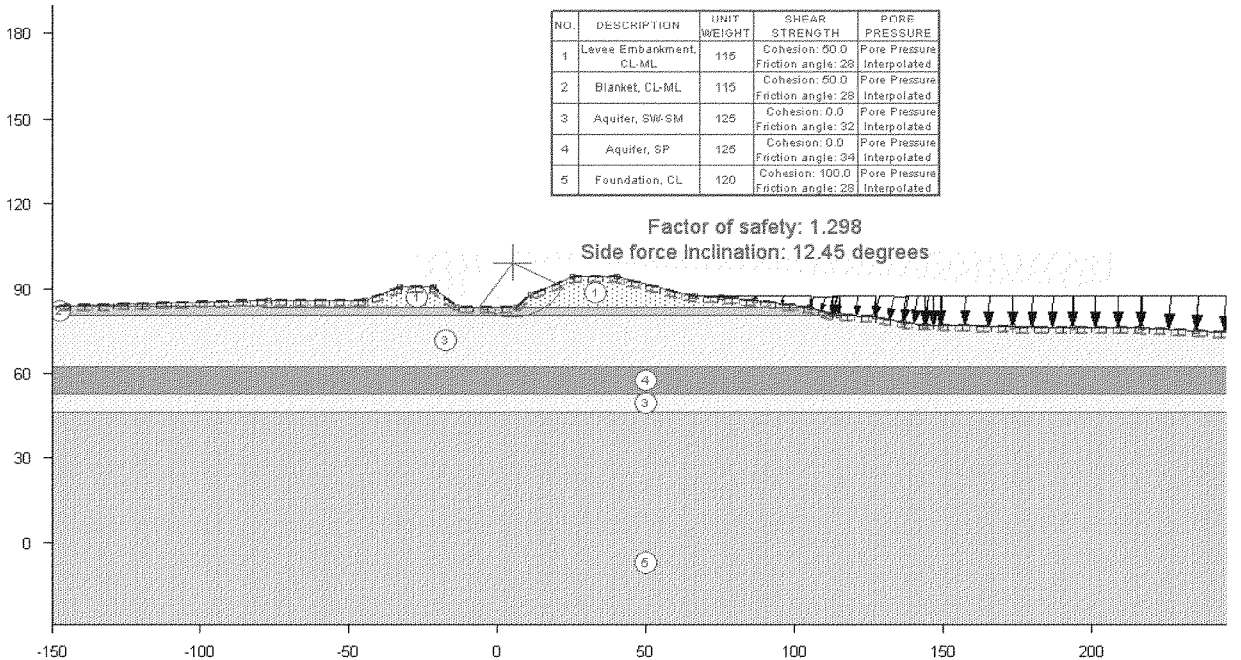
FEATHER RIVER STATION 1615+62
EXISTING CONDITION SEEPAGE DWSE

28-Jun-2012 | SCALE: AS SHOWN | SHEET 2 OF 3

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Levee Embankment, CL-ML	115	Cohesion: 50.0 Friction angle: 28	Pore Pressure Interpolated
2	Blanket, CL-ML	115	Cohesion: 50.0 Friction angle: 28	Pore Pressure Interpolated
3	Aquifer, SW-SM	125	Cohesion: 0.0 Friction angle: 32	Pore Pressure Interpolated
4	Aquifer, SP	125	Cohesion: 0.0 Friction angle: 34	Pore Pressure Interpolated
5	Foundation, CL	120	Cohesion: 100.0 Friction angle: 28	Pore Pressure Interpolated



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	C' (psf)	ϕ'
1	Levee Embankment, CL-ML	0.57	0.14	4	115.00	50.00	28.00
2	Blanket, CL-ML	0.570	0.140	4	115.00	50.00	28.00
3	Aquifer, SW-SM	14.00	1.40	10	125.00	0.00	32.00
4	Aquifer, SP	28.000	2.8	10	125.00	0.00	34.00
5	Aquifer, SW-SM	14.00	1.40	10	125.00	0.00	32.00
6	Foundation, CL	0.03	0.007	4	120.00	100.00	28.00

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WM0016_019S, WM0016-020B
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 87.4 ft.

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SACRAMENTO DISTRICT
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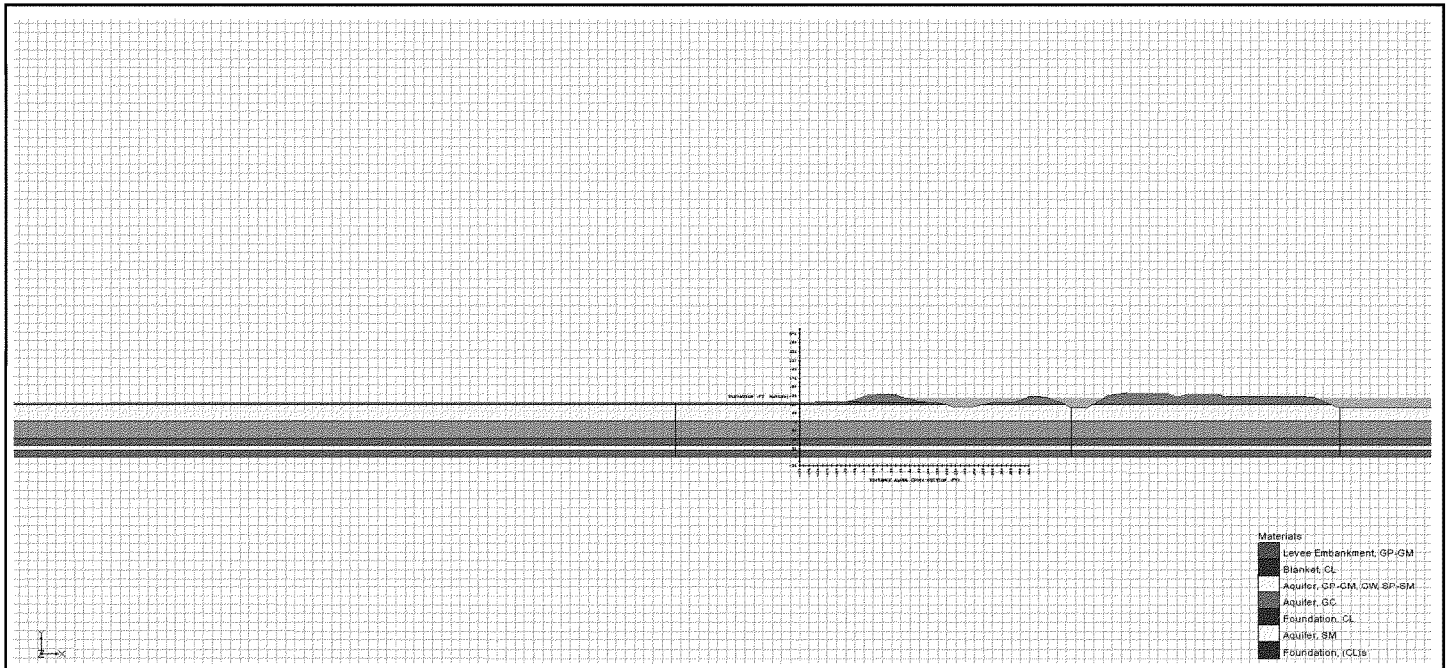
SACRAMENTO, CALIFORNIA

SUTTER BASIN CALIFORNIA

GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
FEATHER RIVER STATION 1615+62
EXISTING CONDITION STABILITY DWSE

28-Jun-2012 | SCALE: AS SHOWN | SHEET 3 OF 3



Seepage and Slope Stability Parameters								
Model Layer No.	Model Layer Name	K_x (ft/day)	K_y (ft/day)	K_x/K_y	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, GP-GM	14.0	1.4	10	125.00	0.00	34.00
2	Blanket, CL	0.028	0.007	4	115.00	150.00	28.00
3	Aquifer, GP-GM, GW, SP-SM	14.0	1.4	10	125.00	0.00	34.00
4	Aquifer, GC	2.80	0.71	4	135.00	0.00	35.00
5	Foundation, CL	0.03	0.01	4	115.00	150.00	28.00
6	Aquifer, SM	1.40	0.35	4	125.00	0.00	32.00
7	Foundation, (CL)s	0.028	0.007	4	115.00	150.00	28.00

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on borings WL0007_0725, WL0007_014S
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 130 ft.

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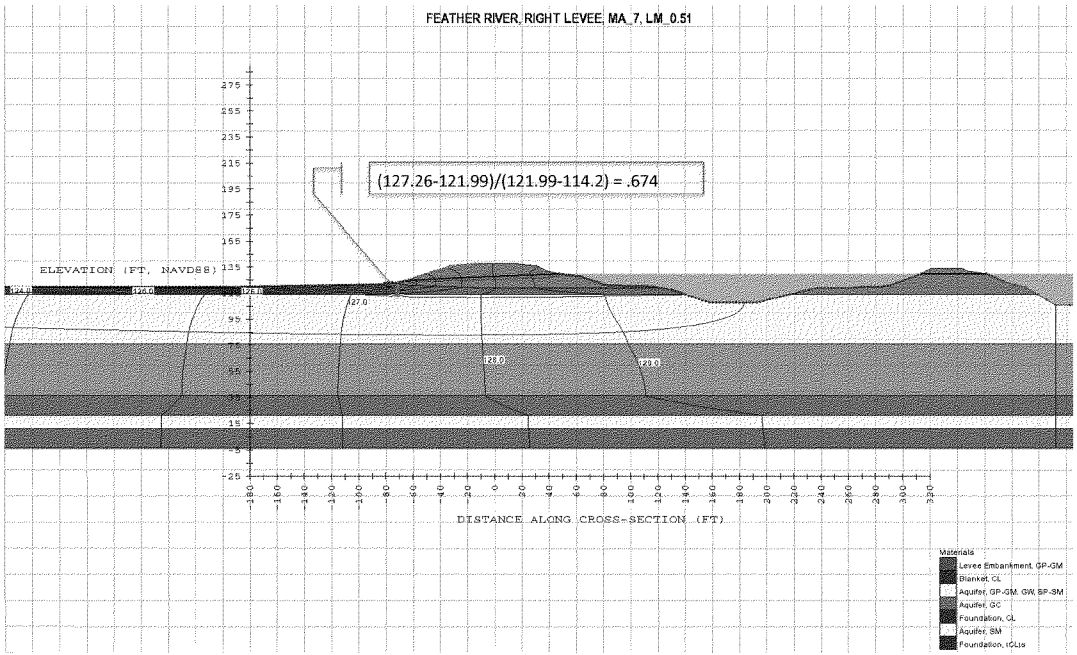
SUTTER BASIN — CALIFORNIA

GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
FEATHER RIVER, LM_0.51, STATION 2332+91
COMPLETE SUBSURFACE MODEL

28-Jun-2012 | SCALE: AS SHOWN | SHEET 1 of 3



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{wet} (pcf)	c' (psf)	ϕ'
1	Levee Embankment, GP-GM	14.0	1.4	10	125.00	0.00	34.00
2	Blanket, CL	0.028	0.007	4	115.00	150.00	28.00
3	Aquifer, GP-GM, GW, SP-SM	14.0	1.4	10	125.00	0.00	34.00
4	Aquifer, GC	2.80	0.71	4	135.00	0.00	35.00
5	Foundation, CL	0.03	0.01	4	115.00	150.00	28.00
6	Aquifer, SM	1.40	0.35	4	125.00	0.00	32.00
7	Foundation, (CL)s	0.028	0.007	4	115.00	150.00	28.00

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on borings WL0007_072S, WL0007_014S
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 130 ft.

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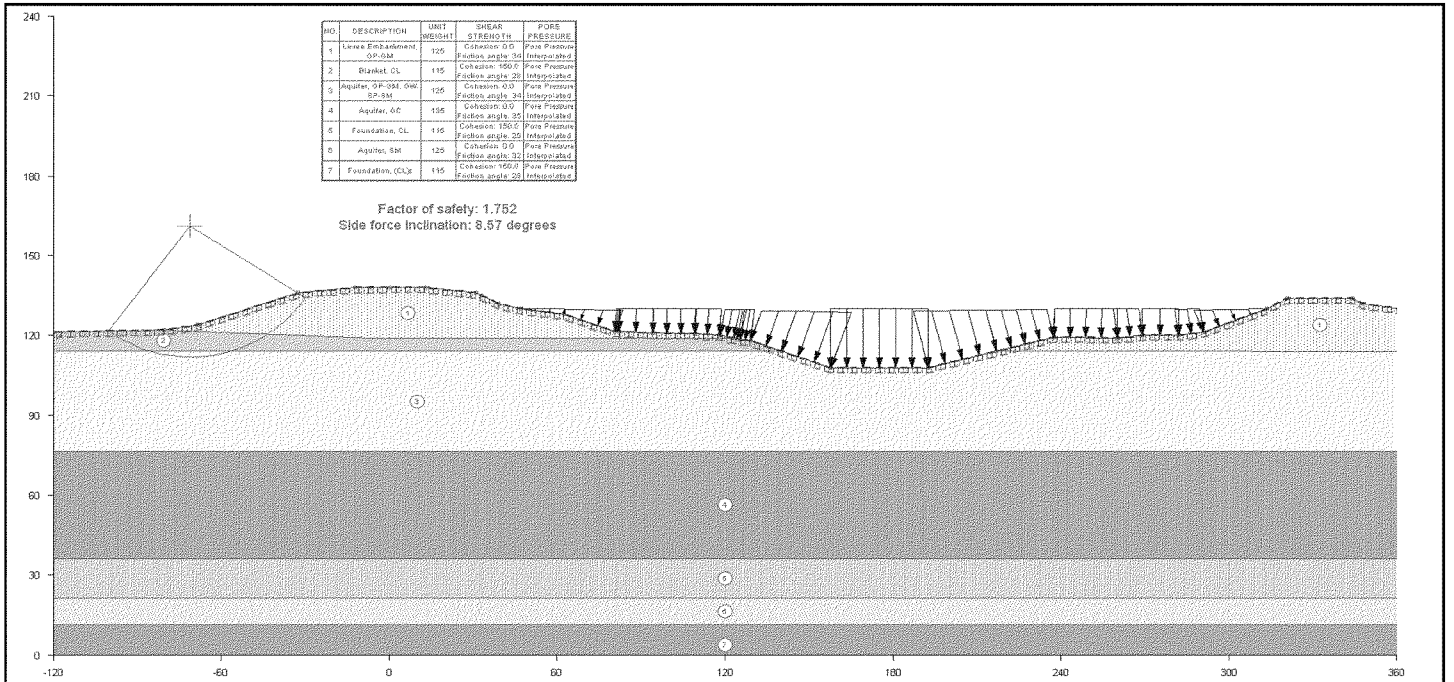
GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
FEATHER RIVER, LM_0.51, STATION 2332+91
EXISTING CONDITION SEEPAGE DWSE

28-Jun-2012 | SCALE: AS SHOWN | SHEET 2 OF 3



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	C' (psf)	ϕ'
1	Levee Embankment, GP-GM	14.0	1.4	10	125.00	0.00	34.00
2	Blanket, CL	0.028	0.007	4	115.00	150.00	28.00
3	Aquifer, GP-GM, GW, SP-SM	14.0	1.4	10	125.00	0.00	34.00
4	Aquifer, GC	2.80	0.71	4	135.00	0.00	35.00
5	Foundation, CL	0.03	0.01	4	115.00	150.00	28.00
6	Aquifer, SM	1.40	0.35	4	125.00	0.00	32.00
7	Foundation, (CL)s	0.028	0.007	4	115.00	150.00	28.00

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on borings WL0007_0725, WL0007_0145
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 130 ft.

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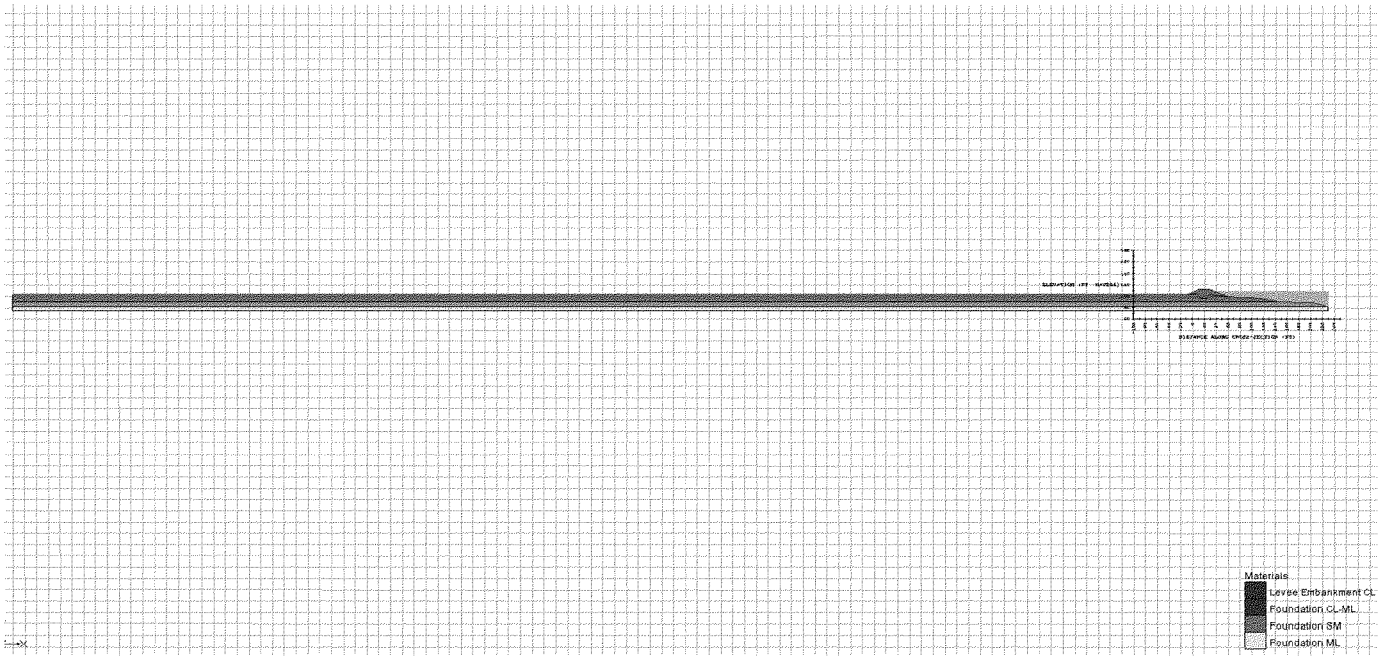
GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
FEATHER RIVER, LM_0.51, STATION 2332+91
EXISTING CONDITION STABILITY DWSE

28-Jun-2012 | SCALE: AS SHOWN | SHEET 3 OF 3



Seepage and Slope Stability Parameters							
Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	Φ'
1	Levee Embankment CL	0.028	0.0071	4	115	150	28
2	Foundation CL-ML	0.028	0.0071	4	115	150	28
3	Foundation SM	2.8	0.71	4	120	0	32
4	Foundation ML	0.14	0.035	4	120	0	31

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring 2F-08-34
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 109 ft.

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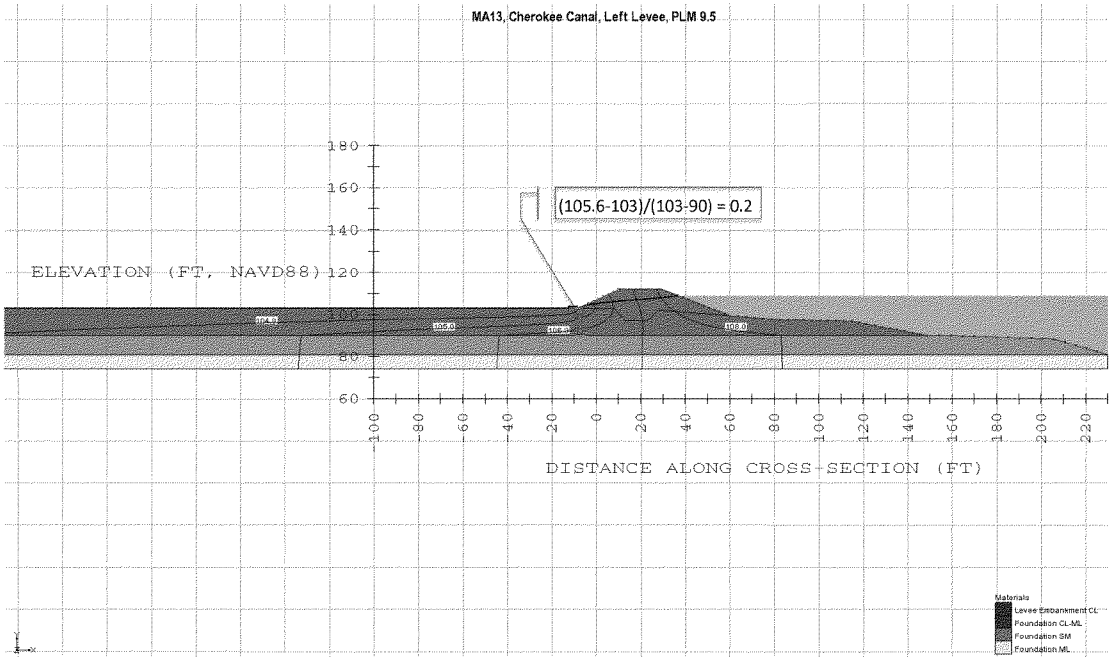
SUTTER BASIN — CALIFORNIA

GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
CHEROKEE CANAL-LEFT LEVEE, PLM 9.5
COMPLETE SUBSURFACE MODEL

28-Jun-2012 | SCALE: AS SHOWN | SHEET 1 of 3



Seepage and Slope Stability Parameters							
Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Embankment CL	0.028	0.0071	4	115	150	28
2	Foundation CL-ML	0.028	0.0071	4	115	150	28
3	Foundation SM	2.8	0.71	4	120	0	32
4	Foundation ML	0.14	0.035	4	120	0	31

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring 2F-08-34
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 109 ft.

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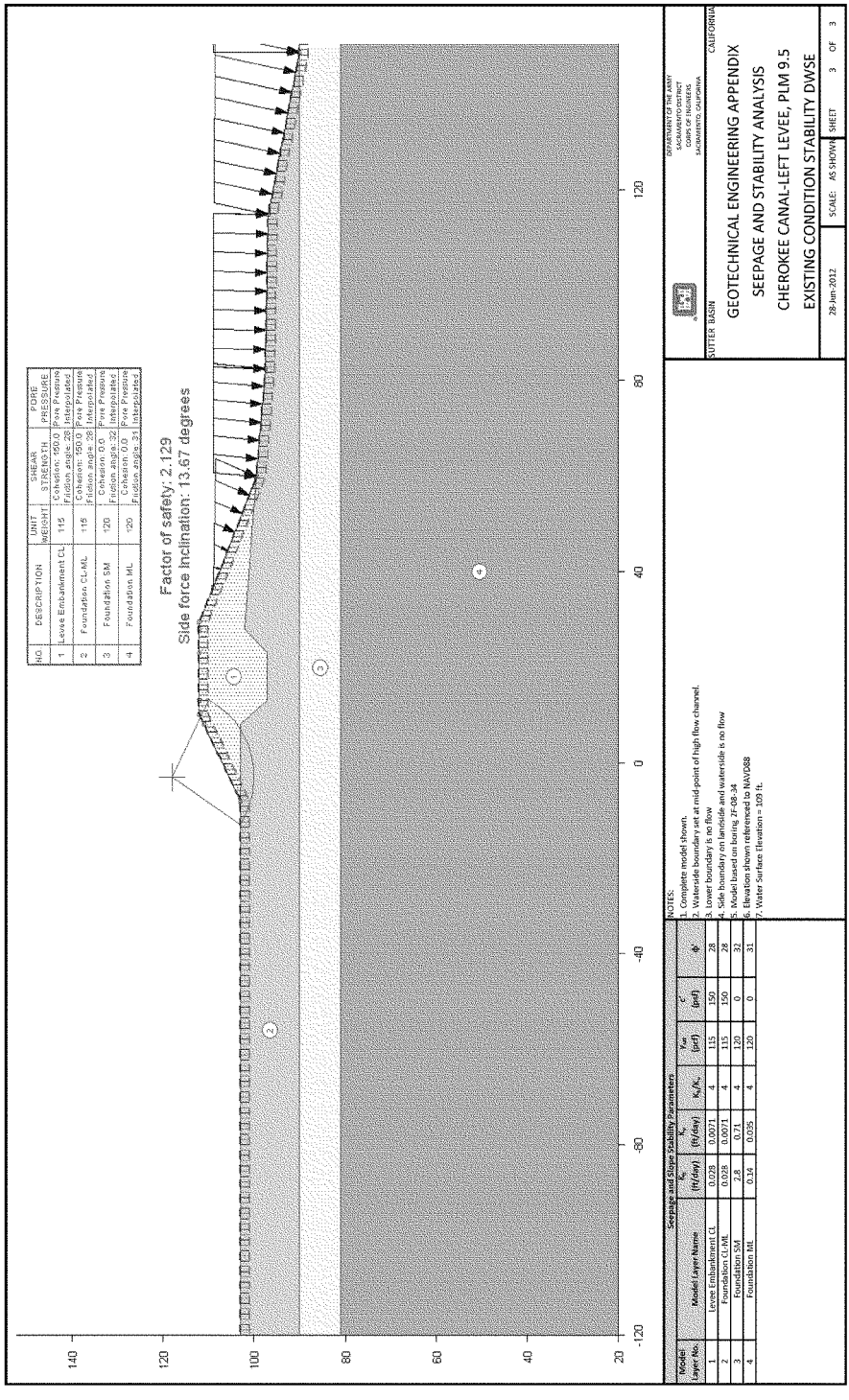
GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
CHEROKEE CANAL-LEFT LEVEE, PLM 9.5
EXISTING CONDITION SEEPAGE DWSE

28-Jun-2012 | SCALE: AS SHOWN | SHEET 2 OF 3


NO. DESCRIPTION UNIT WEIGHT SHEAR STRENGTH PORE PRESSURE
1 Levee Embankment CL 115 Cohesion: 950.0 Friction angle: 28 Pore Pressure Interpolated
2 Foundation CL-ML 115 Cohesion: 950.0 Friction angle: 28 Pore Pressure Interpolated
3 Foundation SM 120 Cohesion: 0.0 Friction angle: 32 Pore Pressure Interpolated
4 Foundation ML 120 Cohesion: 0.0 Friction angle: 31 Pore Pressure Interpolated
Factor of safety: 2.129
Side force inclination: 13.67 degrees
140
120
100
80
60
40
20
-120
-80
-40
0
40
80
120
Seepage and Slope Stability Parameters
Model Layer No.
Model Layer Name
k_x (ft/day)
k_y (ft/day)
k_x/k_y
γ_{sat} (pcf)
c' (psf)
ϕ'
1 Levee Embankment CL 0.029 0.0071 4 115 950 28
2 Foundation CL-ML 0.029 0.0071 4 115 950 28
3 Foundation SM 2.8 0.71 4 120 0 32
4 Foundation ML 0.14 0.035 4 120 0 31
NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring ZF-08-34
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 109 ft.
DEPARTMENT OF THE ARMY
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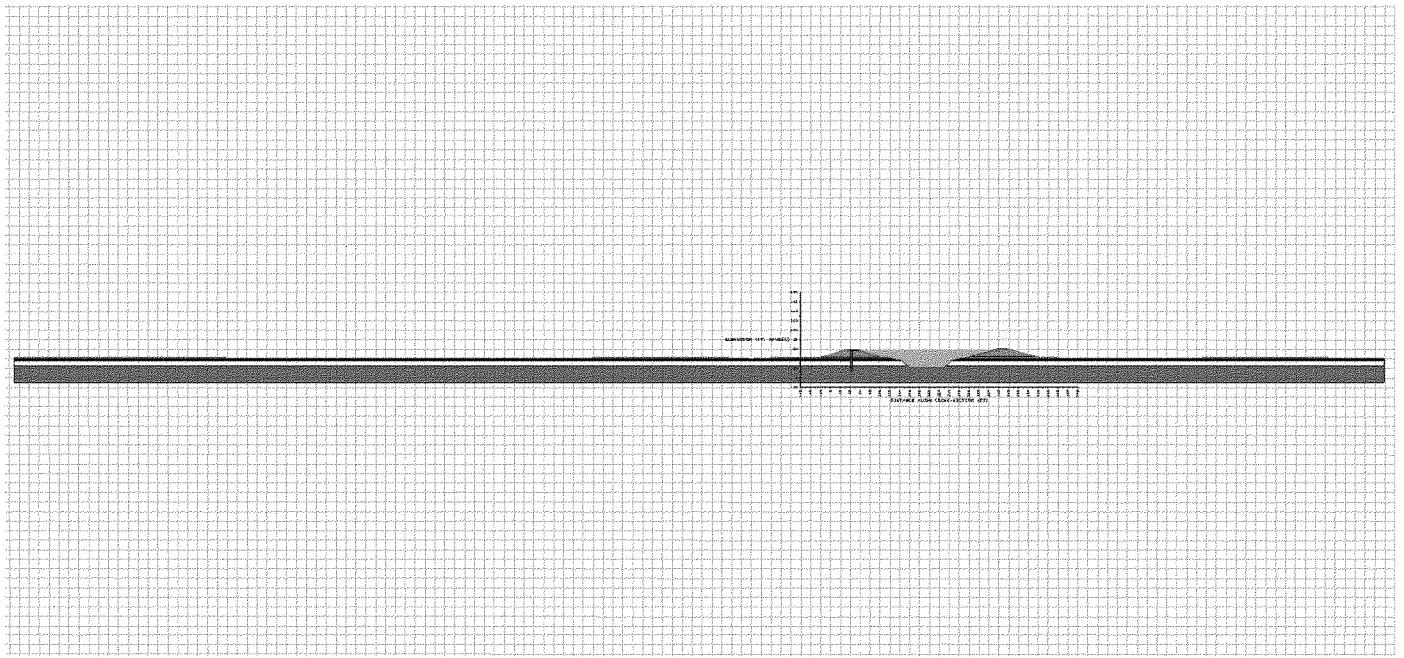
SACRAMENTO, CALIFORNIA
SUTTER BASIN
CALIFORNIA
GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
CHEROKEE CANAL-LEFT LEVEE, PLM 9.5
EXISTING CONDITION STABILITY DWSE
28-Jun-2012
SCALE: AS SHOWN
SHEET 3 OF 3



Seepage and Slope Stability Parameters								
Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	See Attached Sheet A						
2							
3							
4							
5							
6							
7							
8							
9							
10							

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WSEWWC_029B, WSEWWC_001B, WSEWWC_002A
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation =58.5 ft.

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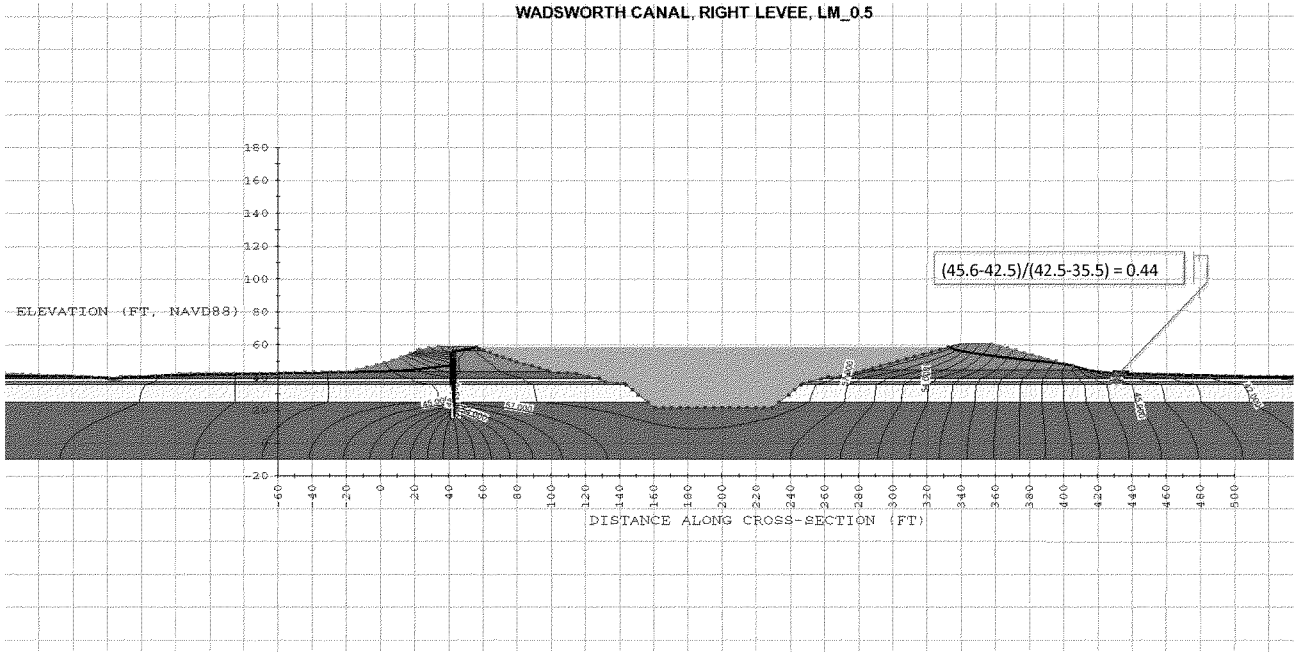
SACRAMENTO, CALIFORNIA

SUTTER BASIN — CALIFORNIA

GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
WADSWORTH CANAL, RIGHT LEVEE, LM_0.5
COMPLETE SUBSURFACE MODEL

28-Jun-2012	SCALE: AS SHOWN	SHEET 1 of 3

WADSWORTH CANAL, RIGHT LEVEE, LM_0.5



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	See Attached Sheet A						
2							
3							
4							
5							
6							
7							
8							
9							
10							

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WSEWWC_029B, WSEWWC_001B, WSEWWC_002A
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation =58.5 ft.

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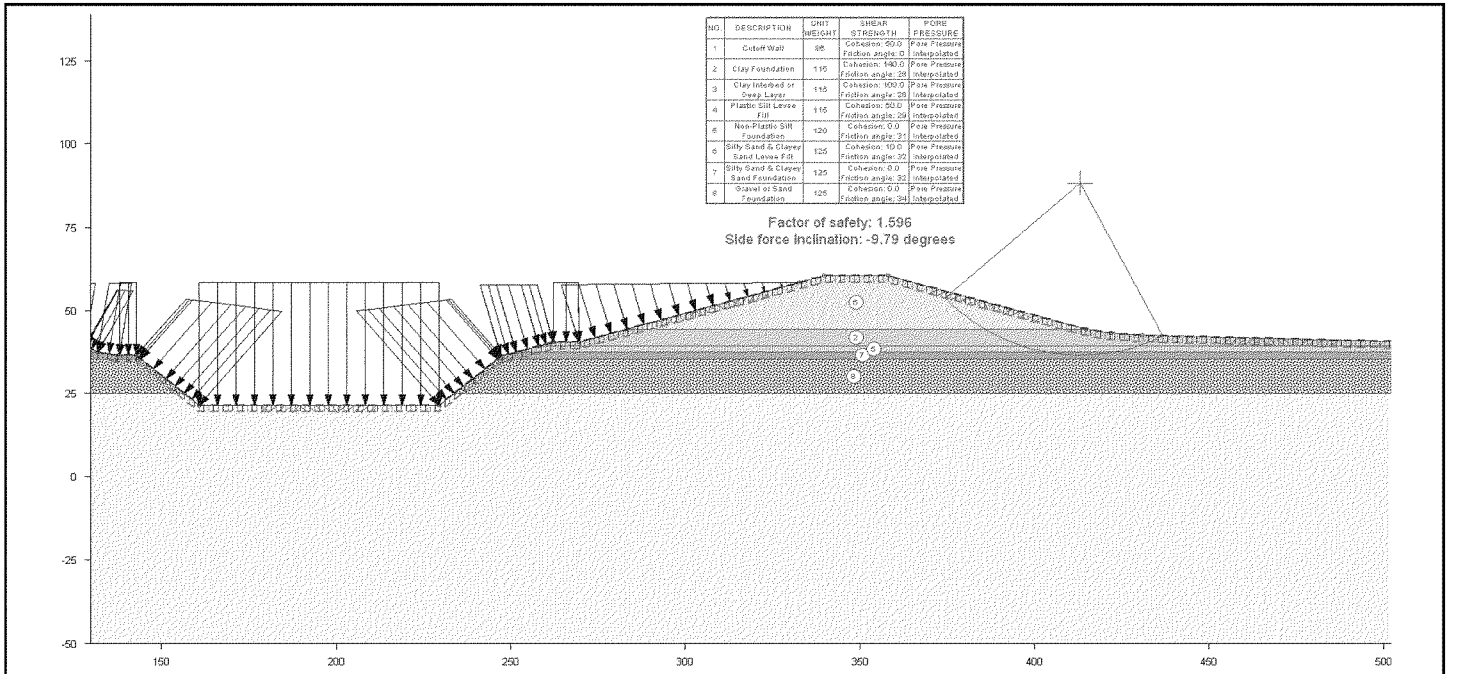
GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
WADSWORTH CANAL, RIGHT LEVEE, LM_0.5
EXISTING CONDITION SEEPAGE DWSE

28-Jun-2012 | SCALE: AS SHOWN | SHEET 2 OF 3



Seepage and Slope Stability Parameters

Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	C' (psf)	ϕ'
1	See Attached Sheet A						
2							
3							
4							
5							
6							
7							
8							
9							
10							

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WSEWWC_029B, WSEWWC_001B, WSEWWC_002A
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation =58.5 ft.

DEPARTMENT OF THE ARMY
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SACRAMENTO, CALIFORNIA

SUTTER BASIN — CALIFORNIA

GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
WADSWORTH CANAL, RIGHT LEVEE, LM_0.5
EXISTING CONDITION STABILITY DWSE

28-Jun-2012 | SCALE: AS SHOWN | SHEET 3 OF 3

Slope Stability Parameters							
Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{wet} (pcf)	c' (psf)	ϕ'
1	Cutoff Wall	0.00284	0.00071	4.0	85	50	0
2	Clay Levee Fill	0.0284	0.0071	4.0	115	150	27
3	Clay Foundation	0.0284	0.0071	4.0	115	150	27
4	Clay Interbed or Deep Layer	0.0284	0.0071	4.0	115	150	27
5	Plastic Silt Levee Fill	0.14	0.035	4.0	115	10	28
6	Plastic Silt Foundation	0.14	0.035	4.0	115	10	28
7	Plastic Silt Interbed or Deep Layer	0.14	0.035	4.0	115	10	28
8	Non-Plastic Silt Levee Fill	0.57	0.1425	4.0	115	0	28
9	Non-Plastic Silt Foundation	0.57	0.1425	4.0	115	0	28
10	Non-Plastic Silt Interbed or Deep Layer	0.57	0.1425	4.0	115	0	28
11	Silty Sand & Clayey Sand Levee Fill	0.14	0.035	4.0	125	0	32
12	Silty Sand & Clayey Sand Foundation	0.28	0.07	4.0	125	0	32
13	Silty Sand & Clayey Sand Interbed or Deep Layer	0.28	0.07	4.0	125	0	32
14	Silty or Clayey Gravel	1.13	0.113	10.0	120	0	32
15	Gravel or Sand Foundation	2.8	0.70	4.0	135	0	34
16	Gravel or Sand Interbeds or Deep Layer	17	1.7	10.0	135	0	34
17	Sand Levee Fill (drainage layer)	1	1	1.0	125	0	32

Seepage and Slope Stability Parameters							
Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{wet} (pcf)	c' (psf)	ϕ'

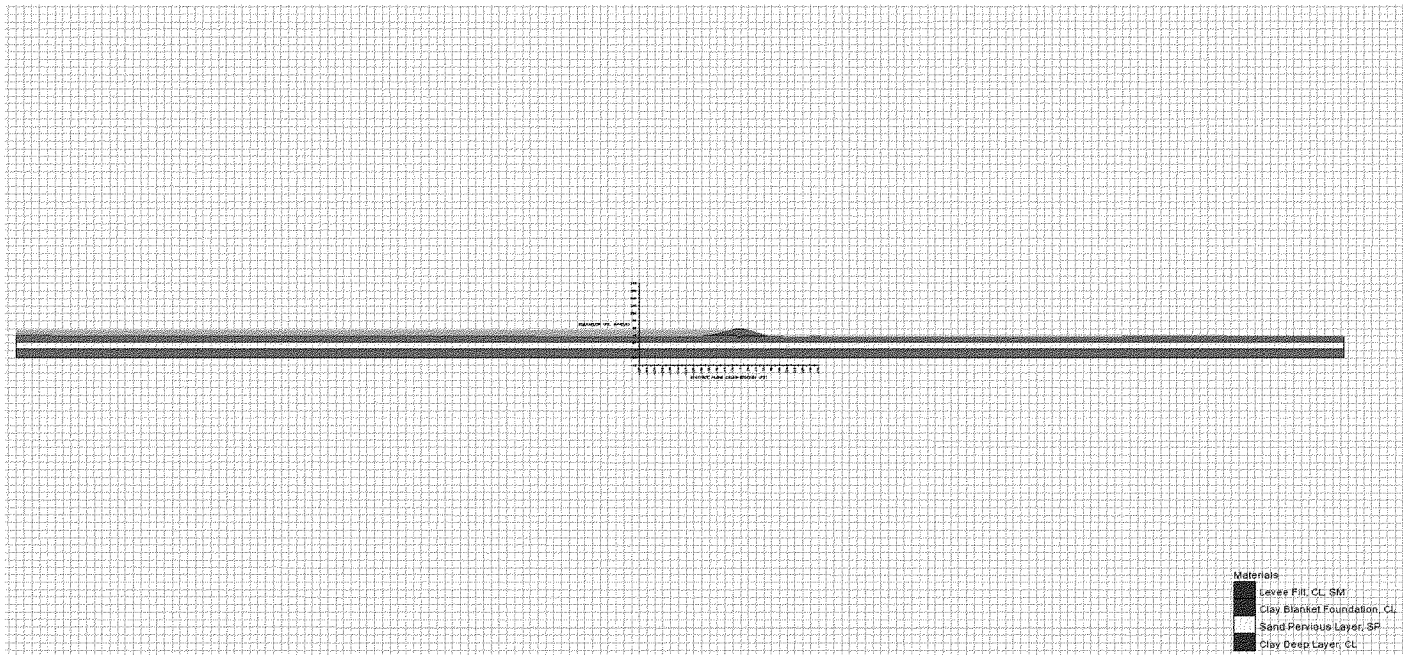
NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WSEWWC_029B, WSEWWC_001B, WSEWWC_002A
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation =58.5 ft.

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SUTTER BASIN — CALIFORNIA

GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
WADSWORTH CANAL, RIGHT LEVEE, LM_0.5
EXISTING CONDITION STABILITY DWSE

28-Jun-2012 | SCALE: AS SHOWN | SHEET A OF A



Seepage and Slope Stability Parameters							
Model Layer No.	Model Layer Name	K_x (ft/day)	K_y (ft/day)	K_x/K_y	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Fill Sand-Clay Clam Fill	2.80	0.71	4	115	50	28
2	Clay Blanket Foundation	0.028	0.007	4	120	100	28
3	Sand Pervious Layer	28.000	2.800	10	125	0	34
4	Clay Deep Layer	0.03	0.01	4	120	150	28

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WSESBP_019B
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 55.3 ft.

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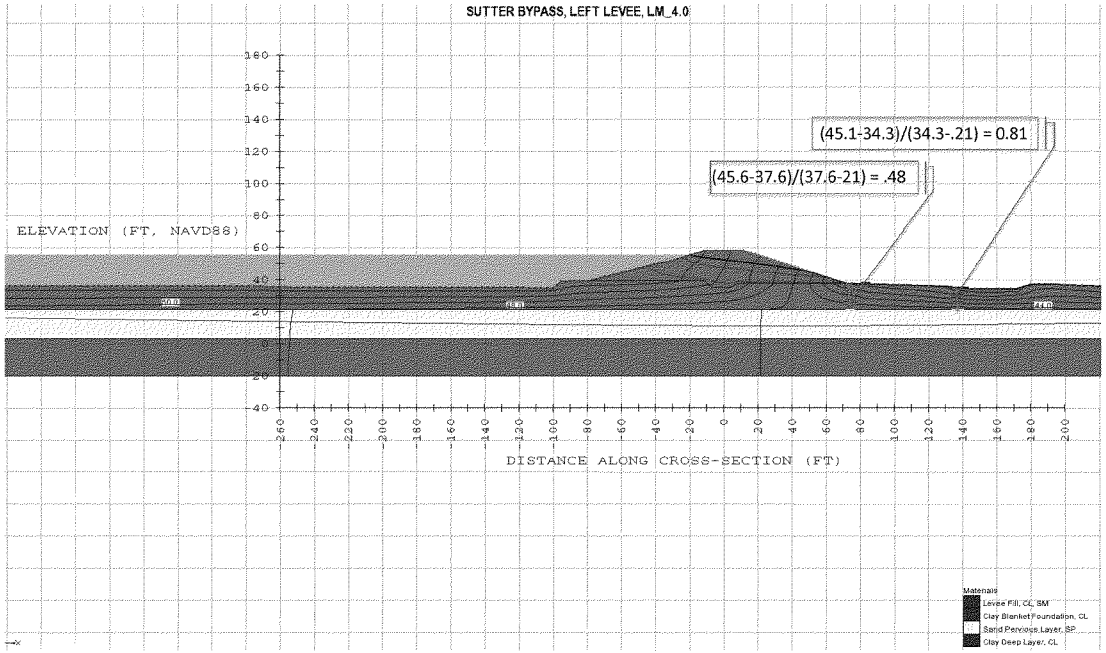
SUTTER BASIN — CALIFORNIA

GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
SUTTER BYPASS LM 4.0
COMPLETE SUBSURFACE MODEL

28-Jun-2012 | SCALE: AS SHOWN | SHEET 1 of 3



Seepage and Slope Stability Parameters							
Model Layer No.	Model Layer Name	K_h (ft/day)	K_v (ft/day)	K_h/K_v	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Fill Sand-Clay Clam Fill	2.80	0.71	4	115	50	28
2	Clay Blanket Foundation	0.028	0.007	4	120	100	28
3	Sand Pervious Layer	28.000	2.800	10	125	0	34
4	Clay Deep Layer	0.03	0.01	4	120	150	28

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WSESBP_019B
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation =55.3 ft.

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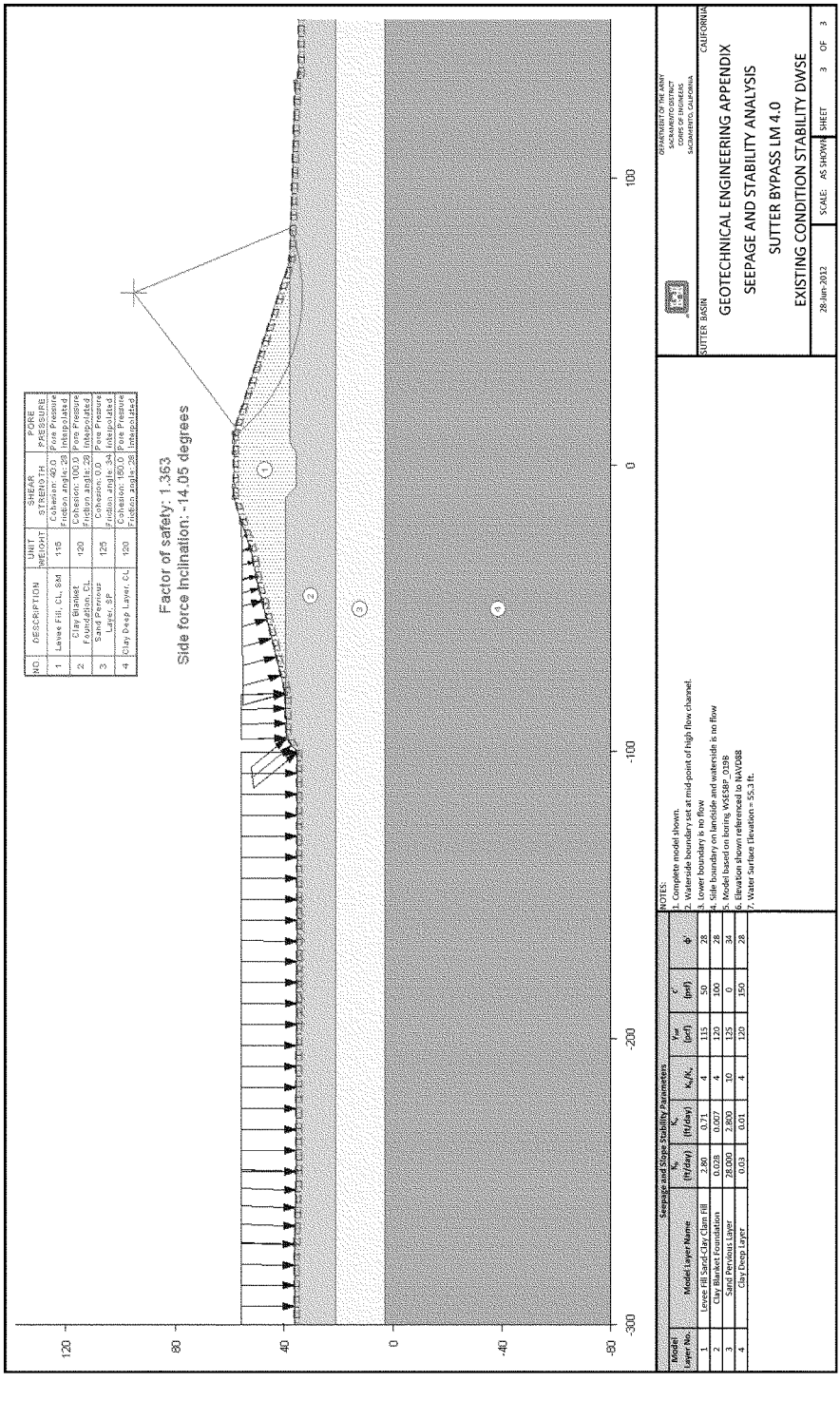
SUTTER BASIN — CALIFORNIA

GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
SUTTER BYPASS LM 4.0
EXISTING CONDITION SEEPAGE DWSE

28-Jun-2012	SCALE: AS SHOWN	SHEET 2 OF 3



Model Layer No.	Seepage and Slope Stability Parameters: Model Layer Name	k_x, k_y (ft/day)	K_{sat} (ft/day)	k_x/k_y	γ_{sat} (pcf)	c' (psf)	ϕ'
1	Levee Fill Sand-Clay-Clam Fill	2.80	0.71	4	115	50	28
2	Clay Blanket Foundation	0.028	0.007	4	120	100	28
3	Sand Pervious Layer	28.000	2.800	10	125	0	34
4	Clay Deep Layer	0.03	0.01	4	120	150	28

NOTES:
1. Complete model shown.
2. Waterside boundary set at mid-point of high flow channel.
3. Lower boundary is no flow
4. Side boundary on landside and waterside is no flow
5. Model based on boring WX65BP_039B
6. Elevation shown referenced to NAVD88
7. Water Surface Elevation = 55.3 ft.

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SUTTER BASIN — CALIFORNIA

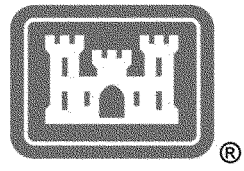
GEOTECHNICAL ENGINEERING APPENDIX
SEEPAGE AND STABILITY ANALYSIS
SUTTER BYPASS LM 4.0
EXISTING CONDITION STABILITY DWSE

28-Jun-2012 | SCALE: AS SHOWN | SHEET 3 OF 3

ENCLOSURE H

TECHNICAL MEMORANDUM FOR ALTERNATIVES SELECTION

GEOTECHNICAL ENGINEERING
TECHNICAL MEMORANDUM
FOR
ALTERNATIVES SELECTION
SUTTER BASIN, CALIFORNIA



Prepared By:

U.S. Army Corps of Engineers

Sacramento District

Geotechnical Branch

Levee Safety Section

January 2013

1.0 INTRODUCTION

This technical memorandum presents the geotechnical recommendations for the Sutter Feasibility Study. These feasibility level recommendations are intended to facilitate the selection of a final alternative. As a result, the recommendations of this report are general and not site-specific, though each reach or segment recommendation is adjusted for large scale understanding of local conditions. Additionally, construction considerations were provided to the Civil Design section including typical design sections, haul and staging, construction sequencing, and borrow. This technical memorandum was prepared not using the analysis typically to develop seepage and stability mitigation measures (i.e. finite element seepage analysis or limit-equilibrium slope stability calculations). Instead engineering judgment and experience on local projects was utilized.

2.0 EVALUATION

This section presents the evaluation of the site conditions based on previous reports and studies, which provides the basis upon which the conclusions and recommendation are developed for the fix-in-place seepage measures.

2.1 Existing Condition Report

The Corps existing condition report indicates that pervasive underseepage concerns exist through the Sutter Feasibility Study area. Each reach has existing conditions where design criteria are not met for embankment geotechnical requirements (i.e. underseepage and stability). Breach failure before overtopping has happened three times during the life of this levee system (1909, 1911, and 1955) near Shanghai Bend, just south of Yuba City; the 1955 breach resulted in 38 fatalities. Without seepage control measures, the system will be subject to failure at less-than-overtopping loading conditions in the future. Levee modifications to the levee systems of the Yuba Basin on the opposite side of the Feather River, including Reclamation District 784 and the City of Marysville levees, have improved or are in the process of improving adjacent systems. Historically, at least one levee system on the Feather River has failed during each major flood during the last century.

2.2 External Document Review

Previous work for this project includes studies done by the local sponsors, the State of California Department of Water Resources and the Sutter Butte Flood Control Agency. This work was reviewed and utilized as part of the basis of our evaluation of the existing conditions , and used to develop the conclusions and recommendations presented for the Sutter – Butte Feasibility Study. These reports indicate that the levees of the Sutter –Butte Basin, including the east (left) levee of the Sutter Bypass from Wadsworth Canal to the Feather River, and the Feather River west (right) levee from Thermolito Afterbay Dam to the Sutter Bypass (see Map Plate 1), do not

meet steady-state stability criteria for underseepage. The extent to which each reach fails to meet design criteria varies, but without exception, each reach has locations that do not meet underseepage criteria, often in multiple locations.

2.3 Key Assumptions

The following assumptions were used in the evaluation of the existing conditions (including for a potential ring levee around Yuba City, bypass and setback levees.) and for the analyzed alternatives.

- Levees will be modified or constructed considering seepage control or stability measures to provide embankment performance in accordance with USACE criteria for the entire levee system.
- Seepage and stability mitigation will be provided by construction of a cut-off wall along the entire system for all alternatives. Alternative selections are not based on a choice of seepage or stability mitigation measure. Selection of different mitigation measures such as seepage berms, relief wells, or cut-off walls along each reach is considered a design refinement and will be addressed in PED. Cutoff walls are less impactful to the environment and do not require the acquisition of real estate. The cost of soil-bentonite (SB) cutoff walls is competitive with berm construction.
- The exception to cutoff walls as seepage control mitigation measures are:

  Existing Relief Well Systems: used to the maximum extent possible in the reaches south of Yuba City at Shanghai Bend and Abbot Lakes/Star Bend.

  Seepage and Stability Berms: used in the northern reach near Thermalito Afterbay. The sponsor had previous indicated an interest and using gravel from the Oroville Goldfields dredger tailings to facility environmental mitigation. The presence of this gravel very close to the levee makes berm construction highly cost-effective in this area.

- Fix-in-place levee modifications have adequate subsurface geotechnical data for the development of feasibility level alternatives. For ring, setback, and bypass levees, there is no geotechnical subsurface data meeting the needs of a feasibility study. In order to develop feasibility recommendations that provide a reasonable basis for comparing alternatives, the structural measures for existing levees and new levees should ideally have a similar level of detail. This would best be achieved by having subsurface information and loading conditions developed to the same level of detail for new and existing levees. Since this is not possible without subsurface data on the ring, bypass and setback levee measures, a parametric approach was used. This approach was based only on a generalized understanding of the subsurface condition in Sutter and Butte counties, combined with past experience on fix-in-place and setback construction projects in the area (Yuba Basin).

- The parametric approach uses the maximum and minimum expected value concept. For example, design of a cutoff wall used estimates of the minimum and maximum expected depth and percentage of reach length requiring seepage control. After the maximum and minimum values were chosen, they were used to guide the selection of expected value. The median value was not used directly. These values were provided to civil designer so that quantities could be developed.
- New levees founded on older alluvium and located away from depressions, ditches or canals will likely require less seepage control (e.g. cutoff walls, seepage berms, etc) by percent of length.
- New levees will require more seepage control by percentage of length if the levee is taller (e.g. 8 feet or more) and less if it is shorter (e.g. 8 feet or less).
- For existing and new levees, deep cutoffs requiring specialized technology (e.g. deep soil mixing, jet grouting, etc) were considered design refinements and are not recommended at the feasibility level. It is expected that the reaches requiring the use of these methods will be short (e.g. bridge abutments or major utility crossing which may be left in place, etc). The increased cost of deep soil mixing (DSM) at $25 per square foot versus SB cutoff walls using slurry methods and excavators at $12 per square foot is significant; however, the percentage of the reaches is likely less than one percent of the entire project length. If long reaches requiring deep seepage control were encountered, the design level determination would most likely be the utilization of seepage using seepage berms or relief wells in lieu of cutoff walls.
- For areas where levee modification is required, including the addition of seepage control or stability mitigation, the resulting levee after construction will provide 1V:2H landside and 1V:3H waterside slopes and a 20-ft crest width.
- O&M easements for existing levees will be provided in the design of reaches requiring modification to not less than that prescribed by the current O&M manual. Additional O&M should be required to 15 or 20 ft of the landside to when feasible.
- Vegetation removal for ETL 1110-1-571 compliance will require at a minimum, removal of all non-compliant vegetation on the upper two-thirds of the waterside of the levee, the crest, landside slope and the existing landside easement.(if less than 15 feet, than a flooding easement will be required at least 15 feet from the landside toe free of woody vegetation)
- Seismic evaluation will be performed later in the Feasibility Study process, but seismic considerations are not considered to have a significant impact in alternative selection. Seismic analyses will be performed only to evaluate the extent of the damages but the levee alternatives will be not be affected by the seismic evaluation.
- A levee design template will be used by the civil and cost engineers to develop quantities based on inputs from this geotechnical engineering report. This template was developed by URS, and takes input for several key factors of a levee modification design (e.g. existing levee height and crest width, new depth of cutoff wall or width of seepage berm) and provides a parametric cost estimate for the levee segment for which this template is applied. The typical sections used are provided in the plates for Typical Drawing in this report.

3.0 CONCLUSIONS

The following geotechnical engineering conclusions are based on the evaluation of the subsurface conditions identified along the levees part of the Sutter basin and on the past performance of these levee and of the levees east site of Feather River. These conclusions are based heavily on engineering judgment which is guided strongly by experience in the local region and knowledge of the local soils.

3.1 General Conclusions for Fix-in-Place Alternatives

Based on the results of seepage and stability modeling, the existing levee system fails seepage design criteria within every reach, typically within multiple subreaches, and at a range of water surface profiles. The existing levee system fails to meet seepage and stability to varying degrees through the system, and underseepage mitigation in every reach is required to varying degrees.

3.2 Conclusions by Structural Segment

The conclusions are presented in clockwise order beginning with the Wadsworth Canal at the East/West Interceptor and progressing along the Sutter Bypass and Feather River to Thermalito Afterbay. Structural measure designations were developed by the Sutter PDT, and are broken down by geotechnical reach for the fix-in-place alternatives.

3.2.1 Wadsworth Canal (S7J)

The levee in this reach is approximately 20 ft in height (as measured from the landside toe to crest) at the downstream end, and the upper one-half of the segment, the levee is less than 7 feet tall, dropping to 3 feet at the upstream connection to the interceptor canals. A one-half mile long, 30 to 60 ft deep centerline soil-cement-bentonite (SCB) cutoff wall was constructed in this segment by the Corps near the downstream connection with the Sutter Bypass. Exploration performed by the State of California as part of their levee evaluation show that upstream of the cutoff wall, borings indicate sand layers covered by a thin impervious blanket or next to the surface which may require seepage control. Considering the adequate existing cutoff wall, the underseepage concerns upstream of the cutoff wall, and the lack of height of the levee upstream, a seepage control consisting of a seepage cut-off wall is recommended along approximately 25% of the segment. Based on the geotechnical conditions and of the existing cut-off wall, the depth varies between 20 and 50 feet, with an average depth of 40 ft.

3.2.2 Sutter Bypass (S7I)

The geotechnical and geomorphologic data provided by the State of California for the levee evaluation studies were used to evaluate the existing conditions and to recommend the mitigation

alternatives. Exploratory borings and cone penetrometer testing (CPT) spaced at 1000 ft intervals, a long history of general past performance issues, and a series of seepage control measures of unknown quality and performance (toe drains, small seepage berms) indicate that additional seepage mitigation is required. The geology of this area consists of shallow basin deposits overlying hard pan layers. The general direction of geologic trend of soil deposits is roughly perpendicular to the levee, meaning a high frequency of small sand deposits is likely. The borrow pit cut through the hardpan layer near the waterside levee toe for construction of the existing levee creates a direct seepage connection to underlying sand layers. These factors indicate this levee has seepage concerns. Seepage cut-off wall is recommended for 100% of the reach, the depths of positive cutoff walls being relatively shallow (30 ft depth) but vary as much as 20 to 50 ft.

3.2.3 Sutter Bypass (S7H)

Borings and CPTs spaced at 1000 ft intervals, a long history of general past performance issues, and a series of seepage control measures of unknown quality and performance (toe drains, small seepage berms) indicate that additional seepage mitigation is required. The geology of this area consists of shallow basin deposits overlying hardpan clay layers. The general direction of geologic trend of soil deposits is roughly perpendicular to the levee, meaning a high frequency of small sand deposits is also likely and not easily detected by 1000-ft spaced borings. This reach contains Gilsizer Slough which is the active overbank flow channel from the Feather River to the west. The borrow pit cut through the hardpan layer near the waterside levee toe to construct the existing levee creates a direct seepage connection to underlying sand layers. These factors indicate this levee has seepage concerns and combined with the borings at Gilsizer Slough the cutoff wall may be deeper than other reaches of the Sutter Bypass. Seepage cut-off wall is recommended for 100% of the reach, the depths of positive cutoff walls relatively shallow (30 ft depth) but vary as much as 20 to 75 ft.

3.2.4 Sutter Bypass (S7G)

Borings and CPT spaced at 1000 ft intervals, a long history of general past performance issues, and a series of seepage control measures of unknown quality and performance (toe drains, small seepage berms) indicate that seepage mitigation is required. The geology of this area consists of shallow basin deposits overlying hardpan layers. The general direction of geologic trend of soil deposits is roughly perpendicular to the levee, meaning a high frequency of small sand deposits is likely. The borrow pit cut through the hardpan near the waterside levee toe for construction of the existing levee creates a direct seepage connection to underlying sand layers. These factors indicate this levee has seepage concerns. The levee height in this reach is the tallest of the entire Sutter Bypass. Therefore, seepage cut-off wall is recommended for 100% of the reach, the depths of positive cutoff walls being relatively shallow (30 ft depth) but vary as much as 20 to 50 ft.

3.2.5 Feather River (S7F)

The levee in this reach is tall (20 plus ft), and irrigation ditches are excavated near the landside levee toe. Borings and CPTs indicate shallow sand layers and thin to moderate blanket thicknesses that may lead to seepage sand boils. Seepage cut-off walls are recommended for 75% of the reach, the depths of positive cutoff walls to being moderately deep, 50 ft, but vary as much as 20 to 75 ft.

3.2.6 Feather River (S7E)

The levee in this reach is tall (20 plus ft), and has irrigation ditches excavated near the landside toe. Borings indicate deep sand layers and thin to moderate blanket thicknesses that may lead to high gradients and sand boils, however portions of the reach have deep clay foundations. A portion of this reach has existing relief wells. Seepage cutoff walls are recommended for 25% of the reach, and relief well collection system on additional 25% of the reach length. We expect depths of positive cutoff walls to be moderately deep, 65 ft, but vary as much as 20 to 75 ft.

3.2.7 Feather River (S7D/S5D)

The levee in this reach is tall (20 plus ft), and has irrigation ditches excavated near the landside toe. Borings indicate shallow and deep sand layers and thin to moderate blanket thicknesses that may lead to high gradients at the levee toe; however, portions of the reach have deep clay foundations. A portion of this reach has existing relief wells. Seepage cutoff walls is recommended for 50% of the reach and an additional 15% will require relief well collection system modification. We expect depths of positive cutoff walls to be moderately deep, 65 ft, but vary as much as 20 to 75 ft.

3.2.8 Feather River (S7C)

The levee in this reach is tall (20 plus ft), and has irrigation ditches excavated near the landside toe. Borings indicate shallow and deep sand layers and thin to moderate blanket thicknesses that may lead to high gradients at the levee toe. Based on these considerations, seepage cut-off wall is recommended for 75% of the reach. The depths of positive cutoff walls should be moderately deep, 65 ft, but vary as much as 20 to 75 ft.

3.2.9 Feather River (S7B)

The levee in this reach variable in levee height from as little as 3 feet to as much as 15 ft, and has ditches excavated along the landside toe, including the major irrigation Sutter Butte Canal. Borings indicate shallow sand layers that may lead to high gradients at the levee toe for parts of this reach. Seepage control may be required as part the method in which the Sutter Butte Canal will be addressed. Based on these considerations, seepage cutoff walls are necessary for 100% of the reach, and we expect depths of positive cutoff walls to be moderately deep, 65 ft, but vary as much as 20 to 75 ft.

3.2.10 Feather River (S7A)

The levee in this reach varies in height from 3 to 4 feet to 18 ft. Borings indicate shallow sand layers and thin to moderate blanket thicknesses that may be seepage paths. The levee may require modification to address insufficient geometry in the Goldfields portion. Based on these considerations, seepage mitigation is recommended for 50% of the segment, seepage and stability mitigation for 25% of the segment and stability mitigation is required for 25% of the reach. Seepage berms and stability berms may be the best mitigation here, due to the sponsor's interest in using local borrow sources.

3.3 General Conclusions for New Levees (Setback Levees, Ring Levees and Cross Levees)

Based on experience with new levees, including setback levees previously constructed within the basin (e.g. Star and Shanghai Bends in Levee District 1, and the Feather River Setback Levee in Reclamation District 784), new levees will require a cutoff wall for some percentage of length, though typically to a lesser extent than existing levees. This is likely due to the distance from active river channels, and the lower likelihood of founding the levee on poor foundation conditions. Therefore we conclude that new levees far from the active river system will need seepage mitigation measures at a lower rate per unit length.

3.4 Conclusions by Reach

The conclusions for new levee segments are presented in clockwise order beginning with the Wadsworth Canal at the East/West Interceptor and progressing along the Sutter Bypass and Feather River to Thermalito Afterbay.

3.4.1 Sutter Bypass Setback Levee (S9I)

Seepage mitigation is assumed to be similar to the associated segment of the existing Sutter Bypass levee. Increased seepage path length by moving the levee back from the waterside borrow pit may result in a lower percentage of cutoff walls, but it will not eliminate the need for seepage control.

3.4.2 Sutter Bypass Setback Levee (S9H)

Seepage mitigation is assumed to be similar to the associated segment of the existing Sutter Bypass levee. Increased seepage path length by moving the levee back from the waterside borrow pit may result in a lower percentage of cutoff walls, but it will not eliminate the need for seepage control.

3.4.3 Sutter Bypass Setback Levee (S9G)

Seepage mitigation is assumed to be similar to the associated segment of the existing Sutter Bypass levee. Increased seepage path length by moving the levee back from the waterside borrow pit may result in a lower percentage of cutoff walls, but it will not eliminate the need for seepage control.

3.4.4 Lower Feather River Setback Levee (S11)

Depending on the final alignment, seepage control may be reduced below levels on the Sutter Bypass and south Feather River segment, due to the presence of an intact waterside blanket.

3.4.5 Star Bend Setback Levee (S12)

Based on borings for the Star Bend Setback Levee, seepage mitigation is required through the entire reach to depths of approximately 40 to 60 ft.

3.4.6 Yuba City, Ring Levee – South (S4) and J-Levee - South (S6)

Ring levees are assumed to be relatively short, and if they are constructed in areas with an intact blanket on the waterside of the levee (likely in this area based on experience), a lesser percentage of cutoff walls is expected. Seepage control is likely for one-third of this alignment.

3.4.7 Yuba City, Ring Levee – West (S4), J-Levee – West Lower (S6) and J-Levee – West Upper (S6)

Ring levees are assumed to be relatively short, and if they are constructed in areas with an intact blanket on the waterside of the levee (likely in this area based on experience), a lesser percentage of cutoff walls is expected. Seepage control is likely for one-third of this alignment.

3.4.8 Yuba City, Ring Levee – North (S4)

Ring levees are assumed to be relatively short, and if they are constructed in areas with an intact blanket on the waterside of the levee (likely in this area based on experience), a lesser percentage of cutoff walls is expected. Seepage control is likely for one-third of this alignment.

3.4.9 Northern Feather River Setback Levee (S10)

There is more uncertainty with the foundations conditions in this reach. Deep coarse-grained materials are known to exist in the Biggs area, so seepage mitigation is likely to be extensive. Also, this area was an overflow area for the Feather River during the 1800's and early 1900's.

This indicates that shallow sand layers and a high-frequency of sand lenses or stringers are likely to be present. Seepage mitigation is likely for 100% of the reach.

4.0 RECOMMENDATIONS

Recommendations for typical design sections (templates), new levees, construction staging and hauling, borrow, and structural segment-specific recommendations are provided within this section.

4.1 Typical Design Sections

Typical design sections are provided in the Plates section of this memorandum. These include all typical designs, which correspond to the templates used by URS in their parametric analysis performed for this project.

4.2 New Levee Design

All levees designs shall provide 1V:3H landside and waterside slope with a 20 ft crest width and 15 ft waterside and 20 ft landside O&M easements. Table 3 provides typical levee corridor widths, and Typical Detail Plates 6 and 7 provide the geometrical relationships of new levees with and without SB slurry walls.

4.3 Construction Staging and On-Site Hauling

Levee modification projects typically require long linear haul routes for on-site construction and staging areas situated at periodic intervals. For long slurry wall projects, we recommend that 2 acre sites every 2500 linear feet of levee. Typically slurry wall construction requires bentonite slurry ponds, and typically these are located about every one-half mile. The bentonite slurry is pumped to the active excavation site through pipes. Major staging areas are also required. Major staging areas are where equipment maintenance, employee parking and job trailers are located. Assume 5 acres for a typical 5 mile long slurry wall project. Multiple concurrent cutoff wall projects may require a large central staging area.

4.4 Borrow

We recommend that 15 miles as a typical haul distance for borrow. Values as low as 10 or as high as 30 may be reasonable, but 15 miles is conservative, and higher values are not warranted considering that suitable material can be typically found within the basin. It is likely that borrow will become cost prohibitive if not obtained within this distance, primarily due to air quality impacts. A conservative shrinkage percentage should be used. We recommend 15% at the feasibility level.

4.5 Seepage and Stability Mitigation by Structural Measure

These recommendations are presented as ranges (i.e. remediate reach X with a cutoff wall along 50 to 100% of the reach with a depth ranging from 20 ft to 60 ft). The measures are presented in a clockwise organization beginning on the Wadsworth Canal and progressing through the Sutter Bypass and Feather River to Thermalito Afterbay.

4.6 Fix-in-Place Measures

This section presents recommendation for seepage and stability mitigation, presented by fix-in—place structural segment.

4.6.1 Wadsworth Canal

Construct a centerline SB cutoff wall for 25% of the reach, to an expected depth of 40, with a range of typical depths of 20 to 50 ft.

4.6.2 Sutter Bypass (S7I)

Construct a centerline SB cutoff wall for 100% of the reach, to an expected depth of 30 ft, with a range of typical depths of 20 to 50 ft.

4.6.3 Sutter Bypass (S7H)

Construct a centerline SB cutoff wall for 100% of the reach, to an expected depth of 30 ft, with a range of typical depths of 20 to 75 ft.

4.6.4 Sutter Bypass (S7G)

Construct a centerline SB cutoff wall for 100% of the reach, to an expected depth of 30 ft, with a range of typical depths of 20 to 50 ft.

4.6.5 Feather River (S7F)

Construct a centerline SB cutoff wall for 75% of the reach, to an expected depth of 50 ft, with a range of typical depths of 20 to 75 ft.

4.6.6 Feather River (S7E)

Construct a centerline SB cutoff wall for 25% of the reach, to an expected depth of 40 ft, with a range of typical depths of 20 to 75 ft.

4.6.7 Feather River (S7D/S5D)

Construct a centerline SB cutoff wall for 50% of the reach, to an expected depth of 50 ft, with a range of typical depths of 20 to 75 ft. Modify existing relief well systems by reconfiguration of the collection system, including lower well head rise height from 4 above grade to 1 ft below grade for 15% of the reach for a total of 65% seepage mititgation.

4.6.8 Feather River (S5C)

Construct a centerline SB cutoff wall for 75% of the reach, to an expected depth of 65 ft, with a range of typical depths of 20 to 75 ft.

4.6.9 Feather River (S5B)

Construct a centerline SB cutoff wall for 100% of the reach, to an expected depth of 65 ft, with a range of typical depths of 20 to 75 ft.

4.6.10 Feather River (S5A)

Construct a seepage berm for 75% of the reach, to height of 5 ft and width of 12 ft. Construct a stability berm for 50% of the reach, with a height of 12 ft and top width of 12 ft. The resulting segment recommendation is for 50% of the segment to have a seepage berm only, 25% to have a stability berm only and 25% to have a combined seepage and stability berm.

4.7 Ring, Bypass and Setback Measures

This section presents recommendation for seepage control for new levees, presented by ring, bypass or setback levee structural segment.

4.7.1 Sutter Bypass Setback Levee (S9I)

Construct a centerline SB cutoff wall for 100% of the reach, to an expected depth of 35 ft, with a range of typical depths of 20 to 50 ft.

4.7.2 Sutter Bypass Setback Levee (S9H)

Construct a centerline SB cutoff wall for 100% of the reach, to an expected depth of 35 ft, with a range of typical depths of 20 to 50 ft.

4.7.3 Sutter Bypass Setback Levee (S9G)

Construct a centerline SB cutoff wall for 100% of the reach, to an expected depth of 35 ft, with a range of typical depths of 20 to 50 ft.

4.7.4 Lower Feather River Setback Levee (S11)

Construct a centerline SB cutoff wall for 50% of the reach, to an expected depth of 35 ft, with a range of typical depths of 30 to 70 ft.

4.7.5 Star Bend Setback Levee (S12)

Construct a centerline SB cutoff wall for 100% of the reach, to an expected depth of 65 ft, with a range of typical depths of 30 to 70 ft.

4.7.6 Yuba City, Ring Levee – South (S4) and J-Levee - South (S6)

Construct a centerline SB cutoff wall for 34% of the reach, to an expected depth of 35 ft, with a range of typical depths of 30 to 60 ft.

4.7.7 Yuba City, Ring Levee – West (S4), J-Levee – West Lower (S6) and J-Levee – West Upper (S6)

Construct a centerline SB cutoff wall for 34% of the reach, to an expected depth of 35 ft, with a range of typical depths of 30 to 60 ft.

4.7.8 Yuba City, Ring Levee – North (S4)

Construct a centerline SB cutoff wall for 34% of the reach, to an expected depth of 35 ft, with a range of typical depths of 30 to 60 ft.

4.7.9 Northern Feather River Setback Levee (S10)

Construct a centerline SB cutoff wall for 100% of the reach, to an expected depth of 75 ft, with a range of typical depths of 20 to 75 ft.

5.0 REFERENCES

- State of California, Department of Water Resources Urban Levee Geotechnical Evaluations Program, Phase 1 Preliminary Geotechnical Evaluation Report, Sutter Study Area, March 2008, URS
- State of California, Department of Water Resources Urban Levee Geotechnical Evaluations Program, Phase 1 Geotechnical Data Report, Sutter Study Area, November 2008, URS
- State of California, Department of Water Resources Urban Levee Geotechnical Evaluations Program, Supplemental Geotechnical Data Report, Sutter Study Area, April 2010, URS
- Sutter Butte Flood Control Agency, Pre-Design Formulation Report, West Feather River Project, August 2011, prepared by HDR, Wood Rodgers, URS and MHM
- Sutter Butte Flood Control Agency, 60% design submittal package, West Feather River Project, January 2012, prepared by HDR, Wood Rodgers, URS and MHM

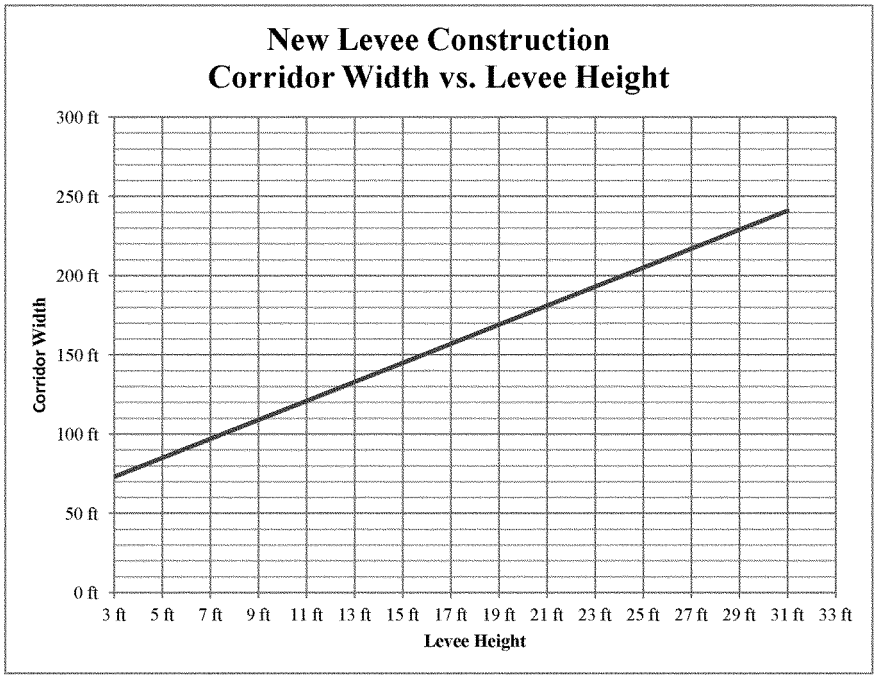
TABLES

Table 1. Summary of Recommendations by Structural Element of the Existing Levee System							
Structural Element	Name	PLM	PLM	Feature	% Length	Depth/Height	Width
S7J	Wadsworth Canal	0	4.66	SB CL Cutoff wall	25	40 ft (20 to 50)	N/A
S7I	Sutter Bypass	4.4	12.65	SB CL Cutoff wall	100	30 ft (20 to 50)	N/A
S7J	Sutter Bypass	12.65	14.35	SB CL Cutoff wall	100	30 ft (20 to 75)	N/A
S7H	Sutter Bypass	14.35	22.37	SB CL Cutoff wall	100	30 ft (20 to 50)	N/A
S7F	Feather River	MA03 0.00 LD1 0.00	MA 5.19 LD1 2.70	SB CL Cutoff wall	75	50 ft (20 to 75)	N/A
S7E	Feather River	LD1 2.70	LD1 6.20	SB CL Cutoff wall	25	65 ft (20 to 75)	N/A
S7D	Feather River	LD1 6.20	LD1 10.5	SB CL Cutoff wall[1]	50	65 ft (20 to 75)	N/A
S5D/S4-EAST	Feather River	LD1 10.5	LD1 16.65	SB CL Cutoff wall[1]	50	65 ft (20 to 75)	N/A
S5C	Feather River	LD9 0.00	LD9 5.50	SB CL Cutoff wall	75	65 ft (20 to 75)	N/A
S5B	Feather River	LD9 5.50| MA16 0 MA7 0.00	LD9 6.24 MA16 4.69 MA7 1.80	SB CL Cutoff wall	100	65 ft (20 to 75)	N/A
S5A	Feather River	MA7 1.80 MA7 HB 0.00	MA7 12.07 MA7 HG 0.08	Stability Berm Seepage Berm	50 75	12 ft 150 ft	12 ft 5 ft

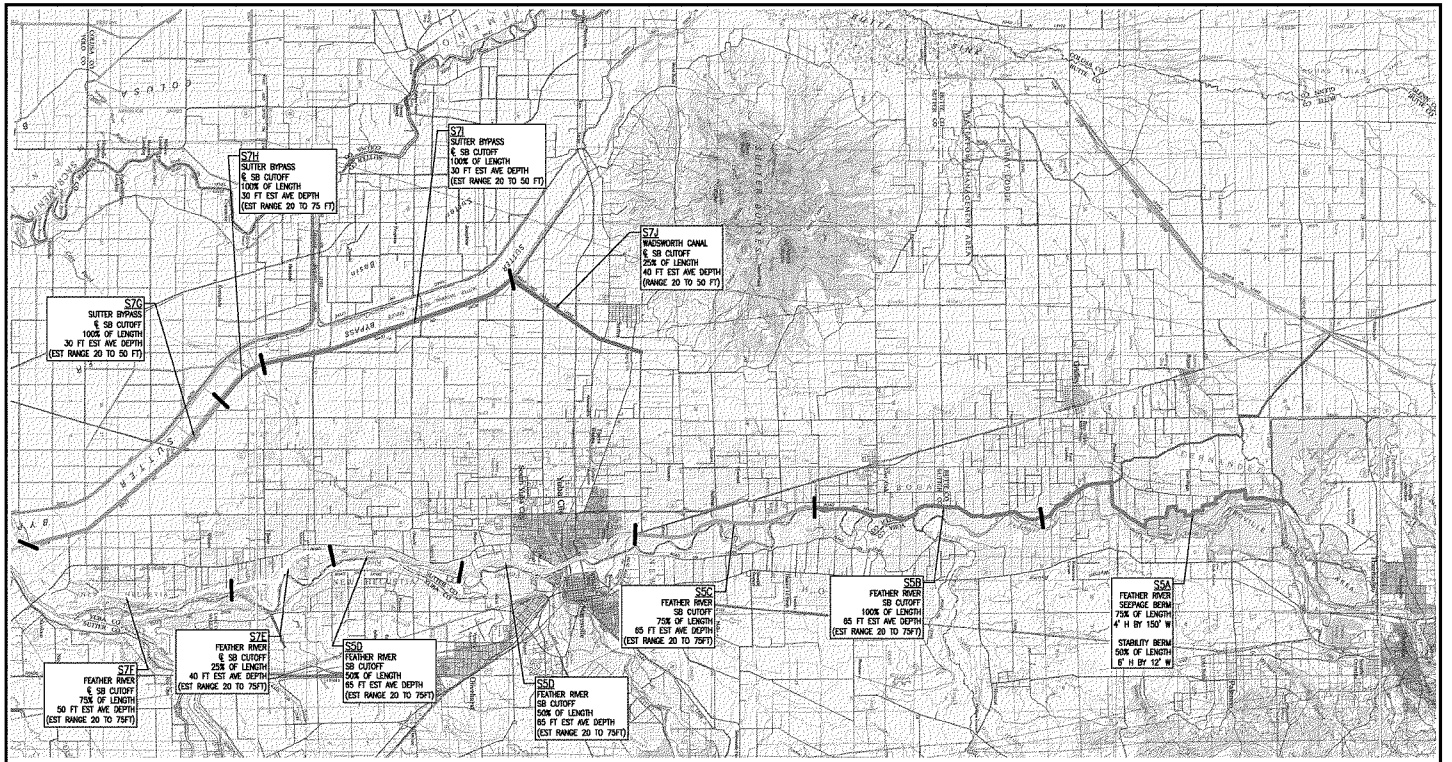
[1] Modifications to the existing relief well system are required per section 4.6.7.

Table 2 Summary of Recommendations for Segments of Ring Levees, Setback Levees, and Bypass Levees							
Structural Element	Name	PLM	PLM	Feature	% Length	Depth/Height	Width
S9I	Sutter Bypass Setback	N/A	N/A	SB CL Cutoff wall	25	35 ft (20 to 50)	N/A
S9H	Sutter Bypass Setback	N/A	N/A	SB CL Cutoff wall	25	35 ft (20 to 50)	N/A
S9G	Sutter Bypass Setback	N/A	N/A	SB CL Cutoff wall	25	35 ft (20 to 50)	N/A
S11	Sutter Bypass and Feather River Confluence Setback Levee	N/A	N/A	SB CL Cutoff wall	50	35 ft (20 to 50)	N/A
S12	Star Bend Setback	N/A	N/A	SB CL Cutoff wall	100	65 ft (30 to 70)	N/A
S4-SOUTH S6-SOUTH	Yuba City J-Levee	N/A	N/A	SB CL Cutoff wall	34	35 ft (20 to 60)	N/A
S4-WEST S6-WEST	Yuba City J-Levee	N/A	N/A	SB CL Cutoff wall	34	35 ft (20 to 60)	N/A
S6-WEST-UPPER	Yuba City J-Levee	N/A	N/A	SB CL Cutoff wall	34	35 ft (20 to 60)	N/A
S4-NORTH	Yuba City J-Levee	N/A	N/A	SB CL Cutoff wall	34	35 ft (20 to 60)	N/A
S10	Northern Feather River Setback Levee	N/A	N/A	SB CL Cutoff wall	100	75 ft (20 to 50)	N/A

TABLE 3. Levee Geometrical and O&M Requirements for New Levees										
Levee Height	Landside O&M	Landside Slope	Landside Length	Landside Height	Crest Width	Waterside Slope	Waterside Length	Waterside Height	Waterside O&M	Corridor
3 ft	20 ft	1V:3H	9 ft	3 ft	20 ft	1V:3H	9 ft	3 ft	15 ft	73 ft
5 ft	20 ft	1V:3H	15 ft	5 ft	20 ft	1V:3H	15 ft	5 ft	15 ft	85 ft
7 ft	20 ft	1V:3H	21 ft	7 ft	20 ft	1V:3H	21 ft	7 ft	15 ft	97 ft
9 ft	20 ft	1V:3H	27 ft	9 ft	20 ft	1V:3H	27 ft	9 ft	15 ft	109 ft
11 ft	20 ft	1V:3H	33 ft	11 ft	20 ft	1V:3H	33 ft	11 ft	15 ft	121 ft
13 ft	20 ft	1V:3H	39 ft	13 ft	20 ft	1V:3H	39 ft	13 ft	15 ft	133 ft
15 ft	20 ft	1V:3H	45 ft	15 ft	20 ft	1V:3H	45 ft	15 ft	15 ft	145 ft
17 ft	20 ft	1V:3H	51 ft	17 ft	20 ft	1V:3H	51 ft	17 ft	15 ft	157 ft
19 ft	20 ft	1V:3H	57 ft	19 ft	20 ft	1V:3H	57 ft	19 ft	15 ft	169 ft
21 ft	20 ft	1V:3H	63 ft	21 ft	20 ft	1V:3H	63 ft	21 ft	15 ft	181 ft
23 ft	20 ft	1V:3H	69 ft	23 ft	20 ft	1V:3H	69 ft	23 ft	15 ft	193 ft
25 ft	20 ft	1V:3H	75 ft	25 ft	20 ft	1V:3H	75 ft	25 ft	15 ft	205 ft
27 ft	20 ft	1V:3H	81 ft	27 ft	20 ft	1V:3H	81 ft	27 ft	15 ft	217 ft
29 ft	20 ft	1V:3H	87 ft	29 ft	20 ft	1V:3H	87 ft	29 ft	15 ft	229 ft
31 ft	20 ft	1V:3H	93 ft	31 ft	20 ft	1V:3H	93 ft	31 ft	15 ft	241 ft



MAP PLATES



SUTTER BASIN

STUDY MAP SHOWING GEOTECHNICAL RECOMMENDATIONS BY REACH FOR FIX-IN-PLACE MEASURES

MEASURE NAMING CONVENTION
S = STRUCTURAL MEASURE
5, 7, ETC = DESIGNATION INDICATING ASSOCIATED ALTERNATIVE
H, G, I = GEOTECHNICAL FIX-IN-PLACE REACH DESIGNATION

SCALE IN FEET
0 7500 15000 30000

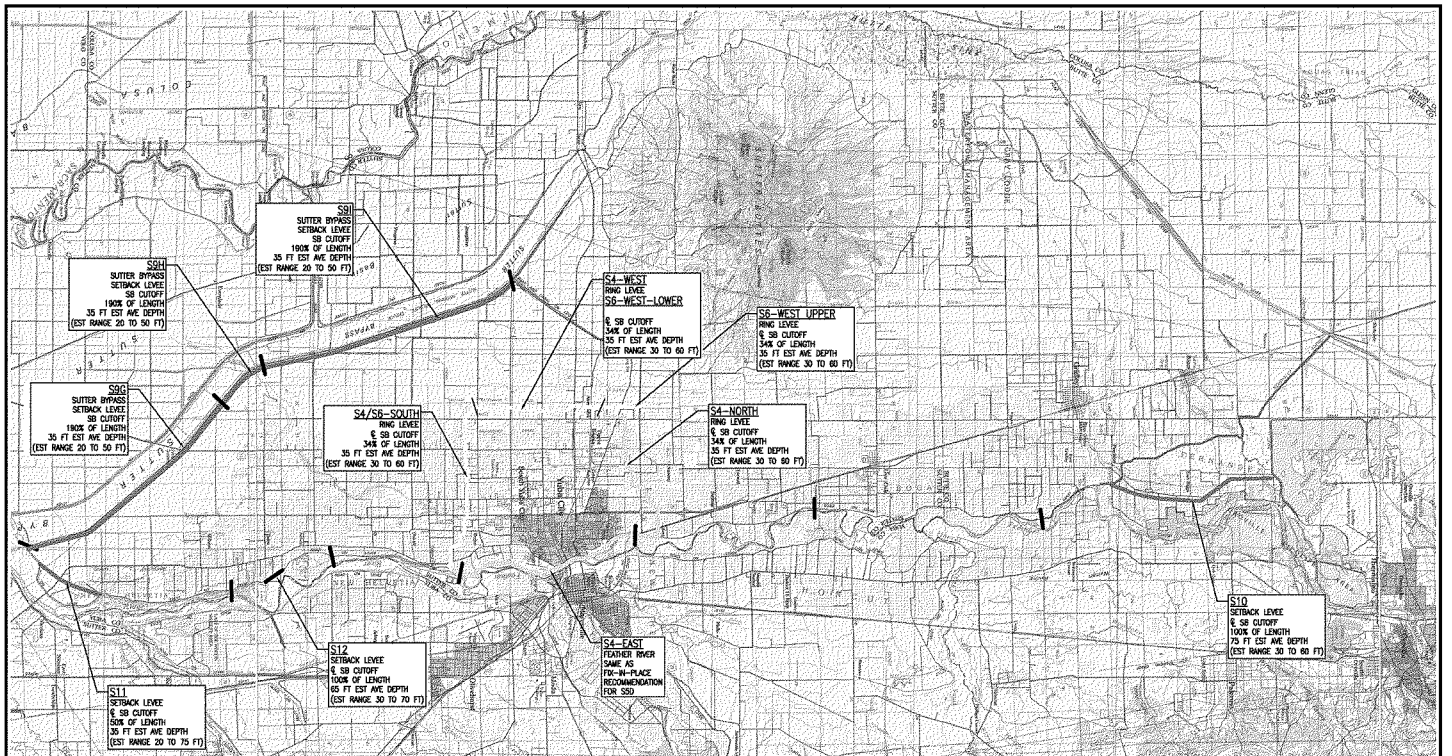
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SUTTER AND BUTTE COUNTIES CALIFORNIA

SUTTER FEASIBILITY STUDY
TECHNICAL MEMORANDUM FOR ALTERNATIVE EVALUATION

GEOTECHNICAL RECOMMENDATIONS FOR FIX-IN-PLACE MEASURES

DATE:	SCALE:	
5/30/12	1" = 15000'	MAP 1



SUTTER BASIN

STUDY MAP SHOWING GEOTECHNICAL RECOMMENDATIONS BY REACH FOR RING, SETBACK, AND BYPASS MEASURES

MEASURE NAMING CONVENTION
S = STRUCTURAL MEASURE
5, 7, ETC. = DESIGNATION INDICATING ASSOCIATED ALTERNATIVE
H, G, I = GEOTECHNICAL FIX-IN-PLACE REACH DESIGNATION

SCALE IN FEET
0 7500 15000 30000

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SACRAMENTO, CALIFORNIA

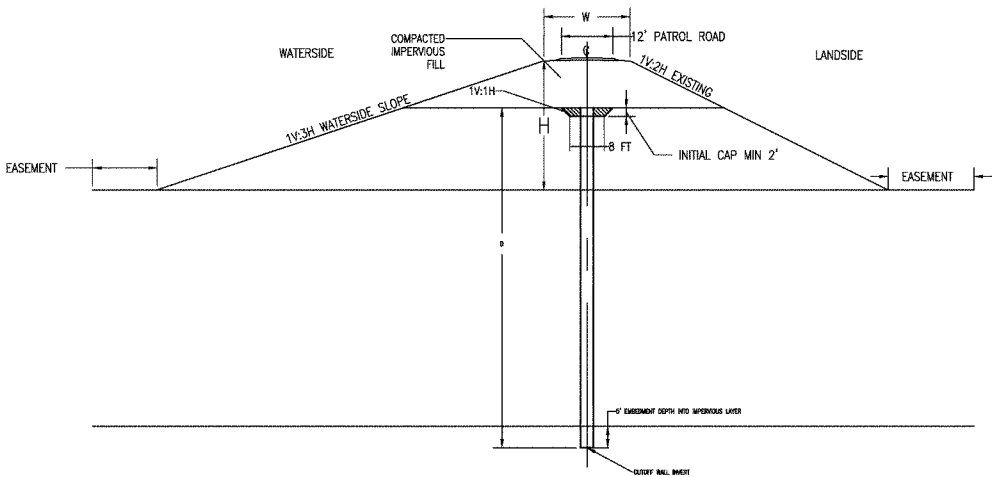
SUTTER AND BUTTE COUNTIES CALIFORNIA
SUTTER FEASIBILITY STUDY
TECHNICAL MEMORANDUM FOR ALTERNATIVE EVALUATION

GEOTECHNICAL RECOMMENDATIONS
RING, SETBACK AND BYPASS ALTERNATIVES

DATE:	SCALE:	
5/30/12	1" = 15000'	MAP 2

TYPICAL DETAIL PLATES

TYPICAL LEVEE DETAILING-EXISTING LEVEE.dwg PLOT 1=30 EWJ 5/30/12



SUTTER BASIN

LEVEE REHABILITATION WITH CENTERLINE SOIL-BENTONITE CUTOFF WALL SLURRY METHOD

PARAMETERS:
D, CUTOFF DEPTH
H, LEVEE HEIGHT
H1, DEGRADE HEIGHT

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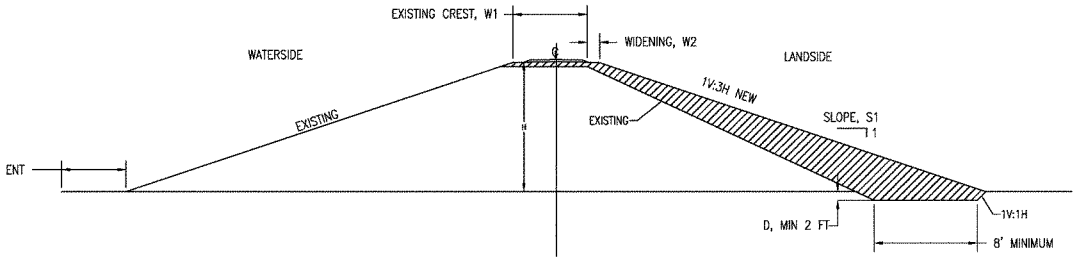
SUTTER BASIN
GEOTECHNICAL ENGINEERING
TECHNICAL MEMORANDUM
LEVEE REMEDIATION MEASURES
SB SLURRY METHOD CUTOFF WALL
TYPICAL SECTION

DATE:	SCALE:	
5/30/12	NO SCALE	TYP 1

TYPICAL LEVEE DETAILING-EXISTING LEVEE.dwg PLOT 1=30 EWJ 5/30/12



SUTTER BASIN

LEVEE REHABILITATION
WIDENING AND SLOPE MODIFICATIONS

PARAMETERS:
D, KEY DEPTH
H, LEVEE HEIGHT
W1 EXISTING CREST WIDTH
W2, ADDITIONAL CREST
S1, SLOPE RUN PER 1' RISE

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SACRAMENTO, CALIFORNIA

SUTTER AND BUTTE COUNTY CALIFORNIA

SUTTER BASIN
GEOTECHNICAL ENGINEERING
TECHNICAL MEMORANDUM
LEVEE REMEDIATION MEASURES
WIDENING AND SLOPE MODIFICATIONS
TYPICAL SECTION

DATE:	SCALE:	
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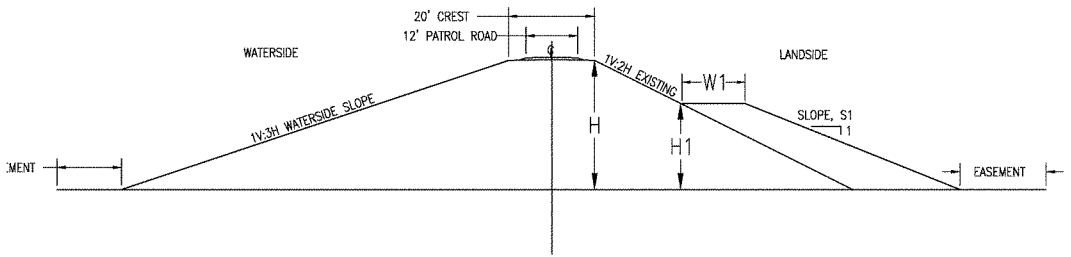
TYPICAL LEVEE DETAILING-EXISTING LEVEE.dwg PLOT 1=30 EWJ 5/30/12



SUTTER BASIN

LEVEE REHABILITATION WITH LANDSIDE STABILITY BERM

PARAMETERS:
H, LEVEE HEIGHT
H1, BERM HEIGHT
W1, BERM WIDTH
S1, SLOPE RUN PER 1' RISE

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SUTTER BASIN
GEOTECHNICAL ENGINEERING
TECHNICAL MEMORANDUM
LEVEE REMEDIATION MEASURES
STABILITY BERM
TYPICAL SECTION

DATE:	SCALE:	
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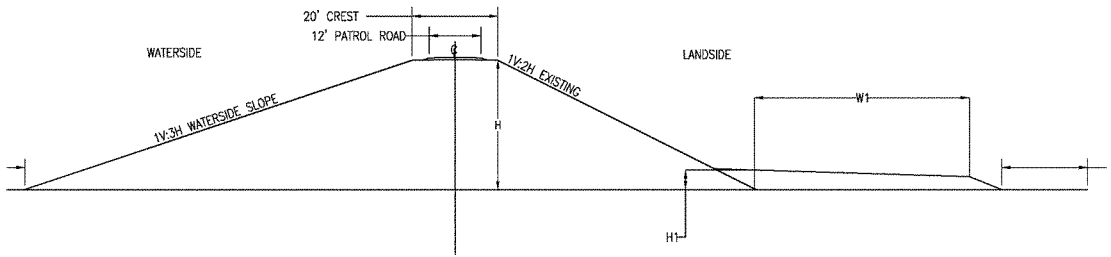
TYPICAL LEVEE DETAILING-EXISTING LEVEE.dwg PLOT 1=30 EWJ 5/30/12



SUTTER BASIN

LEVEE REHABILITATION WITH SEEPAGE BERM

PARAMETERS:
H1, BERM HEIGHT
H2, BERM WIDTH
H, LEVEE HEIGHT

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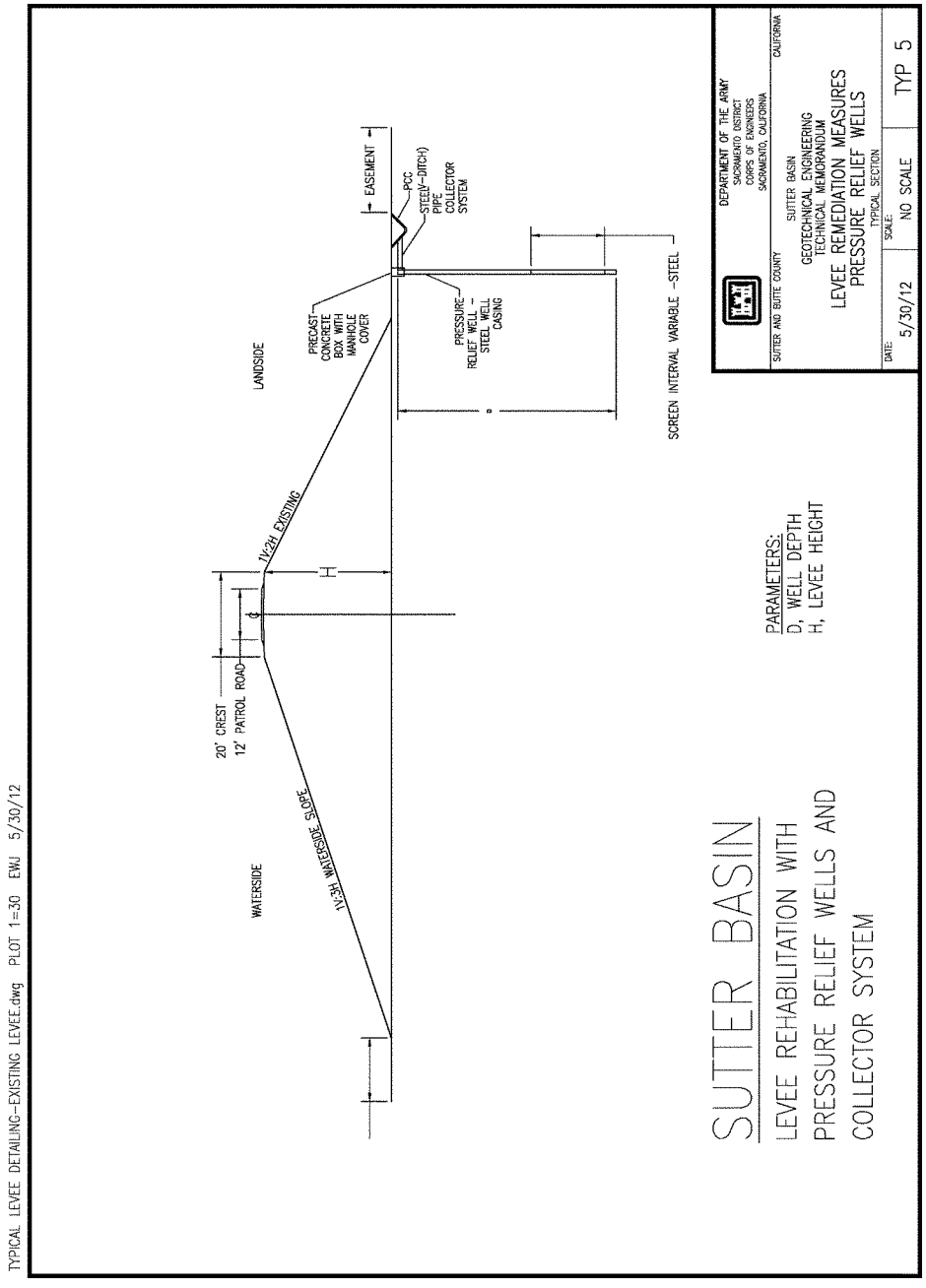
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SUTTER AND BUTTE COUNTY CALIFORNIA

SUTTER BASIN
GEOTECHNICAL ENGINEERING
TECHNICAL MEMORANDUM
LEVEE REMEDIATION MEASURES
SEEPAGE BERM
TYPICAL SECTION

DATE:	SCALE:	
5/30/12	NO SCALE	TYP 4


TYPICAL LEVEE DETAILING-EXISTING LEVEE.dwg PLOT 1=30 EWJ 5/30/12
SUTTER BASIN
LEVEE REHABILITATION WITH
PRESSURE RELIEF WELLS AND
COLLECTOR SYSTEM
PARAMETERS:
D, WELL DEPTH
H, LEVEE HEIGHT
WATERSIDE
LANDSIDE
20' CREST
12' PATROL ROAD
1V:3H WATERSIDE SLOPE
1V:2H EXISTING
H
D
PRECAST CONCRETE BOX WITH MANHOLE COVER
PRESSURE RELIEF WELL - STEEL WELL CASING
SCREEN INTERVAL VARIABLE - STEEL
EASEMENT
PCC
STEEL(V-DITCH)
PIPE
COLLECTOR
SYSTEM
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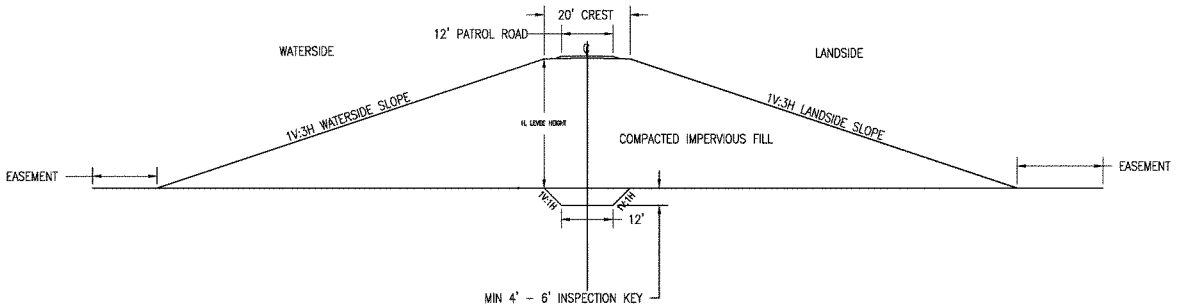
SACRAMENTO, CALIFORNIA
SUTTER AND BUTTE COUNTY
CALIFORNIA
SUTTER BASIN
GEOTECHNICAL ENGINEERING
TECHNICAL MEMORANDUM
LEVEE REMEDIATION MEASURES
PRESSURE RELIEF WELLS
TYPICAL SECTION
DATE:
5/30/12
SCALE:
NO SCALE
TYP 5

TYPICAL DETAILING–NEW LEVEE.dwg PLOT 1=30 EWJ 5/30/12



SUTTER BASIN

NEW LEVEE – NO SEEPAGE CONTROL

PARAMETERS:
H, LEVEE HEIGHT

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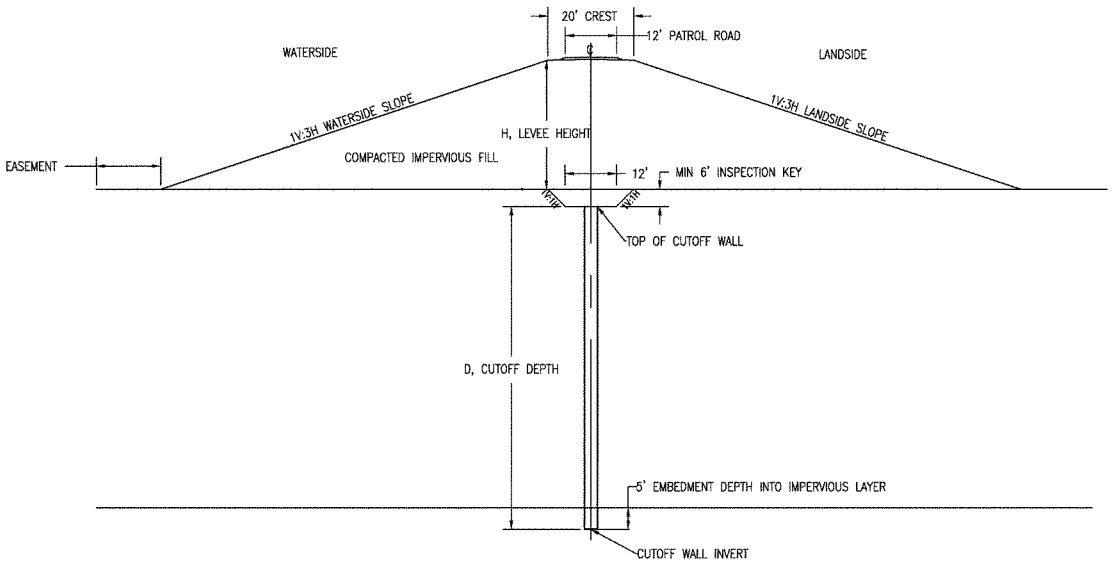
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SUTTER ABD BUTTE COUNTIES CALIFORNIA

SUTTER BASIN
GEOTECHNICAL ENGINEERING
TECHNICAL MEMORANDUM
NEW LEVEE CONSTRUCTION
NO SEEPAGE CONTROL
TYPICAL SECTION

DATE:	SCALE:	
5/30/12	NO SCALE	TYP 6

TYPICAL DETAILING–NEW LEVEE.dwg PLOT 1=30 EWJ 5/30/12



SUTTER BASIN

NEW LEVEE – SOIL–BENTONTITE SLURRY WALL

PARAMETERS:
D, WELL DEPTH
H, LEVEE HEIGHT

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SUTTER AND BUTTE COUNTIES CALIFORNIA

SUTTER BASIN
GEOTECHNICAL ENGINEERING
TECHNICAL MEMORANDUM
NEW LEVEE CONSTRUCTION
SOIL–BENTONITE SLURRY WALL
TYPICAL SECTION

DATE:	SCALE:	
5/30/12	NO SCALE	TYP 7

1363

ENCLOSURE I

VEGETATION ETL COMPLIANCE MEMORANDUM

CESPK-PD-R **15 June 2012**
Revised 24 February 2013

MEMORANDUM FOR FILE: Sutter Basin Pilot Feasibility Study

SUBJECT: Compliance with ETL 1110-2-571

1. REFERENCES

a. Engineering and Design: Guidelines for landscape planting and vegetation management at levees, floodwalls, embankment dams, and appurtenant structures. Engineer Technical Letter (ETL), April 10, 2009.
b. White paper, Sutter Basin Pilot Feasibility Study, Engineer Technical Letter 1110-2-251 Compliance, dated 8 February 2013.
c. Feather River Sutter Basin Protection Area Periodic Inspection January 2010, Report No. 1.
d. Memorandum for Record. Sutter Feasibility Study – Summary of vegetation concerns impacting Sutter Project identified in the Periodic Inspection, dated August 9, 2012.
e. Process for Requesting Variance from Vegetation Standards for Levees and Floodwalls, Federal Register Notice (Friday, February 17, 2012).
f. Sutter Basin Feasibility Study, Future-Without Project Conditions Report, December 2011.
g. Corps Memorandum, Reconstruction of U.S. Army Corps of Engineers Structural Flood Damage Reduction Projects for which Non-Federal Interests are Responsible for Operation, Maintenance, Repair, Rehabilitation and Replacement, August 16, 2005.
h. Pre-Design Formulation Report, Feather River West Levee Project, Sutter-Butte Flood Control Agency, August 2011.

2. PURPOSE

The purpose of this memorandum is to assess the extent of vegetation that is in non compliance with ETL 1110-2-571 (Reference a), to assess the magnitude of the mitigation that might be required, and to identify potential strategies in dealing with this issue. For the study alternatives, impact scale, study risk, and ETL variance and ETL mitigation costs are also identified.

3. BACKGROUND

USACE Vegetation Management.

USACE Engineer Technical Letter 1110-2-571, *Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures*, dated 10 April 2009, provides guidance for maintenance of said structures in order to maintain the authorized level of flood risk management. The ETL mandates

CESPK-PD-R 15 June 2012
SUBJECT: Compliance with ETL 1110-2-571

USACE will maintain a "vegetation free zone" (VFZ), a three dimensional zone surrounding all levees, floodwalls, embankment dams, and critical appurtenant structures in all flood damage reduction systems (shown below). The purpose of the vegetation-free-zone is to provide a reliable corridor of access to and along federally authorized and constructed flood risk management features for surveillance, inspection, maintenance, monitoring, and flood-fighting.

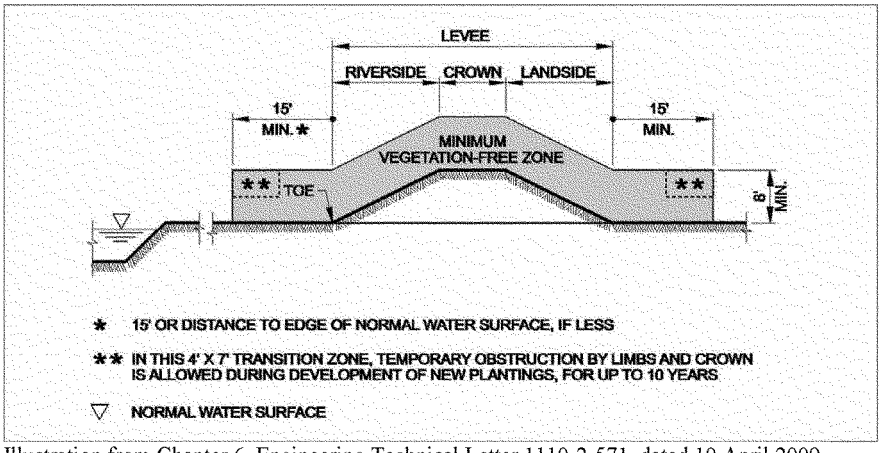


Illustration from Chapter 6, Engineering Technical Letter 1110-2-571, dated 10 April 2009

Existing Project OMRR&R Requirements.

The following description of existing OMRR&R was excerpted from Reference b.

The Sutter study area is fully contained with the Sacramento River Flood Control Project (SRFCP). The SRFCP OMRR&R requirements are contained within a standard manual for the entire SRFCP with supplements outlining more detailed requirements for each Unit within the project. The standard manual has been in place since 1955. In 1949, Headquarters U.S. Army Corps of Engineers approved a deviation from the vegetation standards in effect at the time. The sponsor is required to comply with the following vegetation standards contained within the standard manual for the SRFCP. "The Superintendent shall provide at all times such maintenance as may be required to insure serviceability of the structure at the time of floods. Measures shall be taken to exterminate burrowing animals and provide for clearing of brush, trees, and other wild growth from the levee crown and slopes. Brush and small trees may be retained on the waterward slope where desirable for the prevention of erosion and wave wash. Where practicable, measures shall be taken to retard bank erosion by the planting of willows or other suitable growths on areas riverward of the levees." In addition, each supplement applicable to the Sutter study

area may have more detailed vegetation maintenance standards. Project sponsors for completed levee projects are responsible for OMRR&R of the completed project as provided in the O&M manuals. Issuance of the ETL setting forth new or clarified vegetation and access standards for levee projects does not alter the project O&M requirements and responsibilities. Inspections are conducted to document whether the sponsor is fulfilling their OMRR&R obligations as outlined in the O&M manual and inspection checklist and to determine if continued PL 84-99 rehabilitation assistance is warranted based on the outcome of those inspections. Sponsors receiving an unacceptable inspection rating may choose to pursue a conditional extension to PL 84-99 rehabilitation program eligibility by using a System Wide Improvement Framework (SWIF) as outlined in 29 November 2011 policy subject: Policy for Development and Implementation of System-Wide Improvement Frameworks.

Periodic Inspection Report.

In January 2010, an Inspection of Completed Works (ICW) periodic inspection (PI) (Reference c) was completed of the project levees surrounding the study area (Cherokee canal was not included as is addressed in a separate report). The PI evaluated nine segments and rated seven levee segments as unacceptable and two segments as minimally acceptable due to a number of deficiencies, including vegetative growth. Figure 1 identifies the segments and responsible maintaining entities. The PI report stated that "unwanted vegetative growth" along with other issues "would not prevent the system from performing as intended during the next flood event."

4. EXISTING NONCOMPLIANT VEGETATION

Identification of noncompliant vegetation was determined based on two sources:

- 2010 Periodic Inspection Report
- Vegetation Surveys conducted in 2012

2010 Periodic Inspection (PI) Report.

The PI conducted in 2010, collected GIS-based data on noncompliant vegetation (Reference c). The PI team gathered and recorded data electronically in the field using a GPS enabled tablet PC and GIS software. Vegetation points and lines represent incidents of non-compliance with ETL 1110-2-571. Separate tables were created for the Sutter Bypass, Wadsworth Canal, and Feather River West levees (Reference d). The tables present the data organized by levee mile for the Sutter Bypass and Wadsworth Canal levees, and by SBFCA sub reaches for the Feather River levees. Figure 2 shows the reaches of the Feather River West Levee, and the reaches of the Sutter Bypass and Wadsworth Canal. The non-compliant vegetation (as defined by ETL 1110-2-571) was categorized as being located on the upper third, middle third or lower third of the waterside

slope, the landside slope, the crest, the waterside 15-ft easement or landside 15-ft easement. The purpose of the categories was to breakdown the incidents by degree of criticality.

The violations that were observed were either stands of vegetation or single trees or shrubs. Other reports prepared by ICF for SBFCA's Feather River West Levee Project (FRWLP) were also reviewed to further confirm the extent of vegetation.

The PI evaluation of vegetation assumes that at least a 15-foot ROW exists at the levee waterside and landside toe for levee maintenance and access. In some areas, the preexisting real estate interest may be less than 15 feet. The existing operations and maintenance manual permits brush and small trees to be present.

Existing vegetation is summarized below for the Feather River West Levee, Sutter Bypass East Levee, and Wadsworth Canal South Levee. Noncompliant vegetation is most abundant along the Feather River West Levee. Table 1 lists the significant vegetation identified based on the maintenance entities shown in Figure 1.

The following is a summary of vegetation concerns identified from the PI (Reference c).

West Feather River Levee

The West Feather River levee has 95 and 93 vegetation incidents located on the landside and waterside easements, respectively; and 79 vegetation incidents on the levee crest and slopes. Of the 79 incidents on the levee itself, 41 of them are at critical locations on the crest, landside slope and upper third of the waterside slopes. These critical incidents are concentrated in Levee District (LD) 1 of Sutter County, LD 9 of Sutter County, and State Maintenance Area (MA) 7/Hamilton Bend. These areas of greater critical vegetation impact are located within areas of significant (high percentage of reach) seepage mitigation, where cutoff wall construction is likely.

As shown in Figure 3, all 41 reaches, except one (reach 6), of the Feather River west levee, had at least one incident of noncompliant vegetation found within the VFZ. The number of incidents varied considerably between reaches; reach 16 had the most with 25 incidents, and 19 of the 41 reaches (46%) had less than 2 incidents.

Sutter Bypass Levee

For the Sutter bypass, the results are shown in Figure 4. Compared to the Feather River West Levee there was significantly less vegetation and of smaller size (primarily willows) on or near the levees. Sutter Bypass, with 82 vegetation incidents, 61 of them located on the waterside easement and 21 located on the landside easement and spread out over 18 miles, does not have a significant vegetation compliance problem with respect to ETL 1110-2-571.

Wadsworth Canal

Wadsworth Canal, with three vegetation incidents, all located on the waterside or landside easement and spread over 6 miles, does not have a significant vegetation compliance problem with respect to ETL 1110-2-571.

Vegetation Surveys.

To assess impacts to vegetation from alternatives in the final array, vegetation surveys were conducted in 2012 to identify the location of vegetation on and near the existing levees. The data was collected using GIS. The surveys identified approximately 7,600 trees, including riparian trees, orchards, and nonnative or ornamental trees, in the biological study area (200-foot corridor along the levee alignment).

5. ENVIRONMENTAL REQUIREMENTS

In accordance with Council on Environmental Quality (CEQ) Regulations for Implementing NEPA (40 CFR 1500-1508), and with Appendix C, paragraph C-3 of ER 1105-2-100, "Policy and Planning Guidance for Conducting Civil Works Planning Studies (Planning Guidance Notebook)", the planning of Corps projects must ensure that project-related adverse environmental impacts (i.e., impacts to fish and wildlife resources) have been avoided or minimized to the extent practicable, and that remaining unavoidable significant adverse impacts are compensated to the extent justified. Corps regulations stipulate that the Recommended Plan must contain sufficient mitigation measures to ensure that the plan selected will have no more than negligible net adverse impacts on fish and wildlife resources. Furthermore, a Cost Effectiveness Incremental Cost Analysis must be performed to identify the most cost-effective mitigation plan.

As part of the feasibility study, mitigation costs for vegetation impacts will have to be determined and a mitigation plan developed using incremental cost analysis and the recommendations of the USFWS and other resource agencies. Under WRDA 2007, Section 2036(a) , the Corps must fully develop a mitigation plan that includes the following: 1) monitoring until successful, 2) criteria for determining ecological success, 3) a description of available lands for mitigation and the basis for the determination of availability, 4) the development of contingency plans (i.e., adaptive management), 5) identification of the entity responsible for monitoring; and 6) establishing a consultation process with appropriate Federal and State agencies in determining the success of mitigation.

Significant vegetation losses that justify mitigation would either be mitigated through a commercial mitigation bank and/or a mitigation site acquired in the project vicinity. Mitigation site(s) selected would be located waterward of the project levees along the Feather River on lands currently in agricultural production and that could be restored to riparian habitat. Mitigation plans would be designed to avoid a net change in stage discharge relationships.

In regards to tree protection ordinances or policies that could affect construction, Sutter County does not currently have any specific ordinances or programs (heritage tree program) that protect native oaks in the County. The City of Yuba City protects trees through implementation of general plan policies, and with specific ordinances for street trees. General Plan Policy 8.4-G-3 states that heritage oaks would be preserved and enhanced in the City. Policy 8.4-I-2 requires preservation of oak trees and other native trees that are of significant size, by requiring site designs to incorporate these trees to the maximum extent feasible (Reference e). Butte County also has no specific ordinances or programs and no general plan policies concerning tree protection.

6. DISCUSSION

ETL variance guidance (Reference c) states "New federally authorized cost shared levee projects shall be designed to meet the current vegetation management standards." It is expected that any potential levee project will be required to meet ETL 1110-2-571 requirements for congressional authorization and appropriation.

ETL Variance Procedure.

Corps guidance identifies the situations in which a Corps district may submit a vegetation variance request. Corps guidance defines a variance "as alternative vegetation management standards to be applied to a levee system or portion thereof that provide for the same levee functionality as intended in ETL 1110–2–571" (Reference c). Variances may only be granted to allow the preservation of waterside vegetation below the upper third of the waterside slope. Per the draft variance request procedure, no variance requests will be approved for noncompliant landside vegetation: "To ensure the ability to implement floodfighting activities, such as placement of sandbags or other temporary floodfight measures near the waterside crown, and to see areas of distress on the landside during a flood event, typically the upper third of the waterside slope, the crown, the landside slope, and within 15 feet of the landside toe (subject to preexisting real estate interest) of the levee needs to remain vegetation free, as defined in ETL 1110–2–571" (paragraph 9(d)).

During construction, existing vegetation would be removed adjacent to the riverward and landside toes by root plowing or clearing and grubbing to create the vegetation free zone. Since the landward side of the levee is currently maintained as an access road, very little woody vegetation exists. Following construction, disturbed soils including levee side slopes will be seeded with native grass seed to prevent wind and water erosion. A 15-foot-wide vegetation management zone along the riverward and landside toe of the levee will be permanently maintained to be devoid of trees and shrubs.

A variance request may be applicable because the subject levees are existing federally authorized levees in which the existing O&M manual allows vegetation within the VFZ. The existing O&M manual for the SRFCP states that "Brush and small trees may be retained on the waterward slope where desirable for the prevention of erosion and wave

wash. Where practicable, measures shall be taken to retard bank erosion by the planting of willows or other suitable growths on areas riverward of the levees."

Also per the variance guidance (Reference c), a vegetation variance can be considered if one of the following applies:

a. Comply with applicable law concerning the environment, cultural or historic preservation;
b. Protect the right of Tribal Nations, pursuant to treaty, statute, or Executive Order;
c. Address a unique environmental consideration; and/or
d. Prior vegetation agreement in place.

Criteria (a), (c), and (d) may be an appropriate basis to consider a variance to retain vegetation. However, the guidance states that "even if one of the above criteria is met, life safety is still paramount and the vegetation variance must assure that the structural integrity and functionality of the levee are retained." The levee must still be accessible for maintenance, periodic inspection, monitoring during flood events, and access to perform flood-fighting if required. Because the application process, analysis and review time will be both lengthy and costly, a variance request should be considered in the preconstruction engineering and design phase.

6. ETL COMPLIANCE SCENARIOS

For the evaluation of initial alternatives, two scenarios or strategies were identified to address the ETL compliance issue for fix in place levee alternatives. The two scenarios provide for the full disclosure of environmental effects to vegetation from the extreme of: (1) removal of all (landside and waterside) levee vegetation, to the other extreme of (2) vegetation that is within the construction footprint that would be impacted by levee degrading and construction disturbance to construct the cutoff walls and/or seepage berms. The scale of impacts, the mitigation and variance costs, and the risk to the study was evaluated under each scenario for each alternative. The project alternatives are shown in Figures 5-11.

Scenario: Establish VFZ Per ETL. All vegetation, other than perennial grasses, would be removed from the levee slopes and out 15 feet from the waterside and landside levee toes (subject to preexisting real estate interest). Vegetation within the direct construction footprint will be removed.

a) Mitigation costs were estimated based on costs developed by SBFCA for the Feather River from Thermalito Afterbay to Star Bend (Reference h). The number of incidents for each alternative was compared to the SBFCA estimates, and used to develop an estimate of mitigation costs based on a ratio of incidents identified in the PI. The estimate assumes riparian habitat is mitigated at a ratio of 2 acres for each acre affected, using a mitigation bank cost of $100,000 to 140,000 per acre.

b) The study risk ranges from low to moderate risk depending on the amount of vegetation removal under each alternative. The associated risks are that a jeopardy opinion may be issued and that resource agency and public concerns could increase project costs, or delay compliance with applicable environmental laws. However, these risks could be substantially reduced by development of mitigation plan with the resource agencies to compensate for the loss of vegetation.

Scenario: Variance Per ETL. Corps approval of a variance would be obtained either as part of the pilot study or during the Preconstruction-Engineering and Design (PED) phase. The variance would retain all vegetation outside the immediate construction footprint located on the lower two thirds of the waterside levee slope and out 15 feet from the waterside levee toe; all other levee vegetation would still be removed in accordance with Corps policy.

a) Substantial engineering analysis would be required to support a variance request and to determine what reaches would likely receive variance approval during PED. This analysis would at a minimum entail identification of the tree species, size, root ball size, scour potential if trees fall, increase in seepage gradient, reduction in stability factor of safety, and conclusions regarding rationale for variance approval.

b) Costs to conduct the engineering analyses to support a waterside variance are based on an assumed range of $10,000 to $30,000 per incident. Recent engineering analysis costs have varied significantly from $6,334 per site (PL84-99) to $162,500 per site (Natomas 408 ($1.3 million to evaluate 8 areas)).

c) The study risk ranges from low to moderate depending on the alternative. Alternatives with the most waterside vegetation retained by a variance would have the highest risk if a variance was not granted.

The two scenarios were applied to each of the study alternatives. The estimated costs and study risk are shown in Tables 2 and 3. As shown in Table 2 and 3, the assumed cost to obtain a variance for the alternatives ranges between about $220,000 (SB-3, Ring Levee) to $5.8 million (SB-6, Sutter Bypass) while the assumed mitigation cost of a VFZ is between $1.8 (SB-3 Ring Levee) to $20.9 million (SB-6, Sutter Bypass). The noncompliant vegetation located on the waterside of the levee could be retained if a variance was granted.

7. FINAL ARRAY OF ALTERNATIVES

The planning study evaluated the initial study alternatives based on FRM benefits and costs and determined a final array of alternatives. Alternatives SB-7 and SB-7 were carried forward to the final array. The GIS-based vegetation land cover survey data was then used to more accurately determine vegetation impacts and mitigation costs. Tables 4, 5, and 6 show the results for SB-7 and SB-8. Total mitigation costs are $4.32 million for SB-7, and $9.01 million for SB-8 (Table 6). SB-7 would impact 25.07 acres of riparian forest, 1.30 acres of oak woodland and cause the loss of 129 elderberry shrubs. SB-8 would impact 41.68 acres of riparian forest and scrub shrub, 6.7 acres of oak woodland, and cause the loss of 217 elderberry shrubs. Of the total estimated costs, VFZ requirements account for $1.73 million (40%) for SB-7 and $4.50 million (50%) for SB-8.

8. RECOMMENDED APPROACH

The following recommended approach follows the recommendations provided in Reference b.

a. Future without project condition will assume that project sponsors have maintained the levee in accordance with the O&M manual or that deficiencies in maintaining the levee to the requirements of the O&M manual are being or will be addressed in an approved SWIF(As of this writing, the sponsor has submitted a SWIF draft Letter of Intent).

b. With-project condition will include work, including required mitigation, necessary to comply with access and vegetation requirements of the ETL, including the full 15-foot access (O&M) corridor/vegetation free easement extending from the toe of the levee. Removal or an approved vegetation variance will be considered as being in compliance with the ETL. However, a vegetation variance will not be issued until the design phase of the project. For the feasibility study a vegetation variance will generally not be assumed.

c. For levee segments where a new levee alignment is being proposed (e.g. setback levee), the project as formulated will be in compliance with the ETL (vegetation and access) and all costs associated with ETL compliance will be project costs subject to cost sharing .

d. For levee segments where measures to strengthen existing levees are fix- in-place recommendations (e.g. slurry wall, berms) the following will apply:

    i. If local maintenance has been in compliance with the O&M manual (no deferred maintenance) then all costs associated with ETL compliance, including access of additional real estate interests as may be necessary, will be project costs subject to cost sharing.

ii. If local maintenance has not been in compliance with the O&M manual, project sponsors are responsible for achieving compliance with the O&M manual and required costs to do so are non-federal, non-project costs (Reference g). If a SWIF has been approved, the deferred maintenance may be accomplished in accordance with the terms of the SWIF except that deferred maintenance within the footprint of the new construction must be completed by the sponsors before construction or during construction by the government contractor.

e. During feasibility investigations sufficient information may not be available to distinguish between deferred maintenance costs and new costs to achieve ETL compliance; therefore for the feasibility effort all vegetation clearing and associated mitigation within the construction footprint will be assumed to be a project costs subject to cost sharing.

Matt Davis
Environmental Resources Branch
Sacramento District
U.S. Army Corps of Engineers

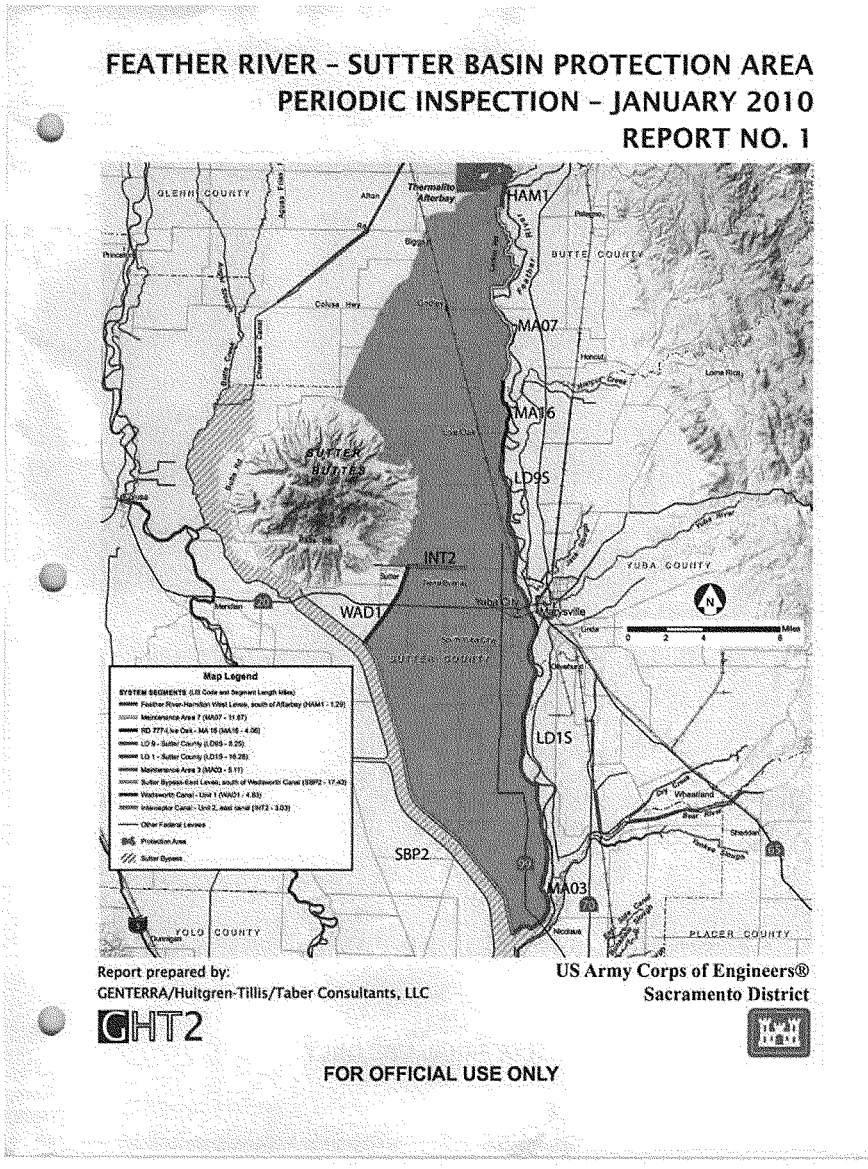


Figure 1. Segments and Responsible Maintaining Entities

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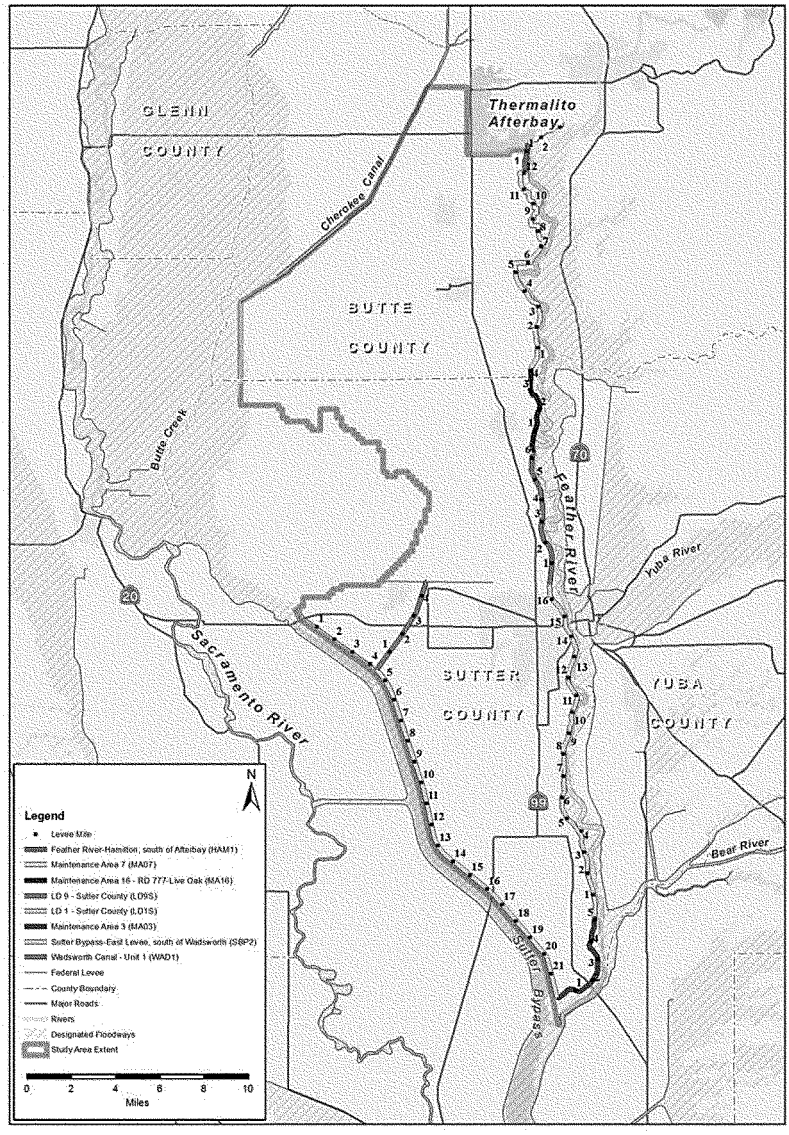

Figure 2. Feather River, Sutter Bypass, and Wadsworth Canal

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Table 1. Sutter ETL Vegetation Inventory Summary

Feather River Afterbay
13 sites out of 18 with veg potentially not conforming to ETL
4 sites with large trees on crest (24"-30")

LD1
36 sites out of 64 with potential ETL issues
1 site with 48" walnut in the landside toe
1 site with 72" cottonwood at WS toe
2 sites with 48" trees at the LS toe
6 sites with numerous unknown (30" & 48") at WS slope and 15' easement
8 sites with oaks (30" & 48)" at WS slope and 15' easement

LD9
5 sites out of 19 with potential ETL issues
1 site with 48" walnut in the landside toe
1 site with unknown 72"+ at WS slope and 15' easement
1 site with oaks 30" at WS slope and 15' easement

MA 3
9 sites out of 31 with potential ETL issues
3 sites with 30"-48"/7 total at WS slope and 15' easement
1 site with unknown 36" on LS easement over seepage berm
1 site with unknown 24" on LS toe

MA7
27 sites out of 76 with potential ETL issues
10 sites with 30"-60" (numerous unknown) at WS slope and 15' easement
14 sites with 30"-60" (numerous unknown) at LS easement

MA 16
14 sites out of 29 with potential ETL issues
4 sites with 30"-48" (numerous unknown) at WS slope and 15' easement
3 site with 30"-60" (numerous unknown) at LS easement

Sutter Bypass
21 sites out of 79 with potential ETL issues
26 sites with 24"-48" (numerous unknown) at WS slope and 15' easement
8 site with 24" (numerous unknown) at LS easement

Wadsworth Canal
2 sites out of 3 with potential ETL issues

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Figure 3
Feather River West Levee

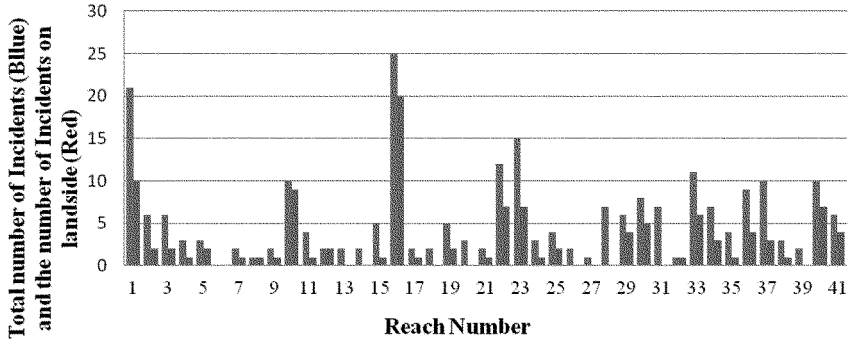
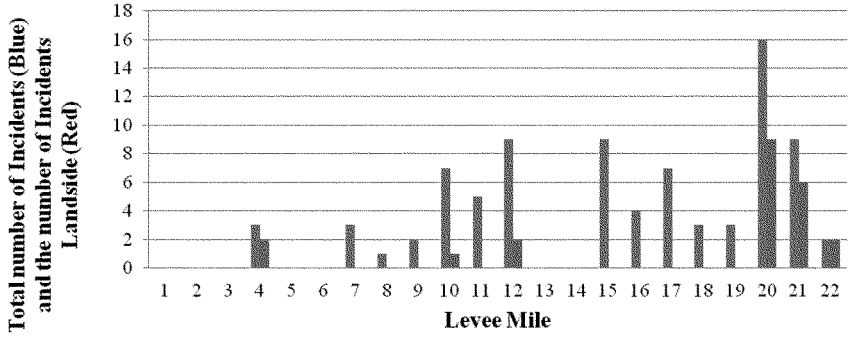


Figure 4
Sutter Bypass



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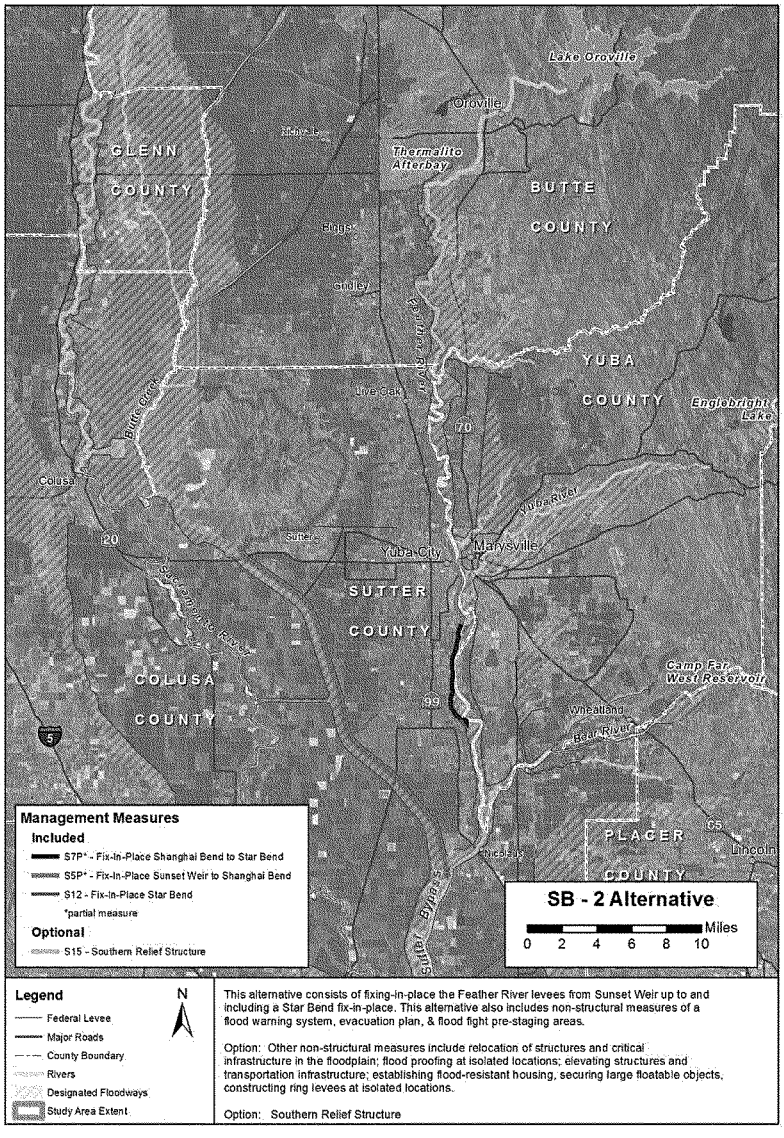

Figure 5. SB – 2 Alternative

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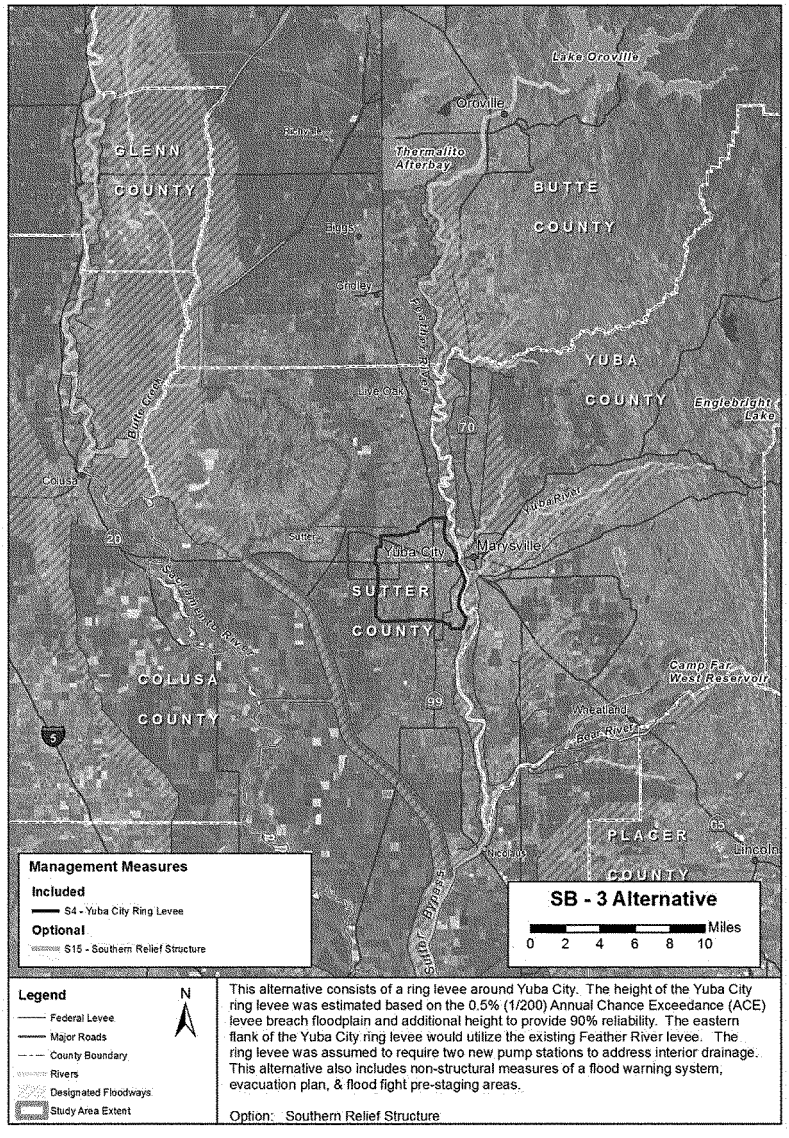

Figure 6. SB – 3 Alternative

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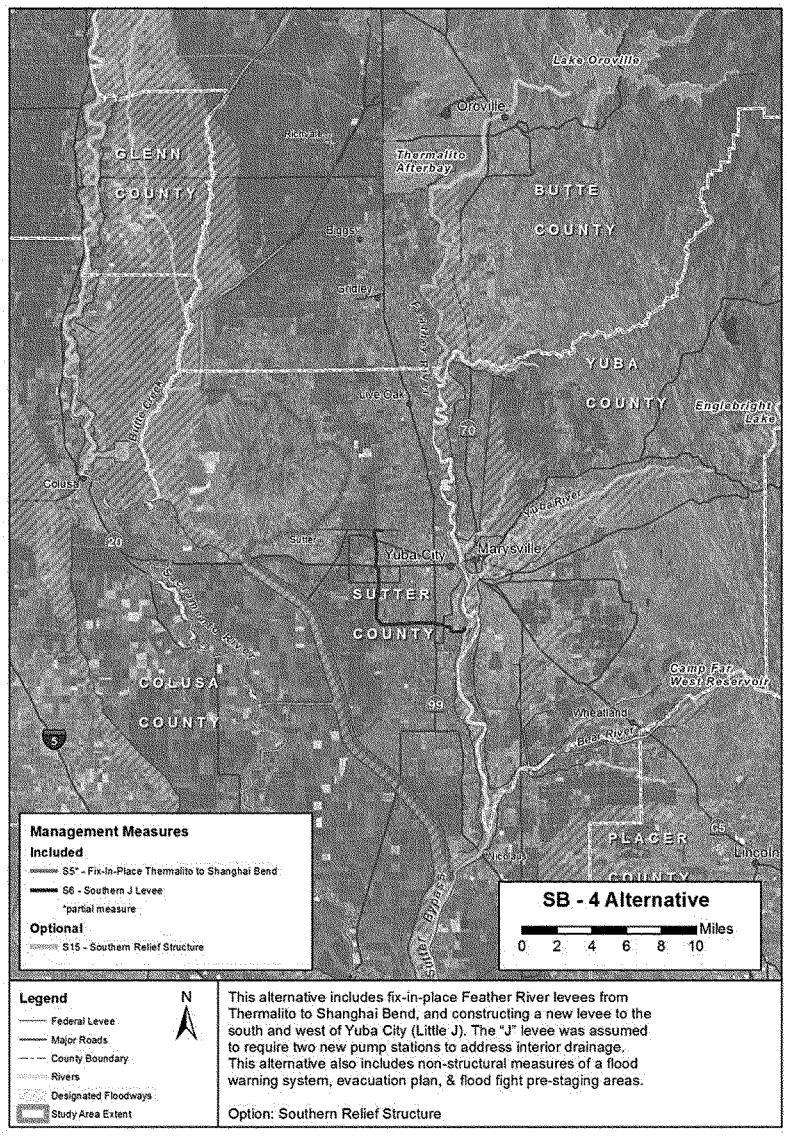

Figure 7. SB – 4 Alternative

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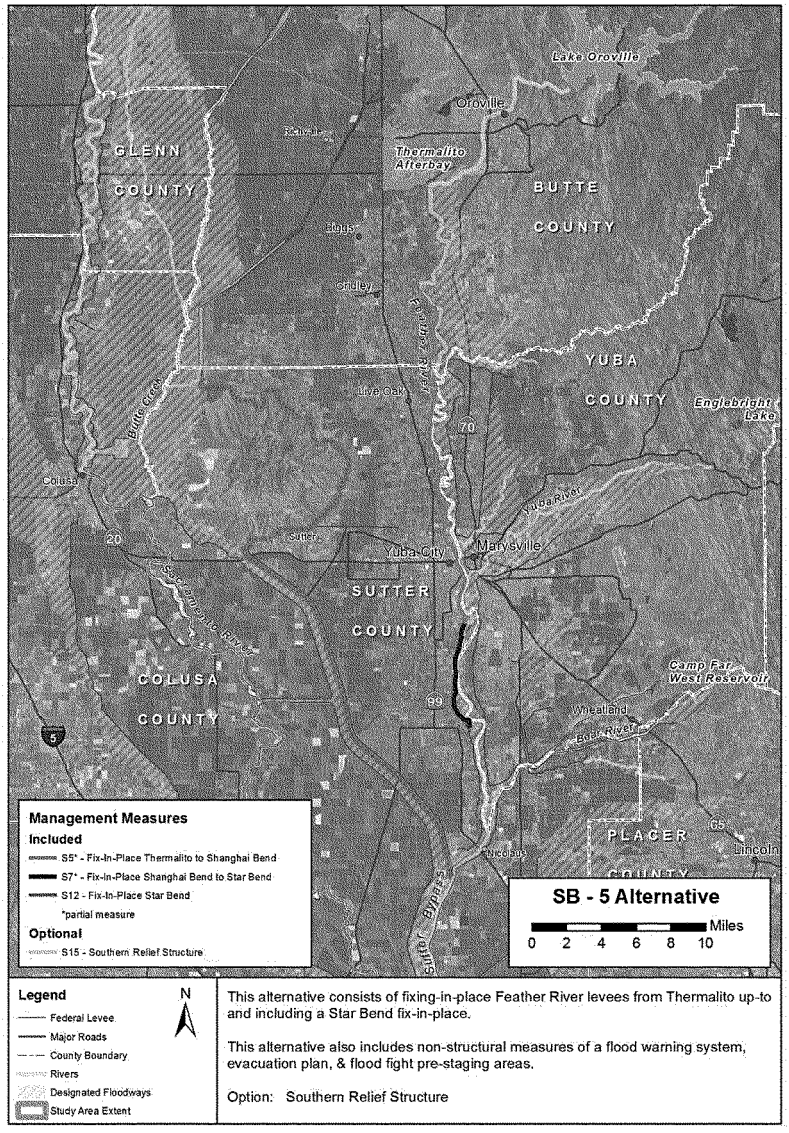

Figure 8. SB 5 Alternative

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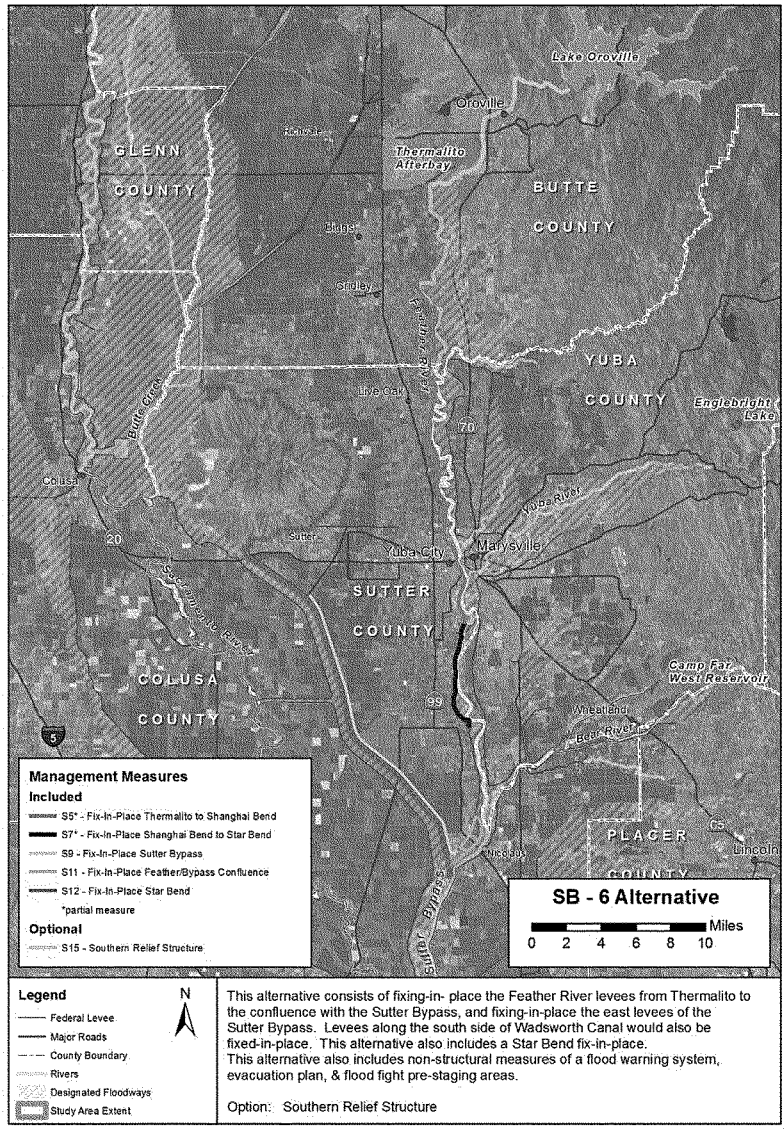

Figure 9. SB – 6 Alternative

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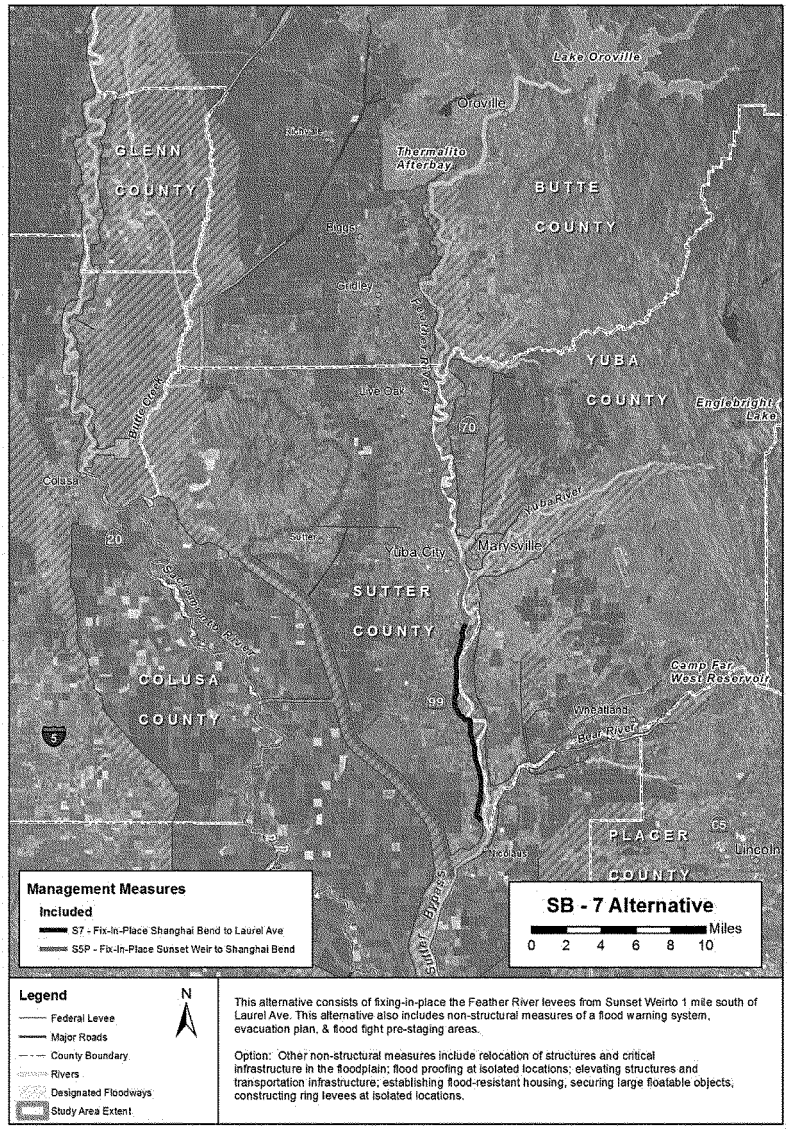

Figure 10. SB-7 Alternative

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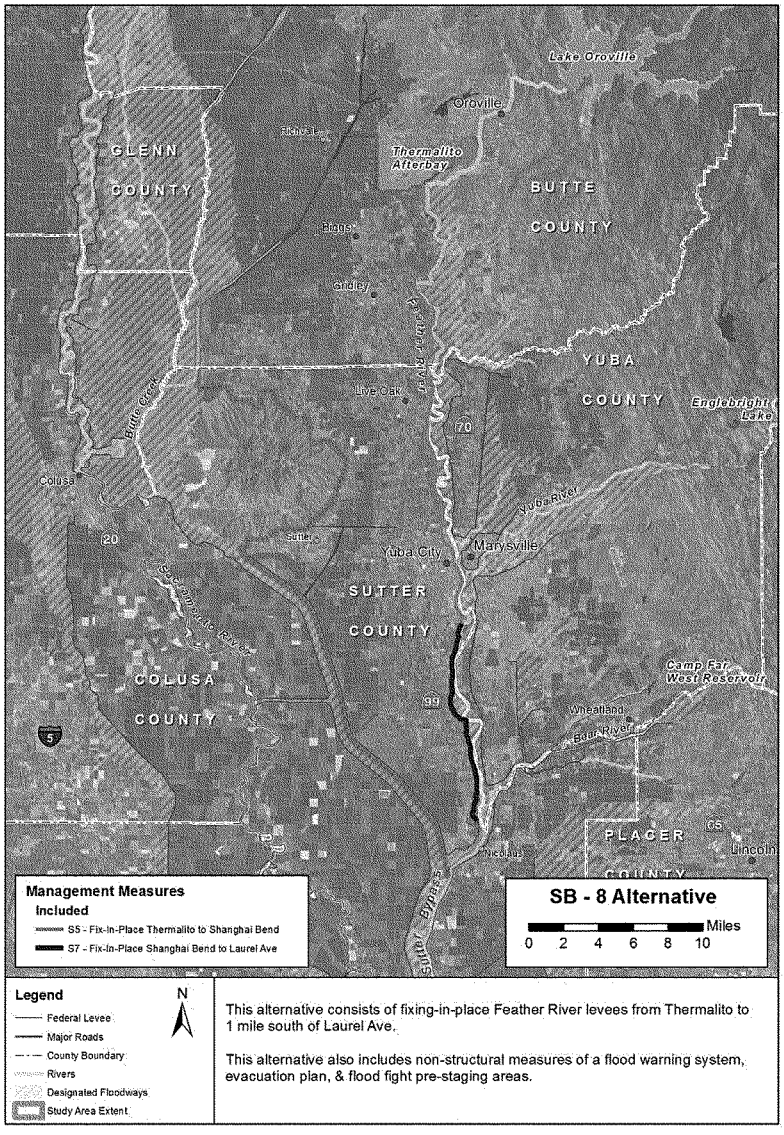

Figure 11. SB-8 Alternative

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SUBJECT: Compliance with ETL 1110-2-571

Table 2
Scenario: Establish VFZ Per ETL

Alternative	Number of Incidents	Mitigation Cost	Study Risk
SB-2, Minimal-Fix-in-Place (Feather reaches 6-21)	71	$3,301,911 to $4,627,675	Low-Moderate. Extent of vegetation removal is less than SB-5 and SB-6 but more than SB-3 and SB-4. Lower risk for jeopardy opinion and resource agency and public concerns.
SB-3, Ring Levee (Feather reaches 12-18)	38	$1,767,220 to $2,474,108	Low. The least amount of vegetation removal compared to other alternatives and therefore the least potential for a jeopardy opinion and project delays.
SB-4, Little J (Feather reaches 12-41)	179	$8,324,536 to $11,654,350	Moderate. Same as SB-5.
SB-5, Fix-in-Place, Thermalito to Star Bend (Feather reaches 6-41)	200	$9,301,158 to $13,021,621	Moderate. Substantial vegetation removal. Along with SB-6, most potential for a jeopardy opinion and permit delays. Compensatory mitigation would substantially reduce identified risk.
SB-6, Sutter Bypass (Feather reaches 1-41, Sutter Bypass LM 0-22, Wadsworth Canal LM 0-3)	321	$14,928,359 to $20,899,702	Moderate. Most vegetation loss and the most potential risk due to greater risk of a jeopardy opinion and permit delays. Compensatory mitigation would substantially reduce identified risk.
SB-7, Fix-In-Place, Feather River, Sunset Weir to south of Laurel Ave (Feather reaches 2-21)	87	$4,046,003 to $5,670,531	Low-Moderate. Same as SB-2.
SB-8, Fix-In-Place, Feather River, Thermalito to south of Laurel Ave (Feather reaches 2-41)	216	$10,045,250 to $14,078,560	Moderate. Similar as SB-5.

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SUBJECT: Compliance with ETL 1110-2-571

Table 3
Scenario: Variance Per ETL

Alternative	Number of Waterside Incidents	Cost to Obtain Variance	Study Risk
SB-2, Minimal Fix-in-Place (Feather reaches 6-21)	38	$380,000 to $1,140,000	Low. Additional ESA consultation and NEPA compliance could be required if a variance is not granted. Mitigation costs would increase but not significantly affect total project costs.
SB-3, Ring Levee (Feather reaches 12-18)	22	$220,000 to $660,000	Low. Similar to SB-2. Least amount of vegetation removal compared to other alternatives and therefore the least potential impact from not obtaining a variance.
SB-4, Little J (Feather reaches 12-41)	103	$1,030,000 to $3,090,000	Moderate. Same as SB-5.
SB-5, Fix-in-Place, Thermalito to Star Bend (Feather reaches 6-41)	111	$1,110,000 to $3,330,000	Moderate. In addition to the risks for other alternatives, this and alternative SB-6 have the most vegetation removal and thus the most potential for a jeopardy opinion and project delays if a variance is not obtained.
SB-6, Sutter Bypass (Feather reaches 1-41, Sutter Bypass LM 0-22, Wadsworth Canal LM 0-3)	193	$1,930,000 to $5,790,000	Moderate. Most vegetation loss and therefore the most potential risk to study if a variance is not granted.
SB-7, Fix-In-Place, Feather River, Sunset Weir to south of Laurel Ave (Feather reaches 2-21)	46	$460,000 to $1,380,000	Low. Same as SB-2.
SB-8, Fix-In-Place, Feather River, Thermalito to south of Laurel Ave (Feather reaches 2-41)	119	$1,190,000 to $3,570,000	Moderate. Same as SB-5.

Table 4. Effects on Land Cover Types for Alternatives SB-7 and SB-8

Land Cover Types	Alt SB-7 (acres)	Alt SB-8 (acres)
Riparian forest		
Construction footprint	14.16	20.63
VFZ Requirement	9.61	14.00
Subtotal	23.77	34.63
Riparian scrub-shrub		
Construction footprint	NA	0.32
VFZ Requirement	NA	NA
Subtotal	NA	0.32
Oak woodland		
Construction footprint	NA	NA
VFZ Requirement	1.30	6.73
Subtotal	1.30	6.73
Total	25.07	41.68

Table 5. Elderberry Shrub Impacts for Alternatives SB-7 and SB-8

Land Cover Types	Alt SB-7 (number of shrubs)	Alt SB-8 (number of shrubs)
Elderberry Shrub Loss		
Construction footprint	31	52
VFZ Requirement	98	165
Total	129	217

Table 6. Mitigation Cost Estimate for Alternatives SB-7 and SB-8

Land Cover Types	Alt SB-7 (X $1 Million)	Alt SB-8 (X $1 Million)
Riparian forest		
Construction footprint	2.83	4.13
VFZ Requirement	1.92	2.80
Subtotal	4.75	6.93
Riparian scrub-shrub		
Construction footprint	NA	0.06
VFZ Requirement	NA	NA
Subtotal	NA	0.06
Oak woodland		
Construction footprint	NA	NA
VFZ Requirement	0.26	1.35
Subtotal	0.26	1.35
Elderberry Shrub Loss		
Construction footprint	0.42	0.70
VFZ Requirement	1.58	2.66
Subtotal	2.00	3.36
Construction footprint Total	3.25	4.89
VFZ Requirement Total	3.76	6.81
*Grand Total**	4.32	9.01

* Reduced to reflect VELB compensation providing riparian and oak woodland compensation.

Cost Assumptions: (1) Compensation ratio of 2:1 for all cover types
(2) Star Bend Mitigation Site is limited to 28.5 acres of available area at a cost of $125,000 per acre;
(3) Elderberry mitigation would occur at Star Bend and would compensate for riparian impacts in addition to VELB impacts;
(4) Mitigation needs not met at Star Bend would be addressed at a mitigation bank at cost of $100,000 per acre; and
(5) VELB mitigation requirements based on the USFWS conservation guidelines.

ENCLOSURE J

SBFCA EXISTING CONDITIONS SEEPAGE RESULTS

Table 4-4. Seepage Gradient Criteria
Feather River West Levee Rehabilitation Early Implementation Project - Task Order 1

Levee Condition	Location	WSE Condition	Maximum Average Exit Gradient
Existing Conditions	Landside levee toe	DWSE	0.5
		HTOL	0.6
	Bottom of empty ditch at landside toe	DWSE	0.5
		HTOL	0.6
	Bottom of ditch and landside field between toe and 150 feet from toe	DWSE	linear interpolation between 0.5 and 0.8
		HTOL	linear interpolation between 0.6 and 0.9
With Rehabilitation Measures	Landside levee toe, without berm (e.g., with cutoff wall)	DWSE + 1 foot	0.5
		HTOL + 1 foot	0.6
	Landside levee toe with relief wells	DWSE + 1 foot	0.5
		HTOL + 1 foot	0.6
	Bottom of empty ditch at landside toe (without berm)	DWSE + 1 foot	0.5
		HTOL + 1 foot	0.6
	Bottom of empty ditch ≥ 150 feet from toe, with or without berm	DWSE + 1 foot	0.8
		HTOL +1 foot	0.9
	Bottom of ditch between toe and 150 feet from toe, with or without berm	DWSE + 1 foot	linear interpolation between 0.5 and 0.8
		HTOL +1 foot	linear interpolation between 0.6 and 0.9
	Landside levee toe, with berm	DWSE + 1 foot	0.5
		HTOL +1 foot	0.6
	Toe of seepage berm, between landside toe and less than 100 feet from levee toe	DWSE + 1 foot	0.8
		HTOL + 1 foot	does not increase more than 20% from that determined for the DWSE
	Toe of seepage berm between 100 feet and 300 feet from landside levee toe	DWSE + 1 foot	0.8
		HTOL + 1 foot	use engineering judgment
	Toe of seepage berm at or greater than 300 feet from landside levee toe	DWSE + 1 foot	use engineering judgment
		HTOL +1 foot	use engineering judgment

WSE = water surface elevation
DWSE = design water surface elevation
HTOL = hydraulic top of levee

TABLE 5-1A: CHARACTERIZATION OF REACH 1
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT – TASK ORDER 1

REACH ID [1]	REACH LIMITS [2] START STATION (SBFCA) [DWR ULE STATION]	REACH LIMITS [2] END STATION (SBFCA) [DWR ULE STATION]	LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION – CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
1	SBFCA 10+00 [DWR 2167+00]	SBFCA 129+66 [DWR 2286+00]	2.25	**Toe** CPT – 4 **Crown** CPT – 9 Borings – 6	**Crown Width** • 17 to 20 feet **Landside Slope** • 1.3H:1V to flatter than 2H:1V **Waterside Slope** • 2.2H:1V to flatter than 3H:1V	• **10+93 (2167+13) 1997:** Light seepage observed. • **29+13 (2185+34) 1997:** Light seepage observed. • **35+85 to 60+50 (2192+06 to 2216+73) 1997:** Severe sloughing due to wave erosion along approximately 1800 feet of waterside slope. • **40+52 to 43+88 (2196+79 to 2200+03) 1997:** Erosion along the waterside levee slope with a vertical face of 6 to 12 inches, half way up the levee. • **48+00 to 53+21 (2204+22 to 2209+44) 1955;** Levee cut to dewater the flooded area in December 1955. • **69+94 (2226+15) 1997:** An area where levee turns sharply to an east-west direction was eroded for about 150 feet. • **73+02 (2229+26) 1986:** A sinkhole approximately 30 feet long, ten feet wide, and ten feet deep right at waterside toe of the levee. This hole was discovered after the 1986 high water receded. There was no landside evidence of this sinkhole during high water. • **98+06 (2254+30) 2006:** Waterside erosion. • Based on DWR's Seepage Area map for the Feather River West Levee area, 100% of Reach 1 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observation. Based on the same map, 100% of Reach 1 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observation.	• **10+03 to 280+77 (2166+00 to 2437+00) 1963:** Levee stabilization construction (USACE Specification 2783, File Drawing 4-4-531). • **73+02 (2229+26) 1986:** Sinkhole at waterside toe filled with gravel • **98+06 (2254+30) 2006:** Waterside erosion, emergency repair made.	• **Land Side:** Between Stations **10+93 and 54+13 (2167+13 and 2210+33)** Geomorphologic consists of Ra with isolated fingers of Rdo. Station **54+13 (2210+33)** to end of reach consist mainly of Ra with fingers of Hch, Rdo, and Rob. • **Water Side:** Mainly Ra along the levee toe with meandering Rch parallel with waterside ditch.	• **10+93 to 45+80 (2167+13 to 2202+00)**: Low to moderate resistivity within upper 15-20', low to very low resistivity to depth • **45+80 to 106+80 (2202+00 to 2263+00)**: High to very high resistivity (occasionally moderate) within upper 15-25' at 45+80 (2202+00) increasing in depth to greater than 50' between 93+80 (2250+00) and 106+80 (2263+00), possible anomalous deep high resistivity readings at depth from 69+80 (2225+00) to 176+80 (2335+00) on waterside due to bend in levee. • **106+80 to 129+76 (2263+00 to 2286+00)**: Moderate resistivity (occasionally high) within upper 15-25', high to very high below, possible anomalous deep high resistivity readings from 118+80 (2275+00) to 129+80 (2286+00) due to irrigation pipe crossings.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13] SBFCA STATION [DWR ULE STATION]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
• **Levee Fill:** Consists of variable lenses of clay, silt, sandy silt, silt sand and silty sand. • **Blanket:** Relatively consistent silt, clay, sandy silt and sandy clay blanket with thicknesses ranging from 45 to 60 ft. Isolated lenses (between 1 and 10 ft. thick) of sand and silty sand are shown within the blanket area at different elevations. Below an elevation of -20 ft. MSL, the logs show alternative thin layers of GM/SP/SM/CL.	1) DWR 2262+50 (SBFCA 105+10) = **100-yr, 52.1 ft** 2) Average Head = 13.7 ft	Parallel landside and waterside unlined ditches are present. Near Stations **45+80, 57+80, and 67+80 (2202+00, 2214+00, and 2224+00)** unlined perpendicular ditches tie into parallel ditch. Land side ditch shifts further away from levee toe near Station **57+80 (2214+00)**. Landside ditches ends near Station **67+80 (2224+00)**. Pump Station located in landside ditch near Station **51+80 (2208+00)**. High voltage power pole and line located near Station **72+80 (2229+00)** on waterside. Hwy 99 crosses levee at Station **97+80 (2254+00)**. Sacramento Ave intersects levee road at Station **106+80 (2263+00)**.	SBFCA Station 106+10.50 [DWR Station 2262]	1) WM0003_012B, SM0003_004C, CM0003_004H	Location of potential underseepage problem due to presence of deep sand layers. A ditch is also present at the landside toe, which increases underseepage potential.

TABLE 5-1B: ANALYSIS RESULTS FOR REACH 1
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Results for Reach 1
Analysis Station: 106+11

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year	0.30 to 0.46		0.33 to 0.52	7 feet above toe	No	The high phreatic breakout point and granular levee fill indicate potential for through-seepage. Past performance records also indicate underseepage.
100-year + 3 feet	0.35 to 0.55		0.38 to 0.61	8.5 feet above toe	No	

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
100-year	1.36		No	
100-year + 3 feet	1.26		Yes	

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	
100-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

For Alternative Analysis, two different models were created using Station 106+11 surface geometry to represent the reach. One model was generated with the existing berm and irrigation ditch and another model was created without the berm or ditch. The analyses results for the cross-section without the berm and ditch are presented, because with the berm and ditch in place the toe gradients move to the bottom of the ditch due to the close proximity of the toe and ditch. Alternative 1 for Reach 1 is a soil-bentonite cutoff wall extending below relatively shallow silty sand layers into a less permeable clay layer. Alternative 2 for Reach 1 is a drained stability berm and an undrained seepage berm. These alternatives were selected to mitigate through-seepage and underseepage.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall.

Dimensions of Primary Features: **10+00 to 58+80** Cutoff Wall Tip Elevation 20 feet, **58+80 to 83+00** Cutoff Wall Tip Elevation 18 feet, **83+00 to 114+00** Cutoff Wall Tip Elevation 24 feet, **114+00 to 129+66** Cutoff Wall Tip Elevation 27 feet. Cutoff wall is 3 feet wide and requires 1/2 levee de-grade/re-grade.

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year + 1 foot	0.31 to 0.49	N/A	0.38 to 0.62	No breakout above toe	Yes	
100-year + 4 feet	0.37 to 0.57	N/A		No breakout above toe	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
100-year + 1 foot	1.93		Yes	
100-year + 4 feet	1.92		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Drained Stability Berm with Undrained Seepage Berm.

Dimensions of Primary Features: **10+00 to 129+66**, 8 feet tall Drained Stability Berm with 88 feet wide Undrained Seepage Berm. Assume 25% of reach will have an undrained seepage berm width extending to 100 feet due to taller levee at some locations. Stability berm is 10 feet wide at top, 2 feet thick drain, and 3H:1V slope. Seepage Berm thickness - 5 feet at levee toe and 3 feet at berm toe.

Seepage

WSE	Exit Gradient Levee Toe	Stability Berm Toe	Seepage Berm Toe	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year + 1 foot		0.16 to 0.23	0.39 to 0.62	Bottom of stability berm	Yes	
100-year + 4 feet		0.21 to 0.30	0.44 to 0.72	Bottom of stability berm	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
100-year + 1 foot	1.90		Yes	
100-year + 4 feet	1.80		Yes	

TABLE 5-2A: CHARACTERIZATION OF REACH 2
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT – TASK ORDER 1

REACH ID [1]	REACH LIMITS [2] START STATION (SBFCA) / [DWR ULE STATION]	REACH LIMITS [2] END STATION (SBFCA) / [DWR ULE STATION]	LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION – CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
2	SBFCA 129+66 [DWR 2286+00]	SBFCA 218+66 [DWR 2375+00]	1.69	**Toe** CPT – 9 Borings – 7 **Crown** CPT – 8 Borings – 15 **Field** CPT – 3 Borings – 5	**Crown Width** • 15 to 20 feet **Landside Slope** • 1.5H:1V to flatter than 2H:1V **Waterside Slope** • 2H:1V to flatter than 3H:1V	• **130+27 to 181+83 (2286+46 to 2338+04) Previous Flood Events:** Excessive seepage occurs during high water between Sacramento Avenue and Laurel Avenue; • **132+87 (2289+07) 1997:** Heavy seepage running clear; • **139+46 (2295+67) 1997:** Heavy seepage running clear; • **144+63 to 146+73 (2300+84 to 2302+92) 1997:** Heavy seepage running clear; • **163+88 (2320+07) 1997:** Heavy seepage running clear; • **175+60 (2331+79) 1997:** Heavy seepage running clear; • **179+72 (2334+92) 1997:** Heavy seepage around tree, running clear; • **183+40 (2339+60) 1997:** Heavy seepage running clear; • **193+16 to 194+70 (2349+37 to 2350+92) 1997:** Heavy seepage running clear; • **197+97 (2354+07) 1986:** Boil 200 feet from landward toe, water was clear and did not carry material; • **201+92 (2358+13) 1997:** Heavy seepage running clear; • **198+42 (2354+62) 1986:** A landside boil occurred in a landside drainage ditch near the levee toe during the 1986 flood, an area of boils appeared at the landside toe and away from the toe, there appears to be a swale or old slough at this location, ditches were reported to be excavated on both sides of the levee to explore for the cause of the boils but no explanation found. • **206+15 to 242+00 (2362+13 to 2398+27) 1997:** Heavy seepage into existing ditch caused sloughing of the bank and the levee slope, clear seepage was entering the ditch. Particularly heavy seepage and sloughing at toe of levee at 2370 to 2374. • **203+77 to 218+79 (2360+00 to 2375+00):** Per B. Hampton of LD-1, this is area of old levee breach and reconstruction. Date unknown. • **Based on DWR's Seepage Area map for the Feather River West Levee area, 100% of Reach 2 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observation. Based on the same map, 100% of Reach 2 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observation.**	• **129+76 to 190+41 (2286+00 to 2346+55) 19621963**: Landside toe berm with 15'-deep drain present (constructed as part of 1962-63 USACE levee stabilization project); • **190+34 to 198+79 (2346+55 to 2355+00 and 2355+41 to 2366+00) 1998**: Toe drain and berm constructed under the Marysville/Yuba City Levee Reconstruction Project (F.R. Site B), 41-foot gap in berm at Laurel Avenue levee ramp access. Also, this is Site 11 (toe drain and berm planned) on project plans entitled "Sacramento River Flood Control Project Phase II, Levee Reconstruction, Contract 3" (As-builts?); • **206+29 to 241+93 (2362+13 to 2398+27) 1998**: During 1997 flood, emergency stability berm constructed using sandbags placed on geotextile fabric in drainage ditch, later that year this was converted to a pervious toe drain under the Marysville/Yuba City Levee Reconstruction Project (F.R. Site B).	• **Landside:** Between Stations **129+76 to 190+41 (2286+00 and 2355+50)** Geomorphology consists of alternating Ra and Rdfc. Between Stations **198+79 (2355+00)** and the end of the reach the Geomorphology consists predominantly of Ha with fingers of Rdfc. • **Waterside:** Consists of Ra along reach.	• **129+76 to 173+80 (2286+00 to 2330+00)**: Moderate resistivity to depths of 20-40' followed by high resistivity to depths of 100-120'. Moderate resistivity at depths greater than 100-120'. • **173+80 to 218+31 (2330+00 to 2375+00):** Moderate resistivity to depths of 15 to 20 feet (high resistivity zones from **173+80 to 188+80 (2230+00 to 2345+00)** on land/water side), thick very high resistivity zone beneath to depths over 100'.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13] SBFCA STATION / [DWR ULE STATION]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
• **Levee Fill:** Consists of variable lenses of clay, silt, sandy silt, silt sand and silty sand. • **Blanket:** With the exception of two borings at Stations 151+80 and 170+05 (2308+00 and 2326+25), the Reach contains a relatively consistent clay and silty clay blanket between 10 and 25 ft thick. The blanket is overlain and underlain by silty sand and sandy silt of varying thicknesses. At Stations 151+80 and 170+05 (2308+00 and 2326+25) borings indicate levee is underlain by sandy silt to 25 feet below the levee toe elevation. Below an elevation of approximately 0 to 10 ft the borings show interbedded layers of CL/GW-GP/SP/SW/ML to the depths explored.	1) DWR 2337+50 (SBFCA 181+13) = **100-yr, 54.1 ft** 2) Average Head = 16.2 ft	Seepage berm with toe drain located along land side levee toe between Stations **129+76 and 210+30 (2286+00 and 2366+50)**. Irrigation pipe through levee crown at Station **199+80 (2365+00)**. Concrete ditch near end of Reach starting at Station **216+80 (2373+00)** continuing into Reach 3. Audubon Society dirt parking lot and metal structure located near the landside toe at Station **199+80 (2365+00)**. Water side ditch along entire alignment.	SBFCA Station 181+13 [DWR 2337+50]	1) WM0003_034C; WM0003_035C; WM0003_003A, and WM0003_018C	Presence of sandy layers both in embankment and foundation. Potential thin blanket condition.

TABLE 5-2B: ANALYSIS RESULTS FOR REACH 2
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Results for Reach 2
Analysis Station: 181+13

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year	0.51 to 1.83			4' above toe	No	Results are consistent with past performance of the reach, which consists of significant boils and sloughing at the toe of the levee.
100-year + 3 feet						

Landside Stability

WSE		Performance			Meets Criteria?	
100-year						

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	
100-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 2 is a soil-bentonite cutoff wall extending below sand/silty sand layers into a less permeable clay/silt layer. This alternative was selected as an in-place alternative to mitigate both through-seepage and underseepage potential. Alternative 2 for Reach 2 includes the use of both stability berm with seepage berm and a shallow cutoff wall with a seepage berm. The seepage berm material type is lean clay, which is similar to the shallow near surface layers. The shallow cutoff wall reduces the potential for seepage through shallow near surface sandy layers and unacceptable gradients through the berm near the levee toe.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall.

Dimensions of Primary Features: **129+66 to 181+00** Cutoff Wall Tip Elevation 20 ft, **181+00 to 191+00** Cutoff Wall Tip Elevation (-10 feet), **191+00 to 218+66** Cutoff Wall Tip Elevation (-73 feet) with full levee de-grade/re-grade. Cutoff wall is 3 feet wide and requires 1/2 levee de-grade/re-grade except between station **191+00 and 218+66** where a full levee de-grade/re-grade is required.

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year + 1 foot	0.09 to 0.12	N/A		Toe	Yes	
100-year + 4 feet	0.15 to 0.13			Toe	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
100-year + 1 foot	1.78		Yes	
100-year + 4 feet	1.75		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Drained Stability Berm with Undrained Seepage Berm and Cutoff Wall with Undrained Seepage Berm

Dimensions of Primary Features: **129+66 to 181+00**, 8 feet tall Drained Stability Berm with 100 feet wide Undrained Seepage Berm, **181+00 to 218+66** Cutoff Wall Tip Elevation 30 feet with 100 feet wide Undrained Seepage Berm. Stability berm is 10 feet wide at top, 2 feet thick drain, and 3H:1V slope. Seepage Berm thickness - 5 feet at levee toe and 3 feet at berm toe. Cutoff wall is 3 feet wide and requires 1/2 levee de-grade/re-grade.

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year + 1 foot	0.15	0.57		At the toe of the slope/top of the seepage berm	Yes	Remove thin CL Blanket and underlying SM (4 feet by 200 feet) and replace with Undrained Stability Berm material (CL).
100-year + 4 feet	0.22	0.66			Yes	Remove thin CL Blanket and underlying SM (4 feet by 200 feet) and replace with Undrained Stability Berm material (CL).

Landside Stability

WSE	FS		Meets Criteria?	Comments
100-year + 1 foot	1.86		Yes	
100-year + 4 feet	1.81		Yes	

TABLE 5-3A: CHARACTERIZATION OF REACH 3
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT – TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION – CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
3	SBFCA 216+66 [DWR 2375+00]	SBFCA 300+66 [DWR 2457+00]	1.55	**Toe** CPT – 5 Borings – 9 **Crown** CPT – 9 Borings – 13 **Field** CPT – 3 Borings – 1	**Crown Width** • 17 to 20 feet **Landside Slope** • 1.5H:1V to flatter than 2H:1V **Waterside Slope** • 2H:1V to flatter than 3H:1V	• **206+15 to 242+00 (2362+13 to 2398+27) 1997**: Heavy seepage into existing ditch caused sloughing of the bank and the levee slope, clear seepage was entering the ditch. • **253+70 to 257+92 (2410+00 to 2414+00)**: Per B. Hampton with LD-1, water level in landside pond rises with increasing water level behind levee, which leads to bank erosion in the pond. • Based on DWR's Seepage Area map for the Feather River West Levee area, 95% of Reach 3 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observation. Based on the same map, 90% of Reach 3 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observation.	• **206+29 to 241+93 (2362+13 to 2398+27) 1998**: During 1997 flood, emergency stability berm constructed using sandbags placed on geotextile fabric in drainage ditch, later that year this was converted to a pervious toe drain under the Marysville/Yuba City Levee Reconstruction Project (F.R. Site 8). • **218+31 to 298+97 (2375+00 to 2455)**: Drain consists of fabric-wrapped gravel placed in existing ditch and then backfilled. Concrete lined landside ditch on slightly elevated berm.	• **Landside:** Geomorphology along levee toe consists of alternating Ha and Rob units. One section of Ros is shown against the levee toe between Stations **291+05 and 292+80 (2447+25 and 2449+00)**. • **Waterside:** Geomorphology consists of Ra.	• **218+31 to 241+80 (2375+00 to 2398+00)**: Low to moderate resistance throughout profile (low within upper 10-20' of this segment). • **241+80 to 288+80 (2398+00 to 2445+00)**: Alternating high to moderate resistivity zones within the upper 10-20' (waterside mainly high resistivity near-surface) followed by high to very high resistivity to depths of about 100', moderate resistivity below 100'. • **288+80 to 300+80 (2445+00 to 2457+00)**: Primarily high to very high resistivity to a depth of about 50', occasional moderate resistivity zones within the upper 10-20'.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
• **Levee Fill:** Consists of variable lenses of clay, silt, sandy silt, silt sand and silty sand. • **Blanket:** ML and CL blanket is present below the levee toe at thicknesses ranging from 10 and 30 ft. The blanket is overlain by thin lenses (less than 5 ft) of silty sand and sand at a few of the boring locations. The blanket is underlain by 10 to 40 ft layers of sand and silty sand. Below an elevation of approximately -20 the borings show interbedded layers of CL/ML/GW/GP/SM to the depths explored.	1) DWR Station 2396+00 (SBFCA Station 239+78) = **100-yr 54.6 ft**, **100-yr + 3ft = 57.5 ft**. 2) Average Head 100 yr = 10.6 ft. Average Head 100 yr + 3ft = 13.6 ft	Concrete lined ditch located on land side along entire reach. Pond located on land side near Station **255+80 (2412+00)**. Irrigation pump structure located on water side near Station **298+97 (2455+00)**. Irrigation piping from pump to farm travels through Levee crown near Station **298+97 (2455+00)** Water side borrow ditch appears to end at Station **265+30 (2421+50)**.	SBFCA Station 239+78 [DWR Station 2396+00]	1) WM0003_022B, WM0003_008C, SM0003_008H	Presence of thin fine-grained blanket layer. The shallow sand and silty layer is about 50 feet thick.

TABLE 5-3B: ANALYSIS RESULTS FOR REACH 3
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Results for Reach 3
Analysis Station: 239+78

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year	0.5	1.7	1.34	Toe	No	Results are consistent with past performance of significant seepage and sloughing at the levee toe.
100-year + 3 feet						

Landside Stability

WSE	FS	Performance			Meets Criteria?	Comments
100-year						

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	
100-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 3 is a soil-bentonite cutoff wall extending below sand/silty sand layers into a less permeable clay/silt layer. This alternative was selected as an in-place alternative to mitigate both through-seepage and underseepage potential. Alternative 2 for Reach 3 consists of a stability berm with a seepage berm. The seepage berm material type is silty sand, which is similar to the shallow near surface layers. Alternative 2 mitigates underseepage and through seepage. Seepage analysis indicate high exit gradients at the toe of the seepage berm. Therefore, monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a collection drain system may be needed.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: **218+66 to 220+00** Cutoff Wall Tip Elevation (-73 feet), **220+00 to 230+00** Cutoff Wall Tip Elevation 20 feet, **230+00 to 250+00** Cutoff Wall Tip Elevation (-35 feet), **250+00 to 289+00** Cutoff Wall Tip Elevation (-20 feet), **289+00 to 300+66** Cutoff Wall Tip Elevation 15 feet. Cutoff wall is 3 feet wide and requires 1/2 levee de-grade/re-grade.

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year + 1 foot	0.08	0.48		At toe of the levee	Yes	
100-year + 4 feet	0.11	0.56		At toe of the levee	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
100-year + 1 foot	1.4		Yes	
100-year + 4 feet	1.4		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Drained Stability Berm with Undrained Seepage Berm.

Dimensions of Primary Features: **218+66 to 300+66** 8 feet tall Drained Stability Berm with 300 feet Wide Undrained Seepage Berm with monitoring for seepage at the toe of the Undrained Seepage Berm. Drained Stability Berm is 10 feet wide at top, 2 feet thick drain, and 3H:1V slope. Undrained Seepage Berm thickness - 5 feet at levee toe and 3 feet at berm toe

Seepage

WSE	Exit Gradient Levee Toe	Stability Berm Toe	Seepage Berm Toe	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year + 1 foot		0.17	1.31	Bottom of stability	Yes	Monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or
100-year + 4 feet		0.29	1.52	berm/top of seepage	Yes	a collection drain system may be needed.

Landside Stability

WSE	FS		Meets Criteria?	Comments
100-year + 1 foot	2.01		Yes	
100-year + 4 feet	2.00		Yes	

TABLE 5-4A: CHARACTERIZATION OF REACH 4
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT – TASK ORDER 1

REACH ID [1]	REACH LIMITS [2] START STATION (SBFCA) [DWR ULE STATION]	REACH LIMITS [2] END STATION (SBFCA) [DWR ULE STATION]	LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION – CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
4	SBFCA 300+67 [DWR 2457+00]	SBFCA 410+67 [DWR 2567+00]	2.1	**Toe** CPT – 5 Borings – 1 **Crown** CPT – 11 Borings – 5 **Field** CPT - 1	**Crown Width** • 15 to 20 feet **Landside Slope** • 1.7H:1V to flatter than 2H:1V **Waterside Slope** • 1.5H:1V to flatter than 3H:1V	• **359+42 (2515+65) 1986**: During the 1986 flood, a crack formed in the levee. (F.R. Site C) This site is located 2.4 miles south of Star Bend (LM 1.5). • **362+10 to 370+02 (2518+29 to 2526+22) 1997**: During the 1997 flood, seepage occurred at the site (same location of 1986 crack). (F.R. Site C) • Based on DWR's Seepage Area map for the Feather River West Levee area, 85% of Reach 4 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observation. Based on the same map, 80% of Reach 4 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observation.	• **354+50 to 364+44 (2510+73 to 2520+67) 1998**: Toe Drain and Seepage/Stability Berm constructed. A pervious toe drain and seepage/stability berm have been constructed at this site under a PL 8499 action (F.R. Site C)	• **Landside:** between **300+80 and 349+80 (2457+00 and 2506+00)** Geomorphology consists of alternating Ra, Hla and Rca. Between **349+80 and 385+80 (2506+00 and 2542+00)**- Geomorphology consists of alternating Hob and Rca. Between **385+80 (2542+00) to the end of the reach** the Geomorphology consists of alternating layers of Rob and Qmu. • **Waterside**. Geomorphology consists of Ra from the **start of the reach to 311+80 (2468+00)** and consists of Rb from **311+80 (2468+00) to the end of the reach**, with Rofo between Ra and Rb and the water.	• **0 - 10' bgs:** Generally low to moderate resistance crest and land side, high resistance water side. Exceptions: At crest: low resistance from 313+80 to 327+80, 351+80, 353+80, from 408+30 to 411+80 (**2470+00 to 2484+00, 2508+00, 2510+00, from 2564+50 to 2568+00**); land side: low resistance from 312+80 to 315+30, 312+80 to 410+80 (**2469+00 to 2471+50, 2469+00 to 2567+00**); water side - low resistance between 323+80 to 334+80 (**2480+00 to 2491+00**) and in between moderate zones at 320+30 to 337+80, 377+80 to 379+80 (**2476+50 to 2494+00, 2534+00 to 2536+00**). Moderate resistance water side: 350+30 (**2506+00**) **to end of reach** with some high resistance near 393+80 and 406+80 (**2550+00 and 2563+00**). • **10' - 40' (50' water side):** High resistance from 300+80 to 317+80 (**2457+00 to about 2474+00**) for water, land and crest. 317+80 (**2474+00**) **to end of reach**, moderate resistance crest and water side, with areas of low resistance along the crest, mainly low resistance land side. • **40' to 150':** moderate resistance for crest, land and water side except areas of low resistance land side from 310+80 to 337+80 and 406+80 to 410+80 (**2476+00 to 2494+00 and 2563+00 to 2567+00**).
			GENERALIZED SUBSURFACE CONDITIONS [10]	**DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]**	**NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]**	**TRANSVERSE SECTION FOR EVALUATION [13]** SBFCA STATION [DWR ULE STATION]	**EXPLORATIONS FOR TRANSVERSE SECTION [14]**	**RATIONALE FOR SECTION SELECTION [16]**	
			• **Levee** materials generally consist of sandy silt and silty sand with lesser sand and clay layers between 300+80 and 363+80 (2457+00 and 2520+00), then predominately silt and clay between 363+80 and 410+80 (2520+00 and 2567+00). • **Blanket** generally consists of silt and clay that extends 25 to 40 feet below the base of the levee. Local soft layers are present 5 to 10 feet below the base of the levee. Isolated silty sand layers are present within the blanket between approximate 372+80 and 391+80 (2529+30 and 2548+00). Below about elev. 12 ft MSL, soil generally consists of alternating layers/lenses of silty sand, sand, gravel, silt, and clay of varying thickness	1) DWR 2462+50 (SBFCA 306+33) **100-yr = 54.7 ft, 100 yr + 3 ft = 57.7 ft** 2) Average Head 100 yr = 12.5 ft. Average Head 100 yr + 3ft = 15.5 ft.	At about **409+80 (2566+00)**, sump pond located at landside toe and sump station located at riverside toe with associated pipes crossing through levee. Otherwise the area adjacent to the landside levee is used for agricultural purposes.	SBFCA 306+33 [DWR 2462+50]	1) WL0001_023C, SL0001_001C SL0001_001H	Shallow thin previous layers are present at this section, which is a good representation of this reach	

*SBFCA station numbers based on 2156+20 subtracted from older DWR stations.
**SBFCA station numbers provided by WoodRodgers.

TABLE 5-4B: ANALYSIS RESULTS FOR REACH 4
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Results for Reach 4
Analysis Station: 306+33

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year	0.17 to 0.46	N/A	0.2 to 0.52	5.8 feet above Toe	No	The high phreatic surface breakout point and granular fill indicate potential for through seepage. Past performance records also indicate underseepage.
100-year + 3 feet	0.22 to 0.59		0.26 to 0.64	7 feet above Toe	No	

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
100-year				
100-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	
100-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 4 is a soil-bentonite cutoff wall extending below sand/silty sand layers into a less permeable clay/silt layer. Alternative 2 for Reach 4 is a stability berm with a seepage berm. Both alternatives were selected to mitigate through-seepage and underseepage.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall.

Dimensions of Primary Features: **300+66 to 349+00** Cutoff Wall Tip Elevation 15 feet, **349+00 to 368+00** Cutoff Wall Tip Elevation 10 feet, **368+00 to 410+67** Cutoff Wall Tip Elevation 20 feet. Cutoff wall is 3 feet wide and requires 1/2 levee de-grade/re-grade.

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year + 1 foot	See Reach 1				Yes	Subsurface conditions, past performance and Problem Identification seepage results are similar to Reach 1 and therefore mitigation is consistent with Reach 1 results.
100-year + 4 feet	See Reach 1				Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
100-year + 1 foot	See Reach 1		Yes	
100-year + 4 feet	See Reach 1		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Drained Stability Berm with Undrained Seepage Berm

Dimensions of Primary Features: **300+66 to 410+67**, 8 feet tall Drained Stability Berm and 100 feet wide Undrained Seepage Berm. Stability berm is 10 feet wide at top, 2 feet thick drain, and 3H:1V slope. Seepage Berm thickness - 5 feet at levee toe and 3 feet at berm toe

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year + 1 foot	See Reach 1			Bottom of stability berm/top of seepage berm	Yes	Subsurface conditions, past performance and Problem Identification seepage results are similar to Reach 1 and therefore mitigation is consistent with Reach 1 results.
100-year + 4 feet	See Reach 1				Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
100-year + 1 foot	See Reach 1		Yes	
100-year + 4 feet	See Reach 1		Yes	

TABLE 5-5A: CHARACTERIZATION OF REACH 5
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT – TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION – CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [6]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA)* [DWR LILE STATION]	END STATION (SBFCA)* [DWR LILE STATION]							
5	SBFCA 410+67 [DWR 2567+00]	SBFCA 478+67 [DWR 2635+00]	1.3	**Toe** CPT – 9 Borings – 3 **Crown** CPT – 7 Borings – 4 **Field** CPT - 2	**Crown Width** • 15 to 20 feet **Landside Slope** • 1.5H:1V to flatter than 2H:1V **Waterside Slope** • 2H:1V to flatter than 3H:1V	• **425+33 to 478+80 (2581+57 to 2635+00) 1997**: Four boils at landside toe of levee • **467+47 to 495+72 (2623+92 to 2650+22) 1986**: During the 1986 flood, boils carrying soil formed near the landside toe of the levee. The ground within approximately 100 feet of landside toe was very soft and wet. The peak floodwater was 5-6 feet below the top of the levee at this location. LDI personnel constructed sandbag rings around three of the worst boils. (F.R Site D) • Based on DWR's Seepage Area map for the Feather River West Levee area, 100% of Reach 7 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observation. Based on the same map, 100% of Reach 7 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observation.	• **242+80 to 478+80 (2581+00 to 2635+00) unknown date**: An undrained stability berm was constructed at landside toe of levee.	• **Landside:** Between **410+80 (2567+00)** to the end of the reach Geomorphology consists predominantly of Rob with a finger of Gmu. • **Waterside**: Consists of Rb with Rofc between Rb and the water.	• Crest, LS, and WS Profiles similar **0 – 150' bgs**: Generally alternating moderate to high resistance for entire reach to about 100' depth, high resistance depths greater than 100'. Exceptions: Low resistance noted from **410+80 to 420+80 (2567+00 to 2577+00)**, and from **435+80 to 439+80 (2592+00 to 2596+00)** at about 40' to 70' depth landside, and from **443+80 to 457+80 (2600+00 to 2614+00)** from the ground surface to 10' and dipping to about 50' near **447+80 (2604+00)** landside.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			DWR LILE STATION (SBFCA STATION)		
• **Levee** materials generally consist of silt and clay with lenses of sandy silt at about Sta. 438+80 (2595+00). • **Blanket** generally consists of silt and clay that extends 5 to 20 feet below the base of the levee. A hardpan layer is generally present at a depth of 5 to 9 feet except at 416+80 (2573+00), 427+34 (2583+54), and 485+40 (2632+60). Sand and silty sand layers/lenses 4 to 10 feet thick are present at a depth of 5 to 20 feet below the base of the levee. Sand and gravel layer present at about 30 to 35 feet below the base of the levee that extends to the bottom of 110'- deep explorations.	1) DWR 2633+00 (SBFCA 477+01) **200-yr 64.0 ft** 2) Average Head 200yr = 13.4 ft	No significant constraints or features identified within this Reach. No landside ditches present. The area adjacent to the landside levee is used for agricultural purposes Significant water-side excavations present along the entire reach.	1) DWR 2633+00 (SBFCA 477+01)	1) WL0001_009C: WL001-059C WL0001_086C: BS-07 (BC); B1-06 (BC); SL0001_003C: SL0001- 003H	A relatively thick layer of sand and silty sand present at about 20 feet below the landside levee toe. The thickness of this layer increases landside based on the toe and field explorations.

1400

TABLE 5-5B: ANALYSIS RESULTS FOR REACH 5
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Results for Reach 5
Analysis Station: 477+01

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.40 to 0.46	0.99 to 1.75		At Toe	No	Results are consistent with historic significant seepage and boils at the toe of the levee.

Landside Stability

WSE		Performance			Meets Criteria?	
200-year						

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect		Meets Criteria?	
200-year + 1 foot	typ. winter WSE					

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 5 is a soil-bentonite cutoff wall and a soil-bentonite cutoff wall with a 200 feet seepage berm. Alternative 2 for Reach 5 is a seepage berm. The seepage berm material type is lean clay, which is similar to the shallow near surface layers. The alternative reduces the potential for seepage through shallow near surface sandy layers and unacceptable gradients. Seepage analysis indicate high exit gradients at the toe of the seepage berm. Therefore, monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a collection drain system may be needed.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall and Soil-Bentonite Cutoff Wall with Seepage Berm

Dimensions of Primary Features: **410+67 to 417+00** Cutoff Wall Tip Elevation 20 feet, **417+00 to 425+00** Cutoff Wall Tip Elevation 10 feet, **425+00 to 456+00** Cutoff Wall Tip Elevation 15 feet, **456+00 to 478+68** Cutoff Wall Tip Elevation 15 feet with 200 feet Wide Undrained Seepage Berm. Cutoff wall is 3 feet wide and requires 1/2 levee de-grade/re-grade. Undrained Seepage Berm thickness: 5 feet at levee toe and 3 feet at berm toe.

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	See Reach 3				Yes	Subsurface conditions, past performance and Problem Identification seepage results are similar to Reach 3 and therefore
200-year + 4 feet	See Reach 3				Yes	mitigation is consistent with Reach 3 results.

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	See Reach 3		Yes	
200-year + 4 feet	See Reach 3		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Undrained Seepage Berm

Dimensions of Primary Features: 300 feet Wide Undrained Seepage Berm. Undrained Seepage Berm thickness: 5 feet at levee toe and 3 feet at berm toe.

Seepage

WSE	Exit Gradient Levee Toe	Seepage Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	See Reach 3				Yes	Monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or
200-year + 4 feet	See Reach 3				Yes	a collection drain system may be needed.

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	See Reach 3		Yes	
200-year + 4 feet	See Reach 3		Yes	

TABLE 5-6A: CHARACTERIZATION OF REACH 6
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT – TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION – CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [6]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA)*	END STATION (SBFCA)*							
	[DWR ULE STATION]	[DWR ULE STATION]							
6	SBFCA 478+67 [DWR 2635+00]	SBFCA 510+37 [DWR 2676+00]	0.78		3:1 land-side and water-side slopes with minimum 20-foot-wide crown.	• Significant seepage prior to construction of setback levee and slurry wall. • Based on DWR's Seepage Area map for the Feather River West Levee area, 95% of Reach 6 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observation. Based on the same map, 95% of Reach 6 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observation.	• Setback levee with SB cutoff wall constructed in 2009 within this entire reach. Cutoff wall tie-ins are SCB and extend 125' north into the existing levee and 150' south into the existing levee. The SB cutoff wall is 40 to 45 feet deep at the north tie-in and 62 to 67 feet deep at the south tie-in. • The new levee was constructed of levee fill meeting USACE classification and compaction criteria. • The wall depths and cutoff clay layer depths were confirmed during construction. • Seepage, stability and settlement analyses were performed during design of the setback levee by Blackburn Consulting consistent with USACE criteria and results indicate all criteria was met with regards to seepage gradients, slope stability factors of safety and settlement magnitude.		
			GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13] [DWR ULE STATION (SBFCA STATION)]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]	
								New setback levee and SB cutoff wall along entire reach constructed in 2009 in accordance with USACE criteria. This reach will be "certified" under the Star Bend Setback Levee project close-out documentation, which will be referenced in the final FRWL design-level report.	

TABLE 5-7A: CHARACTERIZATION OF REACH 7
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT – TASK ORDER 1

REACH ID [1]	REACH LIMITS [2] START STATION (SBFCA)* / (DWR ULE STATION)	REACH LIMITS [2] END STATION (SBFCA)* / (DWR ULE STATION)	LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION – CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
7	SBFCA 510+37 [DWR 2676+00]	SBFCA 568+87 [DWR 2765+00]	1.68	**Toe** CPT – 23 Borings – 11 **Crown** CPT – 30 Borings – 14 **Field** CPT – 4	**Crown Width** • 15 to 20 feet **Landside Slope** • 2H:1V to flatter than 2H:1V **Waterside Slope** • 3H:1V to flatter than 3H:1V	• **510+69 to 556+25 (2677+06 to 2722+50) 1995:** Seepage – the site is located between Star Bend Road and Abott Road at approximate River Mile 18.1 and 19.0 (LM 4.1 to 5.0). During the 1995 flood, clear seepage exited the levee toe and the ground beyond the levee toe while the river level was approximately 12 to 15 feet below the top of levee. (F.R. Site E). • **510+69 to 556+25 (2677+06 to 2722+50) 1997:** Boils and seepage. During the 1997 flood, numerous boils occurred in a 200 linear foot stretch. Sandbag rings were constructed around the boils that were moving material. The following day, the sandbagged boils were flowing clear. (F.R. Site E) • **521+50 (2687+62) 1997:** Boil at landside levee toe. • **532+60 (2698+72) 1997:** Two boils at landside levee toe. • **534+71 (2700+83) 1997:** Three boils at landside levee toe. • **540+02 (2706+13) 1997:** Three boils at landside levee toe. • **543+20 to 547+58 (2709+28 to 2713+51) 1997:** Seventeen (17) boils at landside levee toe. • **563+00 to 568+74 (2729+00 to 2735+00) 1997:** Waterside slope instability due to rapid drawdown when levee breach occurred on east bank of Feather river. • **592+34 (2758+48) 1986:** Erosion, site located at LM 6.1 near Abbott Lake, north of O'Banion Road at approximately River Mile 19.7. During the 1986 flood, holes appeared at the top of waterside levee berm. It is believed that the holes were result of small trees growing on the berm. The berm slope down to natural ground was eroded. The water was within 5 feet of the top of the levee (F.R. Site F) 2006 - Boils reported in 2006 adjacent to and north of the relief well field. • Based on DWR's Seepage Area map for the Feather River West Levee area, 95% of Reach 7 was mapped as seepage area as indicated on aerial photographs of 4-24-83 in conjunction with field observation. Based on the same map, 95% of Reach 7 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observation.	• **510+87 to 555+88 (2677+00 to 2722+00) date unknown**: Toe Berm constructed from the north end of Star Bend Road to the south end of Abbott Lake Road. Project Plans entitled "PL 84-99 Phase III, Relief Wells - LD1, Feather River at Star Bend, dated 8/18/1997, USACE File No. 04-04-617" • **526+72 to 542+10 (2692+50 to 2708+20) 1997**: In 1997, the Corps of Engineers installed relief wells in this area to reduce seepage and instability of the levee under PL 84-99 contract. (F.R. Site E). A total of 25 relief wells from 1550 feet north of north end of Star Bend Road to 1380 feet south of the south end of Abbott Lake Road. Project Plans entitled "PL 84-99 Phase III, Relief Wells - LD1, Feather River at Star Bend, dated 8/18/1997, USACE File No. 04-04-617". Significant seepage continued (heavy in 2005) after wells were constructed. Top of wells and collection ditch appear to be too high to mitigate seepage and/or no confining layer present to force near-surface water into wells. • **563+95 to 568+76 (2729+00 to 2735+00 with an approximately 120 feet gap)**: Waterside slope repair by USACE after the 1997 flood. A gap of about 120 feet was left unrepaired.	• **Landside:** Between **510+25 to 568+38 (2676+00 to 2734+50)** Geomorphology consists of alternating Rcs, Rob, Qmu. From **568+38 (2734+50) to the end of the reach**, Geomorphology consists of Qmu. • **Wateside**: Geomorphology consists of Rb from the beginning **of the reach to 517+88 (2684+00)** and then consists of Ra to the end of the reach.	• **0 - 10' bgs:** Generally low resistance from **509+88 to 529+88 (2676+00 to 2696+00)** with some moderate resistance interspersed. Alternating moderate and high resistance **529+88 (2696+00) to the end of the reach.** • **10' - 40':** Moderate resistance land and creek, moderate to high resistance water side **509+88 to 535+88 (2676+00 to 2702+00)**. Exception: low resistance from about **509+88 to 526+88 (2676+00 to 2693+00)** land side. High resistance **526+88 to 580+88 (2693+00 to 2747+00) 583+88 (2750+00 water side)**. Moderate resistance to end of reach. • **40' to 150':** Generally moderate resistance land and water side from **509+88 to 583+88 (2676+00 to 2750+00)** except areas of low resistance land side from **555+88 to 559+38 (2722+50 to 2724+50)** at about 120' to 150' depths and water side from **548+68 to 555+88 (2715+00 to 2722+00)** at about 100' to 150' depths. High resistance water side from **beginning of reach to 526+88 (2695+00)** to depths of 60' and to **519+88 (2686+00)** at greater depths. Crest - moderate resistance 40' to about 100', low resistance 100' to 150' (moderate resistance from **566+88 to 575+88 (2733+00 to 2742+00)**; From **583+88 to 598+88 (2750+00 to 2765+00)**, moderate resistance from 40' to about 100' depths, low resistance from 100' to 150' depths.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13] DWR ULE STATION (SBFCA STATION)	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
• **Levee** materials generally consist of silt and clay with lenses of sandy silt. • **Blanket** generally consists of silt and clay that extends 7 to 10 feet below the base of the levee. A hardpan layer is locally present below the silt and clay. Locally, 1 to 2 foot thick lenses of sand and silty sand are present near the base of the levee. Sand and silty sand layers/lenses 5 to 35 feet thick are present at a depth of 7 to 10 feet below the base of the levee. 1' to 2' thick lenses of very soft, fine grained soil (sometimes organic) within the upper 5' of soil below levee and at the toe. This is likely old lakebed material.	1) DWR 2705+00 (SBFCA 539+30) **200-yr 65.9 ft** 2) Average Head = 18 ft	Lancside lined ditch present at levee toe between approximate 511+88 and 555+88 (2678+00 and 2722+00) at levee toe. Relief wells present at levee toe between 526+38 to 542+08 (2692+50 to 2708+20). The area adjacent to the landside levee is used for agricultural purposes. Significant water-side excavation present within 50 to 100 feet of levee toe. Levee was constructed over old lakebed.	1) SBFCA 539+30 (DWR 2705+00)	1) WL0001_084C: WL0001_088B: WL0001_089B: SL0001_004C: SL0001_004H	Blanket layer is approximately 10 feet thick and underlain by sand and silty sand layers.

TABLE 5-7B: ANALYSIS RESULTS FOR REACH 7
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Results for Reach 7
Analysis Station: 539+30

Existing Conditions Problem Identification						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	1.55	N/A	2.7	11.5 feet above Toe	No	Results are consistent with significant historic seepage and boils.
Landside Stability						
WSE		Performance			Meets Criteria?	
200-year						
Rapid Drawdown						
WSE - initial	WSE - final	FS	Duration Effect		Meets Criteria?	
200-year + 1 foot	typ. winter WSE					

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 7 is a soil-bentonite cutoff wall extending below sand/silty sand layers into a less permeable clay/silt layer. This alternative was selected as an in-place alternative to mitigate both through-seepage and underseepage. Alternative 2 for Reach 7 consists of a stability berm with a seepage berm. The seepage berm material type is lean clay, which is similar to the shallow near surface layers. Alternative 2 mitigates underseepage and through seepage. Seepage analysis indicate high exit gradients at the toe of the seepage berm. Therefore, monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a collection drain system may be needed.

Rehabilitated Levee Alternative 1						
Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall						
Dimensions of Primary Features: **510+37 to 528+00** Cutoff Wall Tip Elevation 15 ft, **528+00 to 546+00** Cutoff Wall Tip Elevation (-10 ft), **546+00 to 565+00** Cutoff Wall Tip Elevation (-65 ft) with Full Levee Degrade, **565+00 to 576+00** Cutoff Wall Tip Elevation (-50 ft), **576+00 to 584+00** Cutoff Wall Tip Elevation (-10 ft), **584+00 to 598+87** Cutoff Wall Tip Elevation 20 ft. Cutoff wall is 3 ft wide and requires 1/2 levee de-grade/re-grade except between station **546+00 to 565+00** where a full levee de-grade/re-grade is required.						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	<0.05	N/A		Toe	Yes	
HTOL	0.05			Toe	Yes	
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	2.09				Yes	
HTOL	2.09				Yes	

Rehabilitated Levee Alternative 2						
Geotechnical Rehabilitation Measure(s): Drained Stability Berm with Undrained Seepage Berm						
Dimensions of Primary Features: **510+37 to 598+87**, 9.5 feet tall, Drained Stability Berm with 300 feet Wide Undrained Seepage Berm with monitoring for seepage at the toe of the berm. Drained Stability Berm is 13 feet wide at top, 2 feet thick drain, and 3H:1V slope. Height of the Undrained Seepage Berm at Levee Toe is 7 feet tall due to high gradients across the seepage berm/blanket, 3 feet tall at berm toe.						
Seepage						
WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.47	1.39		Stability Berm Toe	No	Monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a collection drain system may be needed.
HTOL	0.57	1.53		Stability Berm Toe	No	
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	1.77				Yes	
HTOL	1.57				Yes	

TABLE 5-8A: CHARACTERIZATION OF REACH 8
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2] START STATION (SBFCA) [DWR ULE STATION]	REACH LIMITS [2] END STATION (SBFCA) [DWR ULE STATION]	LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
8	598+84 [2765+00]	654+75 [2821+00]	1.11	Total Number of Explorations = 19; Crest Explorations = 11 (SPT - 5, CPT - 6); Landside Toe Explorations = 6 (SPT - 3, CPT - 3); Landside Field Explorations = 2 (CPT - 2)	**Crown Width :** approximately 20 feet **Landside slope** approximately 2H:1V to flatter than 2H:1V **Waterside Slope** approximately 2H:1V to flatter than 3H:1V	602+88 [2769+01] to 640+32 [2806+45]: Twenty-six (26) sinkholes on waterside berm of levee (1997). According to Bill Hampton of LD1, these sinkholes were 3 feet to 6 feet deep and 2 feet to 4 feet in diameter and formed on the waterside berm, which was the original levee before it was raised. Based on DWR's Seepage Area map for the Feather River West Levee area, approximately 2/3 rd of Reach 8 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observations. Based on the same map, approximately 2/3 rd of Reach 8 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observations.	602+88 [2769+01] to 640+32 [2806+45]: After the flood, 26 sinkholes were repaired by compacting soil (1997).	R_{SL} (Recent Slough deposits) R_a (Recent Alluvium) R_{ob} (Recent Overbank)	High resistivity soil layers present at approximately 10 feet below the embankment. The highly resistive layers extends to the ground surface occasionally.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13] SBFCA STATION [DWR ULE STATION]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
Levee Embankment: Sand (SP, SM), Silt and Clay **Foundation**: Near Surface layers include Sand (SP), Clay (CL). Landside toe and field explorations indicate shallow Sand layers. Hardpan and soft layers were encountered within shallow foundation layers.	**200 yr WSE** Head = approximately 18.8 feet at the analysis section	Mostly Agricultural. A pond is located on the landside of the levee between Sta. 646+86 [2813+00] and Sta. 648+86 [2815+00].	623+86 [2790+00]	WL0001_049B, WL0001_049C, 2F-91-10 (CREST), WL0001_074C, WL0001_061C, SL0001_005C (LANDSIDE TOE), WL0001_117C, 2F-91-10A, WL0001_110C (FIELD)	Presence of sand in levee embankment may indicate potential for through seepage; shallow sand layers in foundation and relatively thin fine-grained blanket may indicate potential for underseepage; deep sand layers encountered at approximately similar depths as other explorations within this reach.

TABLE 5-8B: ANALYSIS RESULTS FOR REACH 8
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 623+86

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.77	N/A	N/A	1.0	No	The existing levee embankment material is silty sand underlain by approximately 5.2 feet of silty sand and 4.3 feet of clay blanket.
200-year + 3 feet						

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - Initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 8 is soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both through seepage and underseepage potential. Alternative 2 for Reach 8 is a seepage berm with a shallow cutoff wall. The seepage berm material type is silty sand, which is similar to the shallow near surface layer. The shallow cutoff wall reduces the potential for seepage through shallow near surface sandy layers.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: 3 feet wide and 45 feet deep cutoff wall starting at Elevation 60 (half levee degrade)

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	<0.1	N/A	N/A	No breakout	Yes	Fully penetrating (i.e. tip within fine-grained soil) cutoff wall reduces seepage potential.
200-year + 4 feet	<0.1	N/A	N/A	No breakout	Yes	

Landside Stability

WSE	FS	Meets Criteria?	Comments
200-year + 1 foot	1.90	Yes	Fully penetrating (i.e. tip within fine-grained soil) cutoff wall reduces seepage potential.
200-year + 4 feet	1.89	Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Seepage Berm and Shallow Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: Seepage Berm - 130 feet wide berm, 3 feet thick at berm toe and 5 feet thick at levee toe, berm soil type - silty sand
Shallow Cutoff Wall - 3 feet wide and 21.5 feet deep cutoff wall starting at Elevation 60 (half levee degrade)

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.27	0.63	N/A	No Breakout	Yes	Seepage berm and shallow cutoff wall alternative meets criteria both at levee toe and berm toe.
200-year + 4 feet	0.34	0.70	N/A	No Breakout	Yes	

Landside Stability

WSE	FS	Meets Criteria?	Comments
200-year + 1 foot	1.86	Yes	Seepage berm and shallow cutoff wall alternative meets criteria both at levee toe and berm toe.
200-year + 4 feet	1.81	Yes	

TABLE 5-9A: CHARACTERIZATION OF REACH 9
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2] START STATION (SBFCA) [DWR ULE STATION]	REACH LIMITS [2] END STATION (SBFCA) [DWR ULE STATION]	LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
9	654+75 [2821+00]	706+50 [2872+75]	0.98	Total Number of Explorations = 17; Crest Explorations = 10 (SPT - 5, CPT - 5); Landside Toe Explorations = 6 (SPT - 4, CPT - 2); Landside Field Explorations = 1 (CPT - 1)	**Crown Width :** approximately 10 feet to 20 feet **Landside slope** Approximately 2H:1V or flatter than 2H:1V **Waterside Slope** Approximately 3H:1V to flatter than 3H:1V	• 655+57 [2821+72] to 279+10 [2845+25]: Waterside bank erosion encroaching on the levee section. (F.R. Site G) (Unknown Year). The site is located near Messick Road at approximate River Mile 21.2 (LM 7.3). • 677+72 [2843+88]: Scour on waterside berm of levee (1997) • 692+50 [2858+65]: This site is at the Boyd Pump Boat Ramp at LM 8, between Messick Road and Oswald Avenue at approximate RM 21.7. During the 1986 flood, portions of the boat ramp parking lot and subgrade and portions of the levee toe were eroded. (F.R. Site H) (1986) • 699+35 [2865+51]: Bank erosion at pump structure at waterside levee (1997) Based on DWR's Seepage Area map for the Feather River West Levee area, approximately 1/4 th of Reach 9 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observations. Based on the same map, approximately 1/2 of Reach 9 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observations.	655+83 [2820+78] to 706+50 [2872+50]: In 1998, the Corps raised the levee 1-foot and installed a pervious toe drain and seepage/stability berm at the site under the Marysville/Yuba City Levee Reconstruction Project. (F.R. Site H). Site 9: Toe drain and berm from LM 7.28 to LM 8.26. Project plans entitled "Sacramento River Flood Control Project Phase II, Levee Reconstruction, Contract 3 (Sites 1, 2, 3, 8, 9, 10, 11, & 12)," dated 7/4/1997. USACE Design File No. 50-04-6001.	R_{SL} (Recent Slough deposits) R_a (Recent Alluvium) R_{ofc} (Recent Overflow Channels) BP (Borrow Pit present in 1937) SP (Spoils present in 1937)	High resistivity soil layers present at approximately 10 ft below the embankment. The resistive layer extends to the ground surface occasionally.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13] SBFCA STATION [DWR ULE STATION]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
Levee Embankment: Sand (SP, SM) and Silt (ML). Sand encountered in the entire levee embankment (from levee crown to levee toe) in several explorations. **Foundation**: Near Surface layers include Sand (SP-SM), Clay (CL), and Silt (ML). Thick porous layers are present in multiple layers.	**200 yr WSE** Head = approximately 17.6 feet at the analysis section	Mostly Agricultural. Scattered houses and Sheds observed from aerial maps.	705+84 [2872+00]	WL0001_010S, 2F-91-14 (CREST), WL0001_079C, WL0001_004B, 2F-91-14A (TOE), WL0001_111C (FIELD)	Sand and silty sand in levee embankment may indicate potential for through seepage; sandy foundation layer present near the surface indicate potential for shallow seepage (leaking layer); fine-grained layer below surface sandy layer create potential blanket condition for underseepage; deep sand/gravel layers also present.

TABLE 5-9B: ANALYSIS RESULTS FOR REACH 9
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 705+84

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.59	N/A	N/A	3.7	No	High breakout point, which is an indication of through seepage potential is due to sandy materials in the embankment.
200-year + 3 feet						

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 9 is soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both throughseepage and underseepage potential. Alternative 2 for Reach 9 is seepage berm with shallow cutoff wall. Seepage berm material type is silty sand, which is similar to shallow near surface layers. The shallow cutoff wall reduces the potential for seepage through shallow near surface sandy layers.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: 3 feet wide and 45.5 feet deep cutoff wall starting at Elevation 64.5 (half levee degrade)

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.08	N/A	N/A	At the landside levee toe	Yes	Fully penetrating (i.e. tip within fine-grained soil) cutoff wall reduces seepage potential.
200-year + 4 feet	0.10	N/A	N/A	At the landside levee toe	Yes	

Landside Stability

WSE	FS	Meets Criteria?	Comments
200-year + 1 foot	2.37	Yes	Fully penetrating (i.e. tip within fine-grained soil) cutoff wall reduces seepage potential.
200-year + 4 feet	2.28	Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Seepage Berm and Shallow Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: Seepage Berm - 110 feet wide berm, 3 feet thick at berm toe and 5 feet thick at levee toe, and berm soil type - silty sand
Shallow Cutoff Wall - 3 feet wide and 29.5 feet deep cutoff wall starting at Elevation 64.5 (half levee degrade)

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.15	0.49	N/A	At the landside levee toe	Yes	Seepage berm and shallow cutoff wall alternative meets criteria both at levee toe and berm toe.
200-year + 4 feet	0.21	0.54	N/A	At the landside levee toe	Yes	

Landside Stability

WSE	FS	Meets Criteria?	Comments
200-year + 1 foot	2.45	Yes	Seepage berm and shallow cutoff wall alternative meets criteria both at levee toe and berm toe.
200-year + 4 feet	2.39	Yes	

TABLE 5-10A: CHARACTERIZATION OF REACH 10
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2] START STATION (SBFCA) [DWR ULE STATION]	REACH LIMITS [2] END STATION (SBFCA) [DWR ULE STATION]	LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
10	706+50 [2872+75]	774+00 [2940+25]	1.28	Total Number of Explorations = 20; Crest Explorations = 11 (SPT - 6, CPT - 5); Landside Toe Explorations = 8 (SPT - 5, CPT - 3); Landside Field Explorations = 1 (CPT - 1)	**Crown Width :** approximately 18 feet to 20 feet **Landside Slope** approximately 2H:1V to flatter 2H:1V **Waterside Slope** approximately 3H:1V to flatter than 3H:1V	No documentation of past performance problems were found in the reviewed documents or site walk with LD1 representative. However, based on DWR's Seepage Area map for the Feather River West Levee area, approximately 7/10 th of Reach 10 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observations. Based on the same map, approximately 3/5 th of Reach 10 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observations.	No documentation of existing levee improvements were found in the reviewed documents or site walk with LD1 representative.	R_{ob} (Recent Overbank) H_a (Holocene Alluvium) H_{ob} (Holocene Overflow Channels)	Approximately 60 feet thick, continuous, high resistivity soil layer is present at approximately 10 feet below the embankment from 706+65 [2872+65] to 739+92 [2906+00]. The high resistive layer is not observed beyond Sta. 739+92 [2906+00] to the end of the Reach.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13] SBFCA STATION [DWR ULE STATION]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
Levee Embankment: Sand (SP, SP-SM, SC). Foundation: Near Surface layers include SM, CL, ML. Thick (~ 25 feet) pervious zones was encountered at about 25 feet below the embankment in crest explorations. Blanket thins at the toe explorations.	**200 yr WSE** Head = approximately 17.6 feet at the analysis section	Garden highway runs parallel along 1200 feet of this Reach.	733+84 [2900+00]	2F-91-15, CF-88-9, WL0001_057C, WL0001_058C (CREST), 2F-91-15A and SL0001_001B (LANDSIDE TOE)	Sandy layers in levee embankment may indicate potential for through seepage; Location coincide with high resistivity soils shown in HEM differential resistivity profiles; Moderately thick fine-grained blanket layer (about 30 feet thick) encountered in the explorations within this reach in the crest explorations, however blanket thins based on the landside toe explorations.

TABLE 5-10B: ANALYSIS RESULTS FOR REACH 10
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 733+84

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.86	N/A	N/A	5.8	No	High breakout point due to sandy materials in the embankment.
200-year + 3 feet						

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 10 is soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both throughseepage and underseepage potential. Alternative 2 for Reach 10 is seepage berm with shallow cutoff wall. Seepage berm material type is silt, which is similar to shallow near surface layers. The shallow cutoff wall reduces the potential for seepage through shallow near surface sandy layers. Seepage analysis indicate high exit gradients at the toe of the seepage berm. Therefore, monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a collection drain system may be needed.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: 3 feet wide and 68.5 feet deep cutoff wall starting at Elevation 64.9 (half levee degrade)

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	<0.1	N/A	N/A	No Breakout	Yes	Fully penetrating (i.e. tip within fine-grained soil) cutoff wall reduces seepage potential.
200-year + 4 feet	<0.1	N/A	N/A	No Breakout	Yes	

Landside Stability

WSE	FS	Meets Criteria?	Comments
200-year + 1 foot	1.99	Yes	Fully penetrating (i.e. tip within fine-grained soil) cutoff wall reduces seepage potential.
200-year + 4 feet	1.99	Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Seepage Berm and Shallow Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: Seepage Berm - 300 feet wide berm, 3 feet thick at berm toe and 7.2 feet thick at levee toe, and berm soil type - silt
Shallow Cutoff Wall - 3 feet wide and 35 feet deep cutoff wall starting at Elevation 65 (half levee degrade)

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.29	0.89	N/A	0	Meets criteria at levee toe. See Comments on berm toe.	Monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a collection drain system may be needed.
200-year + 4 feet	0.38	1.0	N/A	0		

Landside Stability

WSE	FS	Meets Criteria?	Comments
200-year + 1 foot	2.00	Yes	
200-year + 4 feet	1.99	Yes	

TABLE 5-11A: CHARACTERIZATION OF REACH 11
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (BBFCA) [DWR ULE STATION]	END STATION (BBFCA) [DWR ULE STATION]							
11	774+00 [2940+25]	830+00 [2996+25]	1.06	Total Number of Explorations = 15; Crest Explorations = 9 (SPT - 6, CPT - 3); Landside Toe Explorations = 4 (SPT - 2, CPT - 2); Landside Field Explorations = 2 (CPT - 2)	**Crown Width :** approximately 15 feet to 20 feet **Landside slope** approximately 2H:1V to flatter than 2H:1V **Waterside Slope** approximately 3H:1V to flatter than 3H:1V	812+50 [2978+75]: During 1997 flood, a boil developed around a tree. Clean water was coming out. Based on DWR's Seepage Area map for the Feather River West Levee area, approximately 2/3 rd of Reach 11 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observations. Based on the same map, approximately 2/3 rd of Reach 11 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observations.	No documentation of existing levee improvements were found in the reviewed documents or site walk with LD1 representative.	R_{ob} (Recent Overbank) R_a (Recent Alluvium)	Approximately 50 feet thick, continuous, high resistivity soil layer is present immediately below the embankment in this Reach.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			BBFCA STATION (DWR ULE STATION)		
Levee Embankment: SP, SM, ML, CL **Foundation**: Fine-grained blanket less than 10 feet thick underlain by approximately 10 to 30 feet thick pervious layers.	**200 yr WSE** Head = approximately 14.8 feet at the analysis section	Mostly agricultural with scattered residential houses. Mostly urban in the northern 700 feet (approximately) of the reach (Yuba City)	808+85 [2975+00]	2F-07-01 (CREST), SL0001_008C (TOE), CPT-11 (FIELD)	Thin fine-grained blanket encountered in the boring and CPT underlain by thick pervious layers may indicate potential for underseepage; Approximately 30 feet thick pervious zone (SP layer) below the fine-grained blanket was encountered in both crest and landside toe explorations approximately at the same elevations.

TABLE 5-11B: ANALYSIS RESULTS FOR REACH 11
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 808+85

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	1.38	N/A	N/A	8.4 feet above LS toe	No	High breakout point due to presence of silt layer in the levee.
200-year + 3 feet						

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 11 is soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both throughseepage and underseepage potential. Alternative 2 for Reach 11 is seepage berm with drained stability berm. Seepage berm material type is sandy silt, which is similar to shallow near surface layers. Seepage analysis indicate high exit gradients at the toe of the seepage berm. Therefore, monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a collection drain system may be needed.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: 3 feet wide and 73 feet deep cutoff wall starting at Elevation 67.5 (half levee degrade)

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	<0.1	N/A	N/A	No Breakout	Yes	Fully penetrating (i.e. tip within fine-grained soil) cutoff wall reduces seepage potential.
200-year + 4 feet	<0.1	N/A	N/A	No Breakout	Yes	

Landside Stability

WSE	FS	Meets Criteria?	Comments
200-year + 1 foot	1.56	Yes	Fully penetrating (i.e. tip within fine-grained soil) cutoff wall reduces seepage potential.
200-year + 4 feet	1.54	Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Seepage Berm and Drained Stability Berm

Dimensions of Primary Features: Seepage Berm - 300 feet wide berm, 3 feet thick at berm toe and 7.2 feet thick at levee toe, berm soil type - sandy silt
Drained Stability Berm - 7.5 feet tall, 10 feet wide at top, 2 feet thick drain, and 3H:1V landside slope

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.34	1.41	N/A	0	Meets criteria at levee toe. See Comments on berm toe.	Monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a collection drain system may be needed.
200-year + 4 feet	0.49	1.67	N/A	0		

Landside Stability

WSE	FS	Meets Criteria?	Comments
200-year + 1 foot	2.19	Yes	
200-year + 4 feet	1.91	Yes	

TABLE 5-12A: CHARACTERIZATION OF REACH 12
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [9]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
12	830+00 [2996+25]	845+00 [3011+25]	0.28	Total Number of Explorations = 7; Crest Explorations = 5 (SPT - 3, CPT - 2); Waterside Field Explorations = 2 (SPT - 2)	**Crown Width :** approximately 20 feet **Landside slope** approximately 2H:1V to flatter 2H:1V **Waterside Slope** approximately 3H:1V to flatter than 3H:1V	834+39 [3009+39]: The site is located at Shanghai Bend at approximate River Mile 25.0 (LM 10.8). Seepage occurred at this site during the previous flood events. (F.R. Site I). 839+71 [3005+86] to 908+21 [3074+31]: The site is located between Shanghai Bend and Yuba City Airport between approximate River Miles 25.1 and 26.5 (LM 11.0 and 12.4). 842+22 [3009+39]: Seepage and a boil occurred just beyond the berm toe during the 1995 high water. (F.R. Site I) Based on DWR's Seepage Area map for the Feather River West Levee area, approximately 100% of Reach 12 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observations. Based on the same map, approximately 100% of Reach 12 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observations. However, the setback levee was placed after these maps.	829+85 [2996+00] to 846+20 [3012+50]: Shanghai Bend setback levee with cutoff wall. Additional site investigation report and Star Bend borrow site report for the Project "PL 84-99 Cost Shared, Basin No. 18, Feather River, Shanghai Bend, dated 1999. USACE Drawing File No. 4-4-620" were available during preparation of this report.	R_{ob} (Recent Overbank)	High resistivity soil layer is not present for most of this Reach. The high resistivity layer starts towards the northern end 843+61 [3010+00], immediately below the ground surface.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
Levee Embankment: ML, SC, CL **Foundation**: Shallow Sand layer (potentially cutoff by slurry wall). Deep thick sand layer present approximately 30 feet below embankment.	**200 yr WSE** Head = approximately 16.9 feet at the analysis section	Urban Area (Yuba City)	830+59 [2996+70]	WL0001_064B, WL0001_065C (CREST), SL0001_009C, (LANDSIDE TOE), CPT-11 (FIELD)	Recently built setback levee includes a shallow cutoff wall. Available explorations in the area indicate that the cutoff wall tip embedded within fine-grained soil (fully penetrating cutoff wall); Analysis to evaluate effect of the deep sand and gravel layers.

TABLE 5-12B: ANALYSIS RESULTS FOR REACH 12
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 830+59

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	< 0.1	N/A	N/A	No Breakout	Yes	Shanghai Bend setback levee with cutoff wall. Available explorations indicate that the cutoff wall toe embedded in fine-grained soil layer.
200-year + 3 feet	< 0.1	N/A	N/A	No Breakout	Yes	

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year	1.78		Yes	Shanghai Bend setback levee with cutoff wall. Available explorations indicate that the cutoff wall toe embedded in fine-grained soil layer.
200-year + 3 feet	1.78		Yes	

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s):

Dimensions of Primary Features:

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot				
200-year + 4 feet				

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s):

Dimensions of Primary Features:

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot				
200-year + 4 feet				

TABLE 5-13A: CHARACTERIZATION OF REACH 13
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2] START STATION (SBFCA) / (DWR ULE STATION)	REACH LIMITS [2] END STATION (SBFCA) / (DWR ULE STATION)	LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
13	845+00 [3011+25]	927+00 [3093+25]	1.55	Total Number of Explorations = 70; Crest Explorations = 19 (SPT - 10, CPT - 9); Landside Toe Explorations = 2 (SPT - 1, CPT - 1); Landside Field Explorations = 45 (SPT - 7, CPT - 38); Waterside Field Explorations = 4 (SPT - 4)	**Crown Width** approximately 15 feet to 20 feet **Landside Slope** 1.8 H:1V to flatter than 2H:1V **Waterside Slope** 2.5H:1V to flatter than 3H:1V	839+71 [3005+86] to 908+21 [3074+31]: The site is located between Shanghai Bend and Yuba City Airport between approximate River Miles 25.1 and 26.5 (LM 11.0 and 12.4). The levee broke in this area during the 1909, 1911, and 1955. (F.R. Site J). Based on DWR's Seepage Area map for the Feather River West Levee area, approximately 100% of Reach 13 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observations. Based on the same map, approximately 100% of Reach 13 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observations. However, the setback levee was placed after these maps.	845+71 [3012+00] to 926+51 [3092+65]: In 1957, the USACE reconstructed the levee to the LS of it's previous loc. and installed a row of relief wells near the LS levee toe. Water from the relief wells is pumped to the Feather River (FR). (F.R. Site J). Note: The actual LMs for this improv. meas. are from LM 11.3 to LM 12.8. Relief wells are spaced at 200 feet intervals. Plans are available in the doc. entitled "Emergency Levee Repairs, Relief Wells - Right Bank FR, Shanghai Bend, Sutter County, Ca, USACE File 4-4-435". 845+71 [3012+00] to 926+15 [3092+65]: In 1990, the City of Yuba City installed a seepage interceptor system in the southern part of this site. The interceptor system consists of a perforated pipeline and filter 12-18 feet below ground surface to extract shallow seepage, and relief wells placed between the 1957 relief wells to extract deeper seepage. All water collected is pumped into the Feather River separately from the water collected by the 1957 relief wells. (F.R. Site J). Note: According to Bill Hampton of LD1, this interceptor system cont. up to 3092+65.	R_{ch} (Recent Channels) Ra (Recent Alluvium) R_{ms} (Channel meander scroll deposits) W_{37} (Water)	Approximately 50 feet thick, continuous, high resistivity soil layer is present immediately below the embankment from 845+71 [3012+00] to 893+90 [3060+00]. Beyond 893+90 [3060+00], the layer is present 10 ft below the foundation.
						845+71 [3012+00] to 926+15 [3092+65]: During the 1986 flood, volunteers sandbagged several boils in this area. (F.R. Site J). Site 3: At the downstream of Shanghai Bend, an area of concentrated seepage produced boils during the 1986 high water. These boils were controlled with sack rings. Site 3: According to LD 1 Engineer Mr. Von Geldern, Relief wells in Shanghai Bend area produced 3 gallons per minute during the 1986 high water. Additional seepage occurred in fields adjacent to the levee. Seepage appeared in this area up to several hundred feet away from the levee toe (1986). 893+99 [3050+15] to 902+77 [3069+08]: Heavy seepage near landside toe of levee south of Burns Drive (1997)	845+71 [3012+00] to 926+15 [3092+65]: In 1993, and inspection of the shallow drain perforated pipeline discovered unacceptable deflections over large portions of the pipeline. The deformed plastic pipeline was removed and replaced with a perforated clay pipeline. (F.R. Site J). 829+44 [3058+59] to 926+50 [3092+65]: In 2001, the Corps of Engineers rehabilitated the original 1957 relief wells under a PL 84-99 contract. (F.R. Site J). Project plans entitled "PL 84-99 Cost Shared Added Sites Sacramento Basin No. 18 Relief Well Improvements," dated 7/31/2000. USACE Design File No. 4-04-625. **During the site visit in November 2010, relief wells at a spacing of 100 feet were observed from station 845+61 [3012+00] to 926+15 [3092+65]**		

	GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13] SBFCA STATION/ [DWR ULE STATION]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
	Levee Embankment: Sand (SP, SP-SM, SM) **Foundation**: Near Surface Layers SM, ML, SC. Thick layers of pervious zones (sand and gravel) present at shallow and deep layers.	**200 yr WSE** Head = approximately 22.3 feet at the analysis section	Urban Area (Yuba City)	861+33 [3027+50]	WL0001_067B, WL0001_067C, B-40 (CREST); CPT 22, CPT 23, SL0001_002B (LANDSIDE TOE); B-33 and B-57 (LANDSIDE FIELD); B-51 and B-52 (WATERSIDE TOE AND FIELD)	Near surface layer consists of sand or sandy layers. Shallow silty sand and sandy silt layer overlying a thick porous zone may create a thin blanket condition and potential for underseepage. HEM differential resistivity profiles indicate presence of thick layer of high resistivity soils from ground surface; Sandy layers in levee embankment may indicate potential for through seepage. Levee embankment at this section have SP-SM materials.

TABLE 5-13B: ANALYSIS RESULTS FOR REACH 13
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 861+33

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	1.21	N/A	1.38	9.2 feet above LS toe	No	High breakout point due to presence of sand layers (<10% fine contents) in the levee embankment.
200-year + 3 feet						

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 13 is soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both throughseepage and underseepage potential. Alternative 2 for Reach 13 is relief wells with shallow cutoff wall. Existing relief wells have 100 feet spacing and alternatively 20 feet (installed after 1955 flood) and 50 feet deep (installed in 1990s). Analysis indicated 100 feet wide spacing, however considering presence of existing deep (50 feet deep) relief wells, recommended spacing is 200 feet.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: 3 feet wide and 97 feet deep cutoff wall starting at Elevation 68.8 (half levee degrade)

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	<0.1	N/A	N/A	No Breakout	Yes	Fully penetrating (i.e. tip within fine-grained soil) cutoff wall reduces seepage potential.
200-year + 4 feet	<0.1	N/A	N/A	No Breakout	Yes	

Landside Stability

WSE	FS	Meets Criteria?	Comments
200-year + 1 foot	1.69	Yes	Fully penetrating (i.e. tip within fine-grained soil) cutoff wall reduces seepage potential.
200-year + 4 feet	1.68	Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Shallow Soil-Bentonite Cutoff Wall and Relief Well

Dimensions of Primary Features: Shallow Cutoff Wall - 3 feet wide and 32 feet deep cutoff wall starting at Elevation 68.8 (half levee degrade)
Relief Well - 200 feet Spacing and 65 feet Deep. Existing relief wells have 100 feet spacing and alternatively 20 feet (installed after 1955 flood) and 50 feet deep (installed in 1990s). Analysis indicated 100 feet wide spacing, however considering presence of existing deep (50 feet deep) relief wells, recommended spacing is 200 feet.

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	<0.1	N/A	N/A	No Breakout	Yes	Shallow cutoff wall and relief well system meet criteria
200-year + 4 feet	<0.1	N/A	N/A	No Breakout	Yes	

Landside Stability

WSE	FS	Meets Criteria?	Comments
200-year + 1 foot	1.69	Yes	Shallow cutoff wall and relief well system meet criteria
200-year + 4 feet	1.69	Yes	

TABLE 5-14A: CHARACTERIZATION OF REACH 14
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2] START STATION (SBFCA) [DWR ULE STATION]	REACH LIMITS [2] END STATION (SBFCA) [DWR ULE STATION]	LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
14	927+00 [3093+25]	954+40 [3120+25]	0.52	Total Number of Explorations = 10; Crest Explorations = 9 (SPT - 2, CPT - 2, TP - 5); Landside Toe Explorations = 1 (CPT - 1)	**Crown Width :** approximately 18 feet to 20 feet **Landside slope** approximately 2H:1V to flatter then 2H:1V **Waterside Slope** approximately 3H:1V to flatter than 3H:1V	No documentation of past performance problems were found in the reviewed documents or site walk with LD1 representative. However, based on DWR's Seepage Area map for the Feather River West Levee area, approximately 100% of Reach 14 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observations. Based on the same map, approximately 100% of Reach 14 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observations. However, the setback levee was placed after these maps.	Site 8: Slurry walls from LM 12.76 to LM 13.26. Project plans entitled "Sacramento River Flood Control Project Phase II, Levee Reconstruction, Contract 3 (Sites 1, 2, 3, 8, 9, 10, 11, & 12)," dated 7/4/1997. USACE Design File No. 50-04-6001.	R_a (Recent Alluvium)	Approximately 40 feet thick, continuous, high resistivity soil layer is present immediately below the embankment in this Reach.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13] SBFCA STATION [DWR ULE STATION]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
Levee Embankment: Silty sand and silt (SM, ML) **Foundation**: Near Surface layer silty sand and silt (SM, ML). Thick layers of sand and silt sand (SP, SM) and Gravel (GP).	**200 yr WSE** Head = approximately 13.2 feet at the analysis section	Urban Area, Airport (Yuba City)	939+33 [3105+50]	2F-07-02, WL0001_073C (CREST) and SL0001_011C (LANDSIDE TOE)	Based on the design drawings, slurry wall tip in SP/SM layer (potential partially penetrating cutoff wall). Silty sand encountered at toe location at ground surface. However, based on information provided by Bill Hampton of LD1 during a November 2010 site visit the cutoff wall depth varied to embed tipin fine-grained soil. The model is developed using a deeper cutoff wall than depth shown on design drawings. However, specification requirements and as-built documents should be evaluated or excavation should be performed to investigate the depths and conditions of the cutoff walls in this Reach.

TABLE 5-14B: ANALYSIS RESULTS FOR REACH 14
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 939+33

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.07	N/A	0.3 (approximately 55 feet from landside toe)	No Breakout	Yes	The design drawings for this section indicates that the proposed cutoff wall depth is 40 feet. A sensitivity analysis using 40 feet cutoff wall depth did not meet seepage criteria for 200 year and 200+3 feet WSE as the tip of the cutoff wall was in coarse-grained soil layer. Based on discussion with Bill Hampton of LD1 during a site visit in November, 2010, the cutoff wall depths in this area were varied to embed the tip in fine-grained soil layers. Therefore, the analysis model was developed with an assumed cutoff wall depth of approximately 50 feet i.e. cutoff wall tip embedded in fine-grained soil. Specification requirement and as-built drawings should be evaluated or excavation should be performed to investigate the conditions of the cutoff wall.
200-year + 3 feet	0.16	N/A	0.4 (approximately 55 feet from landside toe)	No Breakout	Yes	Moreover, a sensitivity study using a $K_h = 10^{-5}$ cm/sec in the top 15 feet of the cutoff wall (for 50 feet deep cutoff wall section) was performed to evaluate effect of potential cracking in the upper portion of the wall. The sensitivity analyses meet criteria.

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year	2.0		Yes	
200-year + 3 feet	1.93		Yes	

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s):

Dimensions of Primary Features:

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot				
200-year + 4 feet				

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s):

Dimensions of Primary Features:

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot				
200-year + 4 feet				

TABLE 5-15A: CHARACTERIZATION OF REACH 15
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
15	954+40 [3120+25]	968+50 [3134+50]	0.27	Total Number of Explorations = 8; Crest Explorations = 3 (SPT - 2, CPT - 1); Landside Toe Explorations = 4 (SPT - 2, CPT - 2); Landside Field Explorations = 1 (CPT - 1)	**Crown Width :** approximately 15 feet to 20 feet **Landside slope** 1.5 H:1V to flatter than 2H:1V **Waterside Slope** 1.7H:1V to flatter than 3H:1V	No documentation of past performance problems were found in the reviewed documents or site walk with LD1 representative. However, based on DWR's Seepage Area map for the Feather River West Levee area, approximately 100% of Reach 15 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observations. Based on the same map, approximately 100% of Reach 15 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observations. However, the setback levee was placed after these maps.	Site 8: Toe drain and berm from LM 12.26 to LM 13.57. Project plans entitled "Sacramento River Flood Control Project Phase II, Levee Reconstruction, Contract 3 (Sites 1, 2, 3, 8, 9, 10, 11, & 12)," dated 7/4/1997. USACE Design File No. 50-04-6001. **NOTE: DURING A SITE VISIT ON NOVEMBER 2010, NO BERM WAS FOUND. ACCORDING TO BILL HAMPTON OF LD1, A CUTOFF WALL WAS CONSTRUCTED IN THIS AREA.**	R_a (Recent Alluvium) R_{cs} (Recent Crevasse Splay)	Approximately 40 feet thick, high resistivity soil layer is present immediately below the embankment from 953+80 [3120+00] to 958+80 [3125+00] in this Reach. Beyond this station resistive layer was not observed.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
Levee Embankment: Silty clay, silty sand, and silt (CL, SM, ML) **Foundation**: Near Surface layer consists of silty sand and silt (SM, ML). Sand and Gravel (SP, GM) are present at shallow at deep layers.	**200 yr WSE** Head = approximately 12.4 feet at the analysis section	Urban Area, Airport, Police Station, Baseball Field (Yuba City)	958+83 [3125+00]	WL0001_073C, WL0001_074B, 4F-88-7 (CREST), 2F-88-9A, WL0001_003B, WL0001_103C, WL0001_105C (TOE), and WL0001_108C (LANDSIDE FIELD)	Sand and silty sand in levee embankment may indicate potential for through seepage; Shallow and deep sand/gravel layers may indicate potential for underseepage.

TABLE 5-15B: ANALYSIS RESULTS FOR REACH 15
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 958+83

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.6	N/A	1.15 (at 25 feet from LS toe)	2.4	No	A toe berm and drain was designed for this section by USACE. However, no berm was found during a field visit in November 2010. According to Bill Hampton of LD 1, a cutoff wall was installed in this segment. As-built documents or verification study is needed to investigate the presence and conditions of the cutoff wall.
200-year + 3 feet						

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year	19 feet drop from 200yr WSE	2.14	A drop of 19 feet was estimated from evaluation of 1986 and 1997 flood levels at gage station "YUB," which is located near Yuba city. The duration of drop considered was 7 days.	Yes	

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 15 is soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both through seepage and underseepage potential. Alternative 2 for Reach 15 is a shallow cutoff wall and relief well system. The seepage berm alternative was not considered because this Reach is located near an urban area.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: 3 feet wide and 64 feet deep cutoff wall starting at Elevation 73 (half levee degrade)

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	<0.1	N/A	N/A	No Breakout	Yes	
200-year + 4 feet	<0.1	N/A	N/A	No Breakout	Yes	

Landside Stability

WSE	FS	Meets Criteria?	Comments
200-year + 1 foot	2.09	Yes	
200-year + 4 feet	2.07	Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Shallow Cutoff Wall and Relief Wells

Dimensions of Primary Features: Relief Wells: 23 feet spacing and 51.5 feet deep.
Shallow Cutoff Wall: 3 feet wide and 36 feet deep cutoff wall starting at Elevation 73 (half levee degrade)

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot					Yes	Relief wells are modeled to meet an average exit gradient of 0.5 at the center of two relief wells. The head drop at the relief well location and between the relief well and midpoint between relief wells should be higher i.e. gradients should be lower than 0.5. The analyses was performed in accordance with USACE EM 1110-2-1914.
200-year + 4 feet					Yes	

Landside Stability

WSE	FS	Meets Criteria?	Comments
200-year + 1 foot	1.9	Yes	
200-year + 4 feet	1.87	Yes	

TABLE 5-16A: CHARACTERIZATION OF REACH 16
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2] START STATION (SRFCA) [DWR ULE STATION]	REACH LIMITS [2] END STATION (SRFCA) [DWR ULE STATION]	LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
16	968+50 [3134+50]	1080+00 [3246+25]	2.11	Total Number of Explorations = 48; Crest Explorations = 34 (SPT - 24, CPT - 10); Landside Toe Explorations = 4 (SPT - 3, CPT - 1); Landside Field Explorations = 7 (SPT - 7); Waterside Field Explorations = 4 (SPT - 3)	**Crown Width :** approximately 15 feet to 20 feet **Landside slope** 1.6 H:1V to flatter than 2H:1V **Waterside Slope** 1.4H:1V to flatter than 3H:1V	Based on DWR's Seepage Area map for the Feather River West Levee area, approximately 100% of Reach 16 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observations. Based on the same map, approximately 100% of Reach 16 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observations. However, the setback levee was placed after these maps. 971+00 [3137+19] The site is located near the Yuba City Airport at approximate River Mile 27.0 (LM 13.6). Seepage occurs at the site during high water. (F.R. Site K). 991+94 [3158+16] to 1070+74 [3236+83]The site is located in Yuba City from Garden Highway north to the Drive-in Cinema between approximate River Miles 27.4 to 29.3 (LM 14.0 to LM 15.5). During the 1955 flood, seepage was observed near the 10th Street Bridge. (F.R. Site L). 991+94 [3158+16] to 1070+74 [3236+83]: During the 1986 flood, the landside slope became saturated and unstable and bulged slightly in the area of the Corporation Yard. Water also flowed up through cracks in the parking lot pavement and the floor slab of an auto body shop on Teegarden Avenue. (F.R. Site L). 991+96 [3158+16] to 1070+69 [3236+83]: Site 1: This is a reach of levee extending 4000 feet through downtown Yuba City. During the 1986 flood, this area showed considerable wetness on landside slope. (1986). 1041+99 [3208+07] to 1073+59 [3239+44]: During the 1997 flood, heavy seepage north of 10th Street Bridge. Heavy seepage near two City drainage pipes. 1005+95 [3172+25] to 1021+87 [3188+10]: During the 1986 flood, Erosion of the waterside levee toe occurred in the areas immediately upstream and downstream of the Fifth Street Bridge. (F.R. Site L). 1005+95 [3172+25] to 1021+87 [3188+10]: During the 1997 flood - this is an area of waterside erosion which extends for several hundred feet upstream and downstream of the Fifth Avenue Bridge (Site 2). This erosion occurred mostly low down on the slope and had cut into the levee section causing a steepening of the lower levee slope. Bank and levee erosion south of the 5th Street Bridge. Bank erosion between 5th Street Bridge and 10th Street Bridge (1997).	Site 8: 927+08 [3093+19] to 968+31 [3170+25] Slurry walls from LM 12.76 to LM 13.28. Project plans entitled "Sacramento River Flood Control Project Phase II, Levee Reconstruction, Contract 3 (Sites 1, 2, 3, 8, 9, 10, 11, & 12)," dated 7/4/1997. USACE Design File No. 50-04-6001. 1019+75 [3186+85] to 1080+25 [3246+40] with gap in HWY-20: Slurry wall from LM 14.56 to LM 15.68. Plans entitled "PL 84-99 Cost Shared/Added Sites Sacramento Basin No. 18 LD1 Slurry Wall, undated, USACE Design File No. 4-25-825." Note: Based on Doc. 3045 and 946, an approximately 135 feet gap between slurry walls from two projects. PL 84-99 calls for an overlap between the slurry walls. 991+96 [3158+16] to 1025+84 [3224+00]: Yuba City constructed a berm along the landside toe as an emergency action. A permanent seepage/stability berm was later constructed from the Fifth Street Bridge extending northward to about 2500 feet beyond the 10th Street Bridge. An impermeable cutoff wall was also constructed in this area (See F.R. Site K). (F.R. Site L). 991+96 [3158+18] to 1025+84 [3224+00]: Temporary toe drain/berm: Site 1: In 1966, this area was upgraded by placing a landside berm on the slope with an internal drain protected by filter fabric which extends into the toe. Drainage from this system can be monitored at drain pipes.	R_a (Recent Alluvium) R_{2s} (Recent Crevasse Splay) H_{ch} (Holocene Channel) R_{ob} (Recent Overbank) R_{ch} (Recent Channel) (along almost the entire reach - Gilsizer Slough)	High Resistivity soil layers are present intermittently along the Reach, immediately below the embankment.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13] SRFCA STATION [DWR ULE STATION]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
Levee Embankment: Silty sand and silt (SM, ML), thin layers of silty clay (CL) **Foundation**: Shallow layers of CL, SM, ML, SC. Sand layers are approximately 10 feet thick and interlayered with CL, ML.	**200 yr WSE** Head = approximately 17.1 feet at the analysis section 993+80 and approximately 21.3 feet at the analysis section 1043+88	Urban Area (Yuba City)	993+80 [3160+00] and 1043+88 [3210+00]	SECTION 993+80: 2F-07-03 (CREST), SL0001_012C (LANDSIDE TOE) SECTION 1043+88: WL0001_061B, WL0001_081C, DH-4C, DH-4A (CREST); DH-4D, DH-4B (LANDSIDE TOE)	Location of mapped old Gilsizer Slough. Location of existing slurry wall.

TABLE 5-16B: ANALYSIS RESULTS FOR REACH 16 (ANALYSIS SECTION 1]
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 993+80

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	<0.1	N/A	N/A	No Breakout	Yes	A sensitivity study using a $K_h = 10^{-5}$ cm/sec in the upper 20 feet of the cutoff wall was performed to evaluate effect of potential cracking in the upper portion of the wall. The sensitivity analyses meet criteria. Specification requirement and as-built drawings should be evaluated or excavation should be performed to investigate the conditions of the existing cutoff walls.
200-year + 3 feet	<0.1	N/A	N/A	No Breakout	Yes	

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year	1.48		Yes	
200-year + 3 feet	1.47		Yes	

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year	19 feet drop from 200yr WSE	0.94	A drop of 19 feet was estimated from evaluation of 1986 and 1997 flood levels at gage station "YUB," which is located near Yuba city. The duration of drop considered was 7 days.	No	This section does not meet Rapid Drawdown criteria due to a steep waterside slope (~1.6H:1V).

Rationale for Selection of Two Alternatives for Analysis

Typical alternative section with 3H:1V waterside slope and clay embankment satisfies the criteria. Typical section includes 20 feet wide crest, and 3H:1V waterside slope.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s):

Dimensions of Primary Features:

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot				
200-year + 4 feet				

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s):

Dimensions of Primary Features:

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot				
200-year + 4 feet				

TABLE 5-16C: ANALYSIS RESULTS FOR REACH 16 (ANALYSIS SECTION 2)
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1043+88

Existing Conditions Problem Identification						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	<0.1	N/A	0.4 (280 feet from LS toe)	No Breakout	Yes	A sensitivity study using a $K_h = 10^{-5}$ cm/sec in the upper 20 feet of the cutoff wall was performed to evaluate effect of potential cracking in the upper portion of the wall. The sensitivity analyses meet criteria. Specification requirement and as-built drawings should be evaluated or excavation should be performed to investigate the conditions of the existing cutoff walls.
200-year + 3 feet	<0.1	N/A	0.42 (280 feet from LS toe)	No Breakout	Yes	
Landside Stability						
WSE	FS	Performance			Meets Criteria?	Comments
200-year	2.17				Yes	
200-year + 3 feet	2.14				Yes	
Rapid Drawdown						
WSE - initial	WSE - final	FS	Duration Effect		Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE					

Rationale for Selection of Two Alternatives for Analysis

Rehabilitated Levee Alternative 1						
Geotechnical Rehabilitation Measure(s):						
Dimensions of Primary Features:						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

Rehabilitated Levee Alternative 2						
Geotechnical Rehabilitation Measure(s):						
Dimensions of Primary Features:						
Seepage						
WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

TABLE 5-17A: CHARACTERIZATION OF REACH 17
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
17	1080+00 [3235+00]	1130+86 [3297+00]	0.96	Total Number of Explorations = 17; Crest Explorations = 8 (SPT - 6, CPT - 2); Landside Toe Explorations = 2 (SPT - 1, CPT - 1); Landside Field Explorations = 5 (SPT - 4, CPT - 1); Waterside Toe Explorations = 1 (CPT - 1); Waterside Field Explorations = 1 (SPT - 1)	**Crown Width :** approximately 15 feet to 20 feet **Landside slope** approximately 1.8H:1V to flatter than 2H:1V **Waterside Slope** approximately 2.5H:1V to flatter than 3H:1V	No documentation of past performance problems were found in the reviewed documents or site walk with LD1 representative. However, based on DWR's Seepage Area map for the Feather River West Levee area, approximately 100% of Reach 17 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observations. Based on the same map, approximately 100% of Reach 17 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observations. However, the setback levee was placed after these maps.	No documentation of existing levee improvements were found in the reviewed documents or site walk with LD1 representative.	R_a (Recent Alluvium) R_{ob} (Recent Overbank) BP (Borrow Pit Present in 1937)	High resistivity soil layers are present immediately below the embankment, occasionally.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
Levee Embankment: Silty clay, silty sand, and silt (CL, SM, ML) **Foundation**: Near Surface layer consists of silty sand and silt (SM, ML). Silty sand and silt (SM, ML) are present at shallow at deep layers.	**200 yr WSE** Head = approximately 17.7 feet at the analysis section	Urban Area (Yuba City)	1108+86 [3275+00]	2F-07-05 (CREST), WL0001_003C (WS TOE), WL0001_002C, WL0001_002B (LS TOE), AND WL0001_106C (LANDSIDE FIELD)	A swale or depression is present near the landside toe. Interbedding of ML and CL layers in the levee embankment and foundation. Boring 2F-07-05 encountered sand in foundation.

TABLE 5-17B: ANALYSIS RESULTS FOR REACH 17
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1108+86

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	1.13	N/A	N/A	5.9	No	
200-year + 3 feet						

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 17 is soil-bentonite cutoff wall and fill-in of the landside ditch/swale, which was selected as an in-place alternative to mitigate both through seepage and underseepage potential. Alternative 2 for Reach 17 is shallow cutoff wall with relief well system. The seepage berm alternative was not considered because this Reach is located near an urban area.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall and fill-in ditch

Dimensions of Primary Features: 3 feet wide and 39 feet deep cutoff wall starting at Elevation 74 (half levee degrade)
Soil type of the ditch/swale fill in - sandy silt

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.46	0.29 (soil filled-in ditch)	N/A	3.0	Yes	Considering the cutoff wall and levee degrade and rebuild criteria, the section meets through seepage criteria.
200-year + 4 feet	0.58	0.33 (soil filled-in ditch)	N/A	4.1	Yes	

Landside Stability

WSE	FS	Meets Criteria?	Comments
200-year + 1 foot	1.43		
200-year + 4 feet	1.33		

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Relief Wells and Shallow Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: Relief wells - 45 feet spacing and 40 feet deep.
Shallow Cutoff Wall - 3 feet wide and 16 feet deep cutoff wall starting at Elevation 74 (half levee degrade)

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot					Yes	Shallow cutoff wall and relief well system meet criteria. Relief wells are modeled to meet an average exit gradient of 0.5 at the center of two relief wells. The head drop at the relief well location and between the relief well and midpoint between relief wells should be higher i.e. gradients should be lower than 0.5. The analyses was performed in accordance with USACE EM 1110-2-1914.
200-year + 4 feet					Yes	

Landside Stability

WSE	FS	Meets Criteria?	Comments
200-year + 1 foot	1.69	Yes	Shallow cutoff wall and relief well system meet criteria
200-year + 4 feet	1.69	Yes	

TABLE 5-18A : CHARACTERIZATION FOR REACH 18
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2] START STATION (SBFCA) [DWR ULE STATION]	REACH LIMITS [2] END STATION (SBFCA) [DWR ULE STATION]	LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
18	1130+86 [3297+00]	1213+85 [3380+00]	1.6	Crest:8 Borings 7 CPTs Landside: 2 Borings 6 CPTs 2 Hand augers Waterside: Not available	Levee Height: 20 feet Crown Width: 22 feet Landside Slope: 2.0H:1V Waterside Slope: 3.0H:1V at analysis section	• Seepage reported during storms of late 1996 from 1135+00 to 1214+24 [3299+00 to 3380+44]. • Sinkholes observed on riverside toe of levee in Winter of 1966 from 1136+32 to 1153+14 [3302+46 to 3319+28], repaired in Spring of 1966. • Sinkhole in 1986 at 1173+78 [3339+92]. • Heavy seepage reported in 1997 from 1131+08 to 1199+60 [3297+21 to 3365+74]. • Based on DWR's Seepage Area map for the Feather River West Levee area, 20% of Reach 18 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observation. Based on the same map, 25% of Reach 18 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observation.	• Repair of sinkholes on riverside toe of levee in Spring 1966. Note: As-Constructed Drawings not available.	Rob (Recent Overbank) Qmu (Pleistocene Modesto Formation - Upper) Rofc (Recent Overflow Channel) Ra (Recent Alluvium) Rch (Recent Channel)	Shallow higher resistivity zone near downstream end of reach

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13] SBFCA STATION [DWR ULE STATION]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
• Levee: 19 to 20 feet of sandy silt to lean clay with minor silty sand. • Foundation: 2 to 20 feet of sandy silt to lean clay. • 4 to 27 feet of sand to silty sand with localized silt. • 10 to 40 feet of silty sand to fat clay with minor silty sand and clayey sand. • 3 to 16 feet of poorly-graded gravel to poorly-graded sand with lean clay. • 4 to 23 feet of silty sand to fat clay.	200 Year 13 feet	LS and WS orchards along most of reach, Agricultural buildings at 1179+86 [3346+00]	1138+86 [3305+00]	WL0009_001S (crest), WL0009_008C (crest), WL0009_005C (landside toe), WL0009_004C (landside toe), WL0009_003H (landside), WL009_007A (landside toe)	Thinner blanket over sand layer more susceptible to underseepage.

TABLE 5-18B ANALYSIS RESULTS FOR REACH 18
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1138+86

Existing Conditions Problem Identification						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	1.32	N/A	N/A	8.0	No	The reach has reported seepage deficiencies including seepage reported in 1965 and 1996, and heavy seepage reported in 1997.
200-year + 3 feet						
Landside Stability						
WSE	FS	Performance			Meets Criteria?	Comments
200-year						
200-year + 3 feet						
Rapid Drawdown						
WSE - initial	WSE - final	FS	Duration Effect		Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE					

Rationale for Selection of Two Alternatives for Analysis
Alternative 1 for Reach 18 is undrained seepage berm with relief wells. Seepage berm material type is silt having similar hydraulic conductivity as the clay blanket. Relief wells and/or a drainage system could be used to reduce high gradient. Alternative 2 for Reach 18 is soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate underseepage potential. The cutoff wall will block the flow through the existing thick aquifer, and effectively control the underseepage.

Rehabilitated Levee Alternative 1						
Geotechnical Rehabilitation Measure(s): Undrained Seepage Berm with Relief Wells						
Dimensions of Primary Features: 300 feet wide seepage berm, seepage berm thickness at the levee toe = 7.0 feet, thickness at the berm toe = 3 feet; Relief wells: depth = 30 feet and spacing = 100 feet.						
Seepage						
WSE	Exit Gradient Levee Toe	Berm (near berm toe)	Berm Toe	Phreatic Surface Breakout Point above Berm	Meets Criteria?	Comments
200-year + 1 foot	0.38	0.69	1.31	3.2	No at berm toe; will meet with Relief Wells	The calculated gradient at the berm toe does not meet criteria; Need to provide relief wells to reduce the high gradient at the berm toe; Levee prism mainly consists of clayey soils; Drainage berm not required for through seepage.
200-year + 4 feet	0.55	0.89	1.58	6.0	No at berm toe; will meet with Relief Wells	The calculated gradient at the berm toe does not meet criteria; Need to provide relief wells to reduce the high gradient at the berm toe; Levee prism mainly consists of clayey soils; Drainage berm not required for through seepage.
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	1.59				Yes	
200-year + 4 feet	1.23				Yes	

Rehabilitated Levee Alternative 2						
Geotechnical Rehabilitation Measure(s): Cutoff Wall						
Dimensions of Primary Features: 1130+86 to 1149+50 Cutoff Wall Tip Elevation 0, 1149+50 to 1190+00 Cutoff Wall Tip Elevation 30, 1190+00 to 1213+85 Cutoff Wall Tip Elevation 40.						
Seepage						
WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot					Yes	No separate analysis performed; Alternative 2 of Reach 19 was used in the evaluation; for details see Figures B19-A5 through B19-A8.
200-year + 4 feet					Yes	No separate analysis performed; Alternative 2 of Reach 19 was used in the evaluation; for details see Figures B19-A5 through B19-A8.
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot					Yes	No separate analysis performed; Alternative 2 of Reach 19 was used in the evaluation; for details see Figures B19-A5 through B19-A8.
200-year + 4 feet					Yes	No separate analysis performed; Alternative 2 of Reach 19 was used in the evaluation; for details see Figures B19-A5 through B19-A8.

TABLE 5-19A : CHARACTERIZATION FOR REACH 19
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
19	1213+85 [3380+00]	1297+83 [3464+00]	1.6	Crest:14 Borings 4 CPTs Landside: 5 Borings 6 CPTs 1 Hand auger Waterside: 1 Boring	Levee Height: 20 feet Crown Width: 18 feet Landside Slope: 2.1H:1V Waterside Slope: 2.9H:1V at analysis section	• Boil and piping observed on landside of levee at 1242+86 [3409+01], landward half of levee excavated and recompacted with gravel filter in 1955. • Heavy levee saturation reported by Levee District 9 from 1259+63 to 1267+66 [3425+73 to 3433+88] (year unknown, awaiting information). • Pinhole boils observed on landside of levee in 1997 from 1288+24 to 1296+34 [3454+40 to 3462+52]. • Heavy seepage and boils on landside at 1278+82 to 1293+07 [3444+99 to 3459+25] in 1997 with river near 3 feet freeboard.	• Landward half of levee excavated and recompacted with gravel filter at 1242+86 [3409+01] in 1955. • Bank protection using rock was placed at 1266+45 to 1269+18 [3432+60 to 3435+35] in 1974. • Levee rock slope protection place at 1271+00 [3437+17] in 1974 • Drained toe berm repair was proposed near 1293+82 [3460+00] in 1998. Note: As-Constructed Drawings not available.	Ra (Recent Alluvium) Rofc (Recent Overflow Channel) Rob (Recent Overbank) Rcs (Recent Crevasse Splay) Qmu (Pleistocene Modesto Formation - Upper)	Shallow higher resistivity zone upstream of 1228+85 [3395+00]. Higher resistivity zone thickest from 1228+85 to 1238+85 [3395+00 to 3405+00].

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
• Levee: 18 to 20 feet of sandy silt to lean clay with minor well-graded gravel and clayey sand lenses. • Foundation: 14 to 46 feet of silty sand to fat clay with minor well-graded sand with silt to clayey sand. • 17 to 63 feet of poorly-graded gravel to poorly-graded sand with silt with minor silty sand and clayey sand. • 6 to 58 feet of silty sand to fat clay.	200 Year 13 feet	LS and WS orchards along much of reach, River at levee toe near 1267+84 [3434+00]	1238+85 [3405+00]	WL009_003S (crest), 2F-88-7 (crest), WL009_016C (landside toe), WL009_009A (landside toe), WL009_014C (landside toe), WL009_008A (landside toe)	Thin blanket over sand layer with underlying gravel susceptible to underseepage, near 1955 seepage area

TABLE 5-19B ANALYSIS RESULTS FOR REACH 19
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1238+85

Existing Conditions Problem Identification						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	2.32	N/A	N/A	7.0	No	The reach has reported seepage deficiencies including heavy seepage and boils reported in 1997.
200-year + 3 feet						
Landside Stability						
WSE	FS	Performance			Meets Criteria?	Comments
200-year						
200-year + 3 feet						
Rapid Drawdown						
WSE - initial	WSE - final	FS	Duration Effect		Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE					

Rationale for Selection of Two Alternatives for Analysis
Alternative 1 for Reach 19 is undrained seepage berm with relief wells and drained stability berm. Seepage berm material type is silt having similar hydraulic conductivity as the clay blanket. Relief wells provided at the berm toe to reduce high gradient. The drained stability berm is to control through seepage. Alternative 2 for Reach 19 is soil-bentonite cutoff wall, which was selected as an in-place alternative to effectively mitigate both through seepage and underseepage.

Rehabilitated Levee Alternative 1						
Geotechnical Rehabilitation Measure(s): Undrained Seepage Berm with Relief Wells, and Drained Stability Berm						
Dimensions of Primary Features: 300 feet wide seepage berm, thickness at the levee toe = 7.0 feet, thickness at the berm toe = 3 feet; Relief wells: depth = 50 feet and spacing = 100 feet; stability berm height = 10 feet above seepage berm.						
Seepage						
WSE	Exit Gradient Levee Toe	Berm (near berm toe)	Berm Toe	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.36	0.76	2.13	No breakout	No at berm toe; will meet with Relief Wells	The calculated gradient at the berm toe does not meet criteria; Need to provide relief wells to reduce the high gradient at the berm toe; Drainage stability berm controls through seepage.
200-year + 4 feet	0.57	1.03	2.59	No breakout	No at berm toe; will meet with Relief Wells	The calculated gradient at the berm toe does not meet criteria; Need to provide relief wells to reduce the high gradient at the berm toe; Drainage stability berm controls through seepage.
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	2.56				Yes	
200-year + 4 feet	2.15				Yes	

Rehabilitated Levee Alternative 2						
Geotechnical Rehabilitation Measure(s): Cutoff Wall						
Dimensions of Primary Features: 1213+85 to 1224+00 Cutoff Wall Tip Elevation 40, 1224+00 to 1240+00 Cutoff Wall Tip Elevation -27 , 1240+00 to 1269+00 Cutoff Wall Tip Elevation 5, 1269+00 to 1297+83 Cutoff Wall Tip Elevation 35.						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	< 0.05	N/A	N/A	No breakout	Yes	
200-year + 4 feet	< 0.05	N/A	N/A	No breakout	Yes	
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	1.88				Yes	
200-year + 4 feet	1.86				Yes	

TABLE 5-20A : CHARACTERIZATION FOR REACH 20
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
20	1297+83 [3464+00]	1374+33 [3540+50]	1.4	Crest:9 Borings 9 CPTs Landside: 2 Borings 8 CPTs Waterside: 1 CPT	Levee Height: 16 feet Crown Width: 15 feet Landside Slope: 2.1H:1V Waterside Slope: 3.3H:1V at analysis section	• Heavy levee saturation reported by Levee District 9 from 1316+46 to 1320+70 [3482+64 to 3486+88] (year unknown). • Boil and piping observed on landside of levee at 1321+07 [3487+25], landward half of levee excavated and recompacted with fill in 1955. • Seepage and boil observed on landside of levee at 1328+73 [3495+06] in 1986. • Heavy seepage and boils about 20 feet from levee toe in 1997 at 1368+41 to 1410+63 [3534+58 to 3576+80] • Seepage and boils occur near the landside levee toe during high water at 1336+73 to 1410+70 [3502+94 to 3576+80]	• Landward half of levee excavated and recompacted with fill in 1955 at 1321+07 [3487+25].	Rcs (Recent Crevasse Splay) Rofc (Recent Overflow Channel) Qmu (Pleistocene Modesto Formation - Upper) Rob (Recent Overbank)	Shallow higher resistivity zone upstream of 1348+83 [3515+00].

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13] SBFCA STATION [DWR ULE STATION]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
• Levee: 12 to 18 feet of silty sand to lean clay. • Foundation: 4 to 13 feet of sandy lean clay to lean clay. • 1 to 10 feet of poorly-graded sand with silt to silty sand. • 20 to 43 feet of sandy silt to fat clay with minor poorly-graded sand with silt and silty sand. • 4 to 30 feet of poorly-graded sand with silt to silty sand with minor clayey sand to silt. • 44 to 74 feet of sandy silt to lean clay with minor silty sand and clayey sand.	200 Year 10 feet	Orchards in portions of reach, Agricultural buildings at 1348+33 [3514+50]	1338+83 [3505+00]	WL009_025C (crest), WL009_003A (landside toe), WL009_030C (200 ft landside)	10 feet of silty clayey sand (SC-SM) at toe overlying poorly graded sand with silt (SP-SM) susceptible to underseepage

TABLE 5-20B ANALYSIS RESULTS FOR REACH 20
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1338+83

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.72	NA	NA	3.0	No	The reach has reported seepage deficiencies including heavy seepage and boils reported in 1986 and 1997, and seepage and boils reported during high water.
200-year + 3 feet						

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - Initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative1 for Reach 20 is soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both through seepage and underseepage potential. Alternative 2 for Reach 20 is undrained seepage berm with drained stability berm on Top. Seepage berm material type is SC-SM, which is similar to shallow near surface layer. The drained stability berm is to control through seepage.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Cutoff Wall

Dimensions of Primary Features: 1297+83 to 1359+00 Cutoff Wall Tip Elevation 50, 1359+00 to 1369+00 Cutoff Wall Tip Elevation 40, 1369+00 to 1374+33 Cutoff Wall Tip Elevation 50.

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	< 0.05	N/A	N/A	No breakout	Yes	
200-year + 4 feet	< 0.05	N/A	N/A	No breakout	Yes	

Landside Stability

WSE	FS	Meets Criteria?	Comments
200-year + 1 foot	1.64	Yes	
200-year + 4 feet	1.64	Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Undrained Seepage Berm with Drained Stability Berm on Top

Dimensions of Primary Features: 70 feet wide seepage berm, seepage berm thickness at the levee toe = 5 feet, thickness at the berm toe = 3 feet; 1297+83 to 1309+00 stability berm height = 8.5 feet above seepage berm, 1320+00 to 1374+33 stability berm height = 8.5 feet above seepage berm.

Seepage

WSE	Exit Gradient Levee Toe	Berm (near berm toe)	Berm Toe	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.14	0.09	0.65	No breakout	Yes	
200-year + 4 feet	0.30	0.20	0.79	No breakout	Yes	

Landside Stability

WSE	FS	Meets Criteria?	Comments
200-year + 1 foot	2.09	Yes	
200-year + 4 feet	1.90	Yes	

TABLE 5-21A : CHARACTERIZATION FOR REACH 21
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
21	1374+33 [3540+50]	1433+83 [3600+00]	1.1	Crest:5 Borings 9 CPTs Landside: 4 Borings 5 CPTs 2 Hand augers Waterside: 3 Borings	Levee Height: 15 feet Crown Width: 20 feet Landside Slope: 2.1H:1V Waterside Slope: 2.5H:1V at analysis section	• "Seasonal seepage" noted in 1957 by Levee District 9 from 1375+34 to 1390+17 [3541+54 to 3556+37]. • Boil observed on landside of levee in 1986 at 1401+58 [3567+75]. • Landside embankment distress in 1997. • Heavy seepage and boils in 1997 at [3444+99 to 3559+25] • Heavy seepage and sloughing in 1997 at [3584+13 to 3595+20] • Heavy seepage and boils in 1997 at [3534+58 to 3576+80] • Boils in 1955 at 1385+01 [3551+17] • Seepage and boils occur near the landside levee toe during high water at 1336+73 to 1410+70 [3502+94 to 3576+80]	• Corps plans indicate relocation of an open drainage ditch away from the toe of the levee. Plans call for 5374 feet of landside irrigation ditch back-filled from1375+58 to 1429+32 [3541+75 to 3595+49] (Site 3, completion unknown - awaiting construction documents, USACE Plans dated July, 1997). • Relief well on the landward side of the levee at 1385+83 [3552+00]. • Backfilling of irrigation canal with crushed rock and gravel in 1997 as emergency measure at 1417+95 to 1429+03 [3584+13 to 3595+20]. Note: As-Constructed Drawings not available. Canal observed in field at the landside toe of the levee in November 2010.	Ra (Recent Alluvium) Rch (Recent Channel) Qmu (Pleistocene Modesto Formation - Upper) Rcs (Recent Crevasse Splay) Qml (Pleistocene Modesto Formation - Lower)	Shallow higher resistivity in most of reach

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
• Levee: 10 to 12 feet of silty sand to lean clay with minor silty gravel. • Foundation: 9 to 14 feet of silty sand to lean clay. • 10 to 24 feet of well-graded sand to poorly-graded sand with minor silty and lean clay. • 23 to 36 feet of silty sand to fat clay.	200 Year 10 feet	Orchards on landside, unlined landside ditches	1378+83 [3545+00]	WL009_28C (crest), WL009_006A (landside toe), WL009_004H (260 ft landside), B-3 (crest)	8.5 feet of clay (CL) and silt (ML) at toe over silty sand (SM) and poorly graded sand with silt (SP-SM) susceptible to underseepage

TABLE 5-21B ANALYSIS RESULTS FOR REACH 21
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1378+83

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.17	2.79	1.0	NA	No	The reach has reported seepage deficiencies including heavy seepage and boils reported in 1986 and 1997, and seepage and boils reported during high water.
200-year + 3 feet						

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative1 for Reach 21 is soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both through seepage and underseepage potential. Alternative 2 for Reach 21 is undrained seepage berm with relief wells and drained stability berm. Seepage berm material type is silt, which is similar to shallow near surface layer. The drained stability berm is to control through seepage.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Cutoff Wall

Dimensions of Primary Features: 1374+33 to 1379+00 Cutoff Wall Tip Elevation 40, 1379+00 to 1389+00 Cutoff Wall Tip Elevation 50, 1389+00 to 1409+00 Cutoff Wall Tip Elevation 60, 1409+00 to 1433+83 Cutoff Wall Tip Elevation 40.

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	No exit of water	0.46	N/A	No breakout	Yes	
200-year + 4 feet	No exit of water	0.46	N/A	No breakout	Yes	

Landside Stability

WSE	FS	Meets Criteria?	Comments
200-year + 1 foot	2.33	Yes	
200-year + 4 feet	2.33	Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Undrained Seepage Berm with Relief Wells, and Drained Stability Berm

Dimensions of Primary Features: 300 feet wide seepage berm, seepage berm thickness at the levee toe = 6-1/2 feet, thickness at the berm toe = 3 feet; Relief wells: depth = 20 feet and spacing = 100 feet; stability berm height = 8 feet above seepage berm.

Seepage

WSE	Exit Gradient Levee Toe	Berm (near berm toe)	Berm Toe	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.12	0.23	0.96	No breakout	No at berm toe, will meet with Relief Wells	The calculated gradient at the berm toe does not meet criteria; Need to provide relief wells to reduce the high gradient at the berm toe; Drainage stability berm controls through seepage.
200-year + 4 feet	0.32	0.36	1.18	No breakout	No at berm toe, will meet with Relief Wells	The calculated gradient at the berm toe does not meet criteria; Need to provide relief wells to reduce the high gradient at the berm toe; Drainage stability berm controls through seepage.

Landside Stability

WSE	FS	Meets Criteria?	Comments
200-year + 1 foot	2.88	Yes	
200-year + 4 feet	2.66	Yes	

TABLE 5-22A : CHARACTERIZATION FOR REACH 22
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2] START STATION (SBFCA) [DWR ULE STATION]	REACH LIMITS [2] END STATION (SBFCA) [DWR ULE STATION]	LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
22	1433+83 [3600+00]	1503+83 [3670+00]	1.3	Crest:4 Borings 8 CPTs Landside: 1 Boring 2 CPTs Waterside: Not available	Levee Height: 12 feet Crown Width: 15 feet Landside Slope: 2.0H:1V Waterside Slope: 2.7H:1V at analysis section	Severe animal burrows in levee at 1433+83 to 1459+77 [3600+00 to 3626+00]; extremely severe burrowing at north end of LD-9 observed in 2010	• No known mitigation measures.	Qml (Pleistocene Modesto Formation - Lower) Rob (Recent Overbank) Ra (Recent Alluvium) Rch (Recent Channel) Rcs (Recent Crevasse Splay) Rofc (Recent Overflow Channel)	Shallow higher resistivity in most of reach

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13] SBFCA STATION [DWR ULE STATION]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
• Levee: 7 to 10 feet of silty sand to lean clay. • Foundation: 0 to 15 feet of silt to lean clay. • 5 to 15 feet of poorly-graded sand with silt to silty sand. • 10 to 15 feet of sandy silt to lean clay. • 25 to 50 feet of silty sand to lean clay.	200 Year 7 feet 10 feet in ditch	Orchards on landside, unlined landside ditch	1468+83 [3635+00]	WM0016_001A (crest), WM0016_008C (crest), WM0016011C (landside toe)	Thin blanket over thick sand layer susceptible to underseepage

TABLE 5-22B: ANALYSIS RESULTS FOR REACH 22
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1468+83

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.27	1.34	NA	1.5	No	The reach has extremely severe burrowing at north end of LD-9 observed in 2010; No other reported deficiencies have been identified; For empty ditch condition, the gradient at the bottom of the ditch did not meet criteria.
200-year + 3 feet						

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative1 for Reach 22 is soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both throughseepage and underseepage potential. Alternative 2 for Reach 22 is fill canal and drained stability berm/levee reconstruction. Fill canal option would mitigate the estimated high gradient at the ditch. The drained stability berm/levee reconstruction is to control through seepage.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Cutoff Wall

Dimensions of Primary Features: 1433+83 to 1449+00 Cutoff Wall Tip Elevation 40, 1449+00 to 1469+00 Cutoff Wall Tip Elevation 50, 1469+00 to 1503+83 Cutoff Wall Tip Elevation 55 plus full degrade/reconstruct from 1433+83 to 1459+77 due to severe burrowing.

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	No exit of water	0.18	NA	No breakout	Yes	
200-year + 4 feet	No exit of water	0.24	NA	No breakout	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.23		Yes	
200-year + 4 feet	2.23		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Fill Canal and Drained Stability Berm

Dimensions of Primary Features: Fill canal to top (adj grade); stability berm from sta 1459+77 to 1503+83, height = 10 feet; full degrade/reconstruct from sta 1433+83 to 1459+77 due to severe burrowing.

Seepage

WSE	Exit Gradient Levee Toe	Filled Ditch	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.34	0.30	N/A	No breakout	Yes	
200-year + 4 feet	0.56	0.53	N/A	No breakout	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.15		Yes	
200-year + 4 feet	1.79		Yes	

TABLE 5-23A : CHARACTERIZATION FOR REACH 23
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
23	1503+83 [3670+00]	1609.37 [3775+50]	2.0	Crest:7 Borings 7 CPTs Landside: 1 Boring 1 CPT Waterside: Not available	Levee Height: 11 feet Crown Width: 18 feet Landside Slope: 2.2H:1V Waterside Slope: 3.0H:1V at analysis section	• "Levee erosion" noted by citizens at 1521+05 to 1532+55 [3687+24 to 3698+82] in 1991.	• Landside drainage ditch constructed by USACE from 1521+03 to 1532+83 [3687+20 to 3699+00] in 1968. • Grouted rip-rap placed from 1515+63 to 1527+32 [3681+80 to 3693+49] by USACE in 1968 adjacent to levee and in the river channel for bank protection. • Bank protection placed at 1516+02 to 1534+67 [3682+19 to 3700+84] in 1965. Note: As-Constructed Drawings not available.	Qml (Pleistocene Modesto Formation - Lower) Rofc (Recent Overflow Channel) Rob (Recent Overbank) Rcs (Recent Crevasse Splay) Rch (Recent Channel)	Shallow higher resistivity in most of the reach

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
• Levee: 7 to 10 feet of silty sand to sandy lean clay. • Foundation: 0 to 25 feet of sandy silt to lean clay. • 5 to 60 feet of poorly-graded sand to silty and clayey sand with significant localized silt to clay.	200 Year 4 feet 10 feet in ditch @ ~250 ft LS of toe	Orchards on both sides, unlined ditch about 200 to 600 feet landside of levee, buildings near 1558+83 [3725+00]	1508+33 [3674+50]	WM0016_011B (crest) SM0016_002C (landside)	Silt to clay levee may be susceptible to through seepage; Thin blanket over sand layer susceptible to underseepage.

TABLE 5-23B: ANALYSIS RESULTS FOR REACH 23
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1508+33

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year	0.32	NA	NA	0.9	Yes	
200-year	0.60	NA	NA	1.8	No	No reported seepage or landside stability deficiencies have been identified; However, the reach has thin clay blanket underlain by shallow sand aquifer (high potential for underseepage); Sand aquifer is exposed on the riverside.
200-year + 3 feet						

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
100-year	2.05		Yes	
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 23 is soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate underseepage potential. Alternative 2 for Reach 23 is undrained seepage berm. Seepage berm material type is silt, which has similar hydraulic conductivity as the shallow near surface clay blanket layer. Seepage analysis indicate high exit gradients at the toe of the seepage berm at HTOL WSE. Therefore, monitoring at the toe of the berm for seepage is recommended during the hig water events. If seepage occurs, relief wells or a collection drain system may be needed.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Cutoff Wall

Dimensions of Primary Features: 1503+83 to 1509+00 Cutoff Wall Tip Elevation 55, 1509+00 to 1529+00 Cutoff Wall Tip Elevation 60, 1529+00 to 1566+00 Cutoff Wall Tip Elevation 55, 1566+00 to 1589+00 Cutoff Wall Tip Elevation 60, 1589+00 to 1609+37 Cutoff Wall Tip Elevation 40.

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	< 0.05	N/A	N/A	No breakout	Yes	
200-year + 4 feet	< 0.05	N/A	N/A	No breakout	Yes	

Landside Stability

WSE	FS	Meets Criteria?	Comments
200-year + 1 foot	2.25	Yes	
200-year + 4 feet	2.23	Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Undrained Seepage Berm

Dimensions of Primary Features: 100 feet wide seepage berm, seepage berm thickness at the levee toe = 5 feet, thickness at the berm toe = 3 feet.

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Berm Toe	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	No exit of water	N/A	0.52	No breakout	Yes	As the berm width is 100 feet and the exit gradient meets criteria at DWSE, judgment was used for HTOL. Monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a collection drain system may be needed.
200-year + 4 feet	0.20	N/A	0.89	No breakout	Yes	

Landside Stability

WSE	FS	Meets Criteria?	Comments
200-year + 1 foot	1.83	Yes	
200-year + 4 feet	1.47	Yes	

TABLE 5-24A : CHARACTERIZATION FOR REACH 24
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA)	END STATION (SBFCA)							
	[DWR ULE STATION]	[DWR ULE STATION]							
24	1609.37 [3775+50]	1623+86 [3790+00]	0.3	Crest:1 Boring 1 CPTs Landside: 1 CPT Waterside: Not available	Levee Height: 9 feet Crown Width: 20 feet Landside Slope: 3.2H:1V Waterside Slope: 2.7H:1V at analysis section	• No reported deficiencies have been identified.	• No known mitigation measures.	Rch (Recent Channel) Rob (Recent Overbank) Rcs (Recent Crevasse Splay) Qml (Pleistocene Modesto Formation - Lower)	Shallow higher resistivity zone

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION (DWR ULE STATION)		
• Levee: 7 to 10 feet sandy silt to lean silty clay. • Foundation: 5 to 10 feet of sandy lean clay with silt. • 10 to 15 feet of well-graded with silt. • 5 to 10 feet of sandy silt to lean clay. • 20 to 25 feet of clayey sand to silty sand.	200 Year 2 feet 7 feet in ditch	LS and WS orchards along most of reach, building at 1610+36 [3776+50]	1615+62 [3781+75]	WL0016_020B (crest) WL0016_006C (landside)	Silt to clay levee; waterside levee toe drops to low elevation; shallow SW-SM acquifer exposed at the bottom of the ditch; wide landside toe ditch, susceptible to through seepage and underseepage

TABLE 5-24B: ANALYSIS RESULTS FOR REACH 24
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1615+62

Existing Conditions Problem Identification						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.20	4.14	NA	NA	No	No reported seepage or landside stability deficiencies have been identified; For empty ditch condition, the gradient at the bottom of the ditch did not meet criteria.
200-year + 3 feet						
Landside Stability						
WSE	FS	Performance			Meets Criteria?	Comments
200-year						
200-year + 3 feet						
Rapid Drawdown						
WSE - initial	WSE - final	FS	Duration Effect		Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE					

Rationale for Selection of Two Alternatives for Analysis
Alternative1 for Reach 24 is fill canal. Fill canal option would mitigate the estimated high gradient at the ditch. Alternative 2 for Reach 24 is cutoff wall plus excavate and place 4.5-foot thick compacted clay fill at the bottom of ditch. The cutoff wall and clayey fill below the bottom of the canal will significantly reduce the flow into the canal and thus reduce the exit gradient at the canal bottom.

Rehabilitated Levee Alternative 1						
Geotechnical Rehabilitation Measure(s): Fill Canal						
Dimensions of Primary Features: Fill canal to top (elev 90ft, 40ft wide x 10ft deep).						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	No exit of water	N/A	0.38	No breakout	Yes	
200-year + 4 feet	0.27	N/A	0.69	1.0	Yes	Levee prism mainly consists of clayey soils; Drainage berm not required for through seepage.
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	2.95				Yes	
200-year + 4 feet	2.21				Yes	

Rehabilitated Levee Alternative 2						
Geotechnical Rehabilitation Measure(s): 1609+37 to 1623+86 Cutoff Wall Tip Elevation 64, plus excavate and place 4.5-foot thick compacted clay fill at the bottom of ditch.						
Dimensions of Primary Features: 30ft-deep cutoff wall.						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	No exit of water	0.44	N/A	No breakout	Yes	
200-year + 4 feet	No exit of water	0.58	N/A	No breakout	Yes	
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	1.82				Yes	
200-year + 4 feet	1.70				Yes	

TABLE 5-25A : CHARACTERIZATION FOR REACH 25
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
25	1623+86 [3790+00]	1674+37 [3840+50]	1.0	Crest:4 Borings 2 CPTs Landside: Not available Waterside: Not available	Levee Height: 9 feet Crown Width: 23 feet Landside Slope: 1.6H:1V Waterside Slope: 2.5H:1V at analysis section	• No reported deficiencies have been identified.	• No known mitigation measures.	Qml (Pleistocene Modesto Formation - Lower) Rch (Recent Channel) Rcs (Recent Crevasse Splay)	Shallow higher resistivity zone

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION (DWR ULE STATION)		
• Levee: 5 to 10 feet of sandy silt to lean clay. • Foundation: 10 to 20 feet of sandy silt to lean clay with localized clayey sand. • 0 to 20 feet of poorly-graded sand with silt. • 10 to 20 feet of clayey sand to clayey silty sand. • 0 to 15 feet of well-graded gravel with silt to silty sand.	200 Year 1 foot	Orchards on both LS and WS, building at 1664+37 [3830+50]	1645+86 [3812+00]	WL0016_022S (crest) WL0016_021B (crest)	Silt to clay levee; waterside levee toe drops to low elevation more susceptible to underseepage

TABLE 5-25B: ANALYSIS RESULTS FOR REACH 25
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1645+86

Existing Conditions Problem Identification						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.15	NA	NA	No breakout	Yes	No reported deficiencies have been identified.
200-year + 3 feet	0.43	NA	NA	1.6	Yes	No reported deficiencies have been identified.; Portion of levee prism below the water surface elevation mainly consists of clay; Drainage berm not required for through seepage.
Landside Stability						
WSE	FS	Performance			Meets Criteria?	Comments
200-year	2.25				Yes	No reported deficiencies have been identified.
200-year + 3 feet	1.93				Yes	No reported deficiencies have been identified.
Rapid Drawdown						
WSE - initial	WSE - final	FS	Duration Effect		Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE					

Rationale for Selection of Two Alternatives for Analysis
N/A

Rehabilitated Levee Alternative 1						
Geotechnical Rehabilitation Measure(s):						
Dimensions of Primary Features:						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						
Landside Stability						
WSE					Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

Rehabilitated Levee Alternative 2						
Geotechnical Rehabilitation Measure(s):						
Dimensions of Primary Features:						
Seepage						
WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

TABLE 5-26A : CHARACTERIZATION FOR REACH 26
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
26	1674+37 [3840+50]	1707+11 [3873+25]	0.6	Crest:1 Boring 3 CPTs Landside: 1 CPT Waterside: Not available	Levee Height: 7 feet Crown Width: 19 feet Landside Slope: 1.5H:1V Waterside Slope: 2.6H:1V at analysis section	• Waterside seepage observed during irrigation season from 1677+84 to 1721+90 [3843+98 to 3888+07]. • Sloughing and oversteepening of canal slope at landside toe of levee observed in 2010 at 1689+87 [3856+00]	• No known mitigation measures.	Rob (Recent Overbank) Ra (Recent Alluvium) Rcs (Recent Crevasse Splay) Rch (Recent Channel) Qml (Pleistocene Modesto Formation - Lower)	Shallow higher resistivity zone

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
• Levee: 5 to 8 feet of sandy silt to lean clay. • Foundation: 5 to 20 feet of sandy silt to lean clay. • 5 to 20 feet of poorly-graded sand to clayey silty sand with localized silt to clay. • 5 to 15 feet of gravel with silt to silty sand.	200 Year 4 feet in ditch	Orchards on both LS and WS, Unlined landside ditch	1698+85 [3865+00]	WM0007_018C (crest)	Silt to clay levee, shallow SP-SM acquifer exposed at the bottom of the ditch; wide landside toe ditch susceptible to underseepage

TABLE 5-26B: ANALYSIS RESULTS FOR REACH 26
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1698+85

Existing Conditions Problem Identification						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	No exit of water	N/A	N/A	NA	No	Waterside seepage observed during irrigation season; Sloughing and oversteepening of canal slope at landside toe of levee observed in 2010; Based on interpreted soil profile, the section has shallow foundation sand layer which leads to through seepage into the canal.
200-year + 3 feet						
Landside Stability						
WSE	FS	Performance			Meets Criteria?	Comments
200-year						
200-year + 3 feet						
Rapid Drawdown						
WSE - initial	WSE - final	FS	Duration Effect		Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE					

Rationale for Selection of Two Alternatives for Analysis
Alternative1 for Reach 26 is fill canal, which would mitigate the through seepage into the canal. Alternative 2 for Reach 26 is cutoff wall and reconstruct the landside slope. The cutoff wall is to block the through seepage into the canal. The reconstruction of the landside slope is to mitigate the steep slopes observed along the canal and thus improve slope instability.

Rehabilitated Levee Alternative 1						
Geotechnical Rehabilitation Measure(s): Fill Canal						
Dimensions of Primary Features: Fill canal to top (adj grade, 30ft wide x 5ft deep).						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot					Yes	No separate analysis was performed; Alternative 1 of Reach 27 was used for evaluation; for details see Figures B27-A1 through B27-A4.
200-year + 4 feet					Yes	No separate analysis was performed; Alternative 1 of Reach 27 was used for evaluation; for details see Figures B27-A1 through B27-A4.
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot					Yes	No separate analysis was performed; Alternative 1 of Reach 27 was used for evaluation; for details see Figures B27-A1 through B27-A4.
200-year + 4 feet					Yes	No separate analysis was performed; Alternative 1 of Reach 27 was used for evaluation; for details see Figures B27-A1 through B27-A4.

Rehabilitated Levee Alternative 2						
Geotechnical Rehabilitation Measure(s): Cutoff Wall and Reconstruct the Landside Slope						
Dimensions of Primary Features: 1674+37 to 1686+00 Cutoff Wall Tip Elevation 75, 1686+00 to 1707+11 Cutoff Wall Tip Elevation 65; plus Reconstruct the Landside Slope						
Seepage						
WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot					Yes	No separate analysis was performed; Alternative 2 of Reach 27 was used for evaluation; for details see Figures B27-A5 through B27-A8.
200-year + 4 feet					Yes	No separate analysis was performed; Alternative 2 of Reach 27 was used for evaluation; for details see Figures B27-A5 through B27-A8.
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot					Yes	No separate analysis was performed; Alternative 2 of Reach 27 was used for evaluation; for details see Figures B27-A5 through B27-A8.
200-year + 4 feet					Yes	No separate analysis was performed; Alternative 2 of Reach 27 was used for evaluation; for details see Figures B28-A5 through B27-A7.

TABLE 5-27A : CHARACTERIZATION FOR REACH 27
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA)	END STATION (SBFCA)							
	[DWR ULE STATION]	[DWR ULE STATION]							
27	1707+11 [3873+25]	1721+60 [3887+75]	0.3	Crest:1 Boring 2 CPTs Landside: Not available Waterside: Not available	Levee Height: 6 feet Crown Width: 20 feet Landside Slope: 1.3H:1V Waterside Slope: 3.0H:1V at analysis section	• Waterside seepage observed during irrigation season from 1677+84 to 1721+90 [3843+98 to 3888+07]. • Large voids behind the apron at the Campbell Weir. • Voids in levee during construction of bentonite-tire slurry wall in 1999 from 1707+11 to 1721+62 [3873+25 to 3887+75]	• Bentonite-tire slurry wall installed in 1999 from 1707+11 to 1721+62 [3873+25 to 3887+75] • Waterside monitoring piezometers installed in 2005. Piezometers indicate continuing seepage after installation of wall. Note: As-Constructed Drawings for Slurry Wall not available. Construction report available.	Rob (Recent Overbank) Ra (Recent Alluvium) Rch (Recent Channel)	Shallow higher resistivity zone
			GENERALIZED SUBSURFACE CONDITIONS [10]	**DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]**	**NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]**	**TRANSVERSE SECTION FOR EVALUATION [13]** SBFCA STATION [DWR ULE STATION]	**EXPLORATIONS FOR TRANSVERSE SECTION [14]**	**RATIONALE FOR SECTION SELECTION [15]**	
			• Levee: 4 to 7 feet of lean clay. • Foundation: 10 to 15 feet of lean clay. • 5 to 10 feet of poorly-graded sand to silt. • 25 to 30 feet of clayey sand to fat clay with localized sand and silt.	200 Year 4 feet in ditch	Orchards on both LS and WS, Unlined landside ditch	1708+87 [3875+00]	WM0007_019B (crest), WM0007_019C (crest) WM0007_020C (crest)	Clayey levee; thin CL blanket underlain by SP; wide landside toe ditch; Bentonite-tire slurry wall susceptible to underseepage if wall is not performing well	

TABLE 5-27B: ANALYSIS RESULTS FOR REACH 27
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1708+87

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	No exit of water	0.57	N/A	No breakout	No	Waterside seepage observed during irrigation season; Voids in levee were observed during construction of cutoff wall in 1999; Based on interpreted soil profile, levee is underlain by soft clay; Note that the existing bentonite-tire slurry cutoff wall was not considered as effective in controlling the flow, and was not modeled in the analyses; For empty ditch condition, the gradient at the bottom of the ditch did not meet criteria.
200-year + 3 feet						

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative1 for Reach 27 is fill canal, which would mitigate the high exit gradient at the canal bottom. Alternative 2 for Reach 27 is cutoff wall and reconstruct the landside slope. The cutoff wall is to block the flow into the canal, and reduce the gradient at ditch bottom. The reconstruction of the landside slope is to improve landside slope instability.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Fill Canal

Dimensions of Primary Features: Fill canal to top (adj grade, 30ft wide x 5ft deep).

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	<0.01	N/A	N/A	No breakout	Yes	
200-year + 4 feet	0.16	N/A	N/A	No breakout	Yes	

Landside Stability

WSE	FS	Meets Criteria?	Comments
200-year + 1 foot	2.40	Yes	
200-year + 4 feet	1.94	Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Cutoff Wall and Reconstruct the Landside Slope

Dimensions of Primary Features: 1707+11 to 1721+60 Cutoff Wall Tip Elevation 65; plus Reconstruct the Landside Slope.

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.22	N/A	N/A	No breakout	Yes	
200-year + 4 feet	0.35	N/A	N/A	No breakout	Yes	

Landside Stability

WSE	FS	Meets Criteria?	Comments
200-year + 1 foot	1.76	Yes	
200-year + 4 feet	1.68	Yes	

TABLE 5-28A : CHARACTERIZATION FOR REACH 28
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
28	1721+60 [3887+75]	1769+31 [3935+50]	0.9	Crest:3 Borings 5 CPTs Landside: Not available Waterside: Not available	Levee Height: 6 feet Crown Width: 23 feet Landside Slope: 1.4H:1V Waterside Slope: 2.4H:1V at analysis section	• No reported deficiencies have been identified.	• No known mitigation measures.	Ra (Recent Alluvium) Qml (Pleistocene Modesto Formation - Lower) Rob (Recent Overbank) Rcs (Recent Crevasse Splay)	Localized shallow higher resistivity zones

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
• Levee: 4 to 8 feet of silt to lean clay. • Foundation: 0 to 20 feet of sandy silt to lean clay with localized clayey sand to silty sand. • 0 to 10 feet of sand to sand with silt. • 10 to 40 feet of silt to lean clay.	200 Year 5 feet in ditch	Orchards on both LS and WS along much of reach, Agricultural buildings at 1738+87 and 1744+87 [3905+00 and 3911+00], Unlined landside ditch	1760+87 [3927+00]	WM0007_024B (crest) WM0007_025C (crest)	Clayey levee; CL blanket underlain by SC/SC-SM; wide landside toe ditch susceptible to underseepage

TABLE 5-28B: ANALYSIS RESULTS FOR REACH 28
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1760+87

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	No exit of water	0.38	N/A	No breakout	Yes	No reported deficiencies have been identified; Based on interpreted soil profile, levee is underlain by soft clay; The canal is located at the landside levee toe; For empty ditch condition, the gradient at the bottom of the ditch did not meet criteria.
200-year + 3 feet	No exit of water	0.61	N/A	No breakout	No	

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year	1.10		No	
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative1 for Reach 28 is fill canal, which would mitigate the high exit gradient at the canal bottom. Alternative 2 for Reach 28 is cutoff wall and reconstruct the landside slope. The cutoff wall is to block the flow into the canal, and reduce the gradient at ditch bottom. The reconstruction of the landside slope is to improve landside slope instability.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Fill Canal

Dimensions of Primary Features: Fill canal to top (adj grade, 30ft wide x 5ft deep).

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	No exit of water	N/A	N/A	No breakout	Yes	
200-year + 4 feet	0.15	N/A	N/A	No breakout	Yes	

Landside Stability

WSE	FS	Meets Criteria?	Comments
200-year + 1 foot	1.94	Yes	
200-year + 4 feet	1.67	Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Cutoff Wall and Reconstruct the Landside Slope

Dimensions of Primary Features: 1721+60 to 1728+00 Cutoff Wall Tip Elevation 65, 1728+00 to 1749+00 Cutoff Wall Tip Elevation 80, 1749+00 to 1769+31 Cutoff Wall Tip Elevation 45; Plus Reconstruct the Landside Slope.

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	No exit of water	0.16	NA	No breakout	Yes	
200-year + 4 feet	No exit of water	0.23	NA	No breakout	Yes	

Landside Stability

WSE	FS	Meets Criteria?	Comments
200-year + 1 foot	1.85	Yes	
200-year + 4 feet	1.80	Yes	

TABLE 5-29A : CHARACTERIZATION FOR REACH 29
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
29	1769+31 [3935+50]	1813+33 [3979+50]	0.8	Crest:5 Borings 1 CPT Landside: Not available Waterside: Not available	Levee Height: 4 feet Crown Width: 20 feet Landside Slope: 3.5H:1V Waterside Slope: 2.7H:1V at analysis section	• No reported deficiencies have been identified.	• No known mitigation measures.	Ra (Recent Alluvium) Rcu (Recent Crevasse Splay Cutoff Channel) Rob (Recent Overbank)	~ 50 feet thick low resistivity zone below the ground surface

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
• Levee: 4 to 7 feet of silty sand to lean clay. • Foundation: 0 to 20 feet of sandy silt to lean clay with localized surficial clayey sand to silty sand. • 0 to 25 feet of fat clay. • 0 to 10 feet of clayey sand to silty sand with localized clayey gravel to silty gravel. • 10 to 40 feet of lean sandy silt to lean clay.	200 Year N/A	Orchards on both LS and WS along much of reach, Agricultural buildings at 1782+81 and 1786+81 [3949+00 and 3953+00]	1788+81 [3955+00]	WM0007_026B (crest) WM0007_027S (crest)	Clayey levee; low blowcount SC-SM shallow foundation layer susceptible to underseepage

TABLE 5-29B: ANALYSIS RESULTS FOR REACH 29
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1788+81

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	N/A	N/A	N/A	N/A	Yes	Water surface elevation is lower than the landside toe elevation; Seepage analysis performed for pore pressure input to slope stability; No reported deficiencies have been identified.
200-year + 3 feet	N/A	N/A	N/A	N/A	Yes	Water surface elevation is lower than the landside toe elevation; Seepage analysis performed for pore pressure input to slope stability; No reported deficiencies have been identified.

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year	4.73		Yes	Short levee with flatter landside slope; No reported deficiencies have been identified.
200-year + 3 feet	3.80		Yes	Short levee with flatter landside slope; No reported deficiencies have been identified.

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

N/A

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s):

Dimensions of Primary Features:

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

Landside Stability

WSE	FS	Meets Criteria?	Comments
200-year + 1 foot			
200-year + 4 feet			

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s):

Dimensions of Primary Features:

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

Landside Stability

WSE	FS	Meets Criteria?	Comments
200-year + 1 foot			
200-year + 4 feet			

TABLE 5-30A: CHARACTERIZATION OF REACH 30
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA)	END STATION (SBFCA)							
	[DWR ULE STATION]	[DWR ULE STATION]							
30	1813+33 [3979+50]	1902+00 [4058+00]	1.68	Total Number of Explorations = 18. Crown Explorations = 12 (Borings-10, CPT-2); Landside Toe Explorations = 4 (Borings-3, CPT-1) Waterside Toe Explorations = 2 (Borings-2, CPT-0)	At analysis section: Crown width = 15 feet Landside Slope = 2.8H:1V Waterside Slope = 2.4H:1V	At 1871+91 [4037+06], in 1986, a boil appeared on the landslide slope of levee.	After high water receded, approximately 300 feet of levee at this location was excavated to surrounding grade and rebuilt, no evidence of the boil was found during excavation.	Old levee fill mapped meandering along current levee alignment. Ra waterside and landside, with Rou along landside of old levee fill (which at some locations is just to waterside of and underneath current levee alignment).	High resistivity present, fair correspondence with logs.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
Levee silty sand to silt. Silty sand and silt from native grade to about 20 to 25 feet bgs, underlain by olean gravel to about 40 to 60 feet bgs, underlain by clay, clayey sand, and/or clayey gravel >5 feet thick.	**200 yr WSE** Head = approximately 5.6 feet at analysis section	Predominantly agricultural on landside and on waterside where levee set back from river. From approximately sta 1896+00 [4060+20] to 4068+00 [1902+00] there are homes on the landside of the levee (observed from the aerial map).	1826+94 [3993+10]	WM0007_004S	Section selection based on location that appears most likely to have highest gradient (i.e. underseepage potential).

TABLE 5-30B: ANALYSIS RESULTS FOR REACH 30
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TASK ORDER 1

Analysis Station: 1826+94

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year	0.39	NA	NA	0.6	Yes	
200-year	0.48	NA	NA	1.2	Yes	Thin waterside blanket (if extrapolate crown boring) removed for analysis. Toe gradient marginally passes; through-seepage marginal*.
200-year + 3 feet	0.78	NA	NA	2.2	No	Toe gradient clearly does not meet criterion. Through-seepage more clearly not meeting criterion (daylights on slope, erodible material)

Landside Stability

* Consistent with past performance, report of one "boil" on the landside slope during 1986 high water event.

WSE	FS	Performance	Meets Criteria?	Comments
100-year	1.61		Yes	
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 30 is a soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both through-seepage and underseepage potential. Alternative 2 for Reach 30 is a seepage berm (for underseepage) with a drained stability berm on top (for through-seepage). Seepage berm material type modeled as silt, which is similar to shallow near surface layers. Seepage analysis indicate high exit gradients at the toe of the seepage berm. Therefore, monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a collection drain system may be needed.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: 1813+33 to 1816+40 Cutoff Wall Tip Elevation 80 , 1816+40 to 1865+90 Cutoff Wall Tip Elevation 40 , 1865+90 to 1877+90 Cutoff Wall Tip Elevation 50, 1877+90 to 1902+00 Cutoff Wall Tip Elevation 30

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	No exit of water	N/A	N/A	No breakout	Yes	Moderate depth wall ties in to fine-grained layer, mitigates through-seepage and underseepage. Fine-grained layer varies in depth
200-year + 4 feet	No exit of water	N/A	N/A	No breakout	Yes	over length of reach, so wall depth varies over length of reach, as indicated above

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	1.81		Yes	
200-year + 4 feet	1.78		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Seepage Berm (ML) with stability berm

Dimensions of Primary Features: 1813+33 to 1831+00 seepage berm 300 feet wide, 6.5 feet thick at levee toe, 1831+00 to 1888+00 seepage berm 100 feet wide, 5 feet thick at levee toe, 1888+00 to 1895+00 seepage berm 300 feet wide, 6.5 feet thick at levee toe, 1895+00 to 1902+00 seepage berm 100 feet wide, 5 feet thick at levee toe, for each, thickness at seepage berm toe = 3 feet and stability berm height = 4 feet (on top of seepage berm)

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	No Exit of Water	0.86	NA	1.3	Meets criteria at levee toe. See comments on berm toe.	Monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a collection drain system may be needed.
200-year + 4 feet	No Exit of Water	1.14	NA	Top of berm	Meets criteria at levee toe. See comments on berm toe.	Monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a collection drain system may be needed.

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	4.72		Yes	Drained stability berm (for through-seepage) significantly increases stability FS.
200-year + 4 feet	4.15		Yes	

TABLE 5-31A: CHARACTERIZATION OF REACH 31
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2] START STATION (SBFCA) [DWR ULE STATION]	REACH LIMITS [2] END STATION (SBFCA) [DWR ULE STATION]	LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
31	1902+00 [4068+00]	1958+00 [4125+00]	1.06	Total Number of Explorations = 11. Crown Explorations = 9 (Borings-8, CPT-1); Landside Toe Explorations = 2 (Borings-2, CPT-0)	At analysis section: Crown width = 16 feet Landside Slope = 1.4H:1V Waterside Slope = 2.5H:1V	none documented	none documented	Old levee fill mapped along current levee alignment for much of length (where river adjacent). Ra landside, with Ros and Rcfo at southern end landside River waterside for much of length, with Hch along waterside where levee set back from current river alignment.	High resistivity present, fair correspondence with logs; gap in HEM at upstream end of reach.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13] SBFCA STATION (DWR ULE STATION)	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
Levee lean clay, with some SC and ML. Foundation profile partly mostly clay, partly 10 to 15 foot clay blanket over clean gravel, sand, and some silt to 40 to 50 feet below ground surface, underlain by >5 feet clay.	**200 yr WSE** Head = approximately 8 ft above base of canal (no head above levee toe)	Butte Main Canal runs along LS toe of levee. The landside and waterside (where the levee is setback from the river) is mainly agricultural. A canal is located approximately 25 feet away from the landside toe. The canal is about 55 feet wide and 7 feet deep.	1907+91 [4074+00]	WM0007_37S SM0007_003A SM0007_004A	If address canal, reach has potential to meet criteria otherwise, so section selection based on location that appears most likely to have highest gradient (after addressing canal). Note that depth of wall (for cost purposes) controlled by other location (036S at d/s end of segment).

TABLE 5-31B: ANALYSIS RESULTS FOR REACH 31
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TASK ORDER 1

Analysis Station: 1907+91

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	NA	2.3	0.14	5.1	No	High gradient at canal due to thin blanket (canal bottom close to underlying sand). Breakout point measured from bottom of canal.
200-year + 3 feet						No documentation of performance problems occurring in canal during high water events; unknown if canal was empty or full at time

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 31 is a soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both through-seepage and underseepage potential. The potential seepage problems, however, are due to the presence of the canal; if the canal were not present, the potential seepage problems would not occur. So Alternative 2 for Reach 31 is filling of the canal (and re-locating the canal a large distance from the levee). Canal fill material type is silt, to be permeability-compatible with underlying material (may use more permeable fill than silt).

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: 1902+00 to 1916+90 Cutoff Wall Tip Elevation 30, 1916+90 to 1933+90 Cutoff Wall Tip Elevation 75, 1933+90 to 1958+00 Cutoff Wall Tip Elevation 40

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	No Exit of Water	0.18	NA	No Breakout	Yes	Moderate depth wall ties in to fine-grained layer, mitigates through-seepage and underseepage. Fine-grained layer varies in depth
200-year + 4 feet	No Exit of Water	0.24	NA	No Breakout	Yes	over length of reach, so wall depth varies over length of reach, as indicated above

Landside Stability

WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	2.62				Yes	
200-year + 4 feet	2.58				Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Filled Canal

Dimensions of Primary Features: Canal filled up to adjacent grade; 1.4 % slope on top of fill for drainage. The filled canal and its existing embankments effectively become a landside berm, about 100 feet wide.

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	No Exit of Water	0.24	NA	No Breakout	Yes	Filled canal and embankments considered a berm, so gradient criterion used at embankment toe is that for berms.
200-year + 4 feet	No Exit of Water	0.51	NA	No Breakout	Yes	

Landside Stability

WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	9.61				Yes	Berm condition, with fill up against short landside levee slope, significantly increases stability FS.
200-year + 4 feet	8.10				Yes	

TABLE 5-32A: CHARACTERIZATION OF REACH 32
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
32	1958+00 [4125+00]	1989+00 [4155+00]	0.59	Total Number of Explorations = 7; Crown Explorations = 5 (Borings-4, CPT-1); Landside Toe Explorations = 2 (Borings-2, CPT-0)	At analysis section: Crown width ≈ 14 feet; Landside Slope = 2.1H:1V; Waterside Slope = 2.1H:1V	none documented	none documented	H_{ch} (Holocene Channel deposits); R_a (Recent Alluvium); R_{co} (Recent Cutoff Channel); Rob (Recent Overbank)	Approximately 10ft thick, continuous. High to Moderate Resistive Soil layers observed immediately below the embankment.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION (DWR ULE STATION)		
Levee Embankment: SM, CL, ML, SC **Foundation**: Near Surface layers include SM, CL, ML. Thick (~ 20ft) pervious zones present at about 30ft below the embankment (GW).	**200 yr WSE** Head = approximately 12.9 feet at the analysis section	Predominantly agricultural on the landside and waterside (where levee set back from river). Scattered houses and sheds were observed from the aerial map.	1965+80 [4132+00]	WM0007_042B WM0007_042S SM0007_002B	Section likely to control gradient, berm design (wall depth ~constant).

TABLE 5-32B: ANALYSIS RESULTS FOR REACH 32
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TASK ORDER 1

Analysis Station: 1965+80

Existing Conditions Problem Identification						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.83	NA	NA	4.6	No	High gradient at toe, due to thin blanket over permeable layers, clearly does not meet criteria. Through-seepage a concern (erodible soils).
200-year + 3 feet						No documented problems during floods. Gradient not FS<1, and analyzed WSE higher than floods; analysis and performance consistent
Landside Stability						
WSE	FS	Performance			Meets Criteria?	Comments
200-year						
200-year + 3 feet						
Rapid Drawdown						
WSE - initial	WSE - final	FS	Duration Effect		Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE					

Rationale for Selection of Two Alternatives for Analysis
Alternative 1 for Reach 32 is soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both through-seepage and under seepage potential. Alternative 2 for Reach 32 is a seepage berm (for underseepage) with a drained stability berm on top (for through-seepage). Seepage berm material type is modeled as silty sand, which is similar to there more permeable of the shallow near surface layers (some silty sands on the finer blanket layer materials).

Rehabilitated Levee Alternative 1						
Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall						
Dimensions of Primary Features:	1958+00 to 1965+80 Cutoff Wall Tip Elevation 40, 1965+80 to 1986+80 Cutoff Wall Tip Elevation 58 1986+80 to 1989+00 Cutoff Wall Tip Elevation 10					
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.27	NA	NA	No Breakout	Yes	Moderate depth wall ties in to fine-grained layer, mitigates through-seepage and underseepage.
200-year + 4 feet	0.29	NA	NA	No Breakout	Yes	Fine-grained layer varies in depth over length of reach, so wall depth varies over length of reach, as indicated above
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	1.65				Yes	
200-year + 4 feet	1.65				Yes	

Rehabilitated Levee Alternative 2						
Geotechnical Rehabilitation Measure(s): Seepage Berm (SM) with stability berm						
Dimensions of Primary Features:	1958+00 to 1982+00 seepage berm 120 feet wide, 6 feet thick at levee toe, with stability berm height = 6 feet (on top of seepage berm) 1982+00 to 1989+00 seepage berm 50 feet wide, 5 feet thick at levee toe, with stability berm height = 4 feet (on top of seepage berm) for each, thickness at seepage berm toe = 3 feet					
Seepage						
WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.20	0.76	NA	No Breakout	Yes	
200-year + 4 feet	0.30	0.92	NA	No Breakout	Meets criteria at levee toe. See comments on berm toe.	No criteria of exit gradient at berm toe greater than 100 feet in width. Seepage condition should be monitored during flood. If needed, a relief well or drainage system may be needed at the toe of the berm.
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	2.25				Yes	
200-year + 4 feet	2.16				Yes	

TABLE 5-33A: CHARACTERIZATION OF REACH 33
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA)	END STATION (SBFCA)							
	[DWR ULE STATION]	[DWR ULE STATION]							
33	1989+00 [4155+00]	2122+00 [4288+00]	2.52	Total Number of Explorations = 22 Crown Explorations = 17 (Borings-14, CPT-3); Landside Toe Explorations = 5 (Borings-2, CPT-3)	At analysis section: Crown width = 16 feet Landside Slope = 2H:1V Waterside Slope = 3.3H:1V	none documented	none documented	Ra (Recent Alluvium) Rcu (Recent Cutoff Channel) DT (Dredge Tailings)	Continuous, High to Moderate Resistive Soil layers observed immediately below the embankment. Low resistivity observed occasionally. Gap in HEM data intermittently.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
Levee Embankment: SM, ML. **Foundation**: Near Surface layers include ML, SM, SP-SM. Thick (~ 40ft) pervious zones present at about 30ft below the embankment (GP, GW).	**200yr WSE** Head = approximately 4.9 feet at the analysis section	Predominantly agricultural on the landside and waterside (where levee set back from river). Scattered houses and sheds were observed from the aerial map.	2076+90 [4243+00]	WM0007_006S (Crown) WM0007_002C (LS Toe) SM0007_005A (Crown)	Section likely to control gradient, berm design, and wall depth. Previous analyses at this location showed marginal/close to criteria.

TABLE 5-33B: ANALYSIS RESULTS FOR REACH 33
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TASK ORDER 1

Analysis Station: 2076+90

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.55	NA	NA	1.6	No	Gradient at toe does not meet. Dredge tailings (DT) modeled as GM-GP, about 60ft deep. DT has relatively little effect on gradients here.
200-year + 3 feet						No documented performance problems; gradient not much over criterion, though; consistent. Reach has ≤90-degree bends (3D effect).

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 33 is a soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both through-seepage and underseepage potential. Alternative 2 for Reach 33 is a seepage berm (for underseepage) with a drained stability berm on top (for through-seepage). Seepage berm material type modeled as silt, which is similar to shallow near surface layers. Seepage analysis indicate high exit gradients at the toe of the seepage berm. Therefore, monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a collection drain system may be needed.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: 1989+00 to 2000+80 Cutoff Wall Tip Elevation 10, 2000+80 to 2026+80 Cutoff Wall Tip Elevation 90
2026+80 to 2036+90 Cutoff Wall Tip Elevation 20, 2036+90 to 2086+90 Cutoff Wall Tip Elevation 35
2086+90 to 2122+00 Cutoff Wall Tip Elevation 90

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	<0.1	NA	NA	No Breakout	Yes	Relatively deep wall needed to tie in to fine-grained layer, mitigate through-seepage and underseepage.
200-year + 4 feet	<0.1	NA	NA	No Breakout	Yes	Fine-grained layer varies in depth over length of reach, so wall depth varies over length of reach, as indicated above.

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	1.82		Yes	
200-year + 4 feet	1.81		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Seepage Berm (ML) with stability berm, optionally with relief wells

Dimensions of Primary Features: 1989+00 to 2020+00 seepage berm 50 feet wide, 5 feet thick at levee toe , 2020+00 to 2028+00 seepage berm 100 feet wide, 5 feet thick at levee toe ,
2028+00 to 2037+00 seepage berm 50 feet wide, 5 feet thick at levee toe , 2037+00 to 2050+00 seepage berm 100 feet wide, 6 feet thick at levee toe,
2050+00 to 2065+00 connect berm toe as straight line across bend, 2065+00 to 2087+00 seepage berm 100 feet wide, 6 feet thick at levee toe,
2087+00 to 2102+00 seepage berm 50 feet wide, 5 feet thick at levee toe, 2102+00 to 2106+00 connect berm toe as straight line across bend,
2106+00 to 2122+00 seepage berm 60 feet wide, 5 feet thick at levee toe, for each, thickness at seepage berm toe = 3 feet, stability berm height = 4 feet (on top of seepage berm)

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.02	0.72	NA	Top of Berm	Yes	
200-year + 4 feet	0.22	1.05	NA	Top of Berm	Meets criteria at levee toe. See comments on	Monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a collection drain system may be needed.

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.96		Yes	Drained stability berm (for through-seepage) significantly increases stability FS.
200-year + 4 feet	2.73		Yes	

TABLE 5-34A: CHARACTERIZATION OF FOR REACH 34
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA)	END STATION (SBFCA)							
	[DWR ULE STATION]	[DWR ULE STATION]							
34	2122+00 [4286+00]	2182+00 [4348+00]	1.14	Total Number of Explorations = 9; Crown Explorations = 8 (Borings-7, CPT-1); Landside Toe Explorations = 1 (Borings-0, CPT-1)	At analysis section: Crown width = 20 feet Landside Slope = 1.6H:1V Waterside Slope = 3.0H:1V	none documented	none documented	Ra (Recent Alluvium) Rcu (Recent Cutoff Channel) DT (Dredge Tailings)	Continuous, High Resistive Soil layers observed immediately below the embankment. Gap in HEM data intermittently.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
Levee Embankment: SM, ML **Foundation**: Near Surface layers include ML, CL, SM, SP, SW-SM. Thick (~ 20ft) pervious zones present at about 30ft below the embankment (GP, GW).	**200 yr WSE** Head = approximately 1.4 feet at the analysis section	Predominantly agricultural on the landside and waterside (where levee set back from river).	2138+99 [4305+20] (hinged section)	WM0007_055S (crown)	High ground along this reach, but steep levee LS slopes along parts, so section targeted at characterizing levee LS slope stability.

TABLE 5-34B: ANALYSIS RESULTS FOR REACH 34
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TASK ORDER 1

Analysis Station: 2138+99

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.06	NA	NA	No Breakout	Yes*	Very low WSEs, result is low gradients. Dredge tailings (DT) modeled as GM-GP, about 60ft deep; DT has little effect on results here.
200-year + 3 feet	0.19	NA	NA	1.0	Yes*	* See note below in rationale for selection

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year	1.62		Yes	
200-year + 3 feet	1.45		Yes	

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Most of reach does not require rehabilitation. However, downstream end of reach needs rehabilitation for seepage. Rehabilitation measures for reach 33 should extend 1600 feet into reach 34, as described below. See reach 33 for rationale of rehabilitation measures and analysis results. Seepage analysis indicate high exit gradients at the toe of the seepage berm. Therefore, monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relie wells or a collection drain system may be needed.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Cutoff Wall

Dimensions of Primary Features: 2122+00 to 2138+00 Cutoff Wall Tip Elevation 90
2138+00 to 2182+00 no wall (no rehabilitation required)

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	**					** See Reach 33 for representative analysis results.
200-year + 4 feet	**					

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot				
200-year + 4 feet				

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Undrained Seepage Berm with Drained Stability Berm on Top

Dimensions of Primary Features: 2122+00 to 2138+00 seepage berm 60 feet wide, 5 feet thick at levee toe, with stability berm height = 4 feet (on top of seepage berm)
2138+00 to 2182+00 no berm (no rehabilitation required)

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	**					** See Reach 33 for representative analysis results. Monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a collection drain system may be needed.
200-year + 4 feet	**					

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot				
200-year + 4 feet				

TABLE 5-35A: CHARACTERIZATION OF REACH 35
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2] START STATION (SBFCA) [DWR ULE STATION]	REACH LIMITS [2] END STATION (SBFCA) [DWR ULE STATION]	LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
35	2182+00 [4349+00]	2224+00 [4390+00]	0.8	Total Number of Explorations = 11 Crown Explorations = 8 (Borings-7, CPT-1); Landside Toe Explorations = 1 (Borings-1, CPT-0) Field Explorations = 2 (Borings-2, CPT-0)	At analysis section: Crown width = 16 feet Landside Slope = 2.1H:1V Waterside Slope = 3H:1V	Bold 1986 - "The foundation soils are susceptible to seepage and piping". (1986)	Site 1: Levee raise LM 9.69 to LM 10.39. Project plans entitled "Sacramento River Flood Control Project Phase II, Levee Reconstruction, Contract 3 (Sites 1, 2, 3, 8, 9, 10, 11, & 12)," dated 7/4/1997. USACE Design File No. 50-04-6001. Note: Document 314, which included as-constructed improvement measures did not include this levee raise in the "Sutter County, California Past Problem Sites Map." "Rebuilt 300' levee section" Note: No detail of this rebuilt work was available during preparation of this SQDR. NOTE: AS-BUILT DOCUMENT NOT AVAILABLE TO HDR TEAM.	Ra (Recent Alluvium) Rcu (Recent Cutoff Channel) DT (Dredge Tailings)	Continuous. High to Moderate Resistive Soil layers observed immediately below the embankment. Gap in HEM data intermittently.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13] SBFCA STATION [DWR ULE STATION]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
Levee Embankment: SM, ML, CL **Foundation**: Near Surface layers include ML, SM, SP-SM. Thick (~ 15ft) pervious zones present at about 30ft below the embankment (GP, GP-GM).	**200 yr WSE** Head = approximately 8.2 feet at analysis section	Predominantly agricultural on the landside. A warehouse is located on the landside of the levee at approximately station 2185+00 [4351+25]	2211+30 [4377+50]	WM0007_062B (Crown) WM0007_062S (Crown) SM0007_004B (Toe)	Section likely to control gradient, berm design, and wall depth. Previous analyses at this location showed marginal/close to criteria.

TABLE 5-35B: ANALYSIS RESULTS FOR REACH 35
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TASK ORDER 1

Analysis Station: 2211+30

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.36	NA	0.57	1.8	Yes	Dredge tailings (DT) modeled as GM-GP, about 40ft deep. Underseepage gradients meet criteria, through-seepage marginal.
200-year + 3 feet	0.50	NA	0.72	3.6	No	Underseepage does not meet the field criterion, nor through-seepage (daylights on slope, erodible materials). Reach has 90-deg bends. A boil reported in 1986 (different location on same reach); consistent with analysis results showing not meeting criteria.

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 35 is a soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both through-seepage and underseepage potential. Alternative 2 for Reach 35 is a seepage berm (for underseepage) with a drained stability berm on top (for through-seepage). Seepage berm material type modeled as silty sand, which is similar to shallow near surface layers.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: 2182+00 to 2224+00 Cutoff Wall Tip Elevation 55

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	<0.1	NA	0.12	No Breakout	Yes	Moderate depth wall ties in to fine-grained layer, mitigates through-seepage and underseepage.
200-year + 4 feet	<0.1	NA	0.14	No Breakout	Yes	

Landside Stability

WSE	FS	Meets Criteria?	Comments
200-year + 1 foot	1.79	Yes	
200-year + 4 feet	1.79	Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Undrained Seepage Berm with and without Drained Stability Berm on Top

Dimensions of Primary Features:
2182+00 to 2199+00 seepage berm 65 feet wide, 5 feet thick at levee toe (no drained stability berm on top)
2199+00 to 2203+00 connect berm toe as straight line across bend (no drained stability berm on top)
2203+00 to 2224+00 seepage berm 65 feet wide, 5 feet thick at levee toe, with drained stability berm height = 5 feet (on top of seepage berm)

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.08	0.62	NA	Top of Berm	Yes	Gradients at berm toe same values as in field for ex. conditions, but farther from levee; berm width extended to point where meet criteria.
200-year + 4 feet	0.19	0.78	NA	Top of Berm	Yes	

Landside Stability

WSE	FS	Meets Criteria?	Comments
200-year + 1 foot	2.44	Yes	
200-year + 4 feet	2.15	Yes	

TABLE 5-36A: CHARACTERIZATION OF REACH 36
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
36	2224+00 [4390+00]	2259+00 [4425+00]	0.66	Total Number of Explorations = 7; Crown Explorations = 5 (Borings-4, CPT-1); Landside Toe Explorations = 2 (Borings-2, CPT-0)	At analysis section: Crown width = 8 feet Landside Slope = 3.2H:1V Waterside Slope = 2.9H:1V	none documented	none documented	Generally runs along boundary between DT and Ra, crossing onto and overlying each along part, with Rcu crossing under at several locations. H_{es} (Holocene meander Scrolls)	Moderate resistivity, gap in HEM in d/s part of reach.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION (DWR ULE STATION)		
Silt levee. Silty sand, silt, and clay from native grade to about 15 to 20 feet bgs, underlain by clean sand and gravel to about 35 feet bgs, underlain by clay and/or clayey gravel >5 feet thick	**200 yr WSE** Head = approximately 7.5 ft at analysis section	Predominantly agricultural on the landside and waterside (where levee set back from river). Scattered houses and sheds on the landside and waterside were observed from the aerial map.	2250+78 [4417+00]	SM0007_005B (TOE)	Section likely to control gradient, berm design, and wall depth.

TABLE 5-36B: ANALYSIS RESULTS FOR REACH 36
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TASK ORDER 1

Analysis Station: 2250+78

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.94	N/A	N/A	3.4	No	Gradient at toe does not meet. Dredge tailings (DT) modeled as GM-GP, about 40ft deep, about ≥300 feet to waterside of levee.
200-year + 3 feet						No documented performance problems; gradient not much over criterion, though; consistent. Reach has 90-degree bends (3D effect).

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 36 is a soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both through-seepage and underseepage potential. Alternative 2 for Reach 36 is a seepage berm (for underseepage) with a drained stability berm on top (for through-seepage). Seepage berm material type modeled as clayey sand, which is similar to shallow near surface layers. Clayey sand may be of higher value for other uses on the project; a more permeable material may be used as berm material. Seepage analysis indicate high exit gradients at the toe of the seepage berm. Therefore, monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: 2224+00 to 2259+00 Cutoff Wall Tip Elevation 75

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	<0.1	N/A	N/A	No breakout	Yes	Moderate depth wall ties in to fine-grained layer, mitigates through-seepage and underseepage.
200-year + 4 feet	<0.1	N/A	N/A	No breakout	Yes	

Landside Stability

WSE	FS	Meets Criteria?	Comments
200-year + 1 foot	2.03	Yes	
200-year + 4 feet	2.00	Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Seepage Berm (SC) with stability berm

Dimensions of Primary Features: 2224+00 to 2227+00 seepage berm 65 feet wide, 5 feet thick at levee toe, with stability berm height = 5 feet (on top of seepage berm)
2227+00 to 2233+00 connect berm toe as straight line across bend, with stability berm height = 5 feet (on top of seepage berm)
2233+00 to 2259+00 seepage berm 300 feet wide, 7.5 feet thick at levee toe, with drained stability berm height = 4 feet (on top of seepage berm)

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	<0.1	0.95	N/A	Top of berm	Meets criteria at levee toe. See comments on berm toe.	Monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a collection drain system may be needed.
200-year + 4 feet	0.15	1.27	N/A	Top of berm	Meets criteria at levee toe. See comments on berm toe.	Monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a collection drain system may be needed.

Landside Stability

WSE	FS	Meets Criteria?	Comments
200-year + 1 foot	3.19	Yes	Drained stability berm (for through-seepage) significantly increases stability FS.
200-year + 4 feet	2.86	Yes	

TABLE 5-37A: CHARACTERIZATION OF REACH 37
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
37	2259+00 [4425+00]	2290+00 [4456+00]	0.59	Total Number of Explorations = 7: Crown Explorations = 5 (Borings-5, CPT-0); Landside Toe Explorations = 2 (Borings-1, CPT-1)	At analysis section: Crown width = 20 feet Landside Slope = 2.1H:1V Waterside Slope = 3.1H:1V	none documented	none documented	Rcu (Recent Cutoff Channel) DT (Dredge Tailings) H_{res} (Holocene meander Scrolls)	Continuous, High to Moderate Resistive Soil layers observed immediately below the embankment.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13] (SBFCA STATION [DWR ULE STATION])	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
Levee Embankment: ML, CL, CL-ML **Foundation**: Near Surface layers include ML, SM, CL-ML. Thick (~ 15ft) pervious zones present at about 20 to 30ft below the embankment (GP, GP).	**200 yr WSE** Head = approximately 6.1 feet at the analysis section	Predominantly agricultural on the landside and waterside (where levee set back from river). Scattered houses were observed from the aerial map.	2276+76 [4443+00]	WM0007_013S SM0007_006A SM0007_006B	Section selected for location where gradient most likely to control fix dimensions for berm or other non-wall fix. Note that depth of wall (for cost purposes) controlled by other location (058S, at u/s end of segment).

TABLE 5-37B: ANALYSIS RESULTS FOR REACH 37
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TASK ORDER 1

Analysis Station: 2276+76

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.49	N/A	N/A	3.6	No	Through-seepage daylights, erodible soil. Underseepage marginal. Dredge tailings modeled on waterside, instead of projecting silt blanket
200-year + 3 feet	0.72	N/A	N/A	4.3	No	At this WSE, underseepage also does not meet criteria. No documented performance problems; consistent with gradients for WSEs

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 37 is a soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both through-seepage and underseepage potential. Alternative 2 for Reach 37 is a seepage berm (for underseepage) with a drained stability berm on top (for through-seepage). Seepage berm material type modeled as silt, which is similar to shallow near surface layers.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: 2259+00 to 2290+00 Cutoff Wall Tip Elevation 45

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.11	N/A	N/A	No breakout	Yes	Relatively deep wall needed to tie in to layer with fine-grained material, mitigate through-seepage and underseepage.
200-year + 4 feet	0.14	N/A	N/A	No breakout	Yes	

Landside Stability

WSE	FS	Meets Criteria?	Comments
200-year + 1 foot	1.83	Yes	
200-year + 4 feet	1.8	Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Seepage Berm (ML) with stability berm

Dimensions of Primary Features: 2259+00 to 2290+00 seepage berm 65 feet wide, 5.5 feet thick at levee toe, with stability berm height = 6 feet (on top of seepage berm)

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.1	0.53	N/A	Top of berm	Yes	
200-year + 4 feet	0.27	0.75	N/A	Top of berm	Yes	

Landside Stability

WSE	FS	Meets Criteria?	Comments
200-year + 1 foot	2.54	Yes	Drained stability berm (for through-seepage) significantly increases stability FS.
200-year + 4 feet	2.33	Yes	

TABLE 5-38A: CHARACTERIZATION OF REACH 38
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA)	END STATION (SBFCA)							
	[DWR ULE STATION]	[DWR ULE STATION]							
38	2290+00 [4455+00]	2303+00 [4469+00]	0.25	Total Number of Explorations = 1; Crown Explorations = 1 (Borings-1, CPT-0)	At analysis section: Crown width = 29 feet Landside Slope = 2H:1V Waterside Slope = 2.6H:1V	None documented on levee reach. Adjacent "old" levee breached in 1955 event. "Old" levee extends southward, along river, from east end of Reach 38 levee (which runs west-east along Vance Ave). Adjacent levee that extends north from east end of Reach 38 levee is Reach 39 levee, which nearly breached in 1955, with multiple boils and sinkholes and significant flood-fighting to save levee.	none documented	DT (Dredge Tailings) H_{qts} (Holocene meander Scrolls)	Continuous, High to Moderate Resistive Soil layers observed immediately below the embankment. Gap in HEM data towards the downstream end of the Reach.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
Levee Embankment: ML **Foundation**: Thick (~ 30ft) pervious zones present below the embankment (GM, GC, GP, GP-GM), thought to be dredge tailings.	**200 yr WSE** Head = approximately 13.1 feet above berm toe at analysis section	Scattered trees on the landside and waterside of the levee.	2299+69 [4468+00] (hinged section)	WM0007_069B WM0007_069S (CREST)	Section selected to flag anticipated critical gradient, controlling berm dimensions. Note that depth of wall (for cost purposes) controlled by other locations (068S and 070S, at either end of segment).

TABLE 5-38B: ANALYSIS RESULTS FOR REACH 38
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TASK ORDER 1

Analysis Station: 2299+69

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.17	N/A	N/A	0.7	No	Gradients meet. Through-seepage marginal. Does not meet based on past performance. At east end, adjacent levee to south breached
200-year + 3 feet	0.23	N/A	N/A	1.3	No	adjacent levee to north nearly breached, and those levee/foundation conditions still present at Reach 38 (silt levee built on dredge tailings)

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year	2.68		Yes	
200-year + 3 feet	2.56		Yes	

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Mechanisms of potential failure thought to be present for the Reach 38 levee are associated with the incompatibility of the silty levee material with the gravelly (dredge tailings) foundation soils. Under high head conditions, seepage through the silt and into the gravels, or along the silt/gravel interface, can lead to internal erosion and piping of the silt as the silt particles are carried into/through the gravel. Alternative 1 for Reach 38 is a soil-bentonite cutoff wall, to decrease the internal gradient at the silt/gravel interface and to inhibit the flow of water through the foundation along the silt/gravel interface. Alternative 2 for Reach 38 is a full de-grade and reconstruction of the levee, and a seepage berm with the newly reconstructed levee.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: 2290+00 to 2303+00 Cutoff Wall Tip Elevation 45

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						Existing gradients already meet criteria (exit gradients not salient for this reach); no need to analyze gradients for improved condition.
200-year + 4 feet						

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot				
200-year + 4 feet				

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Reconstructed Levee, with Seepage Berm

Dimensions of Primary Features: 2290+00 to 2302+00 De-grade entire levee and reconstruct, with zoned filter at base, and regrade landside to create 300 feet-wide drained seepage berm, 5 feet thick at levee toe, with filter carried out through berm. (2302 to 2303 occupied by berm of Reach 39)

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						Existing gradients already meet criteria (exit gradients not salient for this reach); no need to analyze gradients for improved condition.
200-year + 4 feet						

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot				
200-year + 4 feet				

TABLE 5-39A: CHARACTERIZATION OF REACH 39
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA)	END STATION (SBFCA)							
	[DWR ULE STATION]	[DWR ULE STATION]							
39	2303+00 [4469+00]	2319+00 [4486+00]	0.3	Total Number of Explorations = 3; Crown Explorations = 3 (Borings-2, CPT-1)	At analysis section: Crown width = 60 feet; Landside Slope = Varies, typically nominally 4H:1V; Waterside Slope = Varies (as steep as 1H:1V in some places)	Levee nearly breached in 1955. During flood event, numerous boils and sinkholes, with multiple flood-fight crews and dozers pushing gravel into sinkholes.	Levee raising, setback, and reconstruction. **NOTE: AS-BUILT DOCUMENT NOT AVAILABLE TO HDR TEAM.**	DT (Dredge Tailings); H_{ch} (Holocene Channel deposits)	Continuous, Moderate Resistive Soil layers observed immediately below the embankment. Gap in HEM data towards the upstream end of the Reach.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION (DWR ULE STATION)		
Levee Embankment: GP, GM **Foundation**: GM, GC, GP, GP-GM (~ 50ft thick below the embankment); Silt and silty sands layers (ML,SM) observed below the Gravel layer.	**200 yr WSE** Head = approximately 21.5 feet at analysis section	Scattered trees on the landside and waterside of the levee	2314+91 [4481+00]	WM0007_071B (Crown) WM0007_071S (Crown)	Generally flows through, but projection of GW-GC layer (if acts GC-like) in 071S relative to ground surface profile anticipated to control gradient relationship.

TABLE 5-39B: ANALYSIS RESULTS FOR REACH 39
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TASK ORDER 1

Analysis Station: 2314+91

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	No Exit of Water	N/A	0.27 (Local Y-grad)	No Breakout	Yes	Gradients meet. This reach nearly breached in 1955, with numerous boils and sinkholes, with multiple flood-fight crews and
200-year + 3 feet	No Exit of Water	N/A	0.3 (Local Y-grad)	No Breakout	Yes	dozers pushing gravel into sinkholes. Levee built on dredge tailings. No documentation of rehabilitation. Levee appears to have been rehabilitated after poor performance event.

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year	3.06		Yes	
200-year + 3 feet	2.62		Yes	

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s):

Dimensions of Primary Features:

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot				
200-year + 4 feet				

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s):

Dimensions of Primary Features:

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot				
200-year + 4 feet				

TABLE 5-40A: CHARACTERIZATION OF REACH 40
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA)	END STATION (SBFCA)							
	[DWR ULE STATION]	[DWR ULE STATION]							
40	2319+00 [4495+00]	2359+00 [Old Butte Canal Structure]	0.76	Total Number of Explorations = 6; Crown Explorations = 4 (Borings-4, CPT-0); Landside Toe Explorations = 1 (Borings-1, CPT-0) Waterside Toe Explorations = 1 (Borings-0, CPT-1)	At analysis section: Crown width = 63 feet Landside Slope = 2.1H:1V Waterside Slope = 2.8H:1V	Numerous boils in 1955 event, with significant flood-fighting.	Levee raising, setback, and reconstruction **NOTE: AS-BUILT DOCUMENT NOT AVAILABLE TO HDR TEAM.**	DT (Dredge Tailings) H_{en} (Holocene Channel deposits)	Continuous, High to Moderate Resistive Soil layers observed immediately below the embankment.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
Levee Embankment: GP, GM, GP-GM, GW-GC **Foundation**: GM, GC, GW, GP, GP-GM intermixed thin layers (~2 to 3ft) of ML, SM.	**200 yr WSE** Head = approximatery 10 feet at analysis section	Scattered trees on the landside and waterside of the levee. Some agricultural on the landside of the levee.	2332+91 [4499+00]	WM0007_072S WM0007_014S (CREST) SM0007_008B (FIELD)	Projection of clay layer in 072S relative to ground surface profile at 4499 anticipated to control gradient relationship, dimensions of berm. Depth of wall (for cost purposes) controlled by other location (073S, at u/s end of segment).

TABLE 5-40B: ANALYSIS RESULTS FOR REACH 40
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TASK ORDER 1

Analysis Station: 2332+91

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.64	N/A	N/A	5.3	No	Does not meet gradient at toe. Past performance: boils/flood-fights. Dredge tailings (DT) modeled as GM-GP, about 40ft deep, waterside
200-year + 3 feet						

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 40 is a soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both through-seepage and underseepage potential. Alternative 2 for Reach 40 is a seepage berm (for underseepage) with a drained stability berm on top (for through-seepage). Seepage berm material type modeled as silt, which is similar to shallow near surface layers.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: 2319+00 to 2336+90 Cutoff Wall Tip Elevation 50
2336+90 to 2359+00 Cutoff Wall Tip Elevation 20

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	No exit of water	N/A	N/A	No breakout	Yes	Deep wall needed to tie in to layer with fine-grained material, mitigate through-seepage and underseepage.
200-year + 4 feet	No exit of water	N/A	N/A	No breakout	Yes	Fine-grained layer varies in depth over length of reach, so wall depth varies over length of reach, as indicated above

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.23		Yes	
200-year + 4 feet	2.18		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Seepage Berm (ML) with stability berm and landside depressions (pits) filled.

Dimensions of Primary Features: Fill the large landside pit at 2321+00 to 2332+00 up to el 120,
2321+00 to 2329+00 seepage berm 65 feet wide, 5 feet thick at levee toe, with drained stability berm height = 7 feet (on top of seepage berm)
Fill the large landside pits at 2333+00 to 2343+00
2331+00 to 2346+00 seepage berm 120 feet wide, 5 feet thick at levee toe, with drained stability berm height = 10 feet (on top of seepage berm)
2346+00 to 2359+00 seepage berm 300 feet wide, 5 feet thick at levee toe, with drained stability berm height = 4 feet (on top of seepage berm

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.07	0.78	N/A	Top of berm	Yes	
200-year + 4 feet	0.2	0.82	N/A	Top of berm	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.96		Yes	
200-year + 4 feet	2.68		Yes	

TABLE 5-41A: CHARACTERIZATION OF REACH 41
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
41	2359+00 [Old Butte Canal Structure]	2368+00 [Thermalito]	0.17	Total Number of Explorations = 1, Crown Explorations = 1 (Borings-1, CPT-0)	At analysis section: Crown width = 21 feet Landside Slope = 2.6H:1V Waterside Slope = 2H:1V	none documented	none documented	DT (Dredge Tailings) H_{ch} (Holocene Channel deposits)	Continuous, High to Moderate Resistive Soil layers observed immediately below the embankment

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
Levee Embankment: GP, GM, GP-GM, GW-GC **Foundation**: GM, GC, GW, GP, GP-GM interlmixed thin layers (~2 to 3ft) of ML, SM.	**200 yr WSE** Head = approximately 9.2 feet at analysis section	Scattered trees on the landside and waterside of the levee. Some agricultural on the landside of the levee.	2362+70 [None]	SM0007_010B (CREST)	WSE, geometry fairly consistent, so section at only boring location. Note that depth of wall (for cost purposes) expected to deepen d/s of boring (based on d/s reach characterization).

TABLE 5-41B: ANALYSIS RESULTS FOR REACH 41
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TASK ORDER 1

Analysis Station: 2362+70

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.81	N/A	N/A	4	No	Does not meet gradient at toe. Dredge tailings (DT) modeled as GM-GP, about 60ft deep, waterside of levee, instead of extending blanket
200-year + 3 feet						No documented problems. Gradient not FS<1, analyzed WSE higher than this levee experienced; analysis and performance consistent

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 41 is a soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both through-seepage and underseepage potential. Alternative 2 for Reach 41 is a seepage berm (for underseepage) with a drained stability berm on top (for through-seepage). Seepage berm material type modeled as silt, which is similar to shallow near surface layers.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: Cutoff Wall Tip Elevation 20 at 2359+00, constant decrease in depth up to Cutoff Wall Tip Elevation 70 at 2368+00

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	No exit of water	N/A	N/A	No breakout	Yes	Deep wall needed to tie in to layer with fine-grained material, mitigate underseepage.
200-year + 4 feet	No exit of water	N/A	N/A	No breakout	Yes	Fine-grained layer varies in depth over length of reach, so wall depth varies over length of reach, as indicated above

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	1.92		Yes	
200-year + 4 feet	1.91		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Seepage Berm (ML) with stability berm and drainage relief trench at toe.

Dimensions of Primary Features: 2359+00 to 2368+00 seepage berm 70 feet wide, 5 feet thick at levee toe, with drainage relief trench along berm toe that is 50 feet wide at grade, extending down 12 feet deep, with 1.5:1 backcut and frontcut, filled with drain gravel, with filter zones adjacent in-situ soil

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.12	0.76	N/A	Top of berm	Yes	
200-year + 4 feet	0.27	0.98	N/A	Top of berm	Meets criteria at levee toe. See comments on berm toe.	Berm toe exit gradient marginally exceed the criteria. Seepage condition should be monitored during flood. If needed, a relief well or drainage system may be needed at the toe of the berm.

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.38		Yes	
200-year + 4 feet	2.13		Yes	

Table 5-42: Summary of Geotechnical Analysis for 100 Year WSE

Reach	Design WSE (year)	Rehabilitation Needed for DWSE and or HTOL?	Reach analyzed for 100-year WSE?	Meets geotechnical criteria for 100-year WSE?
1	100	Yes	Yes	No
2	100	Yes	Yes	No
3	100	Yes	Yes	No
4	100	Yes	Yes	No
5	200	Yes	No	No
6	200	No	No	Yes
7	200	Yes	No	No
8	200	Yes	Yes	No
9	200	Yes	Yes	No
10	200	Yes	No	No
11	200	Yes	No	No
12	200	No*	No	Yes*
13	200	Yes	No	No
14	200	No*	No	Yes*
15	200	No*	No	Yes*
16	200	No	No	Yes
17	200	Yes	No	No
18	200	Yes	Yes	No
19	200	Yes	Yes	No
20	200	Yes	Yes	No
21	200	Yes	Yes	No
22	200	Yes	Yes	No
23	200	Yes	Yes	Yes
24	200	Yes	Yes	No
25	200	No	Yes	Yes
26	200	Yes	Yes	No
27	200	Yes	Yes	No
28	200	Yes	Yes	No
29	200	No	Yes	Yes
30	200	Yes	Yes	Yes
31	200	Yes	No	No
32	200	Yes	No	No
33	200	Yes	Yes	No
34	200	Yes	No	No
35	200	Yes	Yes	No
36	200	Yes	No	No
37	200	Yes	Yes	No
38	200	Yes	No	No
39	200	No*	No	Yes*
40	200	Yes	Yes	No
41	200	Yes	Yes	No

NOTE: * = Based on confirmation by receipt of as-constructed drawings or adequate confirmatory investigation.

TABLE 7-1. SUMMARY OF GEOTECHNICAL ANALYSES RESULTS FOR PRE-DESIGN FORMULATION
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

Evaluation Reach ID	Reach Limits		Existing Conditions Meet Analytical Criteria?	Existing Conditions Meet Performance Criteria?	Levee Rehabilitation Needed?	Rehabilitation Alternative	Approximate Dimensions of Primary Features	Comments
	Start Station	End Station						
1	10+00	129+66	No	No	Yes	Cutoff Wall	10+00 to 58+80 Cutoff Wall Tip Elevation 20 58+80 to 83+00 Cutoff Wall Tip Elevation 18 83+00 to 114+00 Cutoff Wall Tip Elevation 24 114+00 to 129+66 Cutoff Wall Tip Elevation 27	
						Undrained Seepage Berm with Drained Stability Berm	Drained Stability Berm: 8 feet tall Undrained Seepage Berm : 88 feet wide and 5 feet thick at levee toe.	Assume 25% of reach will have a seepage berm width extending to 100ft due to taller levee at some locations.
2	129+66	218+66	No	No	Yes	Cutoff Wall	129+66 to 181+00 Cutoff Wall Tip Elevation 20 181+00 to 191+00 Cutoff Wall Tip Elevation -10 191+00 to 218+66 Cutoff Wall Tip Elevation -73 with Full Levee Degrade.	191+00 to 220+00 Full Levee Degrade.
						Undrained Seepage Berm with Drained Stability Berm and Cutoff Wall with Seepage Berm	129+66 to 181+00: 8 feet tall Drained Stability Berm on Seepage Berm; Seepage Berm 100 feet wide and 5 feet thick at levee toe 181+00 to 218+66: Cutoff Wall Tip Elevation 30 feet with 100 feet wide Undrained Seepage Berm. Seepage Berm 5 feet thick at berm toe	
3	218+66	300+66	No	No	Yes	Cutoff Wall	218+66 to 220+00 Cutoff Wall Tip Elevation -73 220+00 to 230+00 Cutoff Wall Tip Elevation 20 230+00 to 250+00 Cutoff Wall Tip Elevation -35 250+00 to 289+00 Cutoff Wall Tip Elevation -20 289+00 to 300+66 Cutoff Wall Tip Elevation 15	
						Undrained Seepage Berm with Drained Stability Berm	8 feet tall Drained Stability Berm on 300 feet wide Undrained Seepage Berm with monitoring for seepage at the toe of the berm	Seepage analysis indicate high exit gradients at the toe of the seepage berm. Therefore, monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a collection drain system may be needed.
4	300+66	410+67	No	No	Yes	Cutoff Wall	300+66 to 349+00 Cutoff Wall Tip Elevation 15 349+00 to 368+00 Cutoff Wall Tip Elevation 10 368+00 to 410+67 Cutoff Wall Tip Elevation 20	
						Undrained Seepage Berm with Drained Stability Berm	8 feet tall Drained Stability Berm on 100 feet wide Undrained Seepage Berm; Seepage berm 5 feet thick at berm toe.	
5	410+67	478+68	No	No	Yes	Cutoff Wall and Cutoff Wall with Seepage Berm	410+67 to 417+00 Cutoff Wall Tip Elevation 20 417+00 to 425+00 Cutoff Wall Tip Elevation 10 425+00 to 456+00 Cutoff Wall Tip Elevation 15 456+00 to 478+68 Cutoff Wall Tip Elevation 15 with 200 feet wide Undrained Seepage Berm.	
						Undrained Seepage Berm	410+67 to 478+68: 300 feet wide Seepage Berm	Seepage analysis indicate high exit gradients at the toe of the seepage berm. Therefore, monitoring at the toe of the berm for seepage is recommended during the high water events. If seepage occurs, relief wells or a collection drain system may be needed.

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ENCLOSURE K

SBFCA WITH-PROJECT SEEPAGE/STABILITY RESULTS

Table 8-1: Geotechnical Analyses Results for Preferred Alternatives

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (ft)	Levee Height[1] (ft)	Flood Level Analyzed	Water Surface Elevation (ft)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
						Average Vertical Exit Gradient at Landside Toe, i	Breakout above Landside Toe (ft)	Comments	Minimum Factor of Safety, FS	Comments	Minimum Factor of Safety, FS[2]	Comments
Reach 2												
210+00	Cutoff Wall Tip Elevation 30' with 100' Wide Undrained Seepage Berm	62.4	23.0	HTOL	59.18	Levee Toe = 0.40 (Berm Toe=0.86)	4.4' above Seepage Berm	Due to the presence of the clay core in the embankment and the cutoff wall, through seepage is considered as "meeting criteria".	1.44	Meets Criteria	1.17	Critical RDD Slope Stability Condition for Reach
				100yr + 1'	56.18	Levee Toe = 0.30 (Berm Toe=0.74)	2.2' above Seepage Berm		1.55			
Reach 3												
239+78	Cutoff Wall Tip Elevation (-)35'	64.3	22.5	HTOL	59.36	Levee Toe <0.05 (Ditch=0.39)	Levee Toe	Meets Criteria	1.52	Meets Criteria	1.18	Critical RDD Slope Stability Condition for Reach
				100yr + 1'	56.36	Levee Toe <0.05 (Ditch=0.34)	Levee Toe		1.55			
255+75 - With Landside Pond	Cutoff Wall Tip Elevation (-)20' Slope flattening	64.6	20.9	HTOL	59.50	Levee Toe <0.05 (Pond=0.78)	Landside Pond	Meets Criteria	1.43	Meets Criteria	n/a	Not Critical RDD Slope Condition
				100yr + 1'	56.50	Levee Toe <0.05 (Pond=0.70)	Landside Pond		1.50			
255+75 - Without Landside Pond (Adjacent Ground Surface)	Cutoff Wall Tip Elevation (-)20' Slope flattening	64.6	20.9	HTOL	59.50	Levee Toe <0.05 (Ditch <0.05)	54' from Levee Toe	Meets Criteria	1.44	Meets Criteria	n/a	Not Critical RDD Slope Condition
				100yr + 1'	56.50	Levee Toe <0.05 (Ditch <0.05)	54' from Levee Toe		1.50			

Table 8-1: Geotechnical Analyses Results for Preferred Alternatives

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (ft)	Levee Height [1] (ft)	Flood Level Analyzed	Water Surface Elevation (ft)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
						Average Vertical Exit Gradient at Landside Toe, i	Breakout above Landside Toe (ft)	Comments	Minimum Factor of Safety, FS	Comments	Minimum Factor of Safety, FS [2]	Comments
299+50	Cutoff Wall Tip Elevation (-)12'	63.3	20.3	HTOL	59.89	Levee Toe <0.05 (Ditch = 0.39)	6.7' above Levee Toe	Due to the presence of the clay core in the embankment and the cutoff wall, through seepage is considered as "meeting criteria".	1.63	Meets Criteria	n/a	Not Critical RDD Slope Condition
				100yr + 1'	56.89	Levee Toe <0.05 (Ditch = 0.34)	5.8' above Levee Toe	Sensitivity Analysis No CL/ML (Layer 8) Landside of Cutoff wall. HTOL i<0.05 (CL at Toe) i=0.52 (Ditch) 100yr + 1' i<0.05 (CL at Toe) i = 0.46 (Ditch)	1.67			
Reach 4												
319+00	Cutoff Wall Tip Elevation 15'	64.4	22.5	HTOL	60.36	Levee Toe in CL/ML Blanket = 0.30, Levee Toe in CL/ML and CL Blanket = 0.25	2.0' above Levee Toe	Due to the presence of the clay core in the embankment and the cutoff wall, through seepage is considered as "meeting criteria".	1.80	Meets Criteria	1.17	Critical RDD Slope Stability Condition for Reach
				100yr + 1'	57.36	Levee Toe in CL/ML Blanket = 0.25, Levee Toe in CL/ML and CL Blanket = 0.19	1.0' above Levee Toe	Sensitivity Analysis Truncated Waterside Blanket HTOL i=0.31 (Toe CL/ML) i=0.25 (Toe CL/ML, CL) 100yr + 1' i=0.25 (Toe CL/ML) i=0.20 (Toe CL/ML, CL)	1.85			

Table 8-1: Geotechnical Analyses Results for Preferred Alternatives

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (ft)	Levee Height [1] (ft)	Flood Level Analyzed	Water Surface Elevation (ft)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
						Average Vertical Exit Gradient at Landside Toe, i	Breakout above Landside Toe (ft)	Comments	Minimum Factor of Safety, FS	Comments	Minimum Factor of Safety, FS [2]	Comments
408+80	Cutoff Wall Tip Elevation 20'	66.7	22.5	HTOL	63.04	Levee Toe = 0.27	2.3' above Levee Toe	Due to the presence of the clay core in the embankment and the cutoff wall, through seepage is considered as "meeting criteria".	1.50	Meets Criteria	n/a	Not Critical Slope Condition
				100yr + 1'	60.04	Levee Toe = 0.18	1.3' above Levee Toe	Sensitivity Analysis Truncated Waterside Blanket HTOL i=0.28 (Toe CL, CL) 100yr + 1' i=0.19 (Toe CL, CL)	1.63			
Reach 5												
435+00	Cutoff Wall Tip Elevation 20'	66.8	22.0	HTOL	63.96	Levee Toe in Thin CL Blanket = 1.18 Levee Toe in CL, SM and CL Blanket = 0.32	1.3' above levee toe	Due to the presence of the clay core in the embankment and the cutoff wall, through seepage is considered as "meeting criteria".	1.88	Meets Criteria	1.08	Critical RDD Slope Stability Condition for Reach
				100yr + 1'	60.96	Levee Toe in Thin CL Blanket = 1.00 Levee Toe in CL, SM and CL Blanket = 0.26	1.0' above levee toe	Sensitivity Analysis Truncated Waterside Blanket HTOL i=1.34 (Toe CL) i=0.33 (Toe CL, SM, CL) 100yr+1' i=1.04 (Toe CL) i=0.27 (Toe CL, SM, CL)	1.89			

Table 8-1: Geotechnical Analyses Results for Preferred Alternatives

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (ft)	Levee Height[1] (ft)	Flood Level Analyzed	Water Surface Elevation (ft)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
						Average Vertical Exit Gradient at Landside Toe, i	Breakout above Landside Toe (ft)	Comments	Minimum Factor of Safety, FS	Comments	Minimum Factor of Safety, FS[2]	Comments
466+25	Cutoff Wall Tip Elevation 15' with 300' Wide Undrained Seepage Berm	67.3	18.0	Physical Top of Levee	67.30	Levee Toe = 0.33 (Berm Toe=0.88)	10.0' above levee toe	Due to the presence of the clay core in the embankment and the cutoff wall, through seepage is considered as "meeting criteria".	1.20	Meets Criteria	n/a	Not Critical RDD Slope Condition
				200yr + 1'	65.25	Levee Toe = 0.26 (Berm Toe=0.80)	9.1' above levee toe	Sensitivity Analysis Extend Cutoff Wall to Elev. 15' and Add Layer of ML between Layers 3 and 4, similar to actual conditions HTOL i=0.08 (Berm and CL at Levee Toe) i=0.60 (CL at Berm Toe) 100yr + 1' i<0.05 (Berm and CL at Levee Toe) i=0.55 (CL at Berm Toe)	1.71			
477+00	Star Bend Setback Levee Cutoff Wall Tip Elevation (-) 20'	69.9	19.9	HTOL	68.56	Levee Toe <0.05	76' from Levee Toe	No rehabilitation measure under the FRWL Project. Existing conditions meet criteria.	1.76	Meets Criteria	n/a	Not Critical RDD Slope Condition
				200yr + 1'	65.56	Levee Toe <0.05	76' from Levee Toe		1.82			

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Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 7													
Station 539+30	Cutoff Wall Tip Elev. -5'	69.8	48	21.8	Physical Top of Levee (PTOL)	69.8	<0.10 [Toe, blanket = 7.8'] 0.54 [50' from toe, blanket=5.2']	0.0	Existing relief well did not perform adequately during previous flood event. Accordingly, they are not included in the model. Exit gradients are calculated at the toe and 50 feet from the toe. Blanket includes Layer 2 (CL).	1.54 (shallow) 2.36 (deep)		-	
					200yr + 1'	67.4	<0.10 [Toe, blanket = 7.8'] 0.50 [50' from toe, blanket=5.2']	0.0		1.65 (shallow) 2.42 (deep)		-	

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Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 541+00	Cutoff Wall Tip Elev. -5'	69.8	47.1	22.7	Physical Top of Levee (PTOL)	69.7	Sensitivity Analysis Only Responding DWR review comment ID # 48, a set of sensitivity analyses were performed with adjusted stratigraphy. Steady State Seepage and Stability Analyses Results are as below; (Exit gradients are calculated at approximately 40 feet from toe through both thin and thick blankets) PTOL i=0.24 [Near toe, thin blanket=7'] i=0.19 [Near toe, thick blanket=12.6'] Breakout above toe =1.2' FS = 2.00 (Slope stability) 200yr+1' i=0.23 [Near toe, thin blanket=7'] i=0.18 [Near toe, thick blanket=12.6'] Breakout above toe =1.2' FS = 2.02 (Slope stability) Sensitivity analysis performed with sand to elev. -8' results in; PTOL i=0.24 [Near toe, thin blanket=7'] i=0.20 [Near toe, thick blanket=12.6'] Breakout above toe =1.2' FS = 1.99 (Slope stability) 200yr+1' i=0.24 [Near toe, thin blanket=7'] i=0.18 [Near toe, thick blanket=12.6'] Breakout above toe =1.2' FS = 2.02 (Slope stability) Sensitivity analysis performed with aquiclude truncated on landside results in; PTOL i=0.39 [Near toe, thin blanket=7'] i=0.33 [Near toe, thick blanket=12.6'] Breakout above toe =2' FS = 1.86 (Slope stability) 200yr+1' i=0.37 [Near toe, thin blanket=7'] i=0.30 [Near toe, thick blanket=12.6'] Breakout above toe =2' FS = 1.90 (Slope stability)			RDD Analysis Only		-	This section was selected for RDD analysis considering waterside slope, bank slope, and embankment, and blanket materials. The embankment and blanket materials are fine-grained plastic soils which are prone to RDD conditions.
					200yr + 1'	67.4						1.30	Waterside Levee Slope: 2.7H to flatter than 3.0H:1V Levee Slope Height = 22 feet Bench Width to Bank Slope = 15 feet Bank Slope: 1.4H to 1.7H:1V Bank Slope Height = 36 feet

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 545+50	Cutoff Wall Tip Elev. -5' Relief Wells: 50 feet deep, spaced 60 feet apart.	70.3	44.9	25.4	Physical Top of Levee (PTOL)	70.3	Sensitivity Analysis Only Responding to USACE review comment ID #1, sensitivity analysis was performed with and without the aquiclude to see if only cutoff wall option for this subreach could work or not. The following sensitivity results showed that the only cutoff wall option would work with the presence of aquiclude.			RDD Analysis Only		-	This section was selected for RDD analysis considering waterside slope, bank slope, and embankment, and blanket materials. The embankment and blanket materials are fine-grained plastic soils which are prone to RDD conditions.
					200yr + 1'	67.5	Sensitivity analysis with hanging wall (tip elev. -54.5') without the aquiclude (SP instead of CL for Layer 6 results in; 200yr+4' :i=0.85 200yr+1': i=0.76 Sensitivity analysis with shallow cutoff wall (tip elev. -0.7') with the aquiclude (5.2' thick Elev. -0.7' to 4.5') results in; 200yr+4' :i=0.30 200yr+1': i=0.27					1.29	Waterside Levee Slope: 2.1H to flatter than 3.0H:1V Levee Slope Height = 22 feet Bench Width to Bank Slope = 30 feet Bank Slope: 1.0H to 1.2H:1V Bank Slope Height = 20 feet
Station 565+50	Cutoff Wall Tip Elev. -5' Relief Wells: 50 feet deep, spaced 60 feet apart.	70.8	47.1	23.7	200yr + 4'	70.7	0.58 [Toe, blanket=20.6'] 0.83 [50' from toe, blanket=18.7']	2.4	Relief wells modeled with fixed total head boundary condition at the bottom of the blanket. Fixed total head values chosen to represent conditions Mid-way between wells (i=0.3 for 200yr+1' at the toe due to thinning blanket conditions away from the toe; i=0.6 for 200yr+4' at the toe) Exit gradients are calculated at the toe and 50 feet from the toe. Blanket includes Layer 3 (ML).	1.52		-	Levee Slope: 2.1H to flatter than 3.0H:1V Levee Slope Height = 24 feet Bench Width to Bank Slope = 8 feet Bank Slope: 2.1H:1V Bank Slope Height = 20 feet Past performance records state instability associated with rapid drawdown was experienced between stations 563+00 and 568+74 when the east bank of the levee was breached during the 1997 flood event.
					200yr + 1'	67.7	0.30 [Toe, blanket=20.6'] 0.58 [50' from toe, blanket=18.7']	2.2		1.80		1.27	

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 585+00	Cutoff Wall Tip Elev. -10'	70.6	46.5	24.1	Physical Top of Levee (PTOL)	70.6	<0.10 [Toe, blanket=9.1']	11.4	Exit gradient is calculated at the toe. Blanket includes Layer 2 (CL). Responding to DWR Review Comments ID #54, sensitivity analysis was performed with truncated waterside blanket to validate the design. The results are as below; PTOL i<0.10 [Toe, blanket=7.9'] Breakout above toe = 11' FS = 1.73 (slope stability) 200yr+1' i<0.10 [Toe, blanket=7.9'] Breakout above toe =0' FS = 1.76 (slope stability) Responding to DWR Review Comments ID #55, sensitivity analysis was performed with truncated landside aquiclude to validate the design. The results are as below; PTOL i=0.37 [Toe, blanket=7.9'] i=0.20 [Toe, blanket=25.4'] Breakout above toe = 3.1' FS = 1.58 (slope stability) 200yr+1' i=0.32 [Toe, blanket=7.9'] i=0.17 [Toe, blanket=25.4'] Breakout above toe =1.8' FS = 1.62 (slope stability) Responding to DWR Review Comments ID #55, sensitivity analysis was performed with truncated landside aquiclude and blanket thinned to elev +40 to validate the design. The results are as below; PTOL i=0.38 [Toe, blanket=7.9'] Breakout above toe = 11' FS = 1.59 (slope stability) 200yr+1' i=0.35 [Toe, blanket=7.9'] Breakout above toe =1.8' FS = 1.61 (slope stability)	1.73		-	
					200yr + 1'	67.8	<0.10 [Toe, blanket=9.1']	0.0		1.74		1.28	Waterside Levee Slope: 4.8H:1V Levee Slope Height = 13 feet Bench Width to Bank Slope = 25 feet Bank Slope: 1.1H:XV Bank Slope Height = 17 feet

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Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 8													
Station 601+00	Cutoff Wall Tip Elev. +15'	72.1	48	24.1	200yr + 1'	68.0	RDD Analysis Only			RDD Analysis Only		1.98	Waterside Levee Slope: 2.7H to flatter than 3.0H:1V Levee Slope Height = 23 feet Bench Width to Bank Slope = 0 feet Bank Slope: 1.2H to 1.4H:1V Bank Slope Height = 31 feet This section was selected for RDD analysis considering waterside slope, bank slope, and embankment, and blanket materials. The embankment and blanket materials are fine-grained plastic soils which are prone to RDD conditions.

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Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 623+86	Cutoff Wall Tip Elev. +15'	72.1	48	24.1	200yr + 4'	71.3	<0.10 [Toe, thin blanket=10.6'] 0.57 [Toe, thick blanket =35.1'] 0.10 [20' from toe, thin blanket =9.7'] 0.59 [20' from toe, thick blanket =33.9']	0.0	Exit gradients are calculated at the toe and 20 feet from the toe. Thin blanket includes Layer 3 (CL); thick blanket includes Layer 3 (CL), Layer 4 (SP-SM) and Layer 5 (CL). Responding to DWR Review Comments ID #113, a sensitivity analysis was performed with SC instead of SP for Layer 2 and truncated waterside blanket. The results are as below;	1.89		-	
					200yr + 1'	68.3	<0.10 [Toe, thin blanket =10.6'] 0.50 [Toe, thick blanket =35.1'] <0.10 [20' from toe, thin blanket =9.7'] 0.52 [20' from toe, thick blanket=33.9']	0.0	200yr+4' i=0.12 [Toe, thin blanket=10.6'] i=0.56 [Toe, thick blanket=35.1'] 200yr+1' i<0.1 [Toe, thin blanket=10.6'] i=0.48 [Toe, thick blanket=35.1'] Responding to DWR Review Comments ID #61, a sensitivity analysis was performed with truncated waterside blanket. The results are as below; 200yr+4' i=0.08 [Toe, thin blanket=10.6'] i=0.57 [Toe, thick blanket=35.1'] i=0.10 [20' from toe, thin blanket=9.7'] i=0.59 [20' from toe, thick blanket=33.9'] Breakout above toe = 0' FS = 1.89 (Slope stability) 200yr+1' i=0.08 [Toe, thin blanket=10.6'] i=0.50 [Toe, thick blanket=35.1'] i=0.09 [20' from toe, thin blanket=9.7'] i=0.52 [20' from toe, thick blanket=33.9'] Breakout above toe = 0' FS = 1.90 (Slope stability) The above sensitivity results are identical to those of the primary model presented. Accordingly, truncated WS has no effect on the results.	1.90		-	

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Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 636+00	Cutoff Wall Tip Elev. +15'	72.5	48.2	24.3	200yr + 4'	71.4	0.21 [Toe, thin blanket=9.6'] 0.60 [Toe, thick blanket=32.2']	0.0	Exit gradient is calculated at the toe. Thin blanket includes Layer 2 (CL); thick blanket includes Layer 2 (CL), Layer 3 (SP), and Layer 4 (CL).	1.68		-	
					200yr + 1'	68.4	0.19 [Toe, thin blanket=9.6'] 0.52 [Toe, thick blanket=32.2']	0.0	Sensitivity analysis was performed with boundary condition changed from the fixed total head to no flow along the water side of model (at the middle of river). The results are as below; 200yr+4' i=0.13 [Toe, thin blanket] i=0.28 [Toe, thick blanket] 200yr+1' i<0.10 [Toe, thin blanket] i<0.10 [Toe, thick blanket] Responding to DWR Review Comments ID # 63, the following explanation is added. The average exit gradient is 0.52 across a 32 feet thick blanket at 200yr + 1 ft WSE. The lower CL layer and thin blanket are separated by a permeable sand layer (SP), which will likely release some pore water pressure across SP layer and 3-dimensional directions in reality, thereby reducing the exit gradient. Furthermore, the gradient criteria (i=0.5 equivalent to FS=0.8/0.5=1.6) is based on an assumed saturated unit weight of 112.5 pcf for the blanket materials. The average estimated saturated unit weight for the 32 ft thick combined blanket layer is nearer 125 pcf. The critical exit gradient, i_{cr} and FS computations are as follows; i_{cr}=(125-62.4)/(62.4)=1.0 and FS =i_{cr}/i = 1.0/0.52=1.9 > 1.6 Given the above it is considered that the section meets criteria.	1.69		-	

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Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 9													
Station 656+00	Cutoff Wall Tip Elev. +15'	74.2	50.8	23.4	200yr + 1'	68.7	Sensitivity Analysis Only Responding to DWR Review Comment ID #64, sensitivity analysis was performed with SM instead of CL for Layer 2 to validate the design. The results are as below; 200yr+4' i=0.33 [Toe, blanket=24.6'] Breakout above toe = 0.3' FS = 2.21 (Slope stability) 200yr+1' i=0.28 [Toe, blanket=24.6'] Breakout above toe = 0.3' FS = 2.31 (Slope stability)			RDD Analysis Only		0.84 1.00 (deep slip surface crossing the levee prism)	Waterside Levee Slope: 2.7H to flatter than 3.0H:1V Levee Slope Height = 23 feet Bench Width to Bank Slope = 0 feet Bank Slope: 1.2H to 1.4H:1V Bank Slope Height = 31 feet This section was selected for RDD analysis considering waterside slope, bank slope, and embankment, and blanket materials. The embankment and blanket materials are fine-grained plastic soils which are prone to RDD conditions. Possible rapid drawdown stability remediation extent may be between station 654+00 and 667+00 Rapid drawdown (RDD) analysis show that slip surfaces with a factor of safety less than or equal to 1 occur within the steep channel slopes and that some of these encroach into the theoretical levee prism. However, slip surfaces that encroach into the existing levee profile and that could impact the global stability of the levee have a factor of safety greater than 1. Therefore, the levee is considered to have an adequate FOS to meet RDD criteria. Wide levee crown and/or waterside bench in this area. Slope maintenance to address sloughing of steep channel bank slopes may be required in the future..

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 683+00	Cutoff Wall Tip Elev. +20'	75.8	49.9	25.9	200yr + 4'	72.4	0.29 [Toe, thin blanket =12.4'] 0.48 [Toe, thick blanket =31.7']	0.0	Exit gradient is calculated at the toe. Thin blanket includes Layer 2 (SP-SM) and Layer 3 (ML); thick blanket includes Layer 2 (SP-SM), Layer 3 (ML) and Layer 5 (ML). Sensitivity analysis was performed with ML instead of SP-SM for Layer 2. The results are as below; 200yr+4' i=0.46 (Toe, thin blanket) i=0.49 (Toe, thick blanket) 200yr+1' i=0.40 (Toe, thin blanket) i=0.43 (Toe, thick blanket) Responding to DWR review comment ID#66, Sensitivity analysis with adjusted layer 6 (SP) referring to CPT SL0001_007C results in; 200yr+4' i=0.38 (Toe, thin blanket) i=0.55 (Toe, thick blanket) FS=2.18 (Slope stability) 200yr+1' i=0.32 (Toe, thin blanket) i=0.48 (Toe, thick blanket) FS=2.21 (Slope stability)	2.22		-	
					200yr + 1'	69.4	0.24 [Toe, thin blanket =12.4'] 0.41 [Toe, thick blanket =31.7']	0.0		2.24		-	

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Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 705+84	Cutoff Wall Tip Elev.-10'	76.6	50.9	25.7	200yr + 4'	72.9	0.30 [Toe, thin blanket =11.3'] 0.52 [Toe, thick blanket =28.6']	0.0	Exit gradient is calculated at the toe. Thin blanket includes Layer 3 (SM) and Layer 4 (CL); thick blanket includes Layer 3 through Layer 6 (CL). Sensitivity Analysis With cutoff wall tip elev. +20' results in; 200yr+4' i=0.30 (Toe, thin blanket) i=0.63 (Toe, thick blanket) 200yr+1' i=0.26 (Toe, thin blanket) i=0.54 (Toe, thick blanket) Accordingly, results do not meet criteria. Sensitivity Analysis With the kh=1.0E-05 cm/s instead of kh=1.0E-6 cm/s for Layer 6 (CL) results in; 200yr+4' i=0.58 (Toe, thin blanket) i=0.33 (Toe, thick blanket) 200yr+1' i=0.50 (Toe, thin blanket) i=0.28 (Toe, thick blanket) Sensitivity Analysis With the anisotropic ratio (kh/kv=10) for Layer 7 (SP-SM) results in the same as the primary analysis. Anisotropic ratio change does not affect the results.	2.40		-	
					200yr + 1'	69.9	0.20 [Toe, thin blanket =11.3'] 0.45 [Toe, thick blanket =28.6']	0.0		2.42		-	

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Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 10													
Station 721+00	Cutoff Wall Tip Elev. -10'	76.6	49	27.6	200yr + 4'	73.3	0.25 [Toe, blanket =24.3']	8.2	Exit gradient is calculated at toe. Blanket includes Layer 3 (CL) and Layer 4 (CL). Sensitivity analysis with cutoff wall tip elev.+25' results in; 200yr+4' ;i=0.87 [Toe] 200yr+1' ; i=0.77 [Toe] Responding to DWR Review Comments ID #70, through seepage flux Q on landside slope are calculated as follows; 200yr+4'; Q=0.00131 gpm/ft of levee 200yr+1'; Q=0.00098 gpm/ft of levee Due to the presence of the clay core in the embankment and very small amount of seepage flux estimated, through seepage is considered as "meeting criteria".	1.85		-	
					200yr + 1'	70.3	0.22 [Toe, blanket =24.3']	8.2		1.87		-	
Station 733+84	Cutoff Wall Tip Elev. -5'	77.7	51.7	26.0	200yr + 4'	73.6	<0.10 [Toe, thin blanket =13.5'] 0.34 [Toe, thick blanket =64.2'] 0.15 [21' from toe, thin blanket =11.7'] 0.37 [21' from toe, thick blanket =63.5']	1.2	Exit gradients are calculated at the toe and 21 feet from toe. Thin blanket includes Layer 3 (CL); thick blanket includes Layer 3 (CL), Layer 4 (SP-SM), and Layer 5 (CL). Responding to DWR Review Comments ID #71, through seepage flux Q on landside slope are calculated as follows; 200ry+4'; Q=0.00047 gpm/ft of levee 200yr+1'; Q=0.00041 gpm/ft of levee Due to the presence of the clay core in the embankment and very small amount of seepage flux estimated, through seepage is considered as "meeting criteria".	1.92		-	
					200yr + 1'	70.6	<0.10 [Toe, thin blanket =13.5'] 0.29 [Toe, thick blanket =64.2'] 0.13 [21' from toe, thin blanket =11.7'] 0.32 [21' from toe, thick blanket =63.5']	0.8		1.95		-	

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Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 11													
Station 808+85	Cutoff Wall Tip Elev. -5'	78.7	56.5	22.2	200yr + 4'	75.6	<0.10 [Toe, blanket=8.8']	0.0	Exit gradients are calculated at the toe. Blanket includes Layer2 (ML) and Layer 3 (CL).	1.61		-	
					200yr + 1'	72.6	<0.10 [Toe, blanket=8.8']	0.0		1.61		-	
Station 810+00	Cutoff Wall Tip Elev. -5'	78.7	55.6	23.1	200yr + 1'	72.6	Sensitivity Analysis Only Responding to USACE review comment ID # 3, sensitivity analysis was performed with refined aquiclude layer 5 (ML) underlain by gravel layer. The cutoff wall embedded into the aquiclude with both kh=1.0E-4 cm/s and kh=1.0E-5 cm/s produced the following results: Sensitivity analysis with thin aquiclude (7' thick) i = 0.42 for 200yr+1 (kh=1.0E-5 cm/s) i = 0.91 for 200yr+1 (kh=1.0E-4 cm/s) It is considered overly conservative to assume a thin aquiclude layer in combination with higher hydraulic conductivity of 1.0E-04 cm/s, As such, URS conclude from the sensitivity analysis that the proposed rehabilitation option is acceptable.			RDD Analysis Only		1.69	Waterside Levee Slope: Flatter than 3.0H:1V Levee Slope Height = 23 feet Bench Width to Bank Slope = 0 feet Bank Slope: 2.7H to flatter than 3.0H:1V Bank Slope Height = 35 feet This section was selected for RDD analysis considering waterside slope, bank slope, and embankment, and blanket materials. The embankment and blanket materials are fine-grained plastic soils which are prone to RDD conditions.
Reach 13													
Station 861+33	Cutoff Wall Tip Elev. -30.5' Rehabilitation of existing relief wells (if needed)	81.2	55	26.2	200yr + 4'	78.2	0.42 [Toe, blanket=12.2'] 0.72 [Ditch 12' from toe, blanket=9.4']	0.0 Seepage flux Q within 100 feet from toe across 100 feet distance of levee (existing relief well spacing) = 0.78 gpm	Existing relief wells are not modeled. Exit gradient is calculated at toe. Design Tech Memo for Reach 13 (July 2012) presents alternatives 1, 2, 3A, and 3B. Alternative 3A is selected for the primary analysis and alternative 2 and 3B results are presented as sensitivity analyses in GDRR. Responding DWR Review Comments #77, #78, and #83, the following sensitivity analyses were performed. Sensitivity analysis (alternative 2) with fully penetrating cutoff wall with full or partial levee degraded results in;	1.56		-	

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
					200yr + 1'	75.2	0.33 [Toe, blanket=12.2'] 0.60 [Ditch 12' from toe, blanket=9.4']	0.0 Seepage flux Q within 100 feet from toe across 100 feet distance of levee (existing relief well spacing) = 0.65 gpm	200yr+4' i<0.10 [Toe, blanket=12.2'] Seepage flux Q within 100 feet from toe across 100 feet distance of levee (existing relief well spacing) = 0.03 gpm FS =1.87 (Slope stability) 200yr+1' i<0.10 [Toe, blanket=12.2'] Seepage flux Q within 100 feet from toe across 100 feet distance of levee (existing relief well spacing) = 0.0 gpm FS =1.87 (Slope stability) Sensitivity analysis (alternative 3B) with full levee degrade and approximately 22 feet gap between cutoff wall tip and aquiclude results in; 200yr+4' i=0.61 [Toe, blanket=12.2'] i=0.96 [Ditch 12' from Levee Toe, blanket= 9.4'] Seepage flux Q within 100 feet from toe across 100 feet distance of levee (existing relief well spacing) = 1.01 gpm FS =1.38 (Slope stability) 200yr+1' i=0.50 [Toe, blanket=12.2'] i=0.81 [Ditch 12' from Levee Toe, blanket=9.4'] Seepage flux Q within 100 feet from toe across 100 feet distance of levee (existing relief well spacing) = 0.85 gpm FS =1.49 (Slope stability)	1.63		-	

1493

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 15													
Station 966+00	No proposed rehabilitation measure as cutoff wall is present	81.5	57.3	24.2	200yr + 1'	77.8	RDD Analysis Only			RDD Analysis Only Responding to DWR Review Comments ID #86, sensitivity analysis was performed with shear strength OCR<2 of CL for Layer 4. The result does not change. No effect on strength change for relatively deep material.		1.52	Representative of LD1 reported that an existing cutoff wall exists at this location, however as-built documents not available. For RDD analyses, dimensions and properties of this existing cutoff wall were assumed. As-builts are needed to confirm. Waterside Levee Slope: 1.2H to 1.4H:1V Levee Slope Height = 24 feet Bench Width to Bank Slope = > 35 feet Bank Slope: NA Bank Slope Height = NA Sensitivity Analysis with shear strength OCR<2 for Layer 4 results in (DWR review comment ID #86) FS=1.51 (same) This section was selected for RDD analysis considering waterside slope, bank slope, and embankment, and blanket materials. The embankment and blanket materials are fine-grained plastic soils which are prone to RDD conditions.

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 16													
Station 993+80	None	82.8	61.3	21.5	200yr + 1'	78.7	RDD Analysis Only			RDD Analysis Only Responding to DWR Review Comments ID # 88, sensitivity analysis was performed with using SP-SM by thickening Layer 4 to elevation 30-56 feet on landside. This had no effect on the results due to same phreatic surfaces conditions as in primary analysis .		0.85	Waterside Levee Slope: 1.2H to 1.4H:1V Levee Slope Height = 24 feet Bench Width to Bank Slope = > 35 feet Bank Slope: NA Bank Slope Height = NA This section was selected for RDD analysis considering waterside slope, bank slope, and embankment, and blanket materials. The embankment and blanket materials are fine-grained plastic soils which are prone to RDD conditions. Critical slip surface occurs in steep levee slope. Possible extent of remediation may be between station 992+00 and 1001+00. Rapid drawdown (RDD) analysis show that slip surfaces with a factor of safety less than or equal to 1 occur within the steep channel slopes and that some of these encroach into the theoretical levee prism. However, slip surfaces that encroach into the existing levee profile and that could impact the global stability of the levee have a factor of safety greater than 1. Therefore, the levee is considered to have an adequate FOS to meet RDD criteria. Wide levee crown in this area. Slope maintenance to address sloughing of steep channel bank slopes may be required in the future.

1495

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 997+00	Monitoring for waterside slope distress during and after high water events	82.9	61.3	21.6	200yr + 1'	78.7	RDD Analysis Only			RDD Analysis Only		0.94	Waterside Levee Slope: 2.7H to flatter than 3.0H:1V Levee Slope Height = 21 feet Bench Width to Bank Slope = 0 feet Bank Slope: 1.2H to 1.4H:1V Bank Slope Height = 33 feet This section was selected for RDD analysis considering waterside slope, bank slope, and embankment, and blanket materials. The embankment and blanket materials are fine-grained plastic soils which are prone to RDD conditions. Rapid drawdown (RDD) analysis show that slip surfaces with a factor of safety less than or equal to 1 occur within the steep channel slopes and that some of these encroach into the theoretical levee prism. Slip surfaces that encroach into the existing levee profile and that could impact the global stability of the levee have a factor of safety greater than 1. Therefore, the levee is considered to have an adequate FOS to meet RDD criteria. However, the theoretical levee prism daylights out of the lower channel slope and monitoring for signs of slope distress should be performed. Slope maintenance to address sloughing of steep channel bank slopes may be required in the future

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx., feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 1005+00	None.	83.2	61.9	21.3	200yr + 1'	78.7	RDD Analysis Only			RDD Analysis Only		1.16	Waterside Levee Slope: 1.7H to flatter than 3.0H:1V Levee Slope Height = 21 feet Bench Width to Bank Slope = 0 feet Bank Slope: 1.7H:1V Bank Slope Height = 30 feet This section was selected for RDD analysis considering waterside slope, bank slope, and embankment, and blanket materials. The embankment and blanket materials are fine-grained plastic soils which are prone to RDD conditions.
Station 1006+20	Closure of gap in cutoff wall at 5th Street Bridge crossing: cutoff wall tip elev. +40 '	84.8	70.1	14.7	200yr + 4'	81.7	<0.10 [Toe, thin blanket =13.7'] 0.15 [Toe, thick blanket =50.2'] 0.29 [50 feet from toe, thin blanket =8.6'] 0.26 [50 feet from toe, thick blanket =46.7']	0.0	Exit gradients are calculated at levee toe and 50 feet from toe. Thin blanket includes Layer 3 (ML); Thick blanket includes Layer 3 (ML), Layer 4 (SC), Layer 5 (SP-SM), and Layer 6 (ML). Responding to DWR Review Comments ID # 93, sensitivity analysis was performed with SM (30-49% fines, anisotropic ratio kh/kv=10) instead of ML for Layer 6 results in: 200yr+4' i<0.10 [Toe, thin blanket=13.7'] i=0.13 [Toe, thick blanket=50.2'] i=0.50 [50 feet from toe, thin blanket=8.6'] i=0.23 [50 feet from toe, thick blanket=46.8'] FS=1.44 (Slope stability) 200yr+1' i<0.10 [Toe, thin blanket=13.7'] i<0.10 [Toe, thick blanket=50.2'] i=0.40 [50 feet from toe, thin blanket=8.6'] i=0.19 [50 feet from toe, thick blanket=46.8'] FS=1.44 (Slope stability)	1.44		-	
					200yr + 1'	78.7	<0.10 [Toe, thin blanket =13.7'] 0.10 [Toe, thick blanket =50.2'] 0.22 [50 feet from toe, thin blanket =8.6'] 0.21 [50 feet from toe, thick blanket =46.7']	0.0		1.44		-	

1497

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 1026+50	Closure of 10th Street Bridge crossing: Existing Conditions	91.8	60	31.8	200yr + 3'	81.3	0.42 [Existing landside toe, blanket =39.8']	10.4	Exit gradients are calculated at the toe of the existing levee. Blanket includes Layer 3 (ML), Layer 4 (ML), and Layer 5 (CL). Sensitivity analysis was performed with SM 13 to 29 % fines for Layer 2 in embankment. The results are as below; 200yr+3' i=0.42 [Levee toe], breakout=3.3 feet FS=1.17 (Slope Stability) 200yr i=0.36 [Levee toe], breakout=3.3 feet FS=1.22 (Slope Stability)	1.09			
					200yr	78.3	0.36 [Existing landside toe, blanket=39.8']	6.9		1.18			
	Closure of 10th Street Bridge crossing: Stability Berm 23 feet wide and approximately 7 feet thick at the levee toe.	91.8	60	31.8	200yr + 4'	82.3	0.26 [Levee Toe, blanket =45.7'] 0.49 [Toe of Stability Berm blanket =38.4']	1.0 above toe of berm	Proposed berm modeled assuming 3 to 7 percent of fines (Kh=4.0E-03 cm/s). Exit gradients are calculated at levee toe and at toe of stability berm. Blanket includes Layer 3 (ML), Layer 4 (ML) and Layer 5 (CL). Responding to DWR comment ID EXT/Reach16-001, the filter compatibility check has been performed (see appendix C). Sensitivity analysis was performed with proposed berm with 0 to 2 percent of fines (kh=1.5E-2 cm/s). The results are as below; 200yr+4' i=0.26 [Levee toe] i=0.49 [Toe of stability berm] breakout =0.0' above toe of berm FS=1.55 (Slope stability) 200yr+1' i=0.20 [Levee toe] i=0.42 [Toe of stability berm] breakout=0.0' above toe of berm FS=1.55 (Slope Stability)	1.46 (1.89) localized shallow failure surface at top of the stability berm)		-	
					200yr + 1'	79.3	0.20 [Levee Toe, blanket =45.7'] 0.42 [Toe of Stability Berm blanket =38.4']	0.8 above toe of berm		1.55 (1.94) localized shallow failure surface at top of the stability berm)		-	
Station 1031+00	None	84.6	62.2	22.4	200yr + 1'	79.3	RDD Analysis Only			RDD Analysis Only		1.25	Waterside Levee Slope: 2.1H to flatter than 3.0H:1V Levee Slope Height = 25 feet Bench Width to Bank Slope = 15 feet to 20 feet Bank Slope: 1.7H:1V Bank Slope Height = 17 feet

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 17													
Station 1108+86	Cutoff Wall Tip Elev. +35' with landside depression backfilled.	86.4	64.5	21.9	200yr + 4'	83.1	0.53 [Toe, blanket =7.0'] 0.64 [65' from toe, blanket=4.9']	3.0	Exit gradients are calculated at toe and approximately 65 feet from toe. Blanket includes Layer 2 (CL). Through seepage flux Q on landside slope across 100 feet of Levee 200yr+4': Q=0.00027 gpm/ft of levee 200yr+1': Q=0.00022 gpm/ft of levee	1.36		-	
					200yr + 1'	80.1	0.46 [Toe, blanket =7.0'] 0.58 [65' from toe, blanket=4.9']	1.8		1.42		-	
Station 1116+00	Cutoff Wall Tip Elev. +35' with landside depression backfilled.	86.0	64.8	21.2	200yr + 1'	80.3	RDD Analysis Only			RDD Analysis Only		1.06	Waterside Levee Slope: 2.1H to flatter than 3.0H:1V Levee Slope Height = 22 feet Bench Width to Bank Slope = 0 feet Bank Slope: Flatter than 3.0H:1V Bank Slope Height = 10 feet Existing embankment has been modeled as a normally consolidated silt with c'=0 and a ϕ'=30°. Sensitivity analysis assuming c'=50 psf and a ϕ'=31° generates a min FS=1.27.

1499

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 1125+00	Cutoff Wall Tip Elev. +35' with landside depression backfilled.	86.0	65.6	20.4	200yr + 4'	83.5	0.19 [Toe, thin blanket =8.3'] 0.19 [Toe, thick blanket=37'] 0.56 [55' from toe, blanket =5.6']	0.0	Exit gradients are calculated at toe and 55 feet from the toe. Thin blanket includes Layer 2 (CL-ML) thick blanket includes Layers 2 through 6. This location is a transition from shallow to deeper cutoff wall. Analysis represents shallow cutoff wall.	1.71		-	
					200yr + 1'	80.5	0.13 [Toe, thin blanket =8.3'] 0.15 [Toe, thick blanket=37'] 0.50 [55' from toe, blanket =5.6']	0.0	Responding IPE review comments ID # 55, sensitivity analysis was performed with CL instead of ML for Layer 6 to evaluate effects of this layer on seepage conditions. Results are as below; <u>200yr+4'</u> i<0.10 [Toe, thin blanket=8.4'] i=0.26 [55' from toe, thin blanket=5.6'] i=0.32 [55' from toe, thick blanket=33.1'] Breakout=0' FS=1.86 (Slope Stability) <u>200yr+1'</u> i<0.10 [Toe, thin blanket=8.4'] i=0.23 [55' from toe, thin blanket=5.6'] i=0.25 [55' from toe, thick blanket=33.1'] Breakout=0' FS=1.92 (Slope Stability)	1.80		-	

1500

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 18													
Station 1138+86	Cutoff Wall Tip Elev. +0'	86.8	66.6	20.2	200yr + 4'	83.6	<0.10 [Toe, blanket =8.8']	0.0	Blanket includes Layer 2 (CL).	1.82		-	
					200yr + 1'	80.6	<0.10 [Toe, blanket =8.8']	0.0		1.84		-	
Station 1163+75	Cutoff Wall Tip Elev. +25'	86.8	66.7	20.1	200yr + 4'	84.1	0.39 [Toe, blanket =5.7'] 0.23 [Toe, blanket =9.8'] 0.20 [Toe, blanket =42.2']	1.2	The first blanket includes Layer 2 (CL). The second blanket includes Layer 2 (CL) and Layer 3 (SM). The third blanket includes Layer 2 (CL) through Layer 5 (ML). Due to the presence of the clay core in the embankment and the cutoff wall, through seepage is considered as "meeting criteria" Responding to DWR review comment #100, exit gradient was calculated through blanket including Layer 2 through Layer 5 (=42.2').	1.60		-	
					200yr + 1'	81.1	0.30 [Toe, blanket =5.7'] 0.18 [Toe, blanket =9.8'] 0.17 [Toe, blanket =42.2']	0.9		1.69		-	

1501

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 19													
Station 1224+00	Cutoff Wall Tip Elev. +5'	87.2	68.1	19.1	200yr + 4'	84.9	0.43 [Toe, blanket =4.9']	1.4	Blanket includes Layer 2(CL).	1.61		-	
					200yr + 1'	81.9	0.33 [Toe, blanket =4.9']	0.7	Sensitivity analysis with cutoff wall tip elev. +25' results in; 200yr+4' :i=0.73 [Toe] 200yr+1' :i=0.59 [Toe]	1.65		-	

1502

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 1244+00	Cutoff Wall Tip Elev. -42'	88.3	68.9	19.4	200yr + 4'	85.0	<0.10 [Toe, blanket =5.5']	0.0	Blanket includes Layer 2 (CL).	1.69		-	
					200yr + 1'	82.0	<0.10 [Toe, blanket =5.5']	0.0	Sensitivity Analysis with the cutoff wall tip elev. -35' results in: 200yr+4': i=0.18 [Toe] 200yr+1': i=0.15 [Toe] Responding to DWR Review Comment ID # 103, the following sensitivity analyses were performed. Sensitivity analysis with truncated landside CL aquiclude and added aquifer below results in; 200yr+4' i=0.31 [Toe, blanket=5.5'] Breakout above toe = 1.7' FS = 1.58 (Slope stability) 200yr+1' i=0.24 [Toe, blanket=5.5'] Breakout above toe =1.3' FS = 1.61 (Slope stability) Sensitivity analysis with truncated landside aquicludes (CL and SM) and add aquifer below results in; 200yr+4' i=0.33 [Toe, blanket=5.5'] Breakout above toe = 1.8' FS = 1.57 (Slope stability) 200yr+1' i=0.25 [Toe, blanket=5.5'] Breakout above toe =1.4' FS = 1.61 (Slope stability)	1.69		-	

1503

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 1293+00	Cutoff Wall Tip Elev. +35'	89.0	70.5	18.5	200yr + 4'	85.4	<0.10 [Toe, thin blanket =8.7'] 0.24 [Toe, thick blanket=40.0']	0.0	Exit gradient is calculated at toe. Thin blanket includes Layer 2 (CL). Thick blanket includes Layers 2, 3, 4, and 5.	1.79		-	
					200yr + 1'	82.4	<0.10 [Toe, thin blanket =8.7'] 0.19 [Toe, thick blanket=40.0']	0.0		1.79		-	
Reach 20													
Station 1338+83	Cutoff Wall Tip Elev. +50'	89.1	73.8	15.3	200yr + 4'	86.0	<0.10 [Toe, thin blanket =10'] 0.20 [Toe, thick blanket =37']	0.0	Exit gradient is calculated at the toe. Thin blanket includes Layer 2 (SC-SM). Thick blanket includes Layer 2 (SC-SM), Layer 3 (SP-SM), and Layer 4 (CL).	1.59		-	Waterside Levee Slope: 2.7H to flatter than 3.0H:1V Levee Slope Height = 16 feet Bench Width to Bank Slope = 15 feet to 20 feet Bank Slope: 2.1H to 2.7H:1V Bank Slope Height = 13 feet
					200yr + 1'	83.0	<0.10 [Toe, thin blanket =10'] 0.15 [Toe, thick blanket =37']	0.0		1.59		1.95	
Reach 21													
Station 1378+83	Cutoff Wall Tip Elev. +32'	89.3	78.4	10.9	200yr + 4'	87.1	<0.10 [Toe, blanket =8.8'] 0.58 [bottom of ditch 40' from toe, blanket=2.4']	0.0	Exit gradients are calculated at the toe and at the bottom of ditch 40 feet from the toe). Blanket at the bottom of ditch includes Layer 2 (CL). Sensitivity analysis with Layer 5 (ML) replaced with SP results in: 200yr+4' i<0.10 [Toe] i=0.58 [bottom of ditch] 200yr+1' i<0.10 [Toe] i=0.58 [bottom of ditch]	1.89		-	
					200yr + 1'	84.1	<0.10 [Toe, blanket = 8.8'] 0.58 [bottom of ditch 40' from toe, blanket=2.4']	0.0		1.89		-	

1504

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 1400+00	Cutoff Wall Tip Elev. +55	89.9	78.7	11.2	200yr + 4'	87.4	Sensitivity Analysis Only			2.37			
					200yr + 1'	84.4	Responding to IPE Review Comment ID #45, analysis was performed at station 1400+00. The results are as below; 200yr+4' i<0.10 [toe, thin blanket =12.5'] i=0.24 [toe, thick blanket =22.3'] i=0.49 [bottom of ditch 50' from toe, thin blanket =6.5'] i=0.51 [bottom of ditch 50' from toe, thick blanket =16.3'] 200yr+1' i<0.10 [toe, thin blanket =12.5'] i=0.19 [toe, thick blanket =22.3'] i=0.44 [bottom of ditch 50' from toe, thin blanket =6.5'] i=0.42 [bottom of ditch 50' from toe, thick blanket =16.3']			2.37			
Station 1427+00	Cutoff Wall Tip Elev. +40'	91.4	80.3	11.1	200yr + 4'	87.6	<0.10 [Toe, blanket =10.2'] 0.37 [bottom of ditch 52' from levee toe, blanket=5.6']	0.0	Blanket at the bottom of ditch includes Layer 3 (SM).	1.69		-	
					200yr + 1'	84.6	<0.10 [Toe, blanket =10.2'] 0.29 [bottom of ditch 52' from toe, blanket=5.6']	0.0		1.70		-	
Station 1430+00	Cutoff Wall Tip Elev. +40'	91.0	74.6	16.4	200yr + 4'	87.6	0.34 [Toe at the bottom of canal, blanket=5.0']	0.0	Exit gradient is calculated at the bottom of canal adjacent to levee. Blanket includes Layer 3 (SM).	1.43		-	
					200yr + 1'	84.6	0.24 [Toe at the bottom of canal, blanket=5.0']	0.0	Total head boundary condition as an elevation head at far field is used for the upper pervious Layer 3 (SP-SM) on right side of model. It prevents unrealistic seepage flow back from landside.	1.48		-	

1505

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 22													
Station 1458+00	Cutoff Wall Tip Elev. +50' Full levee degrade and reconstruction due to severe animal burrowing (not modeled see note in figure C-R22-1A)	90.7	77	13.7	200yr + 4'	88.2	<0.10 [Toe, blanket =5.8'] <0.10 [Ditch 170' from toe, blanket =2.0']	0.0	Exit gradients are calculated at toe and at bottom of ditch 170 feet from toe. Breakout is beyond landside toe	1.90		-	
					200yr + 1'	85.2	<0.10 [Toe, blanket =5.8'] <0.10 [Ditch 170' from toe, blanket =2.0']	0.0		1.90		-	
Station 1468+83	Cutoff Wall Tip Elev. +55'	91.4	79.1	12.3	200yr + 4'	88.4	<0.10 [Toe, blanket =3.0'] <0.10 [at the bottom of ditch 85' from toe, blanket =5.0']	0.0	Exit gradients are calculated at toe and at the bottom of ditch 85 feet from toe. Breakout is beyond landside toe Sensitivity Analysis	2.03		-	
					200yr + 1'	85.4	<0.10 [Toe, blanket =3.0'] <0.10 [at the bottom of ditch 85' from toe, blanket=5.0']	0.0	For Layer 3 (SC-SM) replaced with SP-SM results in; 200yr+4' i<0.10 [Toe] i<0.10 [bottom of ditch] 200yr+1' i<0.10 [Toe] i<0.10 [bottom of ditch] Sensitivity Analysis For the Layer 2 (CL) with kv=1.0E-5cm/s results in; 200yr+4' i<0.10 [Toe] i<0.10 [bottom of ditch] 200yr+1' i<0.10 [Toe] i<0.10 [bottom of ditch]	2.03		-	

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 1470+00	Cutoff Wall Tip Elev. +55'	91.8	81.5	10.3	200yr + 1'	85.4	RDD Analysis Only			RDD Analysis Only		1.51	Waterside Levee Slope: 1.4H to 2.7H:1V Waterside Levee Slope Height = 10 feet Bench Width to Bank Slope = 0 feet Bank Slope: 2.7H:1V Bank Slope Height = 8 feet This section was selected for RDD analysis considering waterside slope, bank slope, and embankment, and blanket materials. The embankment and blanket materials are fine-grained plastic soils which are prone to RDD conditions.

1507

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 1499+00	Cutoff Wall Tip Elev. +55'	90.6	79.5	11.1	200yr + 4'	89.2	<0.10 [Toe, thin blanket=9.2'] 0.17 [Toe, thick blanket=26.3'] <0.10 [170' from toe, thin blanket=4.8'] 0.38 [170' from toe, thick blanket=21.9']	0.0	Exit gradients are calculated at the toe and at bottom of ditch 170 feet from the toe. Breakout is beyond toe. Thin blanket includes Layer 2 (CL). Thick blanket includes Layers 2, 3, and 4. Total head boundary condition as an elevation head at far field is used for the upper pervious Layer 3 (SP) on right side of model. It prevents unrealistic seepage flow back (limitation of 2D model) through Layer 3 SP from landside. Responding to DWR Review Comment ID # 111, sensitivity analysis was performed with truncated landside aquiclude with no flow boundary condition at landside to validate the design. The results are as below; 200yr+4' i=0.35 [Toe, blanket=9.2'] i=1.54 [170' from toe, blanket=4.8'] Breakout 1.1' FS=1.19 (Slope stability) 200yr+1' i=0.26 [Toe, blanket=9.2'] i=1.38 [170' from toe, blanket= 4.8'] Breakout 0.7' FS=1.27 (Slope stability) During meeting with DWR on Aug. 14 2012, URS agrees to an additional exploration in this area.	1.62		-	
					200yr + 1'	86.2	<0.10 [Toe, thin blanket=9.2'] <0.10 [Toe, thick blanket=26.3'] <0.10 [170' from toe, thin blanket=4.8'] 0.29 [170' from toe, thick blanket=21.9']	0.0		1.62		-	

1508

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 23													
Station 1508+33	Cutoff Wall Tip Elev. +55'	91.3	81	10.3	200yr + 4'	89.5	0.0 [Toe, phreatic surface below blanket]	0.0	Breakout is beyond toe. Landside ditch is connected to Layer 4 (SP) at 250 feet from toe. Blanket includes Layer 3 (CL-ML).	1.84		-	
					200yr + 1'	86.5	0.0 [Toe, phreatic surface below blanket]	0.0	Responding to DWR Review Comments ID #112, the following sensitivity analyses were performed to validate the design. Sensitivity analysis with truncated landside aquiclude and added aquifer at elev. +50' to +60' results in; 200ry+4' i<0.10 [Toe, blanket=5.0'] No breakout above toe FS = 1.84 (Slope stability) 200ry+1' i<0.10 [Toe, blanket=5.0'] No breakout above toe FS = 1.84 (Slope stability) Sensitivity analysis with truncated landside aquiclude, added aquifer at elev. +50'-+60' and filled ditch with blanket material results in; 200ry+4' i=0.34 [Toe, blanket=5.0'] Breakout above toe = 1.2' FS = 1.72 (Slope stability) 200ry+1' i=0.22 [Toe, blanket=5.0'] Breakout above toe = 0.6' FS = 1.77 (Slope stability) Sensitivity analysis with truncated landside aquiclude, at elev. +50'-+60', and filled ditch with water results in; 200ry+4' i=0.20 [Toe, blanket=5.0'] Breakout above toe = 0.6' FS = 1.77 (Slope stability) 200ry+1' i=0.14 [Toe, blanket=5.0'] Breakout above toe = 0' FS = 1.80 (Slope stability) During meeting with DWR on Aug. 14 2012, URS agrees to an additional exploration in this area.	1.84		-	

1509

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 1536+00	Cutoff Wall Tip Elev. +55'	92.1	85.1	7.0	200yr + 1'	87.4	RDD Analysis Only			RDD Analysis Only		1.32	Waterside Levee Slope: 2.7H:1V Levee Slope Height = 8 feet Bench Width to Bank Slope = 0 feet Bank Slope: 1.4H to 2.1H:1V Bank Slope Height = 10 feet This section was selected for RDD analysis considering waterside slope, bank slope, and embankment, and blanket materials. The embankment and blanket materials are fine-grained plastic soils which are prone to RDD conditions.
Reach 24													
Station 1610+00	Cutoff Wall Tip Elev.+28'	94.4	81.3	13.1	200yr + 1'	89.3	RDD Analysis Only			RDD Analysis Only		- 1.38	Waterside Levee Slope: 1.7H:1V to flatter than 3.0H:1V Levee Slope Height = 8 feet Bench Width to Bank Slope = > 35 feet Bank Slope: NA Bank Slope Height = NA This section was selected for RDD analysis considering waterside slope, bank slope, and embankment, and blanket materials. The embankment and blanket materials are fine-grained plastic soils which are prone to RDD conditions. Responding to DWR Review Comments ID #115, sensitivity analysis was performed with OCR<2 strength for Layer 1 CL-ML. FS=1.22

1510

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 1615+62	Cutoff Wall Tip Elev.+28'	94.4	81.3	13.1	200yr + 4'	92.3	0.50 [Bottom of ditch, blanket=3.4']	0.0	Exit gradient is calculated at the bottom of ditch. Blanket includes Layer 2 (CL-ML). Sensitivity analysis with cutoff wall tip elev. +60' results in; 200yr+4' i=2.02 [Bottom of the ditch] 200yr+1' i=1.57 [Bottom of the ditch] Responding to DWR Review Comment ID #117, sensitivity analysis was performed with truncated landside aquiclude and added aquifer below. The results are as below; 200yr+4' i=1.43 [Bottom of ditch 22' from toe, blanket=3.5'] Breakout above toe = 2.8' FS = 1.41 (Slope stability) 200yr+1' i=1.29 [Bottom of ditch 22' from toe, blanket=3.5'] Breakout above toe = 2.6' FS = 1.49 (Slope stability) During meeting with DWR on Aug. 14 2012, URS agrees to an additional exploration in this area.	2.03	Responding to the DWR Review Comment ID # 118, sensitivity analysis was performed with OCR<2 strength for layer 1 (c'=0 phi'=30). 200+4' FS=1.97 200+1' FS=2.02	-	
					200yr + 1'	89.3	0.38 [Bottom of ditch, blanket=3.4']	0.0		2.09		-	
Reach 27													
Station 1710+00	Cutoff Wall Tip Elev. +65' and Landside slope reconstruction	96.9	85.4	11.5	200yr + 1'	91.0	RDD Analysis Only			RDD Analysis Only		1.81	Waterside Levee Slope: 1.7H:1V to flatter than 3.0H:1V Levee Slope Height = 8 feet Bench Width to Bank Slope = > 35 feet Bank Slope: NA Bank Slope Height = NA This section was selected for RDD analysis considering waterside slope, bank slope, and embankment, and blanket materials. The embankment and blanket materials are fine-grained plastic soils which are prone to RDD conditions.

1511

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 28													
Station 1764+00	Cutoff Wall Tip Elev. +45' and Landside slope reconstruction	99.4	86.7	12.7	200yr + 1'	93.1	RDD Analysis Only			RDD Analysis Only		2.00	Waterside Levee Slope: 1.0H:1V to 2.7H:1V Levee Slope Height = 12 feet Bench Width to Bank Slope = > 35 feet Bank Slope: NA Bank Slope Height = NA This section was selected for RDD analysis considering waterside slope, bank slope, and embankment, and blanket materials. The embankment and blanket materials are fine-grained plastic soils which are prone to RDD conditions.
Reach 30													
Station 1820+80	Cutoff Wall Tip Elev.+30'	102.2	88.7	13.5	200yr + 4'	98.4	<0.10 [Toe, blanket=3.6']	0.0	Exit gradient is calculated at the toe. Blanket includes Layer 2 (ML)	1.80		-	
					200yr + 1'	95.4	<0.10 [Toe, blanket=3.6']	0.0	Responding to DWR Review Comment ID #123, sensitivity analysis was performed with the following adjustment. Layer 5 (CL) is bottom of model so added 10' thick aquifer (SP) below Layer 5 to make it possible to calculate a gradient across Layer 5. Results are as below; 200yr+4' i=0.17 [Toe, thin blanket=3.6' (Layer 2)] i=0.18 [Toe, thick blanket=49.3' (Layers 2-5)] 200yr+1' i=0.11 [Toe, thin blanket=3.6' (Layer 2)] i=0.15 [Toe, thick blanket=49.3' (Layers 2-5)]	1.80		-	
Station 1826+94	Cutoff Wall Tip Elev.+30'	102.2	88.7	13.5	200yr + 4'	98.5	0.57 [Toe, blanket=2.3']	0.6	Exit gradient is calculated at the toe. Blanket includes Layer 1 (ML)	1.56		-	
					200yr + 1'	95.5	0.35 [Toe, blanket=2.3']	0.6		1.66		-	

1512

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 1892+00	Cutoff Wall Tip Elev. +27'	102.2	88.7	13.5	200yr + 4'	103.3	<0.10 [Toe, blanket=11.3'] <0.10 [180' from the toe, blanket=10.5']	0.0	Exit gradients are calculated at the toe and adjacent landward levee toe. Breakout is beyond toe.	2.07		-	
					200yr + 1'	100.3	<0.10 [Toe, blanket=11.3'] <0.10 [180' from the toe, blanket=10.5']	0.0	Sensitivity Analysis With cutoff wall elev. +75' results in: 200yr+4' i=0.69 [Toe] i=0.87 [180 feet from the levee toe] 200yr+1' i=0.45 [Toe] i=0.65 [180 feet from the levee toe] Sensitivity Analysis With cutoff wall elev. +75 and SM material filled landside ground surface results in: 200yr + 4' i=0.39 [Toe] i=0.87 [180 feet from the levee toe] 200yr+1' i=0.20 [Toe] i=0.65 [180 feet from the levee toe]	2.07		-	

1513

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 1902+00	Cutoff Wall Tip Elev. +27' *Monitoring for waterside slope distress during and after high water events*	111.1	98	13.1	200yr + 1'	100.9	RDD Analysis Only			RDD Analysis Only		1.01	Waterside Levee Slope: 2.7H:1V Levee Slope Height = 15 feet Bench Width to Bank Slope = 0 feet Bank Slope: 1.2H to 2.1H:1V Bank Slope Height = 30 feet Critical slip surface occurs at transition between steep bank slopes and flatter levee slope. Section is considered critical due to steep bank slopes and lack of bench. Possible extent of remediation may extend between station 1899+00 and 1911+00. This section was selected for RDD analysis considering waterside slope, bank slope, and embankment, and blanket materials. The embankment and blanket materials are fine-grained plastic soils which are prone to RDD conditions. *Rapid drawdown (RDD) analysis show that slip surfaces with a factor of safety less than or equal to 1 occur within the steep channel slopes. However, slip surfaces that encroach into the existing levee profile and that could impact the global stability of the levee have a factor of safety greater than 1. Therefore, the levee is considered to have an adequate FOS to meet RDD criteria.* *Wide levee crown and/or waterside bench in this area.* *Slope maintenance to address sloughing of steep channel bank slopes may be required in the future.* Responding to DWR Review Comments ID#129, sensitivity analysis with 16 feet drop was performed. FS=1.00

1514

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 31													
Station 1907+91	Cutoff Wall Tip Elev. +44' *Slope flattening or other appropriate measures.*	107.7	102.4	5.3	200yr + 4'	104.3	0.41 [bottom of ditch, blanket =3.2']	0.0	Exit gradient is calculated at bottom of ditch adjacent to levee. Blanket includes Layer 1 (CL). Responding to DWR Review Comment ID#130, sensitivity analysis was performed with truncated landside aquiclude and added aquifer below. The results are as below; 200yr+4' i=2.53 [Bottom of ditch approx. 55' from toe, blanket=3.2'] Breakout above bottom of ditch = 5.2' FS = 1.30 (Slope stability) 200yr+1' i=2.09 [Bottom of ditch approx.. 55' from toe, blanket=3.2'] Breakout above bottom of ditch = 4.4' FS = 1.49 (Slope stability) During meeting with DWR on Aug. 14 2012, URS agrees to an additional exploration in this area.	2.59		-	Waterside Levee Slope: Flatter than 3.0H:1V Levee Slope Height = 7 feet Bench Width to Bank Slope = 0 feet Bank Slope: 1.2H to 1.4H:1V Bank Slope Height = 30 feet Critical slip surface occurs at transition between steep bank slopes and flatter levee slope. Section is considered critical due to steep bank slopes and lack of bench. Possible extent of remediation may extend between station 1899+00 and 1911+00. *Rapid drawdown (RDD) analysis show that slip surfaces with a marginal factor of safety occur within the steep channel slopes and that these encroach into the theoretical levee prism and could compromise the integrity of the levee.* *The theoretical levee prism daylights out of the lower channel slope.* *Slope flattening or other appropriate measures should be undertaken in this area.*
					200yr + 1'	101.3	0.31 [bottom of ditch, blanket =3.2']	0.0		2.64		1.02	

1515

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 1909+00	Cutoff Wall Tip Elev. +44' *Slope flattening or other appropriate measures.*	107.7	98.1	9.9	200yr+1'	101.5	RDD Analysis Only			RDD Analysis Only NOTE: i). sensitivity analysis performed with higher friction angle for gravel layers results in FS<1.0 *ii). analysis results are controlled by oversteepened channel slope, where the theoretical levee prism daylights out of the slope.*		0.93	Waterside Levee Slope: Flatter than 3.0H:1V Levee Slope Height = 10 feet Bench Width to Bank Slope = 0 feet Bank Slope: 1.2H to 1.4H:1V Bank Slope Height = 45 feet This section was selected for RDD analysis considering waterside slope, bank slope, and embankment, and blanket materials. The embankment and blanket materials are fine-grained plastic soils which are prone to RDD conditions. Critical slip surface occurs at transition between steep bank slopes and flatter levee slope. Section is considered critical due to steep bank slopes and lack of bench. Possible extent of remediation may extend between station 1899+00 and 1911+00. *Rapid drawdown (RDD) analysis show that slip surfaces with a factor of safety less than or equal to 1 occur within the steep channel slopes and that these encroach into the theoretical levee prism and could compromise the integrity of the levee.* *The theoretical levee prism daylights out of the lower channel slope.* *Slope flattening or other appropriate measures should be undertaken in this area.*

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 1924+00	Cutoff Wall Tip Elev. +75'	108.5	101.7	6.8	200yr + 1'	103.0	Sensitivity Analysis Only Responding to DWR Review Comment ID #132, seepage and stability analyses were performed. The results are as below: 200yr+4' i=0.42 [Bottom of ditch, blanket=12.1'] Breakout above toe = 0' FS = 2.09 (Slope stability) 200yr+1' i=0.34 [Bottom of ditch, blanket=12.1'] Breakout above toe = 0' FS = 2.26 (Slope stability)			RDD Analysis Only		1.22	Waterside Levee Slope: 2.7H:1V to flatter than 3.0H:1V Levee Slope Height = 8 feet Bench Width to Bank Slope = 15 feet Bank Slope: 1.4H to 2.1H:1V Bank Slope Height = 28 feet This section was selected for RDD analysis considering waterside slope, bank slope, and embankment, and blanket materials. The embankment and blanket materials are fine-grained plastic soils which are prone to RDD conditions. Responding to DWR Review Comments ID # 133, sensitivity analysis with drained strength c'=0 psf and phi'=28 degree and undrained strength c=100 psf and phi=15 results in FS=1.10

1517

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 1933+00	Cutoff Wall Tip Elev. +50'	109.1	102.8	6.3	200yr + 4'	106.2	<0.10 [Toe, blanket=10.2'] 0.50 [bottom of ditch 70' from toe, blanket =0.6']	0.0	Total head boundary condition as an elevation head at far field is used for the upper pervious Layer 3 (SP-SM) on right side of model. It prevents unrealistic seepage flow back from landside. Exit gradients are calculated at the toe and bottom of ditch 70 feet from the toe. Blanket includes Layer 2 (CL). Sensitivity analysis with no flow boundary condition at landside far field and tip elev. +75 results in; 200yr+1' i > 2.0 [bottom of ditch, blanket=0.6'] Sensitivity analysis with no flow boundary condition at landside far field and tip elev. +40 results in; 200yr+1' i=0.67 [bottom of ditch, blanket=0.6'] Responding to DWR Review Comment ID #134, sensitivity analysis with no flow boundary condition at landside far field and tip elev. +80 results in; 200yr+4' i >2.0 [bottom of ditch, blanket=0.6'] FS=3.83 (Slope stability) 200yr+1' i >2.0 [bottom of ditch, blanket=0.6'] FS=3.00 (Slope stability) Responding to DWR Review Comments ID #135, exit gradient for thick blanket are calculated as below; 200yr+4' i<0.10 [Toe, thick blanket=18.6' through Layers 2 to 5] 200yr+1' i<0.10 [Toe, thick blanket=18.6' through Layers 2 to 5]	3.14		-	
					200yr + 1'	103.2	<0.10 [Toe, blanket=10.2'] 0.33 [bottom of ditch 70' from toe, blanket =0.6']	0.0		3.17		-	

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Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 32													
Station 1965+80	Cutoff Wall Tip Elev. +40'	110.6	89	21.6	200yr + 4'	106.6	0.30 [Toe, blanket=6.3']	0.0	Blanket includes Layer 1 (SC-SM) and Layer 2 (CL).	1.55	Sensitivity Analysis with OCR<2 for layer 2 (CL) results in; 200yr+4 FS=1.38 200yr+1 FS=1.39	-	
					200yr + 1'	103.6	0.25 [Toe, blanket=6.3']	0.0		1.56		-	
Station 1980+00	Cutoff Wall Tip Elev. +48'	110.4	98	12.4	200yr + 4'	106.8	RDD Analysis Only			RDD Analysis Only		-	Waterside Levee Slope: 1.4H to 2.7H:1V Waterside Levee Slope Height = 13 feet Bench Width to Bank Slope = > 35 feet Bank Slope: NA Bank Slope Height = NA This section was selected for RDD analysis considering waterside slope, bank slope, and embankment, and blanket materials. The embankment and blanket materials are fine-grained plastic soils which are prone to RDD conditions. Critical slip failure surface is located within the steeper portion of the levee slope where the existing silt embankment has been modeled as normally consolidated silt with c'=0 and a ϕ'=30°. Sensitivity analysis assuming c'=50 psf and a ϕ'=31° generates a min FS=1.21.
					200yr + 1'	103.8						0.93	

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 1981+50	Cutoff Wall Tip Elev. +48'	111.2	99.1	12.1	200yr + 4'	106.9	<0.10 [Toe, blanket =12.7']	0.0	Breakout is beyond toe.	1.67		-	
					200yr + 1'	103.9	<0.10 [Toe, blanket =12.7']	0.0	Responding to DWR Review Comment ID #139, sensitivity analysis was performed with shallow cutoff tip elev. +86.2'. The results are as below; 200yr+4' i<0.10 [Toe, blanket=12.7'] i=0.88 [Depression 270' from toe, blanket=4.3'] Breakout above toe = 0.7' FS = 1.56 (Slope stability) 200yr+1' i<0.10 [Toe, blanket=12.7'] i=0.78 [Depression 270' from toe, blanket=4.3'] Breakout above toe = 0' FS = 1.67 (Slope stability)	1.67		-	

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Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 33													
Station 2008+00	Cutoff Wall Tip Elev. +90'	113.0	101.7	11.3	200yr + 4'	108.3	<0.10 [Toe, blanket=7.8']	0.0	Sensitivity Analysis Only	1.49		-	
					200yr + 1'	108.3	<0.10 [Toe, blanket=7.8']	0.0	Responding to IPE Review Comment ID #11, analysis was performed at station 2008+00 to verify the design. 200yr+4' i=0.15 [toe, thin blanket =18.4'] i=0.10 [toe, thick blanket=25.8'] breakout=0.7'above toe 200yr+1' i<0.10 [toe, thin blanket =18.4'] i<0.10 [toe, thick blanket=25.8'] breakout at toe	1.61		-	
Station 2076+90	Cutoff Wall Tip Elev. +33'	118.4	103.8	14.6	200yr + 4'	113.6	<0.10 [Toe, blanket=7.8']	0.0	Blanket includes Layer 2 (ML).	1.56		-	
					200yr + 1'	110.6	<0.10 [Toe, blanket=7.8']	0.0	Responding to DWR Review Comment ID#140, sensitivity analysis was performed with cutoff wall tip elev. +60'. The results are as below; 200yr+4' i=0.81 [Toe, blanket=7.8'] Breakout above toe = 3.6' FS = 1.20 (Slope stability) 200yr+1' i=0.56 [Toe, blanket=7.8'] Breakout above toe = 2.4' FS = 1.24 (Slope stability)	1.56			
Station 2114+00	Cutoff Wall Tip Elev. +90'	121.8	107.0	14.8	200yr + 4'	115.5	=0.57 [Toe, blanket=11.3']	3.1	Exit gradient is calculated at the toe. Blanket includes Layer 2 (ML).	1.42		-	
					200yr + 1'	112.5	=0.36 [Toe, blanket=11.3']	1.5	During meeting with DWR on Aug. 14 2012, URS agrees to an additional exploration in this area.	1.56		-	

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 34													
Station 2141+00	Cutoff Wall Tip Elev. +20'	123.5	109.9	13.6	200yr + 4'	117.3	<0.1 [Toe, blanket=9.6']	0.0	Exit gradient is calculated at levee toe. Blanket includes Layer 2 (ML). Sensitivity Analysis With cutoff wall tip elev.+90' results in; 200yr+4': i=0.71 (Toe) 200yr+1': i=0.43 (Toe) Responding to DWR Review Comment ID#145, sensitivity analysis was performed with a thicker blanket, connecting the crown and landside boring, and cutoff wall toe elev. +90'. The results are as below; 200yr+4' i=0.39 [Levee toe, blanket=17.8'] i=0.69 [70 feet from toe, blanket=9.6'] Breakout=1.7' FS=1.47 (Slope Stability) 200yr+1' i=0.23 [Levee toe, blanket=17.8'] i=0.41 [70 feet from toe, blanket=9.6'] Breakout=0.5' FS=1.60 (Slope Stability) During meeting with DWR on Aug. 14 2012, URS agrees to an additional exploration in this area (responding to DWR comment #145).	1.65	Responding to DWR Review Comment ID#144, sensitivity analysis was performed with shear strength of c'=0 psf and p'=30 deg. (OCR<2) for Layer 2. The results are as below; FS=1.44 for 200yr+4 FS=1.45 for 200yr+1	-	
					200yr + 1'	114.3	<0.1 [Toe, blanket=9.6']	0.0		1.65		-	

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Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 2171+00	Cutoff Wall Tip Elev. +50'	123.9	110.3	13.6	200yr + 4'	119.4	<0.10 [Toe, thin blanket=5.5'] <0.10 [Toe, thick blanket=14.4']	0.0	Exit gradient is calculated at the toe. Thin blanket includes Layer 2 (SM). Thick blanket includes Layer 2 (SM), Layer 3 (SP) and Layer 4 (SM).	1.78		-	
					200yr + 1'	116.4	<0.10 [Toe, thin blanket=5.5'] <0.10 [Toe, thick blanket=14.4']	0.0	Responding to DWR Review Comment ID#146, sensitivity analysis was performed with tip elevation +97.2'. The results are as below; 200yr+4' i = 0.25 [Toe, thin blanket=5.5'] i = 0.39 [Toe, thick blanket=14.4'] Breakout above LS Toe = 1.2 feet FS = 1.56 (Slope stability) 200yr+1' i = 0.18 [Toe, thin blanket=5.5'] i = 0.26 [Toe, thick blanket=14.4'] Breakout above LS Toe = 0.7 feet FS = 1.66 (Slope stability) Responding to DWR Review Comment ID#146, sensitivity analysis was performed with tip elevation +97.2' and with assumed ML for Layer 2 (SM) and Layer (SP). The results are as below; 200yr+4' i = 0.85 [Toe, blanket=8.4'] Breakout above LS Toe = 4.4 feet FS = 1.32 (Slope stability) 200yr+1' i = 0.57 [Toe, blanket=8.4'] Breakout above LS Toe = 3.0 feet FS = 1.59 (Slope stability)	1.80		-	

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Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 2177+00	Cutoff Wall Tip Elev. +50'	123.9	110.3	13.6	200yr + 4'	119.7	0.25 [Toe, blanket=13.1']	0.5	Exit gradient is calculated at the toe. Blanket includes Layer 2 (ML). Sensitivity Analysis With the cutoff wall tip elev.+90' results in; 200yr+4': i=0.60 [Toe] 200yr+1': i=0.41 [Toe] NOTE: 2D analysis result did not meet the criteria for 200yr+4. Location is at 90 degree bend of levee; 3D effect expected to increase gradient to higher than allowable.	1.44	Sensitivity Analysis With the cutoff wall tip elev.+90' results in; 200yr+4' FS=1.04 200yr+1' FS=1.27	-	
					200yr + 1'	116.7	0.17 [Toe, blanket=13.1']	0.5		1.53			

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Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 35													
Station 2211+30	Cutoff Wall Tip Elev. +45'	126.2	110.3	15.9	200yr + 4'	124.7	<0.10 [Toe, blanket=15.1'] <0.10 [60 ' from toe blanket=13.3']	0.0	Exit gradients are calculated at the toe and 60 feet from the toe. Blanket includes Layer 2 (ML). Sensitivity Analysis With the thin blanket (=7.0 feet) determined based on WM0007_007B results in; 200yr+4': i<0.10 [Toe] 200yr+1': i<0.10 [Toe]	1.81		-	Waterside Levee Slope: 2.7H:1V to flatter than 3.0H:1V Levee Slope Height = 17 feet Bench Width to Bank Slope = > 35 feet Bank Slope: NA Bank Slope Height = NA
					200yr + 1'	121.7	<0.10 [Toe, blanket=15.1'] <0.10 [60' from toe, blanket=13.3']	0.0		1.81		1.40	
Reach 36													
Station 2250+78	Cutoff Wall Tip Elev. +70'	130	113.2	16.8	200yr + 4'	126.6	<0.10 [Toe, blanket=6.5'] =0.16 [Toe, blanket=38.5']	0.0	Exit gradient is calculated at levee toe. Blanket includes Layer 2 (SC). A set of sensitivity analyses were performed by raising the cutoff wall tip elevation to +70 feet and incorporating a 3 feet thick aquiclude from elevation 75 to 78 feet. Both GC and CL materials were considered for the aquiclude. Responding to DWR Review Comment ID#152, sensitivity analysis was performed with aquiclude modeled as GC (kh=4.0E-04 cm/s) material. The results are as below; 200yr+4' i=0.65 [Levee toe (6.5 feet blanket – SC(2))] i=0.13 [Levee toe (38.5 feet blanket-SC, GW, and GC)] Breakout above LS Toe = 3.0 feet FS = 1.55 (Slope stability) 200yr+1' i=0.49 [Levee toe (6.5 feet blanket – SC(2))] i=0.10 [Levee toe (38.5 feet blanket-SC, GW, and GC)] Breakout above LS Toe = 2.3 feet FS = 1.68 (Slope stability)	2.05		-	
					200yr + 1'	123.6	<0.10 [Toe, blanket=6.5'] =0.12 [Toe, blanket = 38.5']	0.0		2.06		-	

Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 37													
Station 2276+76	Cutoff Wall Tip Elev. +42'	132.4	117.2	15.2	200yr + 4'	127.8	0.28 [10' from Toe, blanket=9.7']	0.0	Exit gradient is calculated at the toe. Blanket includes Layer 2 (ML).	1.75		-	
					200yr + 1'	124.8	0.22 [10' from Toe, blanket=9.7']	0.0	Responding to DWR Review Comment ID#153 a set of sensitivity analyses were performed with revised Layer 3 (SP) layering, a cutoff wall tip elevation of +70 feet, and hydraulic conductivity of Kh = 1.2E-03 cm/s for the aquiclude (Layer 5), based on WM007_067S. The results are as below: 200yr+4' i = 0.93 [10' from toe (9.7' blanket –ML(2)] Breakout above LS Toe = 3.5 feet FS = 1.14 (Slope stability) 200yr+1' i = 0.69 [10' from toe (9.7' blanket –ML(2)] Breakout above LS Toe = 2.2 feet FS = 1.43 (Slope stability) Responding to DWR review comment #25, sensitivity analysis was performed with Layer 4 Kh increased by factor 10 to 5.0E-01 cm/s. The results are as below; 200yr+4' i=0.24 [10' from toe (x=54.5), blanket=9.7'] Breakout above toe = 0' FS = 1.80 (Slope stability) 200yr+1' i=0.19 [10' from toe (x=54.5), blanket=9.7'] Breakout above toe = 0' FS = 1.82 (Slope stability) Above gradients are slightly lower than the original analysis. Results for analysis with Layer 4 Kh increased by factor of 100 are the same as those above.	1.81		-	

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Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 2280+00	Cutoff Wall Tip Elev. +45'	132.1	116.3	15.8	200yr + 1'	124.9	RDD Analysis Only			RDD Analysis Only		1.53 (slip surface on WS bank) 1.58 (deep slip surface)	Waterside Levee Slope: 2.7H:1V to flatter than 3.0H:1V Levee Slope Height = 15 feet Bench Width to Bank Slope = 15 feet Bank Slope: 1.2H to 2.7H:1V Bank Slope Height = 12 feet
Reach 38													
Station 2291+75 (WITHOUT ML BLANKET LAYER)	Seepage berm 11' high extending horizontally at elev. 200yr + 4' for a distance of 50' from the landside levee slope before tapering to a height of 3' at a distance of 170' from levee centerline	132.9	117.6	15.3	200yr + 4'	128.5	No blanket condition	No breakout above seepage berm	Considering the presence of the pond north of this reach, total head boundary condition equal to ground surface elevation was used. The ground surface head boundary condition was assigned along the vertical face of landside in model at 1,000 feet away from the levee. Poorly graded Gravel (GP-GM, 5% fines) was assumed for seepage berm. The cutoff wall from Reach 37 extends about 200 feet into Reach 38 (from station 2290+00 to station 2292+00). This cutoff wall was not modeled in the analysis.	4.09		-	
					200yr + 1'	125.5	No blanket condition	No breakout above seepage berm		4.44		-	
Station 2291+75 (WITH ML BLANKET LAYER)	Seepage berm 11' high extending horizontally at elev. 200yr + 4' for a distance of 50' from the landside levee slope before tapering to a height of 3' at a distance of 170' from levee centerline	132.9	117.6	15.3	200yr + 4'	128.5	0.77 [toe of berm, blanket=10.6']	1.5	Considering the presence of the pond north of this reach, total head boundary condition equal to ground surface elevation was used. The ground surface head boundary condition was assigned along the vertical face of landside in model at 1,000 feet away from the levee. Poorly graded Gravel (GP-GM, 5% fines) was assumed for seepage berm. Responding to DWR comment ID EXT/Reach38-002 and IPE comment ID EXT/Reach38-001, the filter compatibility check has been performed (see appendix C).	2.68		-	
					200yr + 1'	125.5	0.57 [toe of berm, blanket=10.6']	1.5		3.25		-	

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Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 40													
Station 2328+58	No rehabilitation measure	137.0	119.0	18.0	200yr + 4'	133.0	No blanket condition	Elev. 119.7' (Pond WSE 119.0') Elev. 108.0' (Pond WSE 106.5')	The pond was evaluated with a lower water level equal to that recorded during the LiDAR survey (Elevation 106.5 feet) and a higher water level equal to the landside ground surface elevation (Elevation 119.0 feet). A no flow boundary condition at a distance of 2,000 feet from the levee centerline was assumed for the landside vertical face of the model. A continuous bathymetry survey is not available for these landside ponds. However, the HDR design team has performed a line survey at Station 2328+00. The cross section for Station 2328+58 was developed using the DWR ULE LiDAR data and extended in the pond using the FRWL survey data. Responding to DWR review comment ID EXT/Reach40-002 for Design Tech Memo, the rate of seepage flow into the landside pond is calculated as below: <u>Pond WSE 119.0'</u> 200yr+4': Total Q = 0.42 gpm/ft Q above El. 119.0' = 0.08 gpm/ft 200yr+1': Total Q = 0.30 gpm/ft Q above El. 119.0' = 0.06 gpm/ft <u>Pond WSE 106.5'</u> 200yr+4': Total Q = 0.63 gpm/ft Q above El. 106.5' = 0.26 gpm/ft 200yr+1': Total Q = 0.52 gpm/ft Q above El. 106.5' = 0.19 gpm/ft	1.47 (Pond WSE 119.0') 1.57 (Pond WSE 106.5')			
					200yr + 1'	130.0	No blanket condition	Elev. 119.0' (Pond WSE 119.0') Elev. 108.0' (Pond WSE 106.5')		1.52 (Pond WSE 119.0') 1.65 (Pond WSE 106.5')			

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Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 2332+91	Seepage berm 120' feet wide, 9' thick at levee toe and 3' thick at berm toe	137.6	120.2 (Top of seepage berm: 129.2)	17.4 (Top of levee to top of seepage berm: 8.4)	200yr + 4'	134.1	<0.10 [Toe of levee, blanket=14.6'] <0.10 [Toe of seepage berm, blanket=5.2']	No breakout above seepage berm	Exit gradients are calculated at the toe of levee and toe of seepage berm. Blanket at levee toe includes Layer 11 (GP-GM, seepage berm) and Layer 3 (CL). Blanket at seepage berm toe includes Layer 3 (CL). Responding to DWR comment ID EXT/Reach40-003, and IPE comment IDs EXT/Reach40-002 and EXT/Reach40-003, the filter compatibility check has been performed (see appendix C). Responding to DWR review comment ID EXT/Reach40-002 for Design Tech Memo, the rate of seepage flow from the berm toe extending 125 ft landside is calculated as below: 200yr+4': Total Q = 0.33 gpm/ft 200yr+1': Total Q = 0.29 gpm/ft	2.25		-	
					200yr + 1'	131.1	<0.10 [Toe of levee, blanket=14.6'] <0.10 [Toe of seepage berm, blanket=5.2']	No breakout above seepage berm		2.25		-	
Station 2349+00	Seepage berm 100' feet wide, 9' thick at levee toe and 3' thick at berm toe	139.0	120.0	19.0	200yr + 4'	135.4	<0.10 [Toe of levee, blanket=22.3'] 0.23 [Toe of seepage berm, blanket=13.4']	No breakout above seepage berm	Considering the presence of the Sutter Butte Canal in this area, a total head boundary condition used at the landside vertical face of the model at 1,800 feet away from the levee. Exit gradients are calculated at the toe of levee and toe of seepage berm. Blanket at levee toe includes Layer 8 (GP-GM, seepage berm), Layer 1 (GP-GM), and Layer 2 (SC). Blanket at seepage berm toe includes Layer 1 (GP-GM) and Layer 2 (SC). Responding to DWR comment ID EXT/Reach40-003, and IPE comment IDs EXT/Reach40-002 and EXT/Reach40-003, the filter compatibility check has been performed (see appendix C).	2.27		-	
					200yr + 1'	132.4	<0.10 [Toe of levee, blanket=22.3'] 0.13 [Toe of seepage berm, blanket=13.4']	No breakout above seepage berm		2.27		-	

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Table 8-1. Seepage, Stability and Rapid Drawdown Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 41													
Station 2362+70	Seepage berm 100' wide, 5' thick at levee toe (including 1' thick filter layer) and 3' thick at berm toe	139.2	123.2	16.0	200yr + 4'	135.8	0.35 [Toe of levee, blanket=16.1'] 0.92 [Toe of berm, blanket=10.6']	No breakout above seepage berm	Considering the presence of Thermalito Afterbay on north of this reach and a lateral canal on west of this reach, total head boundary condition equal to the ground surface elevation was used for analysis. The ground surface head boundary condition was assigned along the landside vertical face in the model at 1000 feet away from the levee. Gravel (GP-GM, 3-7% fines) was used for seepage berm material. ASTM C33 fine aggregate was used as filter drain. Geotextile separator was not modeled in the analysis. Exit gradients are calculated through the clay blanket at the toe of levee and toe of berm. Responding to DWR comment ID EXT/Reach41-002, and USACE comment ID #14, the filter compatibility check has been performed (see appendix C).	1.77		-	Waterside Levee Slope: 2.1H to 2.7H:1V Levee Slope Height = 16 feet Bench Width to Bank Slope = > 35 feet Bank Slope: NA Bank Slope Height = NA
					200yr + 1'	132.8	0.19 [Toe of levee, blanket=16.1'] 0.70 [Toe of berm, blanket=10.6']	No breakout above seepage berm		1.77		1.65	

[1]Measured from the landside toe to the top of the levee.
[2]Assumed a 26-foot drop for Reaches 2 to 17 and a 15-foot drop for Reaches 18 to 41.

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ENCLOSURE L

MEMORANDUM ON ULE AND SBFCA SEISMIC EVALUATIONS

REVIEW
of the ULE – Sutter Task Area: Feather River West (Right Bank) Levee
Seismic Vulnerability Issues

Reviewed Documents

The reviewed documents were:

- (1) Phase 1 Preliminary Geotechnical Evaluation Report (P1GER) – Sutter Study Area, prepared by URS for DWR, dated March 2008 (Chapter 5.4 and Appendix C-3)
- (2) Geotechnical Design Recommendations Report – Feather River West Levee Project Segment 7, prepared by Blackburn Consulting for SBFCA, dated October 2012 (Sections 2.6.5 and 8.4, Appendix A, Appendix B(-1), Appendix B-2, Appendix D
- (3) Geotechnical Design Recommendations Report – Feather River West Levee Project Segments 1 through 6, prepared by URS for SBFCA, dated October 2012 (Sections 6.5 and 8.3, Appendix A, Appendix B(-1), Appendix B-2, Appendix D

Additional data were obtained from the following documents:

- Phase 1 Geotechnical Data Report (P1GDR) – Sutter Study Area, prepared by URS for DWR, dated November 2008

Seismicity Assessment

Ground accelerations for 100-year, 200-year and 500-year return period earthquake events were estimated using information from the Guidance Document for Geotechnical Analyses version 5 (URS, 2007). The evaluations in document (1) considered all 3 return periods; documents (2) and (3) used the 200-year return period only. The computed peak ground acceleration values in document (1) are compared below with data from USGS Interactive Deaggregations (2008) recommended by USACE, for slightly different return periods:

Table 1 – Seismicity Assessment in Document (1)

Levee Segment	Return Period (years) URS / USGS*	Peak Ground Acceleration	
		Per URS	Per USGS
Sutter Bypass and Wadsworth Canal	100 / 108	0.11g	0.11g
	200 / 224	0.14g	0.15g
	500 / 475	0.18g	0.19g to 0.20g
Feather River South	100 / 108	0.10g to 0.11g	0.10g to 0.11g
	200 / 224	0.13g to 0.14g	0.14g to 0.15g
	500 / 475	0.16g to 0.18g	0.18g to 0.19g
Feather River North	100 / 108	0.10g	0.10g
	200 / 224	0.13g	0.13g to 0.14g
	500 / 475	0.16g	0.18g

Note: * USGS date are available for 50% probability of exceedance in 75 years, or 108-year average return period; 20% probability of exceedance in 50 years, or 224-year average return period; and 10% probability of exceedance in 50 years, or 475-year average return period.

It is evident that the URS evaluation and our independent one are in good agreement. Differences of up to 0.02g for the 500-year return period event are not significant.

It is noted that of major importance in PGA evaluation is the assumed amplification of the seismic motion, which depends mainly on the shear wave velocity of the upper 30 meters near the ground surface, Vs30. URS assumed in all cases Vs30 = 800 fps = 240 m/s. For verification of this assumption shear wave velocity measurements were not available, but 20 borings with SPT's to a depth of at least 100 feet were used to evaluate Vs30 through correlations with N_{60} available in literature, as shown in Figure 1 [Figures 23 for large data base of all types of soils and Figure 24 for granular soils, from USACE WES (1987)]. The 20 borings considered were along the Feather River South levee system (MA3), between Stations 2204+77 and 3211+79.

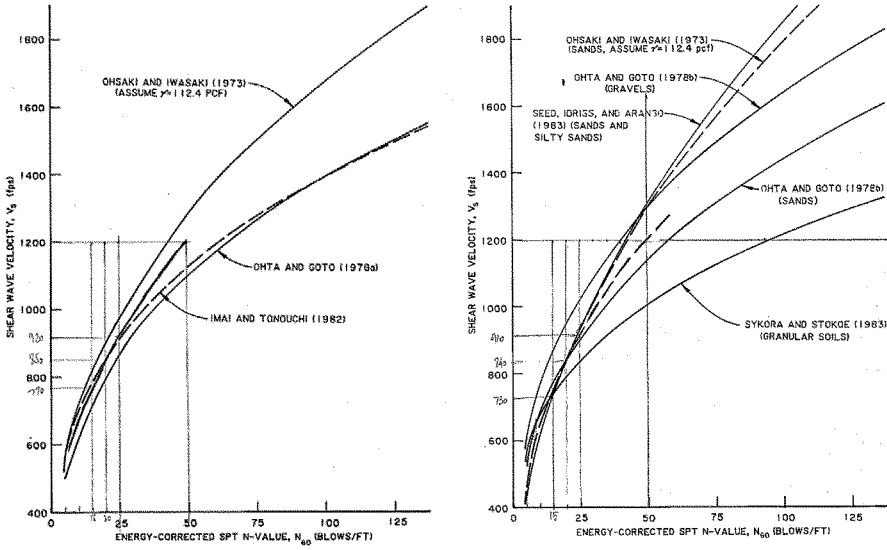

Figure 23. Comparison of results for N versus V_s correlations (proposed by select studies)

Figure 24. Comparison of results for N versus V_s correlations in granular soils (proposed by select studies)

Figure 1. Excerpt of USACE WES (1987): Average curves were considered that pass through the point represented by N_{60} = 50 and Vs = 1200 fps, which is the boundary between stiff soil and soft rock in USGS classification.

The harmonic mean (which is the average value definition appropriate for velocity and, therefore, for N_{60} when it is used as a proxy for Vs) for each boring varied between 12.3 and 31.0, with an arithmetic mean of them of 19.6; the corresponding Vs value on the average curves

in Figure 1 is 844 fps and 834 fps, respectively. The selected value of 800 fps is considered appropriate, slightly conservative with respect to the average curves but close to the middle of the range corresponding to the various recommended criteria. It is mentioned that the same value of 800 fps (240 m/s) was used in conjunction with the evaluation of PGA per USGS, as presented in the last column of Table 1.

The expected earthquake magnitudes (Mw) associated with the three return period events listed in Table 1 are:
- Mw = 6.5 for 100-year return period event,
- Mw = 7.0 for 200-year return period event, and
- Mw=8.0 for 500-year return period event, per URS study.

The USGS reference confirmed these estimates, except for the 500-year return period event where Mw can be as high as 9.0 for Feather River North, probably due to relative proximity to the Cascadia Subduction zone.

In summary, the reviewer found the seismicity assessment in document (1) correct.

Documents (2) and (3) used for the seismicity assessment the ULE Hazard Map for a 200-year Return Period developed for Marysville, Sacramento, and Stockton regions. This map provides PGA assuming stiff soil condition (V_{s30} = 335 m/s); this is different from V_{s30} = 240 m/s used in document (1) and we found acceptable and corresponds to stiff soil outcropping motion. Consequently, there is a significant difference between URS estimates and the values recommended by USGS for a similar return period but a softer soil condition. See the comparison in the following table:

Table 2 – Seismicity Assessment in Documents (2) and (3)

Levee Segment	Return Period (years) URS / USGS*	Peak Ground Acceleration	
		Per URS	Per USGS
Feather River South Reaches 1 – 6	200 / 224	0.125g	0.14g
Feather River South Reaches 7 – 22	200 / 224	0.125g	0.13g to 0.14g
Feather River North Reaches 23 – 41	200 / 224	0.11g	0.13g

Based on the graph in Figure 1 we estimate V_{s30} = 335 m/s to correspond to N_{60} = 42.5. Our spot checks found, as shown before, an average N_{60} of about 20, with the range of 12 to 31 for the evaluated locations (20 borings along the Feather River South levee). It is emphasized that the representative average for an individual boring is the harmonic mean, as N_{60} is a proxy for shear wave velocity; consequently the low values occurring generally near the surface have a much higher weight than the high values at greater depth on the mean value.

The non-conservative assumption with regard to PGA selection may be compensated by a conservative triggering criterion, as shown below.

Liquefaction Triggering Analyses

As specified in Chapter 5.4 "Seismic Vulnerability Analyses" of the report (1), liquefaction analyses have been done for the following levee units:

In Northern Sutter Bypass (Tisdale Bypass to Wadsworth Canal) and Wadsworth Canal (ENGEO analysis sections), liquefaction triggering analyses for 500-year return period earthquake events were performed using the results of SPT borings and 2 year flood elevations. No seismic deformation analyses were performed in these sections. The liquefaction triggering analyses were not available and, therefore, not reviewed. However, it is believed the same methodology as for the unit listed below was used, so the comments below should apply to this unit also.

In Southern Sutter Bypass (Tisdale Bypass to Feather River Confluence) and Feather River South sections (URS analysis sections), liquefaction triggering analyses for 500-year, 200-year, and 100-year return period earthquake events were performed using the results of SPT borings and typical winter water levels (February Mean). The liquefaction analyses were performed to the bottom of the exploration depths. Based on the results of the liquefaction analyses, seismic deformation analyses were performed in eight sections using the results of liquefaction analyses for 500-year return period earthquake event. If the results of the analyses indicated "probably uncompromised" seismic vulnerability class, no further analyses were performed. If the results of the analyses indicated "Possibly Compromised," "Likely Compromised," or "Compromised" seismic vulnerability classes, further analyses were performed using liquefaction analyses results for 200-year and 100-year return period earthquake events. The evaluations by URS will be discussed in detail in what follows.

In Feather River North sections (GEI analysis sections), liquefaction triggering analyses for 500-year, 200-year, and 100-year return period earthquake events were performed using the results of SPT borings and typical winter (February Mean) or summer (August Mean) water levels, which one was higher. The liquefaction analyses were performed to a depth of 50 feet below the bottom of the levee base. Based on the results of the liquefaction analyses, seismic deformation analyses were performed in nine sections using the results of liquefaction analyses for 500-year return period earthquake event. Neither the results of the liquefaction triggering analysis nor those of seismic deformation analyses were available, but it is assumed the same procedures as URS did for Feather River South sections were used.

URS spreadsheet for liquefaction triggering analysis is based on the procedure recommended by Cetin et al. (2004), that is slightly more conservative than the procedure by Youd et al. (2001) recommended in USACE Guidelines (draft ETL 1110-2-580); however, both procedures are considered state-of-the-practice and can alternatively be used.

The analyses were performed on 20 borings with SPT drilled along the Feather River South, practically one representative boring for each reach, M through Z4 (Stations 2166+00 to 3295+59). The results for the first two analyzed borings are plotted in Figure 2.

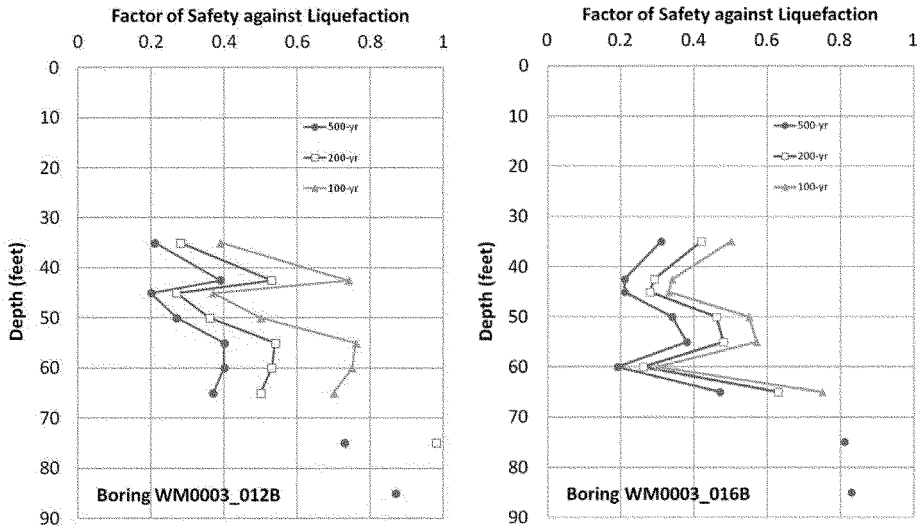

Figure 2. Variation with depth of the factor of safety against liquefaction for two locations in the southern part of the Feather River South levee system (Stations 2204+77 and 2282+82).

The plots in Figure 2 are representative for many other locations along the Feather River South. With the exception of some deep, isolated layers (at 75 feet and 85 feet), the easiest liquefiable layer (in these cases between depths of 35 feet and 65 feet) liquefies under the action of the 500-year return period event, but also under the 200-year and 100-year. It makes little difference if FS_{liq} is of the order of 0.2-0.4 or 0.3-0.5 or 0.4-0.7; in all cases the 30-foot layer is expected to fully liquefy. In all three cases the residual undrained strength is expected to mobilize, which theoretically depends on N (SPT) only and is independent on the FS_{liq}.

It is noted that in the cases presented in Figure 2 the liquefiability index ($N_{1,60\text{-}cs}$) was relatively low, with the 33-percentile average of the 30-foot liquefiable layer of 8.9 and 5.0, respectively. There is, however, little difference in other locations. Figure 3 presents the results obtained in two locations at the northern limit of the Feather River South levee system, where the liquefiability index ($N_{1,60\text{-}cs}$) was relatively higher, with the 33-percentile average of the 20-foot or 30-foot liquefiable layer of 11.6 and 11.0, respectively. It is evident that in this case also the liquefaction occurs with all three different return period considered.

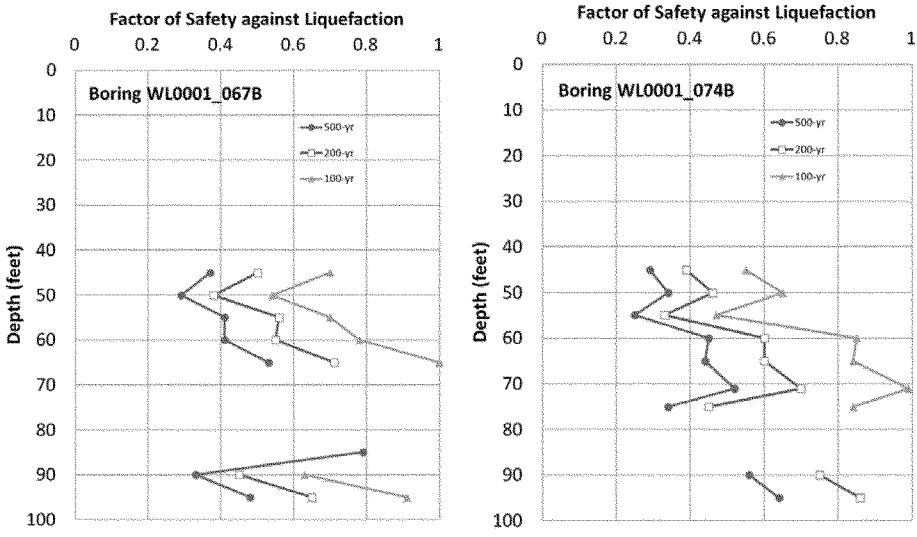

Figure 3. Variation with depth of the factor of safety against liquefaction for two locations in the northern part of the Feather River South levee system (Stations 3027+34 and 3073+29).

Documents (2) and (3) used similar procedure for triggering analysis, but for 200-year return period only. Not all details were available, but the DWR Guidance Document, Revision 10, developed by URS was used in both cases.

In general, the evaluation of the liquefaction susceptibility is satisfactory with all three documents.

Levee Stability Evaluation

Once significant liquefaction of the foundation soil was found probable, stability analysis is performed in steps:

- First, post-earthquake slope stability analyses were performed using limit equilibrium software. The computer program used is not specified in documents (2) and (3); with document (1) Utexas4 was apparently used. In accordance with USACE requirements, the DWR-ULE Guidance requires the Spencer approach be the basis for all stability analyses. We believe this requirement was met.

An important parameter in post-earthquake analyses is the residual strength of liquefiable materials. As with USACE (2013) draft guidelines the correlation proposed by Seed and Harder (1990) is recommended. Correctly, for estimating the undrained residual strength from the Seed & Harder plot, the lower 1/3 curve of the upper and lower range limits was used.

USACE (2013) recommends to alternatively use Seed and Harder (1990) and Olson and Stark (2002) procedures and to consider both results as possible occurrences. Although we would prefer both procedures to be considered in evaluation, the URS recommended approach is state-of-the-practice and acceptable.

Also in accordance with USACE concepts, if the calculated post-earthquake FS, for any calculated potential failure surface, is less or equal to 1.0, then the study-section should be considered unstable (i.e. "compromised") and no further evaluations are needed. In addition to this criterion, USACE (2013) Guidelines state that for intermittent-hydraulically loaded levees (like Feather River levees) further evaluation is not needed if FS > 1.2 and the levee should be considered stable and continuing to function after the design earthquake occurrence.

- Next step was to perform a pseudo-static stability analysis with a horizontal seismic coefficient not well defined; the suggested value (0.5 K_{max}, where K_{max} is the maximum seismic coefficient for a potential sliding mass) is not justified. It is noted that this evaluation is not mentioned in the Guidance Document (URS, 2012) or the USACE (2013) Guidelines. However, it was included in a Technical Memorandum prepared by URS in October 2012 for SBFCA and apparently accepted by technical reviewers (Les Harder, Jr., Lelio Mejia, John Hess, and Francke Walberg).

If the minimum calculated FS for this pseudo-acceleration level ($K = 0.5\ K_{max}$) was greater than 1.0, no additional evaluation was considered necessary and the study section was classified as probably uncompromised and further refinement for the vulnerability evaluation was considered unnecessary.

It is noted that the criterion FS > 1.0 for the pseudo-static stability analysis is in lieu of the USACE supported (USACE, 2013) criterion of FS > 1.2 for the post-earthquake stability analysis. More evaluations are necessary for deciding which criterion is the most appropriate.

Deformation Analysis

Deformation analysis should be done if the study section could not be classified through previous analyses as "Compromised" or "Probably Uncompromised". The goal of the seismic deformation analyses is to evaluate post-seismic vertical displacements at the levee crest, classification into the other two categories ("Likely Compromised" and "Possibly Compromised") be made possible. USACE (2013) Guidelines offer several alternate methods for estimation of displacements, including that based on the Newmark approach which is the only one recommended by URS Technical Memorandum and used in documents (2) and (3).

The recommended approach is based on the Makdisi and Seed, 1978 method, but replaces the original range of results with an average one. Figure 4 compares the range in the original Makdisi & Seed study (interpolated for M7 between the original ranges provided for M6.5 and M7.5) with the average curve recommended in URS Technical Memorandum. The obtained Newmark displacement should be multiplied by 0.7 to obtain an estimate of the freeboard loss (vertical displacement).

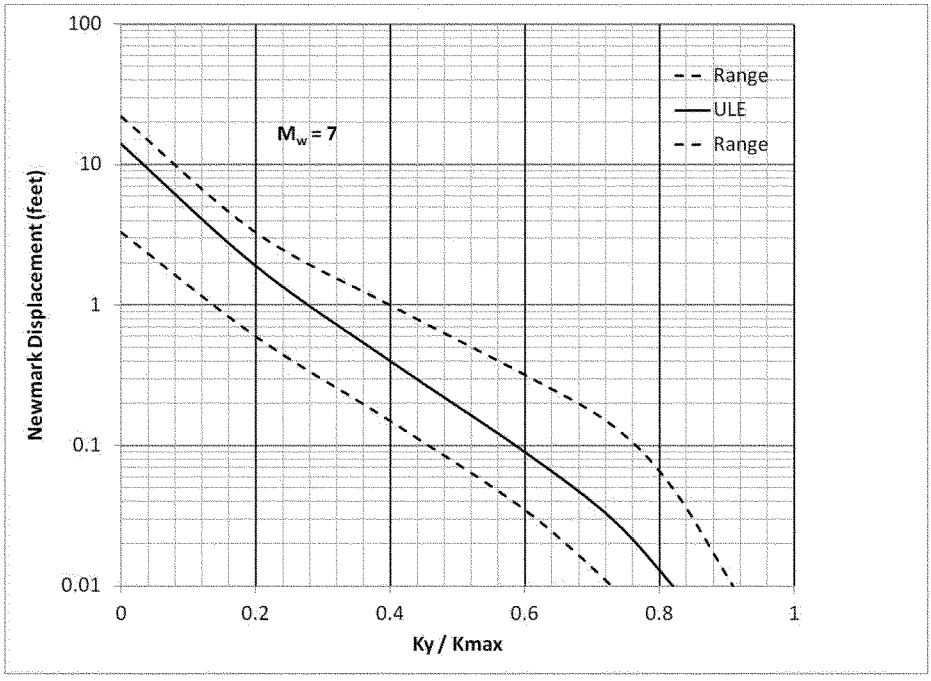

Figure 4. Comparison between the URS (2012) recommended correlation for ULE (solid line) and the range indicated by Makdisi and Seed (1978) (dashed lines).

It is evident that the actual scatter of the results, which is not mentioned in URS (2012) Guidelines, for a credible classification based on more or less than 1 foot remaining freeboard after the seismic deformation. For example, if the original freeboard was 3 feet, for a remaining 1 foot of freeboard the estimated Newmark deformation should be 2 feet/0.7 = 3 feet. From Figure 4, an estimate of 3 feet would correspond to $K_y / K_{max} = 0.15$, but the range corresponding to this ratio is 0.9 feet to 5 feet. Based on the average curve (solid line) the seismic vulnerability classification would be on the boundary between "Possibly Compromised" and "Likely Compromised" (remaining freeboard = 1 foot), but based on the possible range the study section can be classified either "Likely Compromised" (no remaining freeboard) or "Probably Uncompromised" (0.9 x 0.7 = 0.6 feet vertical deformation, which leaves a freeboard of 2.4 feet and represents less than 5% of landside levee height). It is considered that the procedure is not sensitive enough for a credible seismic vulnerability classification.

It is also noted that in the main text of the document (3), section 6.5, the main parameter used in seismic vulnerability classification is "the amount of deformation", but in the referenced Appendix B-2 "Technical Memorandum" the corresponding parameter is "the amount of vertical deformation". There is significant difference between the two parameters, because the amount

of deformation can be the Newmark deformation or the displacement in any direction, including horizontal.

Conclusions

All reviewed documents are satisfactory with reference to liquefaction assessment, evaluation of levee stability, and seismic vulnerability classification in class "compromised". There are not currently available trustable procedures for classification in the other classes. USACE (2013) Guidelines recommend using 2-3 procedures of several presented in appendices, including the procedure recommended and used by URS, but there is no indication if one is better than the others. More experience with using the proposed methods is necessary for an acceptable methodology of seismic vulnerability classification.

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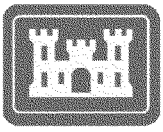
ENCLOSURE M

REPORTS PREPARED BY OUTSIDE AGENCIES (AVAILABLE AS SEPARATE FILES UPON REQUEST)

DWR ULE P1GER
DWR ULE P1GDR
DWR ULE SGDR
DWR NULE GAR
DWR NULE GAR Appendix C
DWR NULE GAR Appendix E
SBFCA Geotechnical Design Recommendations for the PFR
SBFCA Final GDR
SBFCA Final GDRR
Modified SBFCA 65% Plans



US Army Corps
of Engineers.

Sacramento District

Sutter Basin Feasibility Study

Butte and Sutter Counties, California

HYDROLOGY APPENDIX

October 2013

SUTTER BASIN FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA
HYDROLOGY APPENDIX

October 2013

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SUTTER BASIN FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA
HYDROLOGY APPENDIX

JUNE 2012

1. Purpose, Scope, and Authority

1.1 PURPOSE AND NEED FOR THE PROJECT AND REPORT

A high risk of flooding from levee failure threatens the public safety of approximately 80,000 people, as well as property and critical infrastructure throughout the Sutter Basin study area. Past flooding has caused loss of life and extensive economic damages. Recent geotechnical analysis and evaluation of historical performance during past floods indicate the project levees do not meet U.S. Army Corps of Engineers (USACE) levee design standards and are at risk of breach failure at stages less than overtopping. Within the study area, as throughout the Sacramento Valley, floodplain and native habitats have been lost or degraded. Federally listed species and other special status species that are dependent on floodplain habitats have declined. Opportunities exist to restore land formerly converted by mining or agriculture to more natural habitats through Ecosystem Restoration (ER) in conjunction with flood risk management (FRM). There are also opportunities to provide outdoor recreational features on FRM and ER project lands. The purpose of the Sutter Basin Feasibility Study is to address FRM in conjunction with ER and recreation.

The purpose of this hydrology report is to describe the hydrologic features of the basin and to document the design rainfall, the wind-wave analysis, the Sutter Bypass and Feather River discharge frequency, the Cherokee Canal discharge frequency, and the tributary/interior hydrology of the Sutter basin to include the Wadsworth canal discharge-frequency.

1.2 STUDY AUTHORITY

The authority for the U.S. Army Corps of Engineers (USACE) to study FRM and related water resources problems in the Sacramento River Basin, including the study area in Sutter and Butte Counties, is provided in the Flood Control Act of 1962 (Public Law 87-874).

2. Descriptive Information

The study area is located in Sutter and Butte Counties California and is roughly bounded by the Feather River, Sutter Bypass, Wadsworth Canal, Sutter Buttes, and Cherokee Canal. The study area covers approximately 300 square miles and is approximately 43 miles long and 9 miles wide. The study area includes the communities of Yuba City, Live Oak, Gridley, Biggs, and Sutter with a total population of approximately 80,000. Yuba City is the largest community in the study area, with a population of approximately 65,000. A map of the watershed is included as Plate 1 and a map of the study area is included as Plate 2.

The study area is essentially encircled by project levees of the Sacramento River Flood Control Project shown on Plate 3 and high ground of the Sutter Buttes. In 1917, the Federal government authorized the Sacramento River Flood Control Project, which adopted a system of locally built levees as Federal levees, and constructed additional levees, bypasses, overflow weirs, and pumping facilities. Although the Sacramento River Flood Control Project levees were often constructed of poor foundation materials such as river dredge spoils that would not meet today's engineering standards, the levees are relied upon today to provide FRM for numerous communities.

The primary sources of flooding within the study area are the Butte Basin, Sutter Bypass, Feather River, Cherokee Canal, Wadsworth Canal, and local interior drainage. Flood depths and frequency vary throughout the study area. Probability of flooding within the study area is primarily related to the stage of floodwaters within the river channels and the geotechnical probability of levee failure at flood stage.

The Butte Basin is a natural overflow and flood storage area north west of the Sutter Buttes and east of the Sacramento River. The basin provides approximately 1 million acre-feet of transitory storage at flood stage (DWR, 2010). Excess floodwaters from the Sacramento River enter Butte Basin via overbank areas along the river and through the Moulton and Colusa weirs. Butte Creek and its tributaries, including Cherokee Canal, also flow into the Butte Basin. Outflow from the Butte Basin is regulated by hydraulic conditions of Butte Slough and floodplain topography at the upstream entrance to the Sutter Bypass. In order to maintain the flood storage capabilities within Butte Basin, California has included regulation of the overflow area in Title 23 of the California Code of Regulations. In general these standards require approval from the board for any encroachments that could reduce or impede flood flows or would reclaim any of the floodplain within the Butte Basin (DWR, 2010).

The Sutter Bypass is a leveed flood control channel approximately three quarters of a mile wide, bordered on each side by levees. The bypass is an integral feature of the Sacramento River Flood Control Project's flood bypass system. The Sutter Bypass conveys flood waters from the Butte Basin, Sacramento River, and Feather River to the confluence of the Sacramento River and Yolo Bypass at Fremont Weir. Additional flood flows from the Sacramento River enter the Sutter Bypass through Tisdale Bypass. The lower portion of the Sutter Bypass also conveys the Feather River. Within this reach the Feather River is separated from the main conveyance of the bypass by a low levee. This design maintains higher velocities and sediment transport capacity within the Feather River during low flow events while utilizing the large conveyance of the Sutter Bypass during larger events. The Sutter Bypass also receives minor natural flow and agricultural return flow from Reclamation District 1660 to the west and from Wadsworth Canal and DWR pumping plants 1, 2, and 3 to the east. The Sutter Bypass is described by four hydrologic reaches based on tributary inflows; Butte Slough to Wadsworth Canal, Wadsworth Canal to Tisdale Bypass, Tisdale Bypass to Feather River, Feather River to Sacramento River. The Feather River is a major tributary to the Sacramento River, merging with the Sutter Bypass upstream from the Sacramento River and Fremont Weir. The Yuba and Bear Rivers are major tributaries to the Feather River. Two major flood management reservoirs are located within the Feather River watershed: Oroville on the Feather River and New Bullards Bar on the Yuba River. The Feather River is described by four hydrologic reaches based on significant inflows;

Thermalito to Honcut Creek, Honcut Creek to Yuba River, Yuba River to Bear River, and Bear River to Sutter Bypass.

The Cherokee Canal is a tributary to Butte Creek and the Butte Basin. The leveed canal was constructed between 1959 and 1960 by USACE. The canal drainage area is 94 square miles and varies in elevation from 70 feet to 2200 feet. The drainage area is bounded by the Feather River watershed to the east and southeast, Butte Creek and its tributaries to the north and west, and by Wadsworth Canal drainage to the south.

The Wadsworth Canal is a leveed tributary to the Sutter Bypass near the town of Sutter. The canal conveys flow from the East and West interceptor canals to the Sutter Bypass. The East and West interceptor canals collect runoff from canals and shallow floodplain runoff into the Wadsworth Canal.

3. Flood Problems

3.1 GENERAL CHARACTERISTICS

Historically, large areas outside the low-water channel were inundated by Feather River flows in the valley, generally extending from the City of Oroville to the Sacramento River near Verona and encompassing some 292,000 acres, much of which is now agricultural land consisting primarily of orchards, dairy farms, and truck crops. The communities of Marysville and Yuba City are particularly vulnerable to inundation. The average elevation of these two leveed cities varies from 5 to 20 feet below the high water level in the river.

3.2 TOPOGRAPHY

The watershed above Oroville Dam includes mountain crests over 8,000 feet high, mountain valleys at elevations as high as 5,000 feet, deep canyons, and rolling foothills. Elevations range from 10,466 feet at Mt. Lassen Peak to 900 feet at the dam site. A topographic map and stream profiles of the Feather River Basin are presented in Plates 4 and 5.1 and 5.2, respectively. About 58 percent of the basin area is above an elevation of 5,000 feet, and only 7 percent is below 2,500 feet. Table 1 shows the distribution of the basin area above Oroville Dam and the corresponding area-elevation curve is shown on Plate 6. The percentage of the drainage area controlled by the major dams in the Feather River basin and Sacramento River basin downstream to the streamgage at Verona are sown in table 2 below.

TABLE 1

AREA ELEVATION (Percent of Area in Each Elevation)		
ELEVATION RANGE (ft)	AREA (SQMILES)	PERCENT OF AREA
<1000	33	0.9
1000-2000	115	3.2
2000-3000	178	4.9
3000-4000	337	9.4
4000-5000	854	23.7
5000-6000	1,257	34.9
6000-7000	710	19.7
7000-8000	113	3.1
8000-9000	4	0.1
>9000	0.01	0.0
Source: USGS 30 meter DEM		

TABLE 2

Drainage Area and Area Controlled in the Sacramento Basin to Verona						
huc_cd	Station_name	USGS_Stn#	Total Darea(sq-mi)	Local Darea(sq-mi)	Percent of Area Controlled	Elev (ft)
18020005	SACRAMENTO R A KENNETT CA	11369500	6355	6355	100.0%	618
---	Shasta Lake and Dam		6421	6421	100.0%	585
18020101	SACRAMENTO R A KESWICK CA	11370500	6468	47	99.3%	480
18020103	SACRAMENTO R NR RED BLUFF CA	11378000	9020	2599	71.2%	254
18020103	SACRAMENTO R NR HAMILTON CITY CA	11383800	10833	4412	59.3%	
18020103	STONY C NR HAMILTON CITY CA	11388500	773	773	100.0%	150
18020104	SACRAMENTO R A BUTTE CITY CA	11389000	12075	4881	59.6%	
18020104	SACRAMENTO R A COLUSA CA	11389500	12090	4896	59.5%	
18020104	SACRAMENTO R BL WILKINS SLOUGH NR GRIMES CA	11390500	12915	5721	55.7%	
18020104	SACRAMENTO R A KNIGHTS LANDING CA	11391000	14535	7341	49.5%	
18020123	COMPUTED INFLOW TO LK OROVILLE CA	11406799	3607	3607	100.0%	
---	Oroville Lake and Dam		3611	3611	100.0%	180
18020106	FEATHER R A OROVILLE CA	11407000	3624	13	99.6%	
18020106	FEATHER R NR GRIDLEY CA	11407150	3676	65	98.2%	
---	New Bullards Bar Lake and Dam		489	489	100.0%	1392
18020125	N YUBA R BL BULLARDS BAR DAM CA	11413500	487	487	100.0%	1390
18020125	N YUBA R LOW FLOW REL BL NEW BULLARDS BAR DAM CA	11413517	489	2	99.6%	1280
18020125	YUBA R BL NEW COLGATE POWERPLANT NR FRENCH CORRAL	11413700	717	230	67.9%	550
18020125	YUBA R BL ENGLEBRIGHT DAM NR SMARTSVILLE CA	11418000	1108	621	44.0%	
18020125	YUBA R A SMARTSVILLE CA	11419000	1200	713	40.6%	264
18020106	YUBA R A DAQUERRA PT NR BROWNS VALLEY CA	11420800	1330	843	36.6%	
18020107	YUBA R NR MARYSVILLE CA	11421000	1339	852	36.4%	
18020106	FEATHER R BL SHANGHAI BEND NR OLIVEHURST CA	11421700	5334	1236	76.8%	
18020108	BEAR R NR WHEATLAND CA (6.5 mi d/s of Camp Far West Dam)	11424000	292	292	100.0%	72
18020106	FEATHER R NR NICOLAUS	11425000	5921	1531	74.1%	
18020109	SACRAMENTO R A VERONA CA	11425500	21251	10440	50.9%	43

Data Source: USGS gage station inventory at http://nwis.waterdata.usgs.gov/nwis/inventory
Data Source for Dams: Pertinent data sheets for Water Management, Sacramento District, USACE.

3.3 GEOLOGY AND SOILS

Geologically, the Feather River Basin includes portions of the Cascade and Sierra Nevada Ranges. The basin is bounded on the northwest and north by volcanic ridges and mountains radiating from Mt. Lassen, the predominant feature of the northern extremity of the Feather River Basin and the southern limit of the Cascades. On the northeast and east, the basin boundaries correspond roughly to the northern and eastern limits of the Sierra Nevada. The Feather River Basin terminates on the south with the northern boundary of the American River Basin. The majority of the basin is located within the Sierra Nevada, a huge monoclinal fault block tilted very slightly westward and extending beneath the alluvium filled Sacramento Valley on the west. The geologic formations in the basin consist of a wide variety of metamorphic rocks into which granitic rocks of various types have intruded. Recent (in geologic time) stream channel deposits comprise an' important portion of the basin including mountain meadows and stream floodplains, which consist of boulders, gravel, sand and silt. Several faults and fault systems located in areas adjacent to the basin are considered active.

Soils of the Feather River Basin consist of those residual soils formed in place by deterioration and weathering of underlying parent rock; valley fill soils, with the older soils having been modified during the period since deposition and the recent fills showing little change in physical or chemical composition since deposition; and lacustrine soils derived from decomposition of organic materials under marshy conditions. The residual soils are found on mountainous areas and vary in depth from very shallow with considerable surface rock to soils having good depth and little or no surface rock. The older alluvial soils usually have been modified by leaching processes to form dense clay pans or cemented hardpans. These soils are found in lower valley-floor areas, particularly on the west, where they join the alluvial areas of the Sacramento Valley floor. The rich soil of the valley floor below the dam grows a great variety of farm crops.

3.4 SEDIMENT

Sedimentation rates in the Feather River Basin and adjacent basins are relatively low due to limited development, the general shallowness of soils and a low rate of upstream erosion. The annual sediment yield for the drainage area above Lake Oroville is estimated to be about 0.2 acre-feet per square mile, which corresponds to 720 acre-feet/year. Much of the recent deposition that has occurred in the lower Feather River Basin was due to the extensive use of hydraulic mining in the late nineteenth century. DWR conducted a siltation study of Lake Oroville during 1993-1994. The study concluded that 18,000 acre-feet of sediment deposition has occurred since completion of the project. This corresponds to an annual rate of 667 acre-feet/year.

4. Climate

4.1 GENERAL

The climate of the Feather River Basin is significantly influenced by the topography of the area and there are marked variations in temperature and precipitation within short distances. Climate is characterized by cool, wet winters and hot, dry summers. The majority of the annual rainfall

occurs in 2 or 3 of the winter months. The seasons are so distinctly different that the period from May to October may be termed the dry season and November to April the wet season.

4.2 TEMPERATURE

Temperatures in the valley are high in the summer and moderate in the winter. Temperatures in the mountains decrease generally with elevation; the summers are moderate at higher elevations while the winters are severe. Observed temperature extremes are113 and 17 degrees at Marysville, 115 and 12 degrees at Oroville, 110 and -24 degrees at Quincy, and 104 and -29 degrees at Sierraville. The monthly and annual distribution of mean, maximum, and minimum temperatures at representative stations are presented in Table 3.Except for extremely high elevations, these temperatures are representative of the whole watershed area.

TABLE 3

MONTHLY AND ANNUAL
MEAN, MAXIMUM, AND MINIMUM TEMPERATURES
(Degrees Fahrenheit)

Month	Marysville (57 ft)			De Sabla (2720 ft)			Canyon Dam (4560 ft)			Portola (4850 ft)		
	Mean	Max	Min	[Mean	Max	Min	Mean	Max	Min	Mean	Max	Min
January	46.0	54.1	38.0	41.7	51.4	31.9	30.5	39.1	21.9	29.9	41.9	17.9
February	51.4	61.1	41.7	43.9	54.4	33.3	33.5	43.4	23.5	33.3	46.1	20.6
March	55.3	66.3	44.3	46.4	57.8	34.9	37.8	49.0	26.6	37.9	51.3	24.4
April	60.8	73.7	47.9	51.4	64.3	38.5	43.8	57.3	30.2	43.2	58.5	27.8
May	67.7	81.8	53.6	58.4	72.6	44.2	51.8	67.3	36.4	50.3	67.5	33.1
June	74.5	90.1	58.9	66.4	82.0	50.9	59.4	76.1	42.7	57.4	76.8	38.1
July	79.1	96.3	61.9	72.3	89.3	55.3	66.0	84.7	47.3	63.6	85.8	41.5
August	77.5	94.5	60.5	71.2	88.5	54.0	64.6	83.5	45.7	62.2	84.4	39.8
September	73.5	89.7	57.3	66.9	83.5	50.4	59.0	76.9	41.2	56.8	78.3	35.3
October	65.3	79.7	50.8	58.4	72.9	44.0	49.5	64.5	34.4	48.4	67.6	29.3
November	53.9	64.7	43.1	47.2	58.1	36.3	38.4	48.5	28.4	38.3	52.5	23.9
December	46.7	55.0	38.4	42.0	51.7	32.3	31.8	39.9	23.6	31.5	43.6	19.5
Annual	62.6	75.6	49.7	55.5	68.9	42.2	47.2	60.9	33.5	46.1	62.9	29.3
Period of Record	1948-2004			1948-2004			1948-2004			1948-2002		

Source: Western Regional Climate Center, 2004

4.3 PRECIPITATION

Annual precipitation varies throughout the drainage area, ranging from 20 to 25 inches on the valley floor to about 100 inches in the higher mountains, and averages about 45 inches over the watershed above Oroville Dam. Winter precipitation usually falls as rain up to the 5,000 foot elevation and as snow at higher elevations, but some storms produce rain up to the highest elevations of the basin and snowfall occurs as low as the valley floor at rare intervals. About 90 percent of the runoff producing precipitation occurs during the winter months of November through April. The areal distribution of normal annual precipitation is shown on Plate 7. The mean monthly distribution at selected stations is given in Table 3.

TABLE 4

MEAN MONTHLY PRECIPITATION								
Month	Marysville (57 ft)		De Sabla (2720 ft)		CanyonDam (4560 ft)		Portola (4850 ft)	
	Inches	%	Inches	%	Inches	%	Inches	%
January	4.37	20.4%	12.75	19.2%	7.4	19.1%	4.13	18.8%
February	3.53	16.4%	10.81	16.3%	6.34	16.4%	3.34	15.2%
March	2.93	13.7%	8.98	13.5%	5.21	13.5%	3.03	13.8%
April	1.61	7.5%	4.93	7.4%	2.6	6.7%	1.34	6.1%
May	0.64	3.0%	2.28	3.4%	1.54	4.0%	1.09	5.0%
June	0.23	1.1%	0.89	1.3%	0.74	1.9%	0.58	2.6%
July	0.04	0.2%	0.1	0.2%	0.18	0.5%	0.36	1.6%
August	0.08	0.4%	0.28	0.4%	0.32	0.8%	0.35	1.6%
September	0.33	1.5%	1.09	1.6%	0.71	1.8%	0.53	2.4%
October	1.27	5.9%	3.65	5.5%	2.2	5.7%	1.18	5.4%
November	2.82	13.1%	8.74	13.2%	4.87	12.6%	2.36	10.7%
December	3.61	16.8%	11.88	17.9%	6.52	16.9%	3.73	16.9%
Average Annual	21.46	100%	66.37	100%	38.65	100%	22.02	100%
Maximum Annual	1983		1983		1983		1996	
Minimum Annual	1976		1976		1976		1976	
Period of Record	1948-2004		1948-2004		1948-200		1919-2004	
Source: Western Regional Climate Center, 2004								

4.4 SNOWFALL

Winter snowfall above 5,000 feet elevation normally accumulates until the first of April when increasing temperatures mark the beginning of the snowmelt season. Snow falling at lower elevations usually melts within a relatively short time. Snow course data are collected at 25 locations within the Feather River Basin by Pacific Gas and Electric Company, California Department of Water Resources, the East Lake Ranger District, and the Eagle Lake Ranger District as part of the California Cooperative Snow Survey program. Basin snowpack data for six representative snow courses are presented in Table 4. The locations of the snow courses are shown on Plate 8.

TABLE 5

SNOW SURVEY DATA (Water Equivalent - Inches)							
Snow Course	AVERAGE					MAXIMUM	MINIMUM
	1-Jan	1-Feb	1-Mar	1-Apr	1-May	(Date)	(Date)
Lower Lassen Peak (Elev 8250 ft.) (POR 1930-2000)	33.4	48.2	62.8	78.7	80.8	162.1 3/27/1995	6.4 1/1/1987
Mount Dyer #1 (Elev 7100 ft) (POR 1930-2000)	9.6	14.5	19.4	25	23	71.7 5/1/1983	0 Multiple
Rowland Creek (Elev 6700 ft) (POR 1950-2000)	6.9	11.8	15.4	17.7	13.3	43.8 4/1/1952	0 Multiple
Eureka Lake (Elev 6200 ft) (POR 1939-2000)	n/a	19.5	28	31.6	21.7	72.9 4/1/1952	0 Multiple
Letterbox (Elev 5600 ft) (POR 1940-2000)	17.8	25.8	37.3	48.4	40.6	106.5 4/1/1952	0 Multiple
Chester Flat (Elev 4600 ft) POR 1930-2000)	3.7	7.5	9	6.4	1.6	29.1 4/1/1952	0 Multiple
Source: California Department of Water Resources, California Data Exchange Center, 2003							

4.5 EVAPORATION AND WIND

The average historical evaporation at Lake Oroville is listed in Table 5. Pan evaporation was measured with a class "A" pan. Peak wind velocities in California are generally associated with winter-type storm fronts, whereas the strongest sustained winds occur in the summer with maximum sunshine. The prevailing wind direction in the lower Feather River Basin is from the south and southeast during the months of April through September, and from the north during the months of October through December. A continuous recording ground level anemometer was recently installed at Oroville Dam. Table 7 is a compilation of the mean and peak monthly wind velocities for Beale Air Force Base and the Red Bluff Airport.

TABLE 6

HISTORICAL MONTHLY PAN EVAPORATION LAKE OROVILLE	
MONTH	MEAN EVAPORATION (in)
January	1.2
February	2.02
March	3.59
April	5.36
May	7.96
June	10.1
July	11.99
August	10.86
September	8.36
October	5.36
November	2.12
December	1.17
Annual Total	70.09

Source: DWR Bulletin 73-79, Nov 1979 (Period of Record WY1959-WY1979). DWR and University of California Statewide Integrated Pest Management Program (Period of Record WY198l-WY2002)

TABLE 7

MEAN AND PEAK MONTHLY WIND VELOCITIES				
Month (mph)	Beale Air Force Base		Red Bluff Airport	
	Mean (mph)	Peak Gust (mph)	Mean (mph)	Peak Gust
January	5	59	9	47
February	5	62	9	55
March	6	51	10	60
April	6	53	10	47
May	6	43	9	45
June	6	44	9	41
July	5	38	8	39
August	5	35	8	35
September	5	48	8	43
October	3	53	8	48
November	5	64	8	54
December	5	67	8	49
Annual	5	67	9	60

Source: Climatic Wind Data for the United States, 1998, NCDC, Period of Record not specified.

4.6 STORMS AND FLOODS

The Feather River Basin lies on the seaward face of the Sierra Nevada which rises directly across the path of storms moving inland from the Mid-Pacific Ocean. The low barrier of the Coast Range which intervenes between the ocean and the Sierra Nevada is pierced by the large San Francisco Bay Gap westward from the Feather River Basin so that considerable volumes of moist maritime air reach the basin at low elevations.

The most important storms affecting this area are cyclonic wave disturbances along the polar front that usually originate in the vicinity of the Aleutian Islands. The normal trajectory of the waves along this front is to the south and east from the Pacific Ocean to the west coast. In the summertime, this frontal zone is located far to the north and the accompanying precipitation seldom reaches as far south as California. During the summer the air which reaches the region is generally stable and thunderstorms are rare. During the wintertime, from October to April, the frontal zone moves southward and the cyclonic wave disturbances move over California.

The annual precipitation is concentrated almost entirely during the winter storm season from November through March. Precipitation normally falls as snow above the 5,000 foot level. However, during extremely warm winter storms rain has fallen over the entire basin melting some of the snow and at times stripping most of the snowpack from the basin. By the end of the winter most of the area above 5,000 feet is covered by a compact snowpack that often averages more than 10 feet in depth over large areas. Occasionally, depths reach 30 feet. Because of this deep snowpack in the higher areas, storm rainfall therein is largely absorbed in the mass of the snow and appreciable storm runoff from such areas is prevented.

Studies of storms and floods of record indicate that critical flood producing conditions on the Feather River Basin will occur only during the winter season when there may be a prolonged series of general storms covering the entire basin. Storm precipitation amounts are typically distributed aerially in the same general pattern as normal annual precipitation amounts, although there are large departures from this rule. On occasion a general storm series may last 2 to 5 days. During such stormy periods, soil saturation occurs, infiltration capacities decline, and the natural and artificial storage within the basin is progressively filled.

Outside the winter season, storms are less severe, cover only a small portion of the basin at a time, and are so widely separated in time that basin storages have an opportunity to replenish, resulting in lower basin runoff. Thunderstorms lasting up to three hours can occur over small areas at higher elevations from late spring through early fall. The resulting runoff is characterized by high peaks of short duration with low volumes. For small tributaries, peak flows from thunderstorms can approach those that occur during major winter rain floods, but flows on the main stem are barely affected.

Floods in the Feather River Basin are typical of those occurring on the other Sierra Nevada streams. Floods are rather frequent and of two general types, winter rain floods and spring snowmelt floods. However, only rain floods, resulting from intense rainfall over the foothills and mountains during the winter season, cause serious flooding because the highest rate of snowmelt runoff is well below that corresponding to the damaging stage of the river.

Rain floods have a high peak discharge, are flashy, and are generally only a few days in duration. When antecedent rainfall has resulted in saturated ground conditions or when the ground is frozen, the volume of runoff can be much greater and flooding more severe. These floods may occur in rapid succession with secondary peaks occurring before flows from the preceding floods have completely receded.

Snowmelt floods can be expected any time from April through July. They are characterized by lower peak flows, long durations, and comparably large volumes of runoff. The snowmelt flood potential varies according to the depth and areal extent of the snowpack and temperature. The highest rates of snowmelt runoff usually occur during years with an unusually deep snowpack. High flows are sustained during May and June when rising temperatures cause the snowpack to melt. The top five historic snowmelt inflow flood events are shown in table 9.

4.7 RUNNOFF CHARACTERISTICS

Runoff occurs primarily during the months of November through June. Maximum flows between the months November and April are the result of direct runoff from intense precipitation augmented occasionally by melting snow (USACE, 1958). Runoff during the months of April through June is primarily from snowmelt. Such runoff generally does not result in flood-producing flows, but is ordinarily adequate to fill reservoir space maintained empty during the winter months for flood control. During late summer and early fall, runoff diminishes and streamflow is sustained by springs and drainage of lakes, reservoirs, and areas of effluent seepage (USACE, 1958). Greatest water demands occur during the months June through September. Thus, in years of normal or above normal snowmelt, flood control operation does not interfere with the filling of the reservoir for subsequent water deliveries.

Runoff accumulates rapidly in the upstream tributary areas where the flows are confined within the natural narrow canyon stream channels and the floods produced are of high intensity but relatively short duration. Flood peaks on the streams in the basin above Oroville Dam are often impaired and delayed by numerous upstream check dams, diversions and reservoirs.

Significant runoff occurs after the ground approaches saturation. Thereafter, successive storms would produce runoff with lower loss rates unless enough time expires between storms for the basin to dry out. Loss rates in the basin vary with the wetness of the ground and the intensity of the rainfall plus snowmelt. Constant loss rates, estimated for eight floods between 1940 and 1955, are presented in the March 1958 office report, Flood Control Hydrology, Feather River Basin, California. Constant loss rates were found to range from 0.06 in/hr to 0.13 in/hr.

Annual runoff volume since project completion has been highly variable, and has ranged from a minimum of 752,000 acre-feet in water year 1977 to a maximum of 8,857,000 acre-feet in water year 1983. The extremes represent 18 and 210 percent, respectively, of the 36-year average runoff of 4,227,000 acre-feet. Mean monthly unregulated runoff at Oroville Dam is presented in Table 8.

TABLE 8

MEAN MONTHLY UNREGULATED RUNOFF FEATHER RIVER AT OROVILLE DAM		
MONTH	TOTAL MONTHLY RUNOFF (1000 AF)	PERCENT OF ANNUAL RUNOFF
JANUARY	509	11.2
FEBRUARY	571	12.6
MARCH	705	15.5
APRIL	739	16.3
MAY	670	14.7
JUNE	349	7.7
JULY	159	3.5
AUGUST	104	2.3
SEPTEMBER	89	2
OCTOBER	106	2.3
NOVEMBER	196	4.3
DECEMBER	350	7.7
ANNUAL	4,547	100.0

The official operation record of Oroville Dam is maintained by the State of California. Operation of Oroville Dam began in October 1967. Daily historical operation data including inflow, outflow, storage and top of conservation are available at the California Data Exchange Center (CDEC) on the web at http://cdec.water.ca.gov/reservoir.html.

4.8 CLIMATE CHANGE

4.8.1. PURPOSE

This section presents a discussion of the potential impact of climate change for the Sutter basin feasibility study (SBFS) hydrology.

4.8. 2. GENERAL

Two possible trends associated with climate change that may affect the SBFS study area are a change in sea level and the shift in Sierra Nevada runoff patterns..

Recent research indicates continued or accelerated rise in global mean sea level height (sea level change) based on decades (and in some cases centuries) of measurements. Climate change has been identified as a likely cause of the increase in global sea level height by many researchers but is still subject to spirited debate. However, the reality of the observed rise in global sea level height at project specific locations and local vertical land movement needs to be adequately addressed by projects in and near coastal areas regardless of the causes (USACE, 2011A).

Also, studies have shown that increasing temperatures associated with climate change are causing a shift in the runoff patterns of Pacific slope watersheds with a large snowmelt component. The runoff shifts for those watersheds include increased runoff in winter, less snowmelt in summer, and earlier runoff in the spring (USACE, 2011B).

4.8.3. SEA LEVEL CHANGE

The discussions of sea-level analysis has been removed to the hydraulic analysis appendix.

4.8.4. IMPACT OF CLIMATE CHANGE ON RUNOFF

A sensitivity study of the potential impact of climate change on runoff was completed. A separate technical memorandum documents that effort in "Sensitivity of Alternative Selection to Climate Change", dated 03January2013 (USACE, 2013).

The procedure used hydrologically was to adopt the percent change in 3-day flood flow at discrete locations in the Sacramento river basin from a paper by Tapas Das (Das, 2011). Those percent changes in 3-day flows were applied to the unregulated flow frequency curves to shift the frequency of future flows to a more frequent occurrence. The future unregulated flows were then input to the economics model were transform curves from the existing without project condition transformed the unregulated flow to regulated flow. The economics model then assessed the ranking of project alternatives based on three future climate scenarios as defined in the Das paper representing wetter and dryer future conditions.

The conclusion of that sensitivity study was that the impact of climate change will not change the selection of draft alternatives for the Sutter Basin Feasibility Study. Table 9 shows the final ranking of alternatives, showing that alternative SB-7 remains in first position. The results indicate that the ranking of the alternatives on the basis of net annual benefits is not sensitive to the climate change scenarios.

TABLE 9.

Rankings of Alternatives Based Upon Equivalent Net Annual Benefits by Climate Scenario

Alternative	NCAR (Driest Condition)	Existing Condition	GFDL (Wettest Condition)
SB-1	8	8	6
SB-2	2	2/3	5
SB-3	4	4	4
SB-4	7	7	8
SB-5	5	5/6	7
SB-6	6	5/6	3
SB-7	1	1	1
SB-8	3	2/3	2

5. Historic Flooding

Historic unregulated flows and volumes for the Feather River at Oroville for the five largest rain floods of record, based on 3-day volumes, are listed in Table 10. Unregulated flows and volumes for the Feather River at Oroville for the five largest snowmelt season (April through July) floods of record based on 3-day volumes are shown in Table 11. A discussion of the 1955, 1964, 1986, and 1997 floods follows.

TABLE 10

HISTORIC RAIN FLOOD INFLOWS FEATHER RIVER AT OROVILLE DAM			
DATE	PEAK a/ (cfs)	UNREGULATED 1-DAY VOLUME (acre-feet)	UNREGULATED 3-DAY VOLUME (acre-feet)
Jan- 1997	302,000	620,600	1,454,800
Feb- 1986	275,000	430,500	1,112,800
Dec- 1964	250,000	354,100	984,100
Mar- 1907	230,000	370,900	894,500
Dec- 1955	203,000	360,100	874,200
Source: USCAE 1999, and CDEC, Period of Record WY 1902- WY 2003 Excerpted fom Oroville DRAFT 2005 WCM a/ Peak flows impaired due to upstream regulation			

TABLE 11

HISTORIC UNREGULATED SNOWMELT SEASON INFLOW FLOODS OF RECORD FOR THE FEATHER RIVER AT OROVILLE DAM		
WATER YEAR	1-DAY VOLUME (acre-feet)	3-DAY VOLUME (acre-feet)
1995	491,000	4,263,000
1982	425,000	3,156,000
1915	362,000	2,940,000
1911	308,000	4,368,000
1963	290,000	1,685,000
Source: USACE, CDEC, Period of Record WT 1902 - WY 2003 Excerpted from Oroville DRAFT 2005 WCM Snowmelt season begins April 1st		

During the week preceding Christmas 1955, northern and central California was subjected to one of the greatest floods in the area's history. The intense flood-producing precipitation covered an area of about 100,000 square miles, which represents over sixty percent of the gross area of the state. By December 15, the Feather River Basin was moderately wet from preceding storms, the snowline was at about 4,000 feet, and there was about 36 inches of snow above 7,000 feet. During the first cold phase of the storm, from the 15th to the 20th, about 10 inches of precipitation fell on the basin, as rain below about 5,500 feet and as snow above that elevation. The snowline retreated about 500 feet in elevation, but snow depths at 7,000 feet elevation increased to about 75 inches. After the 21st, temperatures and wind velocities increased greatly and the rainfall extended to the highest point in the basin. The snowline retreated about 700 feet in elevation and snow depths decreased about 18 inches at all elevations, contributing to heavy runoff from most of the basin below above 7,000 feet. Extensive flooding occurred throughout the basin. At Shanghai Bend, south of Yuba City, the west levee of the Feather River failed at about midnight on the 23rd. Water from this break entered Yuba City and flooded about ninety-five percent of the city. In the residential areas, the depth of flooding varied from a few inches to over 12 feet. Because the flooding occurred so quickly, and in the middle of the night, practically none of the contents of homes and businesses could be saved. About 12,000 people were evacuated from the Yuba City area for a period varying from a few days to several months. It was reported that 38 people lost their lives in this area as a result of the flood.

On December 23, 1955, a peak flow of 203,000 cfs and a gage reading of 76.5 feet above streambed occurred at the gaging station in the Feather River Canyon a few miles east of Oroville. An estimated peak discharge of 230,000 cfs occurred during the great flood of March 1907. However, in December 1955, upstream reservoirs, which did not exist in 1907, stored 137,000 acre-feet of floodwater between December 21 and December 28. It is estimated had Oroville Dam existed, the inventoried damages, losses, and costs below the dam site of about $50,000,000 and the loss of human lives could have been prevented. Such a reduction in flood

flows in the Feather River would also have relieved the threat to the remaining portion of the levee system.

The flood of December 1964 - January 1965 resulted from a winter rainstorm that followed a meteorological pattern typical of other flood-producing storms over the basin. Heavy precipitation occurred in the preceding 60 days over the general area, with up to 5 inches of rain recorded at some valley stations. The storm came in four distinct waves. The first wave, which occurred during 18-20 December, was cold, and deposited 2-3 inches of snow in the mountains down to the 3,000 foot level. The following wave brought rising temperatures and heavy rains up to 6,000 feet elevation. Within the 4-day period, 20-23 December, about 13 inches of rain fell. The warm winds and rain melted most of the new snow accumulated during the initial storm. Another cold wave occurred during 26 December - 4 January, and brought rain to lower elevations and snow in the mountain. The final wave of this storm series occurred on 4-6 January when 3 to 10 inches of precipitation fell on the Feather and Yuba River Basins. Inflow to Oroville Reservoir peaked at 250,000 cfs. Flow at Oroville was attenuated by the partially constructed dam to a maximum outflow of 158,000 cfs.

The storms of February 1986 severely affected northern California and northwestern Nevada. Heavy precipitation reached record levels in many locations. The heaviest precipitation occurred 200 miles north to 100 miles south of a line from San Francisco to Sacramento to Lake Tahoe. Over much of this area the precipitation ranged between 100 to 350 percent of normal February Precipitation. In the Feather River Basin, the heavy rains began on February 12 and continued through February 21. With the continued rain and storm runoff, storage increases at Oroville from February 13 through February 23 were 640,300 acre-feet or approximately seventy percent of the space available at the beginning of the flood.

Several reservoirs above Oroville contributed to incidental flood flow retention. Collectively, these reservoirs stored 408,000 acre-feet during the flood. The maximum release from Oroville Dam was 147,400 cfs on February 18 and 19. The Feather River at Gridley gage recorded a peak flow of approximately 150,000 cfs on February 19 compared to the past Oroville Dam peak flow of 90,100 cfs on January 15, 1980. Flows on the Feather River below the dam equaled but did not exceed the design flows of the downstream levees. However, on February 20, a levee break occurred on the south bank of the Yuba River at the towns of Linda and Olivehurst causing extensive residential and commercial damage.

Flooding in early January 1997 resulted when a series of three subtropical storms followed a cold storm and one of wettest Decembers on record. Prior to the late December storms, rainfall was already well above normal throughout the Sacramento and San Joaquin River basins. Then, several days before Christmas 1996, a cold storm from the Gulf of Alaska brought snow to low elevations in the Sierra Nevada foothills. The first of three subtropical storms hit Northern California on December 29, 1996, with less than expected precipitation totals. On December 30, the second storm arrived. The third and most severe storm hit late December 31 and lasted through January 2. The snowpack at lower elevations, melted when the trio of warmer storms hit. However, not much snowpack loss was observed at snow sensors over 6,000 feet in elevation in the northern Sierra. Precipitation totals at lower elevations in the Central Valley were not unusually high in contrast to extreme rainfall in the upper watersheds. Extreme precipitation in

the Sierra Nevada resulted in record flows in both the Sacramento and San Joaquin River basins. Several gaging stations used to measure the water level in streams and rivers recorded the largest peaks in the history of their operation during this series of storms. Based on 3-day volume, inflows to Lake Oroville were the largest on record. The estimated peak bi-hourly inflow was 302,000 cfs and occurred on 1 January 1997. The maximum release from Lake Oroville was 160,000 cfs. Oroville came close to reaching design capacity as only 27 percent of the flood management reservation pool remained.

The eastern levee of the Feather River failed on the evening of January 3, 1997, near the town of Arboga, California. Within 24 hours of the initial failure, the levee breach had reached over 800 feet in length. Floodwaters inundated 12,000 acres, damaging over 700 structures. Although the area was primarily agricultural, many of the damaged structures were concentrated along Country Club Road and in the town of Arboga. In total, approximately 600 residential structures were within the flooded area. This area had a wide range of flooding depths, with maximum depths about 20 feet (structures totally covered) in the south near the levee break to minimal depths in the north near the Yuba County Airport.

6. Hydrologic Analysis

In support of the Comprehensive Study (USACE, 2002), the Water Management Section of the Sacramento District, USACE, has developed synthetic 50-, 10-, 4-, 2-, 1-, 0.5-, and 0.2-percent chance exceedence flood events. These seven synthetic exceedence frequency events will provide a basis for defining existing conditions and eventual alternatives analysis and plan formulation. In this sense, this hydrology study will serve as a cornerstone for future Comprehensive Study investigations.

The methodology used by the Water Management Section of the USACE, in performing the Comprehensive Study, including: 1) updated natural flow frequency curves for locations within the basins; 2) a retrospective of historic floods that have impacted Central Valley rivers and the synthetic flood runoff centerings developed to represent flood events of a specific exceedence frequency; and 3) construction of seven synthetic exceedence frequency flood hydrographs.

The synthetic hydrology, as presented in the Comprehensive Study, was created to be "Comprehensive" in nature. Some watersheds were studied in more detail or had more detailed information available than others; the hydrology presented herein for the Sutter Basin is deemed acceptable for use in a feasibility study. The models developed for the Comprehensive Study analysis were created with the following assumptions and limitations:

- The data are stationary.
- The natural flow frequency curves are strictly rainflood frequency curves. Snowmelt runoff is not directly incorporated into the analysis.
- Centering hydrographs are predicated on flood runoff, not precipitation. The approach was driven entirely by historic flow data; precipitation never entered into any portion of the methodology.
- Storm runoff centerings were formulated based on the Composite Floodplain concept.

- The unregulated frequency curves computed for the Comprehensive Study were created by following procedures outlined in Bulletin 17B.
- Travel times and attenuation factors (Muskingum Coefficients) are fixed for all simulated exceedence frequencies.
- Mainstem unregulated flow frequency curves were designed to quantify the total flows that the basins produced in rainfloods, not the average natural flows expected at mainstem locations during any of the synthetic exceedence frequency storm events.
- Patterns for synthetic floods are formulated based on historic storms.

6.1 STORM CENTERING AND MODELING PROCEDURE

The hydrology for the feasibility study will be based upon the storm centering method described in the Comp Study. A storm centering is the simulation of the effect of storms that are positioned (centered) over particular locations in a watershed to produce flow rates of specific frequencies at those locations. In the Comp Study, a suite of storm centerings were used in developing synthetic hydrology for the Sacramento and San Joaquin watersheds to emulate the diverse spectrum of floods that can occur from different combinations of concurrent storms on tributaries, accounting for orographic influences and other factors that influence regional rainfall runoff events. The synthetic hydrology as presented in the Comp Study represents the best available data for the large flood sources (Sutter Bypass and Feather River) of the Sutter Basin Feasibility Study. The hydrology has also been used for several other feasibility studies in the region, such as the American River Common Features, Yuba River, and Marysville studies.

The synthetic hydrology of the Comp Study was based upon a transformation of unregulated hydrologic conditions to regulated conditions. This was accomplished by developing balanced unregulated hydrographs based upon historical patterned storm events, resulting in hydrographs representing the varying flood durations. These balanced hydrographs were then transformed to regulated hydrographs using an HEC-5 reservoir operations model of the system. The HEC-5 model, also developed and calibrated for the Comp Study, simulates reservoir operations and produces regulated flow (USACE, 1996). Resulting hydrographs were obtained from the HEC-5 model at 'handoff' points and modeled in more hydraulic detail using a UNET unsteady hydraulic model. The Sacramento and San Joaquin Comp Study UNET model, developed and calibrated for the Comp Study, is designed to simulate unsteady flow through a network of open channels, weirs, bypasses, and storage areas (USACE, 2002C).

The Comp Study UNET model downstream of the latitude at the City of Colusa has been replaced for the Sutter Basin Feasibility Study with an HEC-RAS unsteady model. Hydrographs were extracted from the Comp Study UNET model at two locations (a United States Geological Survey (USGS) gage, Sacramento River at Colusa, and a California Department of Water Resources (DWR) gage, Butte Slough at Meridian) and transferred to the HEC-RAS model. The two locations represent the entire flow passing the latitude at the City of Colusa. All model assumptions, flow, and routings upstream from these two locations are from the Comp Study (USACE, 2002). There were several simulations that were done for the Comp Study, however for the Sutter Basin Feasibility Study hydraulic model, the UNET model results from a levee overtopping only and no failure simulation were used.

6.2 DESIGN RAINFALL ANALYSIS

The interior drainage analysis required rainfall depth-duration-frequency tables derived from California Department of Water Resources (DWR) gage data. The data is available on the world-wide-web at: http://www.water.ca.gov/floodmgmt/hafoo/csc/climate_data/ (NOAA, 2011). The Nicolaus and Yuba City gages were selected based on their location , elevation, and period of record. Design storm depths for these gages are provided in Table 12.

TABLE 12

Design Storm Depths [inches].						
	Period of Record	Gage Elevation	100-Year		200-Year	
Rainfall Gage	[year]	[feet]	24-Hr	96-Hr	24-Hr	96-Hr
Nicolaus	91	47	3.38	6.77	3.67	7.4
Yuba City	46	60	3.88	7.33	4.2	8.01
Sutter Buttes [a]	n/a	n/a	4.23	8.46	4.59	9.25
[a] Rainfall depths over the Sutter Buttes were calcuated as 125% of the Nicolaus gage depths.						

All subbasins south of Yuba City were assigned storm depths from the Nicolaus gage. The remainder of the subbasins were assigned storm depths according to the Yuba City gage with the exception of the subbasins within the Sutter Buttes. The Sutter Buttes typically receive higher rainfall amounts than the surrounding valley due to orographic effects and were treated as a unique rainfall zone. NOAA atlas 14 point rainfall depths (NOAA, 2011) were evaluated for both the Sutter Buttes and the surrounding valley. From this analysis, it was estimated that the Sutter Buttes typically receive about 25% more rainfall than the surrounding area. Therefore, in the absence of a rainfall gage in the Sutter Buttes, design rainfall depths for this region were estimated as 25% higher than those for the Nicolaus gage.

The 24-hour storm was patterned according to a SCS Type I temporal distribution as recommended in the Sutter County Design Standards (Sutter County, 2005). The 24-hour storm duration was chosen to stress the study area from a peak rainfall intensity and peak flow standpoint.

The 96-hour temporal distribution used was developed for the Sutter Basin region (California- Region 5) as part of the NOAA Atlas 14 Precipitation-Frequency Study for California (NOAA, 2011). The 96-hour storm, although a greater volume, is a less intense storm than the 24-hour storm and was analyzed to stress the study area from a volume standpoint.

The 24-hour and 96-hour temporal distribution patterns are provided in the Sutter Butte Flood Control Agency (SBFCA) Interior Drainage Analysis, dated February 2012, in graphical and table formats.

6.3 WIND WAVE ANALYSIS

The wind wave analysis has been moved to the hydraulic analysis appendix.

7. Analysis for Unregulated Flow Frequency Curves

7.1 GENERAL ANALYSIS

Unregulated frequency curves were developed at key mainstem and tributary locations in both the Sacramento and San Joaquin River basins. Unregulated frequency curves plot historic points and statistical distributions of unimpaired flows (no reservoir influence). Curves display volumes or average flow rates for different time durations over a range of annual exceedence probabilities. These curves can be used to translate: 1) hydrographs to frequencies (i.e., in 1997, the 3-day natural inflow to Oroville Dam, Sacramento River was roughly 209,000-cfs, which translates to a 1.6-percent chance exceedence event); and 2) frequencies to flood volumes (i.e., according to the curves, the 3-day natural inflow to Oroville Dam associated with an annual 10-percent chance exceedence event is approximately 105,000 cfs). After a curve is developed, the runoff volume for any of the seven synthetic exceedence frequency flood events can be obtained from the plot for that curve's specific location.

7.2 UNREGULATED FREQUENCY ANALYSIS

The unregulated frequency curves computed for the Comprehensive Study were created by following procedures outlined in Bulletin 17B, Guidelines for Determining Flood Flow Frequency, U.S. Department of the Interior, dated March of 1982. This report directs Federal agencies to use the procedures included therein for all "planning activities involving water and related land resources." Bulletin 17B requires the use of a Pearson Type III distribution with log transformation of the data (Log Pearson Type III distribution) as the method to analyze flood flow frequency.

In this report, charts containing frequency curves display two types of information. The frequency curve itself is one of these. The curve is derived from a statistical analysis of the recorded data after it has been transformed to log values. The mean, standard deviation and skew of the log-transformed data, are computed for the stream gage or reservoir. The data are screened for high and low outliers and if found, adjustments to the statistics are computed as outlined in Bulletin 17B. In addition, the resulting statistics are reviewed and sometimes adjusted or smoothed to account for sampling error differences among the various durations, or after comparison with similar gages in the watershed or region. The second type of information found on each frequency curve is the plot of the historical events given their estimated frequency. To determine its location on the frequency paper, the peak of each annually recorded event or peak flow value is given a hypothetical frequency based upon its assigned plotting position using a Log Pearson Type III distribution. In some instances, visual examination of the unregulated frequency curves contained in this report reveal a significant difference between the statistical frequency curve and the imaginary curve that would be formed if a pencil line were hand-drawn through the historical data points. For some curves in this report in which the characteristic described above was apparent, further examination was made. In addition, a few frequency curves were re-computed using alternative distributions such as Gumble type III or lognormal. The result was that the other distributions did not result in an improved fit. Bulletin 17B directs the use of a Log Pearson III Distribution unless compelling and substantive evidence can be found that other distributions are more appropriate.

Development of the unregulated frequency curves for the tributaries required daily natural flow data for all target locations. Data were obtained from USACE archives or computed by routing daily change in storage from upstream reservoirs and adding this routed value to the gage record at the location of interest. Most required storage time series were available through USGS publications. Other data were obtained directly from Central Valley and federal water agencies, including U.S. Bureau of Reclamation, U.S. Geological Survey, Oroville-Wyandotte Irrigation District, South Sutter Water District, Placer County Water Association, Nevada Irrigation District, Surface Water Data Inc., Southern California Edison, Sacramento Metropolitan Utility District, and Pacific Gas and Electric.

Data from tributaries were routed to downstream locations for use in constructing mainstem "index" frequency curves. The frequency curves that characterize the total flows through the mainstem index locations represent "at-latitude" flows (i.e., any and all diverted or channelized flows that pass through a particular gage's geographic latitude). Muskingum routings with travel times (in hours) and reach-specific attenuation factors were used to transport daily hydrographs through the basins, as shown in Table 13 for the Sacramento River Basin. Travel times and attenuation factors (Muskingum Coefficients) were obtained from past studies, through communication with local water agencies, or through comparisons of historic flood data. If no information was available from these sources, variables were estimated based on length of reach, average slope, and other channel characteristics. All river routings were assumed to be conservative (routings were simulated with indefinitely large channels); no flow was lost in overbank areas during transit.

TABLE 13

MUSKINGUM ROUTING PARAMETERS FOR SACRAMENTO RIVER BASIN INDEX POINTS				
Source	From	To	Travel Time (Hours)	Muskingum Coefficient
Sacramento River	Shasta Dam	Keswick	2	0.4
Sacramento River	Keswick	Clear Creek	3	0.4
Clear Creek	Whiskeytown Dam	Mouth	2	0.4
Sacramento River	Clear Creek	Cow Creek	2	0.1
Cow Creek	Gage near Millville	Mouth	1	0.2
Battle Creek	Gage below Coleman F.H.	Mouth	1	0.2
Sacramento River	Battle Creek	Bend-Bridge	3	0.1
Sacramento	Bend-Bridge	Ord Ferry	18	0.2
Mill Creek	Gage near Los Molinos	Ord Ferry	14	0.2
Elder Creek	Gage near Paskenta	Ord Ferry	20	0.2
Deer Creek	Gage near Vina	Ord Ferry	14	0.2
Thomes Creek	Gage at Paskenta	Ord Ferry	20	0.2
Big Chico Creek	Gage near Chico	Ord Ferry	6	0.2
Stony Creek	Black Butte	Ord Ferry	11	0.2
Sacramento	Ord Ferry	Moulton Weir	13	0.2
Sacramento	Moulton Weir	Colusa Weir	3	0.2
Sacramento	Colusa Weir	Tisdale Weir	9	0.2
Sacramento	Tisdale Weir	Knights Landing	7	0.2
Sacramento	Knights Landing	Fremont Weir	2	0.2
Ord Ferry Overflow	Ord Ferry	Highway 162	32	0.1
Butte Creek	Gage at Chico	Highway 162	7	0.2
Butte Creek and Ord Ferry Overflow	Highway 162	Moulton Weir	10	0.1
Moulton Weir Spill	Sacramento River	Butte Creek	4	0.1
Butte Basin Flow	Moulton Weir/Butte Creek	Colusa Weir	4	0.1
Butte Basin Flow	Colusa Weir	Butte Sink	16	0.1
Butte Basin Flow	Butte Sink	Tisdale Weir	8	0.1
Sutter Bypass/Tisdale	Tisdale Weir	Fremont Weir	20	0.1
Feather River	Oroville	Gridley	3	0.2
Feather River	Gridley	Honcut	1	0.17
Feather River	Honcut	Yuba City	4	0.17
North Yuba River	Bullards Bar Dam	Englebright	3	0.15
Yuba River	Deer Creek	Dry Creek	2	0.15
Yuba River	Dry Creek	Marysville	1	0.15
Yuba River	Marysville	Mouth	1	0.15
Feather River	Yuba River	Bear River	8	0.35
Bear River	Wheatland	Mouth	5	0.35
Feather River	Bear River	Nicolaus	2	0.35
Feather River	Nicolaus	Fremont Weir	4	0.2
Sacramento River	Verona	Sacramento Weir	5	0.2

This procedure was not intended to reflect the natural dynamics of the Central Valley, where large flood flows often discharge to out-of-bank areas and are lost or greatly attenuated. The unregulated flow frequency curves were designed to quantify the total flows that the basins produced in rain floods throughout the period of record, rather than the average natural flows expected at mainstem locations during any of the seven synthetic exceedence frequency storm events.

Historical data were plotted using moving averages of the daily time series for 3-, 5-, 7-, 10-, 15-, and 30-day duration natural flow at all points of interest. Wintertime maxima were picked from the moving average for each water year. All snowmelt-driven events were screened out from these duration maxima; screened events were replaced with the highest rainflood, or rainfall driven, maxima experienced during that water year, which included any rain-on-snow events occurring during the obvious rainflood season of a particular annual record. Values were sorted, ranked, and graphed with median plotting positions. Statistics were computed for these samples of annual rainfloods with USACE statistical analysis tools (FFA and REGFREQ). Sample mean, standard deviation, and skew were computed and, in some cases, smoothed to better represent the values for each duration. The Pearson Type III Distribution with log transformation of the data and final statistics were used to construct best-fit curves for all durations and were plotted on the same graph as the historic values for each location.

Unregulated frequency curves were prepared for 43 tributary locations and 8 mainstem locations. In all cases, curves were developed or updated to reflect post-1997 flood hydrology. For any location, the amount of runoff volume produced during simulation of any one of the seven synthetic exceedence frequency flood events can be read off of the family of best-fit curves or computed directly from the final statistical distribution of each duration.

Flood volumes at mainstem index locations represent the sum of volumes contributed by all upstream tributaries, but do not offer any information regarding how each tributary provides to the whole. In this sense, these index curves can provide exceedence frequency targets, in terms of volumes, at mainstem locations for any of the seven synthetic exceedence frequency flood patterns that involve a number of upstream tributaries. During the development process, it was assumed the effects of increased urbanization occurring throughout the period of record were insignificant on the timing of runoff within the watersheds of the Sacramento and San Joaquin rivers. For a further investigation of this assumption, please reference the "Watershed Impact Analysis" done by HEC (USACE, 2002).

The approach formulated and described above was driven entirely by historic flow data. Each year of record included the influence of snowmelt, infiltration, interception, precipitation distribution, timing of runoff, storm development characteristics, and physical basin attributes for that annual rainflood event. Historic flow data records provided a sufficient sample of flood events to characterize hypothetical flood volumes and tributary-system relationships.

No synthetic precipitation events were required. In fact, precipitation never entered into any portion of the methodology.

Design flows and regulated flow-frequency tabular values are shown below in Table 14. The mainstem storm centering for the Sacramento River used for the Sacramento River below Colusa, and the Sutter Bypass is at the latitude of Sacramento. The tributary storm centering for the Feather River below Oroville Dam is centered at Shanghai bend. The frequency curves for the locations of the Sacramento River at Colusa and the Feather River at Shanghai Bend are shown as plates 9 and 10.

TABLE 14. Design Flows and Regulated Flows

Stream & Reach	1957 Authorized Design Flow (CFS)	Regulated Peak Flows (CFS)						
		50% ACE	10% ACE	4% ACE	2% ACE	1% ACE	0.5% ACE	0.2% ACE
Sacramento River								
Colusa to Tisdale Weir	66,000	44,000	48,000	50,000	53,000	55,000	59,000	68,000
isdale Weir to Sutter Bypass	30,000	28,000	30,000	31,000	32,000	34,000	36,000	41,000
ther River								
oroville to Honcut Creek	210,000	60,000	100,000	150,000	150,000	150,000	174,000	320,400
loncut Creek to Yuba River	210,000	49,000	107,000	157,000	159,600	163,000	182,000	293,600
uba River to Bear River	300,000	71,000	192,000	256,000	281,000	283,000	360,000	534,000
ear River to Sutter Bypass	320,000	78,000	211,000	288,000	321,000	336,000	409,000	574,000
ter Bypass								
eridian to Wadsworth Canal	150,000	57,000	102,000	126,000	155,000	184,000	228,000	327,000
Vadsworth Canal to Tisdale Weir	155,000	56,000	103,000	127,000	156,000	185,000	229,000	327,000
isdale Weir to Feather River	180,000	71,000	117,000	141,000	163,000	197,000	237,000	329,000
eather River to Sacramento River	380,000	141,000	283,000	393,000	436,000	490,000	581,000	799,000
dsworth Canal								
ributary Specific Storm Centering	1,500	820	2,550	3,200	3,980	4,830	5,750	7,070
rokee Canal								
elson Shipee Road to Western Canal	8,500							
Vestern Canal to Afton Road	11,500	6,000	10,300	12,100	13,200	14,300	15,200	16,300
fton Road to Gridley – Colusa Road	12,500							

Notes: data pulled from PBI Addendum 1 models which are the final models for the Sutter Basin Feasibility Study.
Design flows obtained from USACE drawing file 50-10-3334. Levee Channel Profiles, dated 15 March 1957.
Peak flow is the higher of the Sacramento or Shanghai Bend storm centering peak flows.
Wadsworth Canal and Cherokee Canal peak flows are from unregulated streams.
Peak flows for the 0.5% and 0.2% ACE flood events include effects from levee overtopping and may be reduced from the possible maximums.

7.3 UNREGULATED FREQUENCY CURVES FOR SACRAMENTO RIVER AT THE LATITUDE OF SACRAMENTO AND ORD FERRY

The unregulated frequency curve for the latitude of Sacramento is a tool that can be used to develop a mainstem storm centering. Mainstem centerings were designed to stress widespread valley areas. Index frequency curves were prepared at Ord Ferry and Sacramento in the Sacramento River Basin. These curves provide the hypothetical volumes that the basin will produce during simulations of each of the seven synthetic exceedence frequency flood events. The role of the mainstem centerings is to distribute these volumes back into the basin, tributary by tributary, in accordance with patterns visible in historic flood events. Once the volume is distributed it will be translated into hydrographs and routed through reservoir simulation models (Appendix C of the Comp Study) to produce the synthetic exceedence frequency regulated hydrographs at the two locations needed to construct floodplains throughout the Sacramento river system.

Mainstem centerings reflect a generalized flood pattern based on a number of historic events. Through the incorporation of multiple floods into one characteristic pattern, relationships between tributaries become more stable and the influence of powerful, but isolated, storm cells are downplayed.

The frequency curve for the latitude of Sacramento is shown as plate 11. Flow frequency curves are generated at a specific location, usually a gage location. However, for a river basin a large as the Sacramento River basin, a synthetic storm centering approach is required to correctly portray the discharge probability at locations away from the storm center. Table 15 below shows the percent chance exceedence for selected locations throughout the Sacramento River basin with a storm center at Ord Ferry, while table 16 shows the percent exceedance for a centering at the latitude of Sacramento. A flow-frequency table computed from the statistics shown in the Ord Ferry frequency curve is shown in Table 17 below, while the flows from the centering at the latitude of Sacramento frequency curve is shown in Table 18 below.

TABLE 15 Sacramento River Mainstem at Latitude of Ord Ferry

Synthetic Flood Centerings for Sacramento River Total Flow at Latitude of Ord Ferry							
Index Point	Percent Chance Exceedence						
	50%	10%	4%	2%	1%	0.50%	0.20%
Sacramento River at Shasta	82.08	16.91	5.71	2.41	1.25	0.65	0.28
Clear Creek at Whiskeytown	61.56	15.04	9.03	5.61	2.92	1.52	0.65
Cow Creek nr Millville	61.56	13.53	8.02	3.89	2.02	1.05	0.45
Cottonwood Creek nr Cottonwood	61.56	15.04	9.03	5.61	2.92	1.52	0.65
Battle Creek below Coleman FH	61.56	13.53	8.02	3.89	2.02	1.05	0.45
Mill Creek near Los Molinos	87.94	15.03	7.22	5.94	3.1	1.61	0.69
Elder Creek near Paskenta	87.94	19.33	12.5	10.1	5.26	2.74	1.17
Thomes Creek at Paskenta	87.94	19.33	12.5	10.1	5.26	2.74	1.17
Deer Creek near Vina	87.94	15.03	7.22	5.94	3.01	1.61	0.69
Big Chico Creek near Chico	87.94	15.03	7.22	5.94	3.01	1.61	0.69
Stony Creek at Black Butte	87.94	19.33	12.5	10.1	5.26	2.74	1.17
Butte Creek near Chico	87.94	15.03	10.2	8.42	4.39	2.28	0.97
Feather River at Oroville	87.94	19.33	9.62	8.42	4.39	2.28	0.97
Yuba River at New Bullards Bar	87.94	19.33	11.76	9.18	4.78	2.49	1.06
Yuba River at Englebright	87.94	19.33	11.76	9.18	4.78	2.49	1.06
Deer Creek near Smartsville	87.94	19.33	11.76	9.18	4.78	2.49	1.06
Bear River near Wheatland	87.94	19.33	12.03	10.1	5.26	2.74	1.17
Cache Creek at Clear Lake	87.94	19.33	18.05	12.63	6.58	3.42	1.46
North Fork Cache Creek at Indian Valley	87.94	19.33	18.05	12.63	6.58	3.42	1.46
American River at Folsom	87.94	19.33	14.29	12.63	6.58	3.42	1.46
Putah Creek at Berryessa	87.94	19.33	18.05	12.63	6.58	3.42	1.46

TABLE 16 Sacramento River Mainstem at Latitude of Sacramento

Synthetic Flood Centerings for Sacramento River Total Flow at Latitude of Sacramento							
Index Point	Percent Chance Exceedence						
	50%	10%	4%	2%	1%	0.50%	0.20%
Sacramento River at Shasta	84.42	17.03	8.09	4.41	2.21	1.13	0.44
Clear Creek at Whiskeytown	80.91	17.03	10.79	6.47	3.24	1.66	0.65
Cow Creek nr Millville	80.91	16.18	9.71	5.39	2.70	1.38	0.60
Cottonwood Creek nr Cottonwood	80.91	17.03	10.79	6.47	3.24	1.66	0.65
Battle Creek below Coleman FH	80.91	16.18	9.71	5.39	2.70	1.38	0.60
Mill Creek near Los Molinos	88.26	16.18	9.71	4.22	2.35	1.23	0.51
Elder Creek near Paskenta	88.26	19.42	10.79	4.85	2.70	1.38	0.58
Thomes Creek at Paskenta	88.26	19.42	10.79	4.85	2.70	1.38	0.58
Deer Creek near Vina	88.26	16.18	9.71	4.22	2.35	1.23	0.51
Big Chico Creek near Chico	88.26	16.18	9.71	4.22	2.35	1.23	0.51
Stony Creek at Black Butte	88.26	19.42	10.79	4.85	2.70	1.38	0.58
Butte Creek near Chico	66.70	13.63	6.08	2.75	1.38	0.71	0.30
Feather River at Oroville	53.60	11.78	4.42	2.41	1.20	0.62	0.24
Yuba River at New Bullards Bar	55.09	12.52	4.86	2.10	1.05	0.54	0.21
Yuba River at Englebright	55.09	12.52	4.86	2.10	1.05	0.54	0.21
Deer Creek near Smartsville	55.12	12.52	4.86	2.10	1.05	0.54	0.21
Bear River near Wheatland	53.60	11.13	4.42	2.10	1.05	0.54	0.21
Cache Creek at Clear Lake	52.19	12.52	6.95	4.45	2.22	1.14	0.45
North Fork Cache Creek at Indian Valley	52.19	12.52	6.95	4.45	2.22	1.14	0.45
American River at Folsom	55.09	12.52	4.86	2.51	1.26	0.64	0.25
Putah Creek at Berryessa	52.19	12.52	6.95	4.45	2.22	1.14	0.45

TABLE 17

Unregulated Flow Frequency for the "Ord Ferry" storm centering							
Avg flow[2](cfs) for given duration and AEP[3]							
1/AEP[3]	2	10	25	50	100	200	500
Duration (days[1])	0.5	0.1	0.04	0.02	0.01	0.005	0.002
1	102,000	234,000	317,000	386,000	460,000	541,000	657,000
3	81,000	184,000	247,000	299,000	354,000	414,000	499,000
7	65,000	145,000	193,000	232,000	272,000	315,000	376,000
15	49,000	103,000	131,000	153,000	174,000	196,000	225,000
30	38,000	76,000	97,000	112,000	127,000	143,000	163,000

TABLE 18

Unregulated Flow Frequency for the "at latitude of Sacramento" storm centering							
Avg flow[2](cfs) for given duration and AEP[3]							
1/AEP[3]	2	10	25	50	100	200	500
Duration (days[1])	0.5	0.1	0.04	0.02	0.01	0.005	0.002
1	157,000	399,000	561,000	700,000	853,000	1,023,000	1,275,000
3	144,000	357,000	498,000	617,000	749,000	894,000	1,108,000
5	132,000	320,000	444,000	547,000	661,000	786,000	969,000
7	122,000	297,000	410,000	506,000	611,000	726,000	894,000
15	97,000	223,000	299,000	361,000	426,000	496,000	595,000
30	76,000	164,000	213,000	252,000	292,000	334,000	390,000

7.4 UNREGULATED FREQUENCY CURVES FOR FEATHER RIVER AT SHANGHAI BEND

7.4.1 Hypothetical Storm Pattern Generation

The intent of this hydrologic analysis is to prepare a hypothetical storm pattern and flood hydrographs that can be fed into reservoir system and hydraulic models for each frequency event (10-, 2-, 1-, and 0.2-percent chance exceedences). In order to define floodplains for this particular reach of the Feather River, synthetic storms centered over this area were developed. The Comprehensive Study includes a number of synthetic storms that produce large floods along the Feather and Yuba rivers, including storms centered at Oroville Dam on the Feather River, Marysville on the Yuba River, and at the Latitude of Sacramento (USACE, 2002). However, none of these storms were centered at locations along the Feather River within this study area. Therefore, hypothetical storms were developed where the most upstream and downstream locations of the study reach (Feather River at Shanghai Bend and the Sacramento River at Latitude of Verona) experience greater intensity than any other location within the Sacramento Valley.

Large floods at Shanghai Bend result from the combination of high flows from both the Yuba River and Upper Feather River. Historically, large events occurring at Shanghai Bend have resulted from rare events occurring on the Upper Feather River (above Oroville) and also on the Yuba River, with one of these rivers having a slightly rarer event than the other. For example, in 1997 a slightly less frequent event occurred at Oroville than on the Yuba River at Marysville, and in 1965 Marysville experienced a less frequent event than Oroville. However, in both of these years, large floods occurred at Shanghai Bend. Because of the possibility that either scenario could happen, two different hypothetical storm patterns were produced. These storm patterns are shown in Tables 19 and 20.

TABLE 19

Feather River Above Shanghai Bend Storm Centering With a Specific Centering on the Yuba River							
Index Point	Percent Chance Exceedence						
	50%	10%	4%	2%	1%	0.50%	0.20%
Sacramento R at Shasta	101.01	20.20	8.08	5.77	2.89	1.44	0.58
Clear Cr at Whiskeytown	344.83	68.97	27.59	19.70	9.85	4.93	1.97
Cow Cr nr Millville	196.08	39.22	15.69	11.20	5.60	2.80	1.12
Cottonwood Cr nr Cottonwood	344.83	68.97	27.59	19.70	9.85	4.93	1.97
Battle Cr blw Coleman FH	196.08	39.22	15.69	11.20	5.60	2.80	1.12
Mill Cr nr Los Molinos	76.34	15.27	6.11	4.36	2.18	1.09	0.44
Elder Cr nr Paskenta	140.85	28.17	11.27	8.05	4.02	2.01	0.80
Thomes Cr at Paskenta	140.85	28.17	11.27	8.05	4.02	2.01	0.80
Deer Cr nr Vina	76.34	15.27	6.11	4.36	2.18	1.09	0.44
Big Chico Cr nr Chico	76.34	15.27	6.11	4.36	2.18	1.09	0.44
Stony Cr at Black Butte	140.85	28.17	11.27	8.05	4.02	2.01	0.80
Butte Cr nr Chico	76.34	15.27	6.11	4.36	2.18	1.09	0.44
Feather R. at Oroville	54.95	10.87	4.35	2.17	1.06	0.53	0.21
Yuba R. at New Bullards Bar	50.00	10.00	4.00	2.00	1.00	0.50	0.20
Yuba R nr Marysville	50.00	10.00	4.00	2.00	1.00	0.50	0.20
Deer Cr nr Smartsville	125.00	25.00	10.00	5.00	2.50	1.25	0.50
Bear R nr Wheatland	125.00	25.00	10.00	5.00	2.50	1.25	0.50
Cache Cr at Clear Lake	153.85	30.77	12.31	6.15	3.08	1.54	0.62
Cache Cr at Indian Valley	153.85	30.77	12.31	6.15	3.08	1.54	0.62
American R at Folsom	76.34	15.27	6.11	3.05	1.53	0.76	0.31
Putah Cr at Berryessa	153.85	30.77	12.31	6.15	3.08	1.54	0.62

Note – The seven frequency storms centered at Shanghai Bend and Verona are the bold values located in the column headers. The concurrent frequency values for each index location are given below each column header. For example, a 2.89% chance exceedence event occurs on the Sacramento River above Shasta Dam during the 1% chance exceedence event centered at Shanghai Bend and Verona.

TABLE 20

Unregulated Flow Frequency for Feather River at Shanghai Bend storm centering							
Avg flow[2](cfs) for given duration and AEP[3]							
1/AEP[3]	2	10	25	50	100	200	500
Duration (days[1])	0.5	0.1	0.04	0.02	0.01	0.005	0.002
0.0416	93,600	282,800	408,900	513,600	626,300	746,900	918,300
1	73,600	222,600	321,800	404,200	492,900	587,900	722,800
3	56,600	172,200	249,400	313,600	382,800	457,000	562,400
7	39,900	115,800	165,200	205,700	249,000	295,000	359,900
15	29,300	77,600	106,100	128,400	151,200	174,600	206,100
30	22,100	54,900	73,600	88,000	102,600	117,300	137,000

There are only subtle differences between these two storm patterns. These differences lie within the index locations on the Feather and Yuba rivers. For storm centering A, exceedence frequency values generated at Shanghai Bend and the Latitude of Verona are the same as the frequency assigned to the Yuba River. However, for storm centering B, the Yuba River experiences a more frequent event, and the Feather River at Oroville is assigned the same exceedence frequency value that is produced at Shanghai Bend and the Latitude of Verona. In other words, storm centering A has more emphasis on the Yuba River, and storm centering B has more emphasis on the Feather River.

In developing these storm centerings, the guidelines for preparation of mainstem centerings developed for the Comprehensive Study were followed (USACE, 2002). Shanghai Bend and the Latitude of Verona are the bull's eyes of the storm. That is, no other location within the Sacramento River Basin experiences a larger flood than at Shanghai Bend and the Latitude of Verona for the seven hypothetical storms (10-, 2-, 1-, and 0.2- percent chance exceedences). First, the distribution of storm intensity for the Upper Feather and Yuba River basins was developed. Initial exceedence frequency values were assigned to the Yuba River and Feather River index locations. Hydrographs were then constructed at these tributary locations and routed through the system to Shanghai Bend. Duration maxima (peak, 1-, 3-, 7-, 15-, and 30-day) were computed for the hydrographs at Shanghai Bend and compared with the average flows from the frequency curves. The initial pattern was then increased or decreased and the comparison process was repeated until results agreed reasonably with the unregulated rain flood frequency curves.

Once this portion of the pattern was set, the same process was followed for the Latitude of Verona index location. The storm pattern for the rest of the tributary index locations were based upon the average of the Feather and Yuba River storm centerings generated for the Comprehensive Study [#]. This pattern was iteratively adjusted by a fixed percentage until the duration maxima (1-, 3-, 7-, 15-, and 30-day) computed at the Latitude of Verona agreed reasonably with the unregulated rain flood frequency curve at this index location.

The frequency curves used in this process were obtained from the Comprehensive Study (USACE, 2002), except for the Shanghai Bend unregulated flow frequency curve. This curve was adopted from the 1999 FEMA report entitled, "Rain Flood Flow Frequency Analysis, Feather and Yuba Rivers" (USACE, 2002). No adjustments were made to any of the frequency curves except for the peak curve for Shanghai Bend. According to Robert Collins, District Hydrologist, the peak mean for the unregulated flow frequency curve at Shanghai Bend was proportioned based on the relationship of the peak and 1-day means at Oroville, since no peak unregulated data at Shanghai Bend was available. The frequency curve for the Feather River at Shanghai Bend with the modified statistics is presented in Plate 12.

It was determined through a comparison of stages from hydraulic models using as input the hydrology from the various storm centerings that the Feather-Yuba storm centering at Shanghai Bend and the mainstem storm centering at the latitude of Sacramento produced the highest stages. Therefore only those two storm centerings were kept for the analysis of Sutter basin flood risk management.

7.5 UNREGULATED FREQUENCY CURVES FOR CHEROKEE CANAL AT RICHVALE

7.5.1 Purpose:

The hydrology presented in this hydrology appendix for the Butte County portion of the Sutter Basin focuses on the Cherokee Canal, which is a potential source of flooding in the northern portion of the feasibility study area. The hydrology includes the development of flood frequency estimates and 30-day balanced hydrographs for the n-year (50-, 20-, 10-, 4.0-, 2.0-, 1.0-, 0.5-, and 0.2-) percent chance synthetic flood events on the Cherokee Canal from Cottonwood Creek to Afton Road.

7.5.2 Study Area:

The Cherokee Canal, located in Butte County, is tributary to Butte Creek. The Cherokee Canal watershed includes the total drainage above the Cherokee Canal, an artificial channel that flows southwesterly to lower Butte Creek. The watershed is bounded by the Feather River watershed to the east and southeast, by Butte Creek and its tributaries to the north and west, and by Wadsworth Canal drainage to the south. The three primary tributaries to Cherokee Canal are Dry Creek, which, with its tributary, Clear Creek, flows out of the Sierra Nevada foothills, and Cottonwood and Gold Run creeks, which flow west from Table Mountain.

The Cherokee Canal drainage area covers approximately 94 square miles. Its elevation varies from about 70 feet on the Cherokee Canal to about 2,200 feet in the headwaters of Dry Creek. The most heavily urbanized area in the watershed is the incorporated city of Paradise, where the headwaters of Dry and Clear creeks are located. Land use on the valley floor is mostly agricultural, with rice fields predominating. Native vegetation covers the foothills. Plate 14, the general map, shows the boundaries of the upper Cherokee Watershed and the Cherokee Canal watercourse from the headwaters down to the confluence with Butte Creek. Plate 15 shows the area's topography and a more detailed map of the upper Cherokee Canal drainage.

7.5.3. Background:

Between 1959 and 1960 the Corps of Engineers constructed the Cherokee Canal flood control project from Butte Sink up to Dry Creek. The Federal Flood Control Act of 1944 authorized the construction of the Cherokee Canal as part of several flood control projects on Sacramento River tributaries. The objectives of the Cherokee Canal flood control project were to provide flood protection and to control inflow of sediment into the canal. According to the Cherokee Canal Design Memorandum, dated 15 November 1958, the Cherokee Canal Levee Project included levee construction and channel improvement on the Cherokee Canal and its principal tributaries. The project, as designed, would provide flood protection to 22,000 acres of improved agricultural land, highways, railroads, and irrigation canals. The project begins at the Lower Butte Basin and runs northeasterly to high ground about 13 miles north of Biggs, for a total distance of approximately 22 miles. The design capacity for Cherokee Canal was 8,500 cfs from the upstream end of the canal down to the confluence with Cottonwood Creek, 11,500 cfs from Cottonwood Creek down to Afton Road (the Biggs Princeton Highway), and 12,500 cfs from

Afton Road to the downstream end of the canal. The design capacity reaches are identified on Plate 15.

7.5.4. Stream Gage and Recent Flood History:
A streamflow gaging station was established on the Cherokee Canal at Butte City Road Bridge (State Highway 162). The General Map, Plate 14, shows the location of this streamflow gage, "Cherokee Canal near Richvale," California DWR station A02984. Records for this station have been collected from water year 1961 to present. Flow and stage records are available back to 1976 on the Department of Water Resources Water Data Library website(DWR, 2010). Table 21 lists the five highest flows of record for the Cherokee Canal gaging station. See Section 6.3 for information on the October 1962 high flow event and Section 7.1 for information on other high flow events on the Cherokee Canal.

Table 21

Tabulation of High Peak Flows For Cherokee Canal Gage (DWR Station A02984)	
Peak Flow (cfs)	Date
15,200	13-Oct-62
11,000	13-Jan-69
10,000	11-Mar-89
9,750	21-Jan-64
9,460	24-Dec-83

During the first ten years of the project, several high flows reached or exceeded warning stage at the gage. The high flows deposited sediment from the upstream mining debris in the canal; brush and willows growing in the canal fixed the sediment deposits in place.

On 11 March 1989, a levee break occurred on the left bank of Cherokee Canal just upstream of Nelson-Shippee Road Bridge. The break was caused by overtopping, due to backwater from debris blocking the bridge opening. Design capacity of the canal at this location was 8,500 cfs. Apparently, the levee break resulted from an overnight flood on 11 March that carried enough debris to block the bridge opening and produce a peak flow of 10,000 cfs downstream at the Richvale gage. [#]

During the January 1995 flood, a waterside levee slip occurred on the left levee of Cherokee Canal about 300 feet north of State Highway 162, the location of the "near Richvale" gaging station (Plate 15). The slip was covered with sandbags and plastic to prevent levee failure, which would have flooded several farm houses and the USDA Rice Experimental Station 9USACE, 1995). The observed peak flow at the gage for this event was 8,220 cfs.

The Department of Water Resources removed sediment from various reaches of the Cherokee Canal in 1988, 1989, 1990, and 1996. Occasional high flows down Dry Creek continue to deposit sediment in the Cherokee Canal. Sediment accumulation and vegetation in the canal have reduced its channel capacity such that at some locations the Cherokee Canal channel capacity has been reduced between 37 percent and 44 percent of the original 11,500 cfs design capacity [#].

7.5.5 Hydraulic Analysis – General:
The hydrologic analysis in this appendix uses a hypothetical flood pattern to compute balanced flood hydrographs for an 8-flood synthetic series (50-, 20-, 10-, 4-, 2-, 1-, 0.5-, and 0.2% event floods), which will be used in a hydraulic routing model along a critical reach of the Cherokee Canal for a levee break analysis. This critical reach of the canal extends from the Western Canal Levee, at the confluence of Cottonwood Creek, down to the Biggs Extension, about a mile upstream of the Richvale gaging station. The reach is being analyzed to test for a potential left bank levee break that could cause flooding in the town of Biggs to the south. The analysis also includes a test of response time needed to repair a breach in the levee. If the levee is not repaired in a timely manner, later flood waves could increase the flooding to the south. For that reason, the synthetic flood series is 30 days in duration. Hydrographs at the Richvale gaging station are equivalent to those for the critical levee reach as well as for the Cherokee Canal down to Afton Road, the lower end of the hydraulic model. Plate 15 shows the extent of the Cherokee Canal hydraulic model, from Afton Road up to the downstream end of Cottonwood Creek.

7.5.6 Flow Frequency Analysis:
The streamflow gage, Cherokee Canal near Richvale (DWR gage A02984) currently has 46 years of record available, from 1961 to 2006. More recent gaged data are still preliminary. The gage is located at Butte City Road Bridge, 2.1 miles south of Richvale. Flows at the gage are similar to those along the Cherokee Canal reach being analyzed upstream, from the Cottonwood Creek confluence to the Biggs Extension canal. No additional flow enters the canal downstream of the Cottonwood Creek confluence. Daily flows at the gage are available for the period of record; hourly flows are available for water years 1982 to 2006, as well as for the floods of October 1962, January 1964, December 1964, January 1965, and January 1969. DWR Northern District provided a table of annual peak flows for the period of record. Data for the Cherokee Canal near Richvale gage are from (USACE, 2002).

7.5.7 Results and Conclusions:
The unregulated flow frequency of the Cherokee Canal at Richvale is presented in Table 18 below, and on plate 16 at the end of the report. Table 22 lists the peak, and volume flows for the 8-flood series from the flow frequency curves. Plate 17 shows a graphical representation of the 5-day waves for the 8-flood series hydrographs. For this study, it was assumed that the peak flows listed in Table 18 are able to remain in-channel down the Cherokee Canal.

TABLE 22

Peak and Duration Flow Rates for the Synthetic 8-Flood Series Hydrographs							
Percent Exceedence Flood Event	Peak Flow (cfs)	1-Day Flow (cfs)	3-Day Flow (cfs)	5-Day Flow (cfs)	10-Day Flow (cfs)	15-Day Flow (cfs)	30-Day Flow (cfs)
50%	5,900	3,040	1,960	1,540	1,070	869	600
20%	8,700	4,460	2,860	2,260	1,570	1,270	879
10%	10,300	5,280	3,390	2,670	1,860	1,510	1,040
4%	12,100	6,190	3,980	3,130	2,180	1,770	1,220
2%	13,200	6,870	4,360	3,430	2,390	1,940	1,340
1%	14,300	7,310	4,700	3,700	2,580	2,090	1,440
0.50%	15,200	7,780	5,000	3,940	2,750	2,220	1,540
0.20%	16,300	8,340	5,360	4,220	2,950	2,380	1,650

7.5.8. Hydrologic Uncertainty:

EM 1110-2-1619, "Risk-Based Analysis for Flood Damage Reduction Studies," (USACE, 1996), requires use of risk and uncertainty procedures in the evaluation of flood damage reduction studies. An unbroken record of 46 years of stream gage data (1961 to 2006) is available for the DWR station Cherokee Canal near Richvale (DWR gage A02984) that fits a known statistical distribution such as log Pearson III. Based on a review of the flow record and methodology, it is recommended that the systematic record length of 46 years be used as the equivalent record length in the analysis of project performance. The final statistics associated with this record length for the Cherokee Canal near Richvale are:

Mean (Log) = 3.7484
Adopted Standard Deviation = 0.224
Adopted Skew = -0.7

7.6 UNREGULATED FREQUENCY CURVES FOR WADSWORTH CANAL

Wadsworth Canal is an artificial channel that carries rainy season and agricultural runoff from the northeast part of Sutter County south to the Sutter Bypass. The drainage area covers the eastern slopes of the Sutter Buttes, northeastern Sutter County north of the East and West Interceptor canals, and a portion of southern Butte County west of Feather River. The tributaries contributing to Wadsworth Canal are: the West Interceptor Canal and its tributary, Sutter City Lateral; and the East Interceptor Canal with its tributaries (from east to west): Live Oak Slough, RD 777 Lateral 1, Snake River with its tributary, Morrison Slough, and Sand Creek. The drainage area, primarily agricultural, covers about 91 square miles.

The elevation varies from about 54 feet at the upper end of Wadsworth Canal to over 2100 feet on South Butte, the headwaters of the West Interceptor Canal drainage. Aside from Sutter Buttes, the topography of the Wadsworth drainage is relatively flat. The channel capacity of

Wadsworth Canal is 1,500 cfs. During a period of high runoff, the water fills Wadsworth Canal to capacity, then ponds behind the interceptor canals until there is room in Wadsworth Canal to accommodate the ponded water.

The California Department of Water Resources operates two stage gages on Wadsworth Canal:

A0-5927 Wadsworth Canal Near Sutter, Lower Station, and
A0-5929 Wadsworth Canal Near Sutter, Upper Station.

At times, backwater from the Sutter Bypass affects the stage-discharge relationship.

The Wadsworth unregulated frequency curve was developed based on DWR gage A05929, Wadsworth Canal Upper gage. The period of record is 01Oct1939 to 30Sep1996. Annual 1-day maximum flows are available for WY 1939 to WY 1974. Daily data is available from 01Oct1975 to 30Sep1996. The gage was discontinued after WY 1996. A table of peak unregulated flows and volumes for the Wadsworth Canal is shown below in table 23. The flow-frequency curve is shown on plate 18.

TABLE 23

Unregulated Flow at the Wadsworth Canal Upper Gage								
1/AEP	2	5	10	25	50	100	200	500
Duration (days)	0.5	0.2	0.1	0.04	0.02	0.01	0.005	0.002
Peak	817	1,607	2,254	3,197	3,983	4,833	5,750	7,067
1	743	1,390	1,874	2,523	3,024	3,533	4,049	4,740
3	592	1,122	1,522	2,062	2,480	2,906	3,340	3,923
7	455	853	1,151	1,551	1,860	2,173	2,492	2,919
10	400	741	994	1,332	1,591	1,853	2,119	2,474
30	249	434	566	738	867	995	1,124	1,293

7.7 VERIFICATION OF UNREGULATED FLOWS AT INFLOW AND HANDOFF POINTS FOR HYDRAULIC ROUTING

7.7.1. PURPOSE

The purpose of this section is to specify flow hydrographs for use as Sutter Basin Feasibility Study hydraulic model boundary conditions. The Sutter Basin Study Area and hydraulic model hydrologic boundary conditions are illustrated in Plate 19.

7.72. BACKGROUND

A system wide hydrology study of the Sacramento San Joaquin basin was completed in 2002. The study, titled Sacramento San Joaquin Comprehensive Study formed the basis of multiple flood risk management studies throughout the Sacramento and San Joaquin Basins. Several of these studies completed refinements to the hydrologic modeling. Hydrology for the Sutter Basin Feasibility Study is based on the latest hydrologic studies.

7.73. SUTTER BASIN FEASIBILITY STUDY HYDRAULIC MODEL

The Sutter Basin Study Area and HEC-RAS hydraulic model domain are illustrated in the attached Plate 19. The HEC-RAS model is a 1-dimensional unsteady model. The model includes 16 inflow type boundary locations which require hydrograph inputs for 1/2, 1/10, 1/25, 1/50, 1/100, 1/200, and 1/500 AEP flood event simulations.

Due to the size of the tributary area, the hydraulic model is run for two different hydrologic storm-centerings to determine the critical scenario (peak stage and/or flow) at internal model locations. The Sacramento (SAC) storm centering represents a storm centered over the upper Sacramento River watershed with lesser concurrent rainfall/runoff from the Feather/Yuba watershed. The Shanghai Storm Centering (SHY) represents a storm centered over the Feather/Yuba river watershed with lesser concurrent rainfall/runoff from the Sacramento River Basin. Analysis of each storm-centering requires a complete suite of hydrographs (16) for the model boundary conditions. A detailed description of the storm centering procedure is described in the 2002 Comprehensive Study technical documentation (USACE, 2002). The selection of the Sacramento and Shanghai storm centerings from the 25 storm centerings evaluated in the comprehensive study is described in a memorandum for file dated 10 December 2010.

7.74. HYDROGRAPHS

A single DSS file with hydrographs for each of the model boundary locations was provided as a digital attachment as HEC-DSS filename "Sutter_FS_Hydrographs.dss". Tables are provided in the memorandum to describe the refinements made to the boundary conditions used during plan formulation of conceptual and preliminary alternatives.

A tabulation of the period of record and the peak unregulated flows within the study reaches is shown in table 24. The plates following the references of this report show the frequency curves and notes pertaining to the frequency curve creation.

TABLE 24

Period of Record and Peak Un-Regulated Flows								
Stream and Reach	Period of Record	Un-Regulated Peak Flows (cfs)						
		1/2	1/10	1/25	1/50	1/100	1/200	1/500
		0.5	0.1	0.04	0.02	0.01	0.005	0.002
Sacramento River								
Colusa to Tisdale Weir	76	111,000	257,000	328,000	406,000	484,000	566,000	681,000
Tisdale Weir to Sutter Bypass	76	169,000	423,000	625,000	756,000	928,000	1,143,000	1,360,000
Feather River								
Oroville to Honcut Creek	94	47,000	136,000	201,000	253,000	311,000	374,000	464,000
Honcut Creek to Yuba River	94	51,000	144,000	211,000	267,000	328,000	394,000	489,000
Yuba River to Bear River	94	84,000	250,000	365,000	459,000	561,000	670,000	827,000
Bear River to Sutter Bypass	94	90,000	265,000	391,000	491,000	599,000	714,000	878,000
Sutter Bypass								
Butte Slough to Wadworth Canal	76	56,700	101,300	126,300	254,800	182,400	225,400	327,400
Wadsworth Canal to Tisdale Weir	76	57,400	103,200	128,900	157,800	186,000	229,400	332,100
Tisdale Weir to Feather River	76	101,200	259,400	342,200	429,100	516,900	607,800	1,215,200
Feather River to Sacramento River	76	169,100	422,600	624,900	755,800	928,200	1,143,400	1,359,700
Wadsworth Canal								
East - West Interceptor to Sutter Bypass								
Concurrent with Sacramento Storm Centering	56	420	1,240	1,300	1,480	1,520	1,550	1,600
Tributary Specific Storm Centering	56	820	2,550	3,200	3,980	4,830	5,750	7,070
Cherokee Canal								
Nelson Shipee Road to Western Canal	-							
Western Canal to Afton Road	46	6,000	10,300	12,100	13,200	14,300	15,200	16,300
Afton Road to Gridley-Colusa Road	-							

Note: Peak un-regulated flows include the effects of headwater reservoir regulation
Note: Peak Un-Regulated flows are the higher of the Sacramento or Shang Shanghai Bend Storm Centerings
Note: The period of record is used in HEC-FDA to establish the confidence limits for the unregulated and regulated flows. The period of record shown above was taken from the unregulated flow-frequency curves that are shown as plates following the references in this report.

8. Reservoir Simulation Model (HEC-5) Routing

The Hydrologic Engineering Center's HEC-5 software (Simulation of Flood Control and Conservation Systems), Version 8.0 (USACE, 1998), was used to route the synthetic tributary flood hydrographs through the reservoir system on the Sacramento River - Basin for analysis of floodplain and channel hydraulics. The Reservoir Simulation Model User's Guide, (USACE, 2003), documents the reservoir model assumptions and methodology for routing the flood hydrographs through two reservoir system models, the headwater reservoirs model, and the lower basin reservoirs model. The reservoir system models routed tributary flows for the entire Sacramento basin; however, the only hydrographs needed for this study are those upstream of and at Hamilton City. The synthetic unregulated hydrographs constructed for Shasta Dam and Valley tributary locations from the Hamilton City flood centering series were input to the reservoir system models to simulate regulated hydrographs at mains tern points on the Sacramento River, including Hamilton City. The Shasta Dam hydrographs were routed through the HEC-5 headwater reservoirs model, to simulate results from regulation by reservoirs upstream of Shasta Dam for the synthetic flood series. The headwater reservoirs are listed on Table 20, and their relative locations shown in the schematic on Plate 20. The simulated regulated inflow hydrographs to Lake Shasta and the downstream tributary hydrographs were then input to the lower basins reservoir model. The schematic on Plate 21 shows the relationship of the reservoirs and the east- and westside tributaries downstream on the Sacramento River.

TABLE 25

LIST OF RESERVOIRS IN THE SACRAMENTO RIVER BASIN ABOVE ORD FERRY						
Reservoir	**Drainage**	**Owner**	**Gross Pool Storage (ac-ft)**	**Drainage Area (sq.mi.)**	**Began Operation**	**Purpose**
Britton (Pit No. 3)	Pit River	Pac Gas & Electric Co	34,600	4700	1925	Water Supply & Hydropower
Pit No.6	Pit River	Pac Gas & Electiic Co	15,700	5020	1905	Water Supply & Hydropower
Pit No. 7	Pit River	Pac Gas & Electric Co	34,000	5170	1965	Water Supply & Hydropower
McCloud	McCloud River	Pac Gas & Electric Co	35,300	380	1965	Hydropower
Shasta	Sacramento, McCloud & Pit.	US Bureau of Reclamation	4,552,000	6665	1945	Flood Management
Whiskeytown	Clear Creek	US Bureau of Reclamation	241,100	201	1963	Water Supply
East Park	Little Stony Creek	US Bureau of Reclamation	51,000	102	1910	Water Supply
Stony Gorge	Stony Creek	US Bureau of Reclamation	50,350	735	1928	Water Supply
Black Butte	Stony Creek	USACE	143,700	741	1963	Flood Management

Modeled Reservoirs in the Feather and Yuba River Basins				
Reservoir	**Tributary**	**Owner**	**Storage Capacity (ac-ft)**	**Drainage Area (sq mi)**
Feather River				
Mountain Meadows	Hamilton Creek	PGE	24,800	158
Almanor	NFk Feather Creek	PGE	1,308,000	503
Butt Valley	Butte Creek	PGE	49,800	86.2
Antelope	Indian Creek	DWR	22,566	71
Bucks Lake	Bucks Creek	PGE	103,000	29.5
Frenchman	Last Chance Creek	DWR	55,477	82
Lake Davis	Big Grizzly Creek	DWR	83,000	44
Little Grass Valley	SFk Feather River	OWID	93,010	27.3
Sly Creek	Lost Creek	OWID	65,050	23.9
Oroville	Feather River	DWR	3,538,000	3,611
Yuba above Marysville				
New Bullards Bar	NFk Yuba River	YCWA	960,000	489
Jackson Meadows	MFk Yuba River	NID	52,500	37.11
Bowman	Canyon Creek	NID	64,000	28.91
Fordyce	Fordyce Creek	PGE	48,900	30
Spaulding	SFk Jackson Creek	PGE	74,773	118
Scotts Flat	Deer Creek	NID	49,000	20
Merle Collins	Dry Creek	BVID	57,000	72.3

TABLE 26

Oroville Release Schedule		
Actual or Forecasted Inflow (Whichever is Greater) (cfs)	Flood Control Space Used (acre-ft)	Required Releases (cfs)
0 – 15,000	0 – 5,000	Power demand
0 – 15,000	Greater than 5,000	Inflow
15,000 – 30,000	0 – 30,000	Lesser of 15,000 or maximum inflow
0 – 30,000	Greater than 30,000	Maximum inflow for flood
30,000 – 120,000	N/A	Lesser of maximum inflow or 60,000
120,000 – 175,000	N/A	Lesser of maximum inflow or 100,000
Greater than 175,000	N/A	Lesser of maximum inflow or 150,000

TABLE 27

New Bullards Bar Release Schedule		
Actual Inflow (cfs)	Flood Control Space Used (ac-ft)	Required Releases (cfs)
0 – 50,000	0 – 170,000	Inflow
50,000 – 120,000	0 – 170,000	Inflow
Greater than 120,000	0 – 170,000	Inflow up to 180,000
Note – Emergency spillway release diagram used when the combination of the rate of rise and pool elevation dictate.		

TABLE 28

Downstream Flow Target Reductions			
Reservoir (cfs)	Downstream Location (cfs)	Target Flow	Reduced Target Flow
Oroville	Yuba City	180,000	174,000
	Below Yuba R. Confluence	300,000	280,000
	Below Bear R. Confluence	320,000	312,000
New Bullards Bar	Marysville	120,000/180,000	106,000/154,000

9. RESERVOIR OPERATIONS MODELING (HEC-ResSim)

Methodology

Reservoir routing for the Feather River system was accomplished using both HEC-5 and the ResSim modeling package produced by the Hydrologic Engineering Center (USACE, 2007). HEC-5 models were constructed for the entire Sacramento River Basin for the Comprehensive Study. A ResSim model for the Feather-Yuba system has been completed by HEC. The spatial extent of this model is shown in Plate 22. ResSim was used to model the Feather River system from Oroville down to Nicolaus. The Comprehensive Study HEC-5 model was used to model the Sacramento River system down to the confluence with the Feather River (Verona). Output hydrographs from both of these models were used as input into the hydraulic models which cover the majority of the main river system (Feather and Sacramento rivers). Hydrograph input locations to the hydraulic model include:

- Feather River below Oroville Dam
- Honcut Creek
- Yuba River at Englebright
- Deer Creek on the Yuba River
- Dry Creek on the Yuba River
- Bear River at Wheatland
- Dry Creek on the Bear River
- Sacramento River at Vina Bridge
- Big Chico Creek
- Stony Creek
- Butte Creek
- Cache Creek
- Putah Creek

The intent of the HEC-5 to ResSim model conversion was to replicate the results of the Comprehensive Study HEC-5 models using ResSim; therefore, all hydrologic routing parameters and methods, starting storage assumptions, and operational rules found in the Comprehensive Study HEC-5 models were incorporated into the ResSim model. All of the reservoirs included in both the headwater and lower basin Comprehensive Study HEC-5 models for the Feather and Yuba River basins are included in this ResSim model (see Table 25 for a complete listing of these reservoirs).

Model Changes

A number of modifications were made to the ResSim model delivered to the Sacramento District by HEC prior to use in the Lower Feather Floodplain Mapping Study. The Comprehensive Study starting storage assumptions for the headwater reservoirs listed in Table 20 were based on the average reservoir storages prior to the December-January 1997, March 1995, and February 1986 flood events. In a floodplain mapping study, storage capability below the normal pool elevation of dams operated primarily for purposes other than flood control should not be considered because the availability of

such storage is uncertain. Therefore, the storages for all but two of the headwater reservoirs were set to gross pool. The storage for both Bucks Lake and Lake Almanor has never exceeded gross pool. Therefore, the maximum storage that has occurred at the lakes for months of December-March was used as the starting storage.
Slight modifications were also made to the ramp-up criteria scripted for Oroville. The Water Control Plan for Oroville specifies a release schedule that is a function of both flood spaced used and actual/forecasted inflow (Table 26).

The original ResSim model developed by HEC did not incorporate the forecasted inflow component of this release schedule. For example, releases would be restricted to 60,000 cfs until an actual inflow exceeded 120,000 cfs. At this time releases would begin to ramp up to the next specified flow value in the schedule (100,000 cfs for this example). In reality, releases would begin to ramp up to 100,000 cfs much earlier than this if a forecasted inflow greater than 120,000 cfs was known. All events greater than the 10% flood have peak flows greater than the largest value in the release schedule (175,000 cfs); so, for these events, Oroville releases were modeled to allow releases to ramp up freely to the maximum objective flow of 150,000 cfs at a rate of 5,000 cfs per hour. This situation is better understood by reviewing tables 26, 27 and 28 above.

Another change to the ResSim model involved travel times. Total travel time from Oroville Dam down to Yuba City was increased from 8 hours to 16 hours, which is consistent with the published travel times used by the Department of Water Resources and is in better agreement with what has been observed.

Lastly, changes were made to the model to incorporate a forecast uncertainty component to the local flow. The original models assumed complete certainty in local flow contributions downstream of a reservoir. This assumption yields high operational efficiency when operating for downstream flow criteria. In reality, however, local flow contributions could be greater or less than what was forecasted. Because of the possibility that local flows could be more than what is forecasted, reservoir releases are typically less than what the calculated releases would be based on the forecasted information. The magnitude of forecast uncertainty can vary from basin to basin and also from storm to storm. The Corps standard is to incorporate a 20% uncertainty in local flow contributions when operating for downstream flow targets. This uncertainty percentage was modeled in ResSim by reducing all downstream flow targets by 20% of the local flow contributing to that specific location. These modifications are listed in Table 28.

Model runs were also simulated assuming complete certainty in local flow contributions for all frequency events. Results from both scenarios were compared for each flood event. The scenario producing the larger of the two flows was selected for the hydraulic analysis. Generally, the complete certainty scenario was selected for events in which the reservoirs were able to satisfy downstream flow criteria, and the 20% uncertainty scenario was selected for those events in which the downstream flow criteria were exceeded.

RESULTS

Discussion of results will focus on the area in which the synthetic storms are centered, the Feather-Yuba system, even though the spatial extent of the storms covered the entire Sacramento River Basin.

Yuba River Basin

Seven reservoirs were modeled within the Yuba River Basin. New Bullards Bar, located on the North Fork of the Yuba River, is the only reservoir that has dedicated flood space. New Bullards Bar, which contains 170,000 acre-feet of flood space, operates to flow targets at Marysville. The flow criteria at Marysville is 180,000 cfs except when the Feather River is experiencing high flows. When the flows in the Feather River upstream of the Yuba River confluence are high, the flow target at Marysville is reduced to 120,000 cfs. This adjustment is made to assure that 300,000 cfs is not exceeded at the confluence of the Yuba River with the Feather River. New Bullards Bar is able to maintain its objective flow of 50,000 cfs for all events through the 2-percent chance exceedence event. For events larger than the 2-percent chance exceedence event, New Bullards Bar outflow exceeds 50,000 cfs. However, the 300,000 cfs flow target at the confluence is still met for the 1-percent chance exceedence event. See Table 29 for a summary of peak flows.

TABLE 29

Effects of Headwater Regulation

Location	Annual Percent Chance Exceedence	Unregulated Peak Flow (cfs)	Regulated Peak Flow (cfs)	% Peak Reduction Due to Regulation
MF + SF of Yuba	10%	38,800	34,100	12.2
	2%	76,400	68,500	10.3
	1%	96,200	87,300	9.3
	0.2%	149,200	137,000	8.2
Deer Creek	10%	4,900	4,600	5.9
	2%	8,700	8,200	5.9
	1%	10,100	9,500	5.9
	0.2%	13,000	12,400	4.9
Dry Creek	10%	4,900	4,600	5.9
	2%	8,700	8,200	5.9
	1%	10,100	9,500	5.9
	0.2%	13,000	11,600	10.9
Oroville Inflow	10%	153,700	135,900	11.6
	2%	284,100	253,100	10.9
	1%	349,600	311,500	10.9
	0.2%	520,300	464,600	10.7

Notes:
% Peak Reduced = ((Maximum Unregulated Inflow)-(Maximum Regulated Inflow))/(Maximum Unregulated Inflow) X 100%
Values are from model simulations of the Feather River Storm Centering A

TABLE 30

Regulated Peak Flows by Hydrologic Routing					
% Chance Exceedance	Feather R. at Oroville	North Yuba R. at New Bullards Bar Dam	Yuba R. at Marysville	Feather R. at Shanghai Bend	Feather R. At Nicolaus
10	100,000	44,400	92,400	200,000	219,000
2	150,000	50,000	150,000	293,000	323,000
1	150,000	66,100	155,000	296,000	323,000
0.2	327,000	150,000	313,000	607,000	668,000

Note - Values at downstream locations are a result of Muskingum hydrologic routing which assumes infinite channel capacity and neglects backwater effects and channel geometry. Hydraulic model output will differ from these results.

The other six reservoirs modeled in the Yuba Basin, known as headwater reservoirs, are much smaller and do not have any dedicated flood space. Even though the model simulations began with the majority of the reservoirs at gross pool, effects of peak attenuation for many locations along the Yuba River was still evident due to surcharge effects (Table 27). Average peak flows along the Middle and South forks of the Yuba River were attenuated by 8.8% for the 1-, 0.5-, and 0.2-percent chance exceedence events.

Feather River Basin

A total of 9 headwater reservoirs were modeled in the watershed above Oroville. Only 20% of the natural flow hydrograph at Oroville was routed through these headwater reservoirs. However, these reservoirs still had a significant impact on attenuating flows into Oroville (Table 27). Average peak inflows to Oroville were reduced by 10.8% for the 1-, 0.5-, and 0.2-percent chance exceedence events.

Oroville Reservoir has a maximum flood space reservation of 750,000 acre-feet, and is required to maintain flow targets at multiple downstream locations. It is also required to maintain flows at or below 180,000 cfs above the Yuba River confluence, 300,000 cfs below the Yuba River confluence, and 320,000 cfs below the Bear River confluence. These criteria were met for all events except the 0.5% chance exceedence event. In these two events releases specified by the Emergency Spillway Release Diagram (ESRD) were triggered. See Table 28 for a summary of peak flow results.

10.0 BEAR RIVER MODEL

10.1 Purpose of Study

The hydrologic analysis described in this section is for the Bear River (a tributary to the Feather River in Northern California). The hydrology developed in this report will be used to support the Sutter Basin feasibility study on the Bear River mainstem and its lower tributaries including Yankee Slough, UP Intercept Canal, and Dry Creek.

10.2 Scope of Study

This study covers the unincorporated areas of Sutter and Yuba Counties, California within the Bear River Watershed. A detailed map of the study area is shown on Plate 26. Products derived include the 10-, 2.0-, 1.0-, and 0.2-percent chance exceedence flood hydrographs for the Bear River at Wheatland, Yankee Slough at Swetzer Road, UP intercept canal at Plumas Lake and Dry Creek at the Best Slough split and Jasper Lane. The above index points coincide with the upstream end of the levees on each stream. Determining interior runoff behind the levees was not within the scope of this hydrologic analysis.

10.3 Basin Description and Reservoir Regulation

The Bear River Basin is located on the western slope of the Sierra Nevada Mountains. The basin is bounded on the north by the Yuba River Basin and has its confluence with the Feather River about 15 miles south of Marysville. The Bear River drains approximately 550 square miles of mountain, foothill, and valley areas. Elevation varies from 6,000 feet to 60 feet above sea level. A topographic map is shown on Plate 27.

Vegetation at the uppermost elevations, where high mean annual rainfall occurs, is covered with dense forest. Much of the Bear River watershed above Wheatland consists of rolling hills vegetated by grass and oak trees. Grazing is the main use for this land. The Dry Creek watershed consists mainly of rolling hills used for grazing or pasture. Beale Air Force Base, located in the middle of the Dry Creek watershed, is urbanized but only constitutes a small percentage of the total land use. The UP Intercept watershed consists of a mix of pasture, irrigated cropland (including rice farming), and urban areas. The main land-use in the Yankee Slough watershed is irrigated cropland.

There are three major reservoirs on the Bear River. New Camp Far West, constructed in 1963, is the most downstream reservoir, has a drainage area of 283 square miles, and is located in the low foothills. The dam is operated by South Sutter Water District for power, irrigation, and recreation. It has a 300 foot long ungated spillway and storage capacity is 104,000 acre-feet. The next reservoir is located 18 miles upstream at Lake Combie. This reservoir is relatively small and only has about 5,000 acre-feet of storage capacity. Rollins Reservoir is the uppermost major reservoir in the watershed, was completed in 1965, and drains the uppermost 104 square miles of the watershed. It has a 300 foot long ungated spillway and a storage capacity of 66,000 acre-feet. This dam is operated by the Nevada Irrigation District. All three reservoirs are operated to fill and spill as early in the rain season as possible; therefore, the only flood control provided is for early season storms that occur while the reservoirs are filling and surcharge storage during spillway flow. The Comprehensive Study in 2001 modeled the Bear River watershed with an HEC-5 Reservoir Model that included Camp Far West and Rollins Dams. Lake Combie was not modeled since storage capacity is minimal. The Comprehensive Study HEC-5 model of the watershed indicates that the reservoirs attenuate the natural peak flow at Bear River at Wheatland

by about 11% during the 1% chance exceedence event. This attenuation is due to reservoir surcharge during uncontrolled spillway flow.

10.4 Principal Flood Problems

General rainstorms cause flooding on the mainstem of the Bear River and the larger local tributaries. Due to the relatively low elevation of most of the watershed, snowmelt runoff in the spring does not cause flooding. Localized cloudburst storms would only cause high flows on the smaller drainage basins such as the Linda-Olivehurst area and Yankee Slough. Some melting of the snowpack does occur during general rainstorms such as the January 1997 flood event.

10.5 Flood Protection Measures

Levees have been built along Bear River, Yankee Slough, Dry Creek, Best Slough and the UP Intercept Canal. Except for one reach on upper Yankee Slough (right bank), these levees are part of the Sacramento Flood Control Project. They are maintained by local reclamation districts. The three major upstream reservoirs on the Bear River only provide incidental storage that helps to attenuate the peak of major flood events or store floodwater early in the season before the reservoirs have filled.

10.6 Study Results of Hydrologic Analysis

Peak flood discharges for the 10-, 2.0-, 1.0-, and 0.2-percent chance exceedence events were obtained by using a HEC-HMS (USACE, 2010) rainfall-runoff model that was developed for the Bear River Basin and its tributaries. The subbasin delineation for this model is shown on Plate 31. Table 32 lists peak flows when storms are centered over the specific areas above the outlet point.

TABLE 31

TABLE 1: SUMMARY OF PEAK DISCHARGES					
FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. mi)	PEAK DISCHARGE (CFS EXCEEDENCE FREQUENCY			
		10%	2.0%	1.0%	0.2%
Bear River	292				
At Wheatland		25500	39400	44300	54700
Dry Creek					
Above Best Slough Split	82	9510	13700	15600	19800
At Jasper Lane	101	7470	10900	12500	15900
Best Slough					
Below Dry Creek Split	NA	3330	4810	5460	6920
UP Intercept Canal					
At Plumas Lake	87.2	2780	5060	6290	9630
Olivehurst Canal					
At Plumas Lake	9.46	706	1040	1190	1550
Yankee Slough					
At Swetzer Road	28.4	926	1950	2480	4050

TABLE 32

TABLE 2: SUMMARY OF COINCIDENT PEAK DISCHARGES					
FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. mi)	PEAK DISCHARGE (CFS EXCEEDENCE FREQUENCY			
		10%	2.0%	1.0%	0.2%
Bear River					
At Wheatland	292	25500	39400	44300	54700
Dry Creek					
Above Best Slough Split	82	6990	10500	12000	15500
At Jasper Lane	101	5850	8850	10200	13200
Best Slough					
Below Dry Creek Split	NA	2450	3670	4220	5440
UP Intercept Canal					
At Plumas Lake	87.2	2640	4890	6090	9390
Olivehurst Canal					
At Plumas Lake	9.46	594	900	1040	1360
Yankee Slough					
At Swetzer Road	28.4	761	1720	2220	3760

In addition to computing storm centerings at the above locations, coincident discharges for local tributaries during a centering on the mainstem of the Bear River were computed. Table 30 lists

coincident peak discharges at tributary index points when the Bear River at Wheatland gage is experiencing a specific frequency event. Coincident peaks are to be used when specific centerings on the Bear River mainstem are being evaluated.

The Comprehensive Study (USACE, 2002) calculated 1- through 30-day duration frequency curves for the Bear River at Wheatland. The curves were adopted for this study. A peak flow frequency curve was also created for this analysis. Unregulated peak flow values for the Wheatland gage exist for 1929 to 1963, while unregulated flows for the 1- through 30-day durations as calculated by the Comprehensive Study exist for 1929 to 1998. This data was input into HEC's Regional Frequency Computation Program (USACE, 1992). The program derives peak flow statistics based on correlation with the other durations. The 1-day skew was adopted for the peak curve. The adopted peak flow curve along with the other durations derived by the Comprehensive Study are shown in Plate 29. Table 33 displays the unregulated peak flow frequency values adopted for this study.

TABLE 33

Table 8: Unregulated Bear River at Wheatland	
Peak Flow in CFS	Percent Chance Exceedence
61100	0.2
54700	0.5
49600	1.0
44000	2.0
36100	5.0
29700	10.0

10.7 Coincident Flow on the Feather River

The Bear River hydrologic study conducted as part of the Lower Feather River FPMS computed design hydrographs assuming storms were centering on each tributary as shown in table 29. Then a second set of hydrographs were produced that assumed a storm centered on the Bear River at Wheatland, near the centroid of the basin, shown in table 30. The Sacramento – San Joaquin Comprehensive study and this feasibility study are using two storm centerings: one at the Feather River at Shanghai Bend, and the second at the latitude of Sacramento.

Therefore, the Bear River hydrographs from the Lower Feather River FPMS must be adjusted to match the Bear River at Wheatland flows for the Sacramento and Shanghai Bend storm centering used in this feasibility study. Ratios were computed as the Bear River Shanghai Bend or Sacramento centering peak flow divided by the Bear River hydrology study peak flow. These ratios were then applied to the hydrographs at the other locations including: Dry Creek, Best

Slough, UP intercept, and Yankee Slough, in the Bear River basin for which hydrographs were required in the hydraulic flood routings.

Note: the hydrograph for Dry Creek was not available in the Lower Feather FPMS or the Sacramento centering of the Comp Study. Therefore the hydrograph for Dry Creek for the Sacramento centering was derived from the Shanghai Bend centering by ratio of their peak flows.

The peak flows and ratios for the Bear River hydrology coincident storm centering, and the Comp Study Shanghai Bend and latitude of Sacramento centerings are shown in table 34.

TABLE 34

Table of Peak Flows and Ratios of Peak Flows for the Bear River								
AEP	1/2	1/10	1/25	1/50	1/100	1/200	1/500	Notes
Bear River at Wheatland								
Peak Flow	9251	26290	35828	43049	49201	54664	61972	Comp Study SAC centering
Peak Flow	6000	17100	27800	34600	41400	47700	55300	Shanghai-Yuba FPMS
Peak Flow	8500	25500	33500	39400	44300	49000	54700	Bear River Coincident Flow table
Ratio SAC-BR hydro	1.0884	1.0310	1.0695	1.0926	1.1106	1.1156	1.1330	Ratio of Comp Study SAC to Bear River Coincident peak flows
Ratio SHY-BR hydro	0.7059	0.6706	0.8299	0.8782	0.9345	0.9735	1.0110	Ratio of Comp Study SHY to Bear River Coincident peak flows
Ratio SAC - SHY	1.5419	1.5374	1.2888	1.2442	1.1884	1.1460	1.1207	Ratio of Comp Study SAC to SHY peak flows
Dry Creek at Jasper Lane								
	1700	4600	6200	7300	8300	9300	10500	Comp Study SAC centering
	1100	3000	4800	5900	7000	8100	9400	Shanghai-Yuba FPMS
	-	5850	-	8850	10200	-	13200	Bear River Coincident Flow table
Note: the hydrograph for Dry Creek was not available in the Lower Feather FPMS or the Sacramento centering of the Comp Study. Therefore the hydrograph for Dry Creek for the Sacramento centering was derived from the Shanghai Bend centering by ratio of their peak flows.								
Best Slough blw Dry Creek Split								
	1244	2521	3364	4015	4682	5293	6159	Comp Study SAC centering
	810	1640	2610	3230	3940	4620	5500	Shanghai-Yuba FPMS
	1140	2450	3150	3670	4220	4740	5440	Bear River Coincident Flow table
UP Intercept Canal								
	1089	2726	4084	5344	6765	8371	10644	Comp Study SAC centering
	710	1770	3170	4300	5690	7300	9500	Shanghai-Yuba FPMS
	-	2640	-	4890	6090	-	9390	Bear River Coincident Flow table
Yankee Slough								
	268	784	1312	1883	2471	3194	4258	Comp Study SAC centering
	170	510	1020	1510	2080	2790	3800	Shanghai-Yuba FPMS
	-	761	-	1720	2220	-	3760	Bear River Coincident Flow table

11. Interior Drainage Analysis

11.1. Background

The interior drainage analysis was performed by Peterson-Brustad Incorporated (PBI) a consultant to the Sutter Butte Flood Control Agency (SBFCA). The purpose of the SBFCA analysis was to serve as a submittal to FEMA in conformance with 44CFR65.10 requirements, and to support compliance with the State of California Urban Level of Protection criteria. A supplemental hydraulic analysis was also conducted to be used for the design of replacement levee culverts.

The modeling process consisted of using HEC-HMS to analyze 1% and 0.5% annual exceedance probability (AEP) rainfall-runoff and develop hydrographs at key concentration points in the interior of the Sutter basin, and using FLO-2D to analyze flood depths and boundaries.

A FLO-2D model with a 1,000-foot by 1,000-foot grid size was developed by Peterson Brustad, Inc. (PBI) for the U.S. Army Corps of Engineers' (USACE) Sutter Basin Feasibility Study and later modified to add key interior drainage channels and features. Hydrographs from HEC-HMS were input at concentration points into the FLO-2D model, and FLO-2D was used to route the floods, estimate residual floodplains, and estimate residual flood depths. In this instance, "residual" means floodplains which will exist following accreditation of all levees protecting the Sutter Basin, due to rainfall on the interior areas. These residual floodplains could later be modified through local land use changes or drainage improvement projects. The FLO-2D model and interior floodplain mapping will be discussed in the Hydraulics appendix.

The large grid size is expected to reveal areas of significant SFHA flooding, however, it should be noted that smaller areas of shallow flooding may be missed.

The design storm rainfall analysis was discussed above in section 6.2

11.1.2. Location

The study area includes approximately 340 square miles of Sutter and Butte Counties in Northern California. It is primarily bounded by the Feather River to the east and by the Sutter Bypass and Sutter Buttes in the west. Its southern boundary is at the confluence of the Feather River and the Sutter Bypass. The study area includes the cities of Live Oak, Gridley, Biggs, Yuba City, and the town of Sutter. Plate 30 shows the study area and its main features.

11.2. HEC-HMS MODELING

11.2.1. Model Development

11.2.1. Subbasin Delineation

The first step in developing the HEC-HMS model involved the delineation of drainage shed boundaries. Plate 30 provides an overview of the drainage sheds identified for this study. A total

of 16 main sheds covering approximately 340 square miles were identified within the interior drainage study boundary. The main sheds were further divided into a total of 77 subbasins as described below.

Live Oak Slough

The Live Oak Slough watershed includes 2 subsheds covering 16 square miles and drains to the Sutter Bypass through Wadsworth Canal. Subsheds were delineated based on drainage boundaries identified in the City of Live Oak Master Drainage Study (Live Oak, 2011), DWR LiDAR data (DWR, 2011), and the main drainage channels identified in Sutter County's GIS layer (Sutter County, 2011).

Morrison Slough

The Morrison Slough watershed includes 2 subsheds covering 15 square miles and drains to the Sutter Bypass through Wadsworth Canal. Subsheds were delineated based on drainage boundaries identified in the City of Live Oak Master Drainage Study (Live Oak, 2011), DWR LiDAR data (DWR, 2011), and the main drainage channels identified in Sutter County's GIS layer (Sutter County, 2011). RD-777 The RD-777 watershed includes 3 subsheds covering 11 square miles and drains to the Sutter Bypass through Wadsworth Canal. Subsheds were delineated based on drainage boundaries identified in the City of Live Oak Master Drainage Study (Live Oak, 2011), DWR LiDAR data (DWR, 2011), and the main drainage channels identified in Sutter County's GIS layer (Sutter County, 2011).

Snake River

The Snake River watershed includes 10 subsheds covering 32 square miles and drains to the Sutter Bypass through Wadsworth Canal. Subsheds were delineated based on drainage boundaries identified in the Sutter County General Plan (Sutter County, 2010), USGS DEMs (USGS, 2001), DWR LiDAR data (DWR, 2011), and the main drainage channels identified in Sutter County's GIS layer (Sutter County, 2011).

Sutter

The Sutter watershed includes 3 subsheds covering 16 square miles and drains to the Sutter Bypass through DWR Pump Station #3. Subsheds were delineated based on drainage boundaries identified in the Sutter County General Plan (Sutter County, 2010), DWR LiDAR data (DWR, 2011), and the main drainage channels identified in Sutter County's GIS layer (Sutter County, 2011).

Little Blue Creek

The Little Blue Creek watershed includes 2 subsheds covering 6 square miles and drains to the Sutter Bypass through DWR Pump Station #2 (O'Banion Pump Station). Subsheds were delineated based on drainage boundaries identified in the Sutter County General Plan (Sutter

County, 2010), DWR LiDAR data (DWR, 2011), and the main drainage channels identified in Sutter County's GIS layer (Sutter County, 2011).

Lower Snake River

The Lower Snake River watershed includes 4 subsheds covering 20 square miles and drains to the Sutter Bypass through DWR Pump Station #2 (O'Banion Pump Station). Subsheds were delineated based on drainage boundaries identified in the Sutter County General Plan (Sutter County,2010), DWR LiDAR data (DWR, 2011), and the main drainage channels identified in Sutter County's GIS layer (Sutter County, 2011).

West Interceptor Canal

One subshed covering 8 square miles flows from the Sutter Buttes directly into the West Interceptor Canal which drains to the Sutter Bypass through Wadsworth Canal. Subsheds were delineated based on USGS DEMs (USGS, 2001), (DWR LiDAR data is not available over the Sutter Buttes) and the main drainage channels identified in Sutter County's GIS layer (Sutter County, 2011).

Sand Creek

The Sand Creek watershed includes 2 subsheds covering 9 square miles and drains to the Sutter Bypass through Wadsworth Canal. Subsheds were delineated based on USGS DEMs (USGS, 2001), DWR LiDAR data (DWR, 2011) and the main drainage channels identified in Sutter County's GIS layer (Sutter County, 2011).

Sutter City Canal

The Sutter City Canal watershed includes 2 subsheds covering 4 square miles and drains to the Sutter Bypass through Wadsworth Canal. Subsheds were delineated based on USGS DEMs (USGS, 2001), DWR LiDAR data (DWR, 2011) and the main drainage channels identified in Sutter County's GIS layer (Sutter County, 2011).

Live Oak Canal

The Live Oak Canal watershed includes 3 subsheds covering 15 square miles and drains to the Sutter Bypass through DWR Pump Station #2 (O'Banion Pump Station). Subsheds were delineated based on drainage boundaries identified in the West Yuba City Master Drainage Study (Yuba City, 2006) and the storm drain system outlined in the Sutter County Master Drainage Study (Sutter County, 1979).

Gilsizer Slough

The Gilsizer Slough watershed includes 9 subsheds covering 46 square miles and drains to the Sutter Bypass through DWR Pump Station #2 (O'Banion Pump Station). Subsheds were delineated based on drainage boundaries identified in the West Yuba City Master Drainage

Study (Yuba City, 2006) and the storm drain system outlined in the Sutter County Master Drainage Study (Sutter County, 1979).

Chandler

The Chandler watershed includes 2 subsheds that cover 16 square miles and drains to the Sutter Bypass through DWR Pump Station #1 (Chandler Pump Station). Subsheds were delineated based on drainage boundaries identified in the Sutter County General Plan (Sutter County, 2010), DWR LiDAR data (DWR, 2011), and the main drainage channels identified in Sutter County's GIS layer (Sutter County, 2011).

RD-823 (Hamatani Ranch)

The RD-823 watershed includes 2 subsheds covering 8 square miles and drains to the Feather River through a private pump station (Hamatani Ranch Pump Station). Subsheds were delineated based on drainage boundaries identified in the Sutter County General Plan (Sutter County, 2010), DWR LiDAR data (DWR, 2011), and the main drainage channels identified in Sutter County's GIS layer (Sutter County, 2011).

Butte Sink

There are 11 subbasins in the northern portion of the study area that drain west to the Butte Sink. These subbasins total 94 square miles and were delineated based the main drainage channels identified in Sutter County's GIS layer (Sutter County, 2011).

East Biggs

The East Biggs subbasin totals 6.01 square miles. The Butte Canal makes up its western boundary and, based on a phone conversation with the director of the Joint Water Board, this section of the Butte Canal has the ability to capture storm runoff from this area. This subbasin was modeled, but its runoff was not conveyed beyond the Butte Canal boundary.

Feather River

Although most of the interior lands drain in a southwesterly direction away from the Feather River's west levee, there are 19 subsheds covering 25 square miles that drain directly to the Feather River through levee culverts or pump stations. These sheds are independent from the rest of the HEC-HMS model and were delineated to assist SBFCA in the design of replacement levee culverts. Sheds were identified based on DWR LiDAR data (DWR, 2011), the City of Live Oak Master Drainage Study (Live Oak, 2011), the West Yuba City Master Drainage Study (Yuba City, 2006), the Sutter County Master Drainage Study (Sutter County, 1979) and telephone conversations with City of Yuba City officials.

11.3.1.7. Pump Stations and Detention Ponds

Ten stormwater pump stations were included in the analysis (see Plate 30). Three DWR pump stations discharge stormwater to the Sutter Bypass. Capacities for these pump stations were obtained from the DWR Sutter Maintenance Yard (DWR, 2009).

One private pump station (Hamatani Ranch Pump Station) is identified in the Sutter County General Plan (Sutter County, 2010) and discharges to the Feather River. A utilities inventory (Flowserve Inc, 2010) conducted along the Feather River's west levee identified this pump station as a Byron Jackson 17HQH pump. Its pump capacity was obtained from a BJ 17HQH pump curve (Flowserve Inc, 2010).

Six pump stations that drain areas in and around Yuba City and discharge to the Feather River were included in the analysis. Five of these pumps are operated by the City of Yuba City. Capacities for these pumps and their associated detention ponds were estimated by the City of Yuba City. An additional pump station operated by the Gilsizer Drainage District also drains Yuba City. Pump and pond capacities for this pump station were obtained from the Gilsizer Drainage District. Ponds are pumped dry after each storm, so ponds were assumed empty at the start of each simulation.

Pump station data are summarized in Table 35.

Table 35. Pump station capacities.

Pump Station	Details
DWR PS#1	Total Capacity: 280 cfs 4 pumps @ 70 cfs each
DWR PS#2	Total Capacity: 786.6 cfs 6 pumps @ 131.1 cfs each
DWR PS#3	Total Capacity: 182.2 cfs 4 pumps @ 45.55 cfs each
Hamatani Ranch PS	Total Capacity: 9.3 cfs 1 pump @ 9.3 cfs
Yuba City Pump Station #1	Total Capacity: 6,820 gpm (15.2 cfs) 1 pump @ 1,950 gpm; 1 pump @ 770 gpm; 1 pump @ 4,100 gpm Pond Capacity: 9 Acre-Feet (AF)
Yuba City Pump Station #2	Total Capacity: 7,300 gpm (16.3 cfs) 2 pumps @ 3,000 gpm; 1 pump @ 1,300 gpm Pond Capacity: 46 Acre-Feet (AF)
Yuba City Pump Station #3	Total Capacity: 9,800 gpm (21.8 cfs) 3 pumps @ 40 horsepower each Pond Capacity: 68.9 Acre-Feet (AF)
Yuba City Pump Station #4	Total Capacity: 900 gpm (2.0 cfs) Pond Capacity: 15 Acre-Feet (AF)
Yuba City Seepage Pump Station	Total Capacity: 9,700 gpm (21.6 cfs) 1 pump @ 3,270 gpm; 1 pump @ 6,430 gpm Total Capacity: 47,500 gpm (105.8 cfs)
Gilsizer Drainage District Pump Station	2 pumps @ 10,000 gpm; 1 pumps @ 5,000 gpm; 1 pumps @ 22,500 gpm Pond Capacity: 70 Acre-Feet (AF)

[a] Estimated based on horsepower and capacities of similarly sized pumps in Yuba City.

11.3.3. Model Results

Once calibrated, the HEC-HMS model was run with the four design storm events described above in section 6.2. The simulations were extended several days beyond the storm event to ensure that hydrographs had time to return to low-flow conditions and runoff had time to travel to the model's outlet points. Table 36 and Table 37 provide a summary of peak flow and runoff volume results at several key locations in the study area.

In the absence of gage records, high water marks, or other physical tools for model verification, PBI verified results through discussions with several area officials from the City of Yuba City, Sutter County, and Gilsizer Drainage District, as well as with residents within the basin who recalled flooding that took place during the 1997 and 2006 events.

TABLE 36

Summary of peak flow results [cfs].					
Location	Drainage Area [sq.mi.]	100yr-24hr	100yr-96hr	200yr-24hr	200yr-96hr
Live Oak Slough					
at Highway 99	5.97	90	54	110	67
at East Interceptor Canal confluence	18.06	470	120	580	140
RD777 Canal					
at Sheppard Rd	4.66	330	150	410	180
Morrison Slough					
d/s of Sutter/Butte County Line	5.35	290	150	350	190
Snake River					
West Fork at Sutter/Butte County Line	3.87	210	160	250	180
East Fork at Sutter/Butte County Line	2.85	220	170	260	190
u/s of Clark Rd.	29.75	1,900	1,600	2,300	1,900
at Morrison Slough confluence	45.34	2,600	2,300	3,100	2,700
Interceptor Canal					
at RD777 Canal confluence	28.52	1,000	440	1,300	540
at Snake River confluence	74.95	3,700	2,900	4,400	3,400
at Wadsworth Canal entrance	95.44	4,900	4,100	5,900	4,800
Wadsworth Canal Outlet	96.12	4,900	4,200	5,900	4,900
Sutter Main Canal					
DWR Pump Station #3 Inflow	16.26	1,200	520	1,500	650
Little Blue Creek					
at Highway 20	1.43	91	53	110	60
Live Oak Canal					
at Highway 20	4.37	150	100	180	120
at Bogue Rd	10.01	440	220	530	280
Lower Snake River					
at Highway 20	3.08	400	120	480	140
at Little Blue Creek confluence	15.78	780	540	940	630
at Live Oak Canal confluence	31.91	1,600	1,000	2,100	1,200
Gilsizer Slough					
at Lincoln Rd.	6.85	380	380	430	420
at Bogue Rd.	8.36	510	460	560	500
at Oswald Rd.	14.04	700	510	820	560
at George Washington Blvd.	38.28	1,200	690	1,600	810
DWR Pump Station #2 Inflow	87.25	3,100	2,600	3,800	3,000
Chandler Main Drain					
DWR Pump Station #1 Inflow	10.68	540	460	680	520
RD-823 Main Drain					
at Highway 99	3.58	110	21	150	31
Hamatani Ranch Pump Station Inflow	7.63	210	180	270	210
Average Unit Peak Flows [cfs/acre]		0.08	0.05	0.1	0.06

Table 37

Summary of runoff volume results [acre-feet].					
Location	Drainage Area [sq.mi.]	100yr-24hr	100yr-96hr	200yr-24hr	200yr-96hr
Live Oak Slough					
at Highway 99	5.97	340	340	400	410
at East Interceptor Canal confluence	18.06	890	610	1,100	700
RD777 Canal					
at Sheppard Rd	4.66	330	610	390	700
Morrison Slough					
d/s of Sutter/Butte County Line	5.35	330	350	400	460
Snake River					
West Fork at Sutter/Butte County Line	3.87	390	1,100	440	1,200
East Fork at Sutter/Butte County Line	2.85	250	540	290	620
u/s of Clark Rd.	29.75	2,700	6,500	3,100	7,400
at Morrison Slough confluence	45.34	4,200	9,000	4,900	10,000
Interceptor Canal					
at RD777 Canal confluence	28.52	1,700	1,900	2,000	2,200
at Snake River confluence	74.95	6,100	11,000	7,100	13,000
at Wadsworth Canal entrance	95.44	7,800	15,000	9,200	17,000
Wadsworth Canal Outlet	96.12	7,800	15,000	9,200	17,000
Sutter Main Canal					
DWR Pump Station #3 Inflow	16.26	1,200	2,100	1,400	2,400
Little Blue Creek					
at Highway 20	1.43	140	380	150	420
Live Oak Canal					
at Highway 20	4.37	370	470	430	530
at Bogue Rd	10.01	770	930	900	1,100
Lower Snake River					
at Highway 20	3.08	250	520	290	600
at Little Blue Creek confluence	15.78	1,400	3,600	1,600	4,000
at Live Oak Canal confluence	31.91	2,700	5,600	3,100	6,400
Gilsizer Slough					
at Lincoln Rd.	6.85	980	1,700	1,100	1,900
at Bogue Rd.	8.36	1,200	2,100	1,300	2,300
at Oswald Rd.	14.04	1,400	2,300	1,500	2,500
at George Washington Blvd.	38.28	2,100	2,900	2,500	3,200
DWR Pump Station #2 Inflow	87.25	6,500	12,000	7,500	14,000
Chandler Main Drain					
DWR Pump Station #1 Inflow	10.68	940	1,900	1,100	2,100
RD-823 Main Drain					
at Highway 99	3.58	120	160	160	180
Hamatani Ranch Pump Station Inflow	7.63	520	1,300	600	1,400
Average Unit Runoff Volumes [AF/acre]		0.13	0.24	0.15	0.27

12. Analysis of Alternatives by Hydrology

The ring levee and J-levee (the levee) around Yuba City are the two alternatives that required additional hydrologic analysis. The fix-in-place, and other similar levee alternatives will not require a change in the hydrology effecting those alternatives.

For the preliminary screening, an estimate of the runoff within the levee was developed using the rational method of rainfall-runoff analysis. Rainfall depths were extracted from the design rainfall analysis by David Ford Consulting Engineers Inc (Ford) for this study. The Ford analysis is based on rainfall depth-area-duration statistics developed by Jim Goodrich, the former California State Climatologist, and kept up-to-date on the Department of Water Resources (DWR) web site. Areas within the levee were developed from Google Earth sketches of the proposed alternative alignment. The loss rate coefficient was calibrated to match the peak flows shown the West Yuba City master drainage study.

A mean daily flow rate of 918 cfs was estimated for the whole area inside the levee. The area used was 24.23sq.mi. within the levee. A 1-day, 10-year precipitation volume of 2.82 inches, and a rainfall-runoff coefficient of 0.5 was used. Pumps were sized based on this average flow rate. These estimates have been used in the study to this point. Refinements will be made as shown below.

The interior drainage analysis performed by Peterson-Brustad Inc (PBI) for SBFCA using HEC-HMS and FLO2D later determined the 100-year and 200-year 24-hour storm duration flow at two locations. The two locations are natural drainage outlets that must pass through the levee, and include Gilsizer Slough and Live Oak Slough. The discharge and volume at these two locations is shown in tables 33 and 34 to be: 440 and 530 cfs for the 24-hour, 100- and 200-year return periods respectively at Live Oak Slough. And, 1200 and 1600 cfs for the 24-hour, 100- and 200-year return periods respectively at Gilsizer Slough.

The pump size required must be determined in conjunction with an accompanying detention basin. The larger the detention basin, the smaller the required pump size. A detailed analysis of the interior drainage within the ring levee alternatives was done by PBI. In addition, pump sizes and detention basin sizes were calculated. Those results may be found in the Interior Drainage Analysis by Peterson-Brustad, Inc. (SBFCA, 2012).

13. Results

The results of the design rainfall analysis, the discharge probability of the Sutter Bypass and Feather River systems, the Cherokee and Wadsworth Canal systems, and of the Sutter basin interior areas tributary to the Wadsworth canal and the Sutter Bypass are shown above. For further information see the individual reports, Technical Memorandum, and Memorandum for Record.

14. Conclusions

This summary report provides information for the determination of a feasible project within the Sutter Basin, California. This is the complete hydrology appendix document for the Sutter Basin Feasibility Study Draft Report. The information summarized herein is detailed in technical memorandums, and memorandum for record. Those memos are cited in the text above and shown in the references below.

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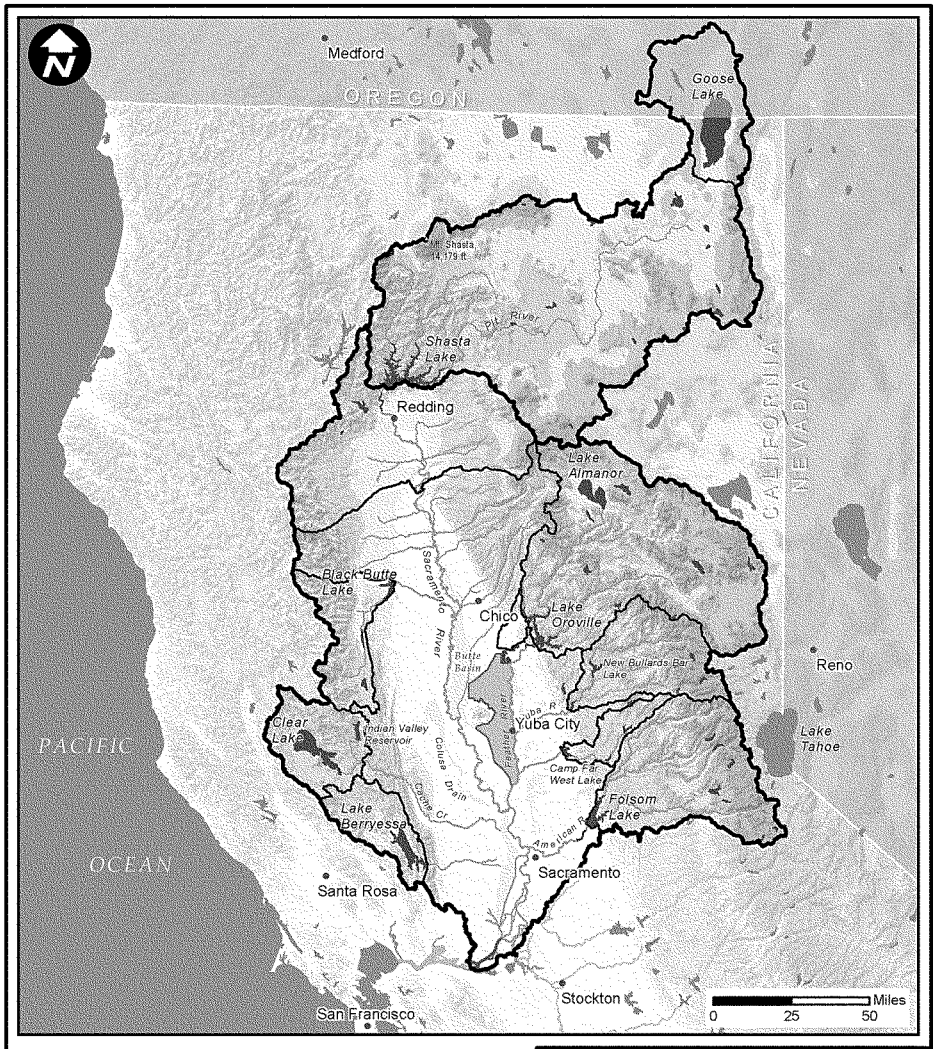


Legend

- Sutter Basin Study Area
- Sacramento Basin
- Watershed Boundary
- Lake or Reservoir
- Designated Floodway
- River or Stream
- City

SUTTER BASIN FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

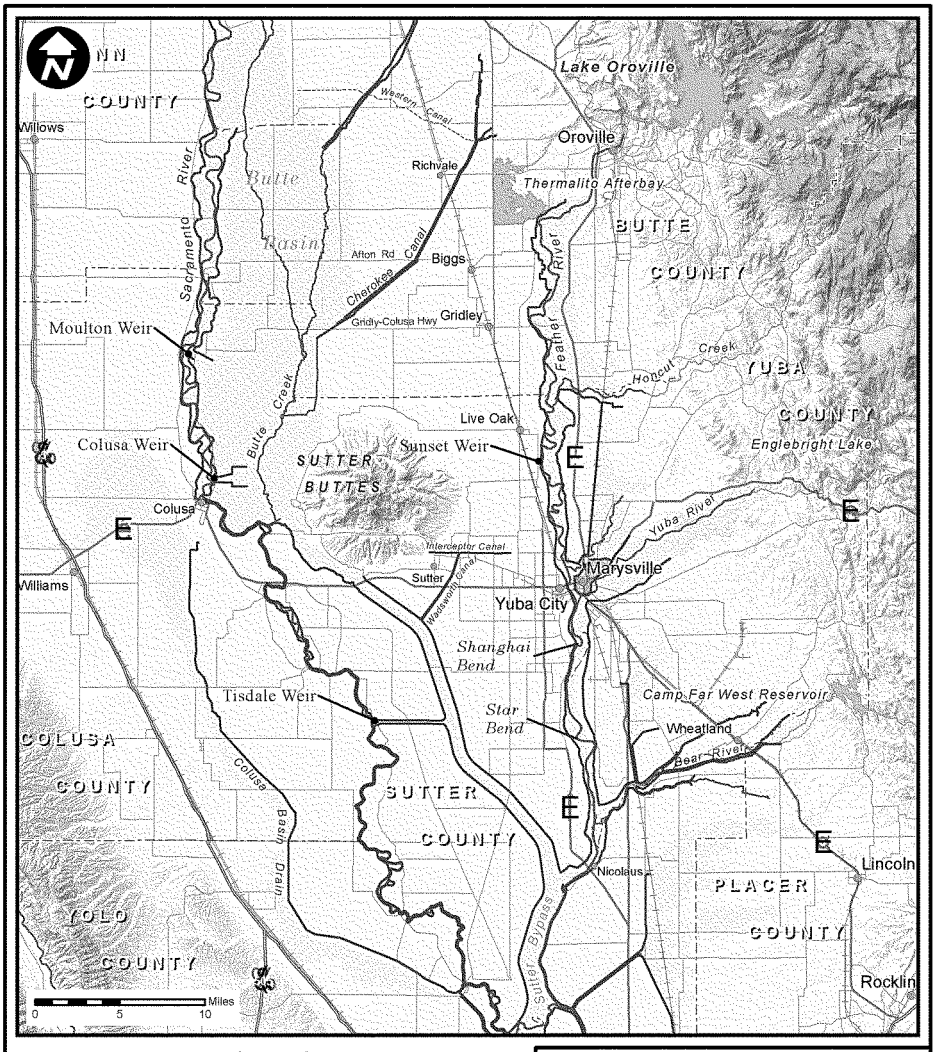
SACRAMENTO RIVER WATERSHED

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

NOV 2012

PLATE 1



Legend

- Study Area Extent
- Designated Floodway
- Lake or Reservoir
- River or Stream
- Federal Levee
- Highway
- Major Road
- Railroad
- County Boundary
- City or Town

SUTTER BASIN FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

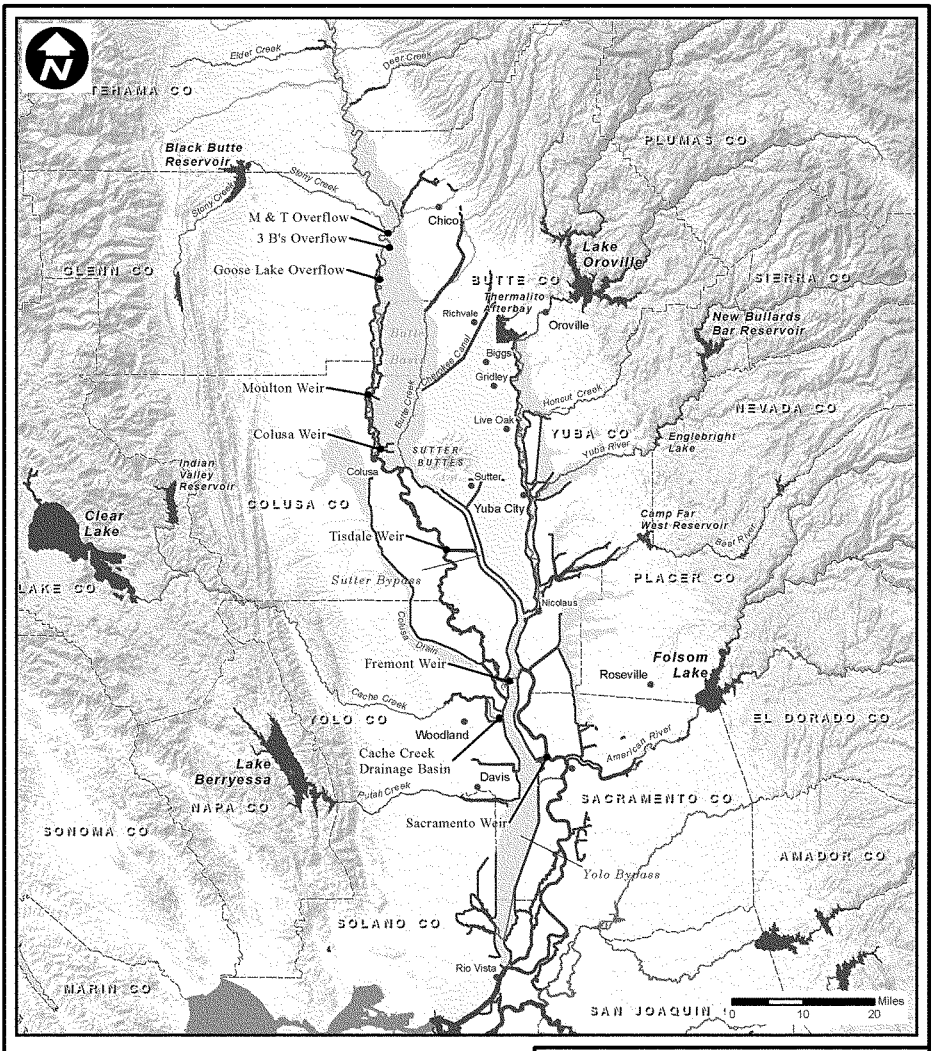
STUDY AREA

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

NOV 2012

PLATE 2



Legend

- Study Area Extent
- Designated Floodway
- Lake or Reservoir
- River or Stream
- Federal Levee
- County Boundary
- City

SUTTER BASIN FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

SACRAMENTO RIVER FLOOD CONTROL PROJECT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

NOV 2012

PLATE 3

Legend

- Stream Gage
- Study Area Extent
- Watershed Boundary
- Designated Floodway
- Federal Levee
- Lake or Reservoir
- River or Stream
- County Boundary
- City

SUTTER BASIN FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

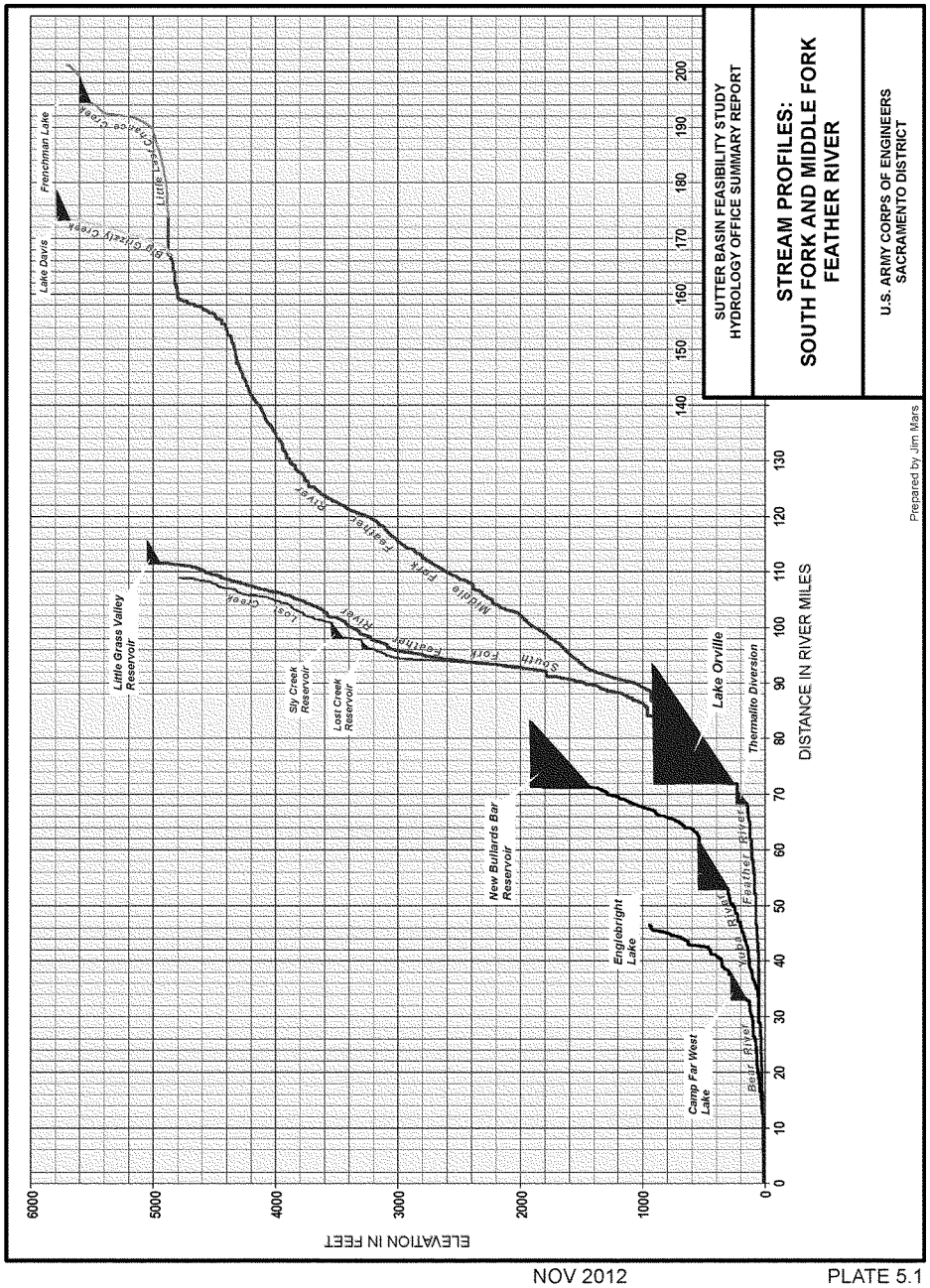
UPPER WATERSHED BASINS TOPOGRAPHY AND STREAM GAGES

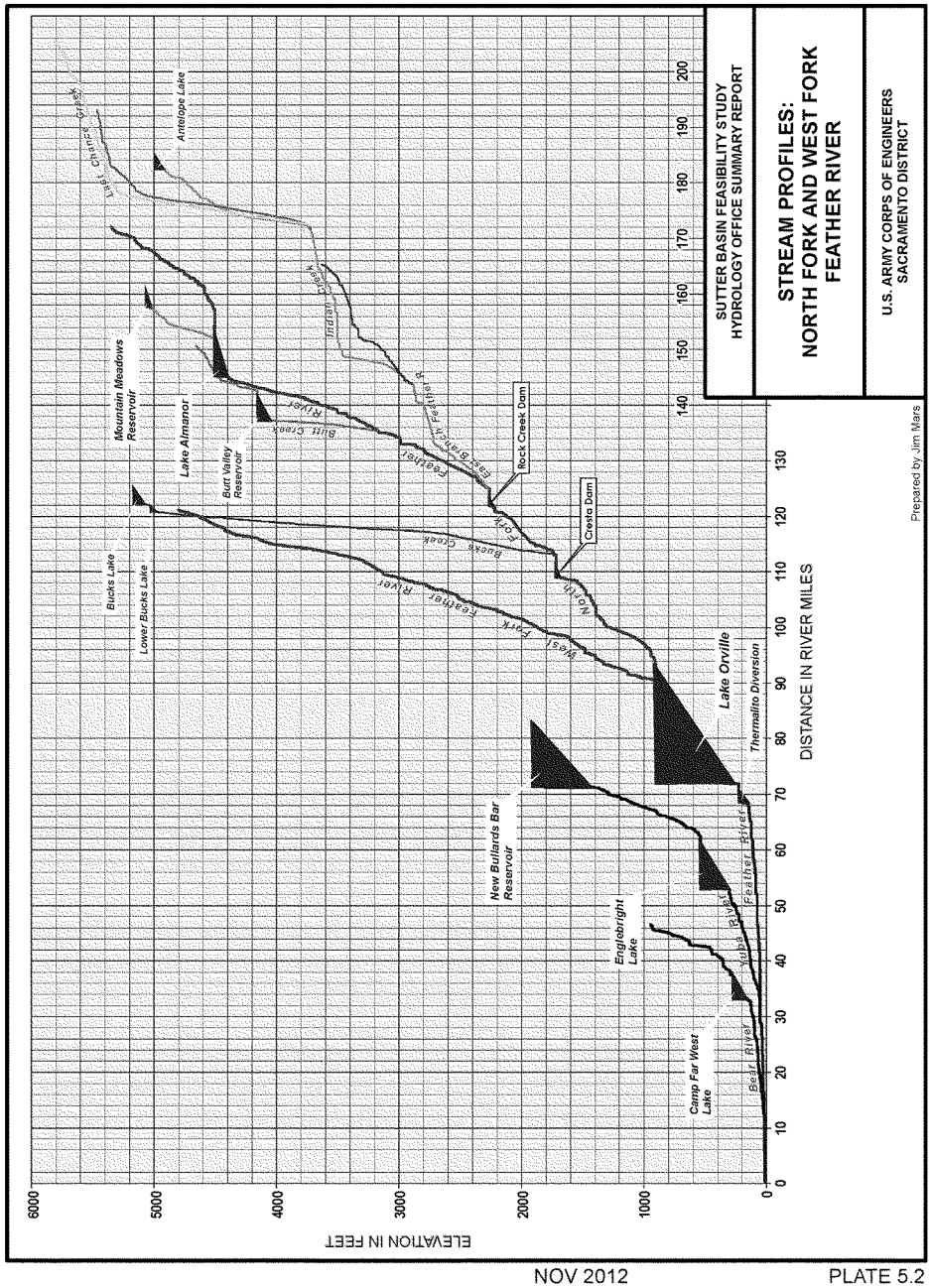
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

NOV 2012

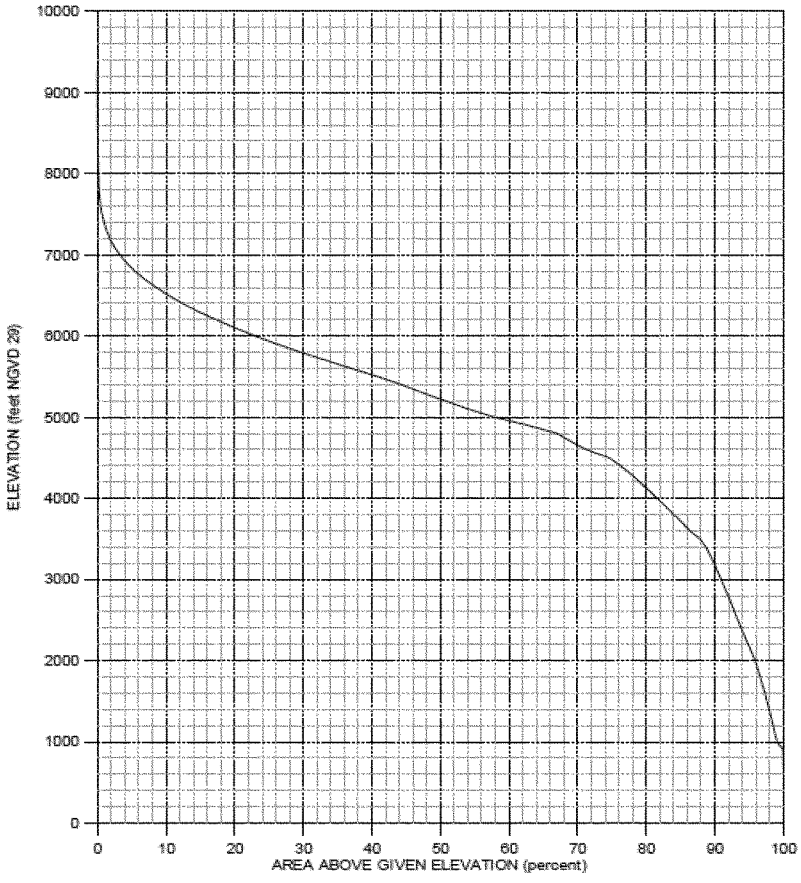
PLATE 4


ELEVATION IN FEET
6000
5000
4000
3000
2000
1000
0
DISTANCE IN RIVER MILES
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
Frenchman Lake
Lake Davis
Big Grizzly Creek
Little Last Chance Creek
Little Grass Valley Reservoir
Lost Creek
Sly Creek Reservoir
Lost Creek Reservoir
Feather River
Middle Fork
Feather River
South Fork
New Bullards Bar Reservoir
Englebright Lake
Yuba River
Feather River
Thermalito Diversion
Lake Oroville
Camp Far West Lake
Bear River
SUTTER BASIN FEASIBILITY STUDY
HYDROLOGY OFFICE SUMMARY REPORT
STREAM PROFILES:
SOUTH FORK AND MIDDLE FORK
FEATHER RIVER
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
Prepared by Jim Mars
NOV 2012
PLATE 5.1



NOV 2012

PLATE 5.2



NOTES:

Watershed above Oroville Dam (3,602 square miles)

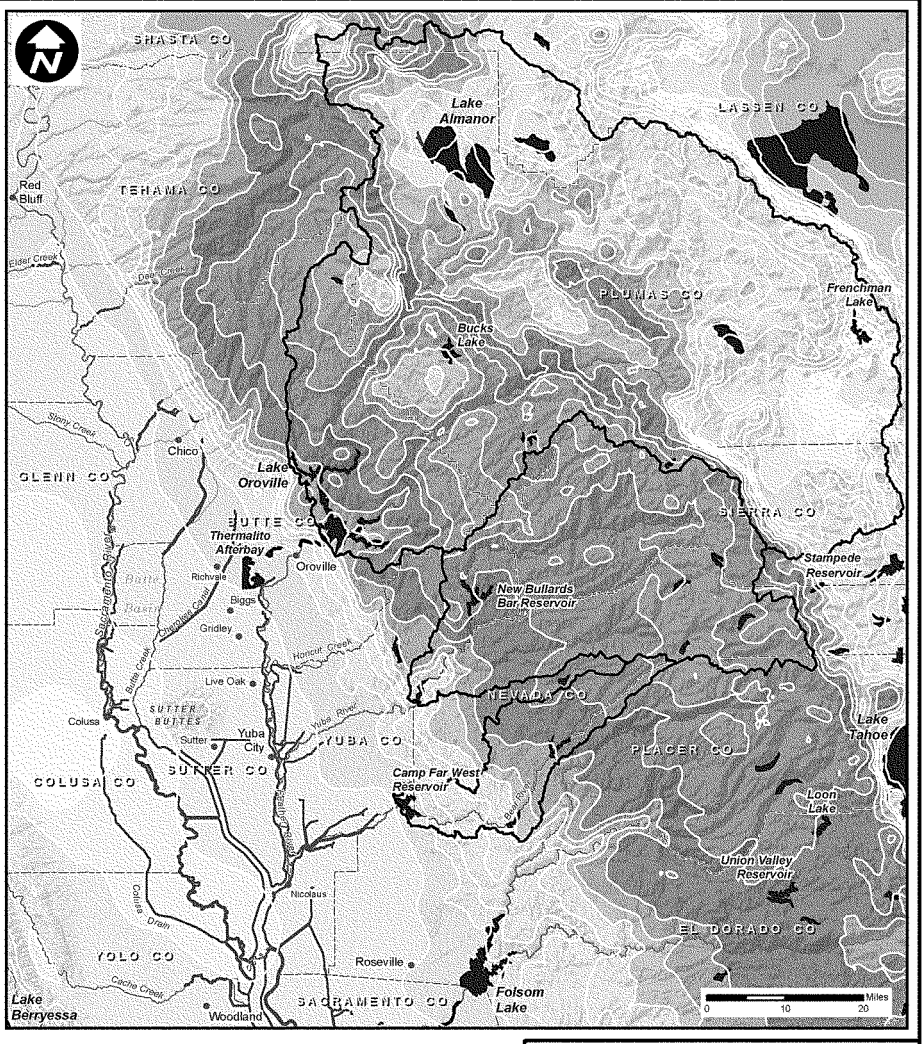
Source: Oroville Water Control Manual, Revised Feb 2005

SUTTER BASIN FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

AREA-ELEVATION CURVE

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

PLATE 6



Legend

- Watershed Boundary
- Federal Levee
- Lake or Reservoir
- River or Stream
- County Boundary
- City

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

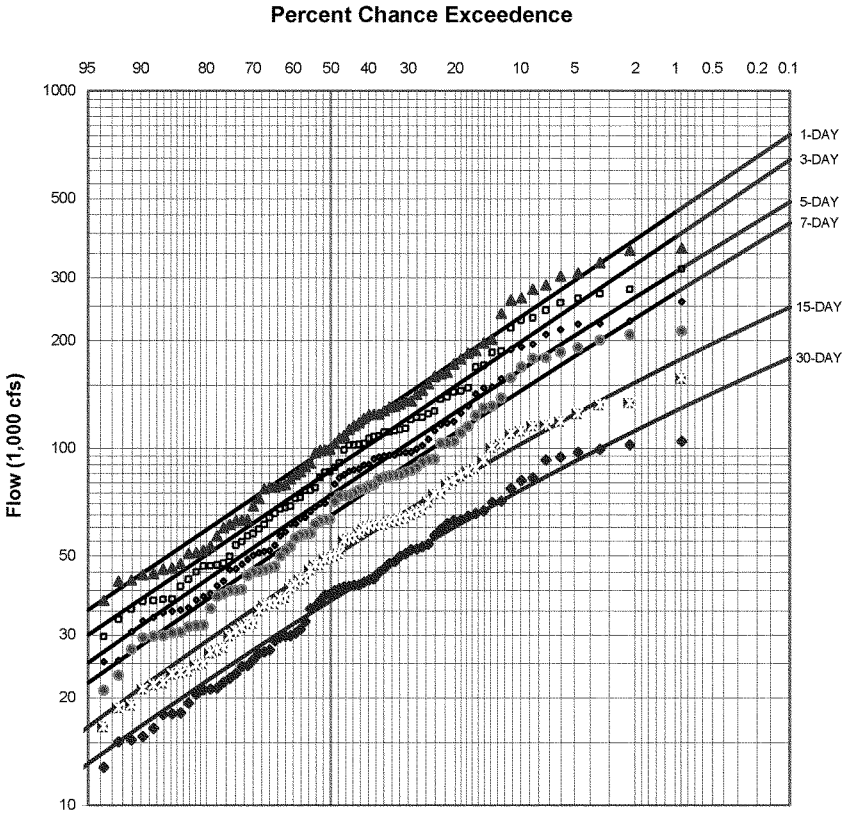
UPPER WATERSHED BASINS NORMAL ANNUAL PRECIPITATION AND CLIMATOLOGICAL GAGES

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

NOV 2012

PLATE 7



ADOPTED STATISTICS:

	Mean	Std.Dev.	Skew
1-day	5.009	0.281	0.0
3-day	4.939	0.281	0.0
5-day	4.866	0.279	-0.1
7-day	4.809	0.278	-0.1
15-day	4.680	0.267	-0.3
30-day	4.562	0.258	-0.3

NOTES:

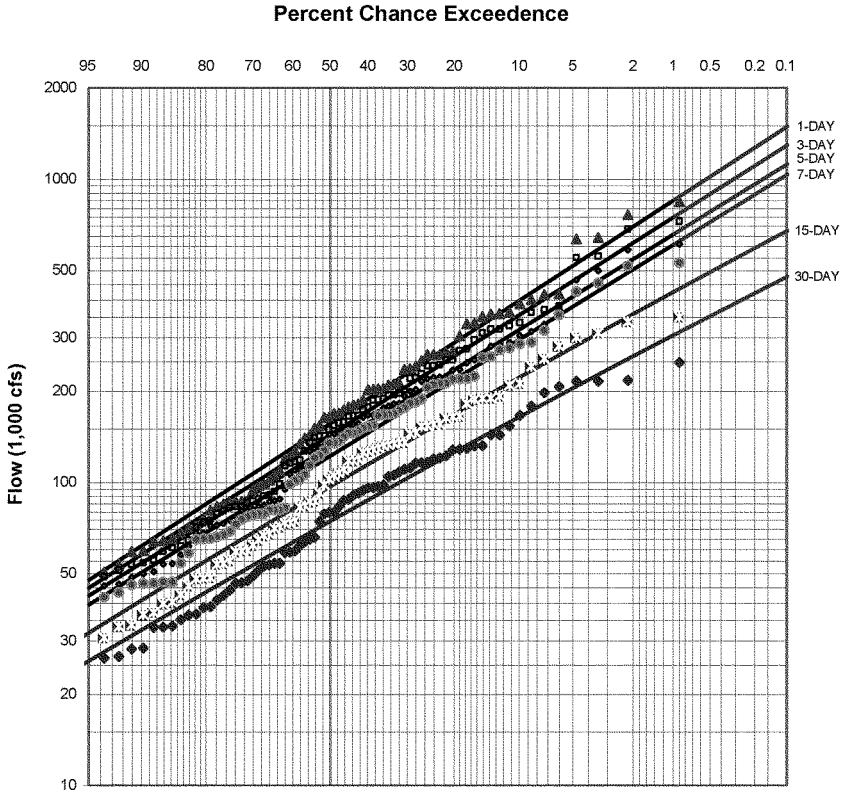
1. Adjusted USGS gage 11388700 to account for daily change in storage at upstream reservoirs (potential channel, out-of-channel, or storage losses neglected).
2. WY 1977 censored as low outlier.
3. Median plotting positions.
4. Drainage area: approx. 12,050 sq. mi.
5. Period of record: 1922-1997.

SACRAMENTO-SAN JOAQUIN COMPREHENSIVE STUDY
SACRAMENTO RIVER BASIN, CALIFORNIA

RAIN FLOOD FREQUENCY CURVES
SACRAMENTO RIVER AT ORD FERRY (LATITUDE)
UNREGULATED CONDITIONS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

PLATE 8 01-Sep-00



ADOPTED STATISTICS:

	Mean	Std.Dev.	Skew
1-day	5.196	0.316	0.0
3-day	5.158	0.308	0.0
5-day	5.120	0.301	0.0
7-day	5.088	0.300	0.0
15-day	4.983	0.287	-0.1
30-day	4.869	0.274	-0.2

NOTES:

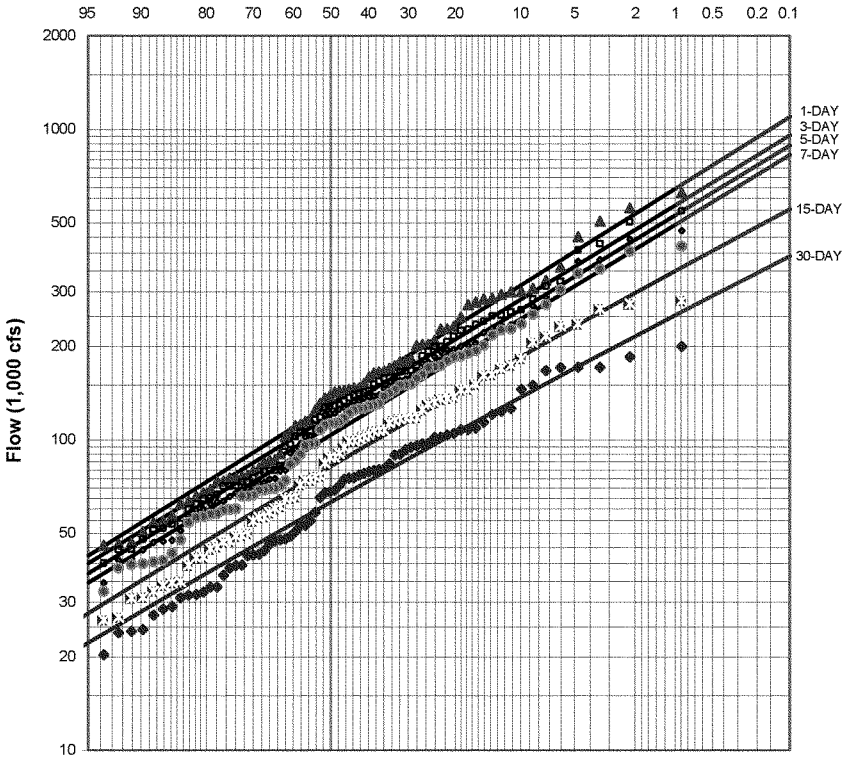
1. Adjusted USGS gage 11447500 to account for daily change in storage at upstream reservoirs (potential channel, out-of-channel, or storage losses neglected).
2. WY 1977 censored as low outlier.
3. Median plotting positions.
4. Drainage area: approx. 26,150 sq. mi.
5. Period of record: 1922-1997.

SACRAMENTO-SAN JOAQUIN COMPREHENSIVE STUDY
SACRAMENTO RIVER BASIN, CALIFORNIA

RAIN FLOOD FREQUENCY CURVES
SACRAMENTO RIVER AT SACRAMENTO (LATITUDE)
UNREGULATED CONDITIONS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

PLATE 9 01-Sep-00



ADOPTED STATISTICS:

	Mean	Std.Dev.	Skew
1-day	5.117	0.298	0.0
3-day	5.081	0.291	0.0
5-day	5.048	0.291	0.0
7-day	5.018	0.291	0.0
15-day	4.912	0.281	-0.1
30-day	4.796	0.269	-0.2

NOTES:

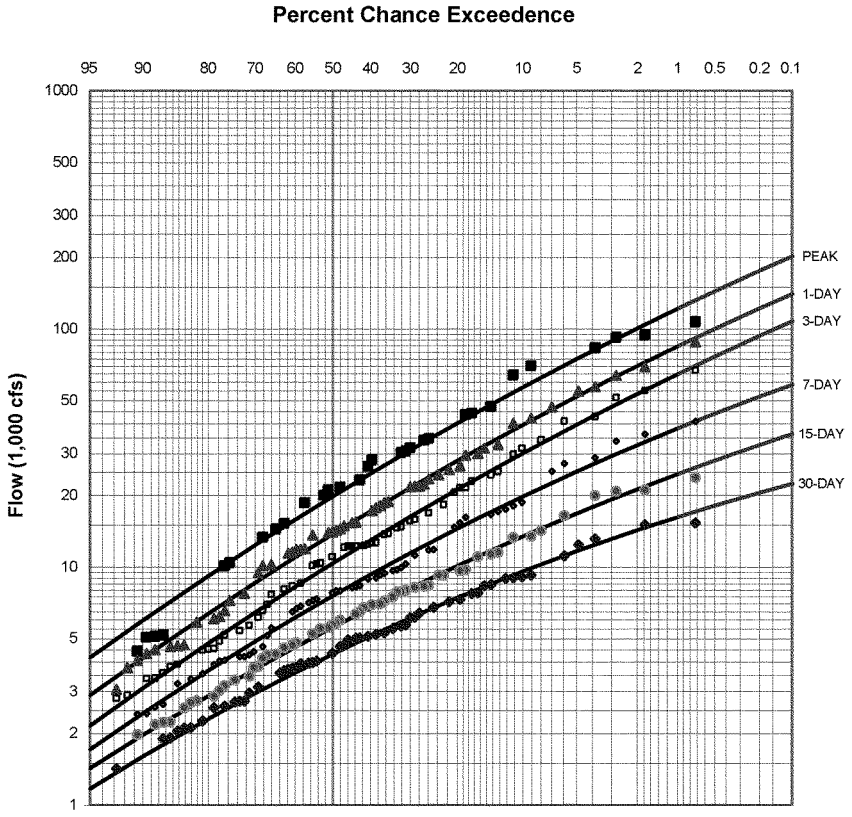
1. Adjusted USGS gage 11425500 to account for daily change in storage at upstream reservoirs (potential channel, out-of-channel, or storage losses neglected).
2. WY 1977 censored as low outlier.
3. Median plotting positions.
4. Drainage area: approx. 21,251 sq. mi.
5. Period of record: 1922-1997.

SACRAMENTO-SAN JOAQUIN COMPREHENSIVE STUDY
SACRAMENTO RIVER BASIN, CALIFORNIA

RAIN FLOOD FREQUENCY CURVES
SACRAMENTO RIVER AT VERONA (LATITUDE)
UNREGULATED CONDITIONS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

PLATE 10 01-Sep-00



ADOPTED STATISTICS:

	Mean	Std.Dev.	Skew
Peak	4.280	0.383	-0.3
1-day	4.122	0.383	-0.3
3-day	3.999	0.386	-0.3
7-day	3.858	0.357	-0.4
15-day	3.727	0.327	-0.4
30-day	3.611	0.306	-0.5

NOTES:

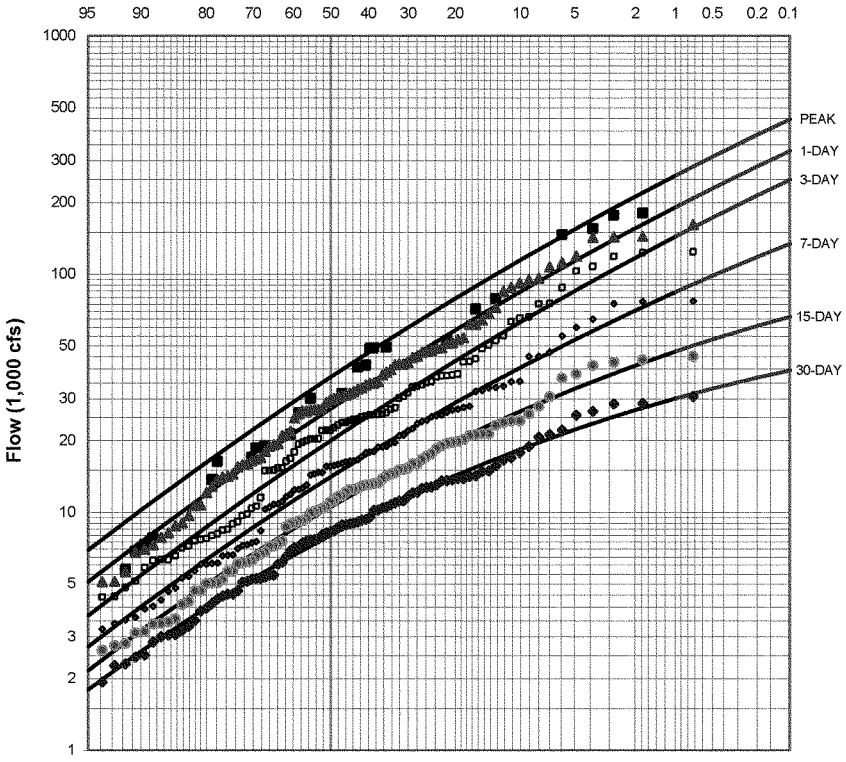
1. Statistics adjusted based on correlation with Yuba River near Marysville station (94 years).
2. Median plotting positions.
3. Drainage Area: 489 sq. mi.
4. Period of record: 1938-1997.

SACRAMENTO-SAN JOAQUIN COMPREHENSIVE STUDY
SACRAMENTO RIVER BASIN, CALIFORNIA

RAIN FLOOD FREQUENCY CURVES
NORTH YUBA AT NEW BULLARDS BAR DAM
UNREGULATED CONDITIONS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

PLATE 11 01-Sep-00



ADOPTED STATISTICS:

	Mean	Std.Dev.	Skew
Peak	4.550	0.411	-0.3
1-day	4.417	0.411	-0.3
3-day	4.283	0.416	-0.3
7-day	4.125	0.394	-0.4
15-day	3.989	0.364	-0.6
30-day	3.867	0.337	-0.7

NOTES:

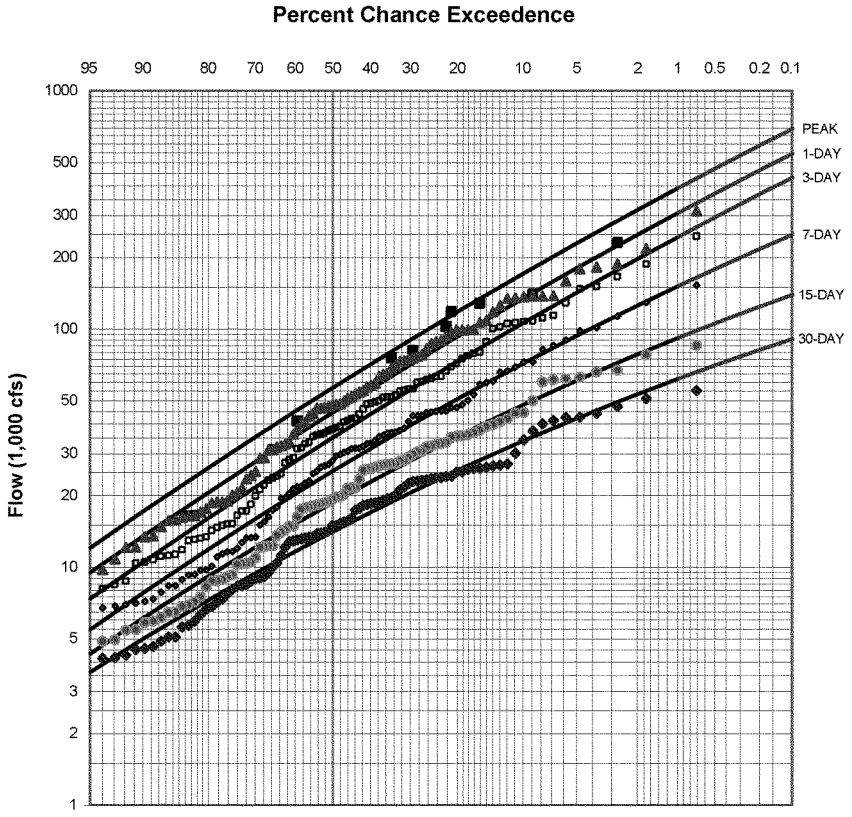
1. Median plotting positions.
2. Peak data available for 25 years of record.
3. Drainage area: 1,339 sq. mi.
4. Period of record: 1904-1997.

SACRAMENTO-SAN JOAQUIN COMPREHENSIVE STUDY
SACRAMENTO RIVER BASIN, CALIFORNIA

RAIN FLOOD FREQUENCY CURVES
YUBA RIVER NEAR MARYSVILLE
UNREGULATED CONDITIONS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

PLATE 12 01-Sep-00



ADOPTED STATISTICS:

	Mean	Std.Dev.	Skew
Peak	4.743	0.390	-0.2
1-day	4.639	0.390	-0.2
3-day	4.533	0.392	-0.2
7-day	4.387	0.377	-0.3
15-day	4.250	0.351	-0.4
30-day	4.129	0.326	-0.4

NOTES:

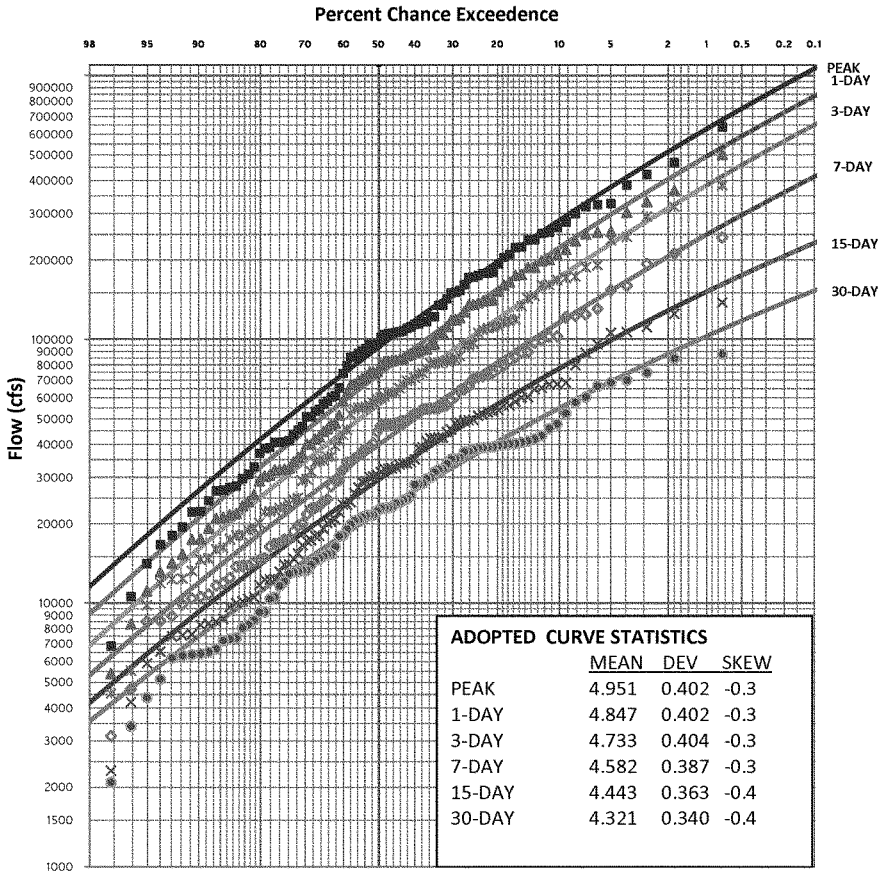
1. Median plotting positions.
2. Peak data available for 11 years of record.
3. Drainage area: 3,624 sq. mi.
4. Period of record: 1901-1997.

SACRAMENTO-SAN JOAQUIN COMPREHENSIVE STUDY
SACRAMENTO RIVER BASIN, CALIFORNIA

RAIN FLOOD FREQUENCY CURVES
FEATHER RIVER AT OROVILLE DAM
UNREGULATED CONDITIONS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

PLATE 13 01-Sep-00



NOTES:

1. Median plotting positions.
2. Computed Probability
3. Drainage area: 5313 sq. mi.
4. 94 years of record (1904 to 1997)

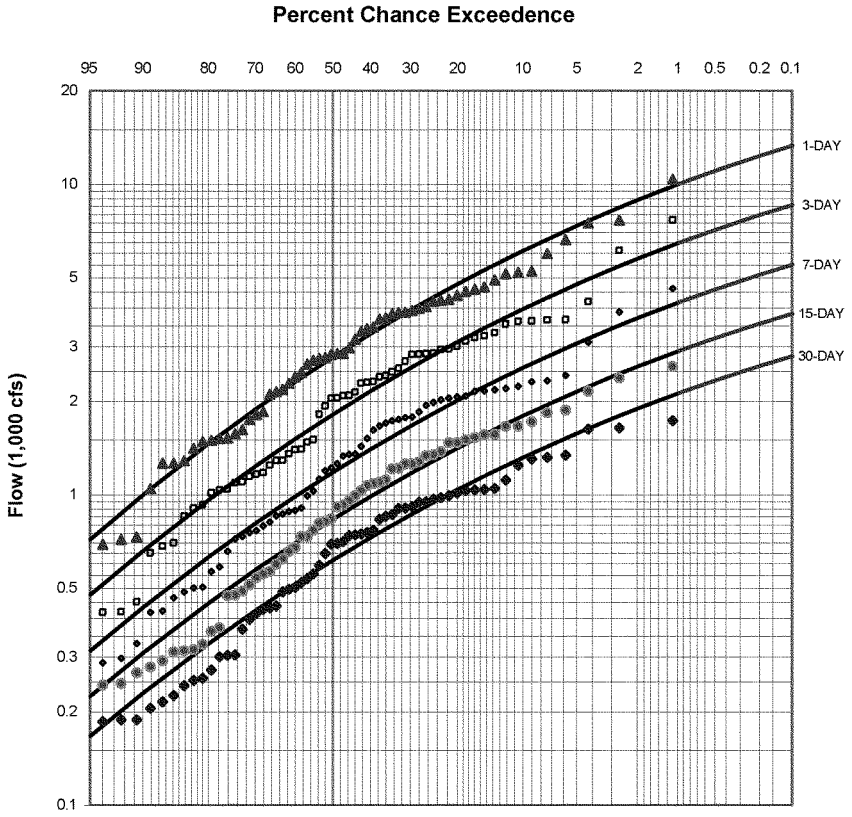
MODIFIED BY BJW MAY 2002

SUTTER BASIN FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

RAINFLOOD FREQUENCY CURVES
FEATHER RIVER AT SHANGHAI BEND
UNREGULATED CONDITIONS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

PLATE 14



ADOPTED STATISTICS:

	Mean	Std.Dev.	Skew
1-day	3.414	0.311	-0.6
3-day	3.230	0.308	-0.6
7-day	3.044	0.305	-0.6
15-day	2.893	0.302	-0.6
30-day	2.761	0.300	-0.6

NOTES:

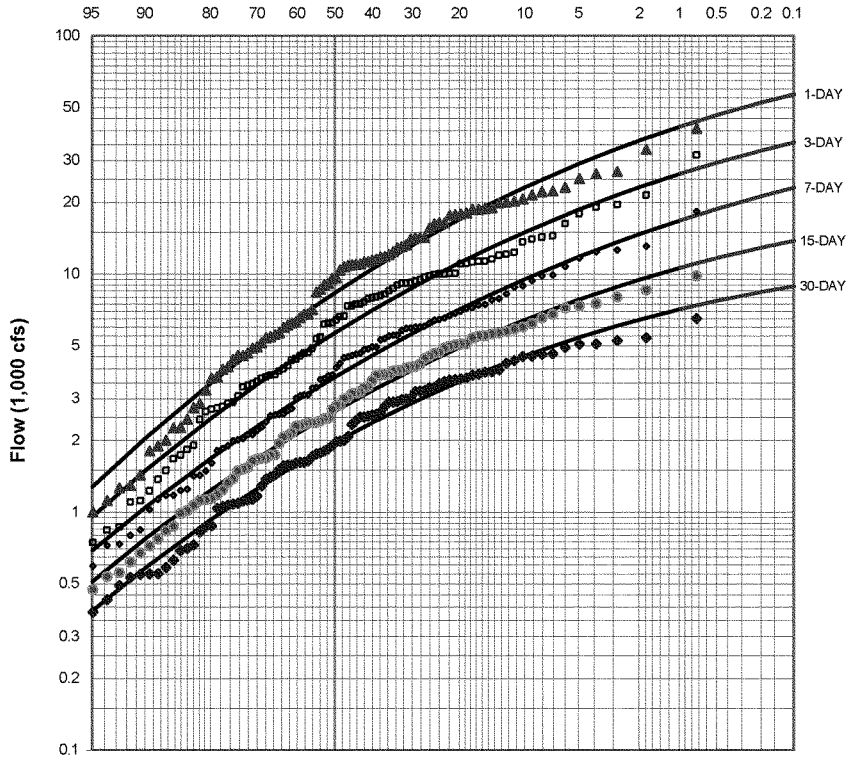
1. Adjusted USGS gage 11418500 to account for daily change in storage at upstream reservoir (potential channel, out-of-channel, or storage losses neglected).
2. WY 1977 censored as low outlier.
3. Median plotting positions.
4. Drainage area: 84.6 sq. mi.
5. Period of record: 1936-1997.

SACRAMENTO-SAN JOAQUIN COMPREHENSIVE STUDY
SACRAMENTO RIVER BASIN, CALIFORNIA

RAIN FLOOD FREQUENCY CURVES
DEER CREEK NEAR SMARTVILLE
UNREGULATED CONDITIONS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

PLATE 15 01-Sep-00



ADOPTED STATISTICS:

	Mean	Std.Dev.	Skew
1-day	3.872	0.420	-0.7
3-day	3.707	0.399	-0.7
7-day	3.527	0.380	-0.7
15-day	3.379	0.367	-0.8
30-day	3.244	0.357	-0.9

NOTES:

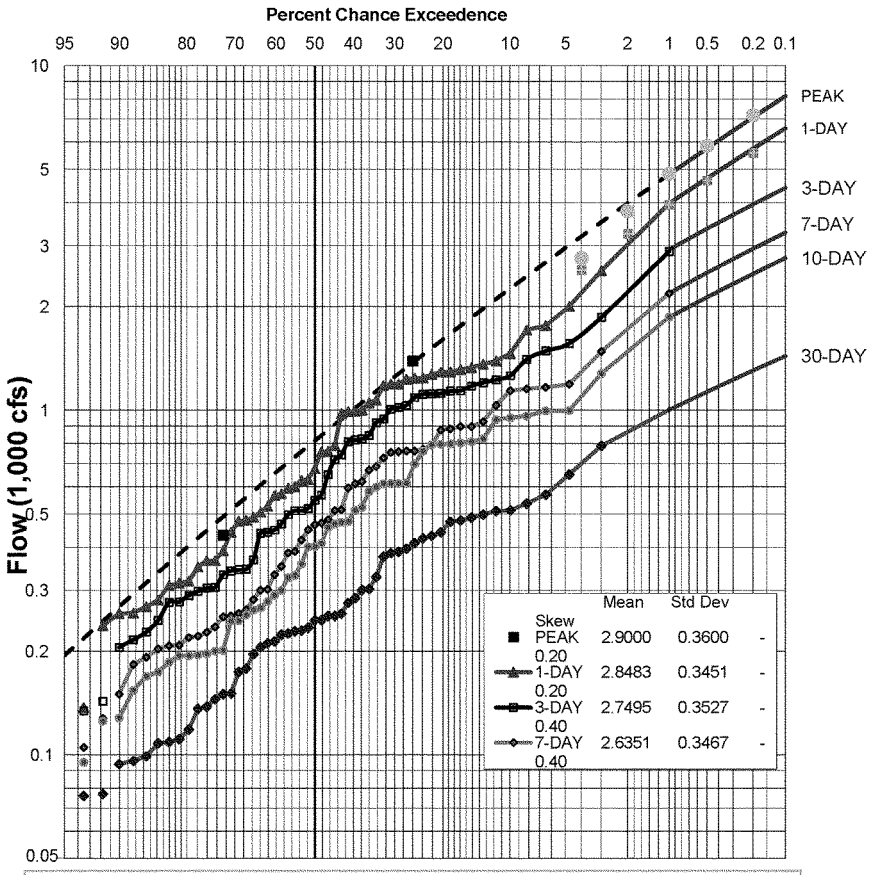
1. Adjusted USGS gage 11424000 to account for daily change in storage at upstream reservoirs (potential channel, out-of-channel, or storage losses neglected).
2. Statistics adusted based on correlation with Van Trent (1906-27) and Yuba R at Smartville (1928).
3. Median plotting positions.
4. Drainage area: 292 sq. mi.
5. Period of record: 1906-1998.

SACRAMENTO-SAN JOAQUIN COMPREHENSIVE STUDY
SACRAMENTO RIVER BASIN, CALIFORNIA

RAIN FLOOD FREQUENCY CURVES
BEAR RIVER NEAR WHEATLAND
UNREGULATED CONDITIONS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

PLATE 16 01-Sep-00



Notes:

1. Recorded flows use median plotting positions for the 56 years of record from 1939 to 1996.
2. Drainage area about 96 sq. mi. for DWR Station A05929.
3. Modeled values from SBFCA HMS model June 2012 with precipitation reflecting The 1-, 3-, 7-, 10-, and 30-day data was plotted to extend the historical data up to the 0.1-percent exceedance frequency of the estimated best fit curve.
4. The peak flow curve was manually adjusted to best fit the historical and modeled data and the 1-day volume curve. Model Runs reflect 10 Year Flows in the Sutter Bypass with storm precipitation reflecting the frequency of the flows reflected on the flow volume frequency curve.
5. The plotted curves to the right of the 1-percent exceedance frequency are manually

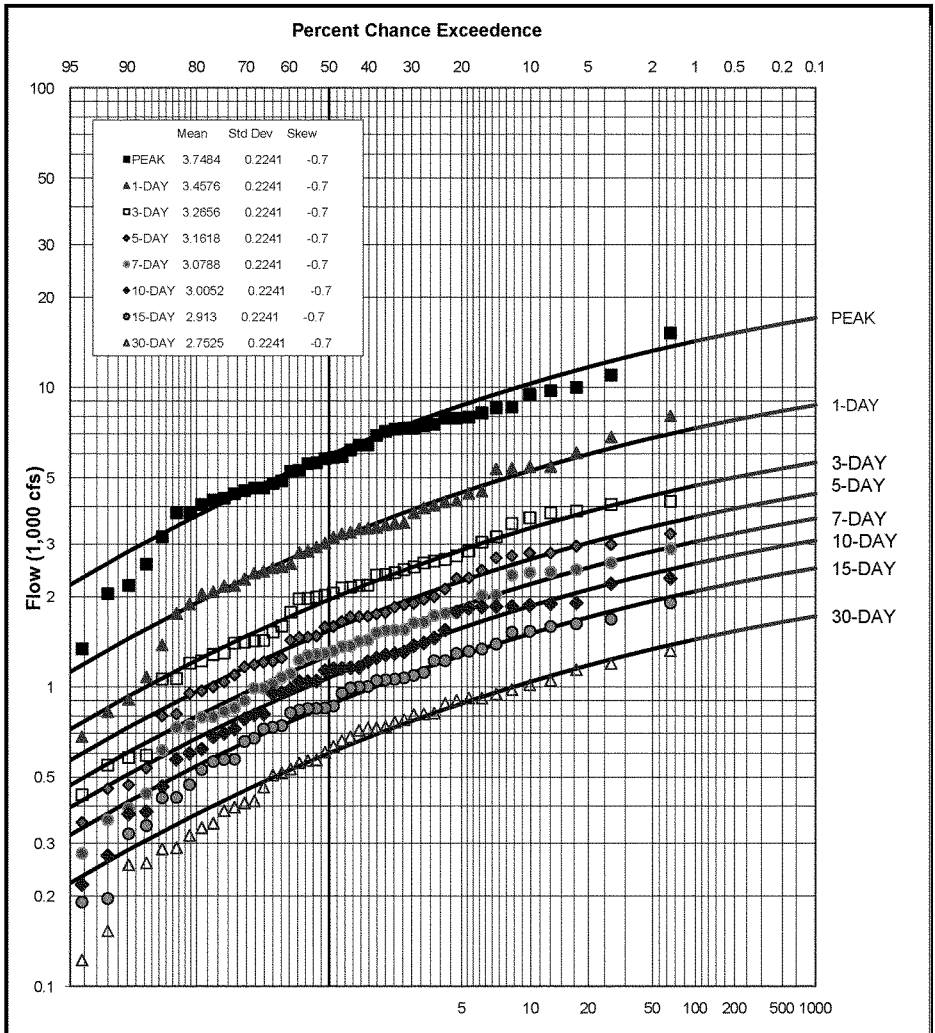
RAIN FLOOD FREQUENCY CURVES
UNREGULATED CONDITIONS

WADSWORTH CANAL NR SUTTER
SACRAMENTO RIVER BASIN.

WATER YEARS 1939 ~ 1996

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

PLATE 17



SUTTER BASIN, CALIFORNIA
Sutter Basin Hydrology Study

NOTES:

1. WY 1977, 1972, 1990 are low outliers.
2. Median plotting positions
3. Drainage area about 94 sq. mi.
4. 46 years of record
5. DWR Station A02984

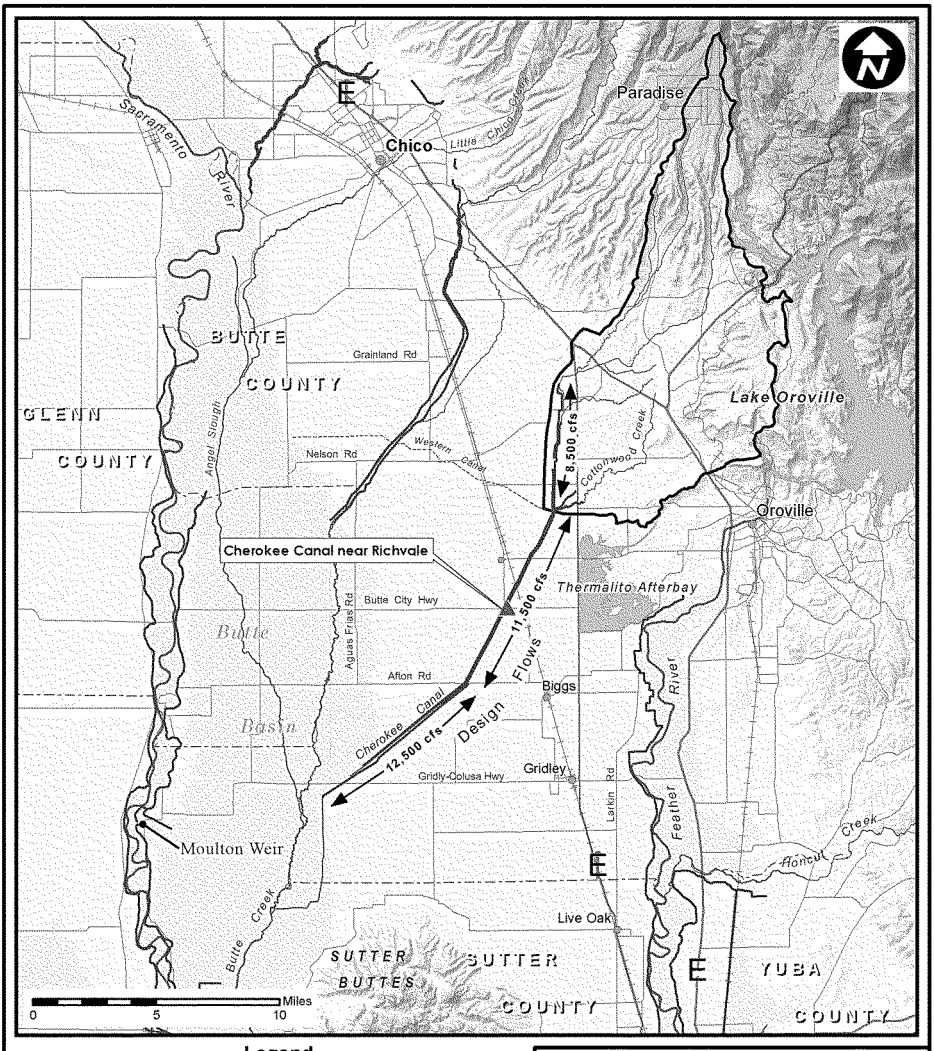
DEC 2008

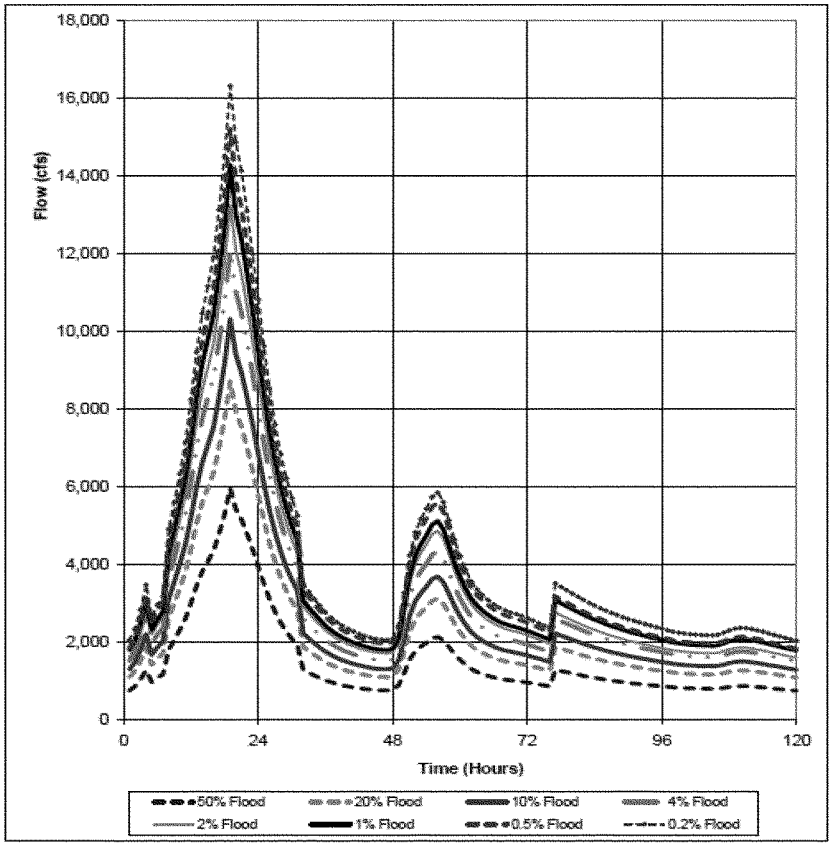
CHEROKEE CANAL NEAR RICHVALE, CA
RAIN FLOOD FREQUENCY CURVES

WATER YEARS 1961-2006

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

PLATE 18


Paradise
Chico
Little Chico Creek
Sacramento River
BUTTE COUNTY
GLENN COUNTY
Grainland Rd
Nelson Rd
Angel Slough
Western Canal
Lake Oroville
Cottonwood Creek
8,500 cfs
Oroville
Cherokee Canal near Richvale
Thermalito Afterbay
Butte City Hwy
Aguas Frias Rd
Butte Basin
Afton Rd
11,500 cfs Flows
Biggs
Feather River
Cherokee Canal
12,500 cfs Design
Gridley
Gridly-Colusa Hwy
Larkin Rd
Moulton Weir
Honcut Creek
Butte Creek
Live Oak
SUTTER BUTTES
SUTTER COUNTY
YUBA COUNTY
0
5
10
Miles
Legend
Stream Gage
Sutter Basin Study Area
Watershed Boundary
Designated Floodway
Lake or Reservoir
River or Stream
Federal Levee
Highway
Major Road
Railroad
County Boundary
City or Town
SUTTER BASIN FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA
CHEROKEE CANAL
WATERSHED AND TOPOGRAPHY
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
Prepared by Jim Mars
NOV 2012
PLATE 19



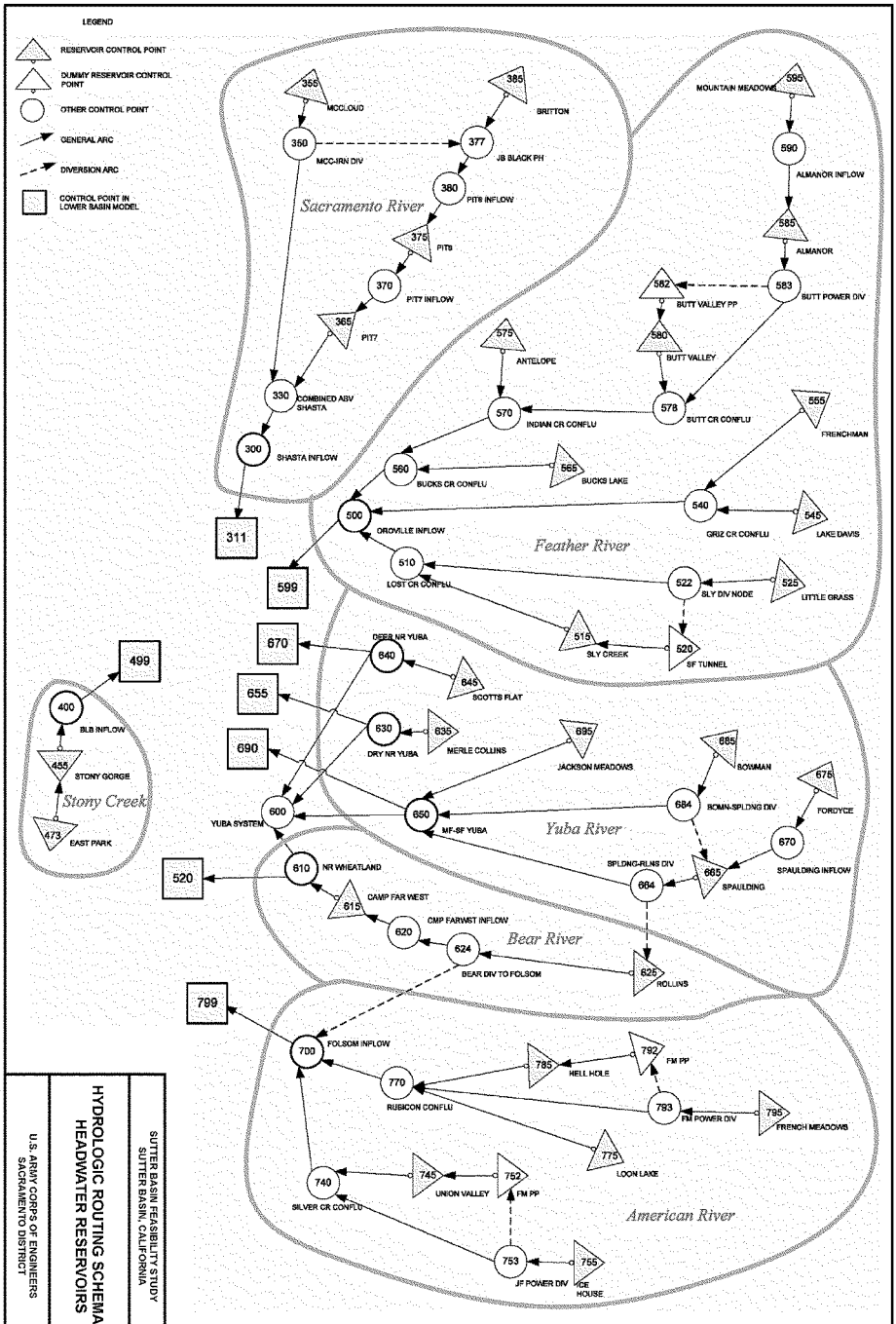
SUTTER BASIN FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

CHEROKEE CANAL
SYNTHETIC 8-FLOOD SERIES
5-DAY WAVE HYDROGRAPHS

Source: Sutter County Feasibility Study, 2004

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

PLATE 20



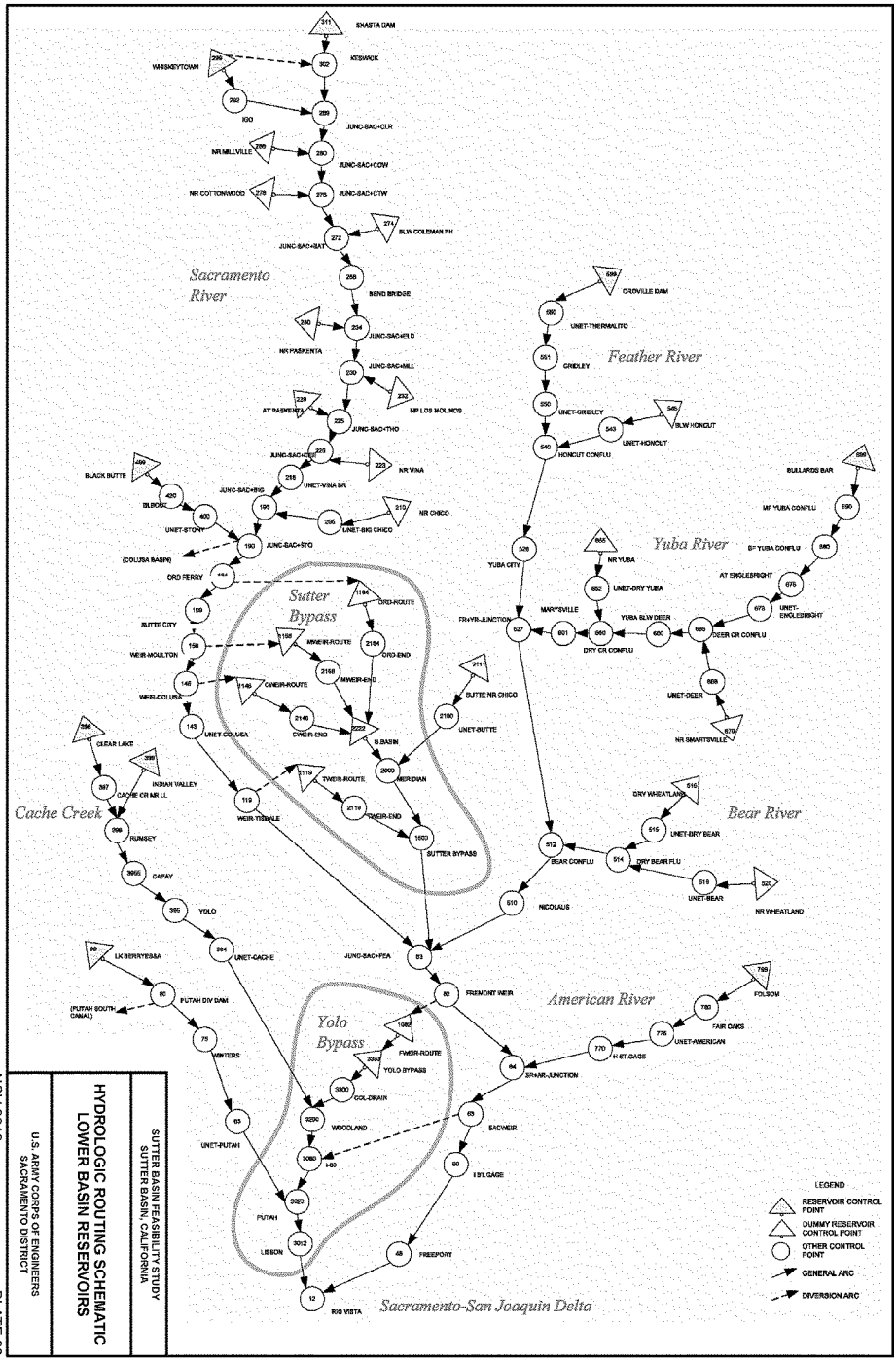
HYDROLOGIC ROUTING SCHEMATIC
HEADWATER RESERVOIRS

SUTTER BASIN FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

NOV 2012

PLATE 21



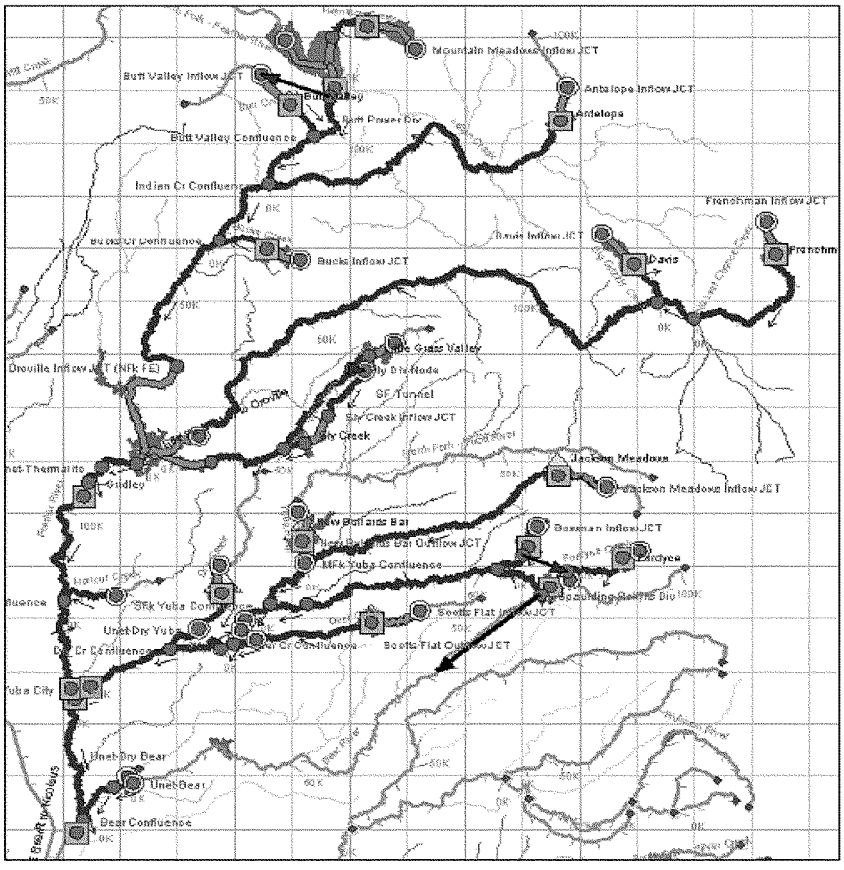
HYDROLOGIC ROUTING SCHEMATIC
LOWER BASIN RESERVOIRS

SUTTER BASIN FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

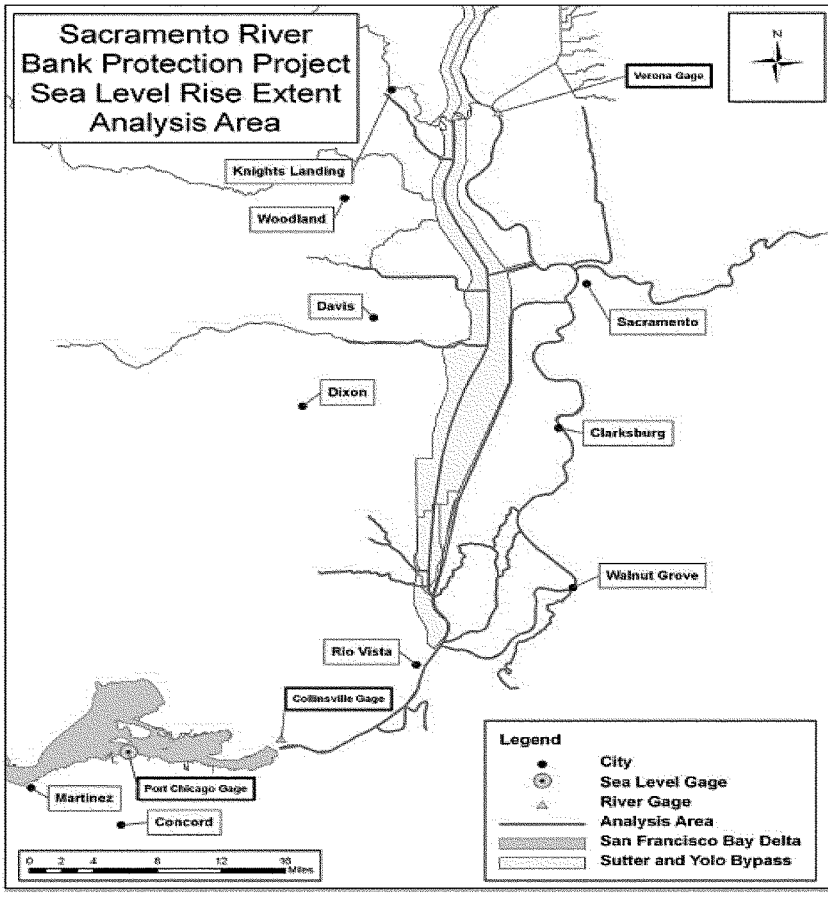
NOV 2012

PLATE 22



SUTTER BASIN FEASBILITY STUDY SUTTER BASIN, CALIFORNIA	
ResSim Model Schematic	
Source: Lower Feather River FPMS, 2004	U.S ARMY CORPS OF ENGINEERS SACRAMENTO DISTRICT

PLATE 23



SUTTER BASIN FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

Sea Level Rise Extent Analysis Area

Source: Sacramento Bank Protection Project, 2011

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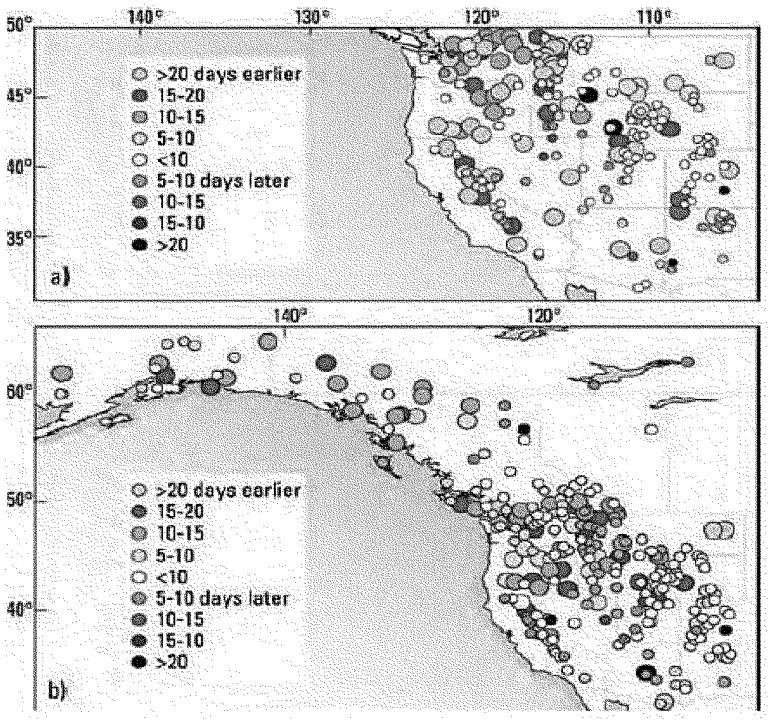
SACRAMENTO DISTRICT

PLATE 24



Trends in (a) yearly dates of spring snowmelt onset and (b) centers of volume of yearly streamflow hydrographs in rivers throughout western North America, based on U.S. Geological Survey streamgages in the United States and an equivalent Canadian streamflow network. Large circles indicate sites with trends that differ significantly from zero at a 90-percent confidence level; small circles are not confidently identified.

Source: USBR, Managing Water in the West, 2011.

SUTTER BASIN FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

Climate Change Trends

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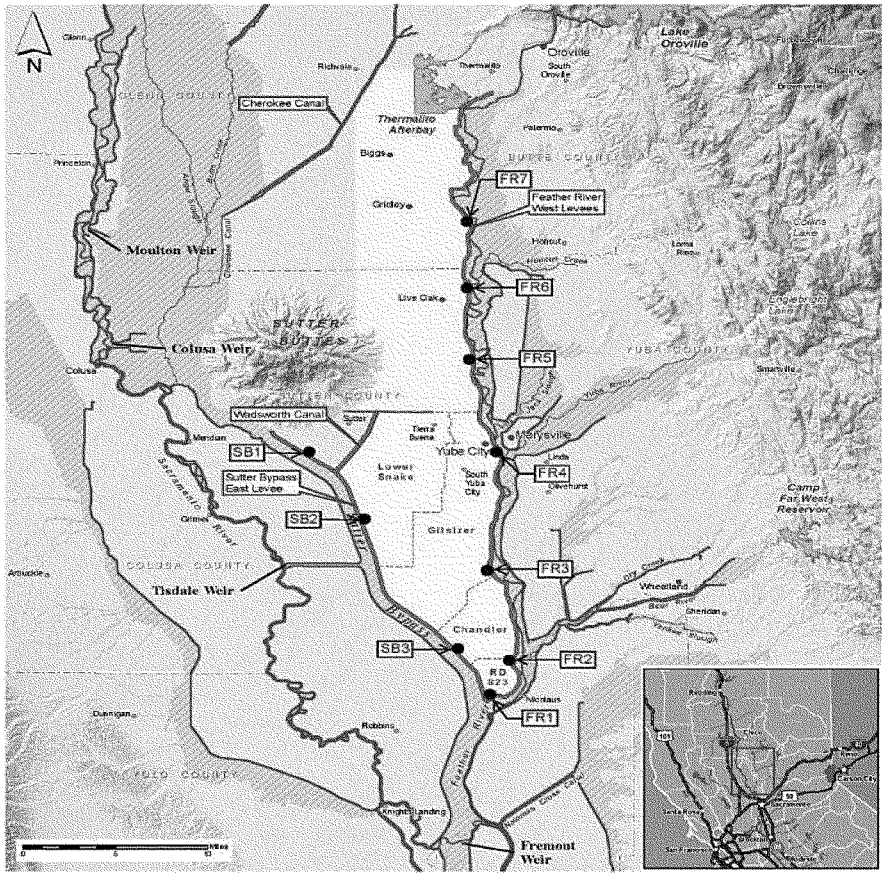
SACRAMENTO DISTRICT

PLATE 25



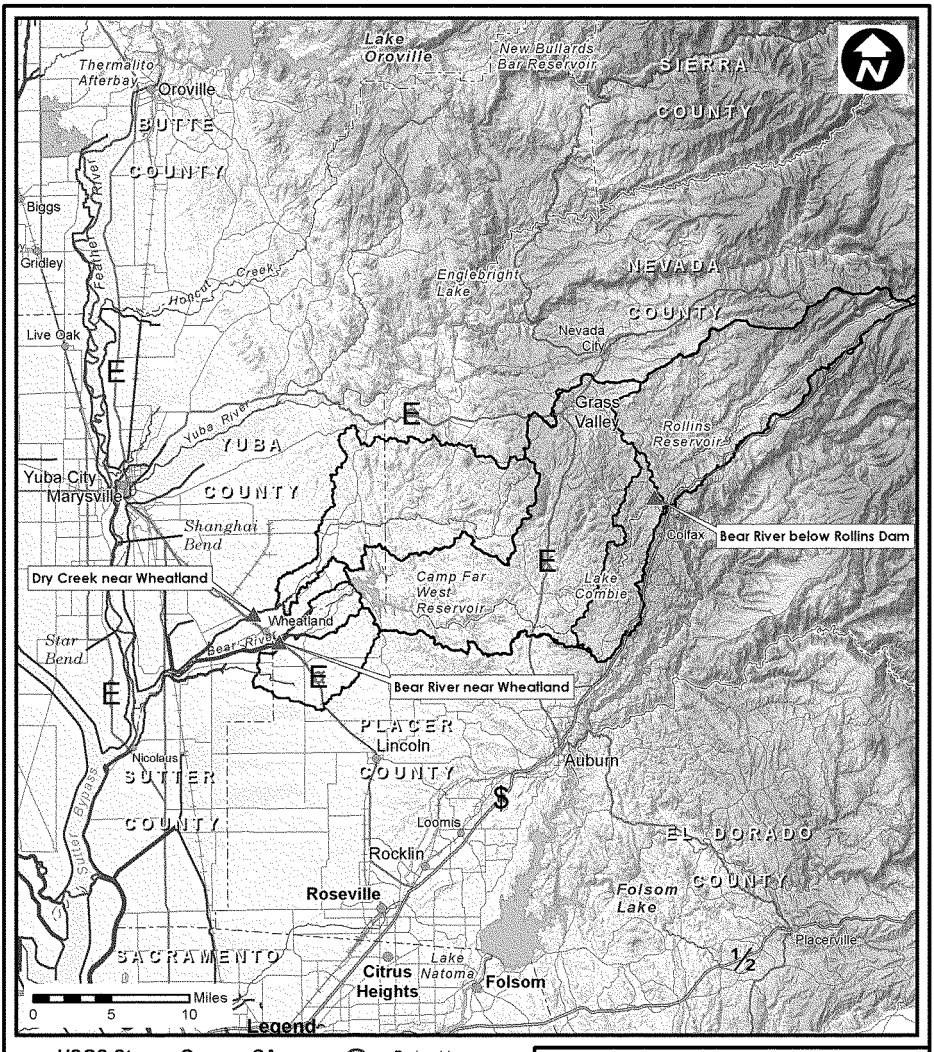
Source: Ford, Wave Runup Analysis, 2011.

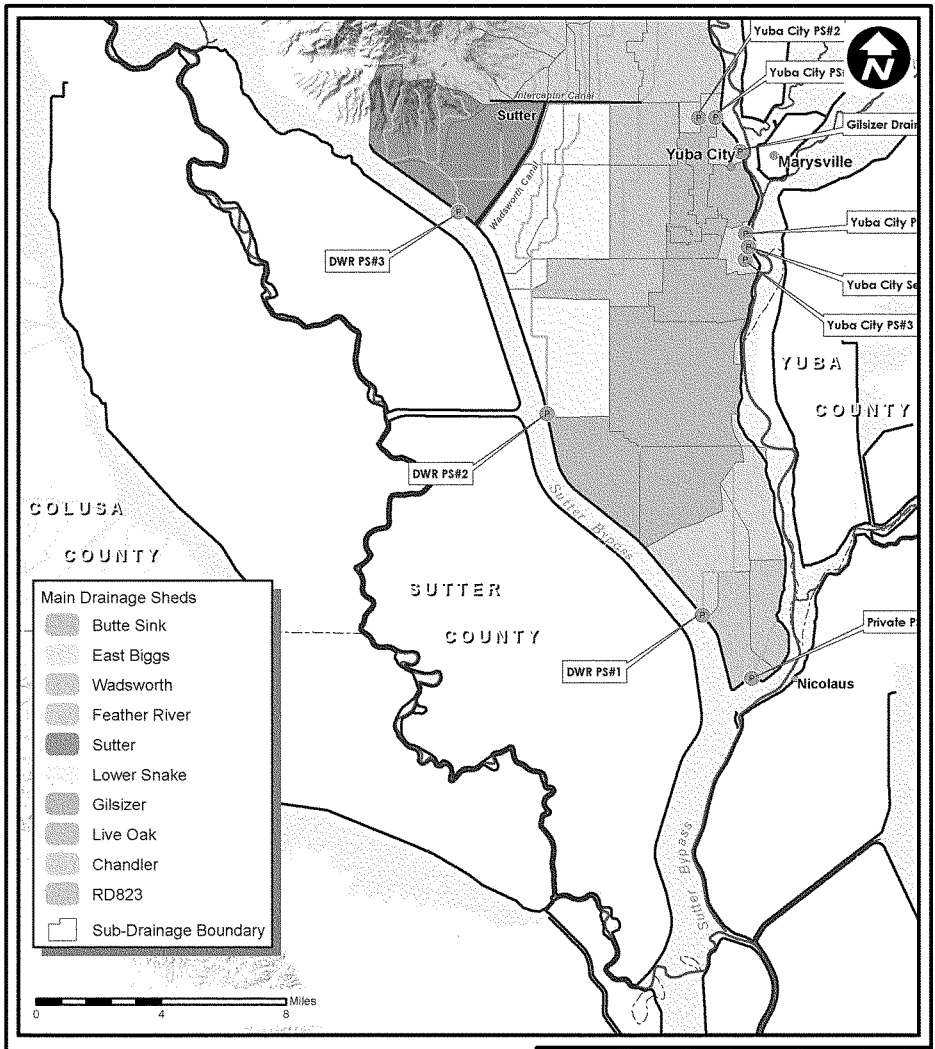
SUTTER BASIN FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

WAVE RUNUP STUDY AREA WITH INTERIOR DRAINAGE AREAS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

PLATE 26


Lake Oroville
New Bullards Bar Reservoir
Thermalito Afterbay
Oroville
SIERRA COUNTY
BUTTE COUNTY
Feather River
Biggs
Gridley
Honcut Creek
Englebright Lake
NEVADA COUNTY
Nevada City
Live Oak
Grass Valley
Rollins Reservoir
Yuba River
YUBA COUNTY
Yuba City
Marysville
Shanghai Bend
Colfax
Bear River below Rollins Dam
Dry Creek near Wheatland
Camp Far West Reservoir
Lake Combie
Wheatland
Star Bend
Bear River
Bear River near Wheatland
PLACER COUNTY
Lincoln
Auburn
Nicolaus
SUTTER COUNTY
Sutter Bypass
Loomis
Rocklin
EL DORADO COUNTY
Roseville
Folsom Lake
Placerville
SACRAMENTO COUNTY
Lake Natoma
Citrus Heights
Folsom
Miles
0 5 10
Legend
USGS Stream Gages - CA
USGS Stream Gages - CA
Sutter Basin Study Area
Watershed Boundary
Designated Floodway
Lake or Reservoir
River or Stream
Federal Levee
Highway
Major Road
Railroad
County Boundary
City or Town
SUTTER BASIN FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA
BEAR RIVER
WATERSHED AND TOPOGRAPHY
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
Prepared by Jim Mars
NOV 2012
PLATE 27



Legend

- Pump Station
- City or Town
- Drainage Flowline
- County Boundary
- River or Stream
- Federal Levee
- Lake or Reservoir
- Designated Floodway

SUTTER BASIN FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

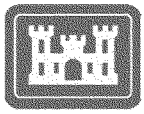
HEC-HMS SUBBASINS and PUMP STATIONS

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

NOV 2012

PLATE 28



US Army Corps
of Engineers.

Sacramento District

Engineering Division

Sutter Basin Pilot Feasibility Report - Environmental Impact Report / Supplemental Environmental Impacts Statement

Butte and Sutter Counties, California

HYDRAULIC DESIGN APPENDIX

July 2013

Revised: 06 October 2013

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54. 1% (1/100) ACE Floodplain Alternative SB-1 Without Project Conditions
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Attachments

Attachment A. Memorandum for File: Sutter Basin Pilot Feasibility Study, Hydraulic Analysis of Refined Alternatives. 8 June 2012

Attachment B. Final Geotechnical Fragility Curves, February 2013.

Acronyms and Abbreviations

ACE	Annual Chance of Exceedance
CNRFC	California Nevada River Forecast Center
CVFED	Central Valley Floodplain Evaluation and Delineation
CVFPP	Central Valley Flood Protection Plan
DWR	Department of Water Resources
FRM	Flood Risk Management
HEC	Hydrologic Engineering Center
HTOL	Hydraulic Top of Levee
NAD83	North American Datum of 1983
NAVD88	North American Vertical Datum of 1988
NGVD29	National Geodetic Vertical Datum of 1929
NLDB	National Levee Database
NWS	National Weather Service
PBI	Peterson Brustad Incorporated
RD	Reclamation District
SD	Standard Deviation
SBFCA	Sutter Butte Flood Control Agency
TRLIA	Three Rivers Levee Improvement Authority
ULDC	Urban Levee Design Criteria (State of California)
USGS	United States Geological Survey
USACE	United States Army Corps of Engineers
UPRR	Union Pacific Railroad
VE	Value Engineering

1.0 Introduction

1.1 Purpose and Scope

The purpose of this report is to describe the hydraulic analysis conducted in support of the Sutter Basin Feasibility Study. This report documents the analysis of the final array of alternatives. Analysis of the draft array of alternatives is described in Attachment A.

1.2 Background

The U.S. Army Corps of Engineers, together with the State of California and Sutter Butte Flood Control Agency (SBFCA) conducted this feasibility study to select a plan that reduces flood risk and provides ancillary Ecosystem Restoration and Recreation Benefits within the study area. The goal of the study is to identify a cost effective, technically feasible and locally acceptable project that best reduces flood risk and flood damages and complies with all Federal, State, and local laws and regulations.

1.3 Location

The Sutter Basin study area is located within the State of California approximately 25 miles north of Sacramento. A map of the watershed is included as Plate 1 and a map of the study area is included as Plates 2 and 3. The study area covers approximately 300 square miles and is approximately 43 miles north-south and 9 miles east-west. The study area includes the communities of Yuba City, Live Oak, Gridley, Biggs, and Sutter. Based on 2010 census data and floodplain mapping presented herein, approximately 95,000 people reside within the study area 0.2% (1/500) Annual Chance Exceedance (ACE) Floodplain. Yuba City is the largest community in the study area with a population of approximately 67,000 within the 0.2% (1/500) ACE Floodplain. A map of population density within the study area is provided in Plate 4 and tabulated in Table 1. The majority of land use in the study area is related to agricultural with rice and orchards comprising approximately 64.5% of land use. A map of land use types in the study area is presented in Plate 5 and tabulated in Table 2. The primary sources of flooding within the study area are the Butte Basin, Sutter Bypass, Feather River, Cherokee Canal, Wadsworth Canal, and local interior drainage.

Table 1. 2010 Population, Sutter Basin Study Area

Economic Evaluation Area	Population within ACE Floodplain						
	50% (1/2)	10% (1/10)	4% (1/25)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
Town of Sutter	0	0	0	0	0	0	251
Yuba City Urban	0	67351	67368	67368	67368	67368	67368
Biggs Urban	0	19	1452	1452	1452	1452	1763
Gridley Urban	0	0	6379	6379	6379	6379	6379
Live Oak Urban	0	0	8362	8362	8362	8362	8362
Sutter County Rural	1089	4837	6260	6314	6323	6354	6378
Butte County Rural	0	9	4776	4788	4788	4793	4899
Total	1089	72216	94597	94663	94672	94707	95400

Table 2. Land Use Types, Sutter Basin Feasibility Study Area

Land Use Type	Acres	Percent of Total
Abandoned	0	0.0
Burned Over Areas	0	0.0
Citrus and Subtropical	960	0.5
Deciduous Fruits and Nuts	61,230	31.2
Entry Denied	0	0.0
Field Crops	3,310	1.7
Grain and Hay Crops	4,520	2.3
Idle	4,800	2.4
Barren and Wasteland	50	0.0
Native Classes Unsegregated	0	0.0
Non-irrigated Idle	0	0.0
Riparian Vegetation	10,580	5.4
Not Surveyed	0	0.0
Native Vegetation	13,110	6.7
Water Surface	2,000	1.0
Pasture	5,810	3.0
Rice	65,360	33.3
Semi Agricultural and Incidental to Ag	2,620	1.3
Truck, Nursery and Berry Crops	3,080	1.6
Urban	6,410	3.3
Commercial	640	0.3
Industrial	1,490	0.8
Urban Landscape	600	0.3
Residential	5,120	2.6
Vacant	4,520	2.3
Vineyards	70	0.0
Outside	0	0.0
Total	196,260	100.0
Sources: DWR 2004 Butte County Land Use Survey DWR 2005 Sutter County Land Use Survey		

1.4 Plan Selection Process

The final array of alternative plans described in this report were selected through a risk informed planning process involving multi-disciplinary analysis at increasing levels of detail. At each level of screening and analysis the level of detail was improved and the relative uncertainty was assessed. Measures and alternatives were carried forward if the level of detail was insufficient to screen it out.

Throughout this process the concept of absolute accuracy versus relative accuracy was considered in alternative comparisons. Although it would appear that every plan should be compared to the most accurate assessment of existing conditions, this is not necessary because the relative accuracy between plans is sufficient to select the most optimal plans to move forward.

Conceptual alternatives were developed from a broad array of measures at a qualitative level of detail. The conceptual alternatives were developed during a planning Charrette attended by the project sponsors and subject matter experts. Development of the conceptual alternatives is described in the Sutter Basin Feasibility Study report.

An array of draft alternatives were derived from the conceptual alternatives and evaluated at an increased level of detail. This level of detail included qualitative and quantitative engineering analyses. Analyses included floodplain hydraulic modeling, cost estimating, and economic

benefit estimations. The level of detail was limited to that required to decide which plans to carry forward. Results were evaluated at a combined Value Engineering (VE) study and planning charette attended by the project sponsors and subject matter experts. At the conclusion of the VE and planning charette, refinements to the draft array of alternatives were identified for further, more detailed analysis. Selection of the draft array of alternatives is described in Progress Document 1.

Final alternatives were selected from the draft alternatives in the next level of detail. This level of detail included additional qualitative and quantitative engineering analyses. Analyses included refined channel hydraulic modeling, cost estimating, and economic benefit estimations. The level of detail was limited to that required to decide which plans to carry forward. Results were presented to the vertical team at Decision Point 2. At the conclusion of the Decision Point, a final array of alternatives was identified for further analysis. A summary of the hydraulic analysis performed for the draft array of alternatives is described in Attachment A. Additional details are described in internal memorandums on file within the Sacramento District Hydraulic Analysis Section.

1.5 Datum

As required by ER 1110-2-8160 all elevations provided herein are referenced to the NAVD88 vertical datum. All horizontal data provided herein are referenced to the North American Horizontal Datum of 1983 (NAD83) Horizontal datum. All horizontal coordinates are projected to the California State Plane Zone II coordinate system. River miles presented in this study are based on the March 2002 Sacramento and San Joaquin River Basins Comprehensive study (Comp Study). Project stationing presented in this study is based on the Feather River West Levee Project Stationing defined by SBFCA.

Historical elevation data were converted to NAVD88 from their original legacy reference datum. The method of conversion followed the requirements in ER 1110-2-8160 and the uncertainty in the conversion is accounted for in the study results.

The following generalized conversion is provided to compare NAVD88 elevations provided in this study to previous studies presented in the legacy NGVD29 datum. Expressed as an equation, Elevation (NGVD29) = Elevation (NAVD88) minus 2.40 feet. The conversion between NAVD88 and NGVD29 ranges from 2.3 to 2.4 feet in the study area.

2.0 Study Area

2.1 Watershed

The Sutter Basin study area is situated within the Sacramento River watershed. A map of the Sacramento River watershed is included as Plate 1. The principle watersheds upstream of the study area are the Sacramento River watershed and Feather River watershed. The Sacramento River watershed encompasses the McCloud River, Pit River, and Goose Lake, and Stony Creek. The watershed drains the Sierra Nevada Mountains and Cascade Ranges in the east and the Coast Range and Klamath Mountains in the west. The Feather River watershed encompasses the Yuba River and Bear Rivers. These watersheds drain the eastern slopes of the Sierra Nevada mountain range. The drainage area of the Sacramento River basin upstream of the study area is approximately 12,000 square miles. The drainage area of the Feather River upstream of the study area (including the Yuba and Bear Rivers) is approximately 5,900 square miles.

2.2 Topography

A topographic map of the study area is presented in Plate 2. Elevations within the study area range from 110 ft NAVD88 in the north to 30 ft NAVD88 in the south. The study area has a general slope from northeast to south west. The general slope of the study area is interrupted by two major embankment features which impact hydraulic conveyance within the floodplain. The raised embankment of the Union Pacific Railroad traverses the study area in a north south alignment and the Sutter Bypass east levee traverses the study area in a north south alignment.

2.3 Flood Sources

The Sutter Basin Study area is susceptible to flooding from multiple sources including Butte Basin, Sutter Bypass, Feather River, Cherokee Canal, Wadsworth Canal, and interior sources.

a. Butte Basin. The northwest portion of the study area is within the Butte Basin. The Butte Basin is a natural overflow and flood storage area north west of the Sutter Buttes and east of the Sacramento River. The basin provides approximately 1 million acre-feet of transitory storage at flood stage (DWR, 2010). Excess floodwaters from the Sacramento River enter the Butte Basin via overbank areas along the river and through the Moulton and Colusa weirs. Butte Creek and its tributaries, including Cherokee Canal, also flow into the Butte Basin. Outflow from the Butte Basin is naturally regulated by hydraulic conditions of Butte Slough and floodplain topography at the upstream entrance to the Sutter Bypass. In order to maintain the flood storage capabilities within Butte Basin, California has included regulation of the overflow area in Title 23 of the California Code of Regulations. In general these standards require approval from the board for any encroachments that could reduce or impede flood flows or would reclaim any of the floodplain within the Butte Basin (DWR, 2010).

b. Sutter Bypass. The southwest portions of the study area including the southern portion of Yuba City are susceptible to flooding from the Sutter Bypass. The Sutter Bypass is a leveed flood control channel approximately three quarters of a mile wide, bordered on each side by levees. The bypass is an integral feature of the Sacramento River Flood Control Project's Flood Bypass System. The Sutter Bypass conveys flood waters from the Butte Basin, Sacramento River, and Feather Rivers to the confluence of the Sacramento River and Yolo Bypass at the Fremont Weir.

Downstream of the Feather River the bypass is separated into two conveyance areas by a low levee. The area east of the middle levee conveys flows from the Feather River. This design maintains higher velocities and sediment transport capacity within the Feather River during low flow events while utilizing the large conveyance of the Sutter Bypass during larger events.

The Sutter Bypass also receives minor natural flow and agricultural return flow from Reclamation District 1660 to the west and from Wadsworth Canal and DWR pumping plants 1, 2, and 3 to the east. The Sutter Bypass is described by four hydrologic reaches based on tributary inflows; Butte Slough to Wadsworth Canal, Wadsworth Canal to Tisdale Bypass, Tisdale Bypass to Feather River, Feather River to Sacramento River.

c. Feather River. Nearly the entire study area is susceptible to flooding from the Feather River. The Feather River is a major tributary to the Sacramento River, merging with the Sutter Bypass upstream from the Sacramento River and Fremont Weir. The Yuba and Bear Rivers are major tributaries to the Feather River. Two major flood management reservoirs are located within the Feather River watershed. Oroville Dam and reservoir was completed on the Feather River in 1967. The reservoir has 3,358,000 acre-feet of storage with 750,000 acre-feet of dedicated flood management space. New Bullards Bar dam and reservoir was completed on the Yuba River 1970. The reservoir has 966,000 acre-feet of storage with 170,000 acre-feet of dedicated flood management space. The Feather River is described by four hydrologic reaches based on significant inflows; Thermalito to Honcut Creek, Honcut Creek to Yuba River, Yuba River to Bear River, and Bear River to Sutter Bypass.

d. Cherokee Canal. The northern portion of the study area is susceptible to flooding from Cherokee Canal which is a tributary to Butte Creek and the Butte Basin. The leveed canal was constructed between 1959 and 1960 by USACE under the authorization of the Flood Control Act of 1944. The canal drainage area is 94 square miles and varies in elevation from 70 feet to 2200 feet. The drainage area is bounded by the Feather River watershed to the east and southeast, Butte Creek and its tributaries to the north and west, and by Wadsworth Canal drainage to the south. The design capacity along the Cherokee Canal is 8,500 cubic feet per second (cfs) upstream of the junction with Cottonwood Creek, 11,500 cfs from the junction with Cottonwood Creek to the Biggs Princeton Highway (Afton Road) and 12,500 cfs from the Biggs Princeton Highway to Butte Creek. Based upon the flood frequency analysis at the time of design, the canal was estimated to provide flood protection from a 4% (1/25) ACE event and mitigated sediment transport problems within its watershed.

e. Wadsworth Canal and associated Interceptor canals are potential sources of flooding in the southwest portion of the study area. The Wadsworth Canal system is a feature of the Sacramento River Flood Control Project and consists of leveed channels that carry rainfall and agricultural runoff from 91 square miles of northeast part of Butte and Sutter Counties south to the Sutter Bypass.

(1) West Interceptor Canal. The West Interceptor Canal begins near the town of Sutter and extends 1.8 miles east to Wadsworth Canal. The canal is approximately 30 feet wide and includes a 4 to 5 foot tall Federal Project levee along its right bank. There is no federal levee along the left bank of the canal. The slope of the canal is approximately 25 feet per mile. The purpose of the canal is to intercept rainfall runoff that would otherwise pond against the eastern levee of the Sutter Bypass. The intercepted flow is diverted into the Wadsworth Canal where it is then conveyed to the Sutter Bypass. During extreme floods the peak flow of the canal would be significantly attenuated by the floodplain storage available along the left bank. The canal is also used for irrigation water. The operations and maintenance manual does not list a design flow for the West Interceptor canal.

(2) East Interceptor Canal. The East Interceptor Canal begins near Yuba City and extends 3.1 miles east to the Wadsworth Canal. The canal is approximately 30 foot wide and includes a 4 to 5 foot tall Federal Project levee along its left bank. The purpose of the canal is to intercept rainfall runoff that would otherwise flow southwest and pond against the eastern levee

of the Sutter Bypass. There is no federal levee along the right bank of the canal. The slope of the canal is negligible and the top of levee has a level grade. The intercepted flow is diverted it into the Wadsworth Canal where it is then conveyed to the Sutter Bypass. During extreme floods the peak flow of the canal would be significantly attenuated by the floodplain storage available along the right bank. The canal is also used for irrigation water during the summer irrigation season. The operations and maintenance manual does not list a design flow for the East Interceptor canal.

(3) Wadsworth Canal. Wadsworth Canal begins at the East and West Interceptor Canals near Butte House Road. The canal extends 4.5 miles south to the Sutter Bypass and includes Federal Project Levees along the left and right banks. The canal is a fairly uniform trapezoidal type channel. The purpose of the canal levee is to collect and convey rainfall runoff and irrigation water from the East and West Interceptor Canals to the Sutter Bypass. The existing Operations and Maintenance Manual for Wadsworth Canal describes a design capacity of 1,500 cfs.

f. Interior Drainage. Runoff from the interior of the study area may result in localized flooding. Interior drainage features include canals and streams tributary to Wadsworth Canal and pumps and culverts along the project levees.

2.4 Stream Gages.

A list of stream gages applicable to the study area is provided in Table 3. The stream gages are operated by the United States Geological Survey (USGS) and California Department of Water resources. Stream gages are shown on Plate 6.

Table 3 Stream Gages, Sutter Basin Study Area

Gage Name	Area (Sq Mi)	Agency	Gage Number	Period of Record	Type
Bear R Nr Wheatland Ca	292	USGS	11424000	1928-2010	S,Q
Bear River at Pleasant Grove	300	DWR	A06535	1987-2010	S,Q
Butte Creek near Gridley	NA	DWR	A04150	1991-1999	S,Q
Butte Slough at Outfall Gates near Colusa	NA	WDL	A02967	1992-2010	S
Butte Slough near Meridian	NA	WDL	A02972	1981-2010	S,Q
Cherokee Canal nr Gridley	NA	DWR	A00910	1991-1998	S,Q
Cherokee Canal nr Richvale	NA	DWR	A02984	1976-2010	S,Q
Camp Far West Reservoir	NA	DWR	A65105	1998-2010	Q
Colusa Weir Spill to Butte Basin near Colusa	NA	WDL	A02981	1975-2010	S,Q
Deer C Nr Smartville CA	84.6	USGS	11418500	1935-2010	S,Q
Feather River at Nicholaus	5,921	DWR	A05103	1942-2010	S,Q(P)
Feather River at Oroville	3,624	USGS	11407000	1902-2010	S,Q
Feather River at Yuba City	3,974	DWR	A05135	1964-2010	S
Feather River near Gridley	3,676	DWR	A05165	1964-2010	S,Q
Moulton Weir Spill to Butte Basin nr Colusa	NA	DWR	A02986		
Sacramento R at Ord Ferry	12,030	DWR	A02570	1922-2010	S,Q
Sacramento R at Colusa Ca	12,090	USGS	11389500	1941-2010	S,Q
Sacramento R at Verona Ca	21,251	USGS	11425500	1929-2010	S,Q
Sacramento R Blw Wilkins Slough nr Grimes Ca	12,915	USGS	11390500	1931-2010	S,Q
Sacramento River at Butte Slough Outfall Gates	NA	DWR	A02400	1992-2004	S
Sacramento River at Fremont Weir (East)	NA	DWR	A02160	1935-2010	S
Sacramento River at Fremont Weir (West)	NA	DWR	A02170	1934-2010	S
Sacramento River at Knights Landing	14,535	DWR	A02200	1982-2010	S
Sacramento Slough near Karnak	NA	DWR	A02925	1981-2010	S
Sutter Bypass at R.D. 1500 P.P. near Karnak	NA	DWR	A02927	1975-2010	S
Sutter Bypass Channel at Pumping Plant #1	NA	DWR	SB1	2008-2010	S
Sutter Bypass Channel at Pumping Plant #2	NA	DWR	SB2	2008-2010	S
Sutter Bypass Channel at Pumping Plant #3	NA	DWR	SB3	2008-2010	S
Tisdale Weir near Grimes	NA	DWR	A02960	1975-2010	S,Q
Willow Slough near Nicolaus	NA	DWR	A02943	1991-2010	S
Yolo Bypass nr Woodland Ca	NA	USGS	11453000	1939-2011	S,Q
Yuba R blw Englebright Dam near Smartsville	1,108	USGS	11418000	1941-2011	S,Q
Yuba R Nr Marysville CA	1,339	USGS	11421000	1940-2011	S,Q
Wadsworth Canal near Sutter (lower)	96	DWR	A05927	1982-1997	S,Q
Wadsworth Canal near Sutter (upper)	96	DWR	A05929	1976-1997	S,Q
Note: S-Stage, Q-Discharge, NA- Not Available, (Partial Record)					

2.5 Historical Floods.

The Feather River near Oroville gage provides an indicator of large historical floods within the study area. The largest fifteen floods from 1951 to 2010 are presented in Table 4. The magnitudes of historical floods prior to 1967 are not directly comparable to later floods due to significant historical changes in the flood management system. In order to provide a comparison of similar hydrologic conditions, the table includes the estimated unregulated flow for each water year. The ranking of unregulated floods is substantially different than observed flood flows with the 1997 flood being the largest unregulated flood from 1951 to 2010. The following is a description of significant flood events within the study area.

Table 4
Fifteen Largest Annual Maximum Floods
WY1951-WY2010, Feather River at Oroville

Measured				Regulated Peak Flow (CFS)	Unregulated Peak Flow (CFS)	Notes
Annual Ranking	Water Year	Date of Peak	Peak Flow (CFS)			
1	1956	12/23/1955	203,000	150,000	203,000	
2	1963	1/31/1963	191,000		191,000	
3	1997	1/2/1997	161,000	161,000	312,900	
4	1965	12/23/1964	158,000	150,000	260,000	Note 1
5	1960	2/8/1960	135,000		135,000	
6	1986	2/18/1986	134,000	134,000	217,000	
7	1953	1/9/1953	113,000		113,000	
8	1958	2/24/1958	102,000		102,000	
9	1951	11/21/1950	92,100		92,100	
10	1957	2/24/1957	83,100		83,100	
11	1995	3/14/1995	71,700	71,700	134,200	
12	1980	1/15/1980	69,500	69,500	137,600	
13	2006	12/31/2005	65,600	65,600		
14	1952	2/1/1952	59,500		59500	
15	1970	1/25/1970	56,300	56,300	117,700	
Note 1/ Dec 1964 Flood regulated by a partially completed Oroville Dam.						

a. December 1955. The December 1955 flood was the largest peak flow recorded at the Feather River at Oroville gage from 1951 to 2010. Major damage to the study area occurred in December 1955 when the west levee of the Feather River breached near Shanghai Bend killing 38 people. The peak flow measured at the Feather River at Oroville stream gage was 203,000 cfs. This flood occurred prior to construction of Oroville Dam (completed 1967) and New Bullards Bar Dam (completed 1970). Therefore, the flood does not reflect existing hydrologic conditions. A hypothetical flood routing of the 1955 flood is presented in the Oroville Dam and Reservoir water control manual. The flood routing indicates the reservoir would have regulated the peak outflow to 150,000 cfs.

b. December 1964. The December 1964 flood was the fourth largest peak flow recorded at the Feather River at Oroville gage from 1951 to 2010. The main center of precipitation was in the Feather, Yuba, and American River Basins. Rainfall was heaviest on December 22 and 23 1964. Runoff from streams of the Coast Ranges, almost without exception produced peak stages and peak flows that exceeded previous records. Runoff from the Sierra Nevada into the Feather, Yuba and American Rivers surpassed all previous records. This flood occurred during construction of Oroville Dam and was partially regulated to an outflow of 158,000 cfs. A hypothetical flood routing of the 1964 flood is presented in the Oroville Dam and Reservoir water control manual. The flood routing indicates the completed reservoir would have regulated the peak outflow to 150,000 cfs. Had it not been regulated, the peak flow would have been approximately 260,000 cfs which would have exceeded the 1955 flood peak by 57,000 cfs.

b. November 1982 - March1983. Water year 1983 was a result of the "El Niño" weather phenomenon. Northern and Central California experienced flooding incidents from November through March due to numerous storms. In early May, snow water content in the Sierra exceeded

230 percent of normal, and the ensuing runoff resulted in approximately four times the average volume for Central Valley streams. System failures in the Sacramento River Basin were limited to a private levee on the Sacramento River and one failure on Cache Creek.

c. February 1986. Flooding in 1986 resulted from a series of four storms over a 9-day period during February. Rains from the first three storms saturated the ground and produced moderate to heavy runoff before the arrival of the fourth storm. Precipitation at Four Trees in the Feather River Basin set both a 24-hour rainfall record for the Sierra Nevada and the monthly record for any station in the State. During the flood, the left levee of the Yuba River failed just upstream of the Feather River confluence. The communities of Linda and Olivehurst were inundated, resulting in one death, 895 destroyed homes, and 150 destroyed businesses.

d. January 1995. "El Nino" conditions in the Pacific forced major storm systems directly into California during much of the winter and early spring of 1995. The largest storm systems hit California in early January and early March. The major brunt of the January storms hit the Sacramento River Basin and resulted in small stream flooding primarily due to storm drainage system failures.

e. January 1997. December 1996 was one of the wettest Decembers on record. Watersheds in the Sierra Nevada were already saturated by the time three subtropical storms added more than 30 inches of rain in late December 1996 and early January 1997. The third and most severe of these storms lasted from December 31, 1996, through January 2, 1997. Rain in the Sierra Nevada caused record flows that stressed the flood management system to capacity in the Sacramento River Basin and overwhelmed the system in the San Joaquin River Basin. During the flood, the left levee of the Feather River failed near Arboga, killing one person, destroying 180 homes and businesses, and prompting evacuation of about 15,000 people from Linda and Olivehurst. Nearly 50,000 people from Yuba City, Marysville, and surrounding areas were evacuated because of fears of additional levee breaks (USACE, 1998).

f. December 2005 - January 2006. Between 28 December 2005 and 9 January 2006, the State of California experienced a series of severe storms which impacted the levees within the Sacramento District's boundaries. Water rose a second time in April 2006, and remained high in some parts of the system until June. Many rivers and streams within the Sacramento and San Joaquin River systems ran above flood stage during these events, and there were significant erosion and seepage problems with the levees. The State of California Department of Water Resources and/or their maintaining agencies conducted the actual flood fight activities while the U.S. Army Corps of Engineers provided technical assistance to the State.

2.5 Climate Change.

The primary impacts of climate change on Flood Risk Management projects are related to changes in flood frequency estimates, changes in sea level, and their associated uncertainties. The primary climate change consideration within the study area is related to the potential changes in flood frequency estimates. An evaluation of project performance related to changes in climate and flood frequency estimates was conducted using the HEC FDA program and is described in the Hydrology Appendix. Appendix C of EC 1165-2-212 provides a flow chart for

evaluating sea level change for a potential project. Based on Step 1 of the flow chart, an evaluation of sea level rise is not required. The study area is approximately 30 feet above mean sea level. Base on sea level trends provided in EC 1165-2-212. Sea level rise would have no impact on the study area up to the year 2100.

3.0 Alternative SB-1 (Without Project Conditions)

3.1 Project Assumptions

a. Levee Design. All existing federal levees are assumed to be maintained to the 1957 design top of levee. The 1957 design top of levee is based on the 1957 design water surface profiles and the minimum freeboard specified in the 1951 Operations and Maintenance Manuals. The 1957 design water surface profile is described on the drawing set, Sacramento River Flood Control Project, California, Levee and Channel Profiles, Drawing File Number 50-10-3334, 15 March 1957. The 1957 design water surface is labeled on the drawing set as the Project Design Flood Plane.

The derivation of the 1957 water surface profiles is described in the memorandum "Levee and Channel Profiles, Sacramento River Flood Control Project" dated 1 July 1957. The 1957 design freeboard is described in the Operations and Maintenance manuals dated 1951. The Sacramento River Flood Control Project adopted multiple existing levees of varying height. The Operations and Maintenance manuals indicates the adopted levee segments met or exceeded the design freeboard. The 1957 design profile and freeboard are described in detail in memorandum on file in the Sacramento District Hydraulic Analysis Section.

b. TRILIA Feather River Setback Levee. The hydraulic analysis of without project conditions includes the setback levee along the left bank of the Feather River constructed by the Three Rivers Levee Improvement Authority (TRILIA).

c. Feather River Star Bend Setback Levee. The without project conditions assumes the levee setback levee on the right bank near Star Bend has not been constructed.

d. Interior Drainage Facilities. The hydraulic analysis assumes all drainage facilities are maintained to their design capacities.

e. Operation and Maintenance. The hydraulic analysis assumes vegetation conditions within the channel will be maintained with similar hydraulic conditions as the existing conditions.

3.2 Hydrology

a. Sutter Bypass, Feather River and Butte Basin. Hydrology for the Sutter Bypass, Feather River, and Butte Basin was based on the Sacramento-San Joaquin Comprehensive study (Comp Study) and Lower Feather River Floodplain mapping study. The Sacramento-San Joaquin Comprehensive study included the entire Sacramento and San Joaquin Valleys. The Lower Feather River Floodplain mapping study was based on the Comprehensive study but included revisions to flow frequencies and hydrographs on the Feather River. Balanced 30-day regulated

flow hydrographs developed for 50% (1/2) ACE, 10% (1/10) ACE, 4% (1/25) ACE, 2% (1/50) ACE, 1% (1/100) ACE, 0.5% (1/200) ACE, and 0.2% (1/500) was used in the hydraulic analysis.

The synthetic hydrology investigated unregulated flood frequencies at mainstem and tributary locations throughout the Sacramento Basin. The flood frequency analysis involved evaluations of long term historical records at the stream gages. The unregulated flow frequency statistics and period of record for the Sacramento River at Bend Bridge, Feather River at Oroville, and Feather River at Shanghai Bend were used to estimate hydrologic uncertainty in the Sutter Basin Feasibility Study. The adopted statistics and period of record for the unregulated conditions are provided in Tables 5, 6, and 7.

Table 5
Rain Flood Frequency, Sacramento River at Ord Ferry
Unregulated Conditions

Flood Duration	Adopted Log Mean	Adopted Log Standard Deviation	Adopted Log Skew	Record (Years)	
				Years Evaluated	Years Used
1-Day	5.009	0.281	0.0	1922-1997 (1977 censored)	75
3-Day	4.939	0.281	0.0	1922-1997 (1977 censored)	75
5-Day	4.866	0.279	-0.1	1922-1997 (1977 censored)	75
10-Day	4.809	0.278	-0.1	1922-1997 (1977 censored)	75
15-Day	4.680	0.267	-0.3	1922-1997 (1977 censored)	75
30-Day	4.562	0.258	-0.3	1922-1997 (1977 censored)	75
1977 censored as a low outlier					

Table 6
Rain Flood Frequency, Feather River at Oroville
Unregulated Conditions

Flood Duration	Adopted Log Mean	Adopted Log Standard Deviation	Adopted Log Skew	Record (Years)	
				Years Evaluated	Years Used
Peak	4.743	0.390	-0.2	11 years	11
1-Day	4.639	0.390	-0.2	1901-1997	97
3-Day	4.533	0.392	-0.2	1901-1997	97
7-Day	4.387	0.377	-0.3	1901-1997	97
15-Day	4.250	0.351	-0.4	1901-1997	97
30-Day	4.129	0.326	-0.4	1901-1997	97

Table 7
Rain Flood Frequency, Feather River at Shanghai Bend
Unregulated Conditions

Flood Duration	Adopted Log Mean	Adopted Log Standard Deviation	Adopted Log Skew	Record (Years)	
				Years Evaluated	Years Used
Peak	4.951	0.402	-0.3	1904-1997	94
1-Day	4.857	0.402	-0.3	1904-1997	94
3-Day	4.733	0.404	-0.3	1904-1997	94
7-Day	4.582	0.387	-0.3	1904-1997	94
15-Day	4.443	0.363	-0.4	1904-1997	94
30-Day	4.321	0.340	-0.4	1904-1997	94

Seven storm centerings were formulated in the Comp Study to represent the many different possibilities of aerial storm distributions and antecedent watershed conditions. For each centering, synthetic 30-day natural flow hydrographs were computed at locations throughout the Central Valley. Typically, each tributary basin contained one hydrograph location. Many of these sites were inflow points to major flood management projects (i.e., Feather River at Oroville Dam). These natural flow hydrographs represent flood time series produced by a wholly unimpaired drainage area. The unimpaired hydrographs do not reflect the influence of headwater reservoirs. The hydrographs were balanced so the average flow for all durations matched the given frequency. For example, the peak, 1-day, 3-day, 5-day, 15-day, and 30-day volumes match the given frequency event.

A 3-step process was required to conduct simulations of reservoir regulations for each storm centering. To begin the sequence, the headwaters reservoirs upstream of the flood control reservoirs were simulated. Then, using the resulting storage time series for select headwater facilities, top of conservation storage for those flood damage reduction projects with established credit space agreements were computed. Next, using the results of the headwater simulations and the computed top of conservation series, the lower basin reservoir models were simulated, thereby completing the reservoir simulation procedure.

A regulated set of hydrographs was obtained from "hand off" points in the lower basin reservoir simulation model. These hydrographs were used as the input to the HEC-RAS unsteady flow models in the feasibility study. A review of the seven storm centerings found that peak stages along the Sutter Bypass and Feather Rivers are generated by either the Sacramento River storm centering or Shanghai Bend storm centering. Therefore, these are the only two centerings modeled in the feasibility study. In order to determine the peak stage for a given frequency event both storm centerings are modeled. The set of unregulated flow hydrographs provided at hydraulic model boundary locations shown on Plate 6 and listed in Table 8.

Table 8 Regulated Boundary Condition Hydrographs

Model Boundary	Name
1	BEAR RIV BLW CAMP FAR WEST
2	BEST SLOUGH AT FORTY MILE ROAD
3	BUTTE SLOUGH AT WEST BUTTE ROAD
4	CACHE C A YOLO CA (#11452500)
5	YUBA - DRY CREEK AT HWY 20
6	BEAR RIVER - DRY CREEK AT JASPER LN
7	FEATHER RIVER AT OROVILLE (#11407000)
8	HONCUT CREEK AT HWY 70
9	JACK SIMMERLY AT WOODRUFF LN
10	KLRC AT KNIGHTS LANDING
11	NATOMAS CROSS CANAL AT GARDEN HWY
12	SACRAMENTO R A COLUSA CA (#11389500)
13	SACRAMENTO R A VERONA CA (#11425500)
14	UP INTERCEPT SA REEDS
15	WADSWORTH CANAL AT HWY 20
16	YANKEE SLOUGH AT SWETZER ROAD
17	YOLO BYPASS NR WOODLAND CA (#11453000)
18	YUBA RIVER AT RS 13.84

b. Wadsworth Canal. Flow frequency analysis for Wadsworth Canal is described in the Feasibility Study Hydrology Appendix. Wadsworth canal is an unregulated stream. The Wadsworth Canal unregulated frequency curve was developed from graphical frequency analysis of gage records at Wadsworth Canal near Sutter (DWR stream gage A05929) following Bulletin 17B guidelines. The analysis was based on mean daily flows from 1939 to 1996. The years 1976 and 1977 were screened as low outliers and were not used in the analysis. The peak flow frequency was estimated from the mean daily flows. A 37 year equivalent period of record is recommended for the peak flow frequency to account for the additional hydrologic uncertainty. A table of peak unregulated flows for Wadsworth Canal is provided in Table 9. These flows represent a storm centered over the Wadsworth canal drainage area.

Table 9
Flow Frequency, DWR Gage Wadsworth Canal near Sutter

Peak Discharge by ACE (cfs)						
50% (1/2)	**10% (1/10)**	**4% (1/25)**	**2% (1/50)**	**1% (1/100)**	**0.5% (1/200)**	**0.2% (1/500)**
820	2,250	3,200	4,000	4,830	5,750	7,070

The water surface profile of Wadsworth Canal is influenced by inflow from the East and West Interceptor Canals and the coincident downstream stage in the Sutter Bypass. Inflow from Wadsworth canal is approximately 1% of the flow in the Sutter Bypass. Therefore, inflow from Wadsworth Canal has negligible impact on stages in the Sutter Bypass during the flood season. Stage and flow frequency estimates for the Sutter Bypass were obtained from the Sutter Bypass and Feather River model. Peak flow and stage frequency estimates are provided in Tables 10 and 11 respectively.

Table 10
Flow Frequency, Sutter Bypass below Wadsworth Canal

Scenario	Peak Flow (FT-NAVD88)						
	50% (1/2)	10% (1/10)	4% (1/25)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
A. No Overtopping or Failure	57,600	102,800	127,200	156,100	185,400	229,500	328,900
B. Overtopping without Failure	Same	Same	Same	Same	Same	228,300	255,000
HEC-RAS model, Sutter Bypass, Wads-Tisdale, Section 84.14							

Table 11
Stage Frequency, Sutter Bypass at Wadsworth Canal Confluence

Scenario	Peak Stage (FT-NAVD88)						
	50% (1/2)	10% (1/10)	4% (1/25)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
A. No Overtopping or Failure	46.87	50.64	52.75	54.42	56.19	58.53	63.21
B. Overtopping without Failure	Same	Same	Same	Same	Same	58.45	59.82
HEC-RAS model, Sutter Bypass, Wads-Tisdale, Section 84.14							

c. Cherokee Canal. Hydrologic analysis conducted for Cherokee Canal is described in the report "Sutter, Basin California, General Investigation Feasibility Study, Cherokee Canal Hydrology Appendix, Cottonwood Creek to Afton Road Butte County, California", August 2010. Flood frequency curves and a suite of 30 day balanced hydrographs were developed for the Cherokee Canal near Richvale Gage (DWR stream gage A02984). The frequency analysis was conducted using Bulletin 17b methods based on 46 years of record from 1961 to 2006. Flood frequency statistics for the Cherokee Canal near Richvale Gage are provided in Table 12. A table of discharges by frequency and duration is provided in Table 13.

Table 12
Flood Frequency Statistics, DWR Gage Cherokee Canal near Richvale

Flood Duration	Log Mean	Log Standard Deviation	Log Skew (Adopted)	Record (Years)	
				Years Evaluated	Years Used
Peak	3.7484	0.2241	-0.70	46	46
1-Day	3.4576	0.2241	-0.70	46	46
3-Day	3.2656	0.2241	-0.70	46	46
5-Day	3.1618	0.2241	-0.70	46	46
10-Day	3.0052	0.2241	-0.70	46	46
15-Day	2.9130	0.2241	-0.70	46	46
30-Day	2.7525	0.2241	-0.70	46	46

Table 13
Flood Frequency, DWR Gage Cherokee Canal near Richvale

Flood Duration	Duration Average Discharge by ACE (CFS)						
	50% ACE	10% ACE	4% ACE	2% ACE	1% ACE	0.5% ACE	0.2% ACE
Peak	5,900	10,300	12,100	13,200	14,300	15,200	16,300
1-Day	3,040	5,280	6,190	6,870	7,310	7,780	8,340
3-Day	1,960	3,390	3,980	4,360	4,700	5,000	5,360
5-Day	1,540	2,670	3,130	3,430	3,700	3,940	4,220
10-Day	1,070	1,860	2,180	2,390	2,580	2,750	2,950
15-Day	870	1,510	1,770	1,940	2,090	2,220	2,380
30-Day	600	1,040	1,220	1,340	1,440	1,540	1,650

Balanced 30-day hydrographs were developed for 50% (1/2) ACE, 10% (1/10) ACE, 4% (1/25) ACE, 2% (1/50) ACE, 1% (1/100) ACE, 0.5% (1/200) ACE, and 0.2% (1/500) ACE events. The hydrographs were developed using the same methodology as described in the Comp Study. The 5-day flood pattern for the synthetic hydrographs was based on the 30 December 2005 to 4 January 2006 flood. The 30-day hydrograph was then constructed from 6 waves, each 5 days in duration. The highest wave volume is distributed into the fourth, or main, wave. The second and third highest volumes precede and follow the main wave, respectively. The fourth highest volume is distributed into the 2nd wave, and the 5th highest is distributed into the final of the 6 waves. The 6th and smallest wave volume is distributed into the 1st wave of the series. The shape of each wave is identical and the magnitude is determined by the total volume that the wave must carry.

d. Interior Drainage. An interior drainage analysis was performed by Peterson-Brustad Incorporated (PBI) for the Sutter Butte Flood Control Agency (SBFCA). The interior drainage analysis evaluated rainfall runoff and flood depths for 2% (1/50) ACE, 1% (1/100) ACE, 0.5% (1/200) ACE flood events. Storm events with 24-hour and 96 hour durations were evaluated.

The analysis utilized an HEC-HMS model to compute sub basin runoff and a FLO-2D two dimensional hydraulic model to route the runoff through the study area. A total of 16 drainage basins covering approximately 340 square miles were identified within the interior drainage boundary. The drainage basins were further divided into a total of 77 sub basins. The model included ten storm water pump stations that pump drainage water into the Feather River or Sutter Bypass. The FLO-2D model uses a 1,000-foot by1,000-foot grid size and includes the main drainage channels throughout the study area as channel elements. The resulting interior drainage maps were reviewed and adopted for use in this study. The maps are further described in the analysis of alternatives below.

3.3 Hydraulic Models

Without project conditions were evaluated using an uncoupled 1-d and 2-d modeling approach that is standard procedure on multiple studies within the Sacramento District. River stages and profiles were simulated using a 1-dimensional HEC-RAS model because RAS incorporates more

detailed hydraulic capabilities for channel flow. Levee breaches were simulated using the same HEC-RAS model because the levee breach capabilities are more detailed in RAS than FLO-2D. These breaches were then transferred to a 2-dimensional FLO-2D model of the floodplain. The FLO-2D model has more detailed capabilities than HEC-RAS for simulating the distribution of the breach hydrographs on the floodplain. This process leverages the most robust capabilities of both models. Ideally, this would be conducted using a coupled 1-d and 2-d model but that capability is not readily available with standard models used by the district.

Five separate hydraulic models that were adapted from existing hydraulic models utilized for studies within the Sacramento Valley. These existing models were reviewed and determined to be adequate for the Sutter Basin Feasibility Studyl analysis. Water surface profiles for Sutter Bypass and Feather River were computed using an HEC-RAS unsteady one-dimensional flow model of the Sacramento River system. Water surface profiles for Wadsworth Canal were computed using an HEC-RAS steady one-dimensional flow model. Water surface profiles for Cherokee Canal were computed using an HEC-RAS unsteady one-dimensional flow model. Water surface elevations for Butte Basin were based on the UNET unsteady model results obtained from the Comp Study. Inundation depths from levee breach simulations were evaluated using a FLO-2D 2-dimensional unsteady flow model of the study area.

Three types of hydraulic model computer programs were used for this analysis. The computer model HEC-RAS calculates steady or unsteady gradually varied flow in natural and manmade channels by performing step-backwater calculations of the 1-D flow energy equation through a series of input geometric cross-sections with empirically defined hydraulic roughness coefficients. The computer model, UNET is a predecessor to HEC-RAS and has similar functionality and assumptions. The computer model FLO-2D is a 2-dimensional, dynamic flood routing model that simulates movement of water across the ground surface while reporting volume conservation. It numerically routes flood hydrographs over a system of grid elements, and predicts the area of inundation and floodwave attenuation.

a. Sutter Bypass and Feather River. Water surface profiles for Sutter Bypass and Feather River were computed using an HEC-RAS unsteady one-dimensional flow model of the Sacramento River system. A map of the HEC-RAS hydraulic model domain showing cross sections and hydrograph boundary locations is provided as Plate 6.

(1) Cross Sections. The model contains a total of 1,382 cross sections. The cross sections are spaced at roughly ¼-mile intervals along the river reaches. Cross section geometry data were obtained from the 1999 Sacramento-San Joaquin Comprehensive Study (NAVD88 datum update). The hydraulic model geometry includes the sloped levee face except at star bend and Three River Levee Improvement Authority (TRLIA) setbacks on the Feather River. This is an appropriate assumption because the sloped portion of the levee is an extremely small fraction of the overall cross sectional area.

(2) Storage Areas. The model contains a total of 53 storage areas throughout the domain.

(3) Bridges and Inline Structures. The model contains a total of 33 bridges, 3 inline structures and 2 major weir diversions (Fremont and Tisdale). The Highway 99 Bridge was modified over the period of the feasibility study. The model represents the widened bridge.

(4) Lateral Stuctures (Levees). The HEC-RAS model utilizes the lateral weir option to simulate overtopping of the levee crest. The structures were manually coded into each HEC-RAS cross section based upon Top of Levee (TOL) elevation data from the USACE National Levee Database (NLDB) survey data. The lateral structure outflow is linked to the storage areas described above.

(5) Blocked Obstructions. Blocked obstructions were used throughout the model to eliminate the cross section area on the landward side of the levee. The landward areas are modeled as storage areas and lateral weirs along the crest of the levee control the flow over and into and out of the storage areas. The blocked obstructions are needed because the cross sections extend approximately 100 feet landward of the levee and this is not a conveyance area under this approach. The levee card is not suitable in this case because the conveyance area on the landward side of the cross section would become conveyance area once overtopped. The heights of the blocked obstructions were made sufficiently high to contain a 0.2% ACE flood event.

(6) Ineffective Flow Areas. Ineffective flow areas were incorporated into the model to simulate areas where water is stored, but is not active conveyance area.

(7) Manning's Roughness Values. Manning's n-values were selected based on model calibration to high water marks collected during the January 1997 and December 2005 - January 2006 flood events. Boundary condition inflows for the model calibration were based on DWR and USGS stream gage records. Manning's roughness values range from 0.031 to 0.07 in the main channel and 0.05 to 0.10 in the overbanks. The model calibration is described below.

(8) Upstream Boundary Conditions. Upstream boundary conditions are a set of regulated flow hydrographs. The boundary locations are shown on Plate 6 and listed in Table 3.

(9) Downstream Boundary Conditions. The PBI Sutter Basin model includes two downstream boundary conditions; 1) the Sacramento River at Verona and 2) the Yolo Bypass near Woodland. Both boundary conditions consist of rating curves developed from stream gage data.

A stage-discharge rating curve was developed for the downstream boundary at the Sacramento River at Verona gage. The current USGS rating at the gage was found to be at the low end of historical data. The USGS stage-discharge rating was modified to reflect the average conditions expected throughout the life of the project. The resulting curve is provided as Plate 7.

A stage-discharge curve was developed for the Yolo Bypass near Woodland Gage. The published USGS Yolo Bypass near Woodland gage rating curve could not be used for the boundary condition because it incorporates an adjustment for Sacramento Weir inflow into the Yolo Bypass. The gage, however, is located upstream of the confluence with the Sacramento Bypass. As a result, the USGS rating curve does not represent the stage-flow relationship at the gage. The curve used for the feasibility study was developed by plotting historical discharge measurements and comparing to modeled profiles of the Yolo Bypass. The resulting curve is provided as Plate 8.

(10) Model Calibration. The model was calibrated to two historic flood events that occurred in January 1997 and December 2005 - January 2006. Calibration efforts were specifically focused on the Feather River, Sutter Bypass, and Wadsworth Canal. Detailed calibration for all of the other rivers and storage areas within the HEC-RAS model was considered outside of the scope of this study.

The differences in the physical configuration of the Feather River between 1997 and 2006 (such as the Shanghai Bend Setback Levee completed in 1999) were taken into account in the calibration process. In addition, due to the fact that both the 2006 and 1997 flood events occurred before the construction of the TRLIA setback levees, the calibration was performed with a HEC-RAS geometry file that does not include the setback levees.

The January 1997 flood event was considered the best flood event to use for calibration due to its size and the quantity of measured data. However, three major levee breaches occurred during the 1997 flood event which introduced significant uncertainty in flow estimates throughout the system. The storm that occurred from December 2005 to January 2006 was smaller in size compared to the 1997 event, but it was large enough to produce overbank flows and reliable measured data throughout the river network with no levee failures.

Manning's n-values were adjusted to duplicate stages for the 2006 flood event. The 1997 flood event was then simulated and adjustments were made to achieve a compromise in modeled versus observed stages for the two calibration events. For the 1997 event the difference between modeled and observed stages ranged from -0.30 feet to +1.92 feet at the 12 stream gages. The greatest deviation between observed stage and the modeled stage occurred at the Sutter Bypass pumping Plant 1 gage.

For the 2006 event the difference between modeled versus observed stages ranged from -0.46 feet to +1.03 feet at the 12 stream gages. The greatest deviation between modeled and observed stages occurred at the Feather River at Yuba City gage. The model overestimated the stage by 1.03 feet. The calibration is described in the PBI report, Design Water Surface Profiles for the Feather River West Levee Project, 26 July 2012.

(11) Stage Uncertainty. The total SD of stage uncertainty was computed at 11 index points on the Feather River and Sutter Bypass. The total SD was found to range from 1.2 feet to 1.7 feet. A SD of 1.5 feet is recommended for all reaches of the Sutter Bypass and Feather River.

Stage uncertainty was estimated following methods described in EM-1110-2-1619. The total stage uncertainty was estimated from natural, model, and sedimentation uncertainty. The following provides a summary of the stage uncertainty analysis. A detailed description of the stage uncertainty analysis is provided in the Sutter Basin Feasibility Study Hydraulics Report prepared by Peterson Brustad Inc. (SBFCA, 2012). The standard deviation (SD) of total stage uncertainty was calculated using the following equations modified from EM1110-2-1619.

$$SD_{total} = \sqrt{SD_{natural}^2 + SD_{model}^2 + SD_{sedimentation}^2}$$

$$SD_{model} = \sqrt{SD_{topo}^2 + SD_{n-value}^2}$$

The natural uncertainty, *SDnatural*, is the uncertainty of the stage-discharge relationship caused by the natural variation in the physical characteristics of the stream and errors that occur in the stage and discharge measurements.The SD of natural uncertainty is 0.70 feet for the Feather River and 0.55 ft for the Sutter Bypass. The SD for natural uncertainty was based on a review of stage discharge measurements at the DWR stream gage Butte Slough near Meridian (A02972) and USGS gage Sacramento River near Verona (11425500).

The uncertainty in hydraulic model results is highly correlated to the uncertainty in the topographic data used to represent the geometric characteristics of the river reaches. The SD for topographic uncertainty is estimated to be 0.48 ft. This uncertainty value was based on the description of the topographic survey data provided in the Aryes Final Topographic Survey Report (AYRES, 2003)

The SD associated with Manning's roughness was estimated at 11 locations throughout the model. The standard deviation was found to range from 0.78 feet to 1.25 feet. The values were estimated by computing water surface profiles with roughness values increased and decreased by 20 percent.

The SD associated with sedimentation accounts for the sensitivity of the computed water surface profiles to future sediment deposition or scour. A SD of 0.75 feet was estimated for all reaches based on a review of sedimentation reports.

b. Wadsworth Canal. Water surface profiles for Wadsworth Canal were computed using an HEC-RAS steady one-dimensional flow model. A map of the HEC-RAS hydraulic model domain showing cross sections and hydrograph boundary locations is provided as Plate 9. The hydraulic model extends 4.5 miles from the East and West Interceptor Channel to the Sutter Bypass.

(1) Cross Sections. The model contains 36 cross sections from the East and West Interceptor Channels to the Sutter Bypass. Cross section geometry data were obtained from the 1999 Sacramento-San Joaquin Comprehensive Study (NAVD88 datum update). The underwater portion of each cross section was adjusted to reflect recent NAVD88 ground surveyed bathymetric cross section data obtained by the State of California Department of Water Resources in 2010 (DWR, 2011).

(2) Storage Areas. The model is a steady state model used to model profiles. Therefore, the model does not include storage areas.

(3) Bridges and Inline Structures. Bridges and inline structures were coded into the model from field sketches obtained during the 1999 Sacramento-San Joaquin Comprehensive

Study and the State of California Department of Water Resources Central Valley Floodplain Evaluations and Delineation (CVFED) mapping. The five bridges within the model reach are Butte House Road, South-Butte Road, Sutter Bike Trail (old railroad bridge), Colusa Highway (State Highway 20), and Franklin Road.

Topographic and NLDB data in the vicinity of the Sutter Bike Trail bridge indicated a dip in the left and right bank levee profile. A review of photographs indicated the top of levee should tie to the concrete wing walls and railing. The DWR Sutter Yard Field Superintendent indicated this location would be sandbagged during a flood event (DWR, 2013). Therefore, the top of levee was coded into the model at the top of the wing wall elevation.

Weir number 4 located just upstream from South-Butte Road was coded into the model as an inline structure assuming the flash boards were removed. The DWR Sutter Yard Field Superintendent indicated the flash boards would not be in place during the flood season (DWR, 2013).

(4) Levees. The levee crest elevation was specified for each cross section. The top of levee elevation was obtained from the NAVD88 National Levee Database (NLDB) ground survey conducted in 2007-2008.

(5) Blocked Obstructions. Blocked obstructions were used throughout the model to eliminate the cross section area on the landward side of the levee. The landward areas are modeled as storage areas and lateral weirs along the crest of the levee control the flow over and into and out of the storage areas. The blocked obstructions are needed because the cross sections extend approximately 100 feet landward of the levee and this is not a conveyance area under this approach. The levee card is not suitable in this case because the conveyance area on the landward side of the cross section would become conveyance area once overtopped. The heights of the blocked obstructions were made sufficiently high to contain a 0.2% (1/500) ACE flood event.

(6) Ineffective Flow Areas. Ineffective flow areas were incorporated into the model to simulate areas where water is stored, but is not active conveyance area.

(7) Manning's Roughness Values. Manning's roughness values were estimated to be 0.035 for the Wadsworth Canal reach. This value was based on a comparison of channel conditions to photographs in Chow, 1959.

(8) Upstream Boundary Conditions. Model boundary conditions for stage and flow are described in the Model Simulations and Results section.

(9) Downstream Boundary Conditions. Model boundary conditions for stage and flow are described in the Model Simulations and Results section of this report.

(10) Model Calibration. The model was not calibrated due to lack of measured data. Selection of Manning's roughness values are described above.

(11) Stage Uncertainty. The total SD was found to vary between 1.5 feet and 1.6 feet throughout the reach. Stage uncertainty was estimated following methods described in EM-1110-2-1619. The total stage uncertainty was estimated from natural, model, sedimentation uncertainty, and coincident flow uncertainty. The SD of stage uncertainty releated to natural, model, and sedimentation uncertainty was assumed to be the same as the Sutter Bypass (1.5 feet) because water surface profiles in Wadsworth Canal are highly correlated to the stage in the Sutter Bypass.

Additional stage uncertainty was included to account for uncertainty in coincident flow conditions. The maximum stage uncertainty related to coincident flow conditions is assumed to be the difference between the maximum and minimum coincident flow extremes. Equation 5-7 of EM 1110-2-1619 was used to compute the standard deviation of stage uncertainty as 1/4 of the difference between the upper and lower bounds. The stage uncertainty associated with coincident flow varies throughout the reach and is the largest (0.6 feet) near Sutter Butte Road (Comp Study River Mile 3.32). The standard deviation (SD) of total stage uncertainty was calculated using the following equation provided in EM1110-2-1619.

$$SD_{total} = \sqrt{SD^2_{natural} + SD^2_{model} + SD^2_{sedimentation} + SD^2_{coincident\ flow}}$$

c. Cherokee Canal. Water surface profiles for Cherokee Canal were computed using an HEC-RAS unsteady one-dimensional flow model. A map of the HEC-RAS hydraulic model domain showing cross sections and hydrograph boundary locations is provided as Plate 10. Model geometry was obtained from an existing California Department of Water Resources model developed in 2006. The model reach extends 9 miles from Nelson Road downstream to Highway 162.

(1) Cross Sections. The Cherokee Canal HEC-RAS hydraulic model contains a total of 153 cross sections. The cross sections are spaced at roughly 400-ft intervals. Cross sections are also coded at the upstream and downstream face of each bridge crossing.

The topography included in the DWR 2006 model (excluding the cross sections imported from the URS 2003 model) was obtained from field surveys completed in June and August of 2006 by DWR. Supplemental field surveys were completed by PBI in June and October of 2009 in order to add 4 cross sections downstream of the Highway 162 Bridge.

(2) Storage Areas. The model contains no storage areas.

(3) Bridges and Inline Structures. The model includes 4 bridges, Nelson-Shippee Road, Richvale Road, Union Pacific Railroad, and Highway 162. All of the bridges geometry data within the model were obtained from the 2006 DWR model and reviewed for reasonableness. The bridge deck elevation for all bridges was surveyed to verify the vertical datum was NAVD88.

(4) Lateral Stuctures (Levees). The HEC-RAS model utilizes the lateral weir option to simulate overtopping of the levee crest. The structures were manually coded into each HEC-RAS cross section based upon Top of Levee (TOL) elevation data from the USACE NLDB survey data described above. Lateral structures were not coded in for the reach upstream of Nelson-Shippee Road in order to ensure that all inflows enter the study area. Lateral structure lengths were coded in to be no greater than 1 mile.

(5) Blocked Obstructions. Blocked obstructions were used throughout the model to eliminate the cross section area on the landward side of the levee. The landward areas are modeled as storage areas and lateral weirs along the crest of the levee control the flow over and into and out of the storage areas. The blocked obstructions are needed because the cross sections extend approximately 100 feet landward of the levee and this is not a conveyance area under this approach. The levee card is not suitable in this case because the conveyance area on the landward side of the cross section would become conveyance area once overtopped. The heights of the blocked obstructions were made sufficiently high to contain a 0.2% (1/500) ACE flood event.

(6) Ineffective Flow Areas. The model contains no ineffective flow areas. The ineffective flow areas upstream of the Nelson-Shippee Road Bridge (outside of the study area) were eliminated from the base DWR model in order to stabilize the unsteady flow calculations.

(7) Manning's Roughness Values. The Manning's n-values for the main channel range from 0.033 to 0.059. The Manning's n-values for the channel overbanks range from 0.037 to 0.088. Manning's n-values were selected based on model calibration to high water marks collected during the December 2005 - January 2006 flood events. Boundary condition inflows for the model calibration were based on DWR stream gage records.

(8) Upstream Boundary Conditions. The hydrograph provided for Cherokee Canal was based on stream records below the Cottonwood creek tributary. However, the model extends upstream of Cottonwood creek. The hydrograph was divided and 75% was applied at the upstream end of the model at Nelson Road and 25% was applied at the Cottonwood Creek confluence. This apportionment was based upon the percent differences in the design capacities of the Cherokee Canal upstream and downstream of the Cottonwood Creek confluence. No detailed hydrologic analysis was completed since these sections were outside of the focus study area. A 1-hour time delay was applied to the inflow hydrograph at Cottonwood Creek in order to synchronize the combined peak flows.

(9) Downstream Boundary Conditions. A normal depth (friction slope) boundary condition of 0.00068 was utilized for the model. The friction slope was estimated from the surveyed high water mark elevations in the downstream one-mile of the model.

(10) Model Calibration. Manning's n-values were selected based on model calibration to high water marks collected during the December 2005 - January 2006 flood events. Boundary condition inflows for the model calibration were based on DWR stream gage records. Manning's n-values were adjusted (within reason) to duplicate stages for the event. The calibrated water surface profile was found on average to be within 0.3-ft of known HWM's.

There are two instances within the study focus area where the difference between the known HWM's and the modeled water surface was greater than 0.5-feet. However, considering uncertainty in high water mark data collection, these were considered outliers. A detailed description of the stage model calibration is provided in the Sutter Basin Feasibility Study Hydraulics Report prepared by Peterson Brustad Inc. (SBFCA, 2012).

(11) Stage Uncertainty. The total SD of stage uncertainty was computed at two index points on the Cherokee Canal and a SD of 1.5 feet is recommended. Stage uncertainty was estimated following methods described in EM-1110-2-1619. The total stage uncertainty was estimated from natural, model, sedimentation, and bridge debris loading uncertainty. The following provides a summary of the stage uncertainty analysis. A detailed description of the stage uncertainty analysis is provided in the Sutter Basin Feasibility Study Hydraulics Report prepared by Peterson Brustad Inc. (SBFCA, 2012). The standard deviation (SD) of total stage uncertainty was calculated using the following equation provided in EM1110-2-1619.

$$SD_{total} = \sqrt{SD_{natural}^2 + SD_{model}^2 + SD_{sedimentation}^2 + SD_{bridge\ debris}^2}$$

$$SD_{model} = \sqrt{SD_{topo}^2 + SD_{n-value}^2}$$

The natural uncertainty, *Snatural*, is the uncertainty of the stage-discharge relationship caused by the natural variation in the physical characteristics of the stream and errors that occur in the stage and discharge measurements. The SD of natural uncertainty is 0.48 feet. The SD for natural uncertainty was based on a review of stage discharge measurements at the DWR stream gage Cherokee Canal nr Richvale (A02984).

The uncertainty in hydraulic model results is highly correlated to the uncertainty in the topographic data used to represent the geometric characteristics of the river reaches. The SD for topographic uncertainty was assumed to be negligible because the cross sections were ground surveyed.

The SD associated with Manning's roughness was estimated at two locations throughout the model. The standard deviation was found to range from 0.73 feet to 0.78 feet. The values were estimated by computing water surface profiles with roughness values increased and decreased by 20 percent.

The SD associated with sedimentation accounts for the sensitivity of the computed water surface profiles to future sediment deposition or scour. A SD of 0.75 feet was estimated for all reaches based on a review of sedimentation reports.

The SD associated bridge debris loading was estimated at two locations throughout the model. The values were estimated by computing water surface profiles with bridge pier widths increased 2 feet. The standard deviation was found to range from 0.02 feet to 0.03 feet.

d. Butte Basin. Water surface elevations within the Butte Basin were obtained from the Sacramento San Joaquin Comprehensive Study UNET model DSS files. All stage data provided

in the Comprehensive Study were based on the NGVD29 datum. These data were converted to the NAVD88 vertical datum using a topographic datum conversion surface developed specifically for converting Comp Study topographic data to NAVD88. Model geometry, details and assumptions are described in the Sacramento San Joaquin Comprehensive Study report.

(1) Boundary Conditions. Hydrologic inputs to the comp study UNET hydraulic model consisted of a set of 30-day regulated flow hydrographs for all inflow boundary locations. Sets of boundary condition hydrographs were provided for each of seven ACE events. Storm centering scenarios were provided for each ACE event to determine the maximum water surface elevations within the river channels. The development of regulated flow hydrographs is described in detail in the hydrology appendix.

(2) Model Calibration. The UNET model of the Sacramento River Basin was calibrated to the 1997 flood during the comp study. Inflow hydrographs to the model were created using 1997 flood gage information from major tributaries and flood control structures. Model result hydrographs were compared to gage records and peak stage data where available. The UNET model parameters for Manning's n, weir coefficients, and levee breaches were then adjusted as needed in an iterative procedure to modify the model results to more closely match the calibration data.

(3) Stage Uncertainty. Stage uncertainty was estimated following methods described in EM-1110-2-1619. The total stage uncertainty was estimated from natural, model, sedimentation uncertainty, and coincident flow uncertainty. The SD of stage uncertainty releated to natural, model, and sedimentation uncertainty was assumed to be the same as the Sutter Bypass and Feather River model described above (1.5 feet) because the comp study UNET model data sources and assumptions are nearly identical to the HEC-RAS model.

e. FLO-2D Model. A FLO-2D model was utilized to evaluate water surface elevations resulting from levee breaches within the study area. A detailed description of the model is provided in the report- Sutter Basin Feasiblity Study, Hydraulics Report prepared by Peterson Brustad, Inc. 14 December 2012. A map of the model domain is provided in Plate 11.

(1) Computational Domain. The valid computational domain is defined as the Sutter Basin Feasibility study area. The model's domain extends beyond the valid computational domain in order to establish model boundary conditions. All results outside the valid domain were truncated from the results.

(2) Grid Elements. A 1,000-ft grid size was selected in order to keep the number of grid elements down to a workable number and to avoid long model run times. The Comp Study and USGS data were used to develop the FLO-2D grid cell elevations, with the Comp Study topography comprising approximately 55% of the FLO-2D grid. The USGS topography is utilized for the areas of the model which Comp Study topography did not cover. Since both the Comp Study and USGS data is based upon NGVD29 datum, the FLO-2D grid cell elevations were converted to NAVD88. This was the best available topographic data at the time of model development. More detailed Lidar topography became available after model simulations had been completed. The more detailed topography was compared against this data set. Although the

uncertainty in absolute elevations may be on the order of 1 to 2 feet, this would have little influence on economic damages which are based on depth.

(3) Channel Elements. Two channels were added to the 2009 Sutter Basin FLO-2D model; the Wadsworth Interceptor Canal Unit 1 (West Canal) and Interceptor Canal Unit 2 (East Canal). The channels were included in order to simulate the collection and drainage of runoff out of the basin via the Wadsworth Canal. The Wadsworth Canal is approximately 4.3 miles in length and conveys runoff from southeast of the Sutter Buttes into the Sutter Bypass. The two interceptor channels act as collectors in the model and route flow towards an outflow node that is located at the beginning of the Wadsworth Canal. The outflow node contains a discharge rating curve that is based upon flood depths. This simulates drainage water flowing through the Wadsworth Canal and out of the basin. The Wadsworth Canal was not modeled as a FLO-2D channel due to model limitations regarding the backwater effects of the Sutter Bypass.

(4) Floodplain Roughness and Area Reduction Factors. Overland n-values and area reduction factors (ARF) were developed for a variety of different land uses. For consistency, the Manning's n and ARF values are based upon reference values utilized in recent USACE FLO-2D studies (which are based upon values listed in the FLO-2D User's Manual, as adapted from the 1990 HEC-1 User's Manual).

(5) Levees and Embankments. Levee elements were added to the FLO-2D model to represent the river channel levees and railroad embankments as found on the floodplain. The model includes the levees & embankments along the Sutter Bypass, Wadsworth Canal, Interceptor Canals, Cherokee Canal Feather River, and UPRR Embankment. The levee crest elevations were determined from the surveyed National Levee Database. The Union Pacific Railroad (UPRR) embankment elevations were based on field survey data obtained by the sponsor in May and June of 2009. The UPRR embankment elevations was input into the model based upon even grades between the survey points. The railroad embankment generally ranges in height from 1 to 7 feet above the existing terrain.

(6) Hydraulic Structures. Hydraulic structures were re-coded into the FLO-2D model using estimated stage-discharge rating curves developed from HEC-RAS, which utilizes a hydraulic gradient based upon the length between the two sides of the embankment. Five estimated rating curves (one for each different bridge length) were developed using HEC-RAS and then coded into FLO-2D.

(7) Pump Stations. Three pumping stations located within the Sutter basin were incorporated into the FLO-2D model. The pumping stations are maintained by the California Department of Water Resources (DWR) Sutter Maintenance Yard. All three pump stations transfer storm water runoff from inside the Sutter Basin into the Sutter Bypass. The plants are modeled as constant flow outflow nodes within the model. The pumping stations are assumed to be inoperable during the 0.2% (1/500) ACE scenario due to extensive flooding and power outages.

(8) Boundary Condition Inflows. The inflow hydrographs for the FLO-2D model consist of levee overtopping and breach hydrographs obtained from HEC-RAS model simulations. A

simulation run time of 720 hours was used in order to allow enough time for the flood waters to collect at the southern portion of the basin.

(9) Boundary Condition Outflows. The purpose of the FLO-2D model is to simulate the movement of breach floodwaters within the study area on the interior side of the Feather River and Sutter Bypass levee system. Therefore outflow elements were specified on the river side of the Sutter Bypass and Feather Rivers and the lowest part of the Butte Basin.

(10) Stage Uncertainty. The total combined standard deviation of stage uncertainty was estimated to be 1.2 feet using the equation above. The uncertainty of computed flood depths for the Sutter Basin FLO-2D model can primarily be attributed to the hydraulic modeling inaccuracies and the levee breach assumptions. The uncertainty was measured for a hypothetical breach along the Feather River at RM 57.17 using the 1% (1/100) ACE flood event (Shanghai storm centering). The uncertainties associated with roughness values and breach widths were evaluated. A detailed description of the stage uncertainty analysis is provided in the Sutter Basin Feasibility Study Hydraulics Report prepared by Peterson Brustad Inc. (SBFCA, 2012). The standard deviation (SD) of total stage uncertainty was calculated using the following equation provided in EM1110-2-1619.

$$SD_{total} = \sqrt{SD_{model}^2 + SD_{breach}^2}$$

$$SD_{model} = \sqrt{SD_{topo}^2 + SD_{n-value}^2}$$

The uncertainty in hydraulic model results is highly correlated to the uncertainty in the topographic data used to represent the geometric characteristics of the river reaches. The SD for topographic uncertainty is estimated to be 0.48 ft. This uncertainty value was based on the description of the topographic survey data provided in the Ayres Final Topographic Survey Report (AYRES, 2003)

The SD associated with roughness was estimated at two locations throughout the model. The values were estimated by computing water surface profiles with roughness values increased and decreased by 20 percent. The standard deviation was found to be 0.3 feet based on the average change in water surface elevation within the upper and lower inundation limits.

The SD associated with breach width was computed by simulating breach widths by +/-33%. The standard deviation was found to be 1.0 feet based on the average change in water surface elevation between the upper and lower inundation limits.

3.4 Hydraulic Model Results.

The hydraulic models described above were utilized to compute water surface profiles for two levee overtopping scenarios. Models were also utilized to simulate inundation depths within the study area from levee breach scenarios at 14 locations.

a. Levee Infinite Height Scenario (Scenario A). For this scenario, water surface profiles were simulated assuming all levees were infinitely high and would contain all flow within the infinite channel without overtopping. This scenario was used to evaluate the sensitivity of water surface elevations to levee overtopping assumptions. Infinite levee water surface profiles were developed for Sutter Bypass (Plate 12), Feather River (Plate 13), Wadsworth Canal (Plate 14), and Cherokee Canal (plates 15 and 16). Peak stage and flow frequency estimates at index points throughout the study area are presented in Tables 14 through 18. Peak stage frequency and flow frequency curves for the index points are provided in Plates 17 to 30.

b. Levee Overtopping Scenario (Scenario B). For this scenario, water surface profiles were based on the assumption that all Flood Risk Management levees can be overtopped but they do not fail. Peak stage and flow frequency tables for index points throughout the study area are presented in Tables 14 through 18. Peak stage frequency and flow frequency curves for the index points are provided in Plates 17 to 30.

Table 14
Feather River Hydraulic Characteristics, Alternative SB-1
Oroville Dam to Yuba River

Economic Index Point Location and Parameter	Flood Event Annual Chance of Exceedance (ACE)							
	Invert	50%	10%	4%	2%	1%	0.5%	0.2%
Feather River at RM 57.95 (Geotechnical Index MA 7 – 0.51)								
1957 Design Top of Levee = 132.32 FT-NAVD88								
2008 NLDB Top of Levee = 136.00 FT-NAVD88								
Controlling Storm Centering	-	SAC	SAC/SHY	SAC	SHY	SAC/SHY	SHY	SHY
Stage Uncertainty (Ft- 1 S.D.)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Infinite Levee Model (Scenario A)								
Flow (CFS) 1/	0	60,000	100,000	150,000	150,000	150,000	174,000	320,400
Stage (FT-NAVD88)	96.13	118.95	123.97	127.58	127.58	127.58	128.84	131.27
Velocity (FPS)	0	5.43	7.28	8.10	8.22	8.22	8.50	9.00
Overtopping Levee Model (Scenario B)								
Flow (CFS) 1/	0	60,000	100,000	150,000	150,000	150,000	174,000	320,400
Stage (FT-NAVD88)	96.13	118.95	123.97	127.58	127.58	127.58	128.84	131.18
Velocity (FPS)	-	5.94	7.28	8.22	8.22	8.22	8.50	9.09
Feather River at RM 44.50 (Geotechnical Index MA 16 – 2.9)								
1957 Design Top of Levee = 93.59 FT-NAVD88								
2008 NLDB Top of Levee = 93.73 FT-NAVD88								
Controlling Storm Centering	-	SAC	SHY	SAC	SHY	SAC	SHY	SHY
Stage Uncertainty (Ft- 1 S.D.)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Infinite Levee Model (Scenario A)								
Flow (CFS)	-	50,300	107,100	157,100	159,600	164,600	182,400	294,600
Stage (FT-NAVD88)	48.65	79.49	83.78	86.61	86.85	86.97	88.16	94.59
Velocity (FPS)	-	1.91	2.23	2.51	2.50	2.55	2.58	2.77
Overtopping Levee Model (Scenario B)								
Flow (CFS)	-	50,300	107,100	157,100	159,600	164,600	182,400	309,800
Stage (FT-NAVD88)	48.65	79.49	83.78	86.61	86.85	86.97	88.16	93.90
Velocity (FPS)	-	1.91	2.23	2.51	2.50	2.55	2.58	3.02
Feather River at RM 41.20 (Geotechnical Index MA 16 – 0.9)								
1957 Design Top of Levee = 90.48 FT-NAVD88								
2008 NLDB Top of Levee = 91.02 FT-NAVD88								
Controlling Storm Centering	-	SAC	SHY	SAC	SHY	SAC	SHY	SHY
Stage Uncertainty (Ft- 1 S.D.)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Infinite Levee Model (Scenario A)								
Flow (CFS)	-	49,400	106,800	157,100	159,600	162,700	182,300	293,600
Stage (FT-NAVD88)	43.04	74.93	80.12	83.49	83.89	83.90	85.48	92.96
Velocity (FPS)	-	2.15	1.91	1.99	1.96	1.99	1.97	2.03
Overtopping Levee Model (Scenario B)								
Flow (CFS)	-	49,400	106,800	157,100	159,600	162,700	182,300	294,200
Stage (FT-NAVD88)	43.04	74.93	80.12	83.49	83.89	83.90	85.47	91.87
Velocity (FPS)	-	2.15	1.91	1.99	1.96	1.99	1.97	2.15
Feather River at RM 30.25 (Geotechnical Index LD9 – 0.52)								
1957 Design Top of Levee = 84.17 FT-NAVD88								
2008 NLDB Top of Levee = 86.52 FT-NAVD88								
Controlling Storm Centering	-	SHY	SHY	SAC	SHY	SHY	SHY	2/
Stage Uncertainty (Ft- 1 S.D.)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Infinite Levee Model (Scenario A)								
Flow (CFS)	-	48,100	106,500	156,700	157,600	156,300	165,400	292,800
Stage (FT-NAVD88)	31.86	63.00	72.01	75.58	76.52	76.50	79.31	87.04
Velocity (FPS)	-	1.88	1.88	2.30	2.17	2.16	2.01	2.67
Overtopping Levee Model (Scenario B)								
Flow (CFS)	-	48,100	106,500	156,700	157,600	156,300	165,400	267,700
Stage (FT-NAVD88)	31.86	63.00	72.01	75.58	76.52	76.50	79.31	85.79
Velocity (FPS)	-	1.88	1.88	2.30	2.17	2.16	2.01	2.56

Notes:
1/ Flow at index point MA 7–0.51 is split into two parallel model reaches. Estimated flow is from cross section 60.81 upstream of split.
2/ Controlling Storm Centering for 0.2% ACE is SHY for Scenario A and SAC for Scenario B.

Table 15
Feather River Hydraulic Characteristics, Alternative SB-1
Yuba River to Sutter Bypass

Economic Index Point Location and Parameter	Flood Event Annual Chance of Exceedance (ACE)							
	Invert	50%	10%	4%	2%	1%	0.5%	0.2%
Feather River at RM 23.25 (Geotechnical Index LD1 – 9.31) 1957 Design Top of Levee = 76.87 FT-NAVD88 2008 NLDB Top of Levee = 78.50 FT-NAVD88								
Controlling Storm Centering	-	SHY	SHY	SHY	SHY	SAC	SHY	SHY
Stage Uncertainty (Ft- 1 S.D.)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Infinite Levee Model (Scenario A)								
Flow (CFS)	-	71,100	192,800	257,000	281,800	283,700	361,900	535,900
Stage (FT-NAVD88)	19.36	53.30	63.06	66.50	67.74	67.96	71.36	77.80
Velocity (FPS)	-	3.72	3.08	3.22	3.27	3.25	3.46	3.90
Overtopping Levee Model (Scenario B)								
Flow (CFS)	-	71,100	192,800	257,000	281,800	283,800	361,900	522,700
Stage (FT-NAVD88)	19.36	53.30	63.06	66.50	67.73	67.94	71.35	76.56
Velocity (FPS)	-	3.72	3.08	3.22	3.27	3.25	3.46	3.99
Feather River at RM 16.75 (Geotechnical Index LD1 – 3.99) 1957 Design Top of Levee = 67.90 FT-NAVD88 2008 NLDB Top of Levee = 68.40 FT-NAVD88								
Controlling Storm Centering	-	SHY	SHY	SHY	SHY	SHY	SHY	SHY
Stage Uncertainty (Ft- 1 S.D.)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Infinite Levee Model (Scenario A)								
Flow (CFS)	-	70,500	191,500	255,800	280,500	283,000	360,200	533,900
Stage (FT-NAVD88)	12.53	47.11	56.47	60.02	61.31	61.73	64.97	71.05
Velocity (FPS)	-	3.96	3.06	3.19	3.24	3.22	3.44	3.96
Overtopping Levee Model (Scenario B)								
Flow (CFS)	-	70,500	191,600	255,700	280,400	282,900	360,200	491,800
Stage (FT-NAVD88)	12.53	47.11	56.46	60.00	61.28	61.68	64.92	69.20
Velocity (FPS)	-	3.96	3.06	3.20	3.25	3.21	3.45	3.91
Feather River at RM 12.50 (Geotechnical Index MA 3 – 4.92) 1957 Design Top of Levee = 59.88 FT-NAVD88 NLDB Top of Levee = 64.59 FT-NAVD88								
Controlling Storm Centering	-	SHY	SHY	SHY	SHY	SAC	SHY	SAC
Stage Uncertainty (Ft- 1 S.D.)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Infinite Levee Model (Scenario A)								
Flow (CFS)	-	53,900	151,800	209,700	233,300	240,800	305,000	449,800
Stage (FT-NAVD88)	16.77	43.87	50.88	53.95	55.19	55.98	58.44	63.14
Velocity (FPS)	-	1.44	2.29	2.64	2.75	2.73	3.09	3.78
Overtopping Levee Model (Scenario B)								
Flow (CFS)	-	53,900	151,500	209,000	232,300	239,600	304,000	403,600
Stage (FT-NAVD88)	16.77	43.83	50.83	53.90	55.14	55.90	58.34	61.63
Velocity (FPS)	-	1.44	2.29	2.63	2.74	2.73	3.09	3.59

Table 16
Sutter Bypass Hydraulic Charachteristics, Alternative SB-1

Economic Index Point Location and Parameter	Flood Event Annual Chance of Exceedance (ACE)							
	Invert	50%	10%	4%	2%	1%	0.5%	0.2%
Sutter Bypass at RM 84.31 (Geotechnical Index Sutter – 4) 1957 Design Top of Levee = 59.57 FT-NAVD88 2008 NLDB Top of Levee = 60.60 FT-NAVD88								
Controlling Storm Centering	-	SAC	SAC	SAC	SAC	SAC	SAC	SAC
Stage Uncertainty (Ft- 1 S.D.)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Infinite Levee Model (Scenario A)								
Flow (CFS)	-	57,400	102,000	126,200	155,100	184,200	228,200	326,900
Stage (FT-NAVD88)	33.97	46.87	50.64	52.75	54.42	56.19	58.53	63.21
Velocity (FPS)	-	1.78	2.16	2.27	2.49	2.66	2.9	3.35
Overtopping Levee Model (Scenario B)								
Flow (CFS)	-	57,400	102,000	126,200	155,100	184,200	228,200	265,200
Stage (FT-NAVD88)	33.97	46.86	50.64	52.75	54.43	56.18	58.45	59.82
Velocity (FPS)	-	1.78	2.16	2.27	2.49	2.66	2.91	3.16
Sutter Bypass at RM 82.45 (Geotechnical IndexSutter – 6.2) 1957 Design Top of Levee = 58.73 FT-NAVD88 2008 NLDB Top of Levee = 58.30 FT-NAVD88								
Controlling Storm Centering	-	SAC	SAC	SAC	SAC	SAC	SAC	SAC
Stage Uncertainty (Ft- 1 S.D.)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Infinite Levee Model (Scenario A)								
Flow (CFS)	-	57,700	102,800	126,800	156,000	185,000	229,000	327,200
Stage (FT-NAVD88)	29.28	44.95	49.08	51.41	53.03	54.82	57.15	61.83
Velocity (FPS)	-	1.69	2.04	2.13	2.36	2.53	2.78	3.23
Overtopping Levee Model (Scenario B)								
Flow (CFS)	-	57,700	102,800	126,800	156,000	185,100	227,900	247,800
Stage (FT-NAVD88)	29.28	44.92	49.08	51.42	53.04	54.81	57.06	58.51
Velocity (FPS)	-	1.69	2.04	2.13	2.36	2.53	2.78	2.82
Sutter Bypass at RM 72.17 (Geotechnical Index Sutter – 17.3) 1957 Design Top of Levee = 54.20 FT-NAVD88 2008 NLDB Top of Levee = 54.10 FT-NAVD88								
Controlling Storm Centering	-	SAC	SAC	SAC	SAC	SAC	SAC	SAC
Stage Uncertainty (Ft- 1 S.D.)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Infinite Levee Model (Scenario A)								
Flow (CFS)	-	71,000	117,300	141,100	162,900	197,000	236,500	328,900
Stage (FT-NAVD88)	25.50	41.00	45.16	47.97	49.15	50.70	52.75	57.13
Velocity (FPS)	-	1.40	1.75	1.80	1.96	2.21	2.43	2.86
Overtopping Levee Model (Scenario B)								
Flow (CFS)	-	69,100	117,400	141,300	163,800	197,600	236,500	257,800
Stage (FT-NAVD88)	25.50	40.94	45.17	47.98	49.15	50.68	52.62	54.41
Velocity (FPS)	-	1.37	1.75	1.80	1.98	2.22	2.44	2.48

Table 17
Wadsworth Canal Hydraulic Characteristics, Alternative SB-1

Economic Index Point Location and Parameter	Flood Event Annual Chance of Exceedance (ACE)							
	Invert	50%	10%	4%	2%	1%	0.5%	0.2%
Wadsworth Canal at RM 4.54 1957 Design Top of Levee = 61.65 FT-NAVD88 2008 NLDB Top of Levee = 62.10 FT-NAVD88								
Controlling Storm Centering	-	WAD	WAD	WAD	WAD	WAD	WAD	WAD
Stage Uncertainty (Ft- 1 S.D.)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Infinite Levee Model (Scenario A)								
Flow (CFS)	-	820	2250	3200	4000	4830	5750	7070
Stage (FT-NAVD88)	40.50	50.18	55.75	58.20	59.75	61.21	62.61	64.75
Velocity (FPS)	-	4.24	4.30	4.42	4.50	4.58	4.61	4.44
Overtopping Levee Model (Scenario B)								
Flow (CFS)	-	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Stage (FT-NAVD88)		N/A	N/A	N/A	N/A	N/A	N/A	N/A
Velocity (FPS)	-	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Wadsworth Canal at RM 0.81 (Geotechnical Index Wadsworth – 0.84 1957 Design Top of Levee = 59.35 FT-NAVD88 2008 NLDB Top of Levee = 58.80 FT-NAVD88								
Controlling Storm Centering	-	SAC	SAC	SAC	SAC	SAC	SAC	SAC
Stage Uncertainty (Ft- 1 S.D.)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Infinite Levee Model (Scenario A)								
Flow (CFS)	-	820	2,250	3,200	4,000	4,830	5,750	7,070
Stage (FT-NAVD88)	36.35	46.88	50.67	52.79	54.46	56.23	58.57	63.24
Velocity (FPS)	-	0.54	1	1.18	1.3	1.39	1.41	1.32
Overtopping Levee Model (Scenario B)								
Flow (CFS)	-	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Stage (FT-NAVD88)		N/A	N/A	N/A	N/A	N/A	N/A	N/A
Velocity (FPS)	-	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Wadsworth Canal at RM 0.25 (Geotechnical Index Wadsworth– 0.5) (XS 0.19) 1957 Design Top of Levee = 59.35 FT-NAVD88 2008 NLDB Top of Levee = 60.30 FT-NAVD88								
Controlling Storm Centering	-	SAC	SAC	SAC	SAC	SAC	SAC	SAC
Stage Uncertainty (Ft- 1 S.D.)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Infinite Levee Model (Scenario A)								
Flow (CFS)	-	820	2,250	3,200	4,000	4,830	5,750	7,070
Stage (FT-NAVD88)	37.06	46.87	50.65	52.76	54.43	56.20	58.54	63.21
Velocity (FPS)	-	0.47	0.86	1.03	1.13	1.2	1.23	1.16
Overtopping Levee Model (Scenario B)								
Flow (CFS)	-	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Stage (FT-NAVD88)		N/A	N/A	N/A	N/A	N/A	N/A	N/A
Velocity (FPS)	-	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Note: N/A - Scenario not modeled.
Velocities based on coincident peak Sutter Bypass stage and peak Wadsworth canal inflow. Velocities would be greater for a low Sutter bypass stage and peak Wadsworth canal inflow.

Table 18
Cherokee Canal Hydraulic Characteristics, Alternative SB-1

Economic Index Point Location and Parameter	Flood Event Annual Chance of Exceedance (ACE)							
	Invert	50%	10%	4%	2%	1%	0.5%	0.2%
Cherokee Canal Cherokee at RM 12.529 Geotech index Cherokee Canal– 9.5 1959 Design Top of Levee = 112.10 FT-NAVD88 2008 NLDB Top of Levee = 112.00 FT-NAVD88								
Controlling Storm Centering	-	CHK	CHK	CHK	CHK	CHK	CHK	CHK
Stage Uncertainty (Ft- 1 S.D.)	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Infinite Levee Model (Scenario A)								
Flow (CFS)	-	5,500	9,700	11,300	12,400	13,300	14,200	15,300
Stage (FT-NAVD88)	98.89	108.34	110.84	111.80	112.40	112.95	113.45	114.00
Velocity (FPS)	-	2.26	2.83	2.99	3.07	3.13	3.18	3.26
Overtopping Levee Model (Scenario B)								
Flow (CFS)	-	5,600	9,500	10,000	10,200	10,200	10,300	10,400
Stage (FT-NAVD88)	98.89	108.36	110.74	111.07	111.14	111.19	111.22	111.25
Velocity (FPS)	-	2.27	2.81	2.86	2.88	2.88	2.89	2.89

c. Levee Breach Scenarios. Inundation maps were developed for fifteen levee breach locations within the study area. These breach locations were spatially distributed throughout the study area to reflect the floodplain characteristics. All breach scenarios assume levees were overtopped without failure at all locations other than the breach location. Breaches were simulated for 50% (1/2) ACE, 10% (1/10) ACE, 4% (1/25) ACE, 2% (1/50) ACE, 1% (1/100) ACE, 0.5% (1/200) ACE, and 0.2% (1/500) ACE events. The resulting inundation maps are hypothetical simulations of levee failures and do not represent the probability of occurrence. A summary of the breach simulation locations is provided in Table 19.

Levee breaches are used to define the inundation if a breach were to occur. The probability of the breach is computed by the FDA model using the discharge-frequency, stage-discharge, failure probability (fragility curve), and their associated uncertainties.

The FLO-2D breach simulation models generate velocities and depths. However these were not post processed as velocity x depth. Only depth is used in the FDA model. For life safety evaluation a simple depth metric was used for alternative evaluations.

Table 19
Simulated Levee Breaches

Breach ID	River Mile	Horizontal Coordinates (FT- NAD83 CCS Zone II)		Breach Width (Feet)	Breach Elevation at Toe (FT-NAVD88)
		Northing	Easting		
Feather River					
FR 9.0 R	57.17	2283867	6661785	1500	115.00
FR 8.0 R	50.20	2258021	6662669	1500	95.74
FR 7.0 R	41.55	2225167	6665302	1500	41.59
FR 6.0 R	34.07	2201918	6666623	1500	69.54
FR 5.0 R	28.25	2178130	6672485	1500	55.82
FR 4.5 R	26.00	2167420	6673291	1500	52.20
FR 4.0 R	17.00	2128205	6675848	1500	45.38
FR 3.0 R	10.50	2095813	6680073	1500	36.45
Sutter Bypass					
SB 5.0 L	88.04	2168107	6626586	1000	39.90
SB 4.0 L	82.45	2158851	6631970	1000	37.36
SB 3.0 L	77.05	2131434	6640141	1000	28.96
Wadsworth Canal					
W2.0R	2.42	2178179	6634678	1000	39.90
W2.0L	2.42	2178079	6634839	1000	43.80
Cherokee Canal					
CC2.0L	13.34	2305152	6638905	50	103.00
CC1.0L	11.4	2296019	6634326	50	103.00

Eight breaches were simulated on the Feather River from the Thermalito Afterbay to the Sutter Bypass. Each breach was simulated using the HEC-RAS model and the breach outflow hydrograph was translated to the FLO-2D model to simulate the inundation area of the breach. A 1,500 foot wide breach width was used for the simulations. The breach width was based on sensitivity analysis presented in the F3 Sutter Basin Feasibility Study report. The size is based on historical breaches within the central valley and achieving a headwater depth to tailwater depth ratio of 0.90.

The breach was initiated at the beginning of the flood simulation and assumed to take 1-hour to develop to the full width. This was done to reflect the hydrologic floodwave assumptions. The comp study hydrographs assume a series of six 5-day floodwaves make up the 30-day hydrograph. They put the largest 5-day wave in the middle of the series. However, the sequence of these 5-day events is uncertain and the largest could be the first. A breach at the initiation of the 30-day wave would reflect the true 30-day flow duration. Breach inundation maps are shown on Plates 31 to 38.

Three breaches were simulated on the Sutter Bypass between Wadsworth Canal and Feather River. Each breach was simulated using the HEC-RAS model and the breach outflow hydrograph was translated to the FLO-2D model to simulate the inundation area of the breach. A 1,000 foot wide breach width was used for the simulations. The breach width was based on sensitivity analysis presented in the F3 Sutter Basin Feasibility Study report. The size is based on historical breaches within the central valley and achieving a headwater depth to tailwater depth ratio of 0.90. Similar to the Feather River breach simulations, the breach was initiated at the beginning of the flood simulation and assumed to take 1-hour to develop to the full width. Breach inundation maps are shown on Plates 39 to 41.

One breach was simulated on the left bank of Wadsworth Canal. The breach was simulated using the HEC-RAS model and the breach outflow hydrograph was translated to the FLO-2D model to simulate the inundation area of the breach. The characteristics of this breach were assumed to be very similar as a breach on the Sutter Bypass because the volume of flow through the breach would originate from the Sutter Bypass. Therefore a 1,000 foot wide breach width was used for the simulations. The breach was initiated at the beginning of the flood simulation and assumed to take 1-hour to develop to the full width. Breach inundation maps are shown on Plate 42.

One breach was simulated on the right bank of Wadsworth Canal. A breach on the right bank levee of the Wadsworth Canal would flood a triangular area between Wadsworth Canal, the Sutter Bypass, and the natural ground elevation south of the Town of Sutter. It was assumed the volume of the Sutter Bypass flood hydrograph would be sufficient to fill this volume to the stage of the channel at the breach location. The breach inundation was simulated by projecting the channel stage on the FLO-2D grid elevations and computing the resulting depths. The breach inundation maps are shown on Plate 43.

Two breaches were simulated on Cherokee Canal upstream and downstream of the Union Pacific Railroad. Each breach was simulated using the HEC-RAS model and the breach outflow hydrograph was translated to the FLO-2D model to simulate the inundation area of the breach. A 50 foot wide breach width was used for the simulations. The breach width was based on historical breach occurrences along the Cherokee Canal. For Cherokee Canal, the PDT was considering the use of FIA modeling where inundation time and velocities plays a role in the calculations. The breach was initiated 1-hour before the peak flood stage and assumed to take 1-hour to develop to the full width. Breach inundation maps are shown on Plates 44 and 45.

d. Natural (Non-Breach) Inundation. Flood depth inundation maps were developed for two natural (non-breach) flood sources within the study area. These sources of flooding are from interior drainage and flood storage within the Butte Basin.

Flood depths from interior drainage were obtained from analysis performed by Peterson-Brustad Incorporated (PBI) a consultant to the Sutter Butte Flood Control Agency (SBFCA). The interior drainage analysis evaluated rainfall runoff and flood depths for 2% (1/50) ACE, 1% (1/100) ACE, 0.5% (1/200) ACE flood events. These maps indicated flooding was limited to non-urban areas and flooding from levee breach sources were far greater sources of damage. Therefore, maps were limited to these three events. Inundation maps from interior flooding are shown on Plate 46.

Flood depths within the Butte Basin were obtained from the Sacramento San Joaquin Comprehensive Study model results. The model is described above. Inundation within the Butte Basin was simulated by projecting the model stage on the FLO-2D grid elevations and computing the resulting depths. Inundation was simulated for 50% (1/2) ACE, 10% (1/10) ACE, 4% (1/25) ACE, 2% (1/50) ACE, 1% (1/100) ACE, 0.5% (1/200) ACE, and 0.2% (1/500) ACE events. The breach inundation maps are shown on Plate 47.

3.5 Hydraulic Design.

Alternative SB1 is the without project condition and does not include any features requiring hydraulic design.

3.6 Wind Wave Analysis.

An analysis of wind wave runup and wind setup was conducted for the east levee of the Sutter Bypass and west levee of the Feather River. The analysis did not include Cherokee Canal or Wadsworth Canal because wind waves were not considered to be a significant factor in these reaches because their fetch lengths are less than 400 feet. The complete analysis is described in the report "Sutter Basin wave runup analysis", 15 July 2011. The analysis was performed for three representative sites on the Sutter Bypass and seven representative sites along the Feather River. Results for wind wave run up and setup up for a hypothetical water level at the levee crest are summarized in Tables 20 and 21.

The wind wave run-up calculations were made assuming they could be incorporated into the HEC-FDA model used to compute economic flood damages. However it was later determined that this module in FDA does not work and the results could not be utilized. However, the information is useful to assess the probability of wind wave overtopping. The information was also used to evaluate the performance relative the California State Urban Levee Design Criteria (ULDC).

Wind wave runup and setup were evaluated for three wind speed scenarios over a range of four flood stages. These results could then be interpolated depending on the needs of the study. An analysis of wind speed and flood stage found very low correlation. This indicated that wind wave run-up could be assessed independently of flood frequency. In addition, it was found that wind wave runup and setup were largely independent of water surface elevation in the top 2/3 of the levee height. At these depths the fetch lengths are similar and the waves are not depth limited.

The minimum probable wind scenario was based on the minimum of the annual maximum wind speeds. The most likely wind scenario was based on the average of the annual maximum wind speeds. The maximum probable wind scenario was based on the annual maximum wind speeds. The wind analyses were based on 80 years of record at the Sacramento Executive Airport wind gage.

For each of the wind scenarios, wind wave runup was calculated for four water levels corresponding to the levee toe, 1/3 height, 2/3 height, and top of levee. As described above, it was found that wind wave runup and setup were largely independent of water surface in the top 2/3 of the levee height. Therefore, only the wind wave runup and setup result for the top of levee stage are provided in the Table.

Table 20
Estimated Wind Wave Runup and Setup at Top of Levee
Feather River West Levee, Alternative SB-1

Reach River Mile	Reach Name	Comp Study River Mile	Wind Wave Analysis Index Point	Wind Scenario	Wind Stress	Wave Runup Ru2% (Feet)	Wind Setup (Feet)
58.75							
	Feather River North Upper	48.85	WW-FR7	Probable High Most Likely Probable Low	82.5 mph 40.7 mph 23.1 mph	7.06 4.52 2.43	0.46 0.15 0.04
48.85							
	Feather River North Middle	43.28	WW-FR6	Probable High Most Likely Probable Low	66.5 mph 40.7 mph 23.1 mph	5.01 2.90 2.43	0.15 0.03 0.01
38.71							
	Feather River North Lower	35.78	WW-FR5	Probable High Most Likely Probable Low	72.3 mph 40.7 mph 23.1 mph	4.67 2.90 1.81	0.10 0.03 0.01
30.25							
	Feather River South Shanghai	27.50	WW-FR4	Probable High Most Likely Probable Low	66.5 mph 37.2 mph 27.3 mph	3.74 1.60 1.24	0.07 0.01 0.00
20							
	Feather River South Abbot	19.25	WW-FR3	Probable High Most Likely Probable Low	72.3 mph 40.7 mph 23.1 mph	5.26 3.26 2.03	0.12 0.04 0.01
15.5							
	Feather River South Bear	11.75	WW-FR2	Probable High Most Likely Probable Low	66.5 mph 40.7 mph 23.1 mph	5.41 3.06 1.91	0.15 0.04 0.01
7.5							

Table 21
Estimated Wind Wave Runup and Setup at Top of Levee
Sutter Bypass East Levee, Alternative SB-1

Reach River Mile	Reach Name	Comp Study River Mile	Wind Wave Analysis Index Point	Wind Scenario	Wind Stress	Wave Runup Ru2% (Feet)	Wind Setup (Feet)
87.86							
	Sutter Bypass above Wadsworth	86.18	WW-SB1	Probable High Most Likely Probable Low	82.5 mph 39.9 mph 24.4 mph	3.67 2.00 1.33	0.12 0.03 0.01
83.62							
	Sutter Bypass Upper	80.96	WW-SB2	Probable High Most Likely Probable Low	105.8 mph 36.0 mph 18.5 mph	4.39 1.84 1.33	0.15 0.02 0.01
75.3							
	Sutter Bypass Lower	70.12	WW-SB3	Probable High Most Likely Probable Low	82.5 mph 39.9 mph 24.4 mph	3.67 2.00 1.33	0.11 0.03 0.01
66.3							

3.7 Sedimentation and Channel Stability. An evaluation of sedimentation and channel stability was based on existing studies. The following gives a brief description of the Sutter Bypass, Feather River, and Cherokee Canal.

a. Sutter Bypass. The Sutter Bypass follows the low point of the historic Sutter Basin. Prior to construction of the Sacramento River Flood Protection project the Sutter Basin was a natural overflow area adjacent to natural levees of the Sacramento and Feather Rivers.

The Sutter Bypass is a depositional feature. The rate of sediment deposition along the Sutter Bypass from Long Bridge to Tisdale Weir has been estimated to be 135,000 tons/yr. The deposition rate from Tisdale Weir to Highway 113 (upstream of the Feather River confluence) has been estimated to be 683,000 tons per year. These rates were estimated as part of the 1970 Sacramento River and Tributaries Bank Protection and Erosion Control Investigation. The results were based on an evaluation of sediment transport capacities and are presented in a 4 September, 1986 USACE information pamphlet for Field Reconnaissance Visit of U.S.- Japan Cooperative Science Project on River Meandering (NSF). Deposition rates from the Feather River to the Sacramento River are estimated at 400,000 tons per year based on a comparison of 1939 and 1979 topographic profiles across the bypass. The USACE report concluded that "a significant" portion of the sediment deposited in the lower bypass was derived from the Feather River System.

The Sutter Bypass is inspected as part of the Sacramento River Bank Protection Project. The last complete inspection of the Sutter Bypass east levee occurred in 2011. One active site was identified at RM 77.2 and was 160 feet long. The site was reported to be a slump caused by wind wave erosion.

b. Upper Feather River (River Mile 61-28). The upper Feather River reach extends from Oroville to the mouth of the Yuba River. Within this reach the levee embankment system on the upper Feather River is set back, and the river occupies a wide meander belt similar to the Sacramento River upstream of Colusa. The Lower Feather River is estimated to be degrading. This reach is inspected for erosion sites as part of the Sacramento River Bank Protection Project. The last complete inspection of the Feather River occurred in 2011. One active site was identified at RM 47.6 and was 850 feet long. The site was reported to be scour along the waterside levee toe.

The upper Feather River is significantly different from the lower Feather River in that it did not receive the tremendous sediment influx from hydraulic mining from the Yuba River. Although hydraulic mining took place on the upper Feather River, the amount of material introduced to the river was significantly less. As with all other locations disturbed by the hydraulic mining debris, the upper Feather River aggraded during the late 19th century due to the influx of sediment. Subsequently, the river has degraded into the debris. In addition to hydraulic mining sediments, the river itself was dredged and the tailings were deposited in mounds which essentially block the hydraulic conveyance of the overbank. Construction of the Oroville Dam has altered the hydrology significantly and has reduced the sediment load.

From Oroville Dam to River mile 56, Gold mining dredge spoils border the river. As high flows bypass the majority of dredge spoils via the Thermalito Afterbay, coarse sediment within the

spoils is rarely transported. In this reach the sinuosity is low, split flow around mid channel bars is common, and sediment is dominated by coarse gravel to cobble-sized materials. From River Mile 56 to River Mile 44.2 (Honcut Creek) the Feather River is a sand to fine gravel-dominated, high sinuosity stream.

From River Mile 44.2 to River Mile 27 (Yuba River) the Feather River is a sinuous, meandering river whose bed material is dominated by sand to fine gravel-size sediment. The river is highly dynamic and contains large point bars and chute channels. Bank erosion is extensive; however, wide levee setback precludes direct levee threat. Where the channel flows close to the levee, Modesto outcrops compose the channel banks, resisting erosion. Sand channels are commonly preserved in the bank stratigraphy, suggesting that during hydraulic mining, large quantities of sand were stored within this reach. Vegetation displaying distinct adventitious root zones also records a period of rapid aggradation. Point bars generally consist of sand-sized sediment. Active point bar growth, chute cutoffs and bendway migration are evidenced active bank erosion and active chutes across the bars.

Sediments that make up the active channel and floodplain deposits of the upper Feather River can be divided into Holocene (recent) and Pleistocene ages. The Pleistocene deposits affecting the river include the Riverbank and Modesto Formations. Pleistocene sedimentary rocks of the Riverbank and Modesto Formations bound the active meanderbelt of the upper Feather River. .The Modesto Formation is the most common bounding unit, bordering the Feather River meanderbelt along the line of the project levees. Consequently, as the river approaches the levee, in many cases lateral migration is effectively arrested as it encounters resistant sediments of the Modesto Formation, similar to the Sacramento River upstream of Colusa. The Modesto Formation consists of fluvial sediments that include channel fill, point bar, and lateral and vertical accretion deposits. It is generally cohesive and resistant to erosion.

Modes of bank failure that occur on the Feather River study reach are highly dependent on bank lithology and stratigraphy. There is a great deal of erosion happening from RM 45-28. Here the channel is sinuous and actively meandering.

Migration rates are highly variable along the Feather River study reach, reflecting the heterogeneity of materials present, and the range of stages of bend development. Although bankline migration rates are commonly high, levee setback is sufficient so that very little direct levee threat can be demonstrated on the Feather River. From RM 45-28 the channel bed has degraded over time.

b. Lower Feather River (River Mile 28 to 0). The Lower Feather River extends from the Yuba River to the Sacramento River opposite the Fremont Weir. The Lower Feather River estimated to be degrading. This reach is inspected for erosion sites as part of the Sacramento River Bank Protection Project. The last complete inspection of the Feather River occurred in 2011. No active erosion sites were identified.

The lower Feather River reach is presently a wide, low sinuosity, sand-dominated system that is presently sediment-laden. The bed of the Feather River in this reach contains large sand waves, which were observed to be slowly migrating downstream under relatively low flow conditions of

mid-summer. These sand waves are generally several hundred feet long and several hundred feet wide, occupying the majority of the channel width. Generally the sinuosity decreases in the downstream direction.

The river planform of this reach prior to 1850 was much like the present-day Sacramento River. Hydraulic mining has had a severe effect on the lower Feather River. The initial surge of hydraulic mining debris in the Feather River consisted of silts and clays known as "slickens". Later on, floods brought down coarser sediment that overlaid the slickens. The average fill thickness in the Feather River from the mouth of the Yuba River to Nicolaus was 20 feet. The original sinuous channel was completely in filled. The high sediment loads caused the rate of bendway cutoffs to increase and the channel sinuosity decreased (slope increased) as a result. Alternate bars formed in response to the generally increased sediment load. The channel was a wide, shallow, sand-dominated system that had low, ill-defined banks, which were commonly overtopped. Levees were later put in place to prevent flooding.

After hydraulic mining was discontinued, the subsequent reduction in sediment load caused the river to incise into the hydraulic mining debris. Degradation of the hydraulic mining has since mostly come to an end. The channel maintained its low sinuosity as it incised, preserving bars as perched geomorphic features. The stratigraphy into which the channel incised consists of clean mining derived sands underlain by fine-grained, thinly bedded silts and clays of the slickens. The slickens add stability to the Feather River system, as the fine-grained sediments commonly form a cohesive toe. Recent data indicate, however, that the Feather River has locally eroded through the slickens such that the lowermost parts of the banks below the water may be composed of pre-hydraulic mining deposits. If the channel has eroded into the sands, then it is important to consider potential ramifications of the changing erodibility of the channel perimeter. Though the Feather River is sand-dominated there is also evidence of coarser materials being deposited from the Yuba River.

The slickens are laterally continuous and very homogeneous, and therefore display little variability in terms of erosion resistance for a given stratigraphic horizon. The slickens are underlain by pre-hydraulic mining Feather River meanderbelt deposits. These older deposits are likely to be much more heterogeneous than those exposed along the river today, in that they were deposited in a coarse grained meanderbelt, much like the Sacramento River above Colusa. Such material diversity will likely result in variable erosion rates, causing planform adjustment to the differences in resistance of materials encountered following degradation. Any rapid lateral adjustment of the river could in turn create a threat to bordering flood control levees.

The erosion-resistant nature of the Modesto Formation has resulted in the formation of a steep knick zone that contains over 5 feet of drop in bed elevation in a few hundred feet of channel. The report indicates the location as river mile 24.8. This headcut has migrated upstream as a horseshoe-shaped feature. Migration of the headcut upstream has serious implications with respect to upstream continuation of the degradation.

Bank failure mechanisms on the Feather River are highly correlated to bank stratigraphy. Sand-sized sediment is derived from Feather River bank erosion as well as from tributaries. Upper bank sediments on this reach of the Feather River commonly consist of clean sands underlain by a fine-grained cohesive toe. Both of these units represent hydraulic mining debris deposited during the

aggradational period of the hydraulic mining era. The upper bank unit is prone to erosion and contributes sand size sediment to the system. Bed sediments consist primarily of sand. Where the bank stratigraphy is not the coarsening upward hydraulic mining sequence, it is generally Pleistocene-age Modesto Formation. The Modesto Formation consists of tan and light gray gravely sand, silt, and clay. Both types of bank materials are relatively erosion resistant at the bank toe and are responsible for the low bank erosion rates in the study reach. In general the Modesto Formation forms a high bank that is highly resistant to erosion and is therefore capable of significant bendway distortion and planform control.

As mentioned previously, the sinuosity generally increases in the upstream direction in this reach of the Feather River. An increase in sinuosity in the upstream direction reflects the increasing amount of Modesto outcrop exposed in the channel banks, which has helped to maintain channel planform. The channel has incised into the cohesive slickens, which has also helped to maintain the channel planform. Flow control in the watershed has also contributed to the maintenance of channel planform. Though the river is largely stable, if the river degrades through the slickens and high shear stresses are imparted on less cohesive underlying bank strata, channel migration rates and sinuosity may increase due to the significant bank erosion and development of channel asymmetry. As the supply of sand to the study reach appears relatively constant and incision rates have slowed significantly since the early part of this century, incision into underlying strata may not be imminent.

d. Wadsworth Canal. The Wadsworth Canal is a leveed channel which conveys interior drainage into the Sutter Bypass. A search of past studies and reports found no information about sedimentation rates in the canal. This reach is inspected for erosion sites as part of the Sacramento River Bank Protection Project. The last complete inspection of the Wadsworth Canal occurred in 2011. Two erosion sites were identified. Site WAD_2-1_L is located on the left bank and extends from River Mile 2.25 to River Mile 1.8. The site was identified as a bank failure with leaning trees and exposed roots. Site WAD_2-4L is also located on the left bank and extends from River Mile 3.15 to River Mile 2.2. The site was identified as a bank failure.

e. Cherokee Canal. Cherokee Canal is a leveed channel that conveys runoff from the Clear Creek, Dry Creek, Gold Run Creek, and Cottonwood Creek watersheds to Butte Slough. DWR has completed several sediment removal projects along the canal to maintain the design capacity. A sediment yield and transport study was completed by URS Corporation for the Sacramento District in January 2003. The study indicated the channel is depositional. Cherokee Canal is not inspected for bank erosion by the Sacramento Bank Protection Project.

3.8 Flood Risk.

Flood risk is defined as the probability of a flood event occurring and the consequences of occurrence. Flood risk was assessed using the USACE FDA model version 1.2.5a (USACE, 2010). The FDA model combines flow-frequency, stage-discharge, geotechnical fragility, and stage-damage relationships to estimate damages. Uncertainty in each relationship is incorporated by assigning uncertainty estimates and applying a Monte Carlo type approach to combine the results.

Flow-frequency, stage discharge, and geotechnical frequency relationships reflect the exterior (probability) side of the risk calculations. Inundation depth and stage-damage relationships reflect the interior (consequence) side of the risk calculations. For the probability side of the risk calculations, the hydraulic model assumptions are based on flows contained to the channel (allowed to overtop without failure). For the consequence side of the risk calculations, the hydraulic model assumptions are based on levee breach failure or simply the depth for natural overbank (non-levee) conditions.

The risk assessment approach included an evaluation of potential flood sources with respect to geotechnical fragility, channel hydrology, channel hydraulics, and potential inundation patterns of a levee breach or natural overbank (non-levee). Thirteen geotechnical reaches were identified. Within each of the geotechnical reaches a representative geotechnical fragility curve was developed and a stage-discharge relationship was developed using a system based hydraulic model. Selection of the geotechnical reaches is described in detail in the geotechnical analysis report. Fifteen breach sources and one non-leveed flood sources were identified. All breach source locations identified within a geotechnical reach were assigned to the same geotechnical fragility curve location.

a. Levee Assurance. The reliability of Flood Risk Management (FRM) features within the study area is expressed as an assurance level (conditional non-exceedance probability) for a given median ACE hydrologic event. The assurance varies over levee reaches due to variations in geotechnical fragility, hydrology, and hydraulic characteristics and their uncertainties.

Levee assurance was computed for the 13 geotechnical reaches within the study area using the HEC-FDA computer program. The reaches are shown on Plate 48 and described in Tables 22 through 26. Assurance was calculated at the geotechnical fragility curve location within each reach and assumed to represent the assurance throughout the entire reach. Assurance was calculated with the HEC-FDA program using an unregulated flow-frequency curve, unregulated to regulated transform, stage-discharge relationships, geotechnical fragility curves, and Hydraulic Top of Levee Elevation (HTOL). Uncertainty in each relationship was incorporated using the FDA Monte Carlo simulation. Wind wave runup and setup were not included in the assurance calculations. FDA input assumptions are described in Tables 22 through 26.

Flow-frequency curves were based on the analytical statistics computed for unregulated conditions. Uncertainty in the flow-frequency curve is based on the period of record described in the hydrology section above. For the Sutter Bypass and Feather Rivers, the nearest upstream analytical curve statistics were utilized in combination with an unregulated-regulated transform. The unregulated flow in the transform is computed directly from the flow frequency statistics. The regulated flow used in the transform was obtained from the hydraulic model at the index location (Tables 14 -18). The transforms are used to translate the uncertainty in flow frequency estimates to the regulated condition.

The geotechnical fragility curves were based on geotechnical analysis and are presented in the geotechnical appendix and provided as Attachment B to this report. The curves are assumed to have a 100% probability of failure at the levee crest. The crest elevation was modified in the

FDA model to reflect the Hydraulic Top of Levee (HTOL). The hydraulic top of levee is defined as the elevation at the index point corresponding to the first point of overtopping within the reach. The HTOL is lower than the actual top of levee at index points with high localized crest elevations.

Stage discharge curves used in the analysis are described in Tables 14 through 18. For index points that represent the first levee segment downstream of high ground, stages and flows are based on Scenario A (infinite levee height). This was done to prevent overestimating the assurance within these reaches. The overestimate would occur if upstream overtopping reduces the flow and stage at the index point but the overtopping failure is not accounted for in the performance evaluation.

Table 22
FDA Input for Feather River West Levee Performance Calculations
Alternative SB-1

Reach River Mile	Reach Name	Index Point Comp Study River Mile	Hydraulic Top of Levee (FT-NAVD88)	Geotechnical Fragility Curve	Hydraulic Model Overtopping Scenario	Unregulated Flow Frequency Curve	Notes
58.75							
	Feather River North Upper	57.95	129.62	MA7-Ham Bend	A	at Oroville with Regulated Transform	- Represents Breaches F9.0R, F8.0R - HTOL based on overtopping at RM 58.25 - NLDB TOL 136.00 FT-88
48.85							
	Feather River North Middle	41.20	91.02 (NLDB)	MA16-0.9	B	at Oroville with Regulated Transform	- Represents Breaches F7.0R
38.71							
	Feather River North Lower	30.25	85.01	LD9-0.52	B	at Oroville with Regulated Transform	-Represents Breaches F6.0R, F5.0R - HTOL based on overtopping at RM 32.35 - NLDB TOL 86.52 FT-88
30.25							
	Feather River South Shanghai	23.25	75.79	LD1-9.31	B	at Shanghai with Regulated Transform	- Assumes gate closure at Railroad. - Represents Breaches F4.5R, F4.4R - HTOL based on overtopping at RM 27.19 - NLDB TOL 78.50 FT-88
20							
	Feather River South Abbot	16.75	67.53	LD1-3.99	B	at Shanghai with Regulated Transform	- Represents Breaches F4.1R, F4.0R - HTOL based on overtopping at RM 19.28 - NLDB TOL 68.50 FT-88
15.5							
	Feather River South Bear	12.50	60.75	MA3-4.92	B	at Shanghai with Regulated Transform	- Represents Breaches F3.0R - HTOL based on overtopping at RM 9.18 - NLDB TOL 64.60 FT-88
7.5							
NLDB - Top of Levee in 2008 National Levee Database							

Table 23
FDA Input for Sutter Bypass East Levee Performance Calculations
Alternative SB-1

Reach River Mile	Reach Name	Index Point Comp Study River Mile	Hydraulic Top of Levee (FT-NAVD88)	Geotechnical Fragility Curve	Hydraulic Model Overtopping Scenario	Unregulated Flow Frequency Curve	Notes
87.86							
	Sutter Bypass above Wadsworth	83.70	59.21	Sutter-4	B	at Ord Ferry with Regulated Transform	- Model XSEC 84.31 - Represents Breach S5.0L - HTOL based on overtopping at RM 85.19 - NLDB TOL 60.60 FT-88
83.62							
	Sutter Bypass Upper	81.92	57.72	Sutter - 6.2	B	at Ord Ferry with Regulated Transform	- Model XSEC 82.45 - Represents Breach S4.0L - HTOL based on overtopping at RM 83.53 - NLDB TOL 58.20 FT-88
75.3							
	Sutter Bypass Lower	71.65	52.93	Sutter - 17.3	B	at Ord Ferry with Regulated Transform	Model XSEC 72.17 -Represents Breach S3.0L - HTOL based on overtopping at RM 66.3 - NLDB TOL 54.10 FT-88
66.3							
NLDB - Top of Levee in National Levee Database							

Table 24
FDA Input for Wadsworth Canal South Levee Performance Calculations
Alternative SB-1

Reach River Mile	Reach Name	Index Point Comp Study River Mile	Hydraulic Top of Levee (FT-NAVD88)	Geotechnical Fragility Curve	Hydraulic Model Overtopping Scenario	Unregulated Flow Frequency Curve	Notes
4.54							
	Wadsworth Canal at Interceptor Canals	4.54	62.10 (NLDB)	None	A	Wadsworth Canal nr Sutter	- No breach represented
4.50							
	Wadsworth Canal Left Levee	0.81	58.80 (NLDB)	Wadsworth LB- 0.83	A	None	- Based on Stage Frequency Curve - Represents Breach WC 2.0L
0							
NLDB - Top of Levee in National Levee Database							

Table 25
FDA Input for Wadsworth Canal North Levee Performance Calculations
Alternative SB-1

Reach River Mile	Reach Name	Index Point Comp Study River Mile	Hydraulic Top of Levee (FT-NAVD88)	Geotechnical Fragility Curve	Hydraulic Model Overtopping Scenario	Unregulated Flow Frequency Curve	Notes
4.54							
	Wadsworth Canal at Interceptor Canals	4.54	62.10 (NLDB)	None	A	Wadsworth Canal nr Sutter	- No breach represented
4.50							
	Wadsworth Canal Right Levee	0.25	60.30 (NLDB)	Wadsworth RB- 0.83	A	None	- Based on Stage Frequency Curve - Represents Breach WC 2.0R
0							
NLDB - Top of Levee in National Levee Database							

Table 26
FDA Input for Cherokee Canal South Levee Performance Calculations
Alternative SB-1

Reach River Mile	Reach Name	Index Point Comp Study River Mile	Hydraulic Top of Levee (FT-NAVD88)	Geotechnical Fragility Curve	Hydraulic Model Overtopping Scenario	Unregulated Flow Frequency Curve	Notes
15.7							
	Cotton Wood Creek to Hwy 162	12.53	110.6 (NLDB)	Cherokee 9.50	A	Cherokee Canal nr Richvale	- Represents Breaches CC1.0L and CC 2.0 L - HTOL based on overtopping at RM 13.42 - NLDB TOL 112.00 FT NAVD88
10.8							
NLDB - Top of Levee in National Levee Database							

b. Composite Flood Depths. Maps showing composite floodplains were developed to demonstrate FRM assurance relative to a standard assurance criterion. The maps show inundation from any flood source that would not meet a risk and uncertainty based assurance criterion. The assurance criterion was based on the NFIP levee system analysis criteria described in EC 1110-2-6067 and was adopted for use in describing the performance of all ACE events. This criterion is described as "Option 2" in the DWR Urban Levee Design Criteria. The assurance criterion utilized for this study does not account for wind wave overtopping.

- For assurance less than 90% the levee does not pass criteria
- For assurance between 90 and 95% levee must have minimum of 3 feet of freeboard to pass criteria.
- For assurance greater than 95% levee must have minimum of 2 feet of freeboard to pass criteria.

The composite floodplains are provided in Plates 49 through 56. All maps include the natural (non-leveed) flood inundation depths. Table27 provides performance values at simulated breach locations. These maps demonstrate the variation of flood risk management assurance throughout the study area.

Table 27
Project Performance at Simulated Levee Breach Locations, Alternative SB-1

Simulated Breach		Annual Exceedance Probability		Long Term Risk			Flood Risk Management Assurance by Event Flood Frequency (Breach included in floodplain map if shaded)						
Label	River Mile	Median	Exp.	10 Years	30 Years	50 Years	50% ACE	10% ACE	4% ACE	2% ACE	1% ACE	0.5% ACE	0.2% ACE
Feather River													
F9.0R	57.17	0.0696	0.0769	0.5506	0.9092	0.9817	0.9909	0.8187	0.6499	0.6087	0.5777	0.4781	0.331
F8.0R	50.20	0.0686	0.0768	0.5504	0.9091	0.9816	0.9909	0.8187	0.6499	0.6087	0.5777	0.4781	0.331
F7.0R	41.55	0.0203	0.0238	0.2138	0.5140	0.6996	0.9999	0.9299	0.7965	0.7586	0.7209	0.5657	0.298
F6.0R	34.07	0.0353	0.0391	0.3286	0.6973	0.8635	0.9999	0.848	0.744	0.6685	0.5995	0.4486	0.2193
F5.0R	28.25	0.0353	0.0391	0.3286	0.6973	0.8635	0.9999	0.848	0.744	0.6685	0.5995	0.4486	0.2193
F4.5R	26.00	0.0909	0.1071	0.6778	0.9666	0.9965	0.9838	0.8025	0.6253	0.581	0.5626	0.4788	0.2988
F4.4R	25.99	0.0909	0.1071	0.6778	0.9666	0.9965	0.9838	0.8025	0.6253	0.581	0.5626	0.4788	0.2988
F4.1R	17.00	0.0622	0.0676	0.5036	0.8777	0.9699	0.9999	0.7722	0.6232	0.5759	0.5396	0.3996	0.175
F4.0R	16.99	0.0622	0.0676	0.5036	0.8777	0.9699	0.9999	0.7722	0.6232	0.5759	0.5396	0.3996	0.175
F3.0R	10.50	0.0167	0.0192	0.1766	0.4418	0.6216	0.9999	0.9443	0.9171	0.889	0.8447	0.6847	0.4057
Sutter Bypass													
S5.0L	88.04	0.2184	0.2331	0.9297	0.9997	0.9999	0.8232	0.5684	0.4267	0.3803	0.2991	0.1896	0.0827
S4.0L	82.45	0.4468	0.5156	0.9993	0.9999	0.9999	0.5362	0.3336	0.3257	0.2956	0.2223	0.1391	0.0631
S3.0L	77.05	0.1945	0.2104	0.9058	0.9992	0.9999	0.8101	0.6612	0.635	0.6009	0.5021	0.3426	0.1654
Wadsworth Canal													
W3.0R	4.54	0.0065	0.0086	0.0826	0.2279	0.3501	0.9999	0.9995	0.9951	0.9338	0.705	0.3791	0.0786
W2.0R	2.42	0.3590	0.3577	0.9880	0.9999	0.9999	0.6394	0.3611	0.239	0.2263	0.1884	0.0874	0.0074
W2.0L	2.42	0.1137	0.1157	0.7075	0.9750	0.9979	0.9583	0.7575	0.5626	0.4783	0.3363	0.1392	0.0056
Cherokee Canal													
CC2.0L	13.34	0.2616	0.2803	0.9627	0.9999	0.9999	0.8618	0.3115	0.1005	0.0373	0.0142	0.0061	0.0015
CC1.0L	11.4	0.2616	0.2803	0.9627	0.9999	0.9999	0.8618	0.3115	0.1005	0.0373	0.0142	0.0061	0.0015

Notes: Assurance based on existing top of levee or 1957 design top of levee, whichever is higher within the reach. Assurance accounts for stage uncertainty, hydrologic uncertainty, and geotechnical uncertainty.

d. Flood Velocities. The average velocity within the floodway is provided in Tables 14 through 18. If a levee breach were to occur, inundation velocities and depths within the study area would vary by proximity to a breach, breach location, and magnitude of flood event. The velocity field for a levee breach can be characterized as highest near the breach due to the rapidly varying flow conditions. The remaining area would have lower velocities associated with the slope of the topography and floodplain roughness. For evaluation of life loss consequence the study area can be divided into a breach zone, zone with rapidly rising water, and a remaining zone (Yonkman, 2008). The simulated levee breach at F9.0R during a 1% (1/100) ACE event is representative of the study area.

(1) Breach zone. The breach zone is characterized by destruction of buildings and the highest life safety consequence. Yonkman describes this area as having velocities greater than 6 feet per second and the product of depth and velocity greater than 22 ft^2 per second. For the Sutter Basin Feasibility study, velocities within 1000 feet of the breach were assumed to be great

enough to destroy buildings. This distance is based on evaluation of the 1955 levee breach which showed structures knocked off their foundations.

(2) Zone with rapidly rising water. This zone is characterized by rapidly changing velocity and depth. Model results indicate velocities of less than 3 feet per second within a few thousand feet from a levee breach.

(3) Remaining zone. This zone is characterized by slower onset of flooding. The majority of the study area is defined as the remaining zone. Models of the F9.0R breach indicate velocities of less than 2fps for the remaining portion of the inundation area. Higher velocities are indicated where flows overtop linear features such as the UPRR railroad embankment. Additional locations with higher velocities may occur. However, they would be localized and uncertain.

e. Evacuation Routes. The composite floodplain maps include the location of potential evacuation routes within the Sutter Basin study area. The Sutter County Evacuation and Mass Shelter/Care Plan identify Highways 20, 99 and 113 as the primary evacuation routes in the region. These routes are subject to change since these routes are event-specific and official routes are established by the County Sheriff's office during an emergency. The Butte County Office of Emergency Management does not have published evacuation routes at this time, but anticipates Highways 99, 162 and the Colusa Highway could be used as conditions allow (SBFCA, 2012).

The maps provide an indication of evacuation reliability associated with potential flood depths within the basin. However, the following limitations should be considered when comparing the floodplain maps to the evacuation routes.

(1) Evacuation routes depicted on the maps may be closed due to localized flooding related to interior drainage. During the 1997 flood event, seven different evacuation zones were established over seven days due to constantly changing conditions (SBFCA, 2012). The main evacuation routes used for this flood event were Highway-99 north and Highway-113 south. Highway-20 west and Highway-99 south were used intermittently since all portions of these roads were not accessible at all times during the flood. During the 1955 flood one of the spans of 5th street bridge crossing from Yuba City to Marysville collapsed into the river due to pier scour.

(2) The destination of the evacuation routes are also at risk of flooding.

(3) The FLO-2D model results shown on the maps are based on a grid element size of 1000 feet. Depths shown are an average over the grid element. The model includes the large scale features that impact the general depth and direction of flooding. These large features include levees, railroad embankment and bridges and culverts through the railroad embankment. Small scale topographic features such as drainage ditches, roadway embankments, and roadway culverts are not represented in the model. In addition, small scale topographic variations along roadways (vertical crests and vertical sags) are not represented. As a result, the small scale depressions that can make a roadway impassable are not represented. Whereas the model results may show 0.1 feet of average depth along a roadway alignment, the actual depths could be 3 feet

deep in the smaller topographic depressions. A model depth of 0.1 feet should be used as a likely indicator that a roadway is impassable.

(4) The maps are the composite of multiple breach simulations. The maps depict long term probabilities. However, each flood event would result from different breach locations. The evacuation route during a breach would be highly uncertain. Individual breach inundation maps are provided in Plates 31 though 48.

(5) The maps include representative breach locations and resulting depth fields. Additional levee breach simulations may result in greater depths in some locations.

f. Flood Warning Time. Flood warning time varies throughout the area and is dependent on the source of flooding. The principle sources of flood warnings are advisories by the National Weather Service (NWS) and river stage forecasts by the California Nevada River Forecast Center (CNRFC).

Flood warnings/small river and stream flood warnings are issued by the NWS when flooding of main stem rivers is occurring or imminent (CNRFC, 2013). Main stem river flooding refers to flooding of gauged and forecasted rivers (CNRFC, 2013). The product can also be used to issue Small River and Stream Flood Warnings for smaller rivers/streams which do not have forecast points.

Flash Flood Warnings are issued when flooding is reported; when precipitation capable of causing flooding is observed by radar and/or satellite; when observed rainfall exceeds flash flood guidance or criteria known to cause flooding; or when a dam or levee failure has occurred or is imminent (CNRFC, 2013). A flash flood is defined as a flood caused by heavy or excessive rainfall in a short period of time, and occurring generally within 6 hours of the causative event (CNRFC, 2013).

In addition to the advisories described above, the NWS in coordination with the California Department of Water Resources issues forecasts and guidance for river flows through the CNRFC. In general, river forecasts are based on modeled runoff from observed precipitation, snowmelt estimates, and reservoir operations. The forecast length varies depending on the location. River guidance is based on modeled runoff from forecasted precipitation, snowmelt estimates, and reservoir operations. The forecasts and guidance are issued for a forecast site in a graphical format that compares the future river stage to a monitor stage, flood stage, and danger stage. The combined forecast and guidance are made 5 days into the future.

Flooding from interior drainage sources within the study area is likely to be the result of localized concentrated rainfall. It is assumed these floods would be preceded by a general flood watch issued by the NWS 12 to 24 hours in advance and a flash flood warning 6 hours in advance of the localized flooding.

Flooding from a levee overtopping event along the Feather River would result from a large regional storm event in the Feather, Yuba, and Bear River watersheds. CNRFC river flood forecast points on the Feather River are located at Gridley, Yuba City, Boyds Landing, and

Nicholas. It is assumed that an overtopping flood would be preceded by a flood warning and river guidance issued by the NWS and CNRFC five days in advance. A more accurate warning of potential levee overtopping, based on river forecasts, would likely be made 24 to 36 hours in advance. This estimate was based on a review of the flood guidance plots for December 2005-January2006 flood which indicate an approximate 24 to 36 hour lag between observed rain plus snowmelt in the basin and the peak measured stage at the Feather River near Gridley stream gage forecast point.

Flooding from a levee overtopping event along the Sutter Bypass would result from a large regional storm event in Sacramento River watershed. There are no CNRFC forecast points on the Sutter Bypass. However, the forecast point on the Sacramento River at Fremont Weir represents flood conditions within the Sutter Bypass. It is assumed these floods would be preceded by a flood warning and river guidance issued by the NWS and CNRFC five days in advance. A more accurate warning of potential levee overtopping, based on river forecasts, would likely be made 24 to 36 hours in advance. This estimate was based on a review of the flood guidance plots for the December 2005-January2006 flood which indicate an approximate 24 to 36 hour lag between observed rain plus snowmelt in the basin and the peak measured stage at the Sacramento River at Fremont Weir gage forecast point.

It is estimated that flooding from a geotechnical levee breach would have little to no advance warning (less than 1 hour) and the floodwave would rapidly inundate the adjacent areas. The levee breach that occurred at Shanghai Bend during the December 1955 flood is an indicator of flood warning times associated with geotechnical related failures. The levee failure was preceded by the Governor of the State of California issuing a "Stage of Emergency" on 22 December due to the abnormal and heavy rainfall (Sutter County, 1957). However, the general evacuation order was given approximately 1-hour after the break (Sutter County, 1957).

g. Loss of Life Potential. To evaluate the potential for loss of life, the population density within the study area was compared to the composite floodplain maps. The distribution of population within the study area was based on 2010 census blocks. The population was assigned to single family residences within the census block. The population of the residences within each FLO-2D grid element was then summed. The population within a floodplain was a simple addition of all grid elements with depths greater than a specified depth. A map of the estimated population density throughout the study area is provided in Plate 4.

The population within areas greater than 0 feet, 2 feet, and 15 feet are provided in Tables 28, 29, and 30 respectively.

Table 28.
Population within Alternative SB1 Floodplain
Depths Greater Than 0 Feet

Economic Evaluation Area	Population within ACE Floodplain						
	50% (1/2)	10% (1/10)	4% (1/25)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
Town of Sutter	0	0	0	0	0	0	251
Yuba City Urban	0	67351	67368	67368	67368	67368	67368
Biggs Urban	0	19	1452	1452	1452	1452	1763
Gridley Urban	0	0	6379	6379	6379	6379	6379
Live Oak Urban	0	0	8362	8362	8362	8362	8362
Sutter County Rural	1089	4837	6260	6314	6323	6354	6378
Butte County Rural	0	9	4776	4788	4788	4793	4899
Total	1089	72216	94597	94663	94672	94707	95400

Table 29.
Population within Alternative SB1 Floodplain
Depths Greater Than 2 Feet

Economic Evaluation Area	Population within ACE Floodplain						
	50% (1/2)	10% (1/10)	4% (1/25)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
Town of Sutter	0	0	0	0	0	0	0
Yuba City Urban	0	57736	63471	64529	64529	66380	67368
Biggs Urban	0	0	1352	1352	1352	1353	1554
Gridley Urban	0	0	1176	1176	1176	1186	5483
Live Oak Urban	0	0	4156	5882	5882	6498	8362
Sutter County Rural	767	4088	4840	5098	5095	5505	6199
Butte County Rural	0	0	2424	2527	2527	2887	3882
Total	767	61824	77418	80564	80561	83809	92847

Table 30.
Population within Alternative SB1 Floodplain
Depths Greater Than 15 Feet

Economic Evaluation Area	Population within ACE Floodplain						
	50% (1/2)	10% (1/10)	4% (1/25)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
Town of Sutter	0	0	0	0	0	0	0
Yuba City Urban	0	0	137	137	137	303	934
Biggs Urban	0	0	0	0	0	0	0
Gridley Urban	0	0	0	0	0	0	0
Live Oak Urban	0	0	0	0	0	0	0
Sutter County Rural	0	499	774	944	958	1059	1183
Butte County Rural	0	0	0	0	0	0	0
Total	0	499	911	1080	1095	1362	2117

3.9 Potential Adverse Effects.

a. Induced Flooding. There is no induced flooding associated with the without project condition.

b. Transfer of Flood Risk. There is no transfer of flood risk associated with the without project condition. However, Alternative SB-1 forms the basis for evaluating the transfer of risk for other alternatives. The transfer of flood risk is evaluated by comparing with-project and without-project performance values at index points throughout the system. For purposes of evaluating system impacts, the risk analysis is limited to hydrologic and hydraulic parameters and their uncertainties. This approach is consistent with Section 3.b (2) of the memorandum "Clarification Guidance on the Policy and Procedural Guidance for the Approval of Modifications and Alterations of Corps of Engineers Projects" (USACE, 2008). The performance values associated with hydrologic and hydraulic parameters, and their uncertainties, are provided in Table 31.

Table 31
Project Performance at Simulated Levee Breach Locations
Hydrologic and Hydraulic Parameters Only

Simulated Breach		Annual Exceedance Probability		Long Term Probability of Failure			Flood Risk Management Assurance by Event Flood Frequency						
Label	River Mile	Median	Exp.	10 Years	30 Years	50 Years	50% ACE	10% ACE	4% ACE	2% ACE	1% ACE	0.5% ACE	0.2% ACE
Feather River													
F9.0R	57.17	0.0020	0.0023	0.0233	0.0683	0.1112	0.9999	0.9999	0.9949	0.9915	0.9726	0.8551	0.6390
F8.0R	50.20	0.0001	0.0023	0.0225	0.0659	0.1075	0.9999	0.9999	0.9949	0.9915	0.9726	0.8551	0.6390
F7.0R	41.55	0.0022	0.0022	0.0220	0.0646	0.1054	0.9999	0.9999	0.9999	0.9999	0.9895	0.8576	0.5427
F6.0R	34.07	0.0022	0.0022	0.0215	0.0630	0.1028	0.9999	0.9999	0.9999	0.9999	0.9901	0.8620	0.5547
F5.0R	28.25	0.0022	0.0022	0.0215	0.0630	0.1028	0.9999	0.9999	0.9999	0.9999	0.9901	0.8620	0.5548
F4.5R	26.00	0.0022	0.0023	0.0224	0.0656	0.1070	0.9999	0.9999	0.9999	0.9999	0.9876	0.8508	0.5434
F4.4R	25.99	0.0022	0.0023	0.0224	0.0656	0.1070	0.9999	0.9999	0.9999	0.9999	0.9876	0.8508	0.5434
F4.1R	17.00	0.0026	0.0032	0.0315	0.0916	0.1479	0.9999	0.9999	0.9999	0.9995	0.9728	0.7665	0.3773
F4.0R	16.99	0.0026	0.0032	0.0315	0.0916	0.1479	0.9999	0.9999	0.9999	0.9995	0.9728	0.7665	0.3773
F3.0R	10.50	0.0024	0.0027	0.0267	0.0781	0.1267	0.9999	0.9999	0.9999	0.9992	0.9744	0.8030	0.4813
Sutter Bypass													
S5.0L	88.04	0.0027	0.0037	0.0362	0.1048	0.1686	0.9999	0.9999	0.9995	0.9874	0.9087	0.7126	0.4666
S4.0L	82.45	0.0029	0.0040	0.0390	0.1126	0.1805	0.9999	0.9999	0.9994	0.9857	0.8992	0.6903	0.4306
S3.0L	77.05	0.0036	0.0036	0.0520	0.1481	0.2344	0.9999	0.9999	0.9977	0.9713	0.8483	0.6001	0.3058
Wadsworth Canal													
W3.0R	4.54	0.0065	0.0086	0.0826	0.2279	0.3501	0.9999	0.9995	0.9951	0.9338	0.705	0.3791	0.0786
W2.0R	2.42	0.0048	0.0055	0.0394	0.1137	0.1823	0.9999	0.9995	0.9995	0.9995	0.9946	0.7118	0.0904
W2.0L	2.42	0.0036	0.0048	0.0540	0.1534	0.2424	0.9999	0.9995	0.9995	0.9984	0.9521	0.4586	0.0181
Cherokee Canal													
CC2.0L	13.34	0.1205	0.1576	0.8200	0.9942	0.9998	0.9999	0.3986	0.1293	0.0474	0.0177	0.0077	0.0018
CC1.0L	11.4	0.1205	0.1576	0.8200	0.9942	0.9998	0.9999	0.3986	0.1293	0.0474	0.0177	0.0077	0.0018

3.10 California State Urban Levee Design Criteria

A local sponsor objective is to achieve the California State Urban Levee Design Criteria (ULDC). The ULDC criteria are described in the DWR report "Urban Levee Design Criteria,

May 2012. The purpose of the ULDC is to provide engineering criteria and guidance for civil engineers to follow in meeting the requirements of California's Government Code Sections 65865.5, 65962, and 66474.5 with respect to findings that levees and floodwalls in the Sacramento-San Joaquin Valley provide protection against a flood that has a 1-in-200 chance of occurring in any given year, and to offer this same guidance to civil engineers working on levees and floodwalls anywhere in California (DWR, 2012). Two options are offered for determining if a levee meets the urban and urbanizing area levee system design.

The freeboard approach requires 3 feet of freeboard above the mean 0.5% (1/200) ACE flood event. The risk and uncertainty approach allows for a lesser amount of freeboard if a high level of assurance can be demonstrated. For assurance less than 90% the levee does not pass criteria 2) For assurance between 90 and 95% levee must have minimum of 3 feet of freeboard to pass criteria. 3) For assurance greater than 95% levee must have minimum of 2 feet of freeboard to pass criteria.

Both ULDC approaches require that water surface profiles do not account for overtopping in urban areas for the 0.5% (1/200) ACE event. An evaluation of the Sutter Basin study area indicated no overtopping occurs for the 0.5% (1/200) ACE event. Therefore, the hydraulic model results were applicable for the ULDC analysis. Both ULDC approaches require that additional freeboard be provided if the wind wave run-up from a 1.3% ACE wind event would exceed the top of levee. Both ULDC approaches also require minimum geotechnical standards.

Based on a review of the ULDC criteria, none of the levee reaches would meet the ULDC criteria without geotechnical remediation.

4.0 Alternative SB-7 (Sunset Weir to Laurel Ave)

4.1 General Design Features

a. Levees. This project would involve fixing the Feather River levees to meet current USACE design standards from Sunset Weir to Laurel Ave. The levee height would be based on the 1957 design profile or the existing profile, whichever is higher. In no cases would the levee be raised above these profiles.

b. Interior Drainage Facilities. The project would involve the replacement of gravity drainage culverts within the reach. All replacement culverts would remain the same capacity as the without project conditions.

c. Operation and Maintenance. The project will be maintained to meet current design standards. The project will rely on one gate type closure structure at the UPRR railroad bridge crossing (RM 29.8).

4.2 Hydrology.

The hydrology associated with Alternative SB-7 is identical to Alternative SB-1 (without project conditions).

4.3 Hydraulic Models

Hydraulic models associated with Alternative SB-7 are identical to Alternative SB-1 (without project conditions). The alternative does not include any features that change the hydraulic conditions or geometry.

4.4 Hydraulic Model Results.

Hydraulic model results associated with Alternative SB-7 are identical to Alternative SB-1 (without project conditions).

4.5 Hydraulic Design.

a. Levee Height. This project would involve fixing the Feather River levees to meet current USACE design standards from Thermalito Afterbay to Laurel Avenue. The levee height would be based on the 1957 design profile or the existing profile, whichever is higher. In no cases would the levee be raised above these profiles.

b. Closure Structures. A gate type closure structure is specified where the UPRR crosses the levee embankment at River Mile 29.8. This location is the lowest point along the levee and the performance of project depends on the closure structure operating correctly. If this structure is not operated correctly the levee could breach due to overtopping. This would result in rapid inundation of Yuba City. This is a highly populated area and a failure would have high life safety consequences. To further increase the robustness of the levee, this location would be made more resistant to overtopping.

c. Levee Superiority. The definition of levee superiority per EC 1110-2-6066 (*Design of I-Walls*, 31 October 2010) is the increment of additional height added to a flood risk management system to increase the likelihood that when the design event is exceeded, controlled flooding will occur at the design overtopping section. Since alternative SB-7 is based on an existing levee profile, the design top of levee was reviewed relative to the modeled mean water surface profiles to determine the likely initial overtopping location. A single initial overtopping location was determined within the SB-7 project reach. It is estimated that the initial overtopping would likely occur between River Miles 19 and 20 (FRWLP Station 547+00 to 604+60). This location is a non-urbanized area and initial overtopping is estimated to occur between the mean 0.5% (1/200) ACE and 0.2% (1/500) ACE events. Within this 1-mile reach, the landward side of the levee will be covered with anchored High Performance Turf Reinforced Mat (HPTRM). This design will increase the erosion resistance of the levee and allow for more controlled failure of the levee due to overtopping.

d. Erosion Protection. Erosion protection was not specified within the design reach.

e. Interior Drainage Facilities. If replacement is required to meet USACE design standards, the existing drainage features will be replaced with the same hydraulic capacity.

4.6 Wind Wave Analysis

Wind wave runup and setup associated with Alternative SB-7 is identical to Alternative SB-1 (without project conditions).

4.7 Sedimentation and Channel Stability

Sedimentation and Channel Stability associated with Alternative SB-7 is identical to Alternative SB-1 (without project conditions).

4.8 Flood Risk.

Flood risk would be reduced by Alternative SB-7 by reduction of the geotechnical fragility within the project reach.

a. Levee Assurance. Levee assurance values within reaches modified by the project were recomputed assuming no failure until overtopping. Detailed with-project fragility curves were not used to conduct the with-project analysis. An economic sensitivity analysis was conducted to evaluate this simplified with-project fragility assumption and it was determined it would have insignificant impacts on the results. All other inputs to calculate assurance were identical to Alternative SB-1, the without project condition. The assurance values are provided in Table 32.

b. Composite Floodplains. Maps showing composite floodplains were developed to demonstrate FRM reliability for Alternative SB-7. The composite floodplains are provided in Plates 57 to 64. All maps include the natural (non-leveed) flood inundation depths. Table 32

provides the assurance values used to determine if a simulated breach was included in the composite floodplain map.

d. Flood Velocities. Flood velocities for a levee beach would be identical as alternative SB-1.

Table 32
Assurance at Simulated Levee Breach Locations, Alternative SB-7

Simulated Breach		Annual Exceedance Probability		Long Term Risk			Flood Risk Management Assurance by Event Flood Frequency (Breach included in floodplain map if shaded)						
Label	River Mile	Median	Exp.	10 Years	30 Years	50 Years	50% ACE	10% ACE	4% ACE	2% ACE	1% ACE	0.5% ACE	0.2% ACE
Feather River													
F9.0R	57.17	0.0696	0.0769	0.5506	0.9092	0.9817	0.9909	0.8187	0.6499	0.6087	0.5777	0.4781	0.331
F8.0R	50.20	0.0686	0.0768	0.5504	0.9091	0.9816	0.9909	0.8187	0.6499	0.6087	0.5777	0.4781	0.331
F7.0R	41.55	0.0203	0.0238	0.2138	0.5140	0.6996	0.9999	0.9299	0.7965	0.7586	0.7209	0.5657	0.298
F6.0R	34.07	0.0022	0.0022	0.0215	0.0630	0.1028	0.9999	0.9999	0.9999	0.9999	0.9901	0.8620	0.5547
F5.0R	28.25	0.0022	0.0022	0.0215	0.0630	0.1028	0.9999	0.9999	0.9999	0.9999	0.9901	0.8620	0.5548
F4.5R	26.00	0.0022	0.0023	0.0224	0.0656	0.1070	0.9999	0.9999	0.9999	0.9999	0.9876	0.8508	0.5434
F4.4R	25.99	0.0022	0.0023	0.0224	0.0656	0.1070	0.9999	0.9999	0.9999	0.9999	0.9876	0.8508	0.5434
F4.1R	17.00	0.0026	0.0032	0.0315	0.0916	0.1479	0.9999	0.9999	0.9999	0.9995	0.9728	0.7665	0.3773
F4.0R	16.99	0.0026	0.0032	0.0315	0.0916	0.1479	0.9999	0.9999	0.9999	0.9995	0.9728	0.7665	0.3773
F3.0R	10.50	0.0167	0.0192	0.1766	0.4418	0.6216	0.9999	0.9443	0.9171	0.889	0.8447	0.6847	0.4057
Sutter Bypass													
S5.0L	88.04	0.2184	0.2331	0.9297	0.9997	0.9999	0.8232	0.5684	0.4267	0.3803	0.2991	0.1896	0.0827
S4.0L	82.45	0.4468	0.5156	0.9993	0.9999	0.9999	0.5362	0.3336	0.3257	0.2956	0.2223	0.1391	0.0631
S3.0L	77.05	0.1945	0.2104	0.9058	0.9992	0.9999	0.8101	0.6612	0.635	0.6009	0.5021	0.3426	0.1654
Wadsworth Canal													
W3.0R	4.54	0.0065	0.0086	0.0826	0.2279	0.3501	0.9999	0.9995	0.9951	0.9338	0.705	0.3791	0.0786
W2.0R	2.42	0.3590	0.3577	0.9880	0.9999	0.9999	0.6394	0.3611	0.239	0.2263	0.1884	0.0874	0.0074
W2.0L	2.42	0.1137	0.1157	0.7075	0.9750	0.9979	0.9583	0.7575	0.5626	0.4783	0.3363	0.1392	0.0056
Cherokee Canal													
CC2.0L	13.34	0.2616	0.2803	0.9627	0.9999	0.9999	0.8618	0.3115	0.1005	0.0373	0.0142	0.0061	0.0015
CC1.0L	11.4	0.2616	0.2803	0.9627	0.9999	0.9999	0.8618	0.3115	0.1005	0.0373	0.0142	0.0061	0.0015

Notes: Assurance based on existing top of levee or 1957 design top of levee, whichever is higher within the reach. Assurance accounts for stage uncertainty, hydrologic uncertainty, and geotechnical uncertainty.
Index points within the Alternative SB-7 project reach shown in Bold Italics

d. Evacuation Routes. Evacuation routes for alternative SB-7 are shown on the composite floodplain maps. Relative to Alternative SB-1, the project increases the reliability of the evacuation route to Marysville.

e. Flood Warning Time. A description of flood warning time is provided in Alternative SB-1. Alternative SB-7 will result in a significant increase in warning time to the population within Yuba City because the probability of flooding from a geotechnical type failure (1-hour warning time) would be reduced and the warning time for overtopping type failures are significantly longer (24 to 36 hours).

f. Loss of Life Potential. To evaluate the potential for loss of life, the population density within the study area was compared to the composite floodplain maps of alternative SB-7. The distribution of population within the study area was based on 2010 census blocks. A map of the estimated population density throughout the study area is provided in Plate 4. The population

within areas greater than 0 feet, 2 feet, and 15 feet are provided in Tables 33, 34, and 35 respectively.

Table 33.
Population within Alternative SB-7 Floodplain
Depths Greater Than 0 Feet

Economic Evaluation Area	Population within ACE Floodplain						
	50% (1/2)	10% (1/10)	4% (1/25)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
Town of Sutter	0	0	0	0	0	0	251
Yuba City Urban	0	43	6194	12519	14429	67368	67368
Biggs Urban	0	19	1452	1452	1452	1452	1763
Gridley Urban	0	0	6379	6379	6379	6379	6379
Live Oak Urban	0	0	8362	8362	8362	8362	8362
Sutter County Rural	1089	1718	4788	5742	5867	6354	6378
Butte County Rural	0	9	4776	4788	4788	4793	4899
Total	1089	1789	31951	39242	41276	94707	95400

Table 34.
Population within Alternative SB-7 Floodplain
Depths Greater Than 2 Feet

Economic Evaluation Area	Population within ACE Floodplain						
	50% (1/2)	10% (1/10)	4% (1/25)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
Town of Sutter	0	0	0	0	0	0	0
Yuba City Urban	0	0	16	699	976	66380	67368
Biggs Urban	0	0	1352	1352	1352	1353	1554
Gridley Urban	0	0	1176	1176	1176	1186	5483
Live Oak Urban	0	0	4156	5882	5882	6498	8362
Sutter County Rural	767	1478	2073	2930	3267	5505	6199
Butte County Rural	0	0	2424	2527	2527	2887	3882
Total	767	1478	11196	14567	15180	83809	92847

Table 35.
Population within Alternative SB-7 Floodplain
Depths Greater Than 15 Feet

Economic Evaluation Area	Population within ACE Floodplain						
	50% (1/2)	10% (1/10)	4% (1/25)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
Town of Sutter	0	0	0	0	0	0	0
Yuba City Urban	0	0	0	0	0	303	934
Biggs Urban	0	0	0	0	0	0	0
Gridley Urban	0	0	0	0	0	0	0
Live Oak Urban	0	0	0	0	0	0	0
Sutter County Rural	0	0	4	231	303	1059	1183
Butte County Rural	0	0	0	0	0	0	0
Total	0	0	4	231	303	1362	2117

4.9 Potential Adverse Effects.

a. Induced Flooding. The hydraulic features associated with Alternative SB-7 are identical to Alternative SB-1. Therefore, there is no induced flooding associated with Alternative SB-7.

b. Transfer of Flood Risk. The hydraulic features associated with Alternative SB-7 are identical to Alternative SB-1. Therefore, there is no induced flooding associated with Alternative SB-7.

4.10 California State Urban Levee Design Criteria

Based on a review of the ULDC criteria, none of the levee reaches only the reaches associated with breaches F4.0R, F4.1R, F4.4R, F4.5R, F5.0R would meet the DWR ULDC criteria. As a result only the Yuba City Urban area would meet the ULDC requirements.

5.0 Alternative SB-8 (Thermalito to Laurel Avenue)

5.1 General Design Features

a. Levees. This project would involve fixing the Feather River levees to meet current USACE design standards from Thermalito Afterbay to Laurel Avenue. The levee height would be based on the 1957 design profile or the existing profile, whichever is higher. In no cases would the levee be raised above these profiles. Within three reaches, the levee will be shifted 20 feet towards the river. This was required to provide an access road on the landward side of the levee toe. Additional details are discussed in the hydraulic design section below.

b. Interior Drainage Facilities. The project would involve the replacement of gravity drainage culverts within the reach. Five of the gravity drainage culverts will be removed because they are no longer used for drainage and one culvert will be downsized. Additional details are discussed in the hydraulic design section below.

c. Operation and Maintenance. The project will be maintained to meet current design standards. The project will rely on one flood gate closure structure at the UPRR railroad bridge crossing.

5.2 Hydrology.

The hydrology associated with Alternative SB-8 is identical to Alternative SB-1 (without project conditions).

5.3 Hydraulic Models

Hydraulic models were revised to incorporate the 20 foot riverward shift in the levee along three reaches. The shift in the levee alignment was necessary to provide an access road adjacent to an existing canal located along the landward toe. The upstream reach is 2.3 miles long and extends from RM 45.5 (FRWL station 1675+00) to RM 47.55 (FRWL station 1753+00). The middle reach is 0.25 miles long and extends from RM 44.6 (FRWL Station 1610+00) to RM 44.8 (FRWL Station 1623+00). The lower reach is 0.28 miles long and extends from RM 38.8 (FRWL Station 1434+00) to RM 39.1 (FRWL Station 1449+00). All other model features are the same as the SB-1 alternative.

5.4 Hydraulic Model Results.

The hydraulic model created for Alternative SB-8 computed the same water surface profiles as Alternative SB-1. Within the three reaches where the levee will be shifted 20 feet riverward, the channel cross section width is over 5000 feet and this was found to have no measureable impact on the water surface throughout the model domain. Therefore, the hydraulic model results provided for Alternative SB-1 are applicable to SB-8.

5.5 Hydraulic Design.

a. Levee Height. This project would involve fixing the Feather River levees to meet current USACE design standards from Thermalito Afterbay to Laurel Avenue. The levee height would be based on the 1957 design profile or the existing profile, whichever is higher. In no cases would the levee be raised above these profiles.

b. Closure Structures. A gate type closure structure is specified where the UPRR crosses the levee embankment at River Mile 29.8. This location is the lowest point along the levee and the performance of project depends on the closure structure operating correctly. If this structure is not operated correctly the levee could breach due to overtopping. This would result in rapid inundation of Yuba City. This is a highly populated area and a failure would have high life safety consequences. To further increase the robustness of the levee, this location would be made more resistant to overtopping.

c. Levee Superiority. The definition of levee superiority per EC 1110-2-6066 (*Design of I-Walls*, 31 October 2010) is the increment of additional height added to a flood risk management system to increase the likelihood that when the design event is exceeded, controlled flooding will occur at the design overtopping section. Since alternative SB-8 is based on an existing levee profile, the design top of levee was reviewed relative to the modeled mean water surface profiles to determine likely initial overtopping locations. Alternative SB-8 extends upstream and downstream of the Yuba River tributary. Initial overtopping locations were identified upstream and downstream of confluence to account for the uncertainty in the aerial centering of storm events.

It is estimated that the initial overtopping location upstream of the Yuba River confluence would occur between River Miles 43.5 and 45.5 (FRWLP Station 1582+00 to 1601+00). This location

is a non-urbanized area and initial overtopping is estimated to occur between the mean 0.5% (1/200) ACE and 0.2% (1/200) ACE events.

It is estimated that the initial overtopping location downstream of the Yuba River would occur between River Miles 19 and 20 (FRWLP Station 547+00 to 604+60). This location is a non-urbanized area and initial overtopping is estimated to occur between the mean 0.5% (1/200) ACE and 0.2% (1/200) ACE events. This is identical to the reach identified for the SB7 alternative.

Within both 1-mile reaches, the landward side of the levee will be covered with anchored High Performance Turf Reinforced Mat (HPTRM). This design will increase the erosion resistance of the levee and allow for more controlled failure of the levee due to overtopping.

d. Erosion Protection. Erosion protection was not specified within the design reach.

e. Interior Drainage Facilities. All drainage features would be replaced with the same capacity except at six locations described in Table 36. Five of the facilities appear to provide no interior drainage function and one location appears to be oversized. Each of the six sites was visited by SBFCA's engineering consultant, PBI, and adjacent land owners were reviewed. The results of the analysis are described in a technical memorandum to the Sutter Butte Flood Control Agency titled, Culvert Removal Analysis for the Feather River West Levee Improvement Project, 17 August, 2012.

Table 36
Proposed Culvert Modifications, Alternative SB-8

River Mile	FRWLP Station	Culvert Size	Notes
44.90	1639+00	2-24"	Remove Culvert, Culvert inlet was filled with soil with no obvious signs of a drainage path leading to the culvert
48.00	1785+24	1-24"	Remove Culvert, Culvert did not appear to be used with no signs of a drainage path leading to the culvert
51.20	1961+03	2-60"	Reduce Culvert Size, Culvert appeared to be oversized. Recommend reducing size to 1-36"
57.05	2239+66	1-24"	Remove Culvert, No culvert inlet was found.
57.10	2245+52	1-24"	Remove Culvert, Culvert inlet was filled with soil with no obvious signs of a drainage path leading to the culvert
57.15	2256+94	1-24"	Remove Culvert, Culvert inlet was nearly buried. Culvert is located near another culvert. Nearby culvert should provide adequate capacity.

5.6 Wind Wave Analysis.

Wind wave runup and setup associated with Alternative SB-8 is identical to Alternative SB-1 (without project conditions).

5.7 Sedimentation and Channel Stability

Sedimentation and Channel Stability associated with Alternative SB-8 is identical to Alternative SB-1 (without project conditions).

5.8 Flood Risk.

Flood risk would be reduced by Alternative SB-8 by reduction of the geotechnical fragility within the reach.

a. Levee Assurance. Levee assurance values within reaches modified by the project were recomputed assuming no failure until overtopping. Detailed with-project fragility curves were not used to conduct the with-project analysis. An economic sensitivity analysis was conducted to evaluate this simplified with-project fragility assumption and it was determined it would have insignificant impacts on the results. All other inputs to calculate assurance were identical to Alternative SB-1, the without project condition.

b. Composite Floodplains. Maps showing composite floodplains were developed to demonstrate FRM reliability for Alternative SB-8. The composite floodplains are provided in Plates 65 through 71. All maps include the natural (non-leveed) flood inundation depths. Table 37 provides the assurance values used to determine if a simulated breach was included in the floodplain map.

Table 37
Project Performance at Simulated Levee Breach Locations, Alternative SB-8

Simulated Breach		Annual Exceedance Probability		Long Term Risk			Flood Risk Management Assurance by Event Flood Frequency (Breach included in floodplain map if shaded)						
Label	River Mile	Median	Exp.	10 Years	30 Years	50 Years	50% ACE	10% ACE	4% ACE	2% ACE	1% ACE	0.5% ACE	0.2% ACE
Feather River													
F9.0R	57.17	0.0020	0.0023	0.0233	0.0683	0.1112	0.9999	0.9999	0.9949	0.9915	0.9726	0.8551	0.6390
F8.0R	50.20	0.0001	0.0023	0.0225	0.0659	0.1075	0.9999	0.9999	0.9949	0.9915	0.9726	0.8551	0.6390
F7.0R	41.55	0.0022	0.0022	0.0220	0.0646	0.1054	0.9999	0.9999	0.9999	0.9999	0.9895	0.8576	0.5427
F6.0R	34.07	0.0022	0.0022	0.0215	0.0630	0.1028	0.9999	0.9999	0.9999	0.9999	0.9901	0.8620	0.5547
F5.0R	28.25	0.0022	0.0022	0.0215	0.0630	0.1028	0.9999	0.9999	0.9999	0.9999	0.9901	0.8620	0.5548
F4.5R	26.00	0.0022	0.0023	0.0224	0.0656	0.1070	0.9999	0.9999	0.9999	0.9999	0.9876	0.8508	0.5434
F4.4R	25.99	0.0022	0.0023	0.0224	0.0656	0.1070	0.9999	0.9999	0.9999	0.9999	0.9876	0.8508	0.5434
F4.1R	17.00	0.0026	0.0032	0.0315	0.0916	0.1479	0.9999	0.9999	0.9999	0.9995	0.9728	0.7665	0.3773
F4.0R	16.99	0.0026	0.0032	0.0315	0.0916	0.1479	0.9999	0.9999	0.9999	0.9995	0.9728	0.7665	0.3773
F3.0R	10.50	0.0167	0.0192	0.1766	0.4418	0.6216	0.9999	0.9443	0.9171	0.8890	0.8447	0.6847	0.4057
Sutter Bypass													
S5.0L	88.04	0.2184	0.2331	0.9297	0.9997	0.9999	0.8232	0.5684	0.4267	0.3803	0.2991	0.1896	0.0827
S4.0L	82.45	0.4468	0.5156	0.9993	0.9999	0.9999	0.5362	0.3336	0.3257	0.2956	0.2223	0.1391	0.0631
S3.0L	77.05	0.1945	0.2104	0.9058	0.9992	0.9999	0.8101	0.6612	0.635	0.6009	0.5021	0.3426	0.1654
Wadsworth Canal													
W3.0R	4.54	0.0065	0.0086	0.0826	0.2279	0.3501	0.9999	0.9995	0.9951	0.9338	0.705	0.3791	0.0786
W2.0R	2.42	0.3590	0.3577	0.9880	0.9999	0.9999	0.6394	0.3611	0.239	0.2263	0.1884	0.0874	0.0074
W2.0L	2.42	0.1137	0.1157	0.7075	0.9750	0.9979	0.9583	0.7575	0.5626	0.4783	0.3363	0.1392	0.0056
Cherokee Canal													
CC2.0L	13.34	0.2616	0.2803	0.9627	0.9999	0.9999	0.8618	0.3115	0.1005	0.0373	0.0142	0.0061	0.0015
CC1.0L	11.4	0.2616	0.2803	0.9627	0.9999	0.9999	0.8618	0.3115	0.1005	0.0373	0.0142	0.0061	0.0015

Notes: Assurance based on existing top of levee or 1957 design top of levee, whichever is higher within the reach. Assurance accounts for stage uncertainty, hydrologic uncertainty, and geotechnical uncertainty.
Index points within the Alternative SB-8 project reach shown in Bold Italics

c. Flood Velocities. Flood velocities for a levee beach would be identical as alternative SB-1.

d. Evacuation Routes. Evacuation routes for alternative SB-8 are shown on the composite floodplain maps. Relative to Alternative SB-1, the project increases the reliability of the evacuation routes for Marysville, Biggs, Gridley, and Live Oak.

e. Flood Warning Time. A description of flood warning time is provided in Alternative SB-1. Alternative SB-8 will result in a significant increase in warning time to the population within Yuba City, Biggs, Gridley and Live Oak because the probability of flooding from a geotechnical type failure (1-hour warning time) would be reduced and the warning time for overtopping type failures are significantly longer (24 to 36 hours).

f. Loss of Life Potential. To evaluate the potential for loss of life, the population density within the study area was compared to the composite floodplain maps of alternative SB-8. The distribution of population within the study area was based on 2010 census blocks. A map of the estimated population density throughout the study area is provided in Plate 4. The population within areas greater than 0 feet, 2 feet, and 15 feet are provided in Tables 39, 40, and 41 respectively.

Table 38.
Population within Alternative SB8 Floodplain
Depths Greater Than 0 Feet

Economic Evaluation Area	Population within ACE Floodplain						
	50% (1/2)	10% (1/10)	4% (1/25)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
Town of Sutter	0	0	0	0	0	0	251
Yuba City Urban	0	43	255	4923	6480	67368	67368
Biggs Urban	0	19	19	19	19	1452	1763
Gridley Urban	0	0	0	0	0	6379	6379
Live Oak Urban	0	0	0	0	0	8362	8362
Sutter County Rural	1089	1718	2110	3036	3269	6354	6378
Butte County Rural	0	9	9	9	18	4793	4899
Total	1089	1789	2393	7987	9786	94707	95400

Table 39.
Population within Alternative SB8 Floodplain
Depths Greater Than 2 Feet

Economic Evaluation Area	Population within ACE Floodplain						
	50% (1/2)	10% (1/10)	4% (1/25)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
Town of Sutter	0	0	0	0	0	0	0
Yuba City Urban	0	0	16	417	665	66380	67368
Biggs Urban	0	0	0	0	0	1353	1554
Gridley Urban	0	0	0	0	0	1186	5483
Live Oak Urban	0	0	0	0	0	6498	8362
Sutter County Rural	767	1478	1700	2368	2704	5505	6199
Butte County Rural	0	0	0	0	0	2887	3882
Total	767	1478	1716	2785	3369	83809	92847

Table 40.
Population within Alternative SB8 Floodplain
Depths Greater Than 15 Feet

Economic Evaluation Area	Population within ACE Floodplain						
	50% (1/2)	10% (1/10)	4% (1/25)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
Town of Sutter	0	0	0	0	0	0	0
Yuba City Urban	0	0	0	0	0	303	934
Biggs Urban	0	0	0	0	0	0	0
Gridley Urban	0	0	0	0	0	0	0
Live Oak Urban	0	0	0	0	0	0	0
Sutter County Rural	0	0	4	231	303	1059	1183
Butte County Rural	0	0	0	0	0	0	0
Total	0	0	4	231	303	1362	2117

5.9 Potential Adverse Effects.

a. Induced Flooding. The hydraulic features associated with Alternative SB-8 are nearly identical to Alternative SB-1. The hydraulic model created for Alternative SB-8 computed the same water surface profiles as Alternative SB-1. Therefore, there is no induced flooding.

b. Transfer of Flood Risk. Analysis of the alternative found no transfer of flood risk. The hydraulic model created for Alternative SB-8 computed the same water surface profiles as Alternative SB-1. Within the three reaches where the levee will be shifted 20 feet riverward, the channel cross section width is over 5000 feet and this was found to have no measureable impact on the water surface throughout the model domain.

5.10 California State Urban Levee Design Criteria

Based on a review of the ULDC criteria, none of the levee reaches only the reaches associated with breaches F4.0R, F4.1R, F4.4R, F4.5R, F5.0R, F6.0R, F7.0R, F8.0R, and F9.0R would meet the DWR ULDC criteria. As a result the area north of Yuba City Urban area would meet the ULDC requirements but the southern portion of the basin below yuba city would not meet the ULDC criteria.

6.0 SUMMARY

This report describes hydraulic, sedimentation, and operations and maintenance analyses performed for the final alternatives of the Sutter Basin Feasibility Study. Analyses were performed for without-project and two project alternative conditions. The report provides an update of the previous analysis of the without-project conditions.

The study is focused on Sutter Basin Feasibility Study area. Composite floodplain delineations are provided for 50% (1/2) ACE, 10% (1/10) ACE, 4% (1/25) ACE, 2% (1/50) ACE, 1% (1/100) ACE, 0.5% (1/200) ACE, and 0.2% (1/500) ACE events for the existing and alternative conditions.

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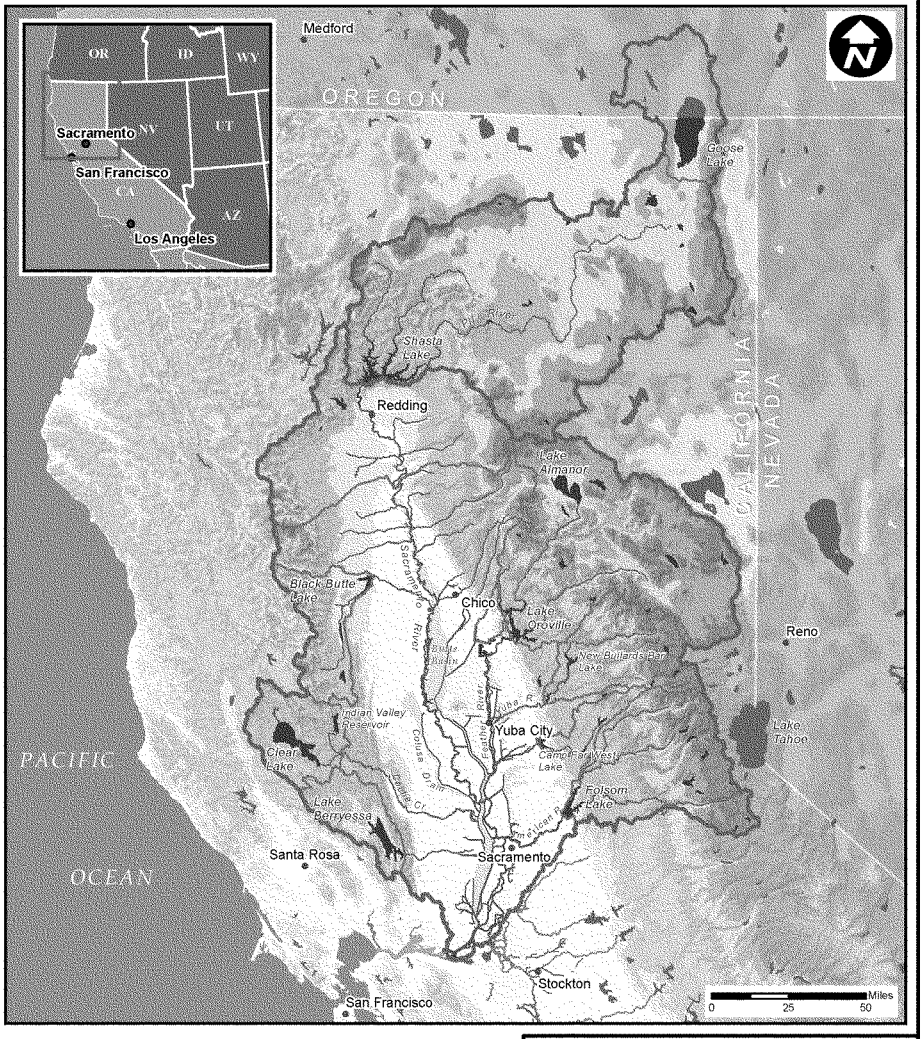
ATTACHEMENT A

Memorandum for File:
Sutter Basin Pilot Feasibility Study,
Hydraulic Analysis of Refined Alternatives
8 June 2012

ATTACHMENT B

Final Geotechnical Fragility Curves
February 2013.



Legend

- Study Area Extent
- Sacramento Basin
- Watershed Boundaries
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Federal Levees
- City

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

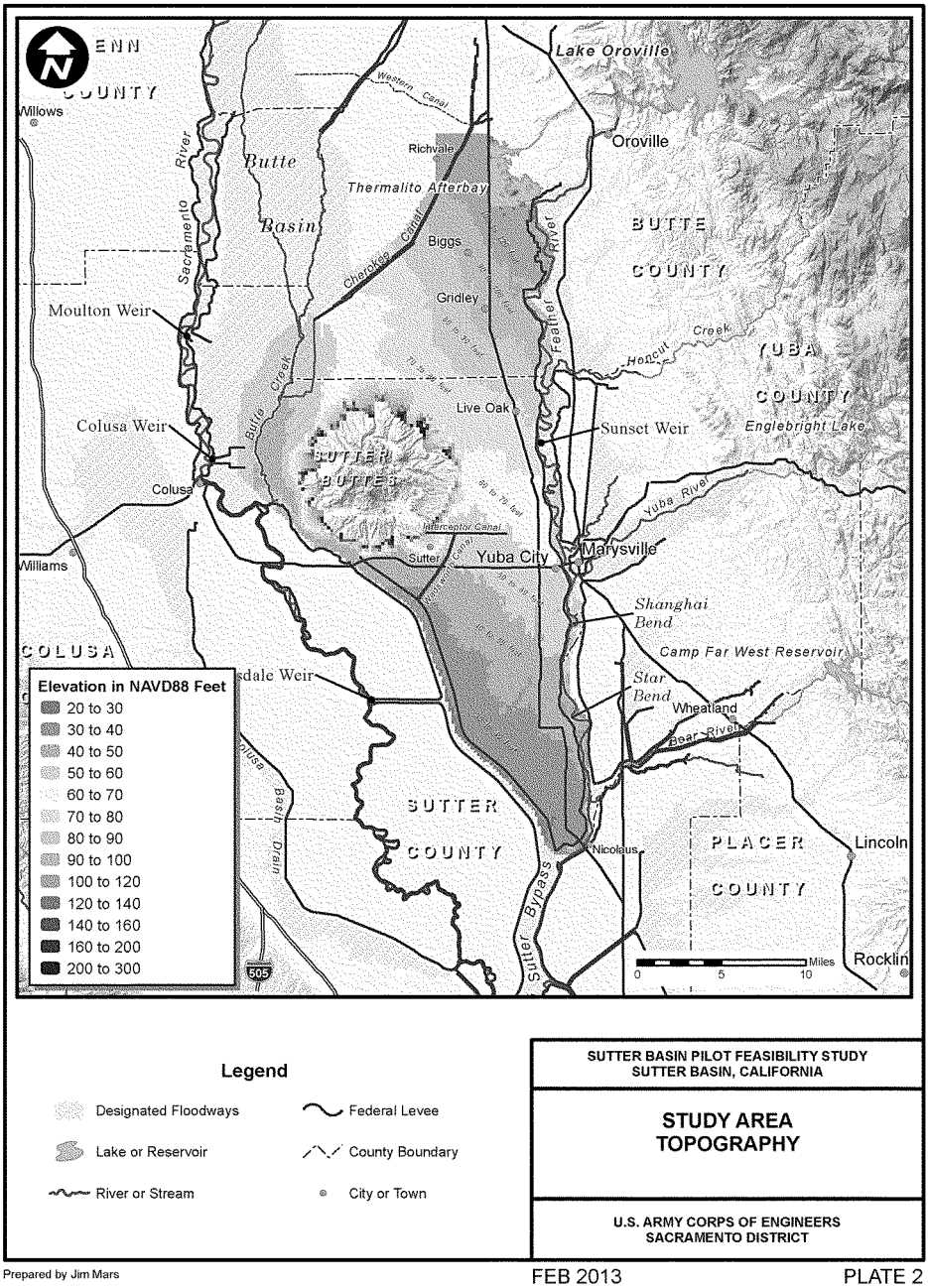
SACRAMENTO RIVER WATERSHED

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 1



Legend

- Designated Floodways
- Federal Levee
- Lake or Reservoir
- County Boundary
- River or Stream
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

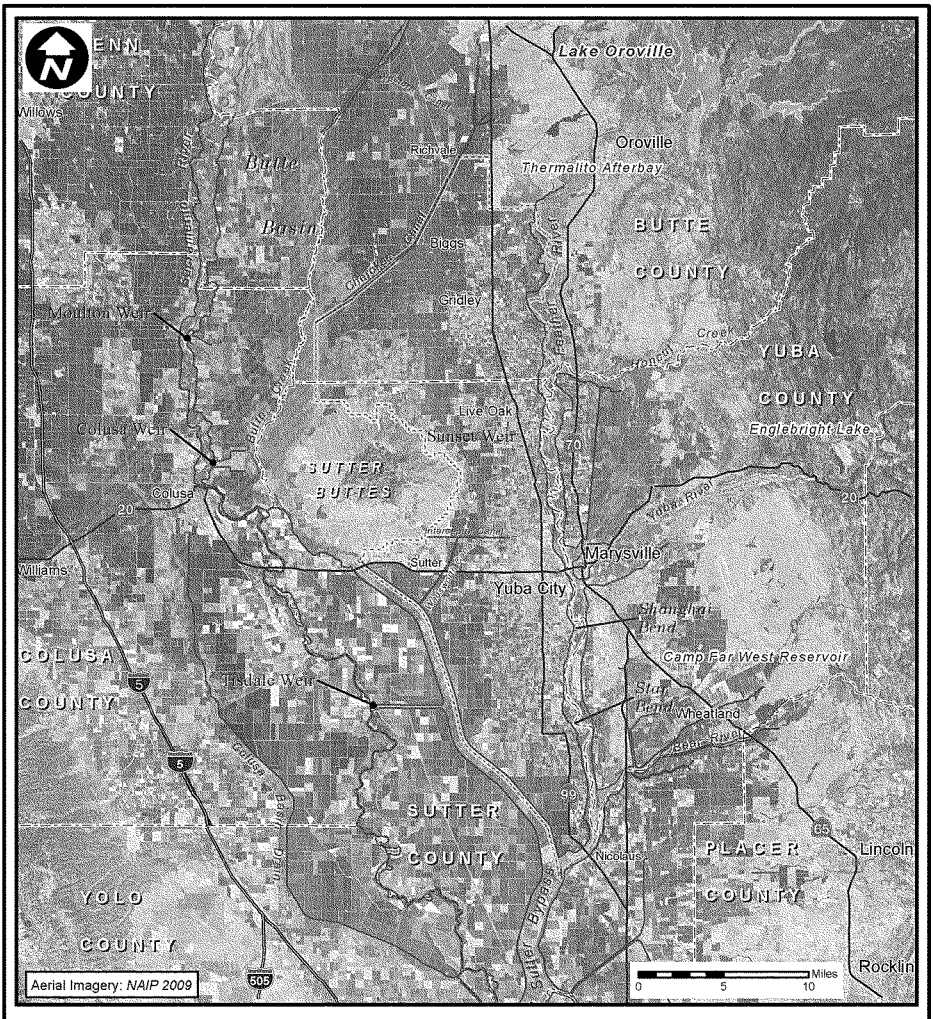
STUDY AREA TOPOGRAPHY

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 2



Legend

- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Federal Levee
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

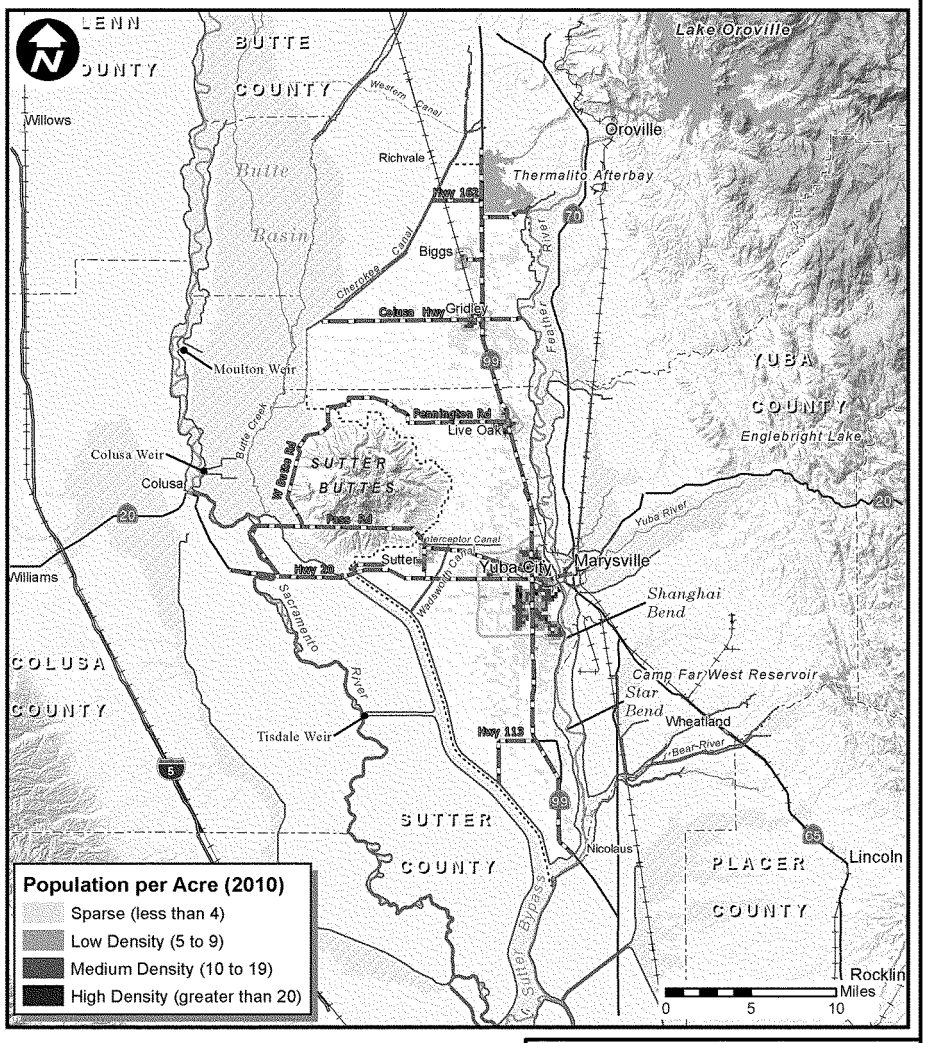
STUDY AREA AERIAL IMAGERY

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 3



Legend

- Federal Levee
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Evacuation Routes
- Highway
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

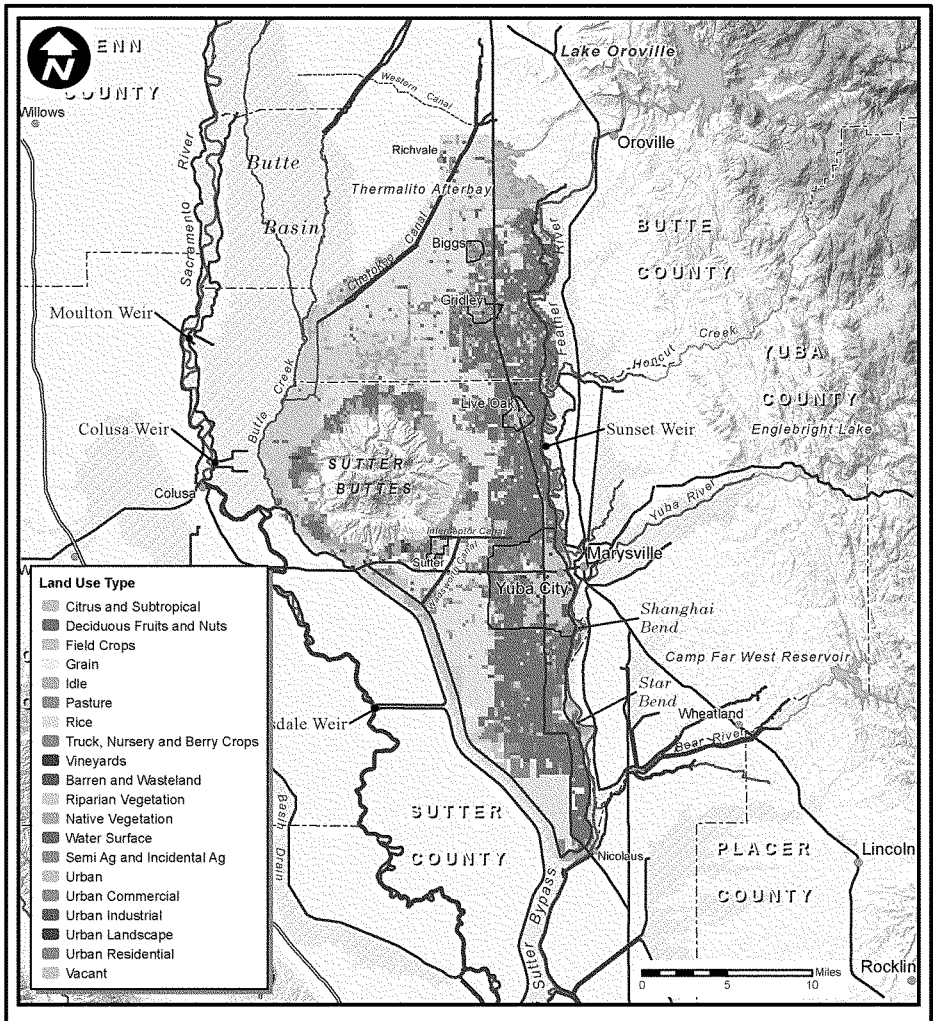
POPULATION DENSITY

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 4



Legend

- Designated Floodways
- Federal Levee
- Lake or Reservoir
- County Boundary
- River or Stream
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

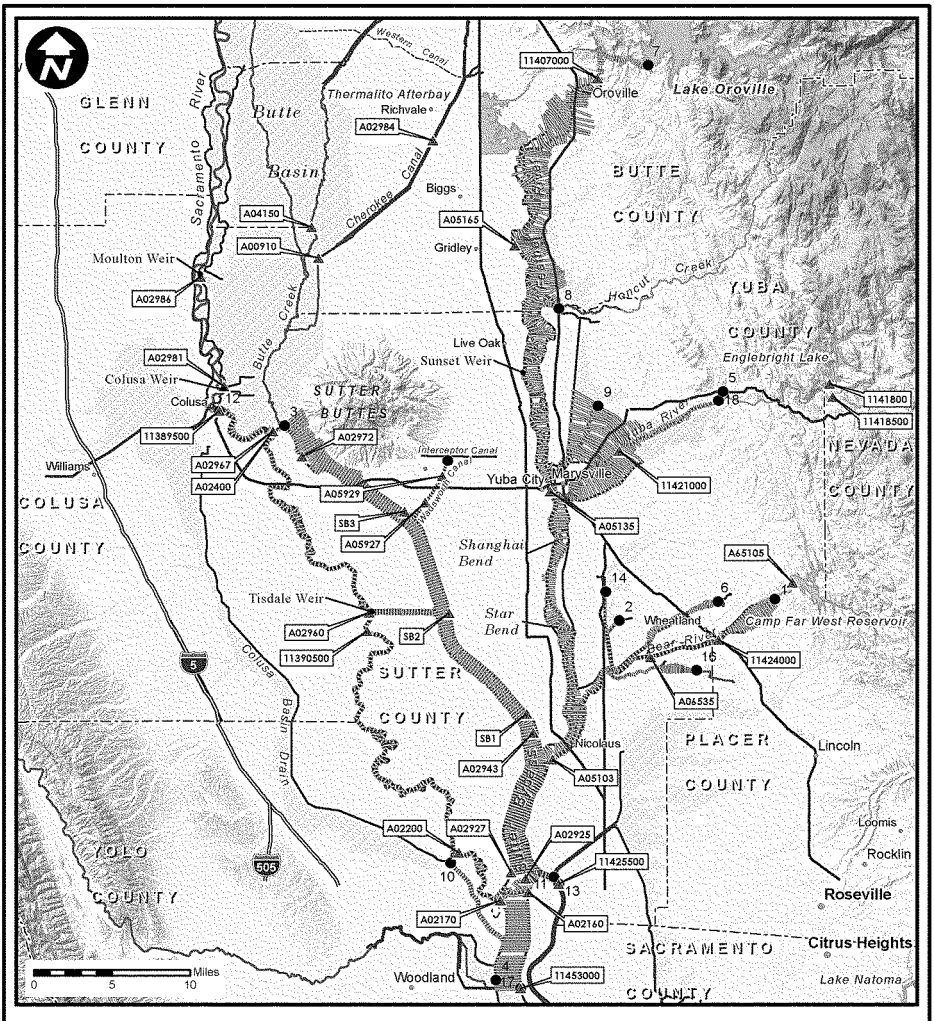
LAND USE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 5



Legend

- Stream Gage
- Model Boundaries
- Model Cross Sectios
- Federal Levee
- Study Area Extent
- Designated Floodways

NOTE: See Table 1 and 2 for Model Boundary Name

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

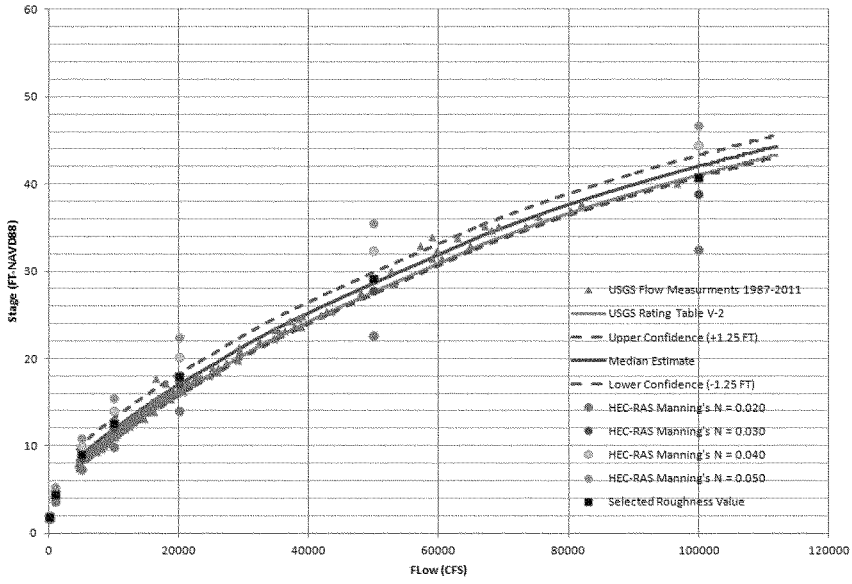
HEC-RAS HYDRAULIC MODEL BOUNDARY CONDITIONS AND STREAM GAGES

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 6



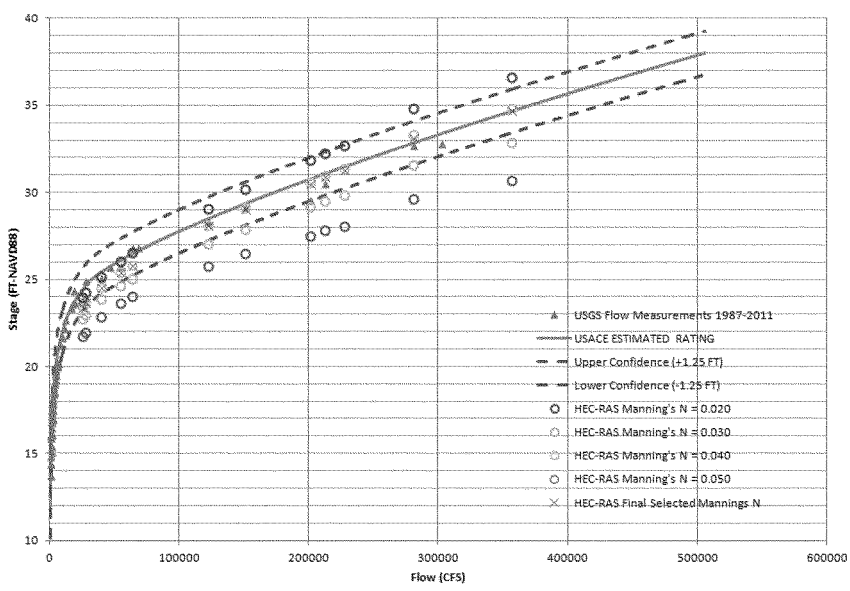
SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE-DISCHARGE CURVE
SACRAMENTO RIVER AT VERONA
WITHOUT PROJECT CONDITIONS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Source:

FEB 2013 PLATE 7

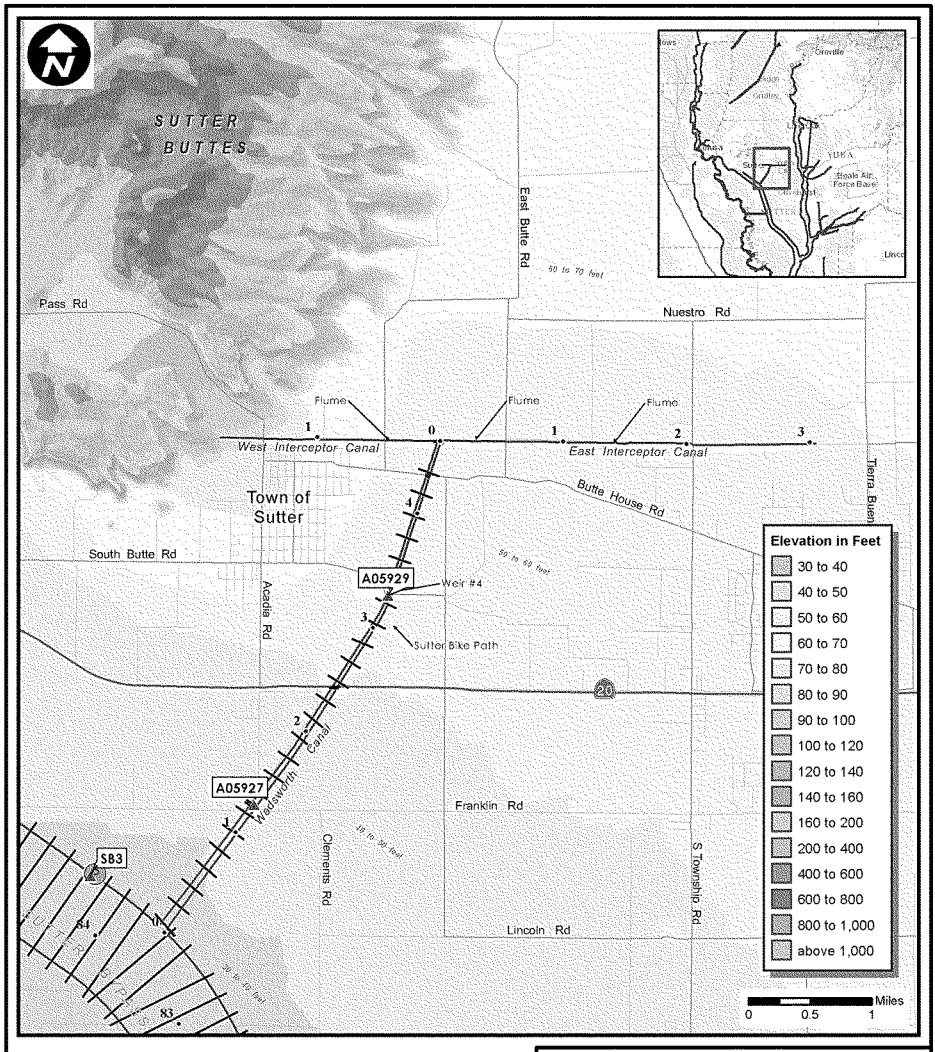


SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE-DISCHARGE CURVE
YOLO BYPASS AT WOODLAND
WITHOUT PROJECT CONDTIONS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

FEB 2013 PLATE 8



Legend

- Model Cross Sectios
- Federal Levee
- Pump Station
- Comp Study River Mile

Note: Topography data is from the USGS DEM and is in NAVD88

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

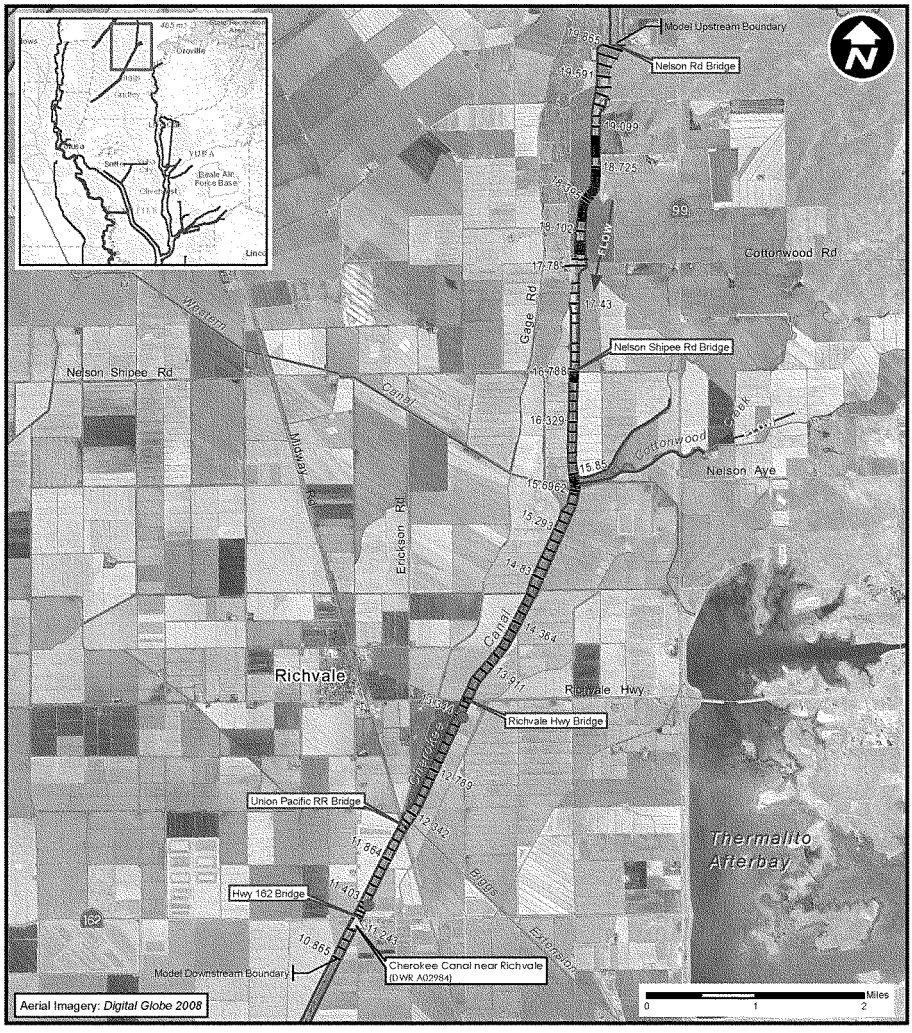
WADSWORTH AND INTERCEPTOR CANALS TOPOGRAPHY

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 9



Legend

- Stream Gage
- Breach Simulation Point
- Model Cross Sections
- Federal Levee

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

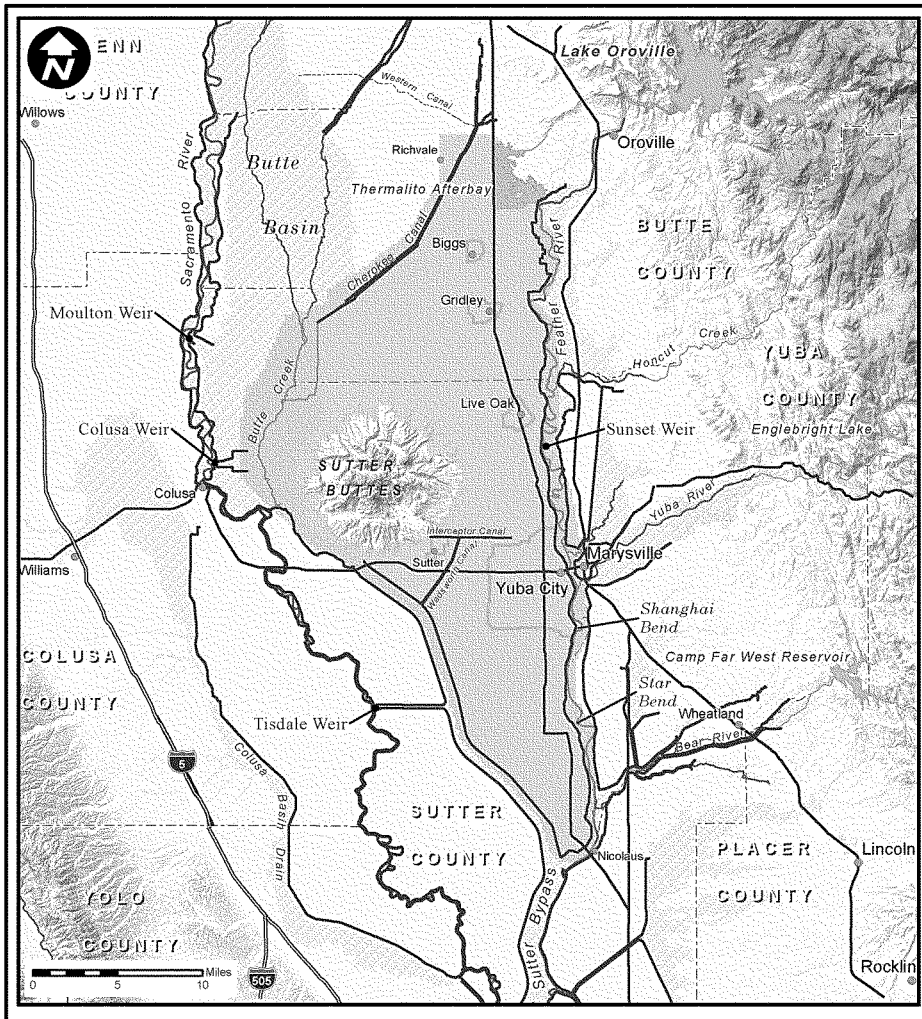
CHEROKEE CANAL HYDRAULIC MODEL

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

MAR 2013

PLATE 10



Legend

- FLO2D Grid - 1000 ft
- Designated Floodways
- Lake or Reservoir
- Economic Evaluation Area
- River or Stream
- Federal Levee
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

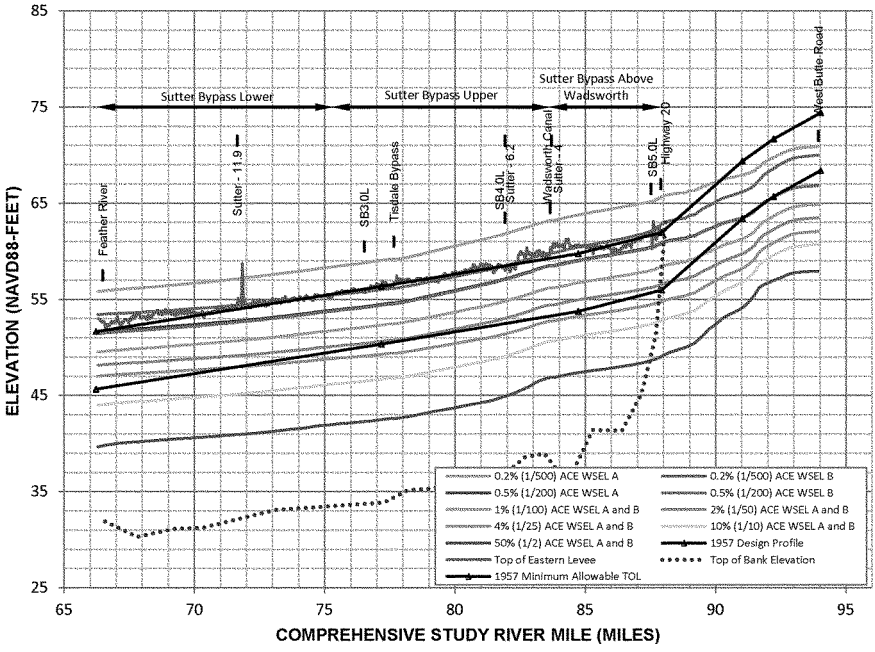
FLO2D MODEL GRID

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 11



Note:

Water Surface Profile A assumes infinite levee height, no overtopping

Water Surface Profile B assumes overtopping only, no failure

WSEL = Water Surface Elevation

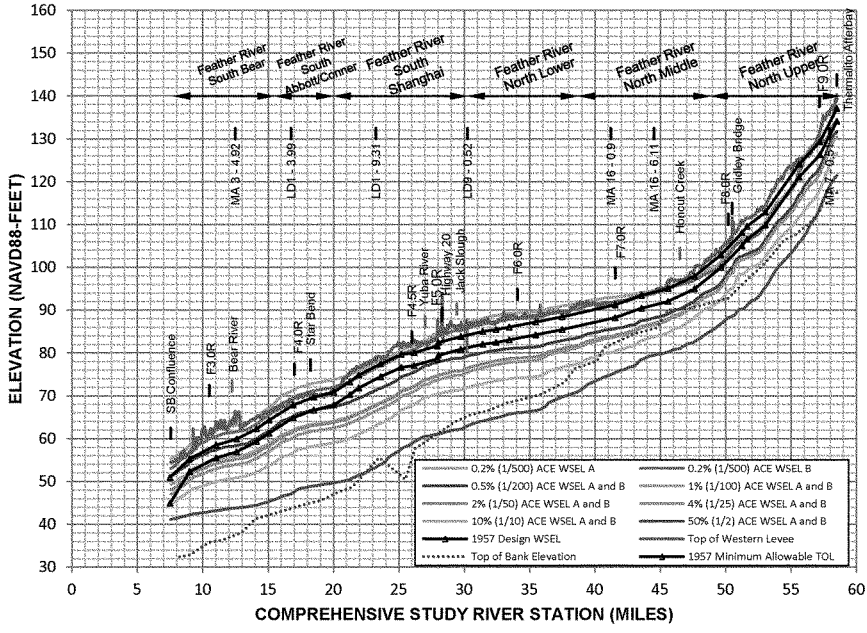
Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

SUTTER BYPASS
WATER SURFACE PROFILES

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

FEB 2013 PLATE 12



Note:

Water Surface Profile A assumes infinite levee height, no overtopping

Water Surface Profile B assumes overtopping only, no failure

WSEL = Water Surface Elevation

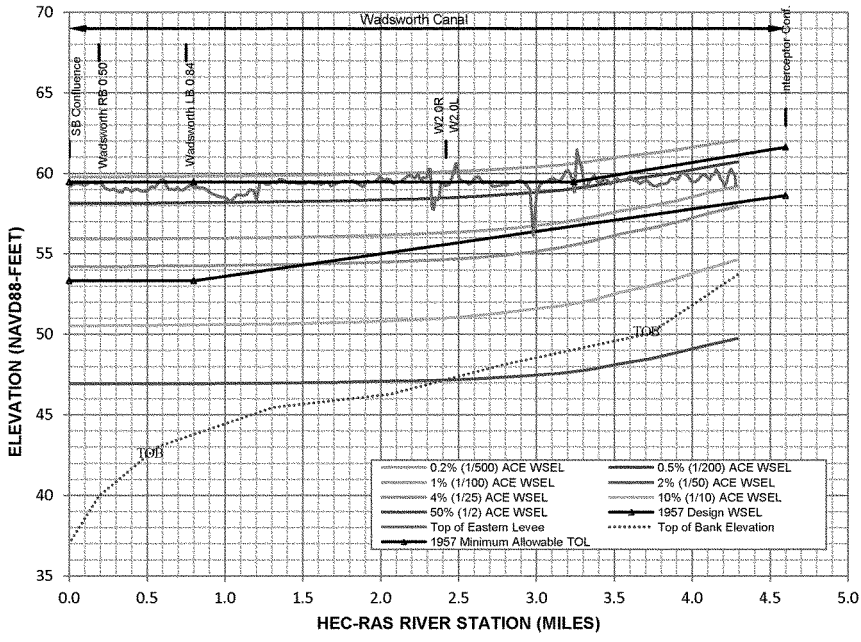
Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

FEATHER RIVER
WATER SURFACE PROFILES

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

FEB 2013 PLATE 13



Note:

Water Surface Profile A assumes infinite levee height, no overtopping

Overtopping, no failure was not created for Wadsworth Canal

WSEL = Water Surface Elevation

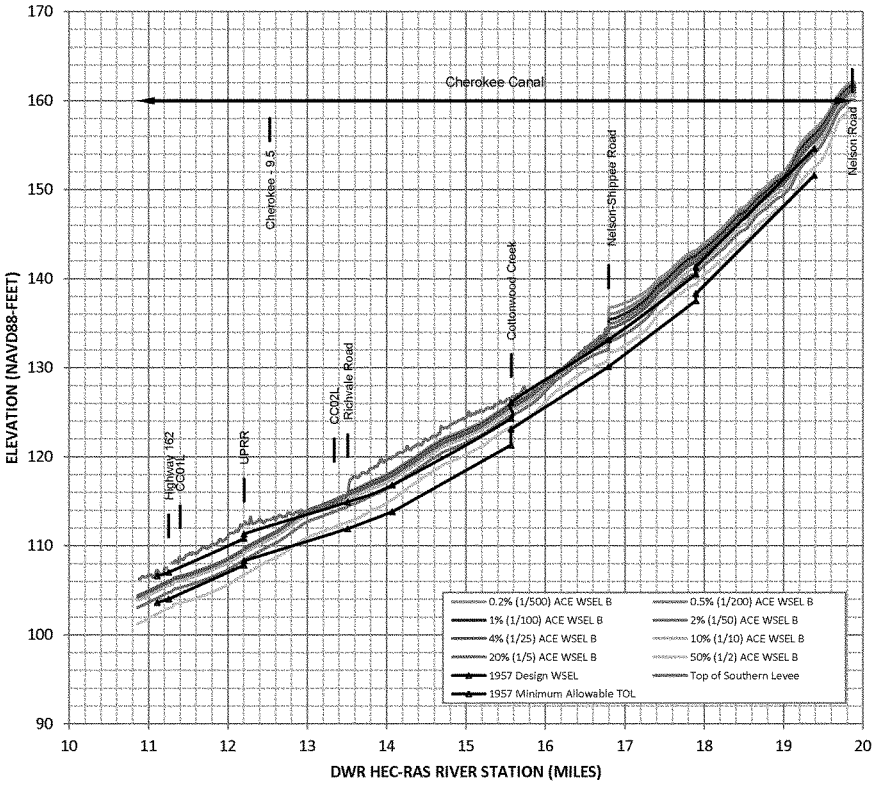
Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

WADSWORTH CANAL
WATER SURFACE PROFILES

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

FEB 2013 PLATE 14



Notes:

Water Surface Profile B assumes overtopping only, no failure.

WSEL = Water Surface Elevation

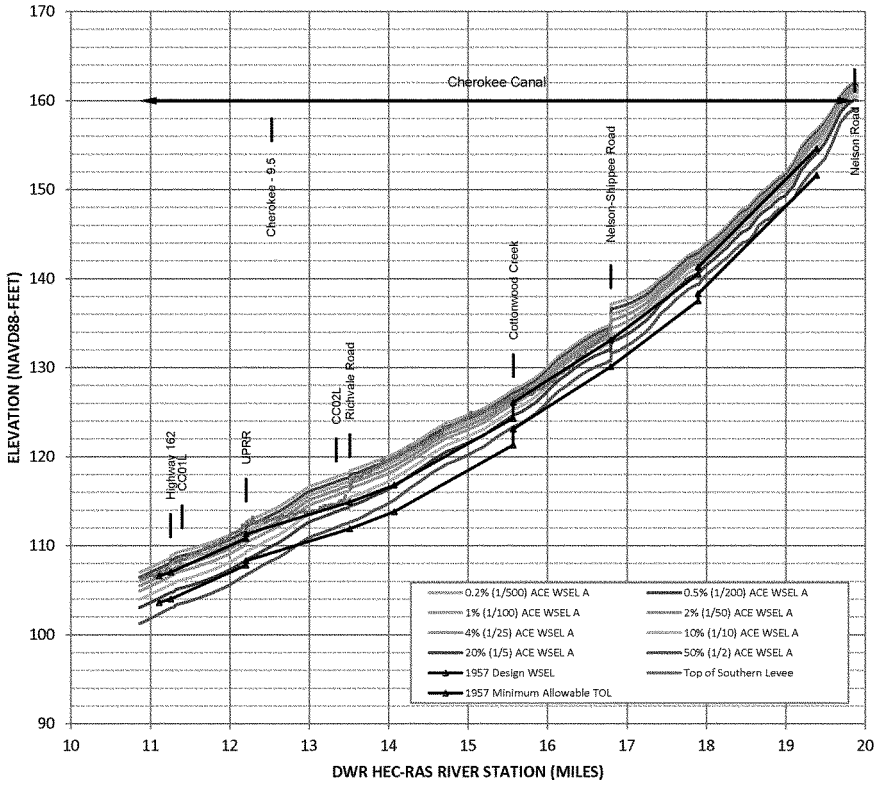
Source:

SUTTER BASIN FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

CHEROKEE CANAL
WATER SURFACE PROFILES

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

FEB 2013 PLATE 15



Notes:

Water Surface Profile A assumes infinite levee height, no overtopping.

WSEL = Water Surface Elevation

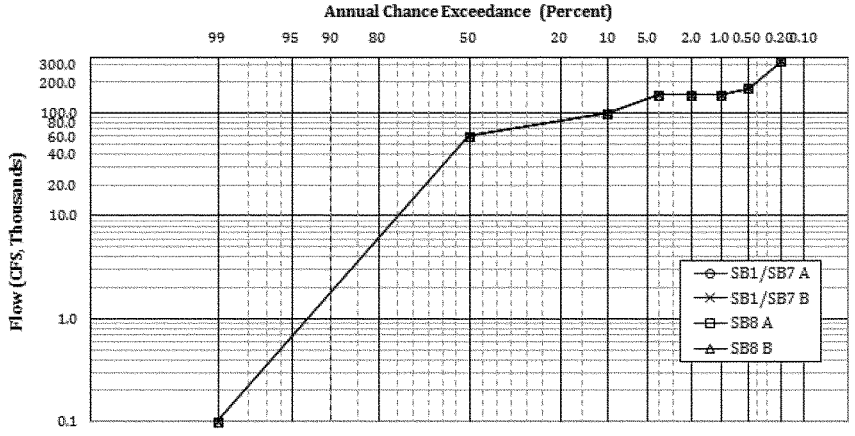
Source:

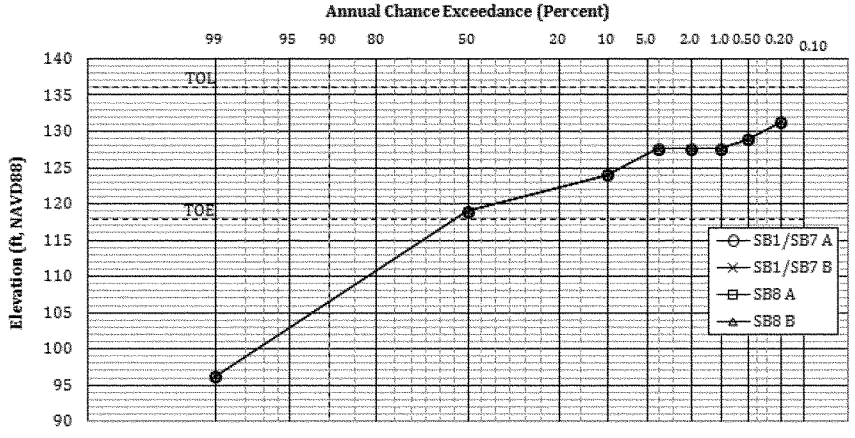
SUTTER BASIN FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

CHEROKEE CANAL
WATER SURFACE PROFILES

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

FEB 2013 PLATE 16





NOTES:
Feather River at Comp Study RM 57.95 refers to Geotechnical index location MA7 – 0.51
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

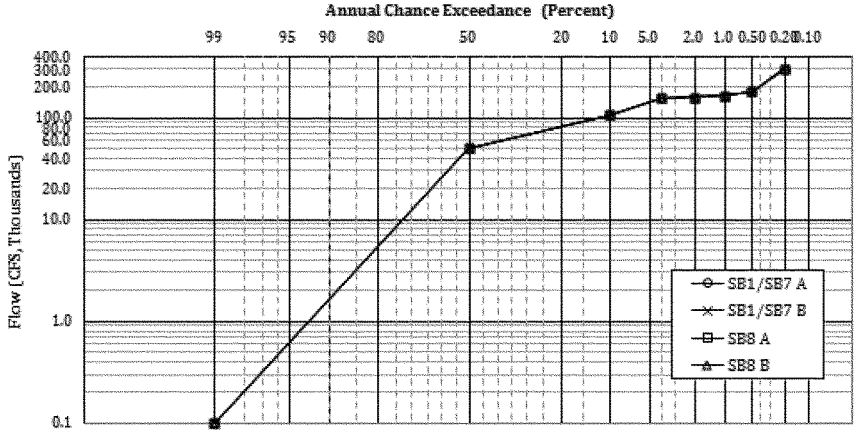
Source:

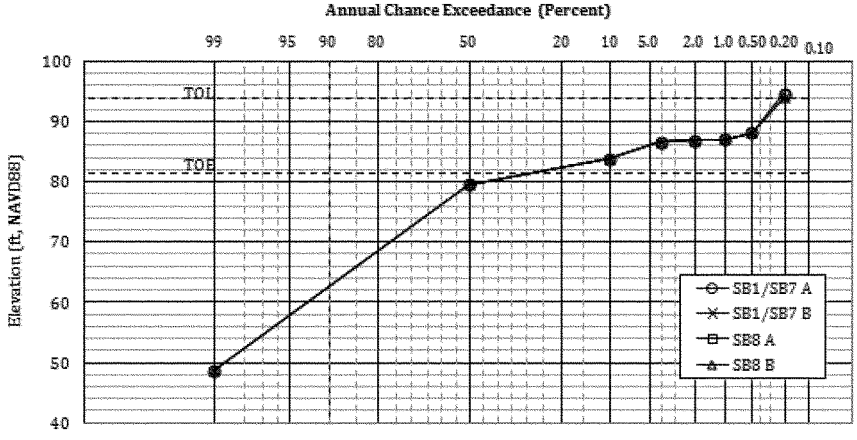
SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE AND DISCHARGE FREQUENCY CURVES
FEATHER RIVER AT RM 57.95

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

FEB 2013 PLATE 17





NOTES:
Feather River at Comp Study RM 44.5 refers to Geotechnical index location MA 16 – 2.9
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

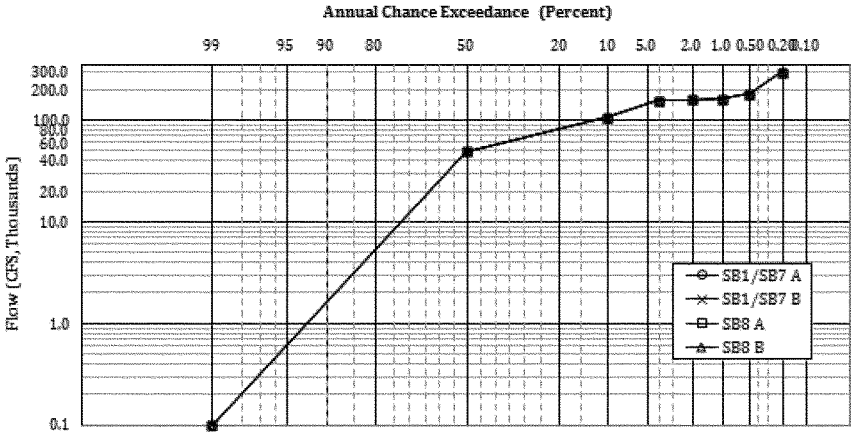
Source:

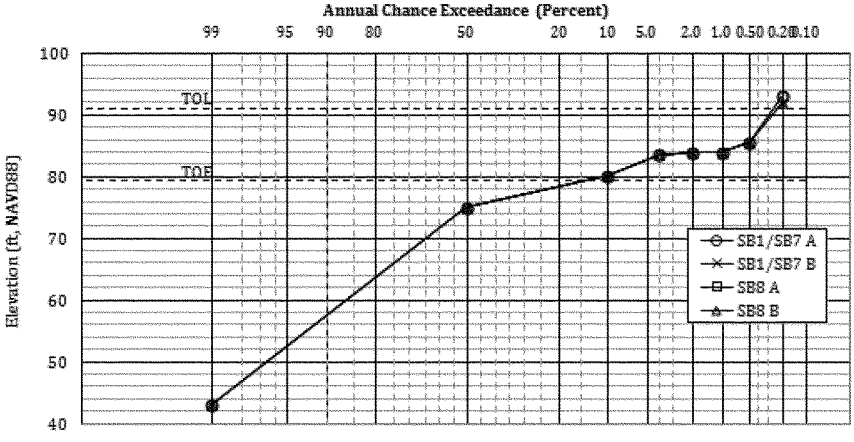
SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE AND DISCHARGE FREQUENCY CURVES FEATHER RIVER AT RM 44.5

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

FEB 2013 PLATE 18





NOTES:
Feather River at Comp Study RM 41.2 refers to Geotechnical index location MA 16 – 0.9
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

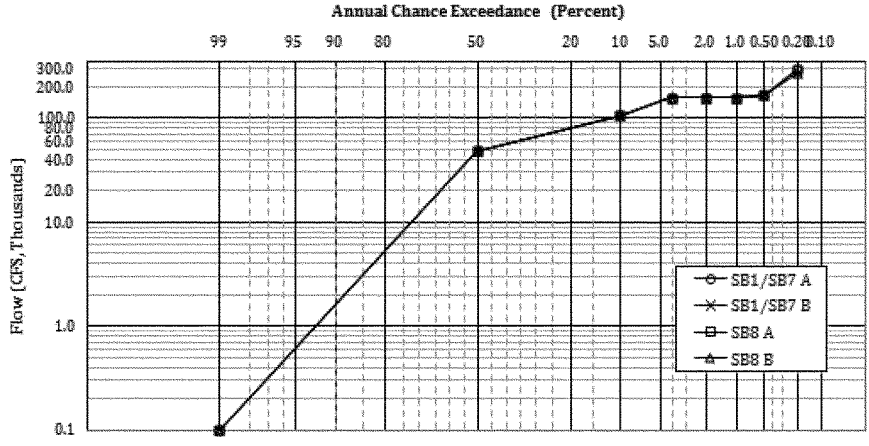
Source:

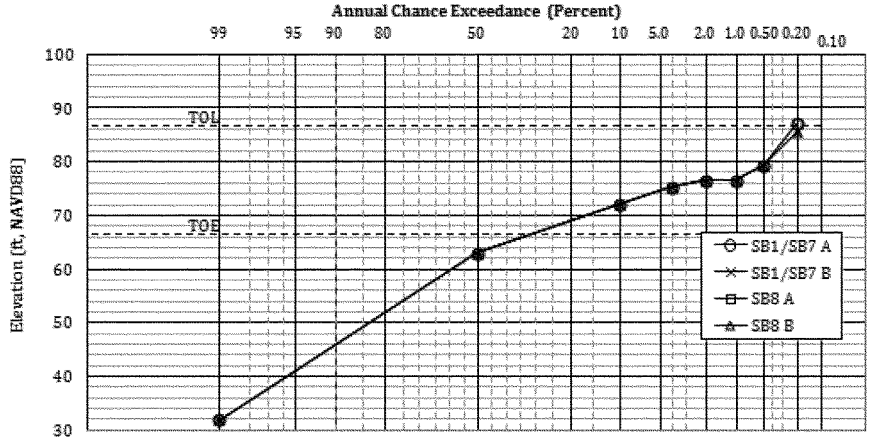
SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE AND DISCHARGE
FREQUENCY CURVES
FEATHER RIVER AT RM 41.2

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

FEB 2013 PLATE 19





NOTES:
Feather River at Comp Study RM 30.25 refers to Geotechnical index location LD9 – 0.52
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

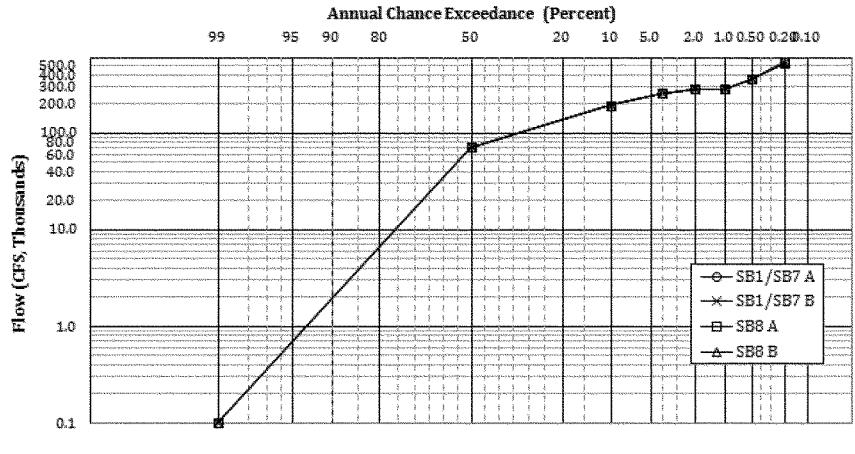
Sou

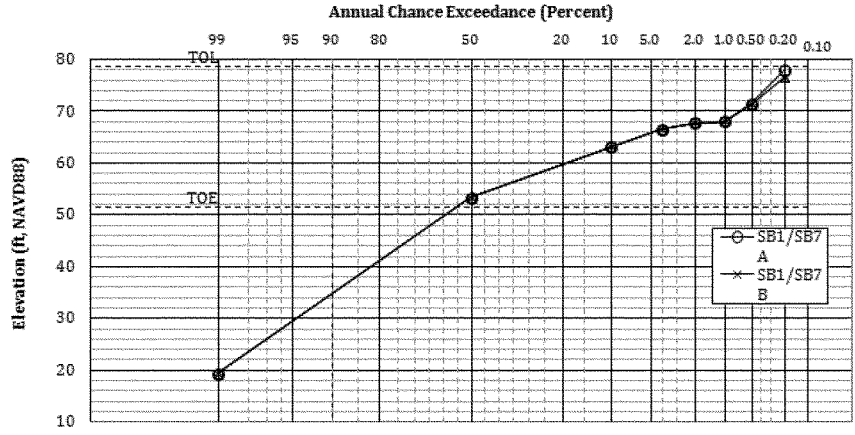
SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE AND DISCHARGE
FREQUENCY CURVES
FEATHER RIVER AT RM 30.25

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

FEB 2013 PLATE 20





NOTES:
Feather River at Comp Study RM 23.25 refers to Geotechnical index location LD1 – 9.31
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

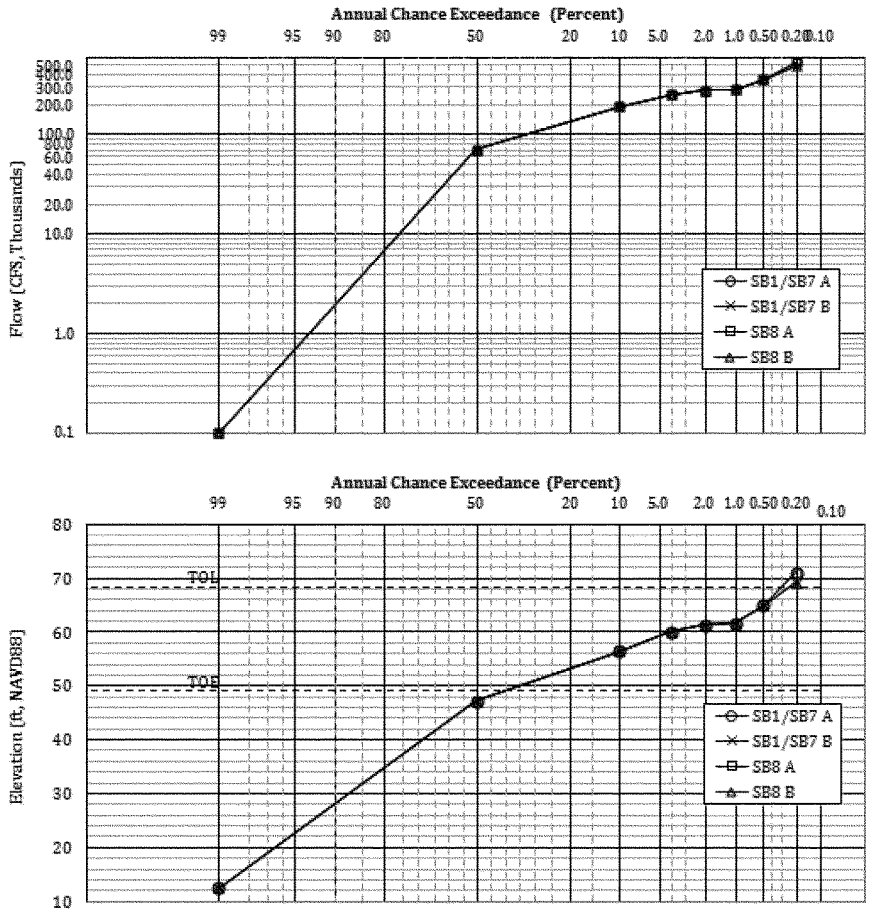
Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE AND DISCHARGE FREQUENCY CURVES
FEATHER RIVER AT RM 23.25

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

FEB 2013 PLATE 21



NOTES:
Feather River at Comp Study RM 16.75 refers to Geotechnical index location LD1 – 3.99
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

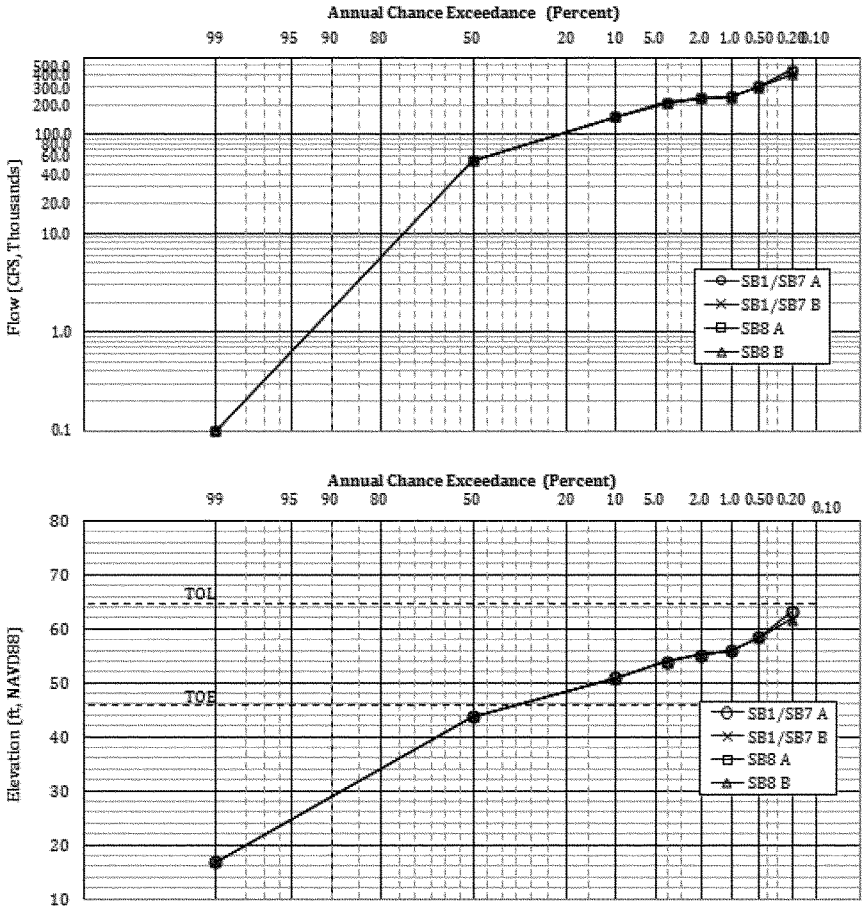
Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE AND DISCHARGE
FREQUENCY CURVES
FEATHER RIVER AT RM 16.75

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

FEB 2013 PLATE 22



NOTES:
Feather River at Comp Study RM 12.5 refers to Geotechnical index location MA3 – 4.92
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

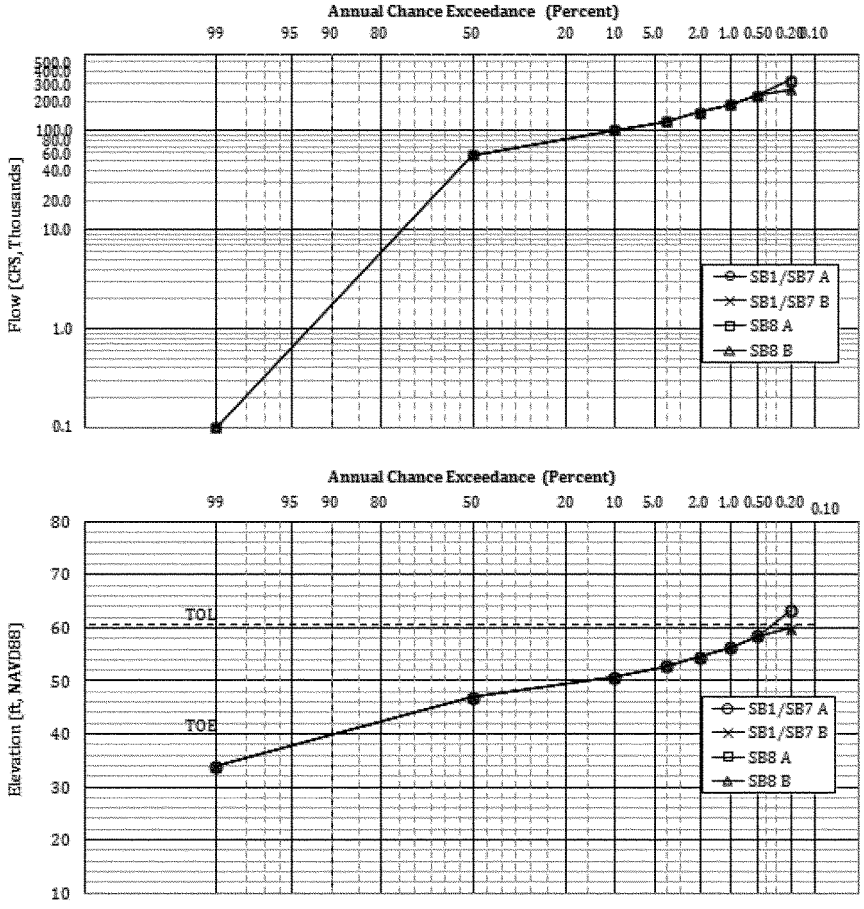
Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE AND DISCHARGE FREQUENCY CURVES
FEATHER RIVER AT RM 12.5

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

FEB 2013 PLATE 23



NOTES:
Sutter Bypass at Comp Study RM 83.79 refers to Geotechnical index location SUTTER – 4
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

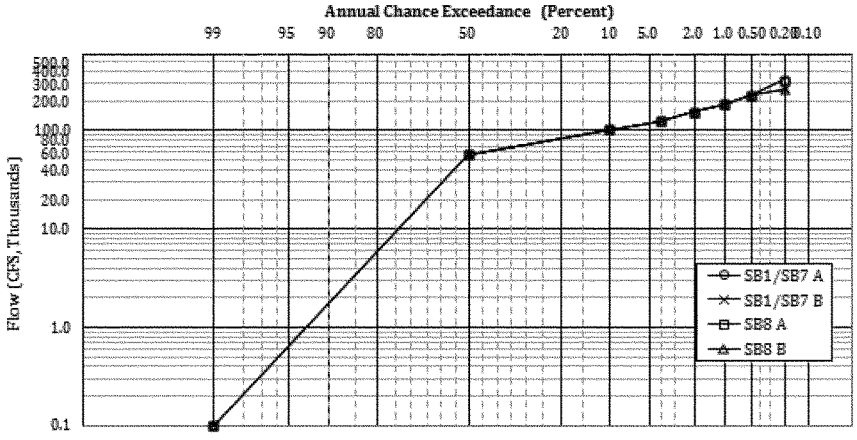
Source:

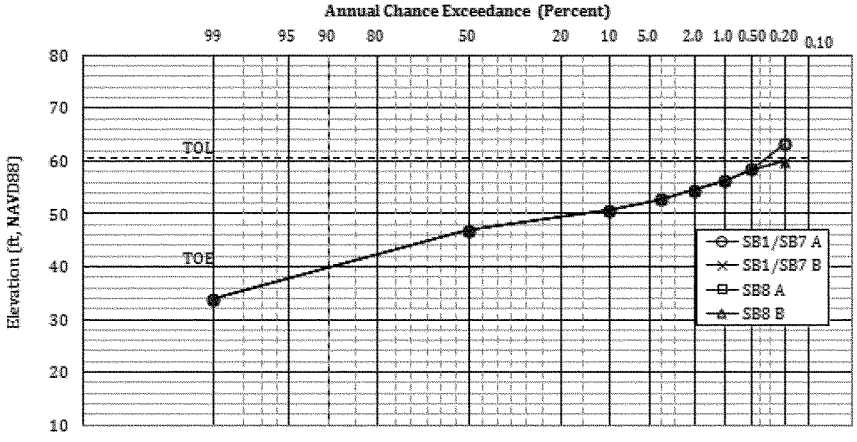
SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE AND DISCHARGE FREQUENCY CURVES
SUTTER BYPASS AT RM 83.79

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

FEB 2013 PLATE 24





NOTES:
Sutter Bypass at Comp Study RM 81.93 refers to Geotechnical index location SUTTER – 6.2
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

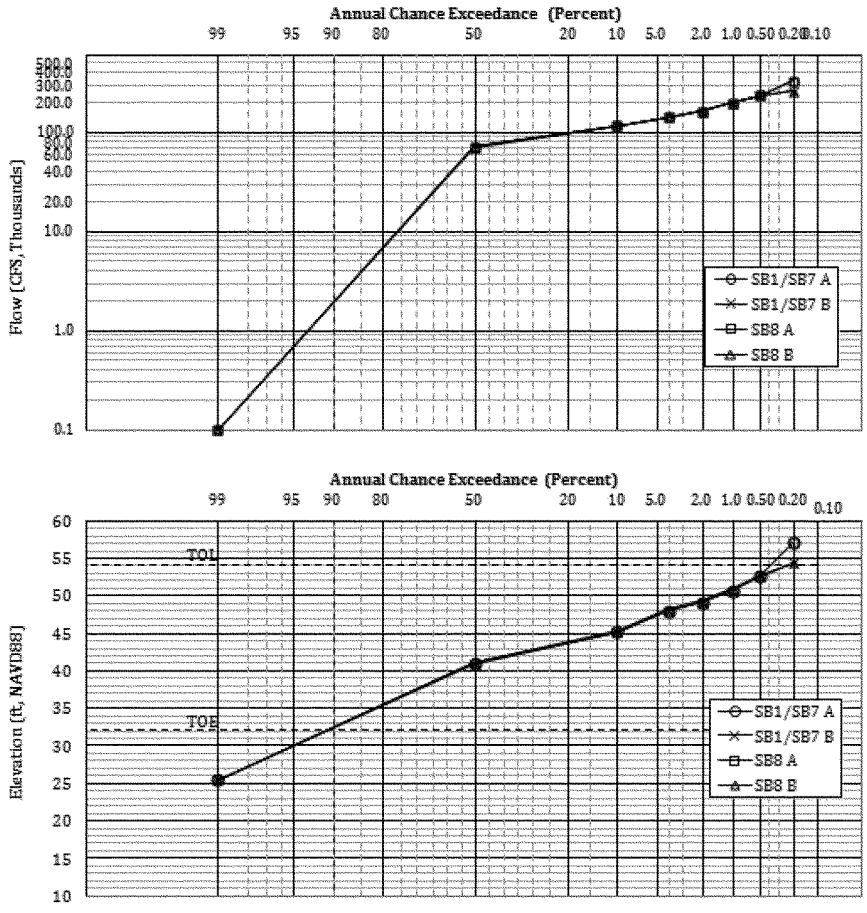
Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE AND DISCHARGE
FREQUENCY CURVES
SUTTER BYPASS AT RM 81.93

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

FEB 2013 PLATE 25



NOTES:
Sutter Bypass at Comp Study RM 71.65 refers to Geotechnical index location SUTTER – 17.3
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

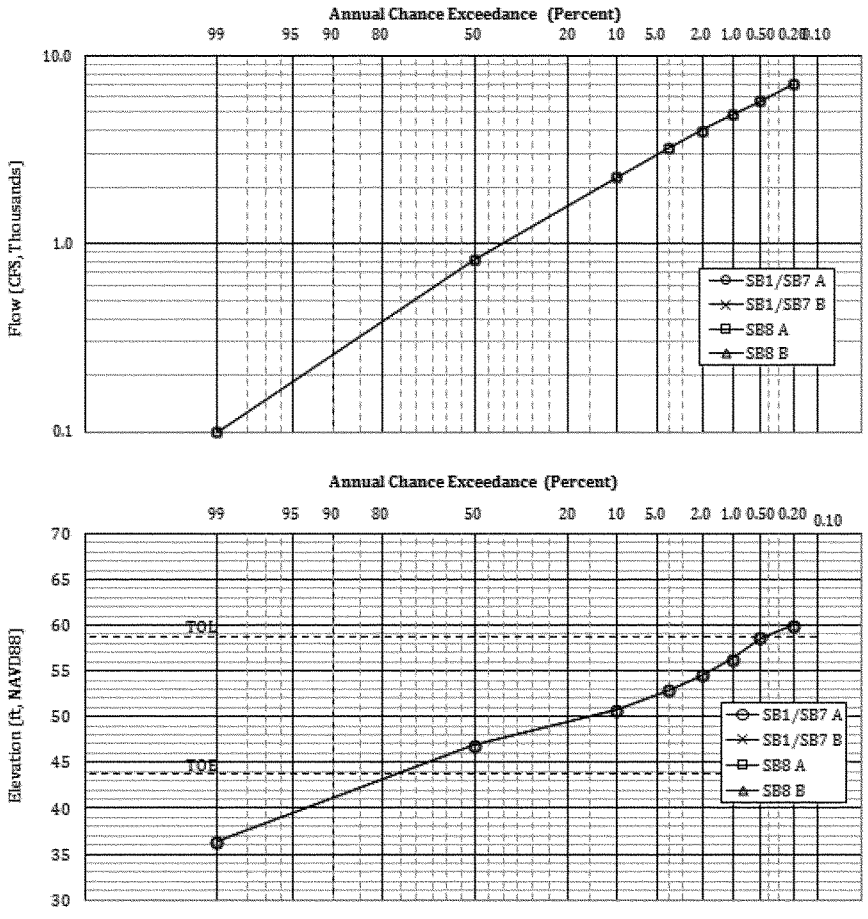
Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE AND DISCHARGE FREQUENCY CURVES
SUTTER BYPASS AT RM 71.65

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

FEB 2013 PLATE 26



NOTES:
Wadsworth Canal at RM 0.81 refers to Geotechnical index location
WADSWORTH – 0.84
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

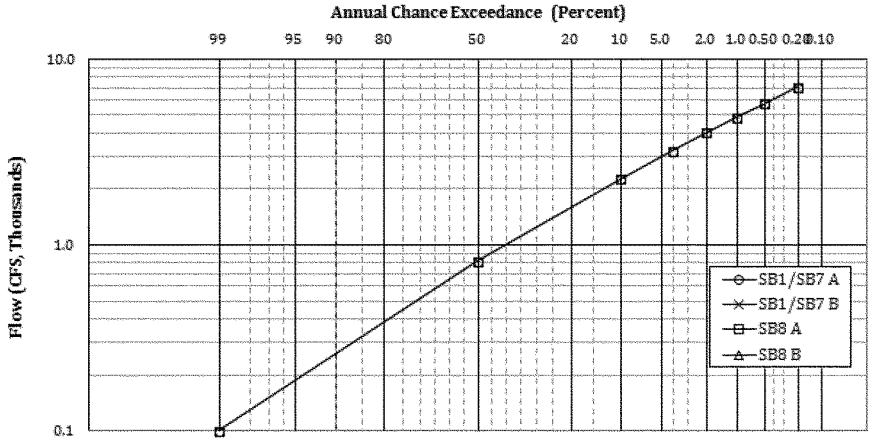
Source:

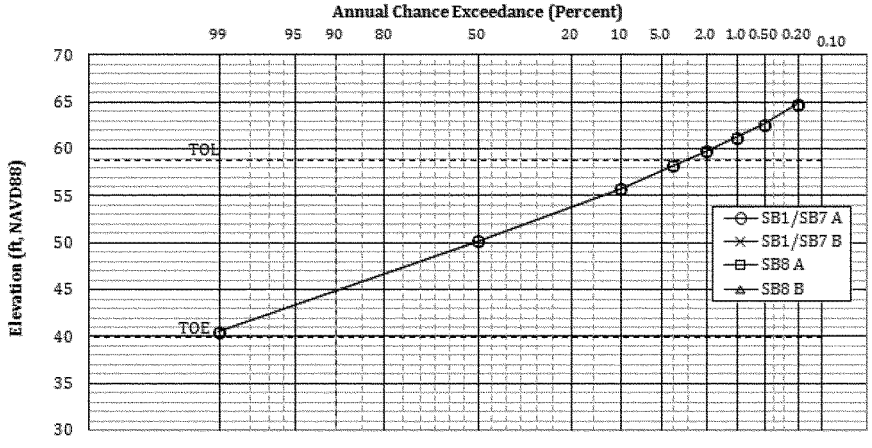
SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE AND DISCHARGE
FREQUENCY CURVES
WADSWORTH CANAL AT RM 0.81

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

FEB 2013 PLATE 27





NOTES:
Wadsworth Canal at RM 4.54 defines the upstream capacity prior to overtopping
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

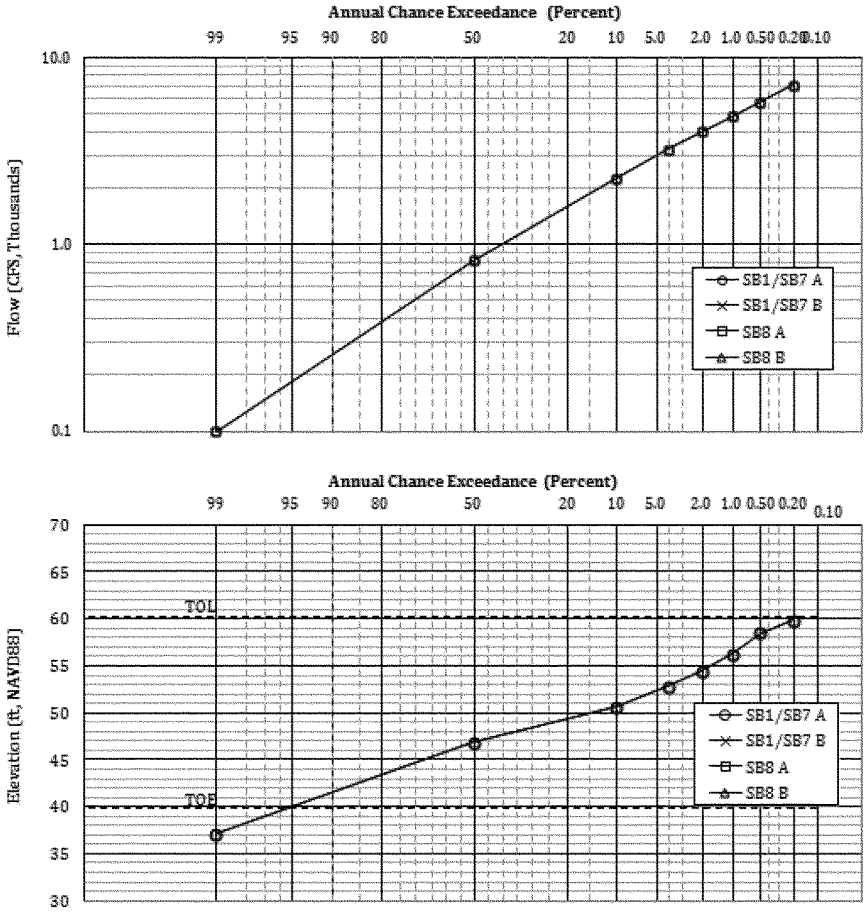
Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE AND DISCHARGE
FREQUENCY CURVES
WADSWORTH CANAL AT RM 4.54

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

FEB 2013 PLATE 28



NOTES:
Wadsworth Canal at Comp Study RM 0.25 refers to Geotechnical Index location WADSWORTH – 0.5
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

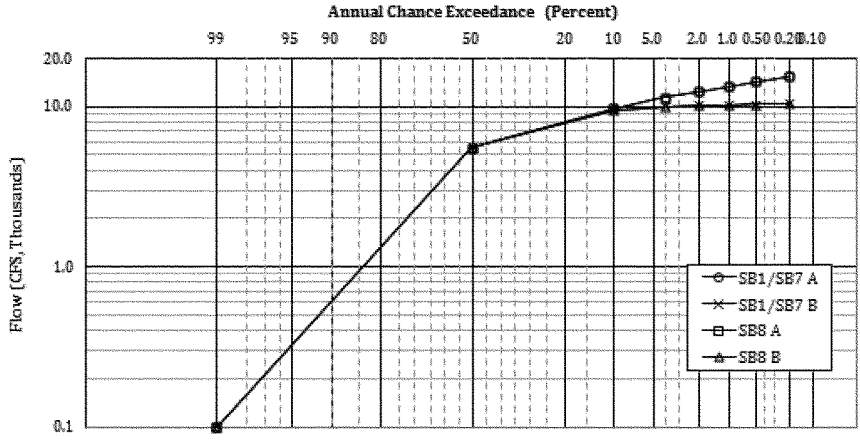
Source:

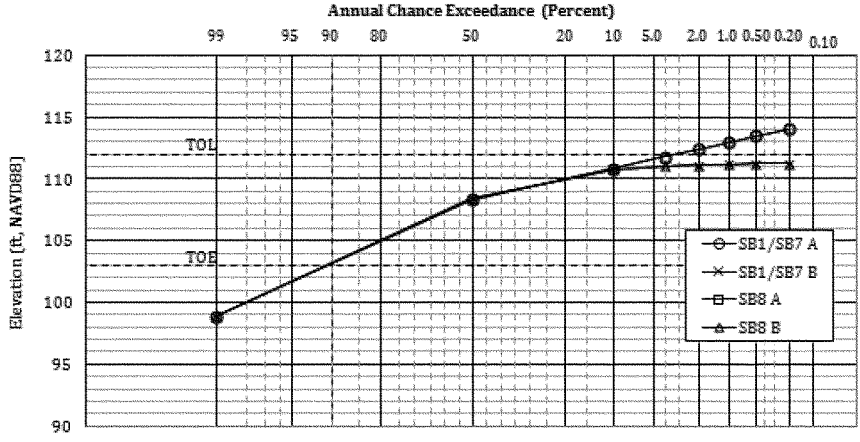
SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

STAGE AND DISCHARGE
FREQUENCY CURVES
WADSWORTH CANAL AT RM 0.25

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

FEB 2013 PLATE 29





NOTES:
Cherokee Canal at DWR HEC-RAS RM 12.529 refers to Geotechnical index location CHEROKEE – 9.5
TOL = top of levee from 2008 NLDB
TOE = average elevation of bank line adjacent to levee
SB1 – Without Project Conditions
SB7 – Fix in Place Sunset Weir to Laurel Avenue
SB8 – Fix in Place Thermalito to Laurel Avenue
Scenario A – Assumes infinite levee height
Scenario B – Assumes levee overtopping with no failure

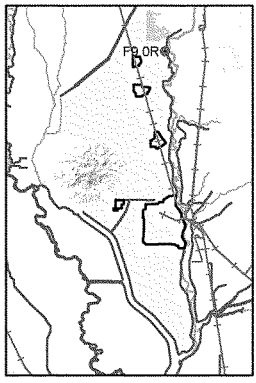
Source:

SUTTER BASIN PILOT FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

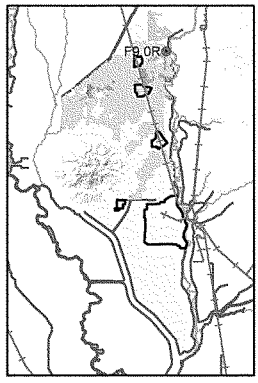
STAGE AND DISCHARGE
FREQUENCY CURVES
CHEROKEE CANAL AT RM 12.529

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

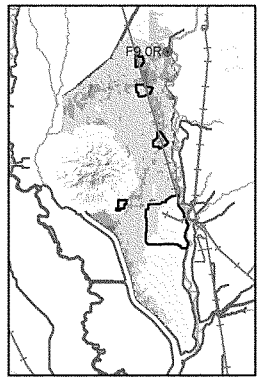
FEB 2013 PLATE 30



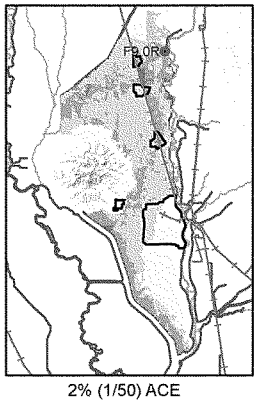
50% (1/2) ACE



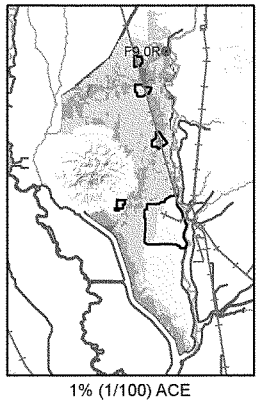
10% (1/10) ACE



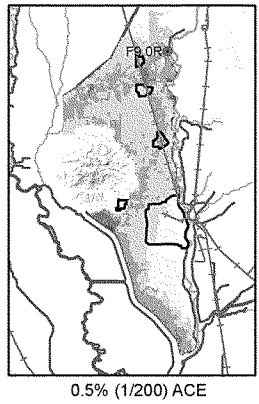
4% (1/25) ACE



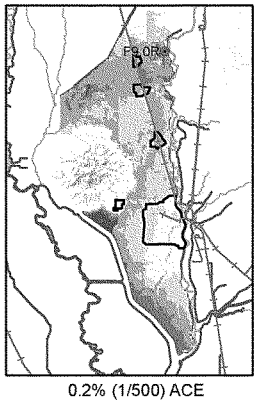
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

0 10 20 Miles

N

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

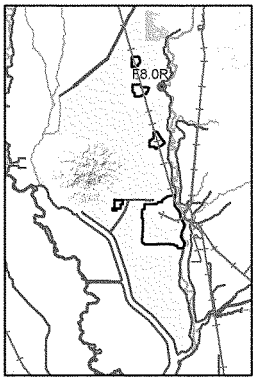
BREACH SIMULATION
ALTERNATIVE SB-1
FEATHER RIVER WEST LEVEE
LOCATION F9.0R

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

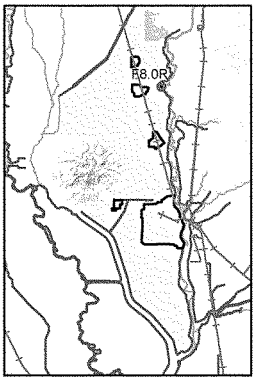
Prepared by T. Hatch

FEB 2013

PLATE 31



50% (1/2) ACE



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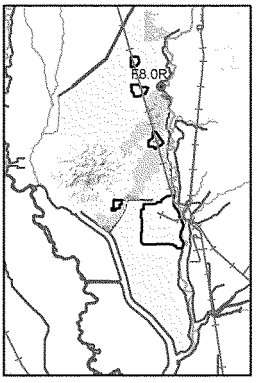

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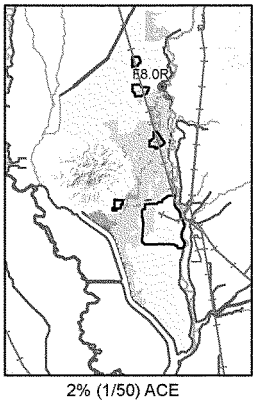

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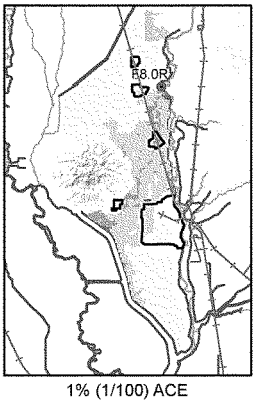
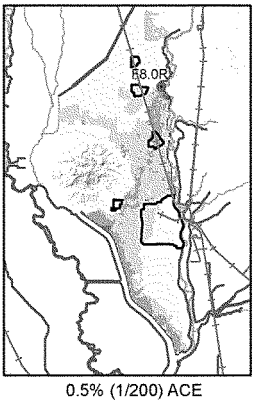


1% (1/100) ACE



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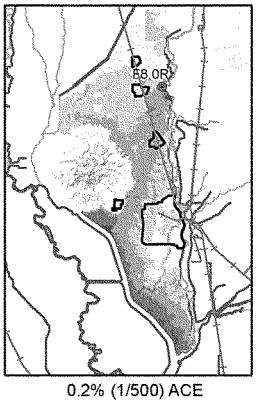


0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20
- Railroad

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

Miles

0 10 20

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

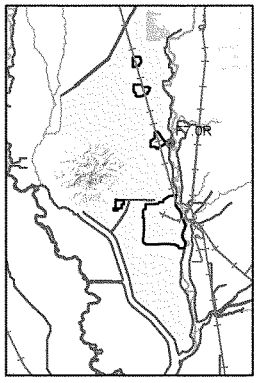
BREACH SIMULATION ALTERNATIVE SB-1 FEATHER RIVER WEST LEVEE LOCATION F8.0R

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

FEB 2013

PLATE 32



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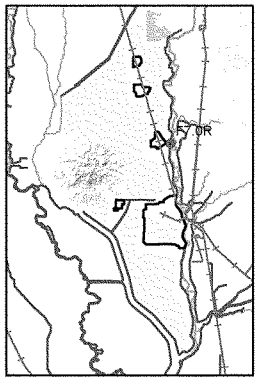

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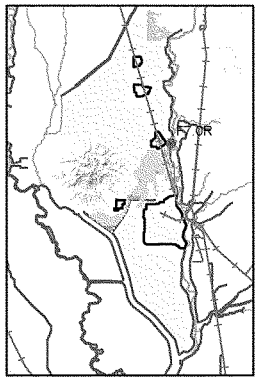

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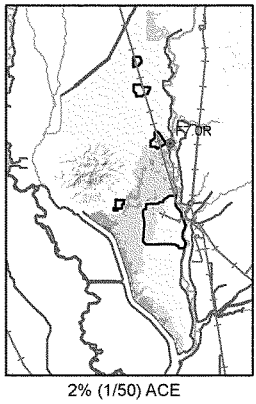

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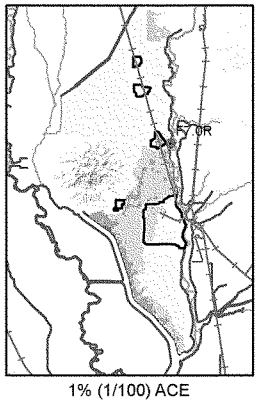

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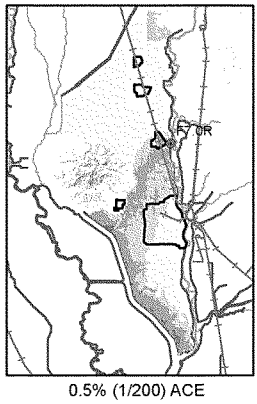
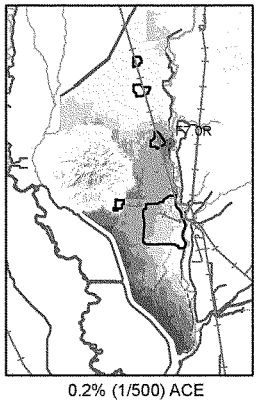


0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20
- Railroad

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

0 10 20 Miles

N

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

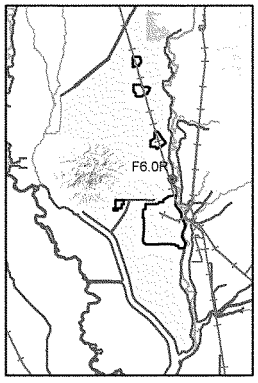
BREACH SIMULATION ALTERNATIVE SB-1 FEATHER RIVER WEST LEVEE LOCATION F7.0R

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

FEB 2013

PLATE 33



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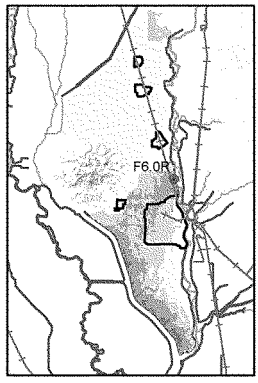
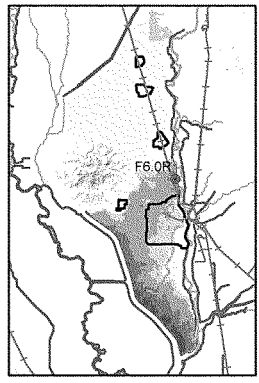
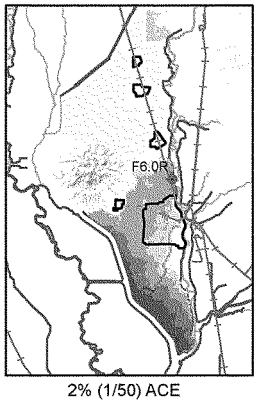


10% (1/10) ACE



4% (1/25) ACE



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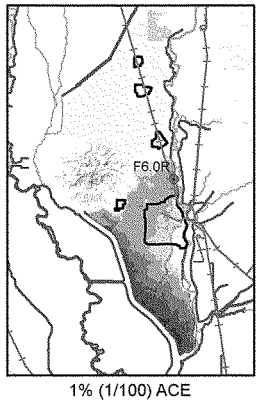
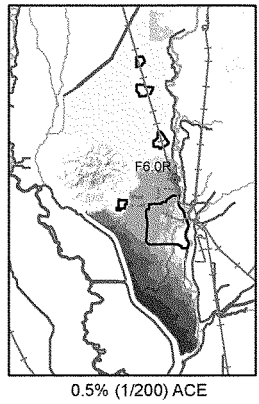


1% (1/100) ACE



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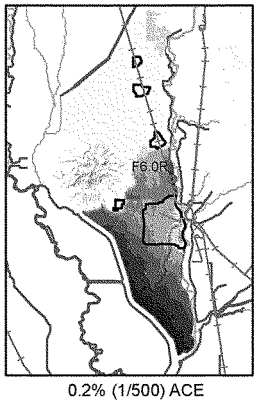


0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20
- Railroad

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

Miles

0 10 20

N

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

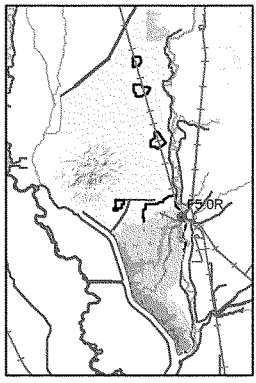
BREACH SIMULATION ALTERNATIVE SB-1 FEATHER RIVER WEST LEVEE LOCATION F6.0R

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

FEB 2013

PLATE 34



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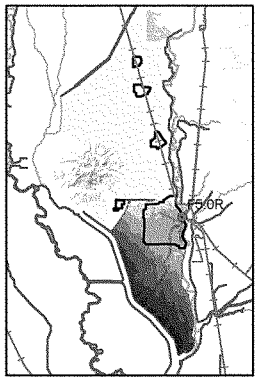

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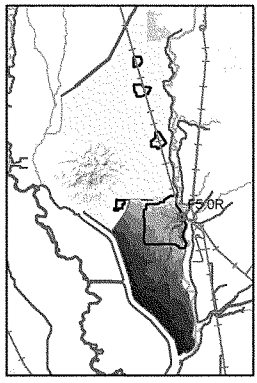

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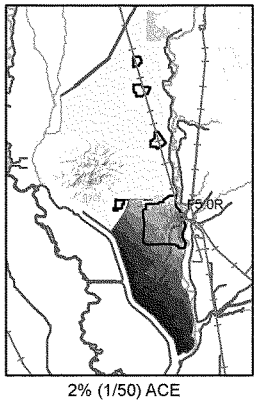

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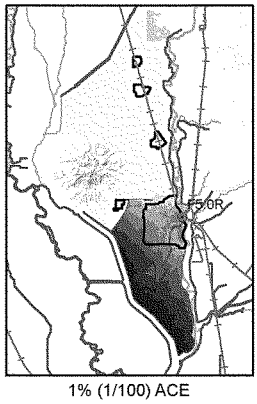
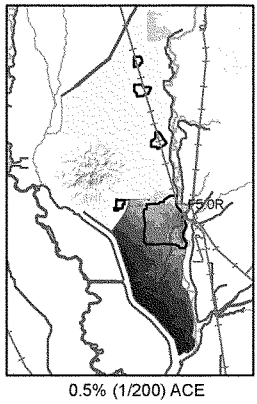
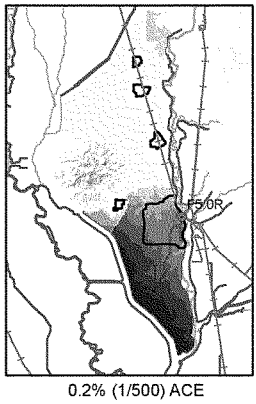


1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20
- Railroad

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

0 10 20 Miles

N

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

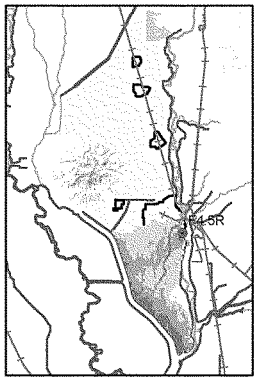
BREACH SIMULATION
ALTERNATIVE SB-1
FEATHER RIVER WEST LEVEE
LOCATION F5.0R

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

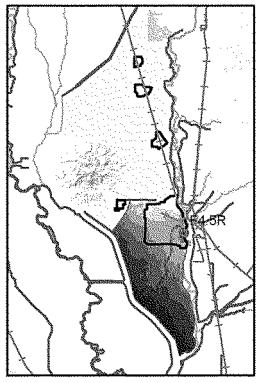
Prepared by T. Hatch

FEB 2013

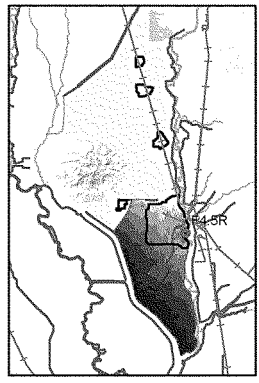
PLATE 35



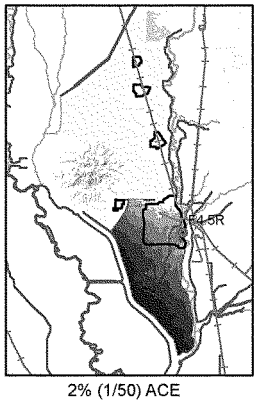
50% (1/2) ACE



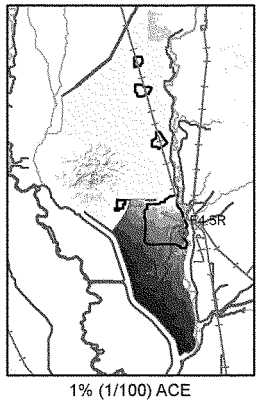
10% (1/10) ACE



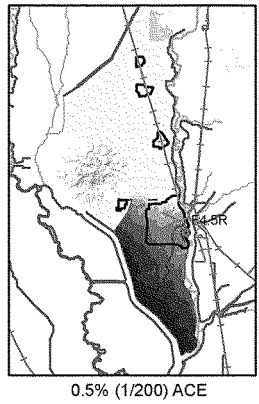
4% (1/25) ACE



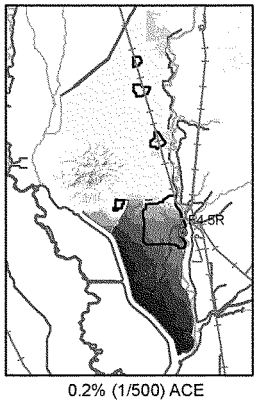
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20
- Railroad

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

Miles

0 10 20

N

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

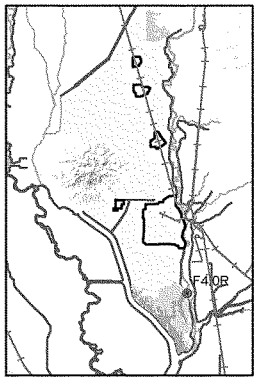
BREACH SIMULATION
ALTERNATIVE SB-1
FEATHER RIVER WEST LEVEE
LOCATION F4.5R

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

FEB 2013

PLATE 36



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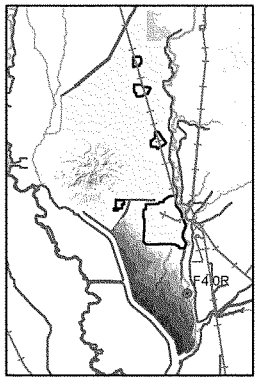

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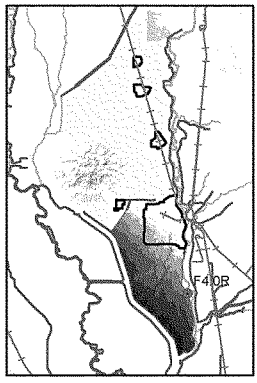
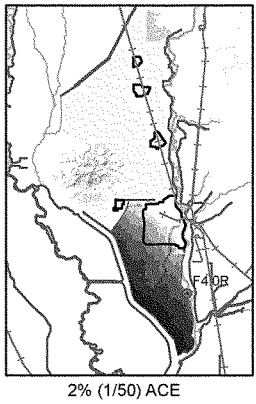
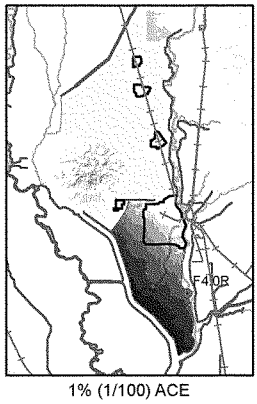


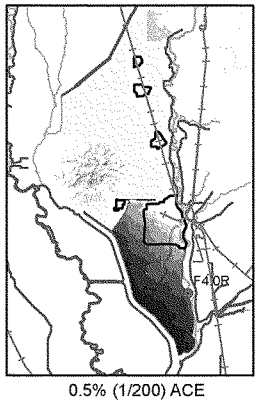
4% (1/25) ACE



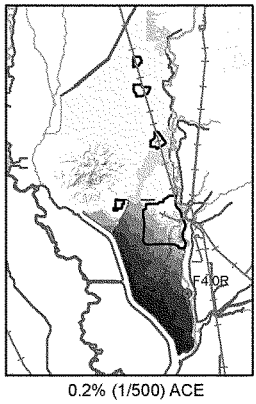
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

0 10 20 Miles

N

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

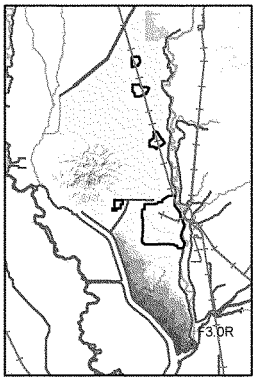
BREACH SIMULATION
ALTERNATIVE SB-1
FEATHER RIVER WEST LEVEE
LOCATION F4.0R

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

FEB 2013

PLATE 37



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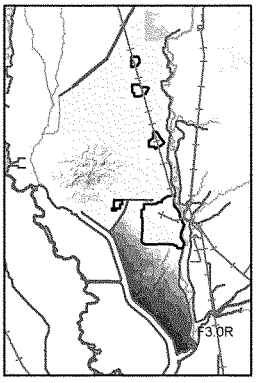
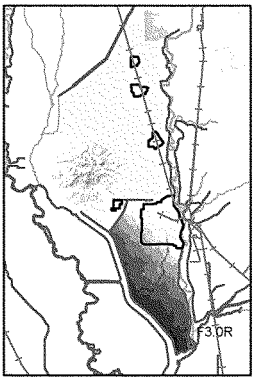
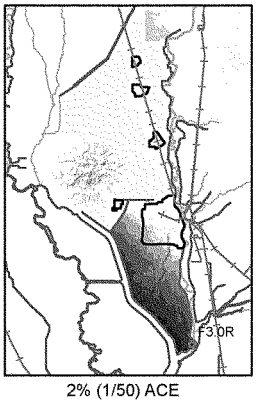


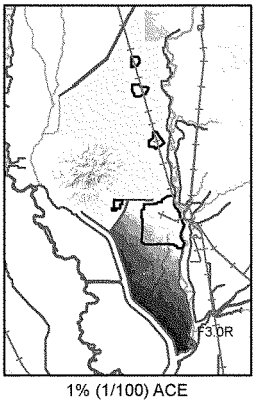
10% (1/10) ACE



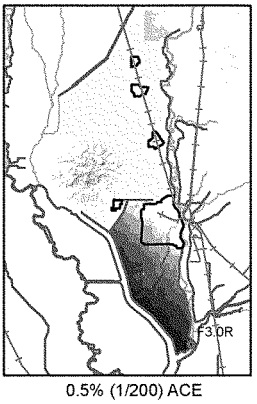
4% (1/25) ACE



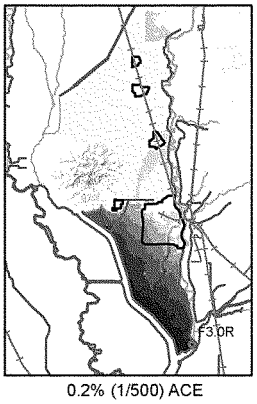
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 25

Railroad

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

Miles

0 10 20

N

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

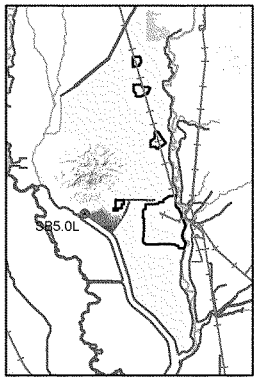
BREACH SIMULATION ALTERNATIVE SB-1 FEATHER RIVER WEST LEVEE LOCATION F3.0R

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

FEB 2013

PLATE 38



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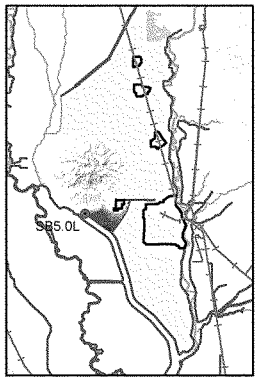

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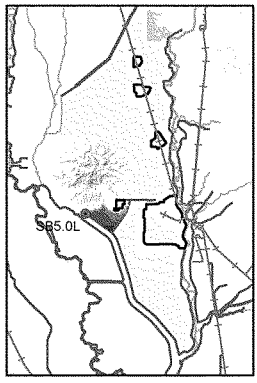
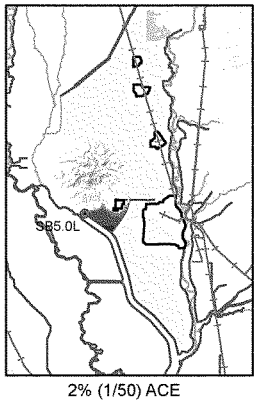
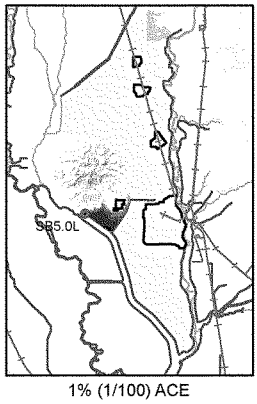


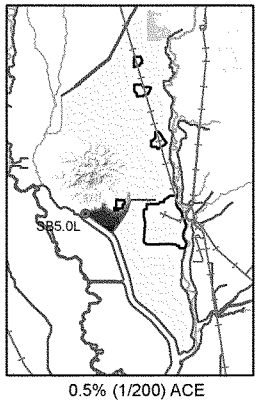
4% (1/25) ACE



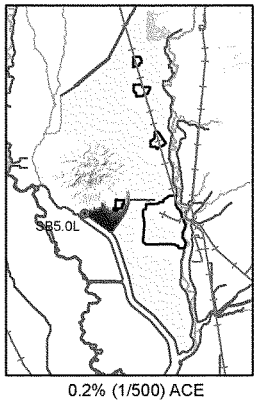
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

0 10 20 Miles

N

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

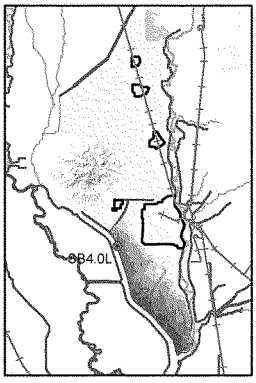
BREACH SIMULATION
ALTERNATIVE SB-1
SUTTER BYPASS EAST LEVEE
LOCATION SB5.0L

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

FEB 2013

PLATE 39



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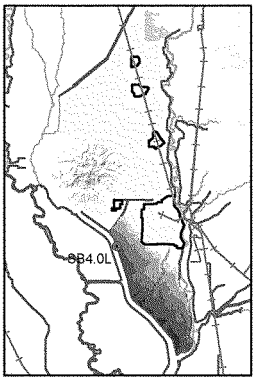
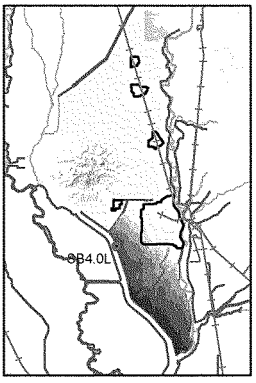
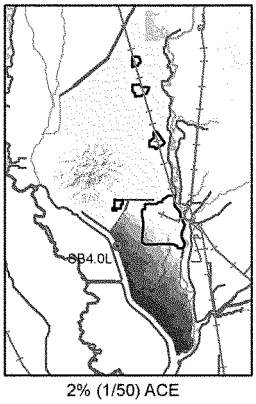


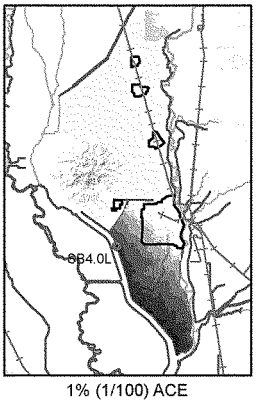
10% (1/10) ACE



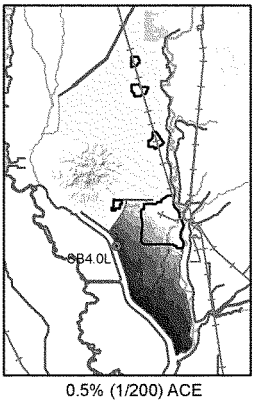
4% (1/25) ACE



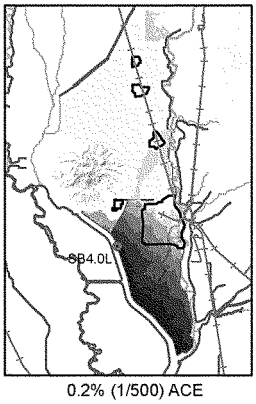
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

Miles

0 10 20

N

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

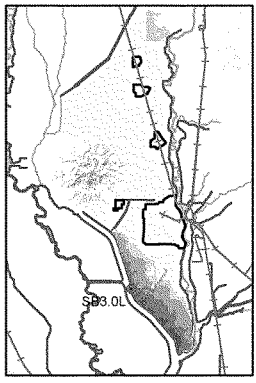
BREACH SIMULATION
ALTERNATIVE SB-1
SUTTER BYPASS EAST LEVEE
LOCATION SB4.0L

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

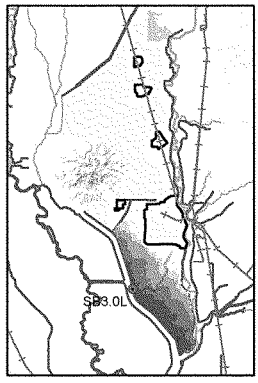
Prepared by T. Hatch

FEB 2013

PLATE 40



50% (1/2) ACE



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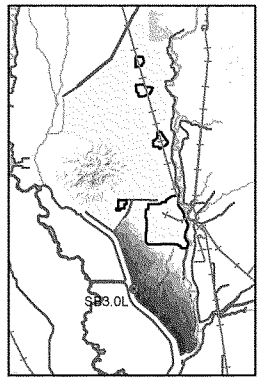
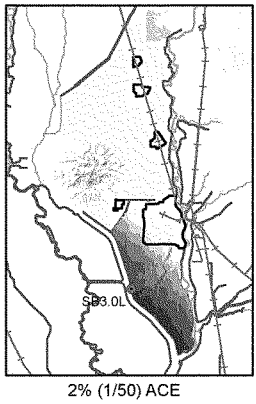
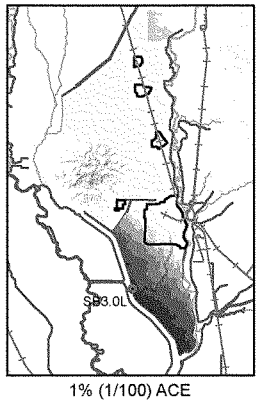


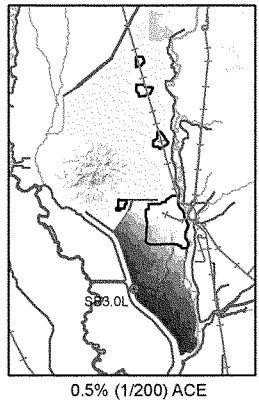
4% (1/25) ACE



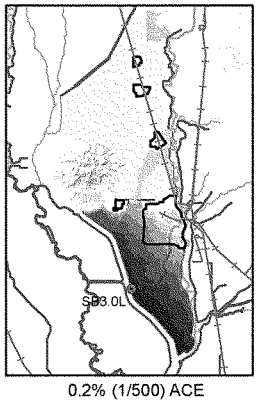
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20
- Railroad

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

0 10 20 Miles

N

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

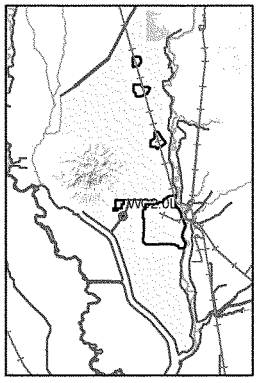
BREACH SIMULATION
ALTERNATIVE SB-1
SUTTER BYPASS EAST LEVEE
LOCATION SB3.0L

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

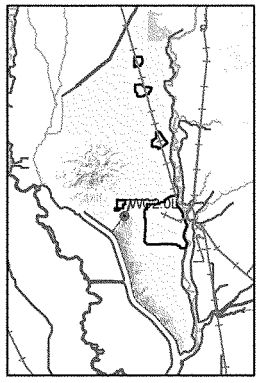
Prepared by T. Hatch

FEB 2013

PLATE 41



50% (1/2) ACE



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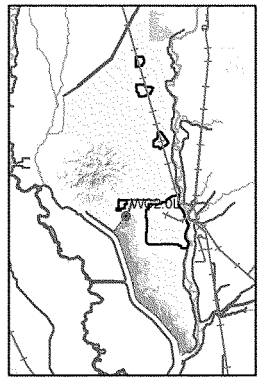
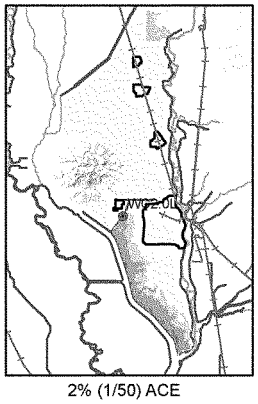
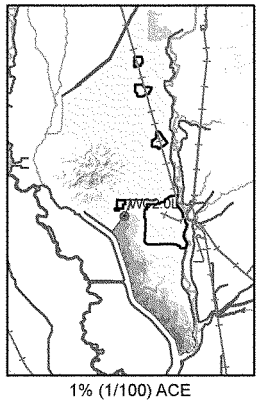


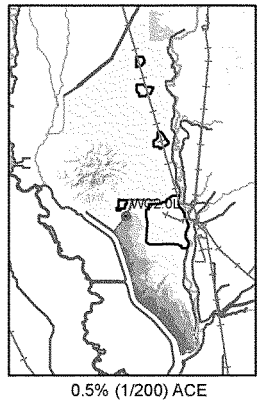
4% (1/25) ACE



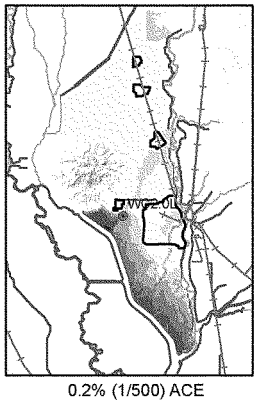
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

Miles

0 10 20

N

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

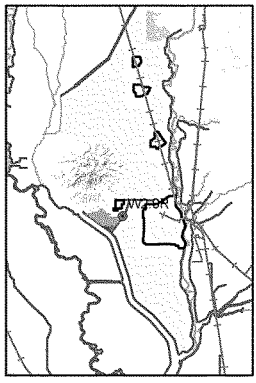
BREACH SIMULATION ALTERNATIVE SB-1 WADSWORTH CANAL SOUTH LEVEE LOCATION WC2.0L

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

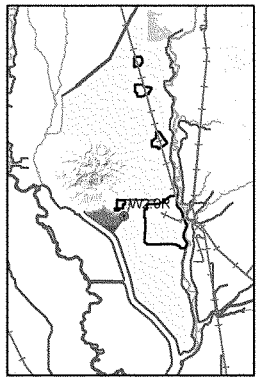
Prepared by T. Hatch

FEB 2013

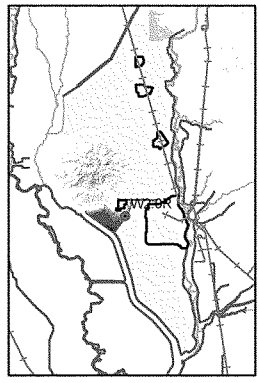
PLATE 42



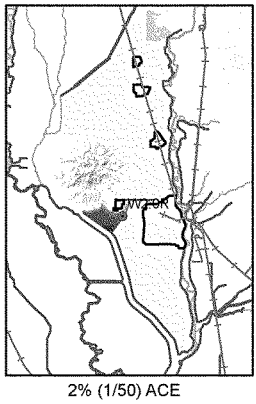
50% (1/2) ACE



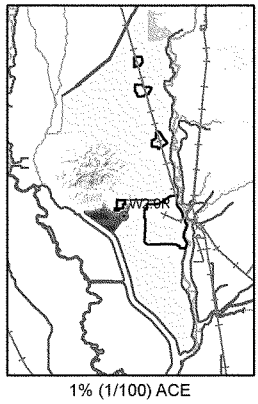
10% (1/10) ACE



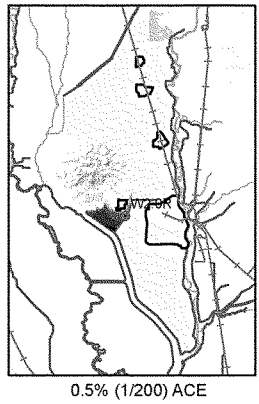
4% (1/25) ACE



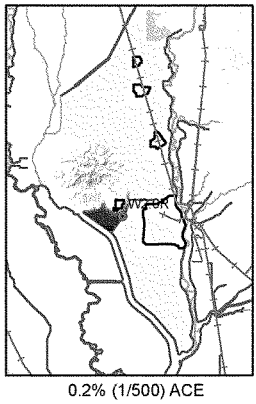
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20

Railroad

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

0 10 20 Miles

N

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

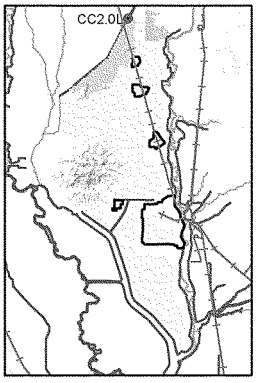
BREACH SIMULATION
ALTERNATIVE SB-1
WADSWORTH CANAL NORTH LEVEE
LOCATION W2.0R

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

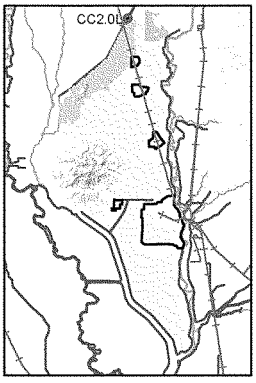
Prepared by T. Hatch

FEB 2013

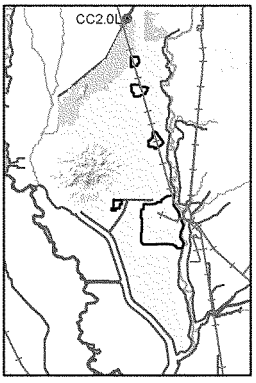
PLATE 43



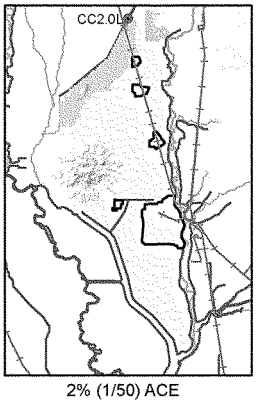
50% (1/2) ACE



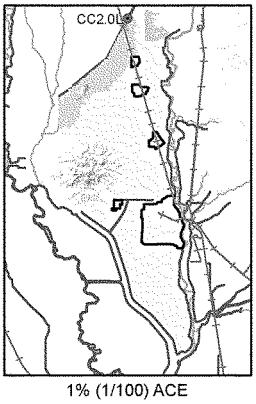
10% (1/10) ACE



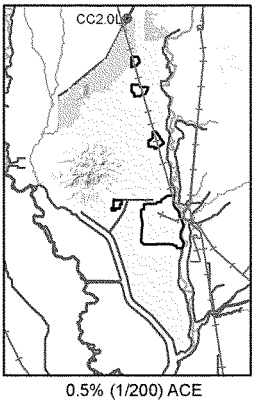
4% (1/25) ACE



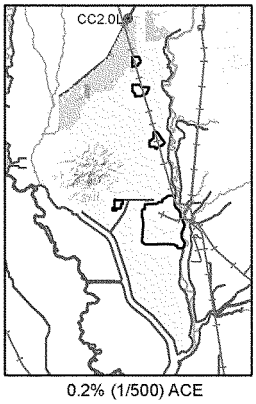
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20
- Railroad

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

Miles

0 10 20

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

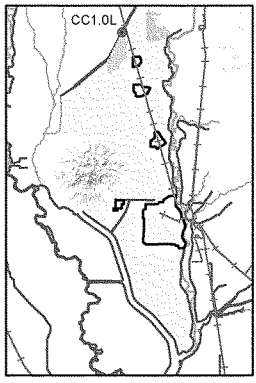
BREACH SIMULATION ALTERNATIVE SB-1 CHEROKEE CANAL SOUTH LEVEE LOCATION CC2.0L

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

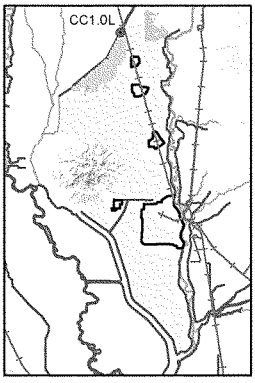
Prepared by T. Hatch

FEB 2013

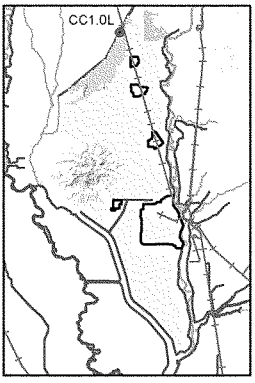
PLATE 44



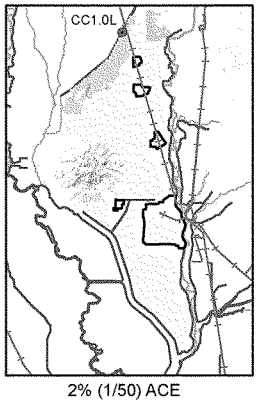
50% (1/2) ACE



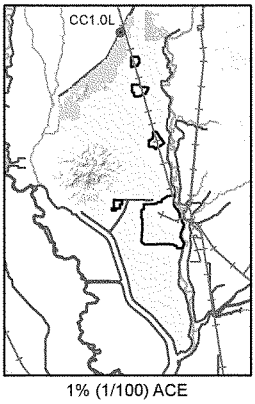
10% (1/10) ACE



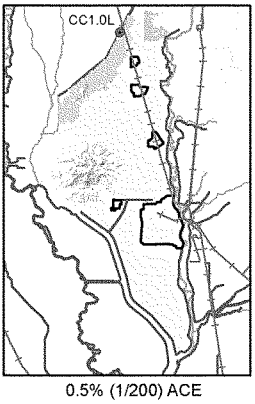
4% (1/25) ACE



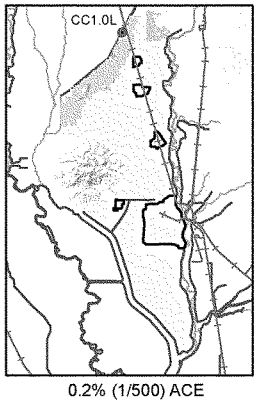
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20
- Railroad

0 10 20 Miles

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

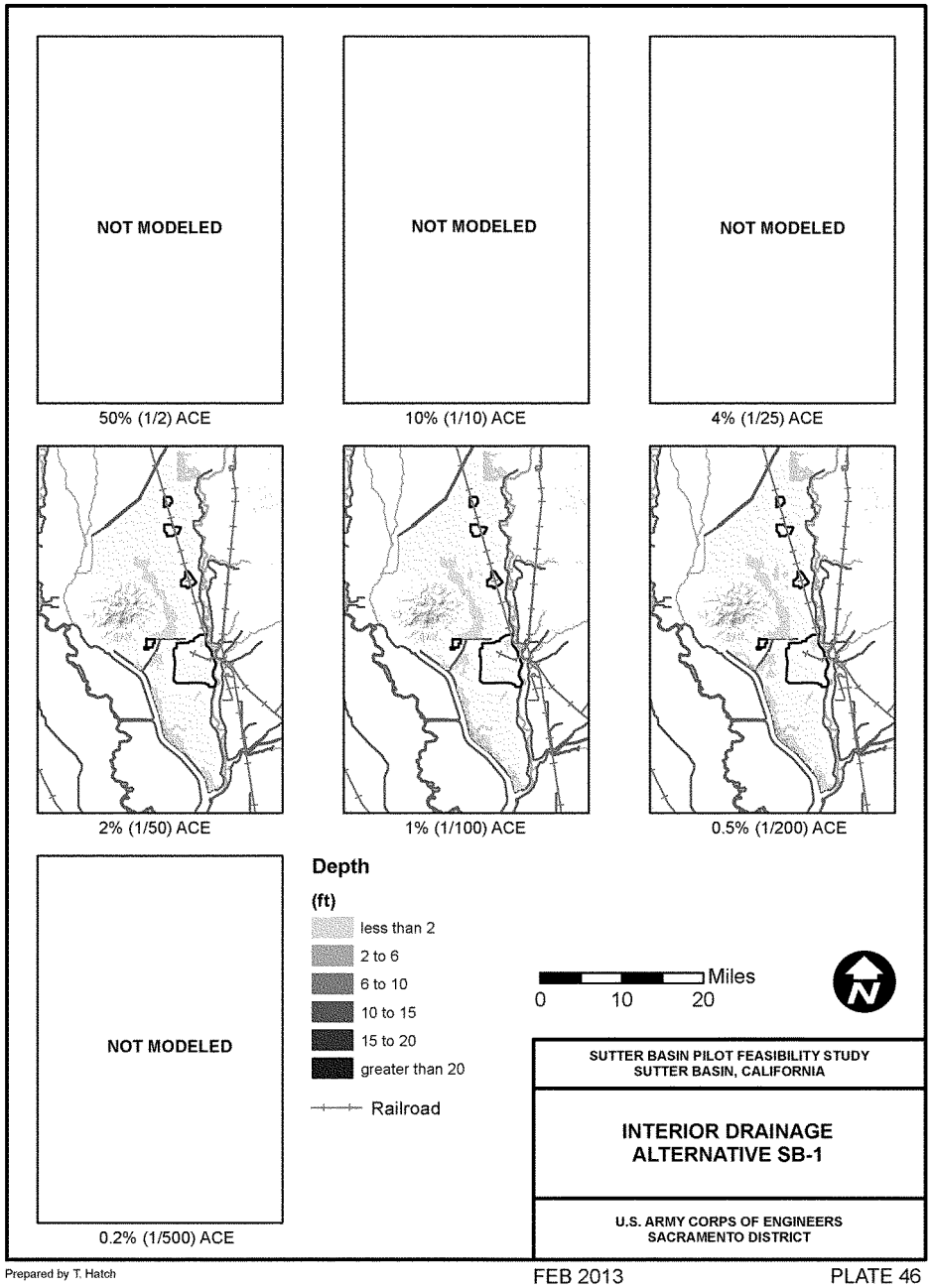
BREACH SIMULATION ALTERNATIVE SB-1 CHEROKEE CANAL SOUTH LEVEE LOCATION CC1.0L

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

FEB 2013

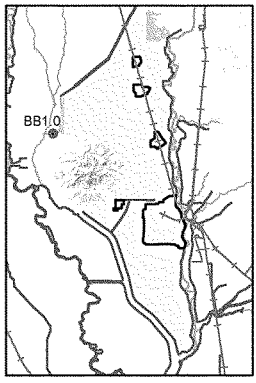
PLATE 45



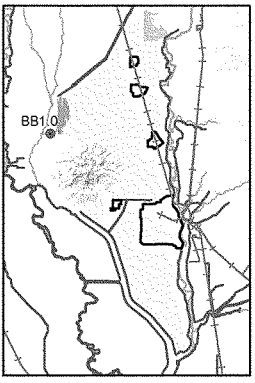
Prepared by T. Hatch

FEB 2013

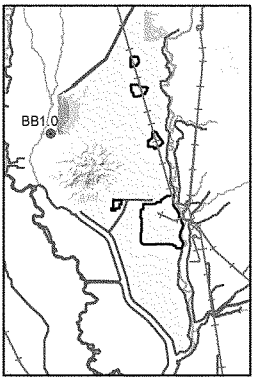
PLATE 46



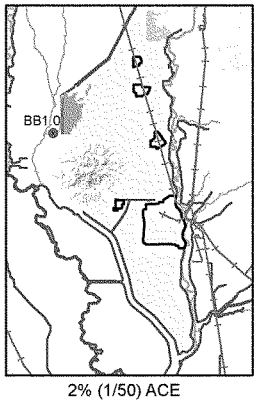
50% (1/2) ACE



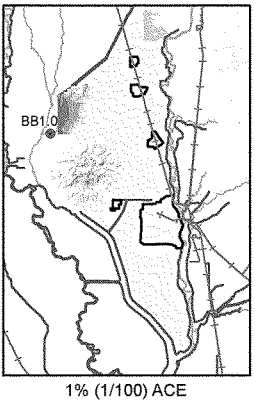
10% (1/10) ACE



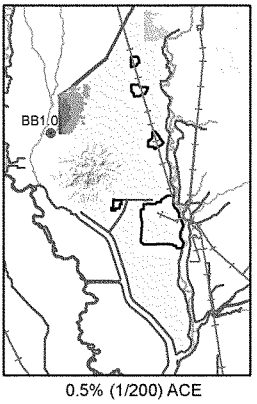
4% (1/25) ACE



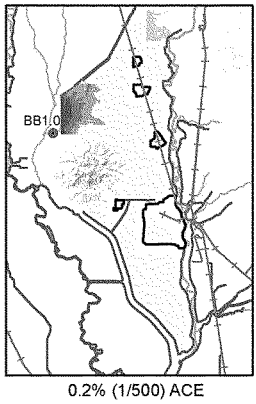
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20
- Railroad

0 10 20 Miles

N

NOTE: MAP DEPICTS OVERTOPPING WITHOUT FAILURE IN REACHES WITHOUT A BREACH

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

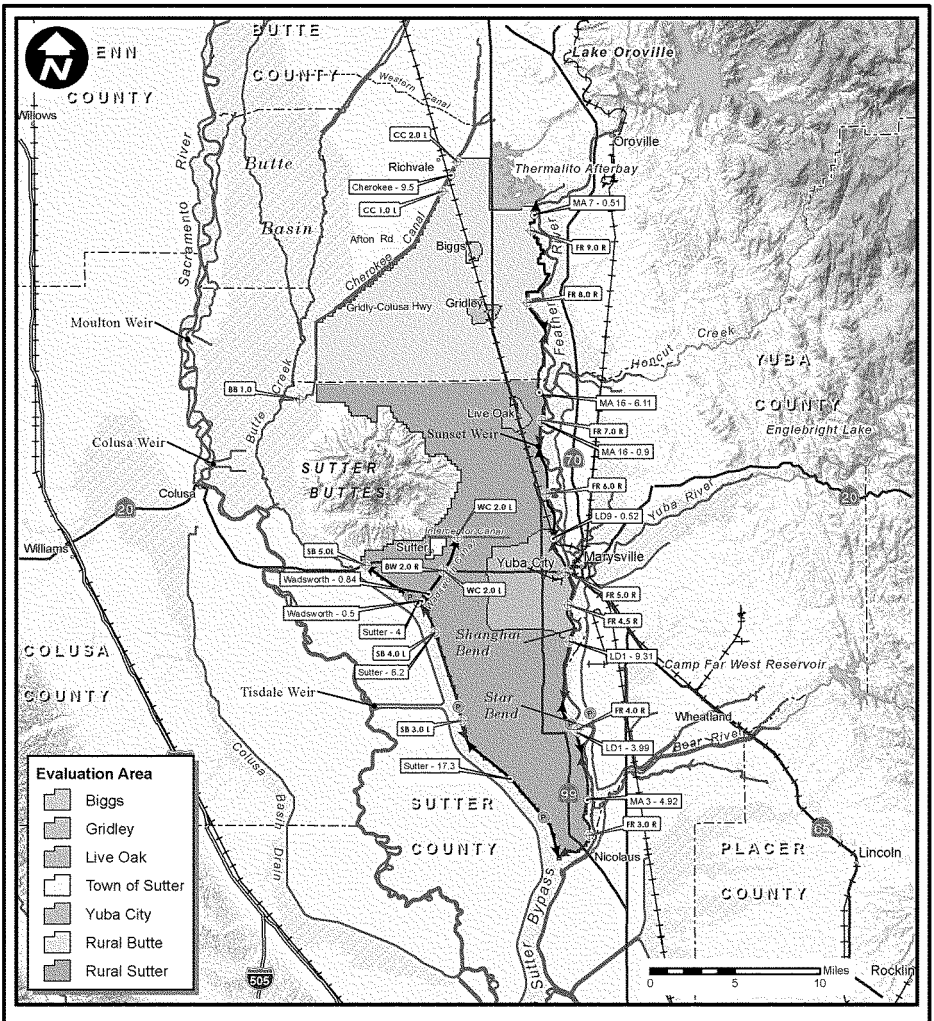
ALTERNATIVE SB-1
BUTTE BASIN
LOCATION BB1.0

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

FEB 2013

PLATE 47



Legend

- Geotechnical Levee Reach
- Federal Levee
- Breach Simulation Site
- Geotechnical Index Point
- Pump Station
- City or Town
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

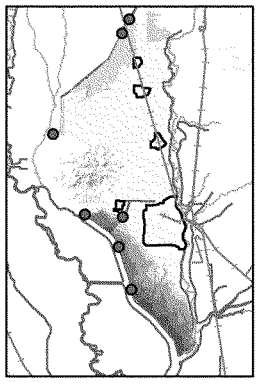
INDEX POINTS AND ECONOMIC IMPACT AREAS

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

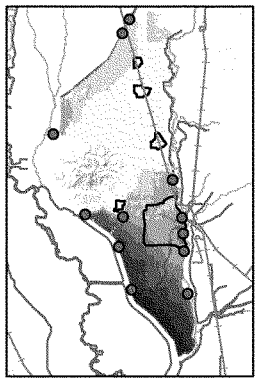
Prepared by Jim Mars

FEB 2013

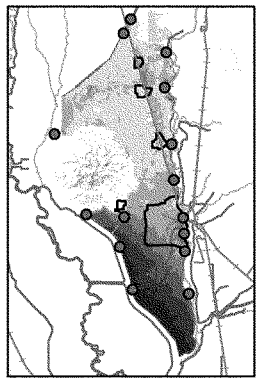
PLATE 48



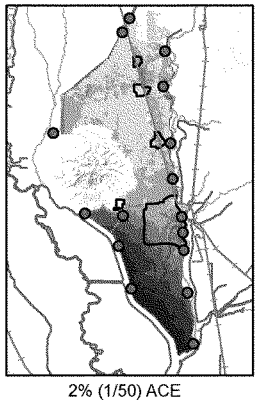
50% (1/2) ACE



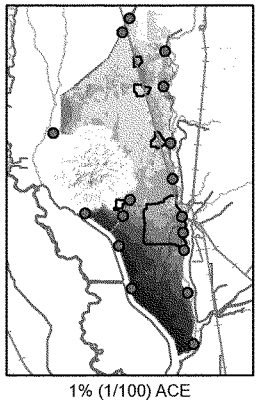
10% (1/10) ACE



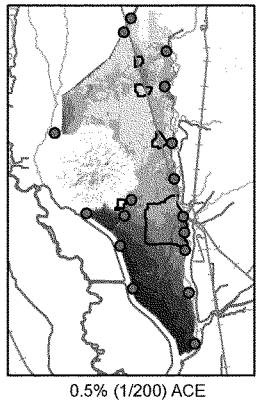
4% (1/25) ACE



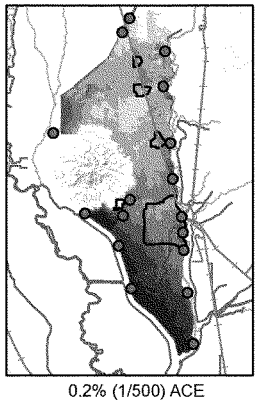
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20
- Railroad
- Levee Fails R&U Criteria

NOTE: Breach simulation shown if levee does not pass assurance criteria.1) Assurance less than 90% the levee does not pass criteria 2) For assurance between 90 and 95% levee must have minimum of 3 feet of freeboard to pass criteria. 3) For assurance greater than 95% levee must have minimum of 2 feet of freeboard to pass criteria

Miles

0 10 20

N

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

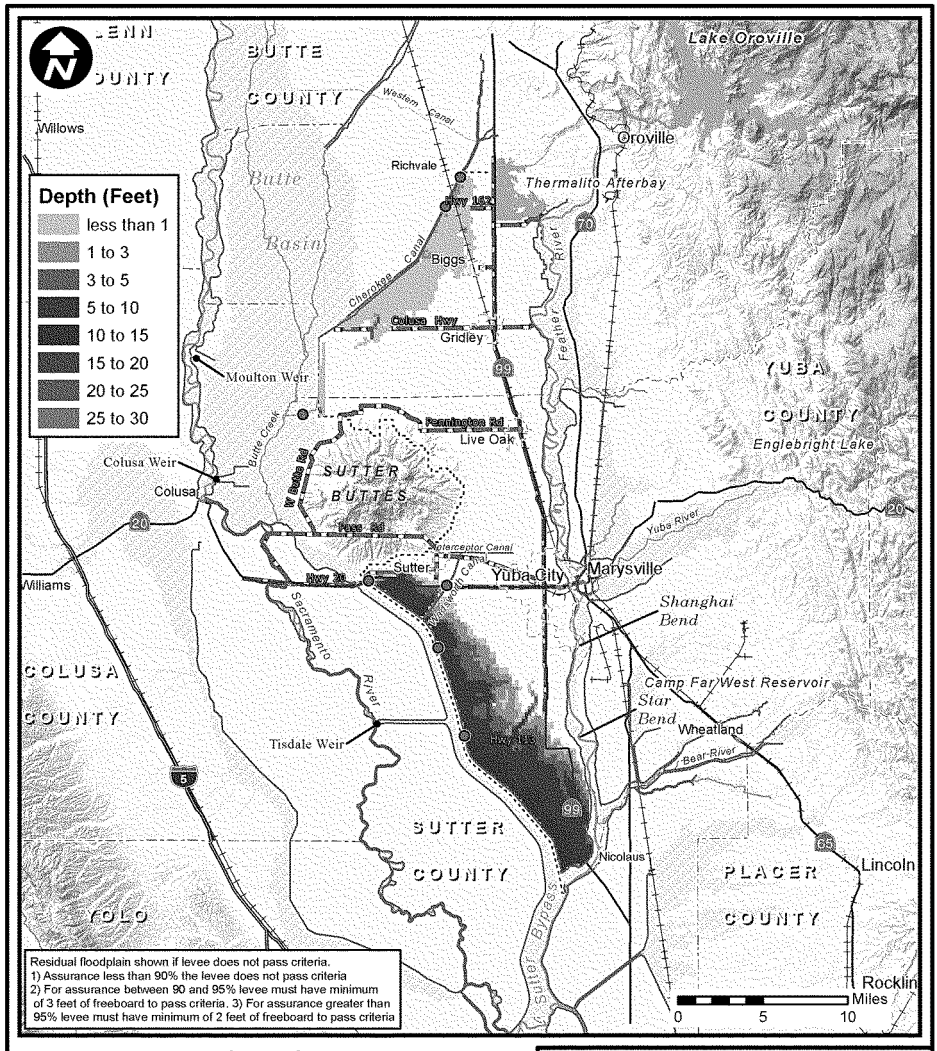
COMPOSITE FLOODPLAINS ALTERNATIVE SB-1 WITHOUT PROJECT CONDITIONS

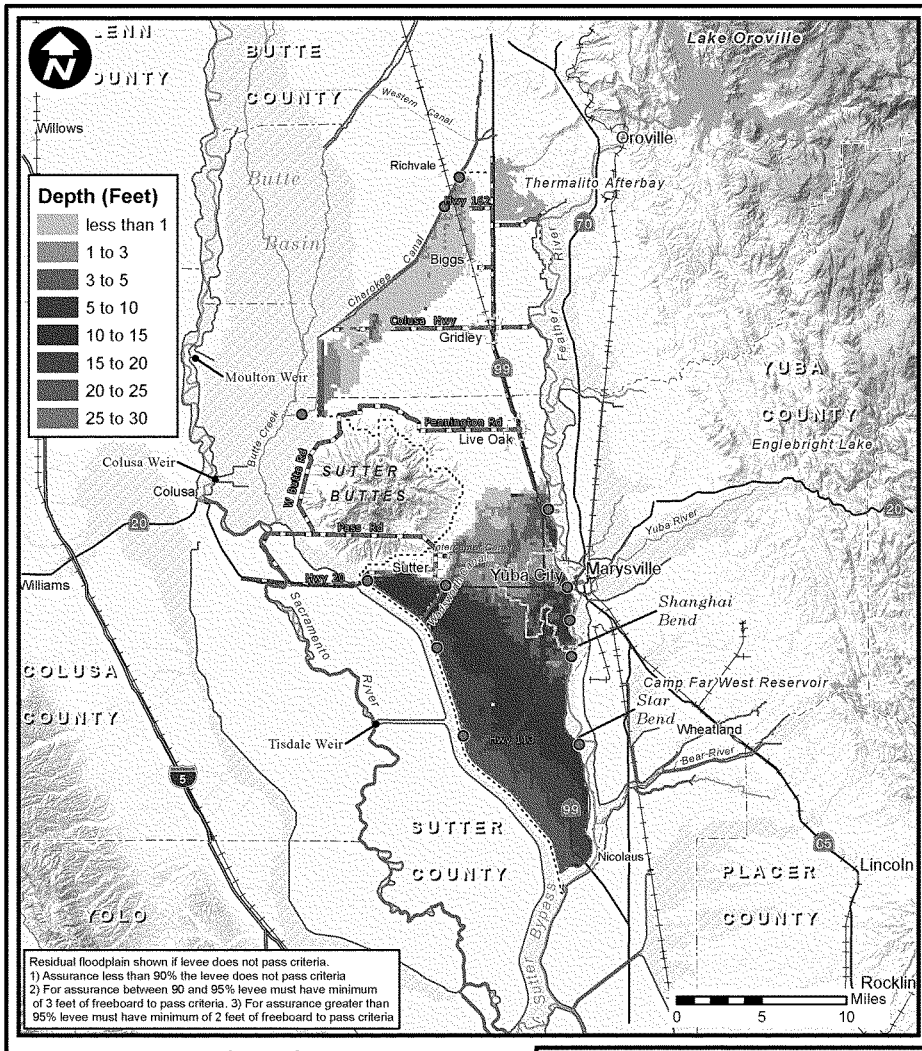
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

FEB 2013

PLATE 49


Depth (Feet)
less than 1
1 to 3
3 to 5
5 to 10
10 to 15
15 to 20
20 to 25
25 to 30
Willows
BUTTE COUNTY
Western Canal
Butte Basin
Richvale
Hwy 162
Biggs
Cherokee Canal
Colusa Hwy
Gridley
Moulton Weir
Butte Creek
Pennington Rd
Live Oak
SUTTER BUTTES
Colusa Weir
Colusa
W Butte Rd
Hwy 20
Interceptor Canal
Sutter
Hwy 99
Yuba City
Marysville
Yuba River
Feather River
Lake Oroville
Oroville
Thermalito Afterbay
Shanghai Bend
Camp Far West Reservoir
Star Bend
Wheatland
Bear River
Williams
COLUSA COUNTY
Sacramento River
Tisdale Weir
SUTTER COUNTY
Nicolaus
Sutter Bypass
PLACER COUNTY
Lincoln
Rocklin
YUBA COUNTY
Englebright Lake
YOLO
Residual floodplain shown if levee does not pass criteria.
1) Assurance less than 90% the levee does not pass criteria
2) For assurance between 90 and 95% levee must have minimum of 3 feet of freeboard to pass criteria. 3) For assurance greater than 95% levee must have minimum of 2 feet of freeboard to pass criteria
0
5
10
Miles
Legend
Federal Levee
River or Stream
Lake or Reservoir
Designated Floodways
Study Area Extent
Breach Simulation Point
Evacuation Routes
Highway
Railroad
County Boundary
City Limit
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA
50% (1/2) ACE FLOODPLAIN
ALTERNATIVE SB-1
WITHOUT PROJECT CONDITIONS
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
Prepared by Jim Mars
FEB 2013
PLATE 50



Legend

- Federal Levee
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Breach Simulation Point
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

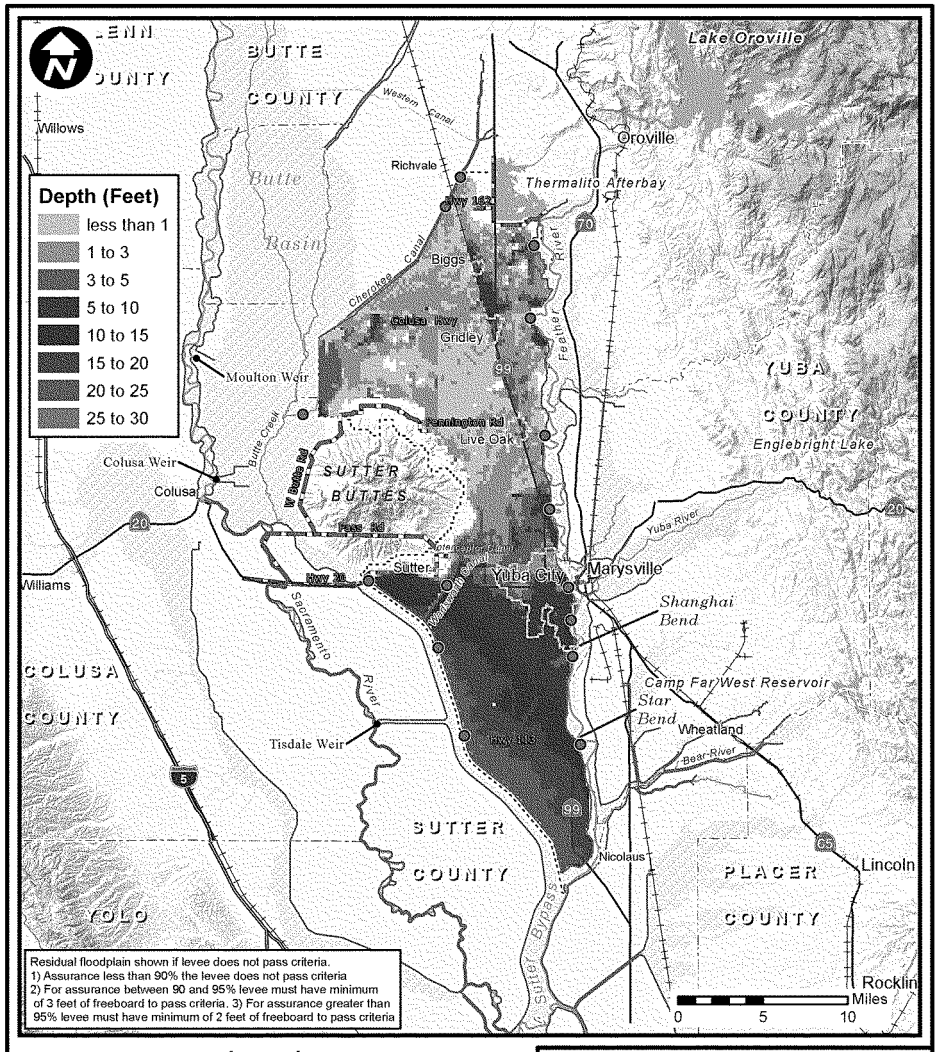
10% (1/10) ACE FLOODPLAIN ALTERNATIVE SB-1 WITHOUT PROJECT CONDITIONS

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 51



Legend

- Federal Levee
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Breach Simulation Point
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

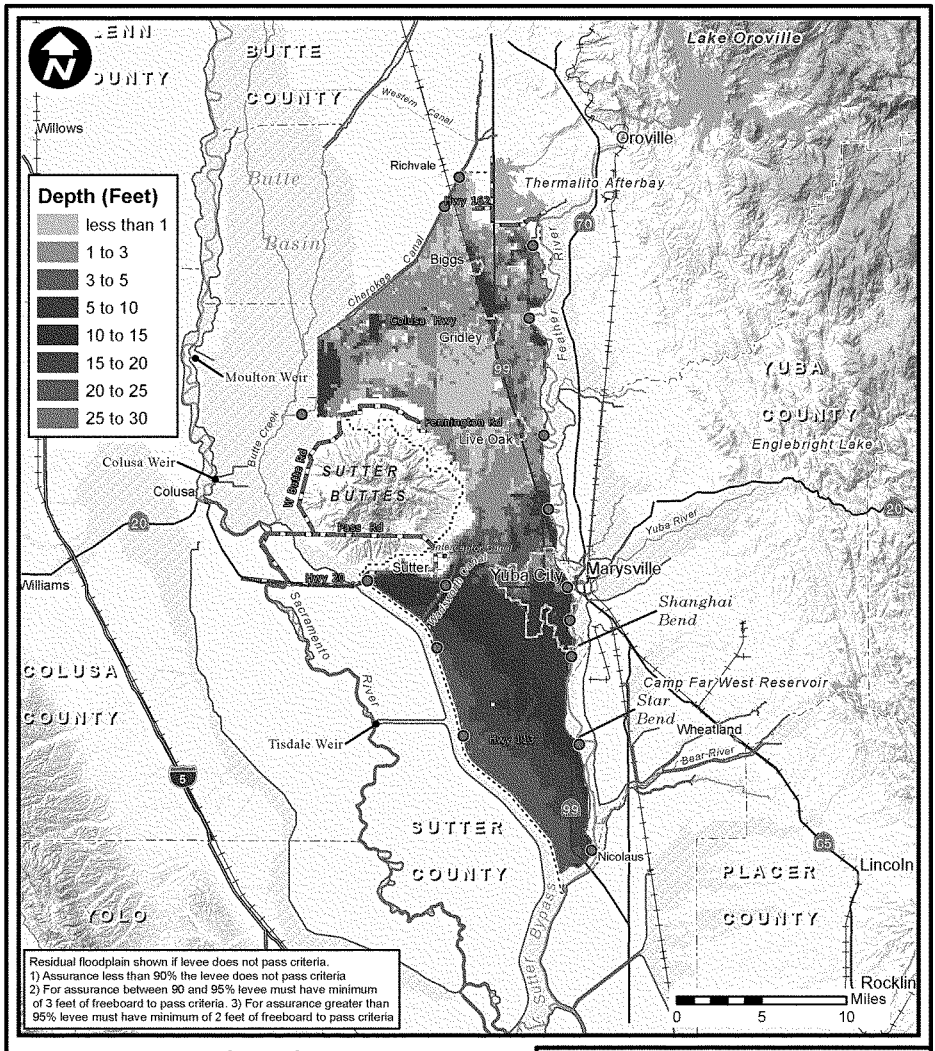
4% (1/25) ACE FLOODPLAIN ALTERNATIVE SB-1 WITHOUT PROJECT CONDITIONS

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 52



Legend

- Federal Levee
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Breach Simulation Point
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

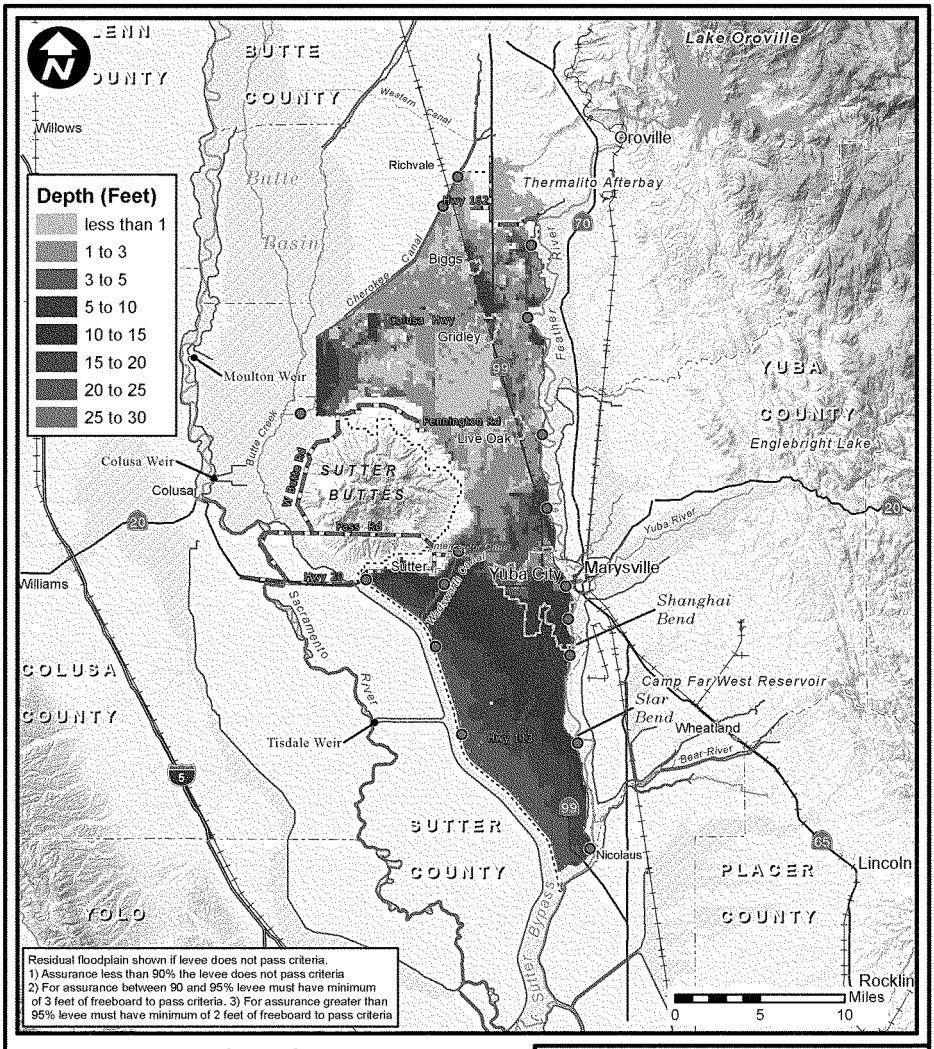
2% (1/50) ACE FLOODPLAIN
ALTERNATIVE SB-1
WITHOUT PROJECT CONDITIONS

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 53



Legend

- Federal Levee
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Breach Simulation Point
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

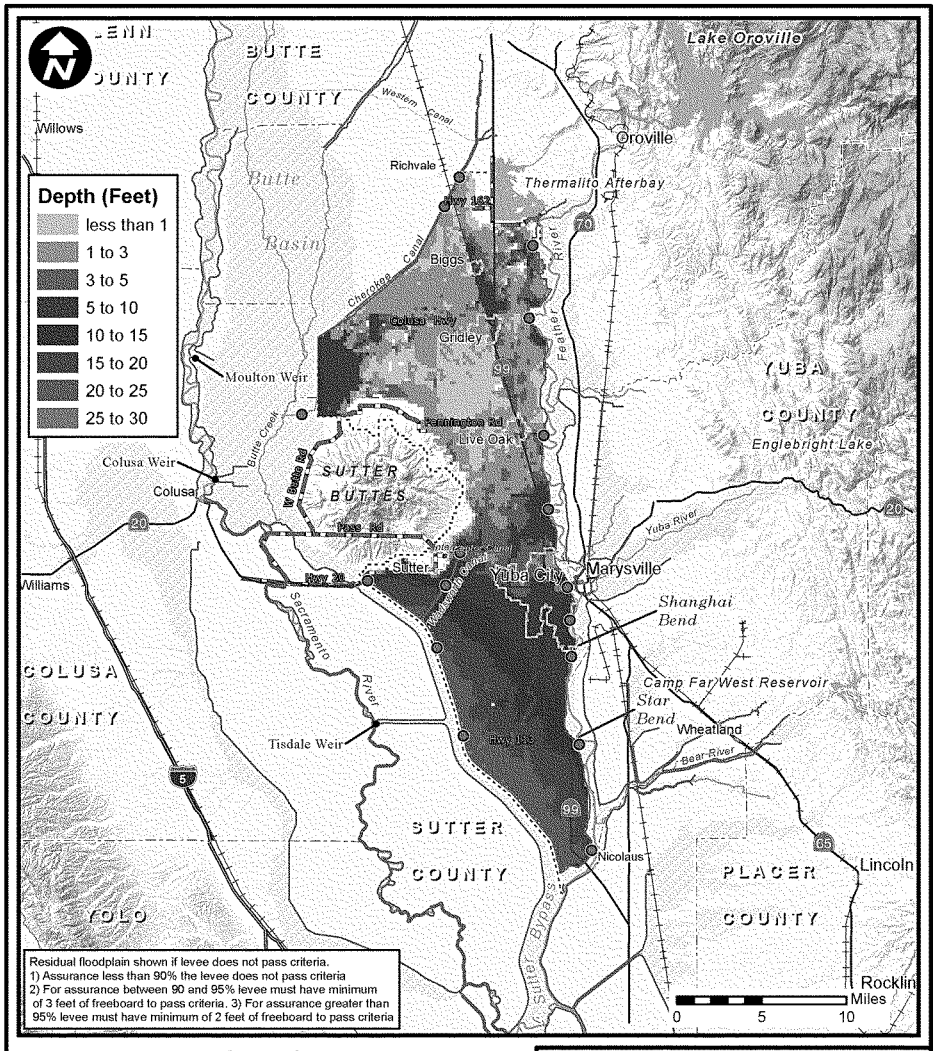
1% (1/100) ACE FLOODPLAIN ALTERNATIVE SB-1 WITHOUT PROJECT CONDITIONS

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 54



Legend

- Federal Levee
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Breach Simulation Point
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

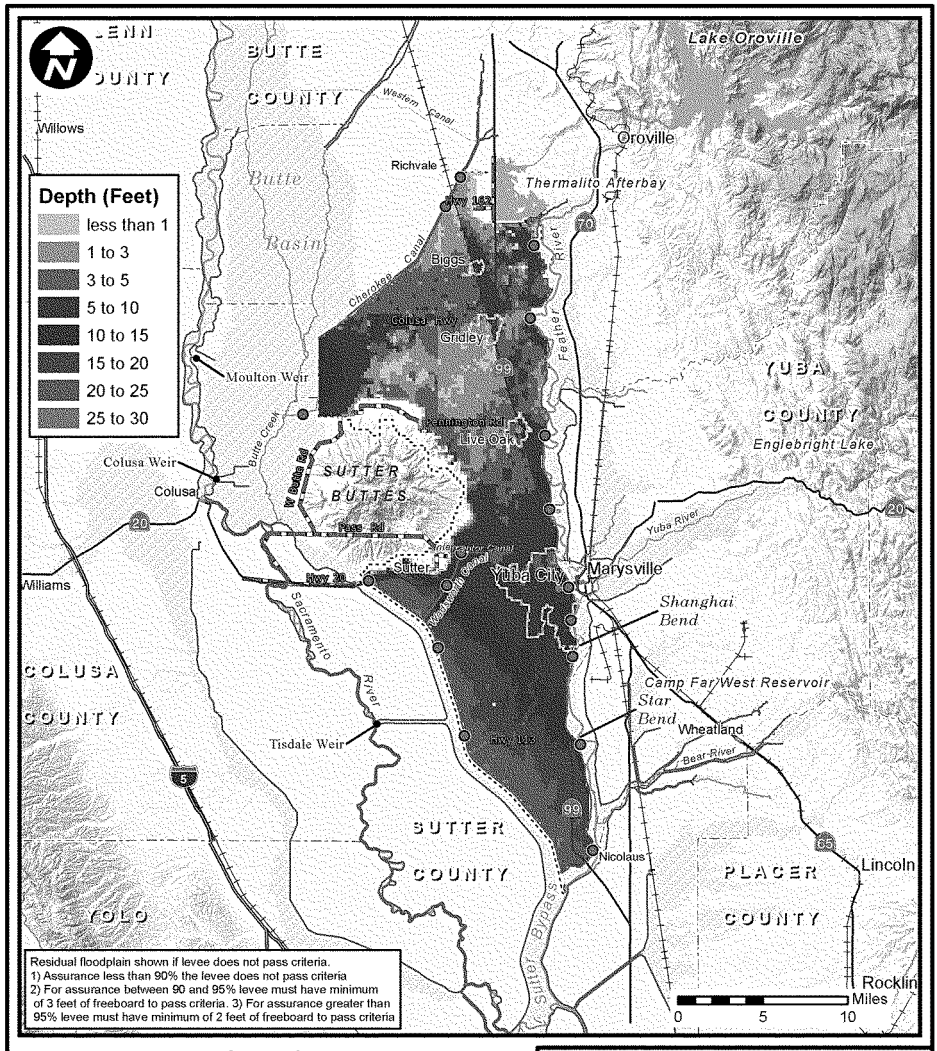
0.5% (1/200) ACE FLOODPLAIN ALTERNATIVE SB-1 WITHOUT PROJECT CONDITIONS

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 55



Legend

- Federal Levee
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Breach Simulation Point
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

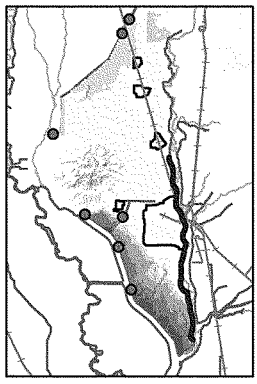
0.2% (1/500) ACE FLOODPLAIN ALTERNATIVE SB-1 WITHOUT PROJECT CONDITIONS

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

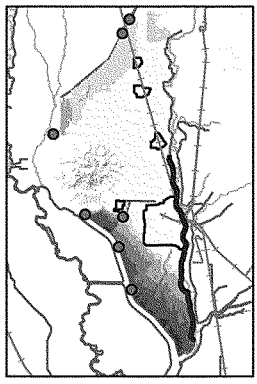
Prepared by Jim Mars

FEB 2013

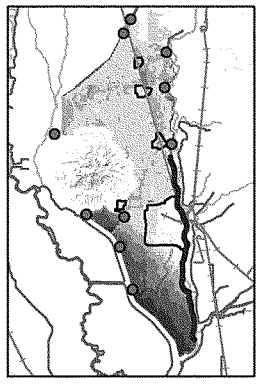
PLATE 56



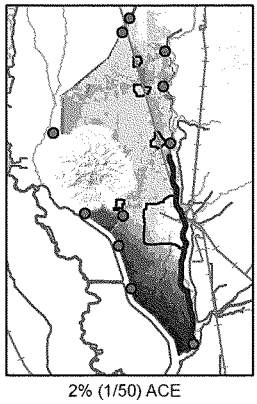
50% (1/2) ACE



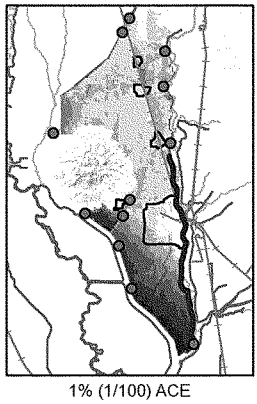
10% (1/10) ACE



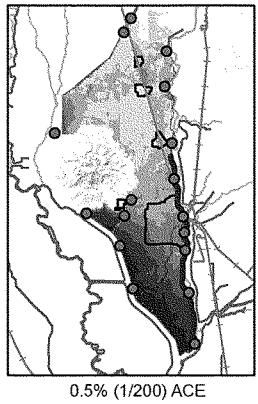
4% (1/25) ACE



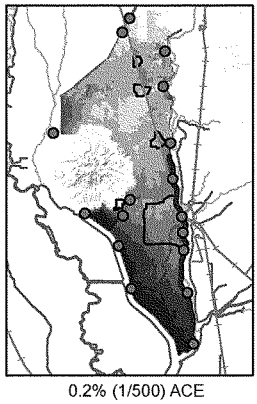
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20
- Railroad
- Alternative
- Levee Fails R&U Criteria

NOTE: Breach simulation shown if levee does not pass assurance criteria.1) Assurance less than 90% the levee does not pass criteria 2) For assurance between 90 and 95% levee must have minimum of 3 feet of freeboard to pass criteria. 3) For assurance greater than 95% levee must have minimum of 2 feet of freeboard to pass criteria

0 10 20 Miles

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

R&U ASSURANCE FLOODPLAINS
ALTERNATIVE SB-7
FIX-IN-PLACE
SUNSET WEIR TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

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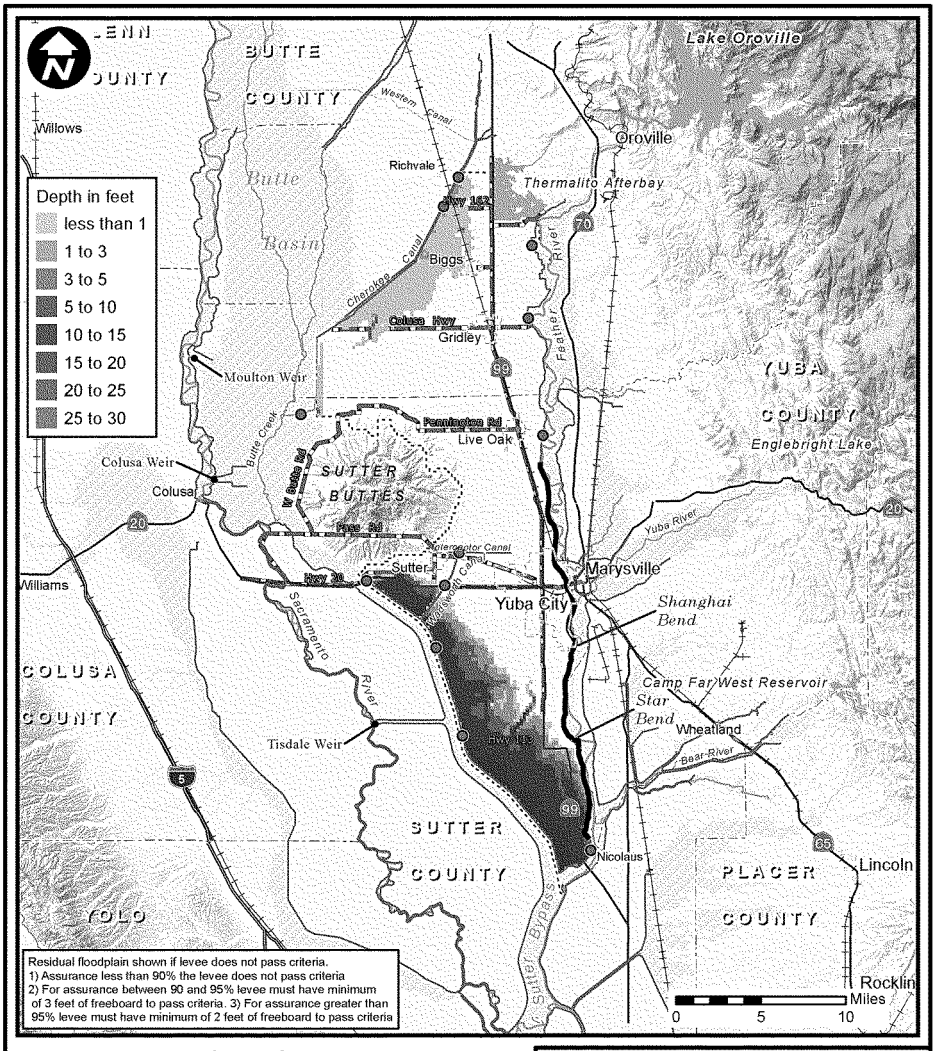
PLATE 57



Legend

- Federal Levee
- Alternative SB-7
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Levee Fails Criteria
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

50% (1/2) ACE FLOODPLAIN
ALTERNATIVE SB-7
FIX IN PLACE FEATHER RIVER,
SUNSET WEIR TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

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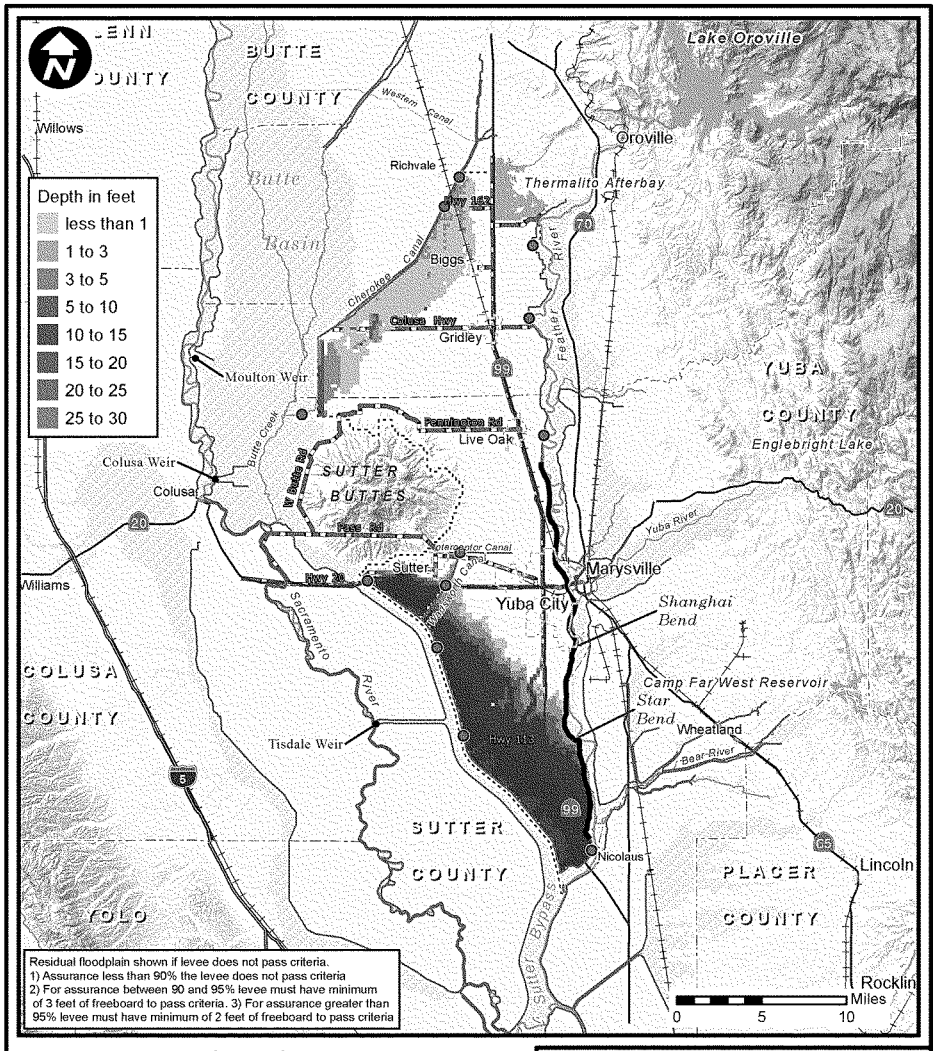
PLATE 58



Legend

- Federal Levee
- Alternative SB-7
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Levee Fails Criteria
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

10% (1/10) ACE FLOODPLAIN
ALTERNATIVE SB-7
FIX IN PLACE FEATHER RIVER,
SUNSET WEIR TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

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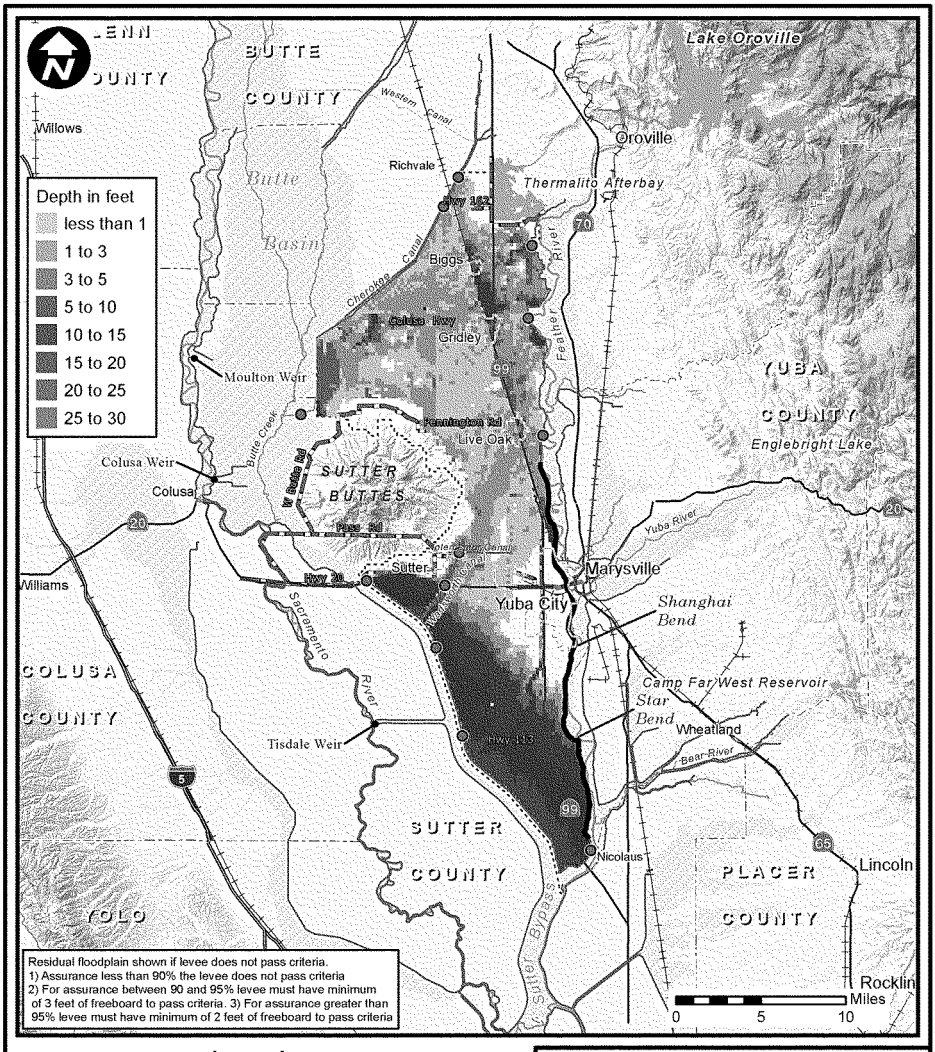
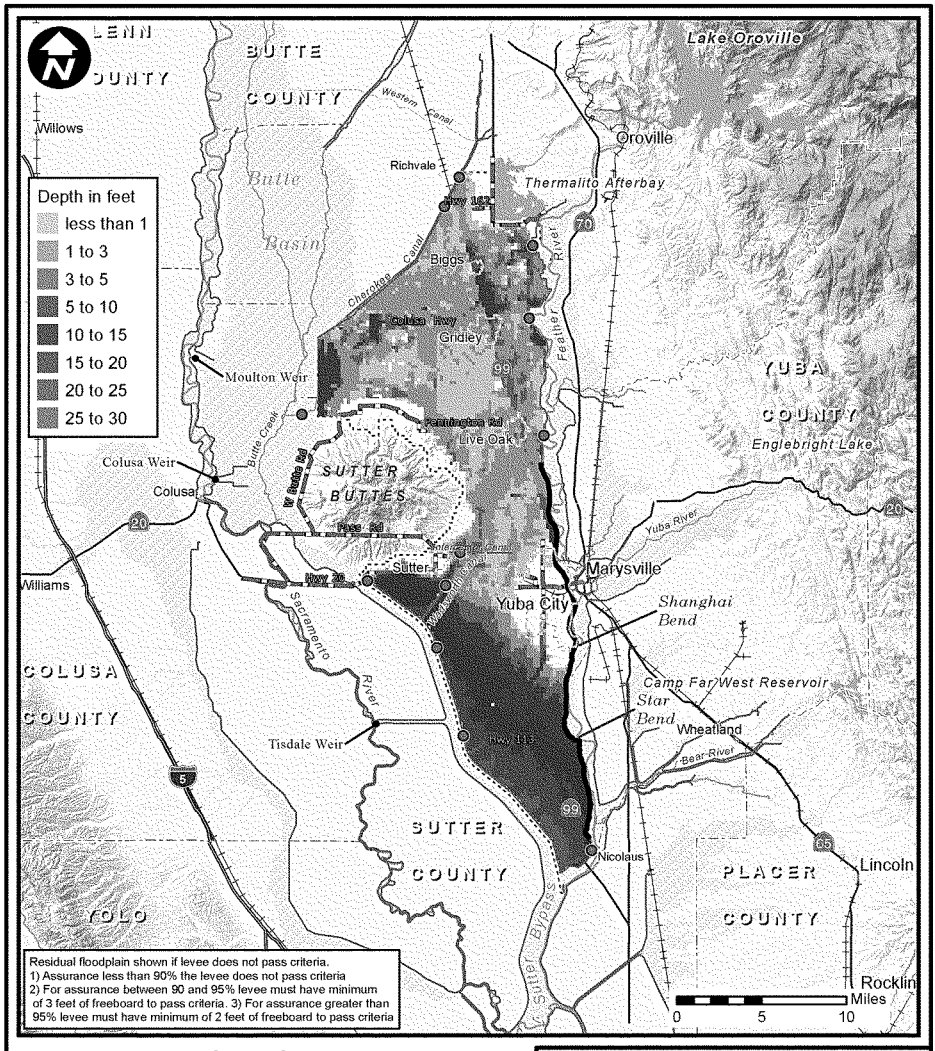
PLATE 59


Depth in feet
less than 1
1 to 3
3 to 5
5 to 10
10 to 15
15 to 20
20 to 25
25 to 30
BUTTE COUNTY
Willows
Butte Basin
Western Canal
Richvale
Hwy 162
Biggs
Cherokee Canal
Gridley
Colusa Hwy
Moulton Weir
Pennington Rd
Live Oak
Butte Creek
Colusa Weir
Colusa
W Butte Rd
SUTTER BUTTES
Pass Rd
Sutter
Hwy 20
Williams
COLUSA COUNTY
Sacramento River
Tisdale Weir
Hwy 113
SUTTER COUNTY
YOLO
Sutter Bypass
Nicolaus
Lake Oroville
Oroville
Thermalito Afterbay
Feather River
YUBA COUNTY
Englebright Lake
Yuba River
Marysville
Yuba City
Shanghai Bend
Camp Far West Reservoir
Star Bend
Wheatland
Bear River
PLACER COUNTY
Lincoln
Rocklin
Miles
0
5
10
Residual floodplain shown if levee does not pass criteria.
1) Assurance less than 90% the levee does not pass criteria
2) For assurance between 90 and 95% levee must have minimum of 3 feet of freeboard to pass criteria. 3) For assurance greater than 95% levee must have minimum of 2 feet of freeboard to pass criteria
Legend
Federal Levee
Alternative SB-7
River or Stream
Lake or Reservoir
Designated Floodways
Study Area Extent
Levee Fails Criteria
Evacuation Routes
Highway
Railroad
County Boundary
City Limit
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA
4% (1/25) ACE FLOODPLAIN
ALTERNATIVE SB-7
FIX IN PLACE FEATHER RIVER,
SUNSET WEIR TO LAUREL AVE
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
Prepared by Jim Mars
FEB 2013
PLATE 60



Legend

- Federal Levee
- Alternative SB-7
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Levee Fails Criteria
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

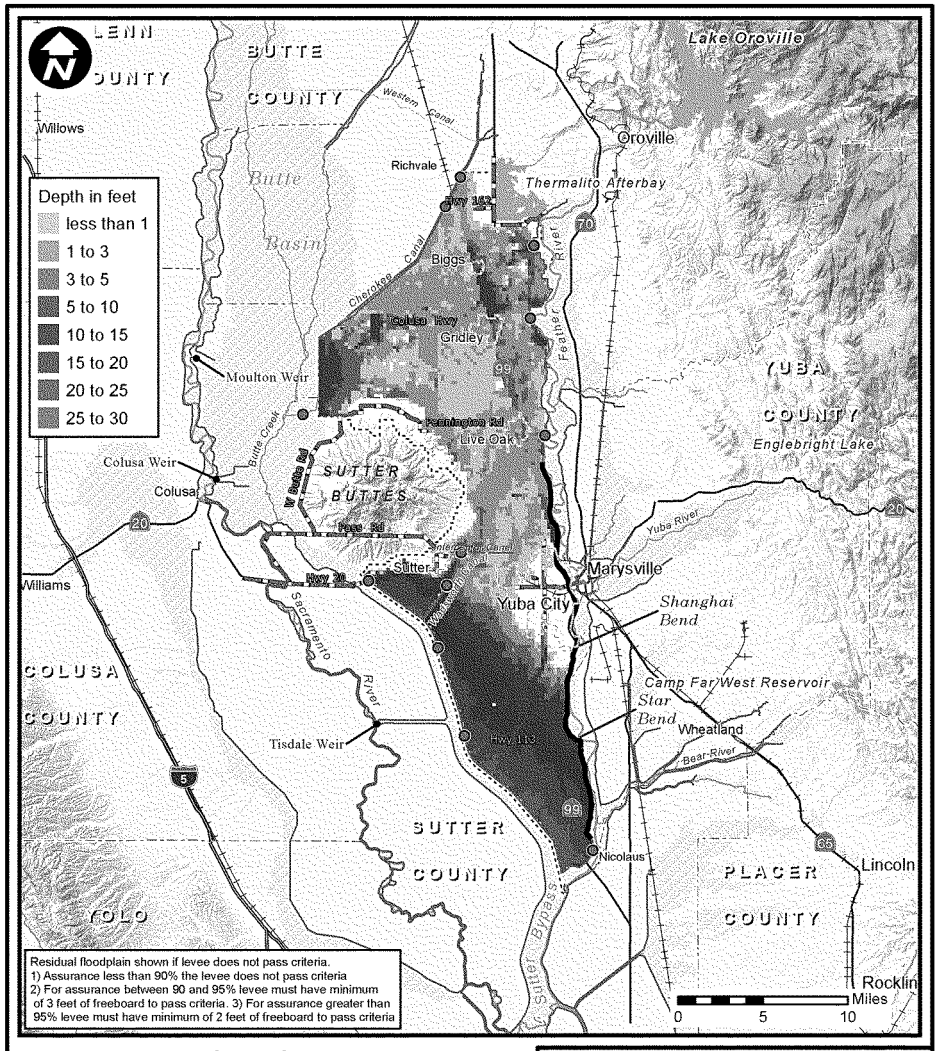
2% (1/50) ACE FLOODPLAIN ALTERNATIVE SB-7 FIX IN PLACE FEATHER RIVER, SUNSET WEIR TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 61



Legend

- Federal Levee
- Alternative SB-7
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Levee Fails Criteria
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

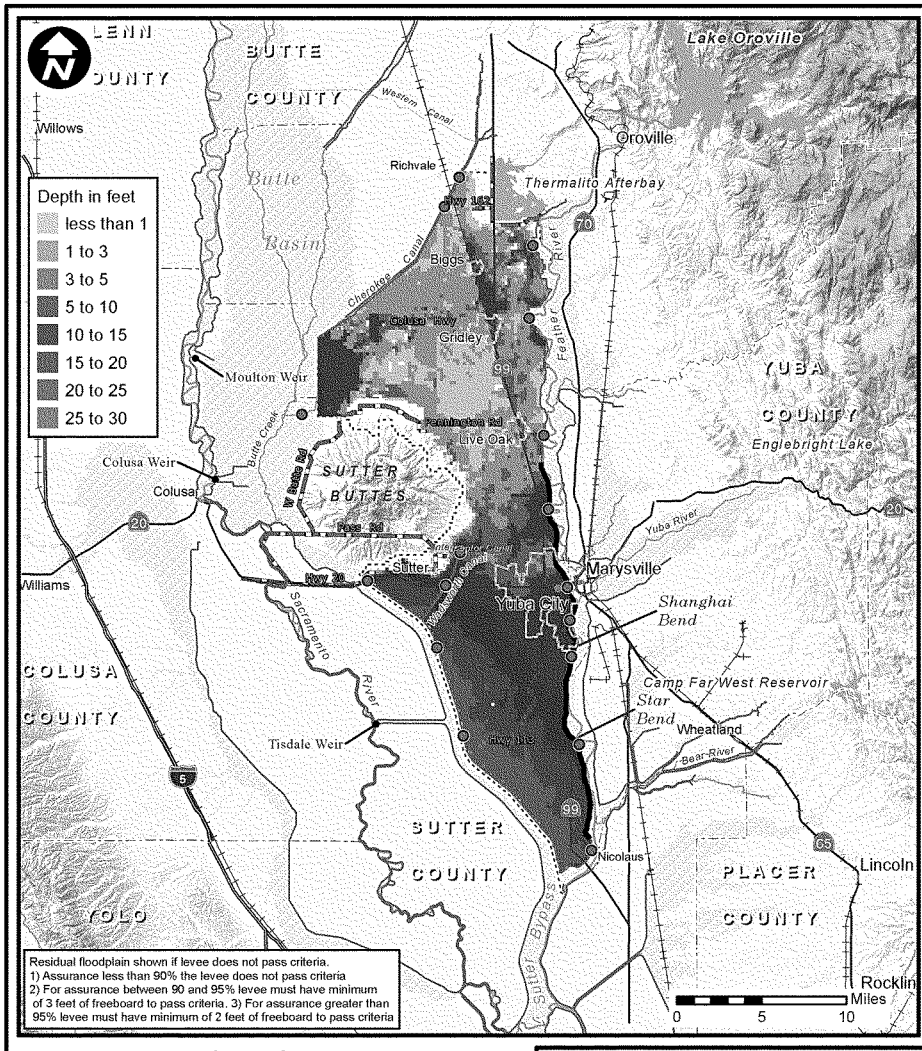
1% (1/100) ACE FLOODPLAIN ALTERNATIVE SB-7 FIX IN PLACE FEATHER RIVER, SUNSET WEIR TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 62



Legend

- Federal Levee
- Alternative SB-7
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Levee Fails Criteria
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

0.5% (1/200) ACE FLOODPLAIN
ALTERNATIVE SB-7
FIX IN PLACE FEATHER RIVER, SUNSET WEIR TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

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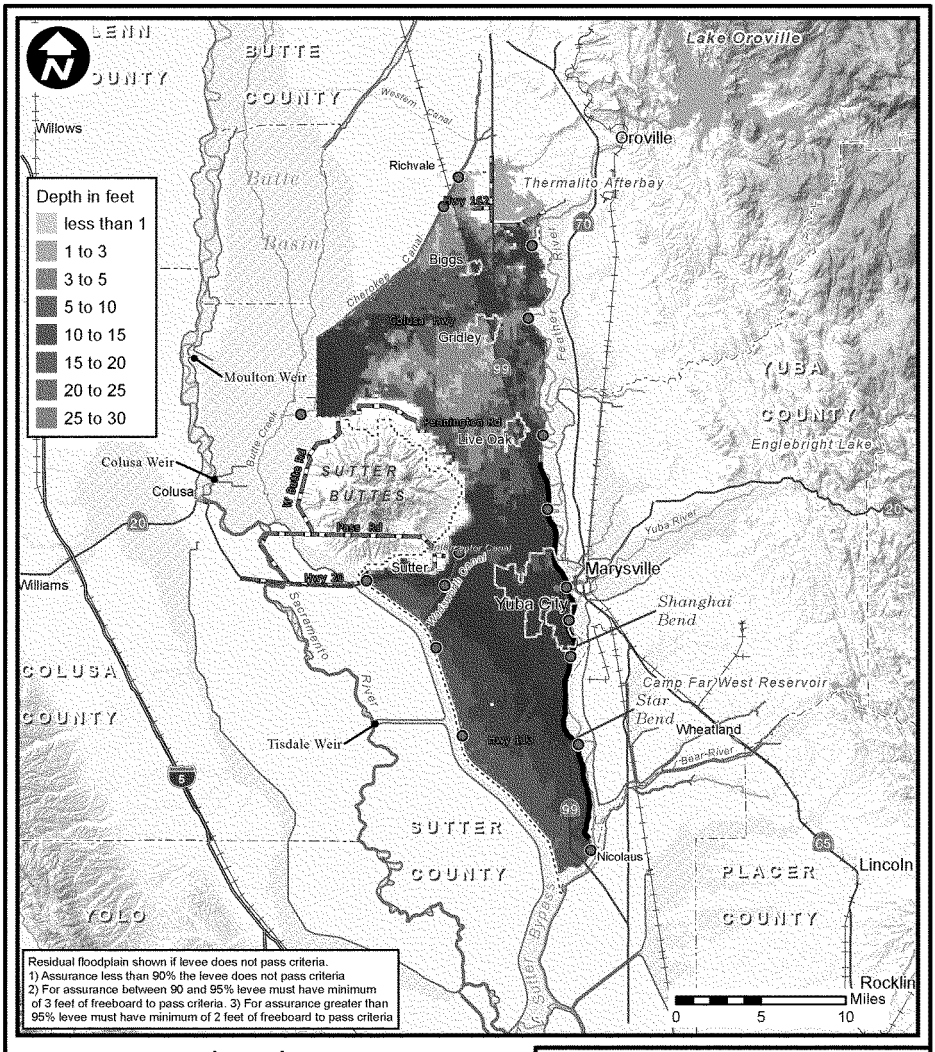
PLATE 63



Legend

- Federal Levee
- Alternative SB-7
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Levee Fails Criteria
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

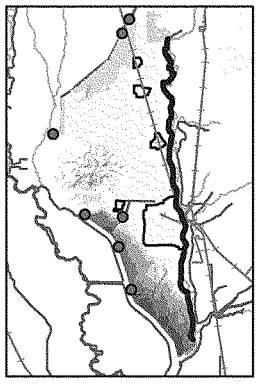
0.2% (1/500) ACE FLOODPLAIN ALTERNATIVE SB-7 FIX IN PLACE FEATHER RIVER, SUNSET WEIR TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

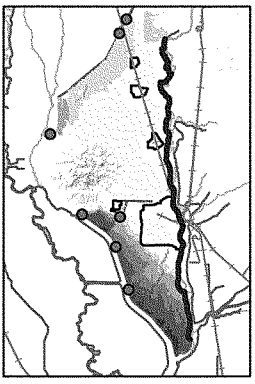
Prepared by Jim Mars

FEB 2013

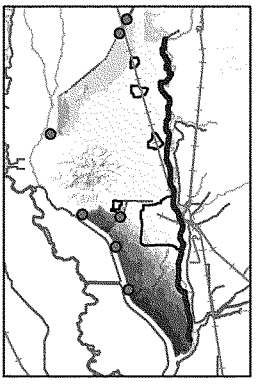
PLATE 64



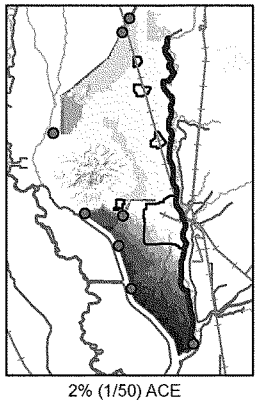
50% (1/2) ACE



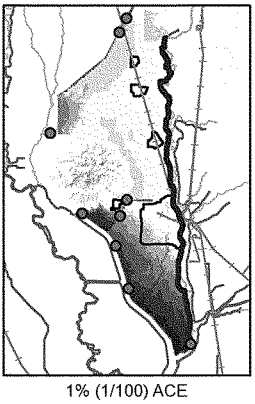
10% (1/10) ACE



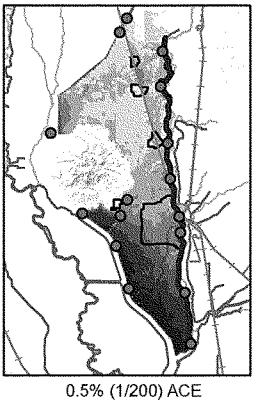
4% (1/25) ACE



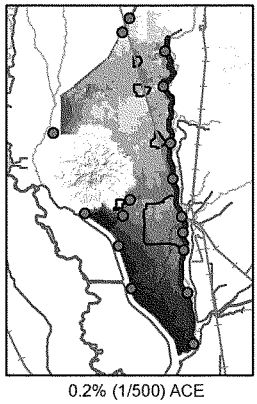
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Depth

(ft)

- less than 2
- 2 to 6
- 6 to 10
- 10 to 15
- 15 to 20
- greater than 20
- Railroad
- Alternative
- Levee Fails R&U Criteria

NOTE: Breach simulation shown if levee does not pass assurance criteria 1) Assurance less than 90% the levee does not pass criteria 2) For assurance between 90 and 95% levee must have minimum of 3 feet of freeboard to pass criteria. 3) For assurance greater than 95% levee must have minimum of 2 feet of freeboard to pass criteria

0 10 20 Miles

N

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

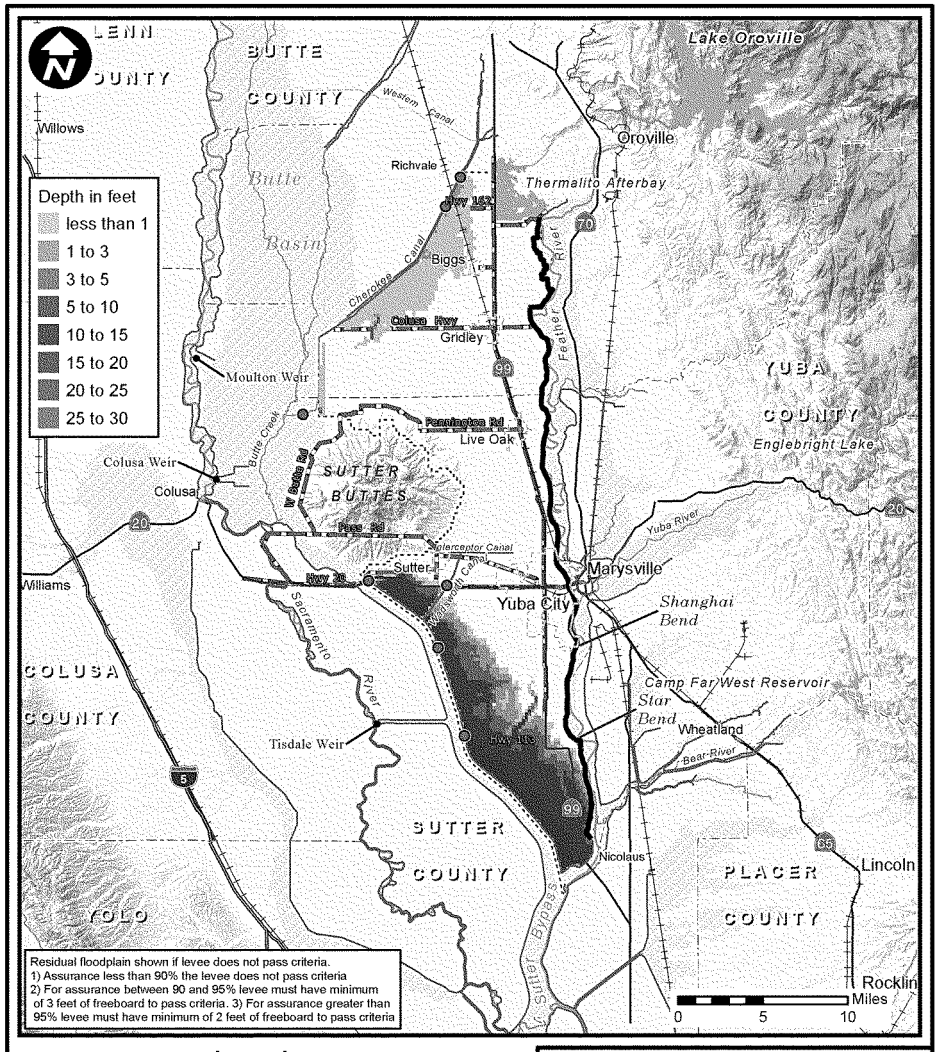
R&U ASSURANCE FLOODPLAINS
ALTERNATIVE SB-8
FIX-IN-PLACE
THERMALITO TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by T. Hatch

FEB 2013

PLATE 65



Legend

- Federal Levee
- Alternative SB-8
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Levee Fails Criteria
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

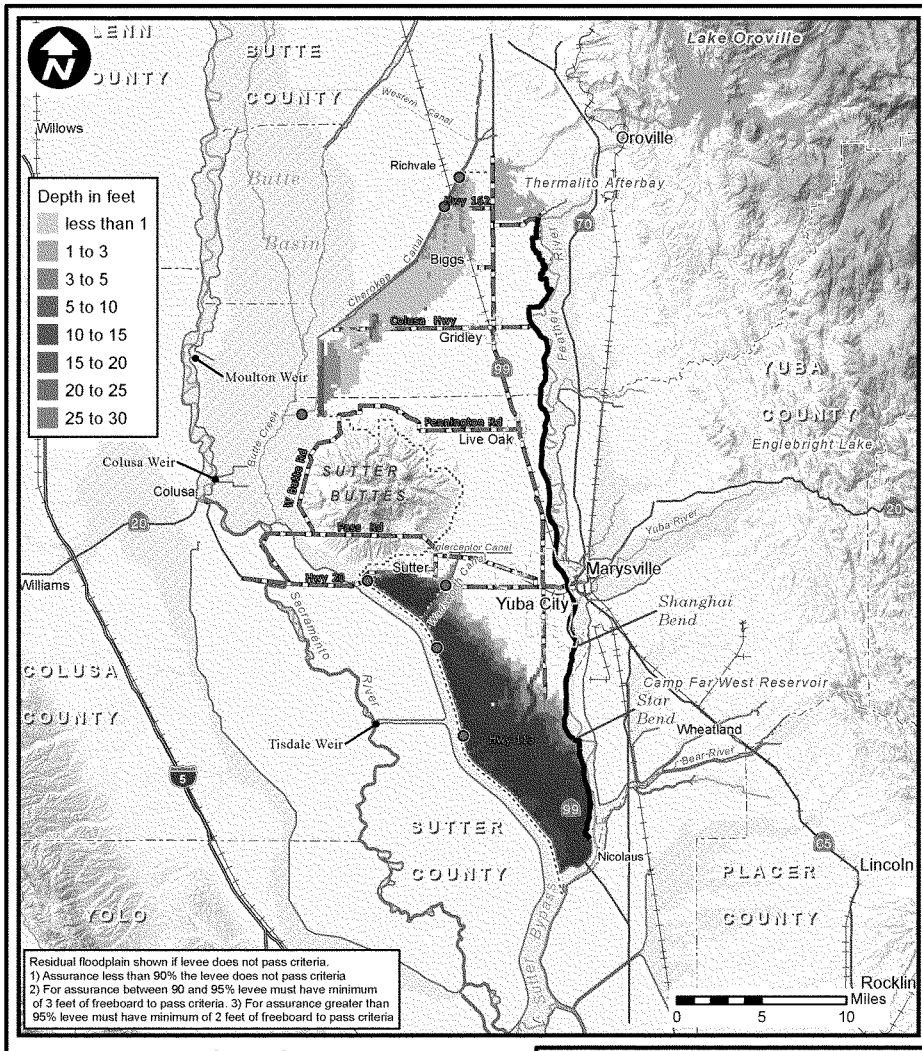
50% (1/2) ACE FLOODPLAIN ALTERNATIVE SB-8 FIX IN PLACE FEATHER RIVER, THERMALITO TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 66



Legend

- Federal Levee
- Alternative SB-8
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Levee Fails Criteria
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

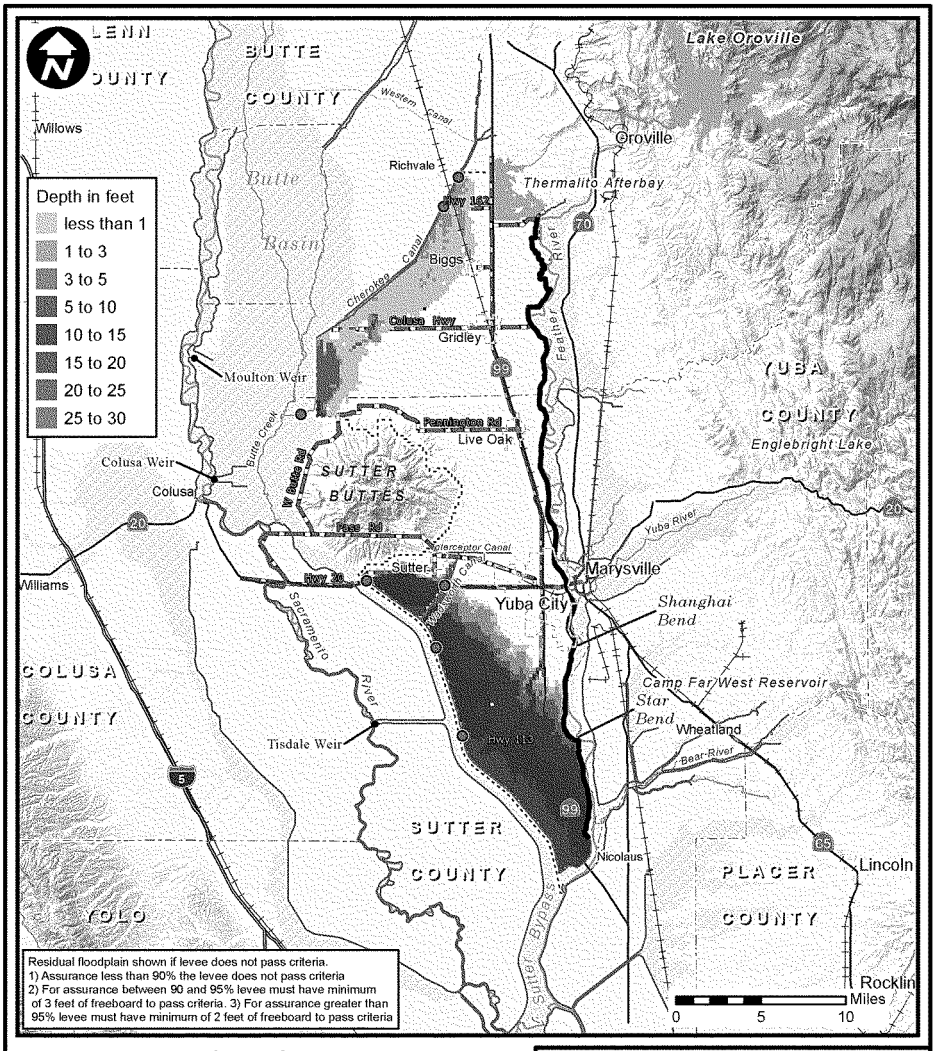
10% (1/10) ACE FLOODPLAIN
ALTERNATIVE SB-8
FIX IN PLACE FEATHER RIVER,
THERMALITO TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 67



Legend

- Federal Levee
- Alternative SB-8
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Levee Fails Criteria
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

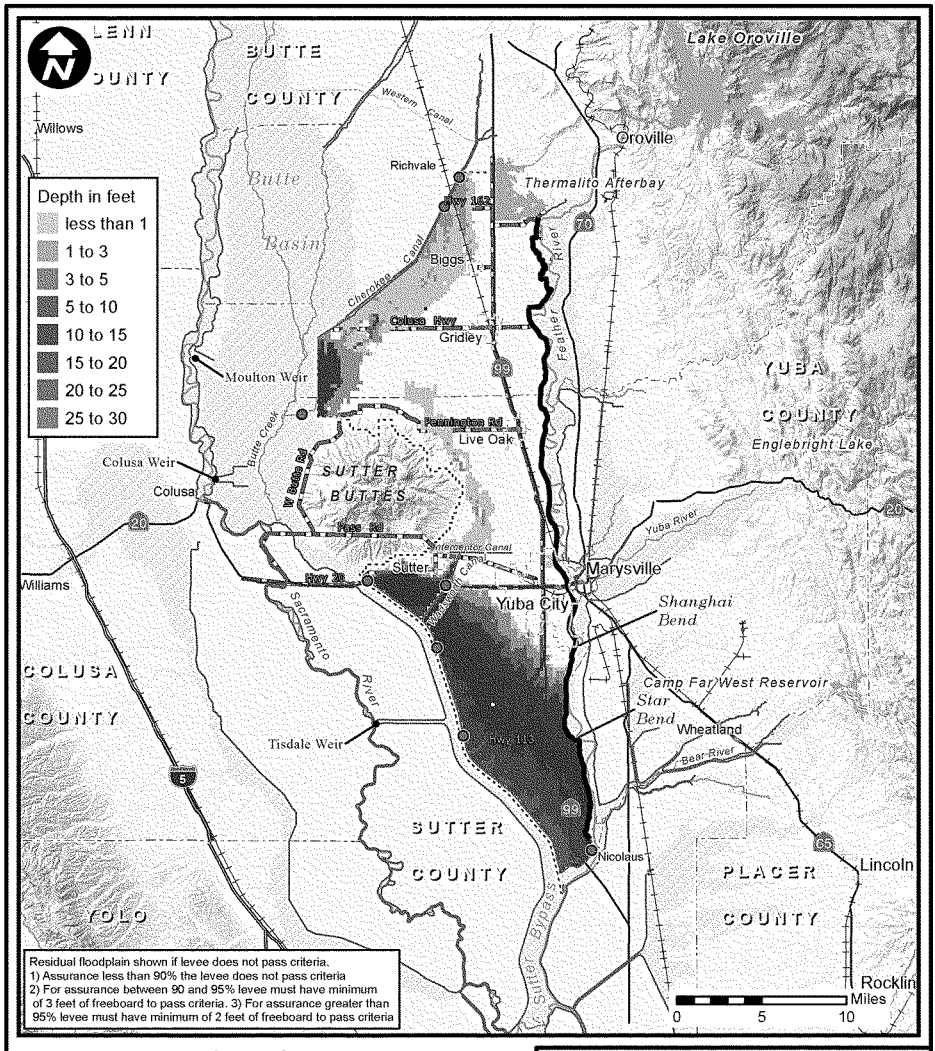
4% (1/25) ACE FLOODPLAIN ALTERNATIVE SB-8 FIX IN PLACE FEATHER RIVER, THERMALITO TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 68



Legend

- Federal Levee
- Alternative SB-8
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Levee Fails Criteria
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

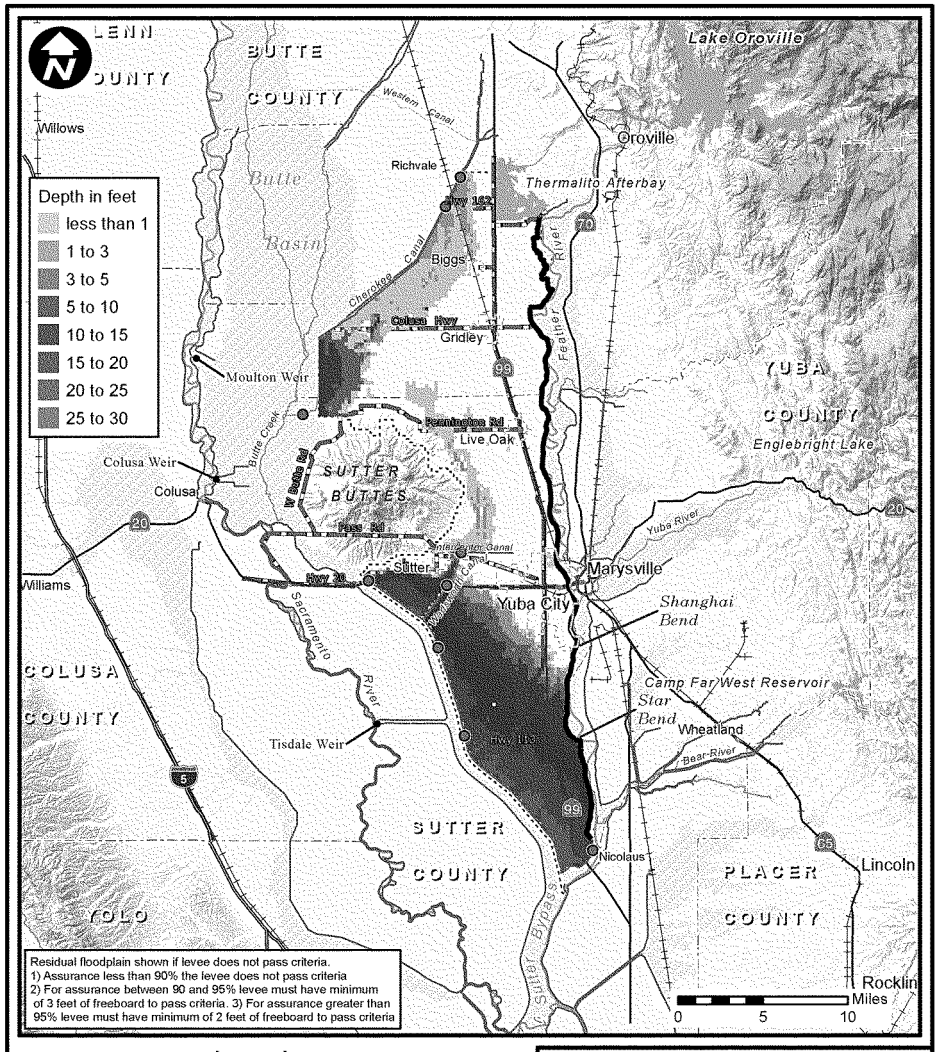
2% (1/50) ACE FLOODPLAIN
ALTERNATIVE SB-8
FIX IN PLACE FEATHER RIVER, THERMALITO TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 69



Legend

- Federal Levee
- Alternative SB-8
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Levee Fails Criteria
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

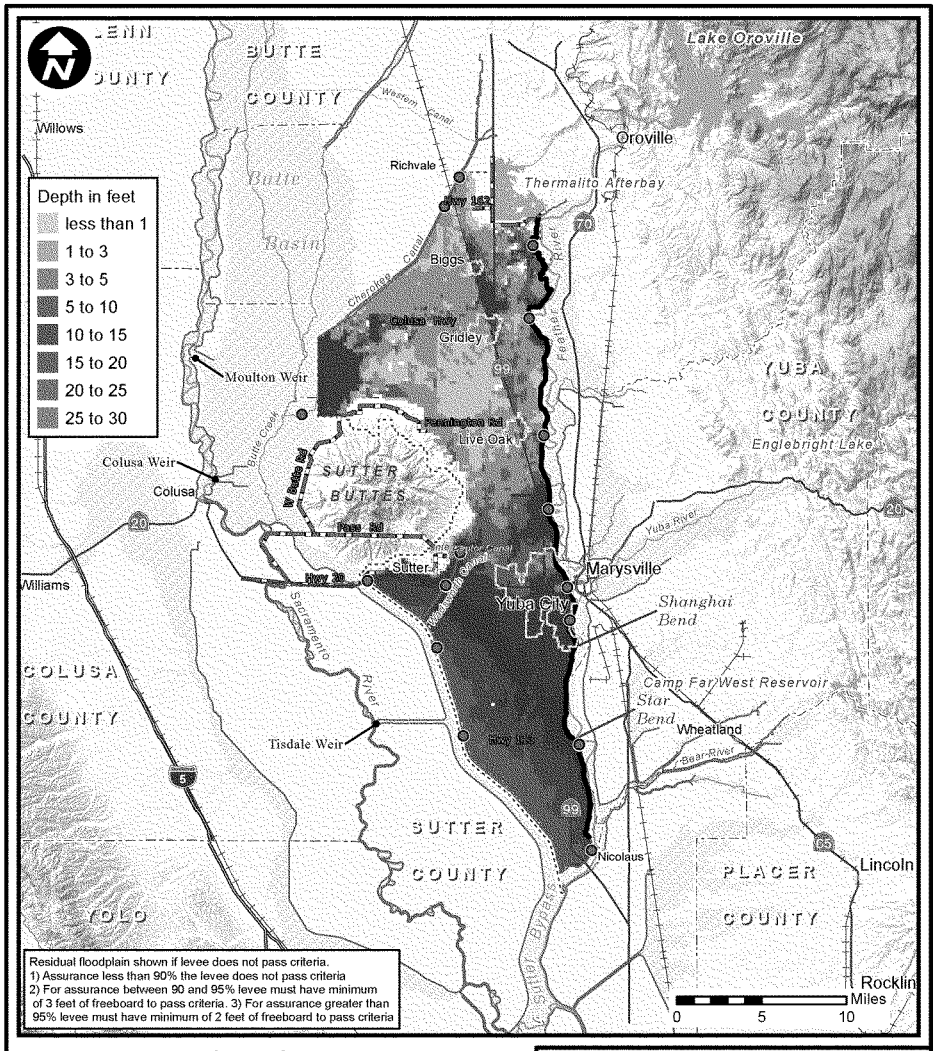
1% (1/100) ACE FLOODPLAIN ALTERNATIVE SB-8 FIX IN PLACE FEATHER RIVER, THERMALITO TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 70



Legend

- Federal Levee
- Alternative SB-8
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Levee Fails Criteria
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

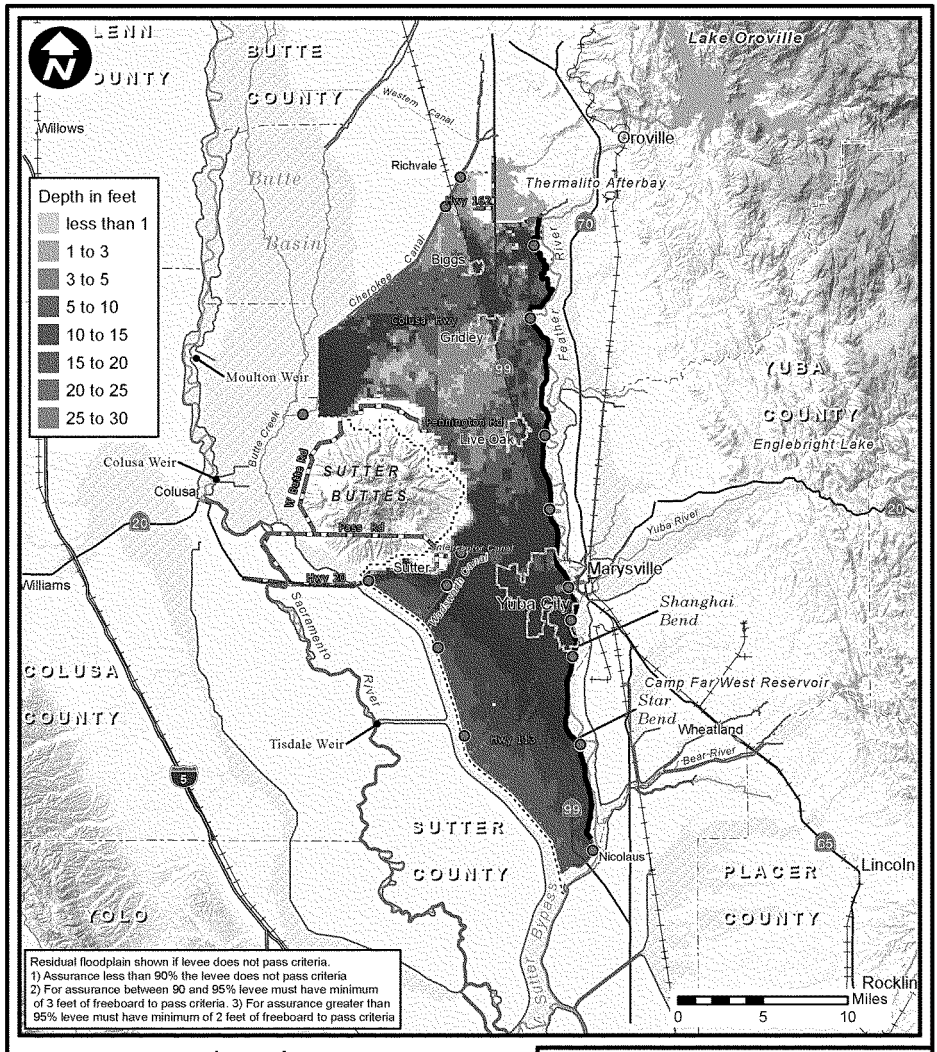
0.5% (1/200) ACE FLOODPLAIN
ALTERNATIVE SB-8
FIX IN PLACE FEATHER RIVER, THERMALITO TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 71



Legend

- Federal Levee
- Alternative SB-8
- River or Stream
- Lake or Reservoir
- Designated Floodways
- Study Area Extent
- Levee Fails Criteria
- Evacuation Routes
- Highway
- Railroad
- County Boundary
- City Limit

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

0.2% (1/500) ACE FLOODPLAIN ALTERNATIVE SB-8 FIX IN PLACE FEATHER RIVER, THERMALITO TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

FEB 2013

PLATE 72

ATTACHEMENT A

Memorandum for File:
Sutter Basin Pilot Feasibility Study,
Hydraulic Analysis of Refined Alternatives
8 June 2012

DRAFT

CESPK-ED-HA

8 June, 2012
23 Oct, 2012 Rev

MEMORANDUM FOR FILE: Sutter Basin Pilot Feasibility Study

SUBJECT: Hydraulic Analysis of Refined Alternatives.

1. REFERENCES:

a. DWR, 2012, Urban Levee Design Criteria, State of California Department of Water Resources, May 2012
b. USACE, 1957, Levee and Channel Profiles, Sacramento River Flood Control Project, File No. 50-10-3334, 4-sheets. 15 March 1957
c. USACE, 1995, Engineering and Design Hydrologic Engineering Requirements for Flood Damage Reduction Studies, EM 1110-2-1419, 31 Jan 1995.
d. USACE, 2002, Sacramento San Joaquin Comprehensive Study, Appendix B-Synthetic Hydrology, December 2002
e. USACE, 2008, Yuba River Basin Project, General Reevaluation Project, Appendix A, Synthetic Hydrology and Reservoir Operations Technical Documentation, April 2004 (Corrected June 2008).
f. USACE, 2010, USACE Process for the National Flood Insurance Program (NFIIP) Levee System Evaluation. 31 August 2010.

2. PURPOSE:

The purpose of this memorandum is to describe hydraulic analysis conducted in support of the Sutter Basin Feasibility Study. A map of the watershed is included as Plate 1 and a map of the study area is included as Plates 2 and 3. The memo documents refined analysis of the existing conditions, without project conditions and alternatives. Identification and evaluation of the alternatives that are refined in this analysis are presented in the report, Sutter Basin Feasibility Study, Progress Document 1, Without Project and Alternative Development.

All elevations provided herein are relative to the NAVD88 vertical datum and NAD83 Horizontal datum. Horizontal coordinates are projected to the California State Plane Zone III coordinate system. The conversion between NAVD88 and NGVD29 ranges from 2.3 to 2.4 feet in this area. Expressed as an equation, the conversion is Elevation (NGVD29) = Elevation (NAVD88) minus 2.40 feet.

CESPK-ED-HA 23 Oct 2012
SUBJECT: Hydraulic Analysis of Refined Alternatives

3. BACKGROUND:

a. General. A high risk of flooding from levee failure threatens the public safety of approximately 80,000 people, as well as property and critical infrastructure throughout the Sutter Basin study area. Past flooding has caused loss of life and extensive economic damages. Recent geotechnical analysis and evaluation of historical performance during past floods indicate the project levees do not meet U.S. Army Corps of Engineers (USACE) levee design standards and are at risk of breach failure at stages less than overtopping. Within the study area, as throughout the Sacramento Valley, floodplain and native habitats have been lost or degraded. Federally listed species and other special status species that are dependent on floodplain habitats have declined. Opportunities exist to restore land formerly converted by mining or agriculture to more natural habitats through Ecosystem Restoration (ER) in conjunction with flood risk management (FRM). There are also opportunities to provide outdoor recreational features on FRM and ER project lands. The purpose of the Sutter Basin Feasibility Study is to address FRM in conjunction with ER and recreation.

b. Alternatives. Alternative plans were evaluated through an iterative planning process. The alternatives evaluated in this memorandum are considered to be the refined array and were the outcome of multi-disciplinary analysis at two levels of increasing detail. Throughout this process the concept of absolute accuracy versus relative accuracy was considered. At each level of analysis the assessment of the existing and without project conditions was improved. Although it would appear that every plan should be compared to the most accurate assessment of existing conditions, this is not necessary because the relative accuracy between plans is sufficient to select the most optimal plan to move forward.

Conceptual alternatives were developed from a broad array of measures. The measures were evaluated at a qualitative level of detail using hydraulic assumptions and calculations. The measures were then combined into conceptual alternatives during a planning Charrette attended by the project sponsors and subject matter experts. Development of the conceptual alternatives is described in Progress Document 1.

Refined alternatives were derived from the conceptual alternatives. The conceptual alternatives described above were evaluated using qualitative and quantitative engineering analyses. Analyses included floodplain hydraulic modeling, cost estimating, and economic benefit estimations. The level of detail was limited to that required to decide which plans to carry forward. Results were evaluated at a combined VE study and planning charette attended by the project sponsors and subject matter experts. At the conclusion of the planning charette, a refined array of alternatives was identified for further analysis. Analysis of the refined array of alternatives is described in this report.

4. STUDY AREA:

a. General. The study area covers approximately 300 square miles and is approximately 43 miles long and 9 miles wide. The primary sources of flooding within the study area are the Butte Basin, Sutter Bypass, Feather River, Cherokee Canal, Wadsworth Canal, and local interior drainage.

The study area includes the communities of Yuba City, Live Oak, Gridley, Biggs, and Sutter with a total population of approximately 80,000. Yuba City is the largest community in the study area, with a population of approximately 65,000. A map of population density within the study area is provided in Plate 4. The majority of land use in the study area is related to agricultural. A map of land use types in the study area is presented in Plate 5.

b. Topography. Elevations within the study area range from 110 ft NAVD88 in the north to 30 ft NAVD88 in the south. The study area has a general slope from northeast to south west. The general slope of the study area is interrupted by two major linear features which would impact hydraulic conveyance within the study area if a levee breach were to occur. The raised embankment of the Union Pacific Railroad traverses the study area in a north south alignment. The Sutter Bypass east levee traverses the study area in a north south alignment. A topographic map of the study area is presented in Plate 2.

c. Stream Gages: A list of applicable stream gages within the study area is provided in Table 1. The stream gages are operated by the United States Geological Survey (USGS) and California Department of Water resources. Steam gages shown on Plate 7.

Table 1 Stream Gages, Sutter Basin Study Area

Gage Name	Area (Sq Mi)	Agency	Gage Number	Period of Record	Type
Bear R Nr Wheatland Ca	292	USGS	11424000	1928-2010	S,Q
Bear River at Pleasant Grove	300	DWR	A06535	1987-2010	S,Q
Butte Creek near Gridley	NA	DWR	A04150	1991-1999	S,Q
Butte Slough at Outfall Gates near Colusa	NA	WDL	A02967	1992-2010	S
Butte Slough near Meridian	NA	WDL	A02972	1981-2010	S,Q
Cherokee Canal nr Gridley	NA	DWR	A00910	1991-1998	S,Q
Cherokee Canal nr Richvale	NA	DWR	A02984	1976-2010	S,Q
Camp Far West Reservoir	NA	DWR	A65105	1998-2010	Q
Colusa Weir Spill to Butte Basin near Colusa	NA	WDL	A02981	1975-2010	S,Q
Deer C Nr Smartville CA	84.6	USGS	11418500	1935-2010	S,Q
Feather River at Nicholaus	5,921	DWR	A05103	1942-2010	S,Q(P)
Feather River at Oroville	3,624	USGS	11407000	1902-2010	S,Q
Feather River at Yuba City	3,974	DWR	A05135	1964-2010	S
Feather River near Gridley	3,676	DWR	A05165	1964-2010	S,Q
Moulton Weir Spill to Butte Basin nr Colusa	NA	DWR	A02986		
Sacramento R at Colusa Ca	12,090	USGS	11389500	1941-2010	S,Q
Sacramento R at Verona Ca	21,251	USGS	11425500	1929-2010	S,Q
Sacramento R Blw Wilkins Slough nr Grimes Ca	12,915	USGS	11390500	1931-2010	S,Q
Sacramento River at Butte Slough Outfall Gates	NA	DWR	A02400	1992-2004	S
Sacramento River at Fremont Weir (East)	NA	DWR	A02160	1935-2010	S
Sacramento River at Fremont Weir (West)	NA	DWR	A02170	1934-2010	S
Sacramento River at Knights Landing	14,535	DWR	A02200	1982-2010	S
Sacramento Slough near Karnak	NA	DWR	A02925	1981-2010	S
Sutter Bypass at R.D. 1500 P.P. near Karnak	NA	DWR	A02927	1975-2010	S
Sutter Bypass Channel at Pumping Plant #1	NA	DWR	SB1	2008-2010	S
Sutter Bypass Channel at Pumping Plant #2	NA	DWR	SB2	2008-2010	S
Sutter Bypass Channel at Pumping Plant #3	NA	DWR	SB3	2008-2010	S
Tisdale Weir near Grimes	NA	DWR	A02960	1975-2010	S,Q
Willow Slough near Nicolaus	NA	DWR	A02943	1991-2010	S
Yolo Bypass nr Woodland Ca	NA	USGS	11453000	1939-2011	S,Q
Yuba R blw Englebright Dam near Smartsville	1,108	USGS	11418000	1941-2011	S,Q
Yuba R Nr Marysville CA	1,339	USGS	11421000	1940-2011	S,Q
Wadsworth Canal near Sutter (lower)	96	DWR	A05927	1982-1997	S,Q
Wadsworth Canal near Sutter (upper)	96	DWR	A05929	1976-1997	S,Q
Note: S-Stage, Q-Discharge, NA- Not Available, (Partial Record)					

5. SOURCES OF FLOODING:

The following describes significant sources of flooding within the study area.

a. Butte Basin. The Butte Basin is a natural overflow and flood storage area north west of the Sutter Buttes and east of the Sacramento River. The basin provides approximately 1 million acre-feet of transitory storage at flood stage (DWR, 2010). Excess floodwaters from the Sacramento River enter the Butte Basin via overbank areas along the river and through the Moulton and Colusa weirs. Butte Creek and its tributaries, including Cherokee Canal, also flow into the Butte Basin. Outflow from the Butte Basin is regulated by hydraulic conditions of Butte Slough and floodplain

topography at the upstream entrance to the Sutter Bypass. In order to maintain the flood storage capabilities within Butte Basin, California has included regulation of the overflow area in Title 23 of the California Code of Regulations. In general these standards require approval from the board for any encroachments that could reduce or impede flood flows or would reclaim any of the floodplain within the Butte Basin (DWR, 2010).

b. Sutter Bypass. The Sutter Bypass is a leveed flood control channel approximately three quarters of a mile wide, bordered on each side by levees. The bypass is an integral feature of the Sacramento River Flood Control Project's flood bypass system. The Sutter Bypass conveys flood waters from the Butte Basin, Sacramento River, and Feather River to the confluence of the Sacramento River and Yolo Bypass at Fremont Weir.

Downstream of the Feather River, the bypass is separated into two conveyance areas by a low levee. The area east of the middle levee conveys the Feather River. This design maintains higher velocities and sediment transport capacity within the Feather River during low flow events while utilizing the large conveyance of the Sutter Bypass during larger events.

The Sutter Bypass also receives minor natural flow and agricultural return flow from Reclamation District 1660 to the west and from Wadsworth Canal and DWR pumping plants 1, 2, and 3 to the east. The Sutter Bypass is described by four hydrologic reaches based on tributary inflows; Butte Slough to Wadsworth Canal, Wadsworth Canal to Tisdale Bypass, Tisdale Bypass to Feather River, Feather River to Sacramento River.

c. Feather River. The Feather River is a major tributary to the Sacramento River, merging with the Sutter Bypass upstream from the Sacramento River and Fremont Weir. The Yuba and Bear Rivers are major tributaries to the Feather River. Two major flood management reservoirs are located within the Feather River watershed. Oroville Dam and reservoir was completed on the Feather River in 1967. The reservoir has 3,358,000 acre-feet of storage with 750,000 acre-feet of dedicated flood management space. New Bullards Bar dam and reservoir was completed on the Yuba River 1970. The reservoir has 966,000 acre-feet of storage with 170,000 acre-feet of dedicated flood management space. The Feather River is described by four hydrologic reaches based on significant inflows; Thermalito to Honcut Creek, Honcut Creek to Yuba River, Yuba River to Bear River, and Bear River to Sutter Bypass.

d. Cherokee Canal. The Cherokee Canal is a tributary to Butte Creek and the Butte Basin. The leveed canal was constructed between 1959 and 1960 by USACE. The canal drainage area is 94 square miles and varies in elevation from 70 feet to 2200 feet. The drainage area is bounded by the Feather River watershed to the east and southeast, Butte Creek and its tributaries to the north and west, and by Wadsworth Canal drainage to the south.

e. Wadsworth Canal. The Wadsworth Canal is a leveed tributary to the Sutter Bypass near the town of Sutter. The canal conveys flow from the East and West interceptor canals to the Sutter Bypass. The East and West interceptor canals collect runoff from 96 square miles of into the Wadsworth Canal.

6. RECENT FLOODS:

The following is a description of recent significant flood events within the study area. The magnitudes of historical floods are difficult to compare due to significant historical changes in the flood management system.

a. December 1955. The last major flood to damage the study area occurred in December 1955 when the west levee of the Feather River breached near Shanghai Bend. The peak flow measured at the Feather River at Oroville stream gage was 203,000cfs. This flood occurred prior to construction of Oroville and New Bullards Bar reservoirs. Therefore, the flood does not reflect existing hydrologic conditions. A hypothetical flood routing of the 1955 flood is presented in the Oroville Dam water control manual. The flood routing indicates the reservoir would have regulated the peak outflow to 150,000cfs.

b. November 1982 - March1983. Water year 1983 was a result of the "El Niño" weather phenomenon. Northern and Central California experienced flooding incidents from November through March due to numerous storms. In early May, snow water content in the Sierra exceeded 230 percent of normal, and the ensuing runoff resulted in approximately four times the average volume for Central Valley streams. System failures in the Sacramento River Basin were limited to a private levee on the Sacramento River and one failure on Cache Creek.

c. February 1986. Flooding in 1986 resulted from a series of four storms over a 9-day period during February. Rains from the first three storms saturated the ground and produced moderate to heavy runoff before the arrival of the fourth storm. Precipitation at Four Trees in the Feather River Basin set both a 24-hour rainfall record for the Sierra Nevada and the monthly record for any station in the State. System breaks in the Sacramento River Basin included disastrous levee breaks in the Olivehurst and Linda area on the Feather River, adjacent to the study area.

d. January 1995. "El Nino" conditions in the Pacific forced major storm systems directly into California during much of the winter and early spring of 1995. The largest storm systems hit California in early January and early March. The major brunt of the January storms hit the Sacramento River Basin and resulted in small stream flooding primarily due to storm drainage system failures.

e. January 1997. December 1996 was one of the wettest Decembers on record. Watersheds in the Sierra Nevada were already saturated by the time three subtropical storms added more than 30 inches of rain in late December 1996 and early January 1997. The third and most severe of these storms lasted from December 31, 1996, through January 2, 1997. Rain in the Sierra Nevada caused record flows that stressed the flood management system to capacity in the Sacramento River Basin and overwhelmed the system in the San Joaquin River Basin. Levee failures due to breaks or overtopping in the Sacramento River Basin resulted in extensive damages.

f. December 2005 - January 2006. Between 28 December 2005 and 9 January 2006, the State of California experienced a series of severe storms which impacted the levees within the Sacramento District's boundaries. Water rose a second time in April 2006, and remained high in some parts of the system until June. Many rivers and streams within the Sacramento and San Joaquin River systems ran above flood stage during these events, and there were significant erosion and seepage problems with the levees. The State of California Department of Water Resources and/or their maintaining agencies conducted the actual flood fight activities while the U.S. Army Corps of Engineers provided technical assistance to the State.

7. FLOOD RISK ASSESSMENT APPROACH

Flood risk is defined as the probability of a flood event occurring and the consequences of occurrence. Flood risk was assessed using the USACE FDA model approach and is described in the economics report. The report presents results for seven economic impact areas within the study area. A map of the economic impact areas is presented as Plate 6.

The FDA approach combines flow-frequency, stage-discharge, geotechnical fragility, and stage-damage relationships to estimate damages. Uncertainty in each relationship is incorporated by assigning uncertainty estimates and applying a Monte Carlo type approach to combine the results.

Flow-frequency, stage discharge, and geotechnical frequency relationships reflect the exterior (probability) side of the risk calculations. Inundation depth and stage-damage relationships reflect the interior (consequence) side of the risk calculations. For the probability side of the risk calculations, the hydraulic model assumptions are based on flows contained to the channel (allowed to overtop without failure). For the consequence side of the risk calculations, the hydraulic model assumptions are based on levee breach failure or simply the depth for natural overbank (non-levee) conditions.

The first step in the risk assessment approach was evaluation of potential flood sources with respect to geotechnical fragility, channel hydrology, channel hydraulics, and potential inundation patterns of a levee breach natural overbank (non-levee). Thirteen geotechnical reaches were identified. Within each of these geotechnical reaches a

representative geotechnical fragility curve was developed and a stage-discharge relationship was developed using a hydraulic model (see below). Selection of the geotechnical reaches is described in detail in the geotechnical analysis. Fifteen breach sources and one non-leveed flood source locations were identified. All flood source locations identified within a geotechnical reach were assigned to the same geotechnical fragility curve location.

8. FLOOD RISK MAPS

The performance of existing Flood Risk Management features varies by reach. Performance was evaluated using the HEC-FDA computer program and is discussed in detail in the economics section. Levee performance is expressed as an assurance level (conditional non-exceedance probability) for a given median ACE hydrologic event.

Maps showing residual flood risk were developed to demonstrate FRM performance levels relative to a standard assurance criterion. The maps show inundation from any flood source that would not meet an assurance criterion. Maps were developed for each of two assurance criteria.

a. Assurance Criteria#1. This criterion was based on the deterministic approach required by FEMA for 1% ACE and DWR for 0.5% ACE. To meet this criteria a levee reach must have a minimum of 3 feet of freeboard for Hydrology and Hydraulic capacity for the given flood event. The geotechnical performance of a levee reach must meet current USACE geotechnical and civil design standards for the given design flood event. This assurance criterion was used to define residual risk maps for all Annual Chance Exceedance (ACE) events.

b. Assurance Criteria #2. This criterion was based on the NFIP levee system analysis criteria described in EC 1110-2-6067 and was adopted for use in describing the performance of all ACE events. This criterion is described as "Option 2" in the DWR Urban Levee Design Criteria. Assurance values were based on an USACE FDA risk and uncertainty analysis which included hydrologic uncertainty, hydraulic uncertainty, and geotechnical fragility curves. All values are relative to the median stage for each ACE event. 1) For assurance less than 90% the levee does not pass criteria 2) For assurance between 90 and 95% levee must have minimum of 3 feet of freeboard to pass criteria. 3) For assurance greater than 95% levee must have minimum of 2 feet of freeboard to pass criteria. Other requirements described in EC1110-2-6067 are not included. For example, operations and maintenance requirements are not included in the criteria.

9. EXISTING CONDITION CHANNEL MODEL

Water surface profiles were computed using HEC-RAS and HEC-UNET one-dimensional flow models. HEC-RAS and UNET calculate steady or unsteady gradually

varied flow in natural and manmade channels by performing step-backwater calculations of the 1-D flow energy equation through a series of input geometric cross-sections with empirically defined hydraulic roughness coefficients.

An unsteady system-wide HEC-RAS model was used for the Sacramento River, Feather River, and Sutter Bypass. A steady state HEC-RAS model was used for the Wadsworth Canal. An unsteady HEC-RAS model was used for Cherokee Canal. An unsteady HEC-UNET model developed for the Sacramento-San Joaquin Comprehensive study was used for Butte Basin flood depths. A map of the HEC-RAS hydraulic models cross sections and location of boundary conditions is provided as Plate 7. The following describes hydraulic model input to the FDA hydraulic model and also used in the assessment of project performance and assurance.

a. Non-Failure Infinite Height Levee Profiles. Models were developed to evaluate two profile scenarios. Scenario A assumed all levees were infinitely high and would contain all flows without overtopping. This scenario was used to evaluate the sensitivity of downstream flow conditions relative to upstream overtopping assumptions. The resulting model profiles are provided in Plates 8, 9, 10, and 11.

b. Non-Failure Overtopping Profiles. Scenario B assumed all levees were overtopped without failure. Scenario B was used in the economic FDA analysis. The resulting model profiles are provided in Plates 8, 9, 10, and 11. As described above, these median profiles are for use in the FDA flood damage assessment model. The profiles do not account for risk and uncertainty which is required to evaluate assurance. Assurance estimates are provided in the economics report.

c. Breach Hydrographs. Simulations were performed for fifteen levee breach flood sources and one natural (non-leveed) flood source. These sources were spatially distributed throughout the study area. Breach locations were selected to represent similar levee and floodplain characteristics. All breach scenarios assume levees were overtopped without failure at all locations other than the breach location. Eight breaches were simulated on the Feather River from Thermalito to Sutter Bypass. Two breaches were simulated on the Sutter Bypass between Wadsworth Canal and Feather River. Two breaches were simulated on Cherokee Canal upstream and downstream of the Union Pacific Railroad. A single breach was simulated on Wadsworth Canal. All breach simulations assume remaining levee reaches would be overtopped without failure. In order to simplify the analysis, breaches were assumed to exist at the start of each flood hydrograph simulation.

c. Stage Uncertainty. Stage uncertainty arises from the use of simplified models to describe complex hydraulic phenomena, including the lack of detailed geometric data, misalignments of hydraulic structures, debris load, infiltration rates, embankment failures, material variability, and from errors in estimating slope and roughness factors.

A standard deviation in stage of 1.5 feet was used for hydraulic uncertainty. This value was estimated following methods in EM-1110-2-1619. The total stage uncertainty was based on the geometric mean of natural and model uncertainty. The total stage uncertainty was based on standard deviations of 0.75 ft and 1.3 feet for natural and model uncertainty respectively.

10. EXISTING CONDITION FLOODPLAIN INUNDATION MODEL

Floodplain inundation was simulated using a FLO-2D two dimensional hydrologic model of the Study Area. The without project condition FLO-2D model was modified from existing USACE models by the Sutter Butte Flood Control Agency as work in kind credit for the study. Models and results underwent Independent Technical Review and District Quality Control. The model includes significant floodplain features which can interfere with the flood conveyance in the floodplain. For example, the model includes railroad embankments and culverts. A map showing the FLO-2D model domain is provided as Plate 12.

a. Breach Scenarios. For each hydrologic frequency event, floodplain inundation breach maps were developed for the fifteen levee breaches and one natural (non-leveed) flood sources throughout the study area. The inundation maps simulate a levee breach during the flood event. The inflow to the FLO-2D model was the outflow from the HEC-RAS model. The specified frequency is not the frequency of inundation. Inundation frequency estimates must account for performance of the levee (probability of the breach). The inundation frequency is computed in the economic flood damage analysis using the geotechnical fragility curves. Simulated inundation maps for levee breaches during a 100-yr event are provided as plates 13 through 28. Digital maps generated for simulated breaches during other ACE flood events are available upon request.

11. REFINED ALTERNATIVES.

The following describes the hydraulic design of new levees, project performance, and residual floodplains for each of the refined project alternatives.

d. SB-1 No Action. Based on a review of historical conditions and proposed actions, the hydraulic conditions in the future are assumed to be the same as existing conditions. Residual flood risk maps for criteria #1 and #2 are presented in Plates 29 and 30 respectively.

e. SB-2 Minimal Fix-In-Place plus NonStructural. This alternative would increase the performance of the levee from Sunset Weir to Star Bend. Residual Flood Risk Maps were based on reducing the fragility curve to overtopping only for breach locations FR6.0R, FR5.0R, and FR4.5R. Residual flood risk maps for criteria #1 and #2 are presented in Plates 31 and 32 respectively.

f. SB-3 Yuba City Ring Levee. This alternative would involve construction of a ring levee around Yuba City. The height of the ring levee was determined by reviewing the flood elevations from the hypothetical levee breaches. Wind wave runup analysis was also conducted and the levee height was increased as necessary to provide 95% assurance from a levee breach outside the ring levee during a 0.5% (1/200) ACE flood. The hypothetical levee breach simulations were conducted for the 0.2% (1/500) ACE flood event with the levee in place. The resulting levee design profile is provided as Plate 33. Residual flood risk maps were based on reducing the fragility curve to overtopping only for breach locations FR5.0R and FR4.5R. Residual flood risk maps for criteria #1 and #2 are presented in Plates 34 and 35 respectively.

g. SB-4 Yuba City J-Levee. This alternative would involve fixing the levees from Thermalito to Shanghai Bend and construction of a partial ring levee around Yuba City. The height of the new portion of levee was determined by reviewing the flood elevations from the hypothetical levee breaches. Wind wave runup analysis was also conducted and the levee height was increased as necessary to provide 95% assurance from a levee breach during a 0.5% (1/200) ACE flood in the unfixed levees. The hypothetical levee breach simulations were conducted for the 0.2% (1/500) ACE flood event with the levee in place. The resulting levee design profile is provided as Plate 36.Residual flood risk maps were based on reducing the fragility curve to overtopping only for breach locations on the Feather River FR9.0R, FR8.0R, FR7.0R, FR6.0R, FR5.0R, and FR4.5R. Residual flood risk maps for criteria #1 and #2 are presented in Plates 37 and 38 respectively.

h. SB-5 Fix in Place Feather River, Thermalito to Star Bend. This alternative would involve fixing the levees from Thermalito to Star Bend. The hypothetical levee breach simulations are the same as the no action plan. Residual flood risk maps were based on reducing the fragility curve to overtopping only for breach locations on the Feather River FR9.0R, FR8.0R, FR7.0R, FR6.0R, FR4.5R. Residual flood risk maps for criteria #1 and #2 are presented in Plates 39 and 40 respectively.

i. SB-6 Fix in Place Feather River, Sutter Bypass and Wadsworth Canal. This alternative would involve fixing the east levee of the Sutter Bypass downstream of Wadworth Canal, Wadsworth Canal south levee and Feather River west levee. The hypothetical levee breach simulations are the same as the no action plan. Flood Residual flood risk maps were based on reducing the fragility curve to overtopping only for all breach locations except BB1.0, CC2.0L,CC1.0L, SB 5.0L, and BW2.0R. Residual flood risk maps for criteria #1 and #2 are presented in Plates 41 and 42 respectively.

j. SB-7 Fix-In-Place Sunset Weir to Laurel Avenue . This alternative would increase the performance of the levee from Sunset Weir to 2200 feet downstream of Laurel Ave. Residual Flood Risk Maps were based on reducing the fragility curve to overtopping only

for breach locations FR6.0R, FR5.0R, and FR4.5R, and FR4.0R. Residual flood risk maps for criteria #1 and #2 are presented in Plates 43 and 44 respectively.

k. SB-8 Fix in Place Feather River, Thermalito to Laurel Avenue. This alternative would involve fixing the levees from Thermalito to 2200 feet downstream of Laurel Ave. The hypothetical levee breach simulations are the same as the no action plan. Residual flood risk maps were based on reducing the fragility curve to overtopping only for breach locations on the Feather River FR9.0R, FR8.0R, FR7.0R, FR6.0R, FR4.5R, and FR4.0R. Residual flood risk maps for criteria #1 and #2 are presented in Plates 45 and 46 respectively.

12. CONCLUSIONS

For questions on the technical content of this report, contact Peter Blodgett, P.E., Hydraulic Design Section, (916) 557-7529.

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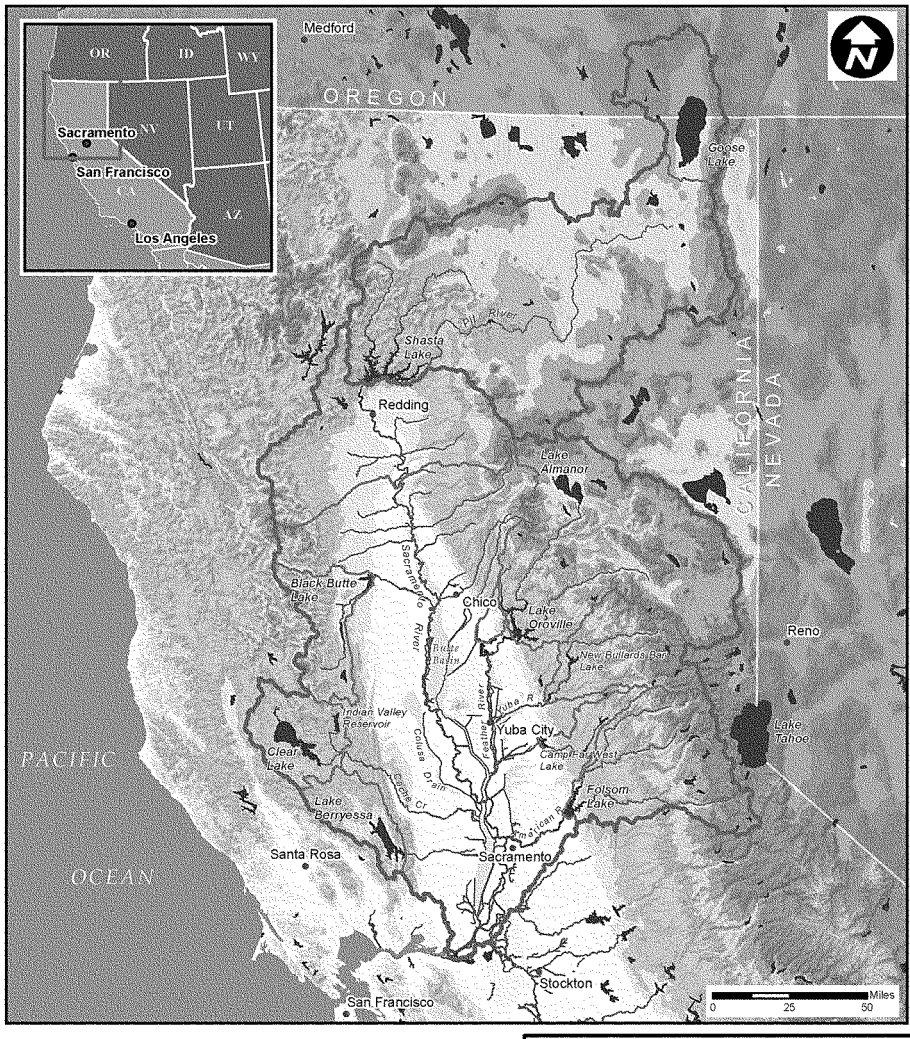


Legend

- Study Area Extent
- Sacramento Basin
- Watershed Boundaries
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Federal Levees
- City

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

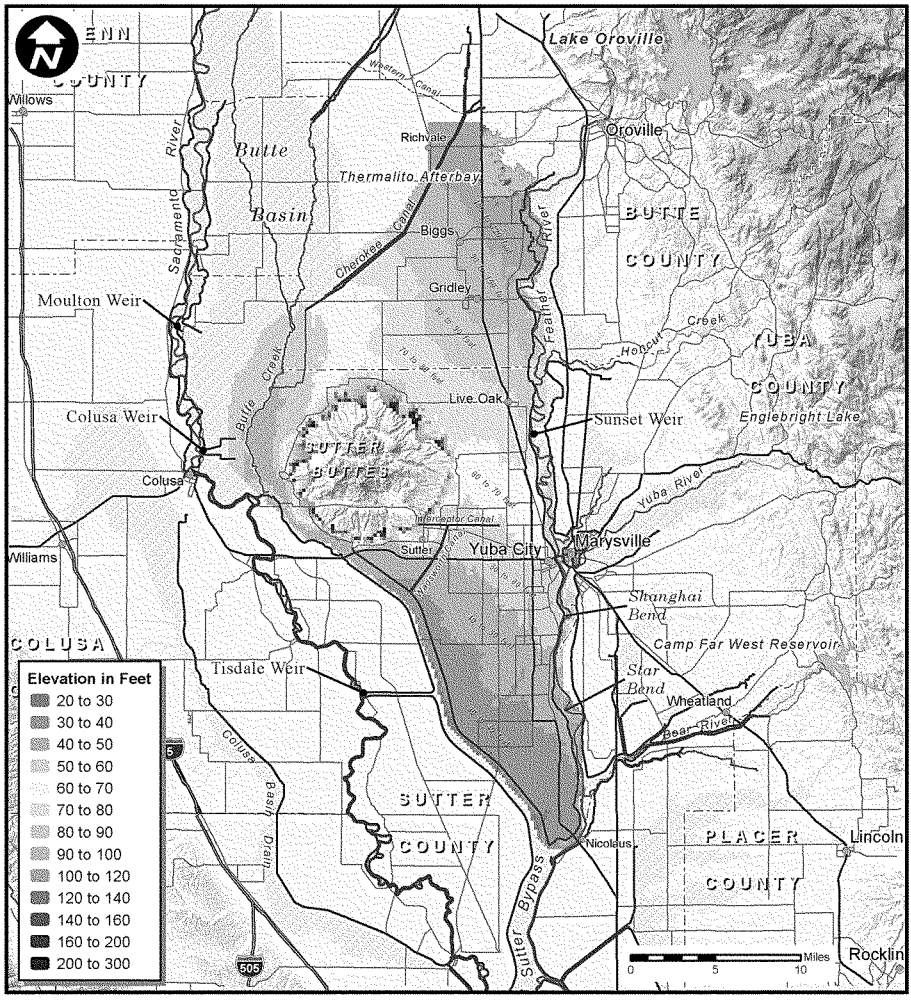
SACRAMENTO RIVER WATERSHED

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012

PLATE 1



Legend

- Designated Floodways
- Federal Levee
- Lake or Reservoir
- County Boundary
- River or Stream
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

TOPOGRAPHY

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

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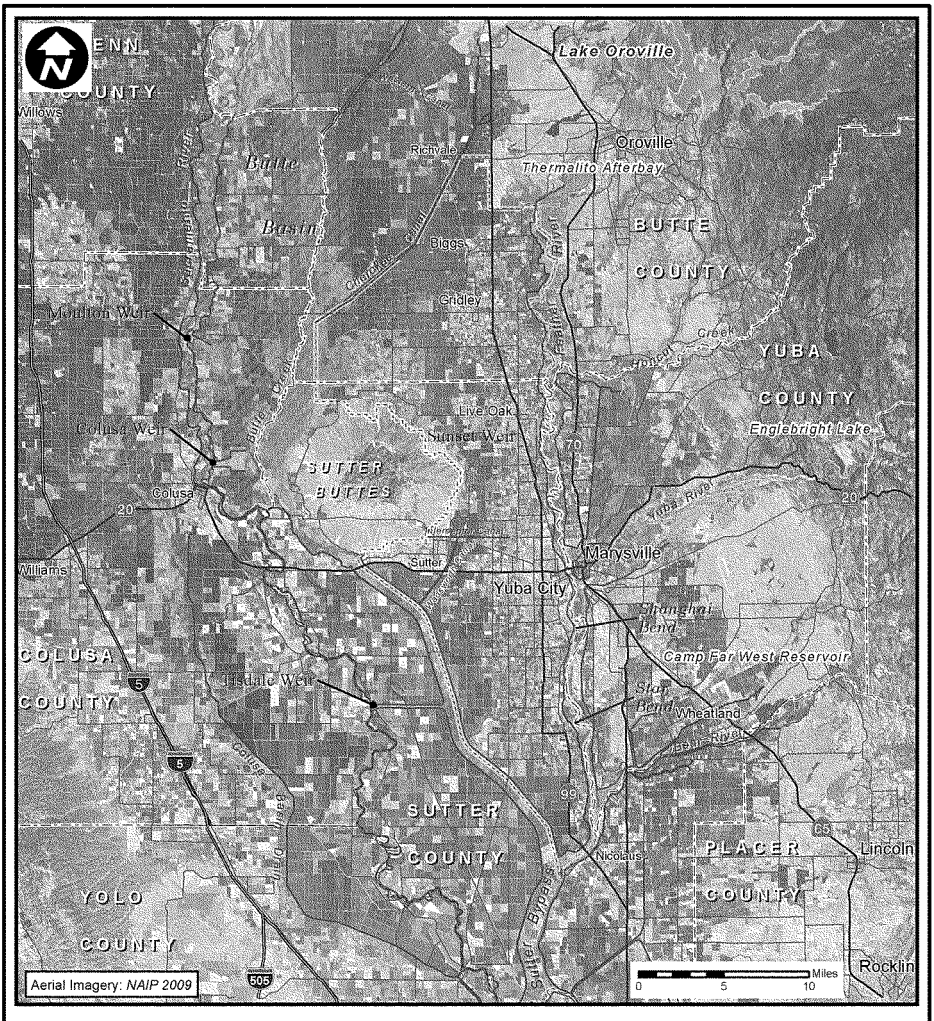
PLATE 2



Legend

- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Federal Levee
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

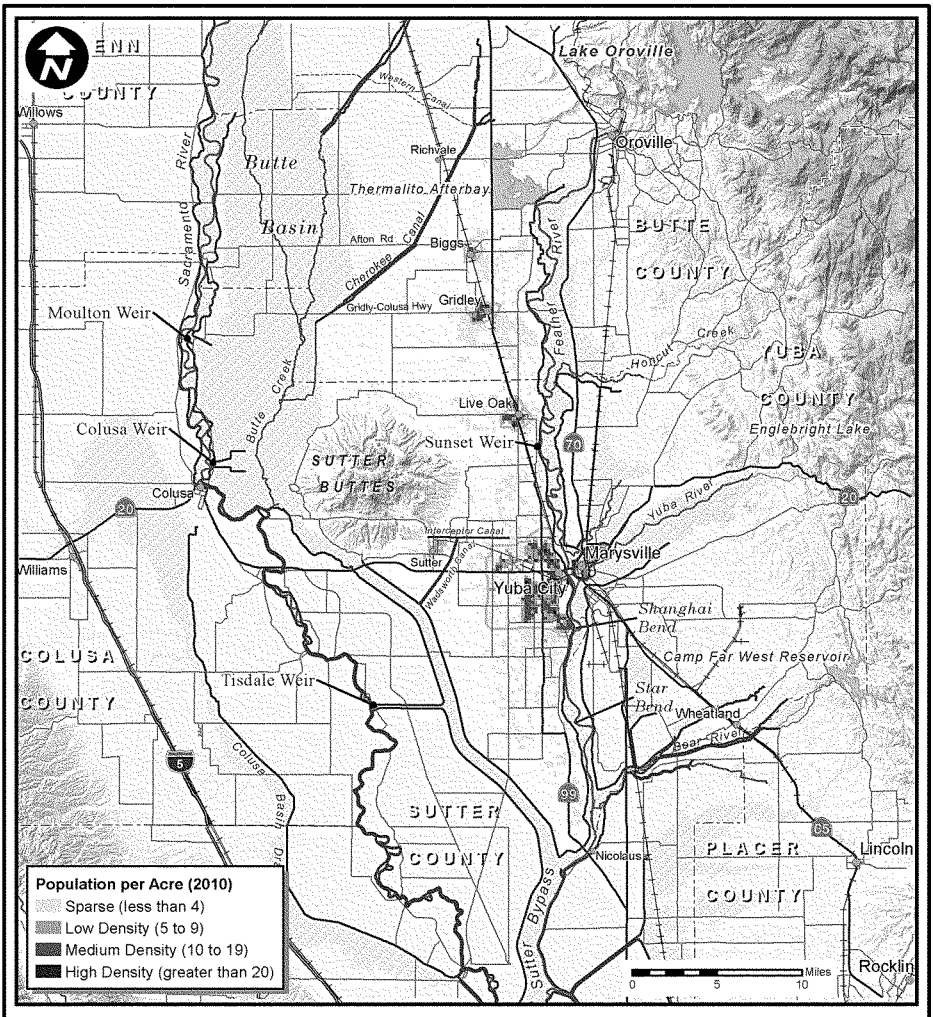
AERIAL IMAGERY

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012

PLATE 3



Legend

- Economic Evaluation Area
- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Federal Levee
- Railroad
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

POPULATION DENSITY

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

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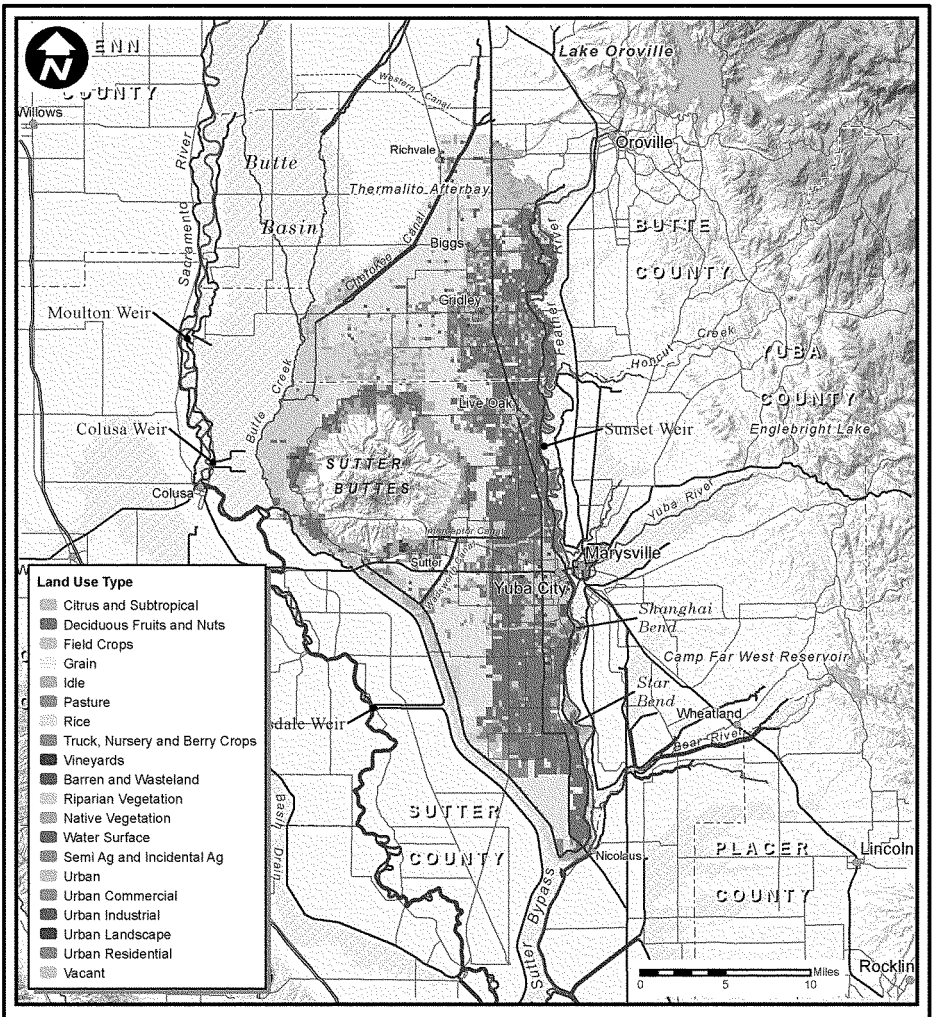
PLATE 4



Legend

- Designated Floodways
- Federal Levee
- Lake or Reservoir
- County Boundary
- River or Stream
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

LAND USE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

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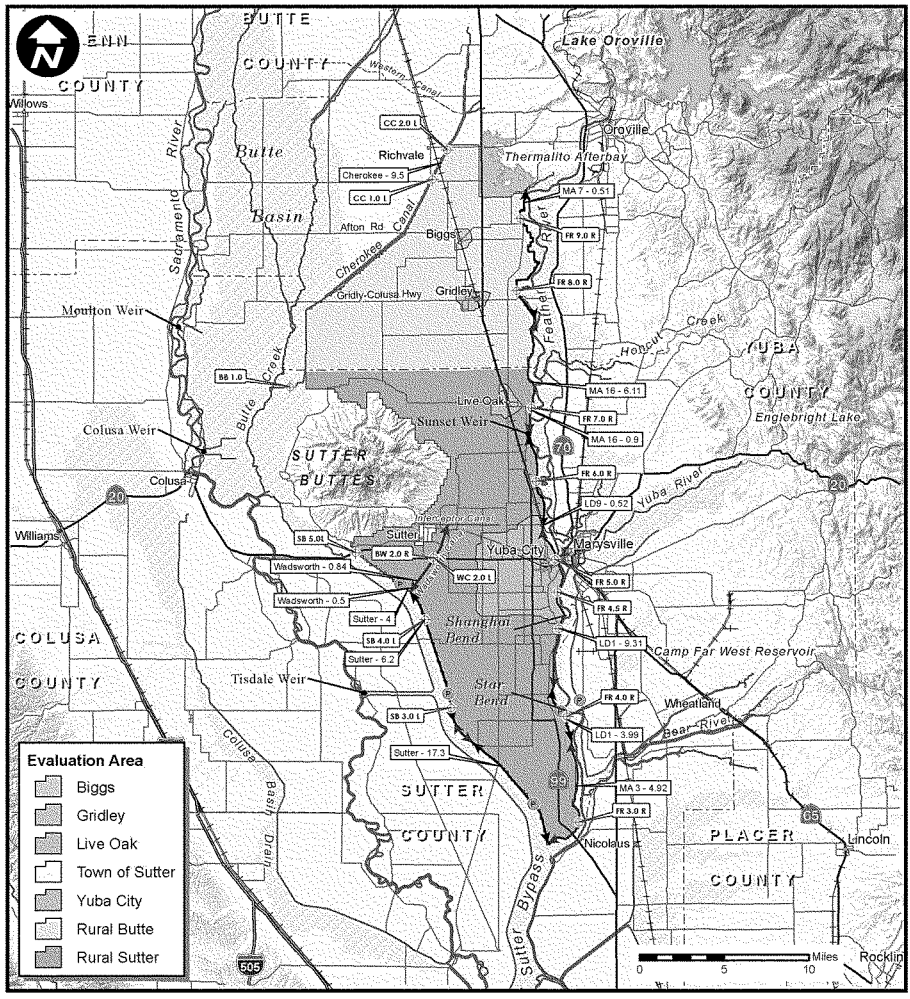
PLATE 5



Legend

- Geotechnical Levee Reach
- Federal Levee
- Breach Simulation Site
- Geotechnical Index Point
- Pump Station
- City or Town
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

ECONOMIC IMPACT AREAS

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

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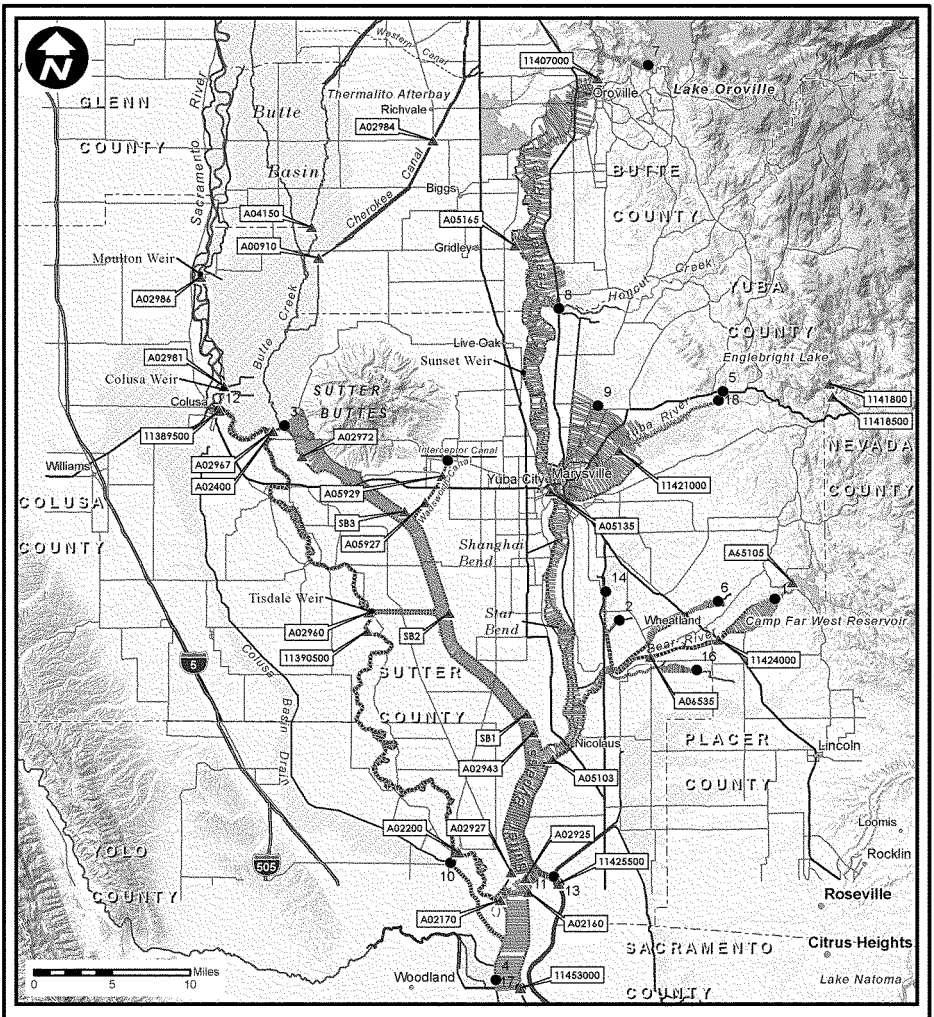
PLATE 6



Legend

- Stream Gage
- Model Boundaries
- Model Cross Sectios
- Federal Levee
- Study Area Extent
- Designated Floodways

NOTE: See Table 1 and 2 for Model Boundary Name

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

HEC-RAS HYDRAULIC MODEL BOUNDARY CONDITIONS AND STREAM GAGES

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

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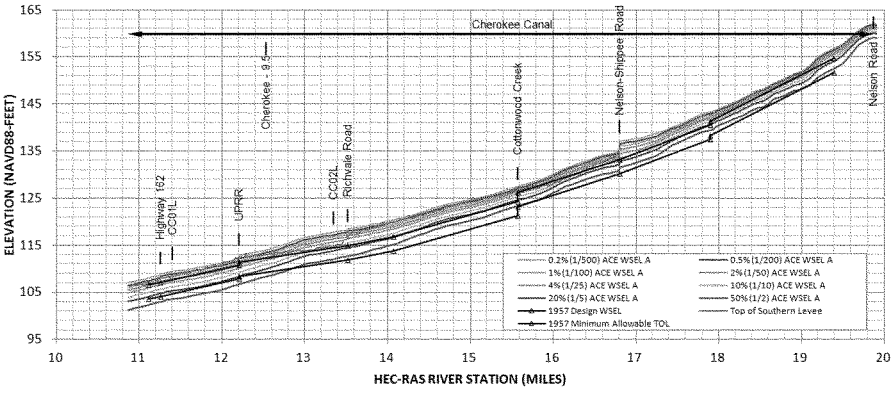
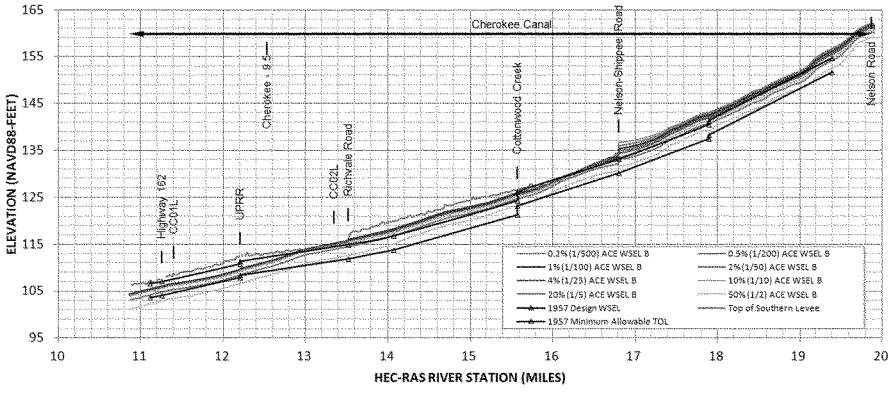
PLATE 7

Water Surface Profile A



Water Surface Profile B



Notes:

Water Surface Profile A assumes infinite levee height, no overtopping.

Water Surface Profile B assumes overtopping only, no failure.

WSEL = Water Surface Elevation

Source:

SUTTER BASIN FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

CHEROKEE CANAL
WATER SURFACE PROFILES

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

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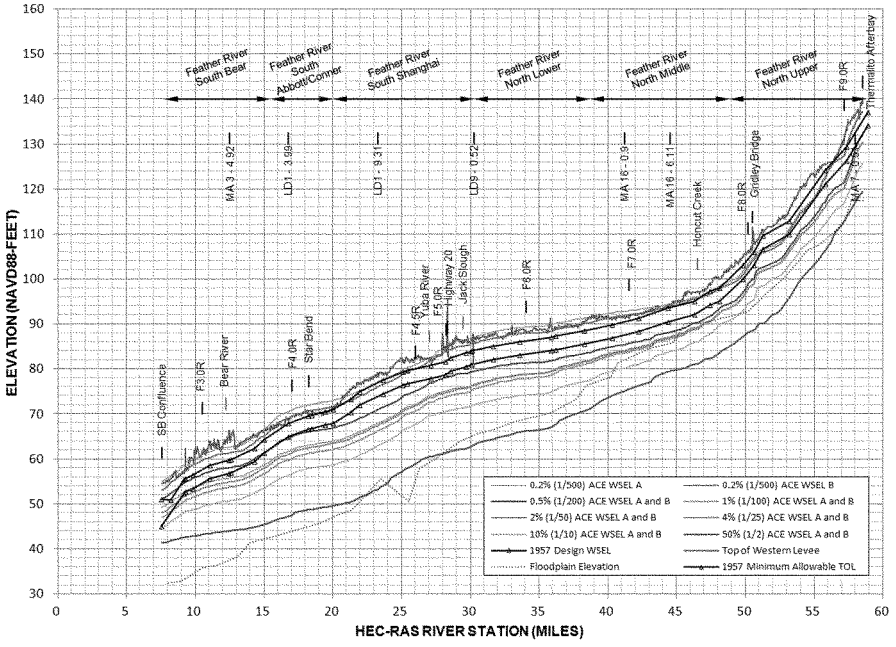
PLATE 8



Notes:

Water Surface Profile A assumes infinite height levee, no overtopping.

Water Surface Profile B assumes overtopping, no failure

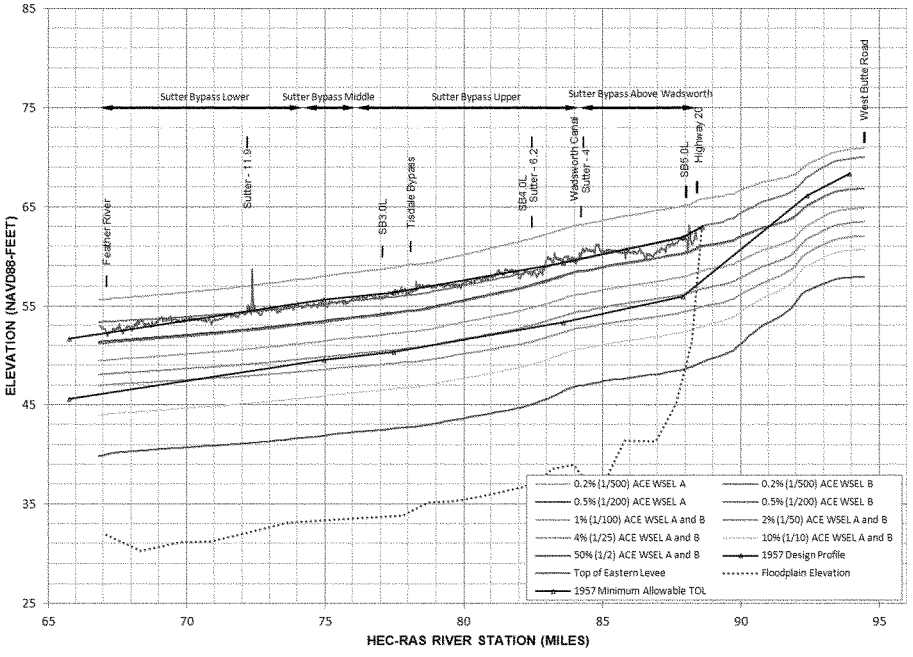
WSEL = Water Surface Elevation

SUTTER BASIN FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

FEATHER RIVER
WATER SURFACE PROFILES

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

OCT 2012 PLATE 9



Note:

Water Surface Profile A assumes infinite levee height, no overtopping.

Water Surface Elevation B assumes overtopping only, no failure

WSEL = Water Surface Elevation

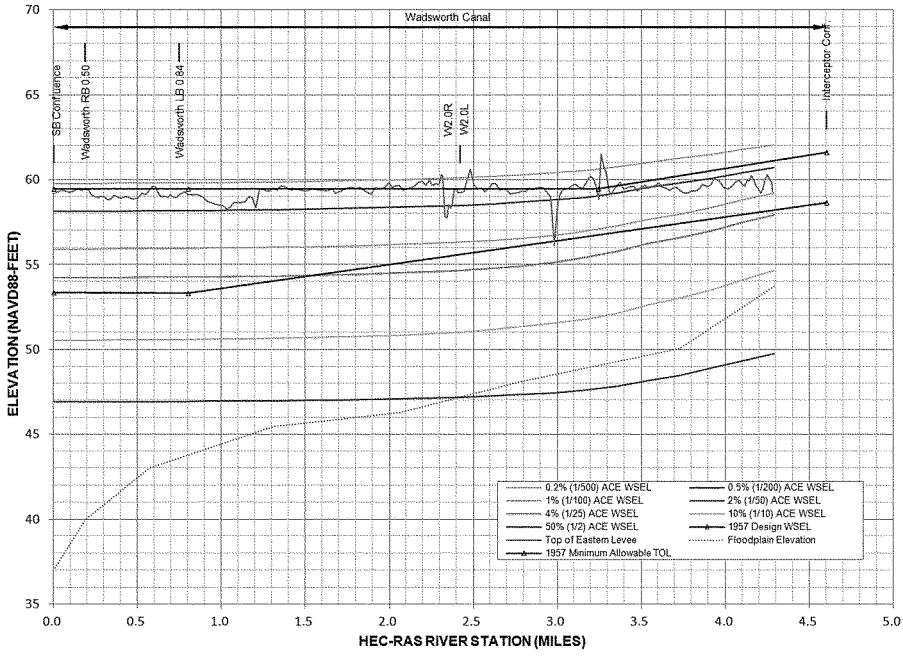
Source:

SUTTER BASIN FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

SUTTER BYPASS
WATER SURFACE PROFILES

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

OCT 2012 PLATE 10



Notes:

Water Surface Profiles assume infinite height levee, no overtopping.

Overtopping, no failure was not created for Wadsworth Canal.

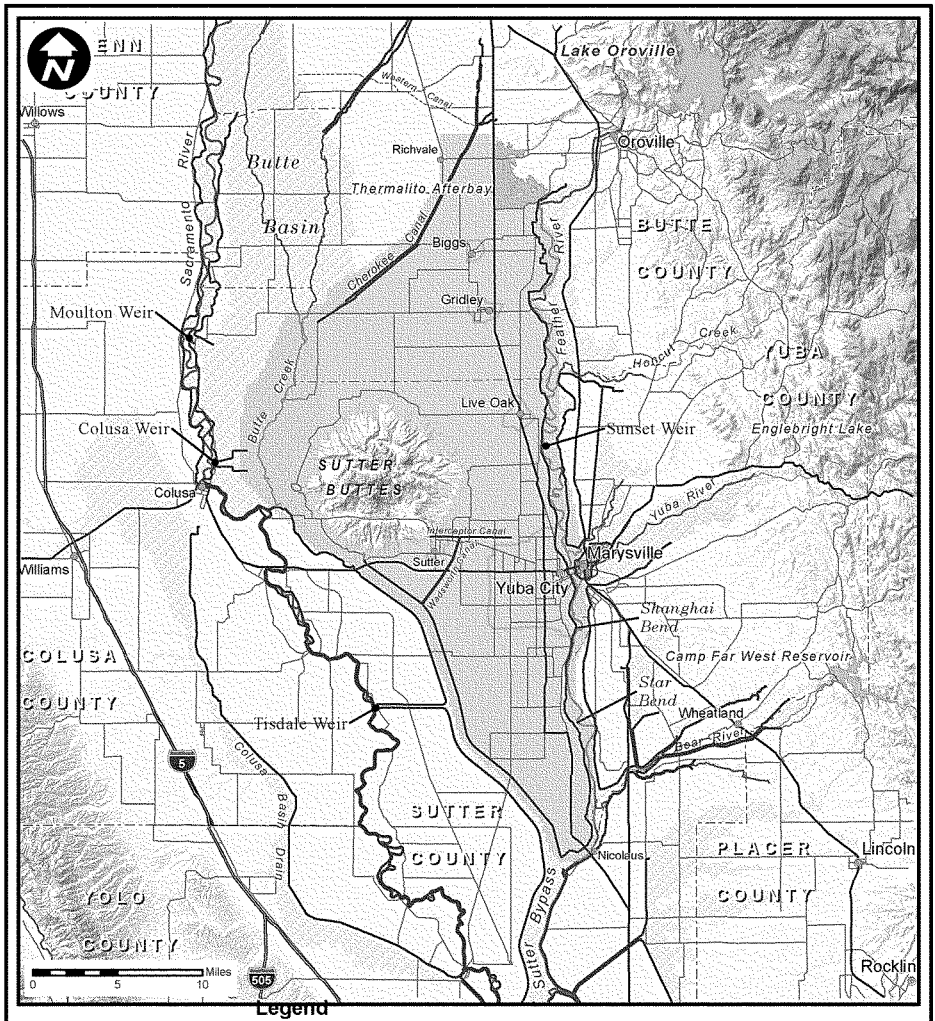
WSEL = Water Surface Elevation

SUTTER BASIN FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

WADSWORTH CANAL
WATER SURFACE PROFILES

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

OCT 2012 PLATE 11



Legend

- FLO2D Grid
- Designated Floodways
- Lake or Reservoir
- Economic Evaluation Area
- River or Stream
- Federal Levee
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

FLO2D MODEL GRID

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

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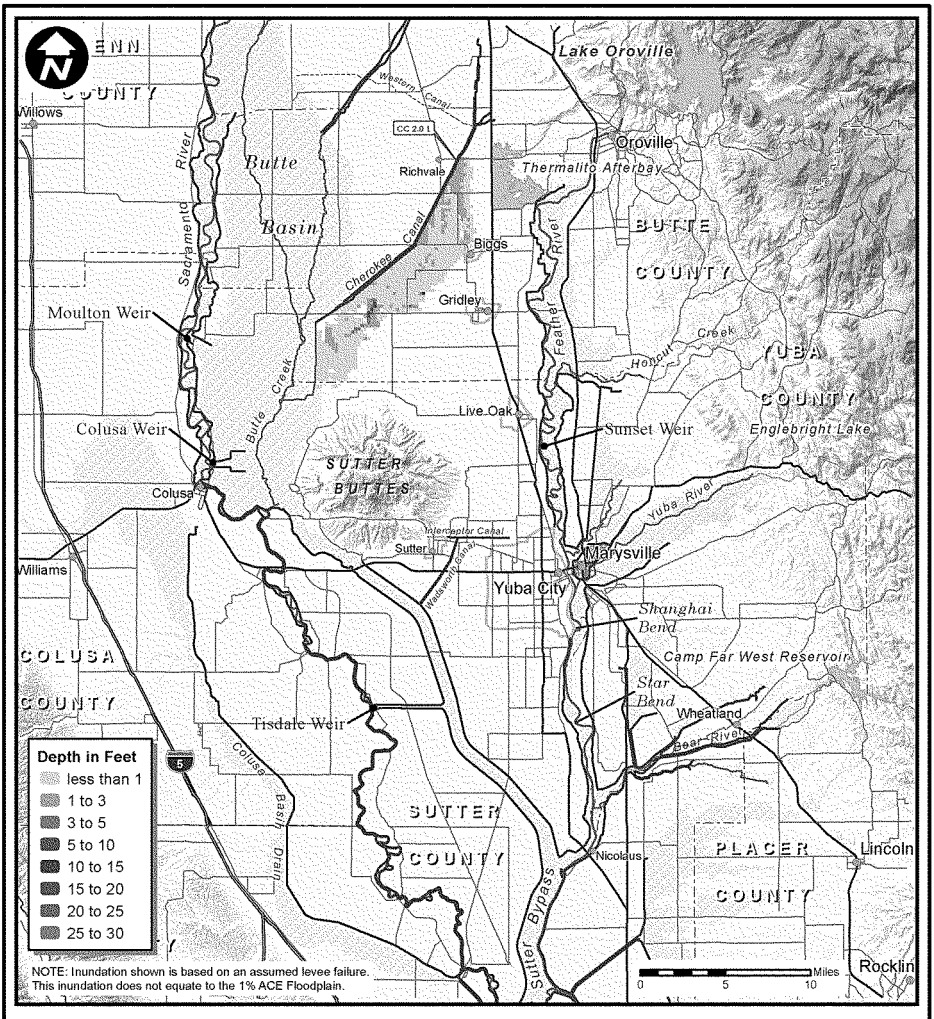
PLATE 12



Legend

- Breach Index Point
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Study Area Extent
- Federal Levee
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED BREACH INUNDATION
CC 2.0 L INDEX POINT
1% ACE EVENT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

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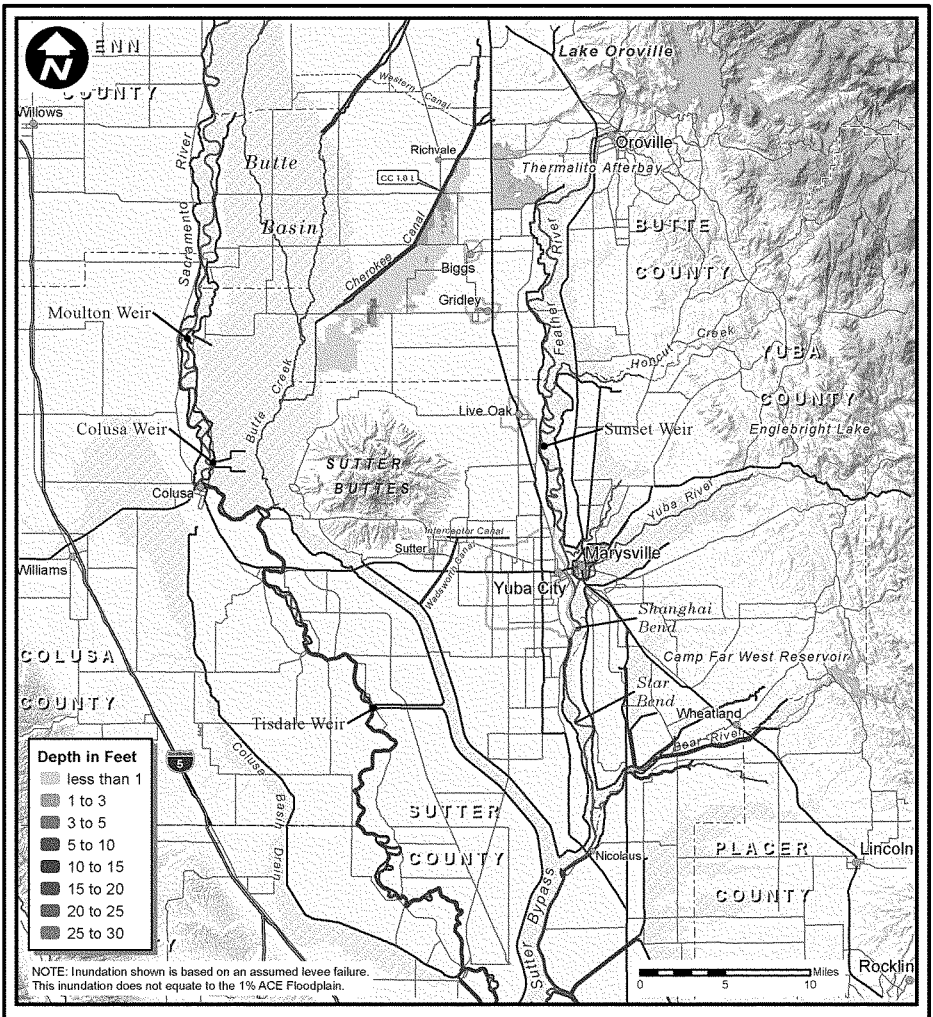
PLATE 13



Legend

- Breach Index Point
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Study Area Extent
- Federal Levee
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED BREACH INUNDATION
CC 1.0 L INDEX POINT
1% ACE EVENT

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SACRAMENTO DISTRICT

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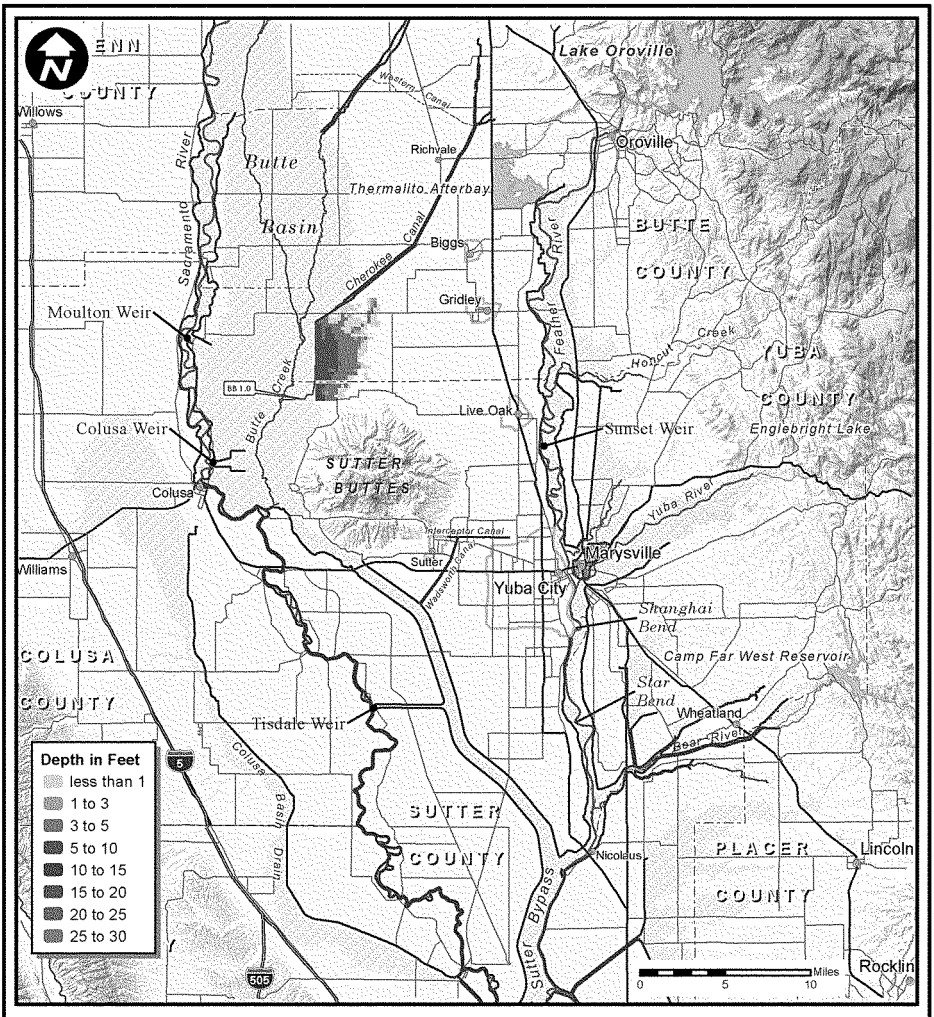
PLATE 14



Legend

- Flood Source Point
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Study Area Extent
- Federal Levee
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED INUNDATION
BB 1.0 INDEX POINT
1% ACE EVENT

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SACRAMENTO DISTRICT

Prepared by Jim Mars

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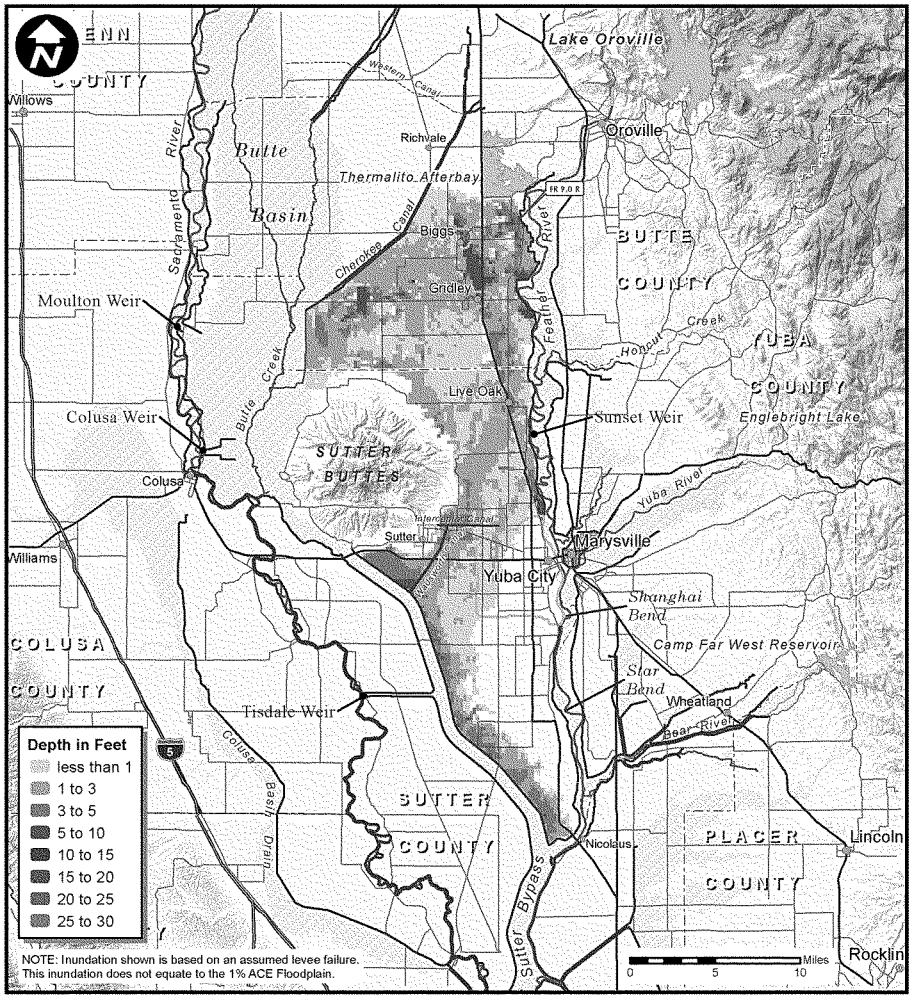
PLATE 15



Legend

- Breach Index Point
- Study Area Extent
- Designated Floodways
- Federal Levee
- Lake or Reservoir
- County Boundary
- River or Stream
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED BREACH INUNDATION FR 9.0 R INDEX POINT 1% ACE EVENT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

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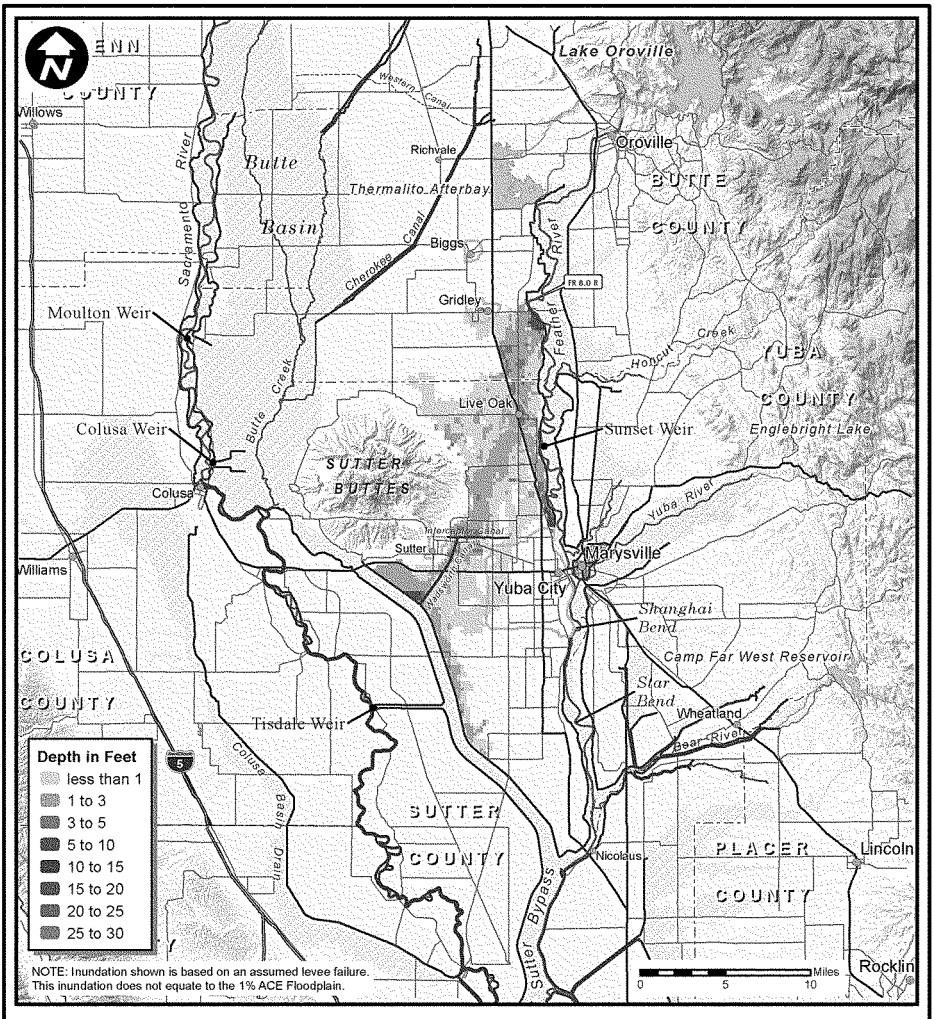
PLATE 16



Legend

- Breach Index Point
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Study Area Extent
- Federal Levee
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED BREACH INUNDATION
FR 8.0 R INDEX POINT
1% ACE EVENT

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SACRAMENTO DISTRICT

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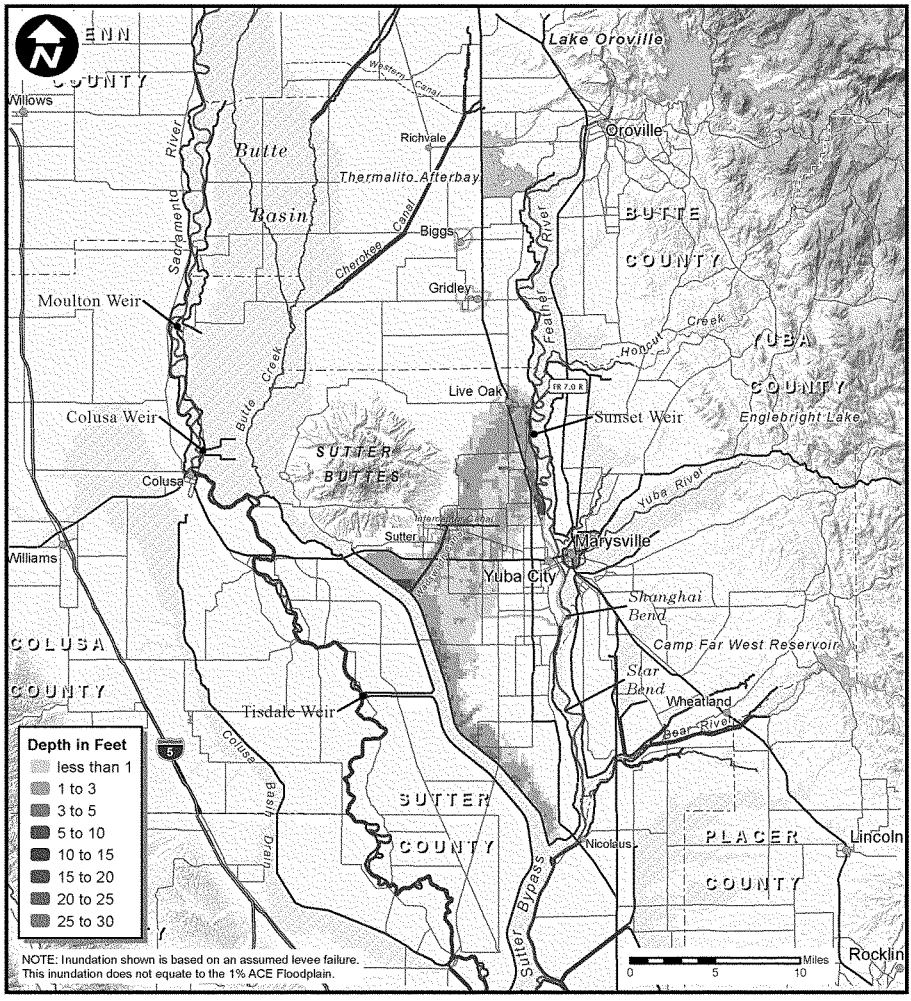
PLATE 17



Legend

- Breach Index Point
- Study Area Extent
- Designated Floodways
- Federal Levee
- Lake or Reservoir
- County Boundary
- River or Stream
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED BREACH INUNDATION
FR 7.0 R INDEX POINT
1% ACE EVENT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

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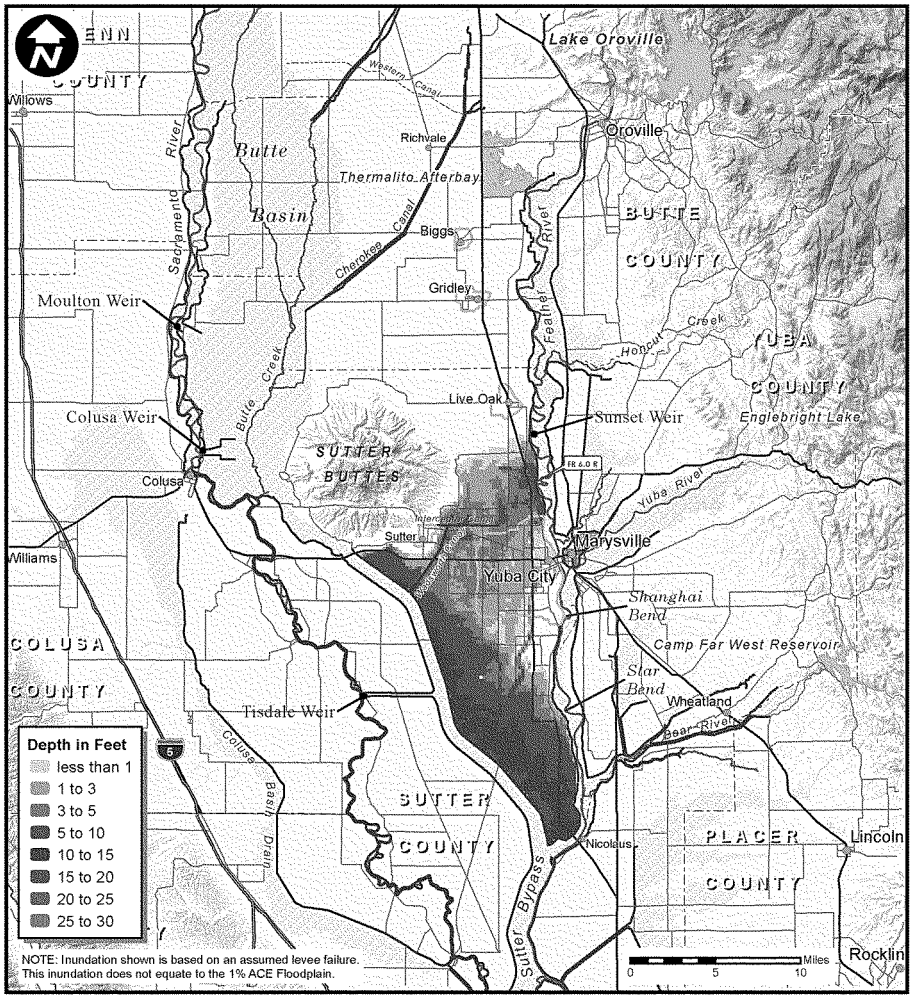
PLATE 18



Legend

- Breach Index Point
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Study Area Extent
- Federal Levee
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED BREACH INUNDATION
FR 6.0 R INDEX POINT
1% ACE EVENT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

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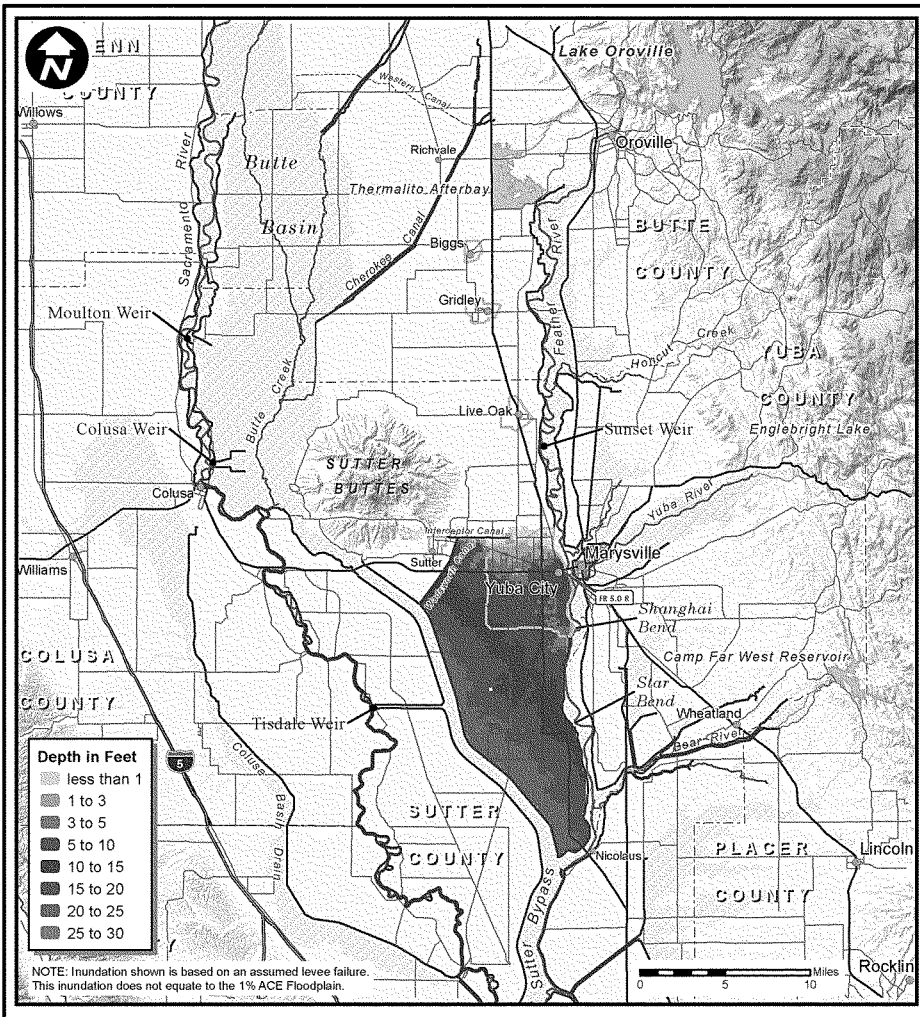
PLATE 19



Legend

- Breach Index Point
- Study Area Extent
- Designated Floodways
- Federal Levee
- Lake or Reservoir
- County Boundary
- River or Stream
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED BREACH INUNDATION FR 5.0 R INDEX POINT 1% ACE EVENT

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SACRAMENTO DISTRICT

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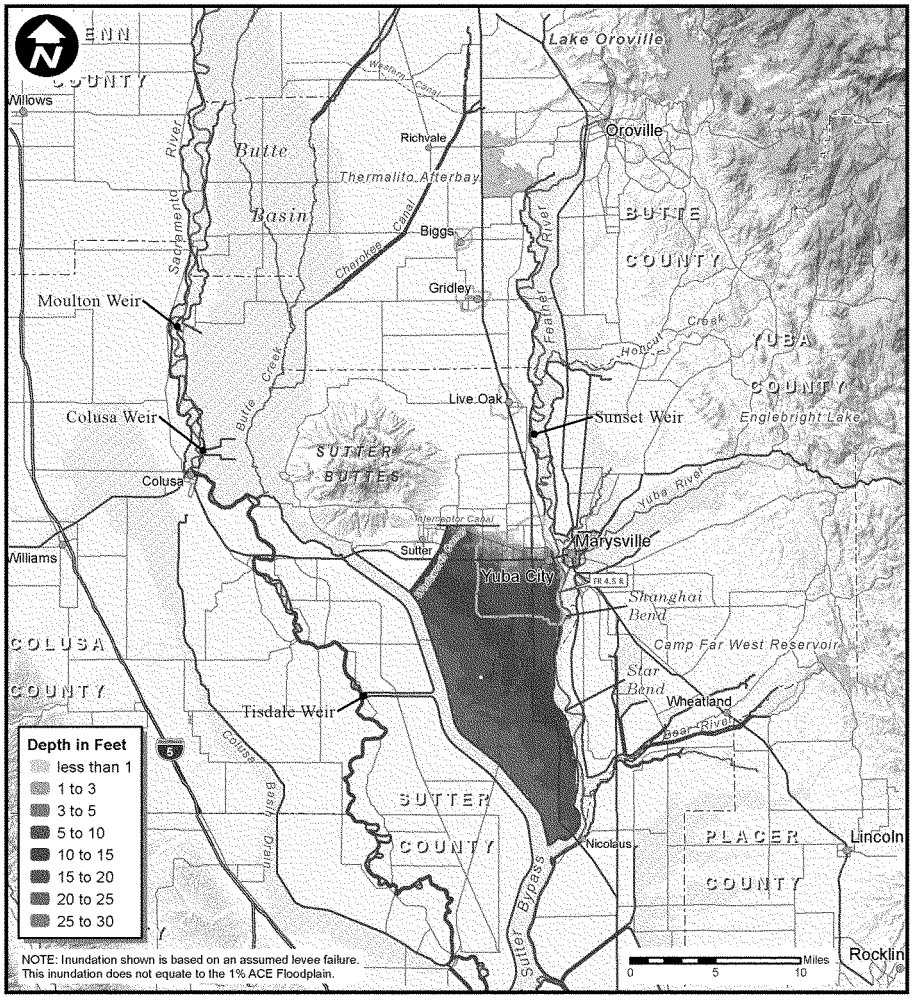
PLATE 20



Legend

- Breach Index Point
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Study Area Extent
- Federal Levee
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED BREACH INUNDATION
FR 4.5 R INDEX POINT
1% ACE EVENT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

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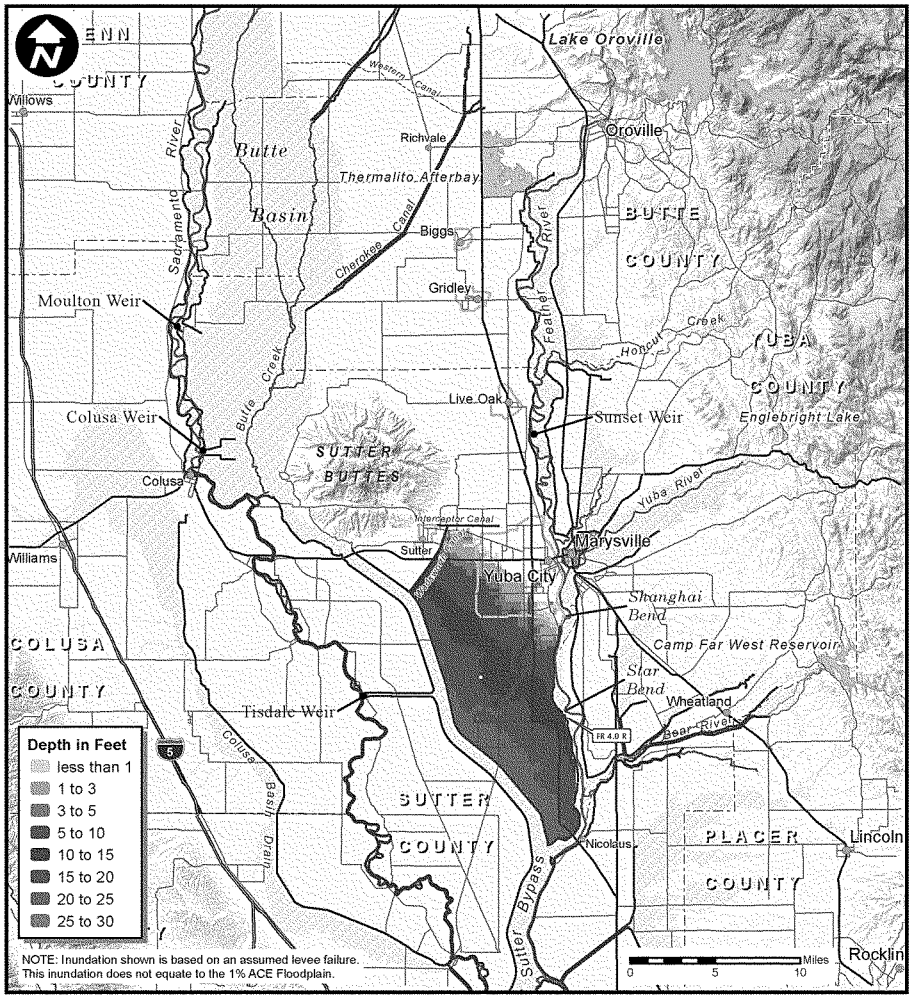
PLATE 21



Legend

- Breach Index Point
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Study Area Extent
- Federal Levee
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED BREACH INUNDATION FR 4.0 R INDEX POINT 1% ACE EVENT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

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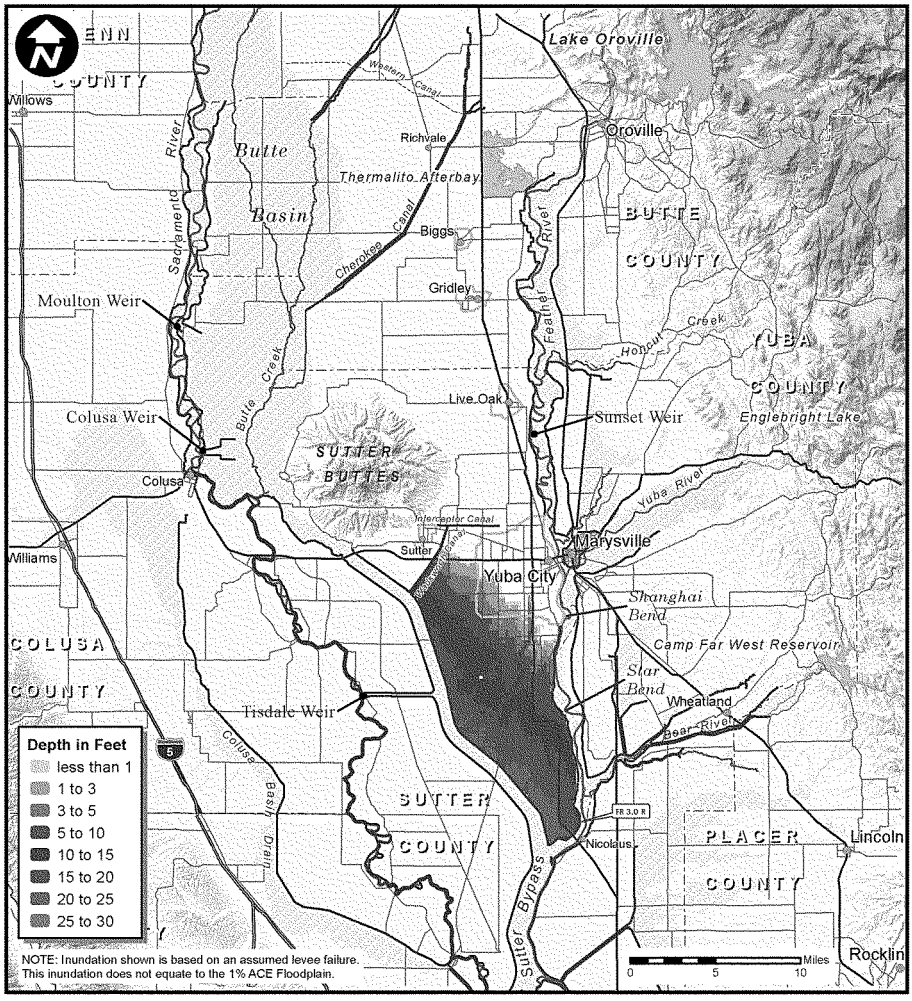
PLATE 22



Legend

- Breach Index Point
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Study Area Extent
- Federal Levee
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED BREACH INUNDATION
FR 3.0 R INDEX POINT
1% ACE EVENT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

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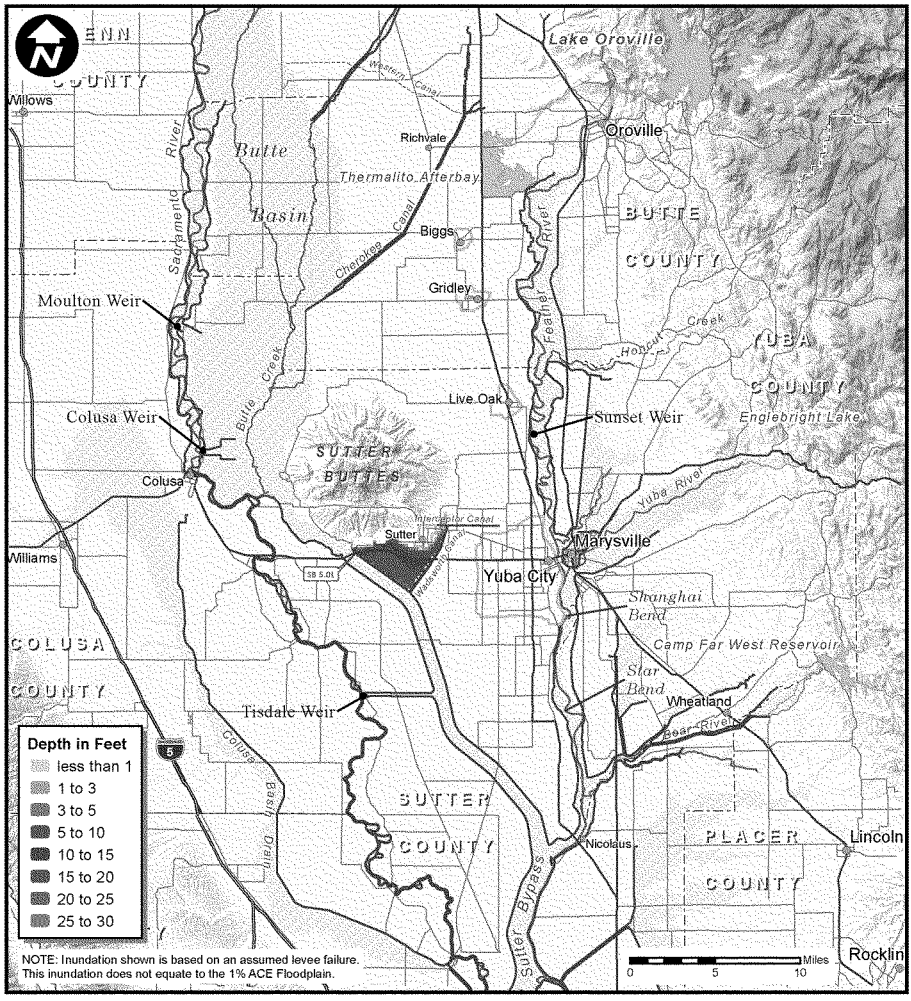
PLATE 23



Legend

- Breach Index Point
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Study Area Extent
- Federal Levee
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED BREACH INUNDATION
SB 5.0 L INDEX POINT
1% ACE EVENT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

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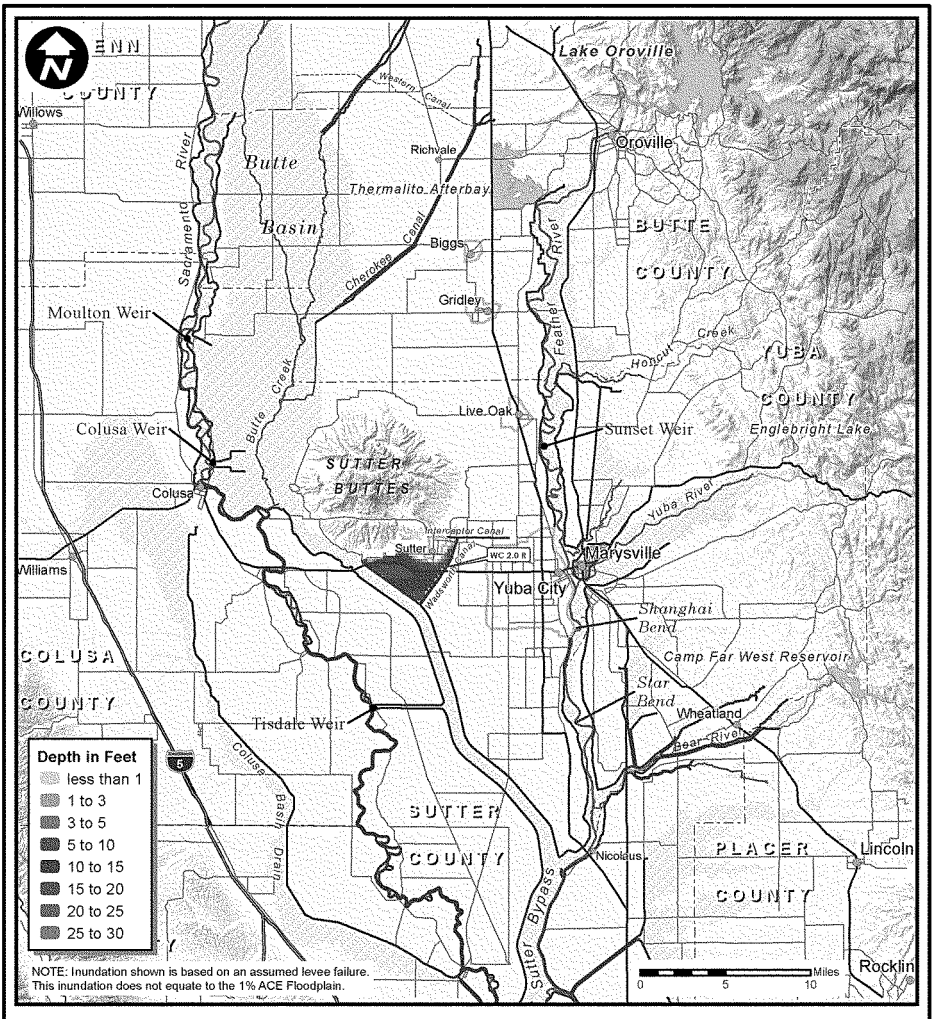
PLATE 24



Legend

- Breach Index Point
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Study Area Extent
- Federal Levee
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED BREACH INUNDATION
WC 2.0 R INDEX POINT
1% ACE EVENT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

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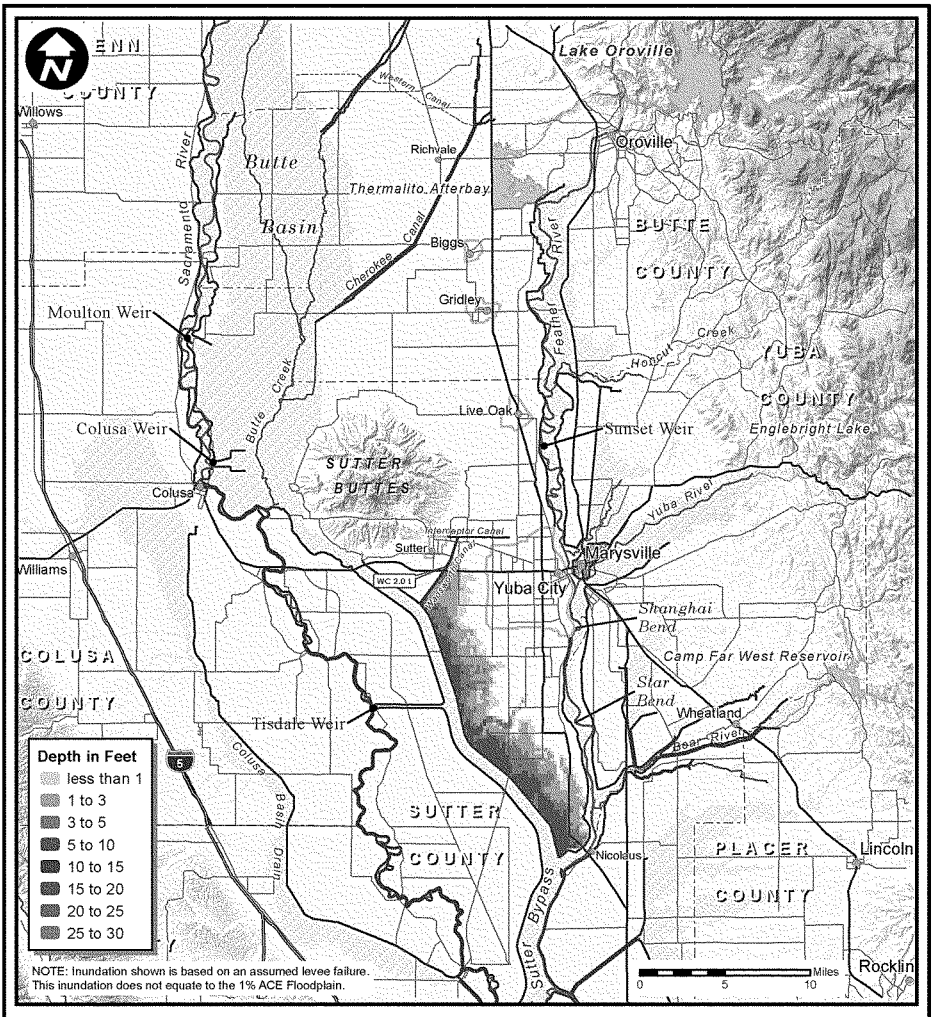
PLATE 25



Legend

- Breach Index Point
- Study Area Extent
- Designated Floodways
- Federal Levee
- Lake or Reservoir
- County Boundary
- River or Stream
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED BREACH INUNDATION
WC 2.0 L INDEX POINT
1% ACE EVENT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

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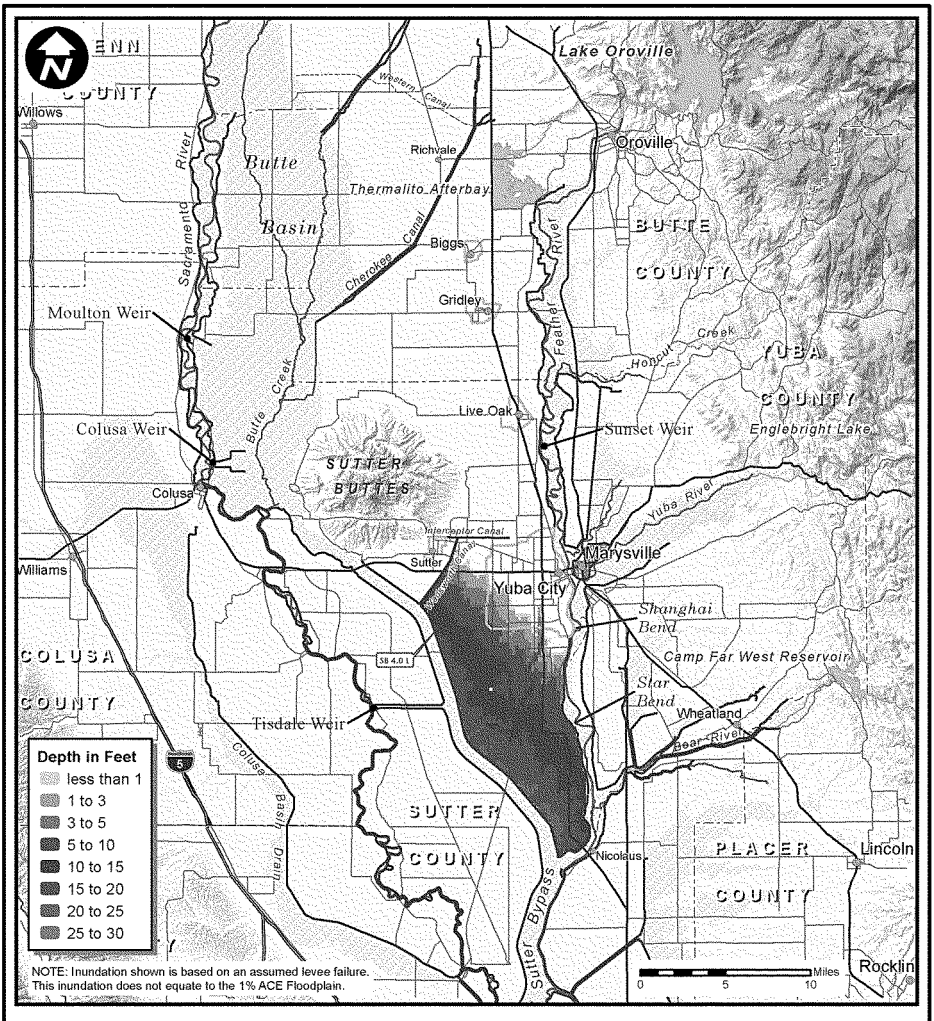
PLATE 26



Legend

- Breach Index Point
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Study Area Extent
- Federal Levee
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

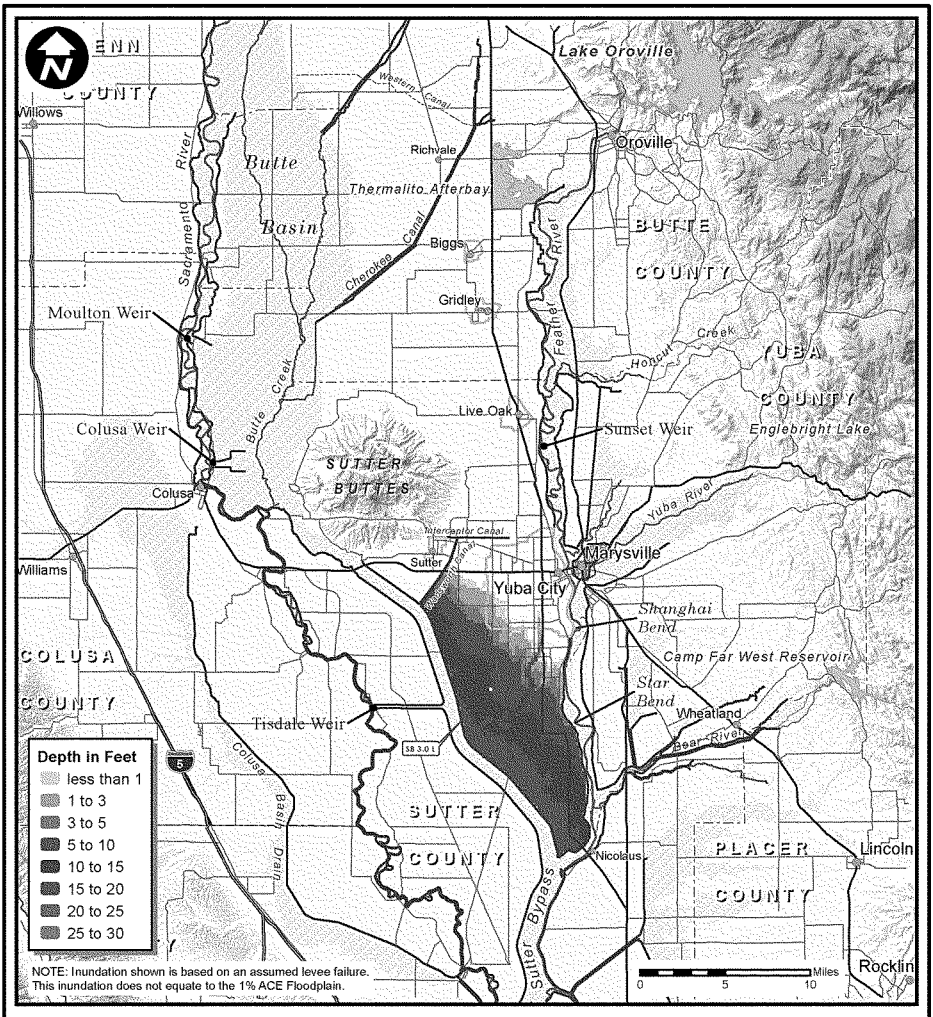
MODELED BREACH INUNDATION
SB 4.0 L INDEX POINT
1% ACE EVENT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012

PLATE 27



Legend

- Breach Index Point
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Study Area Extent
- Federal Levee
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

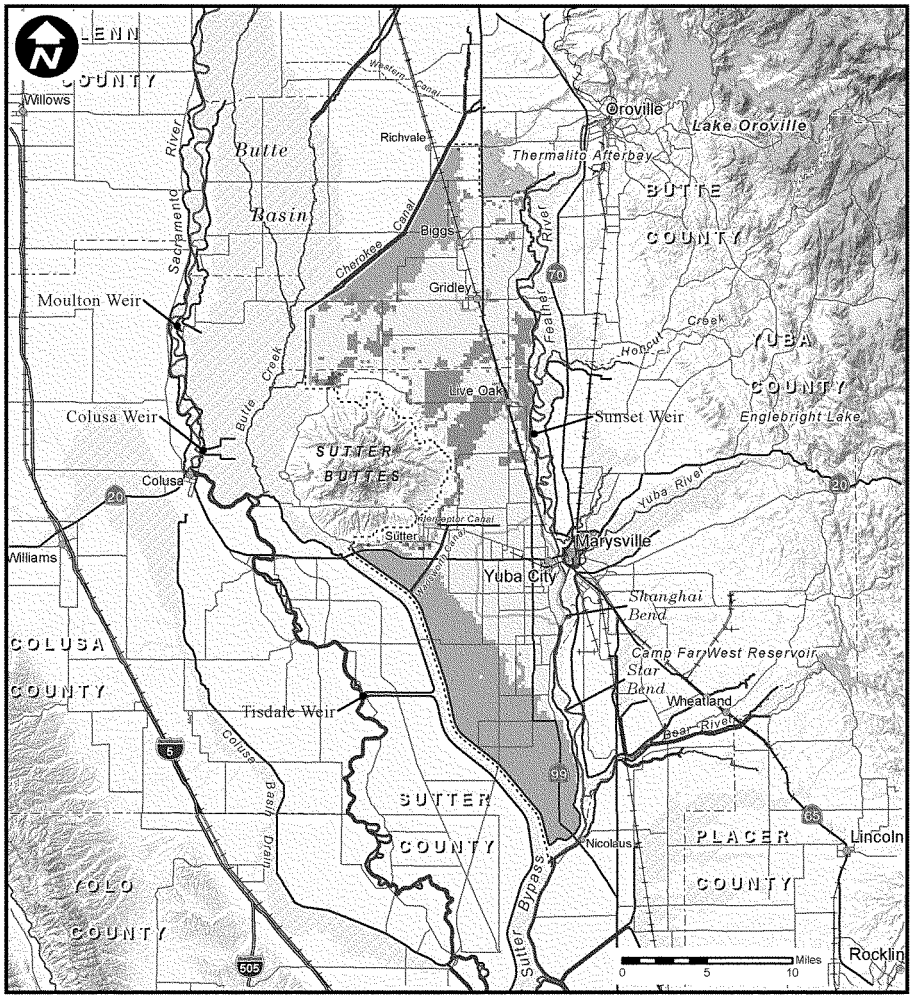
MODELED BREACH INUNDATION
SB 3.0 L INDEX POINT
1% ACE EVENT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012

PLATE 28



Legend

- 0.2% (1/500) ACE Floodplain
- 0.5% (1/200) ACE Floodplain
- 1% (1/100) AEP Floodplain
- 2% (1/50) ACE Floodplain
- 4% (1/25) ACE Floodplain
- 10% (1/10) ACE Floodplain
- 50% (1/2) ACE Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad

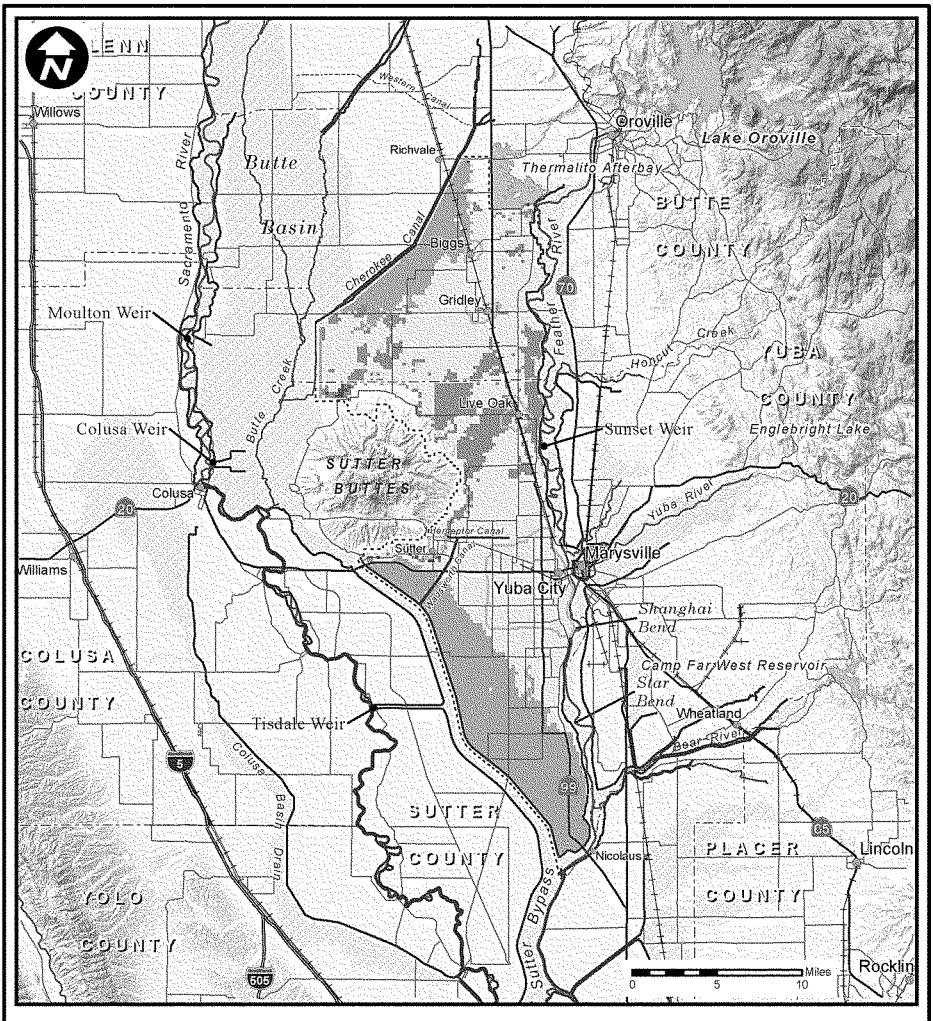
Criteria 1 residual floodplain shown if geotechnical probability of failue is greater than 5% at median top of levee or top of levee less than 3 feet above median water surface elevation,

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

CRITERIA 1 RESIDUAL FLOODPLAIN ALTERNATIVE SB-1 WITHOUT PROJECT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars | OCT 2012 | PLATE 29



Legend

- 0.2% (1/500) ACE Floodplain
- 0.5% (1/200) ACE Floodplain
- 1% (1/100) AEP Floodplain
- 2% (1/50) ACE Floodplain
- 4% (1/25) ACE Floodplain
- 10% (1/10) ACE Floodplain
- 50% (1/2) ACE Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad

Criteria 2 Residual floodplain shown if levee does not pass criteria.
1) Assurance less than 90% the levee does not pass criteria
2) For assurance between 90 and 95% levee must have minimum of 3 feet of freeboard to pass criteria. 3) For assurance greater than 95% levee must have minimum of 2 feet of freeboard to pass criteria

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

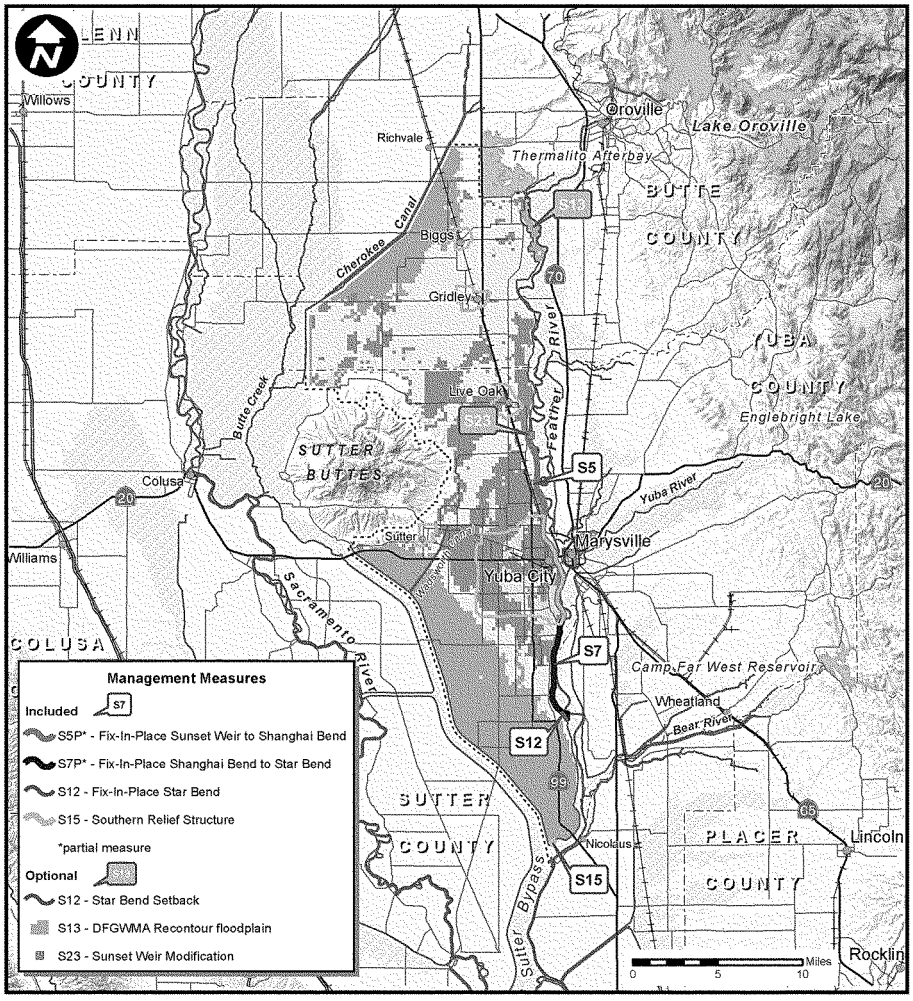
CRITERIA 2 RESIDUAL FLOODPLAIN ALTERNATIVE SB-1 WITHOUT PROJECT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012

PLATE 30



Criteria 1 residual floodplain shown if geotechnical probability of failue is greater than 5% at median top of levee or top of levee less than 3 feet above median water surface elevation,

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

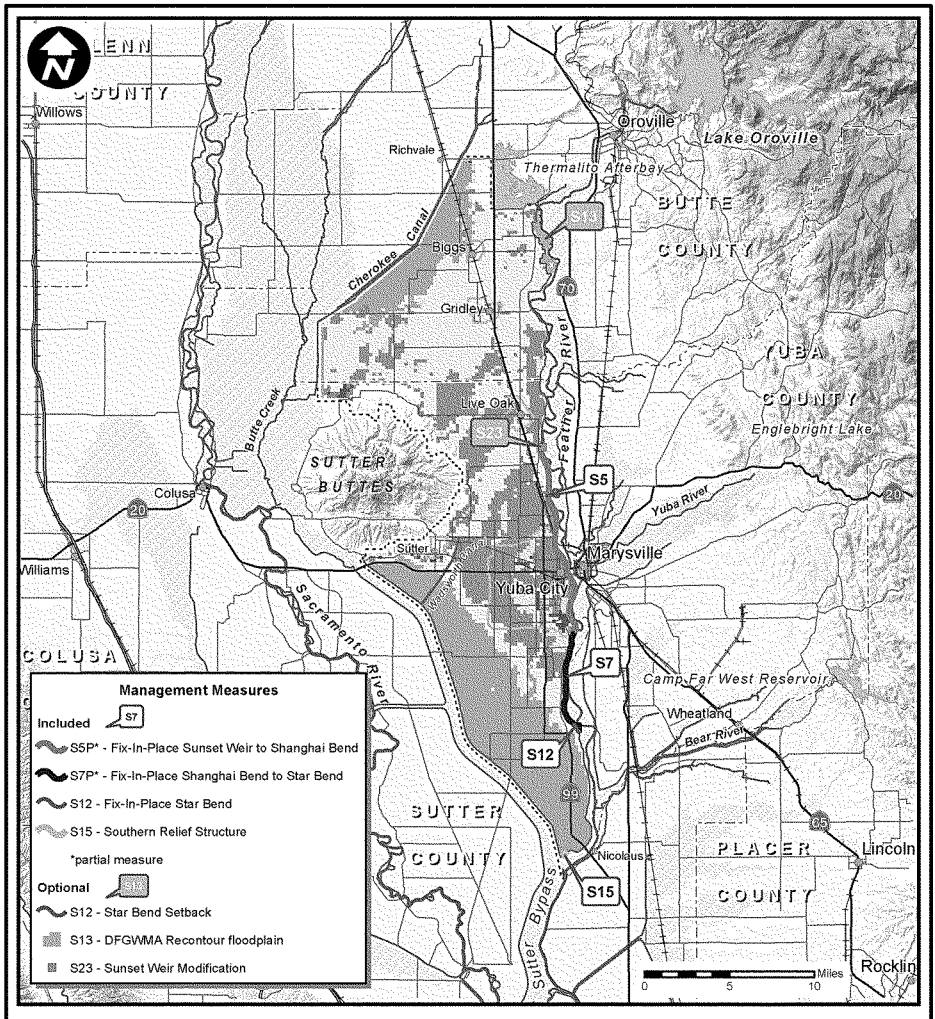
CRITERIA 1 RESIDUAL FLOODPLAIN ALTERNATIVE SB-2 MINIMAL FIX-IN-PLACE PLUS NONSTRUCTURAL

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012

PLATE 31



Legend

- 0.2% (1/500) ACE Floodplain
- 0.5% (1/200) ACE Floodplain
- 1% (1/100) AEP Floodplain
- 2% (1/50) ACE Floodplain
- 4% (1/25) ACE Floodplain
- 10% (1/10) ACE Floodplain
- 50% (1/2) ACE Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad

Criteria 2 Residual floodplain shown if levee does not pass criteria.
1) Assurance less than 90% the levee does not pass criteria
2) For assurance between 90 and 95% levee must have minimum of 3 feet of freeboard to pass criteria. 3) For assurance greater than 95% levee must have minimum of 2 feet of freeboard to pass criteria

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

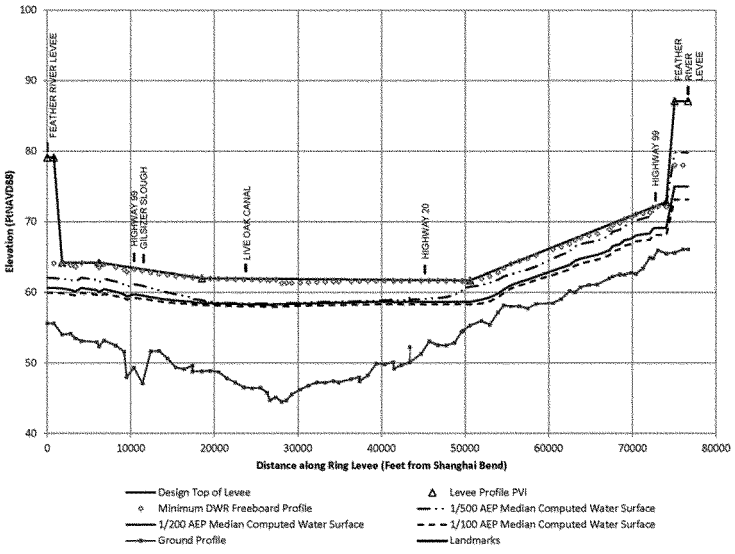
CRITERIA 2 RESIDUAL FLOODPLAIN ALTERNATIVE SB-2 MINIMAL FIX-IN-PLACE PLUS NONSTRUCTURAL

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012

PLATE 32



Notes:

1) WSEL = Water Surface Elevation

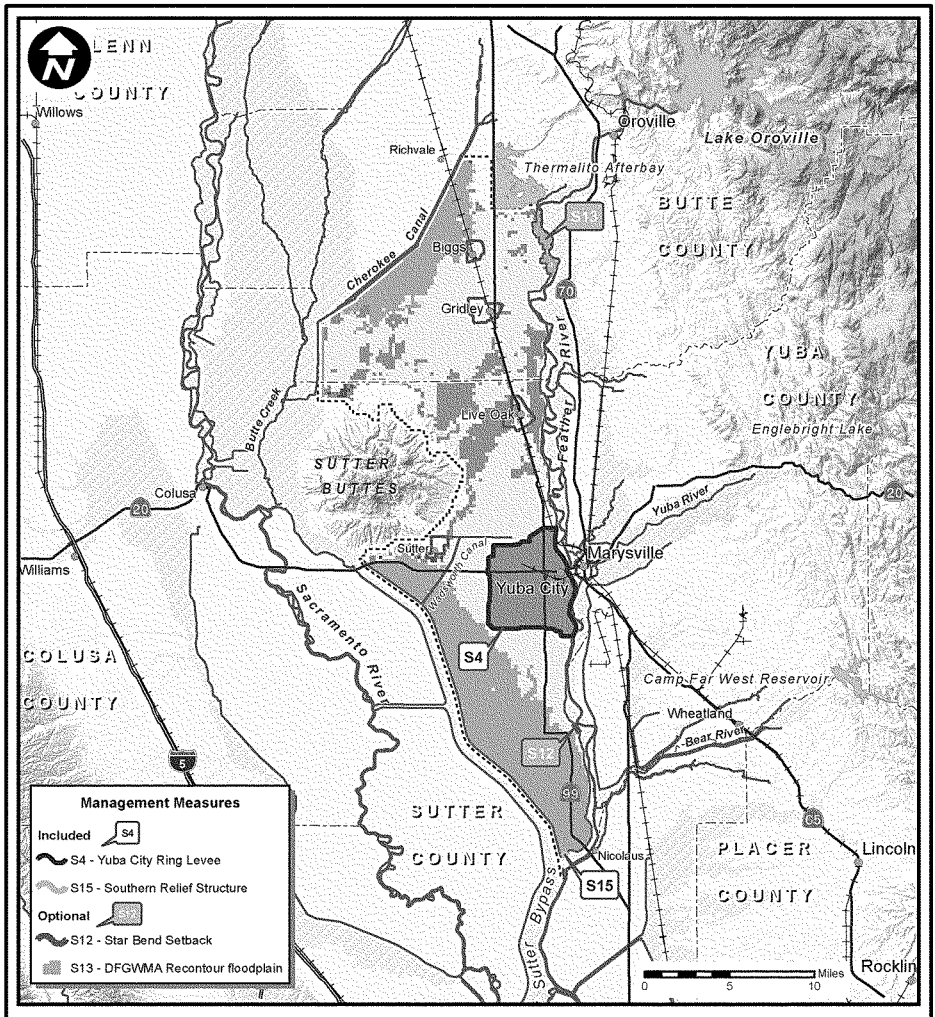
2) Water surface elevations based on maximum water surface from assumed levee breaches outside the ring levee.

SUTTER BASIN FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

LEVEE DESIGN PROFILE
ALTERNATIVE SB-3
YUBA CITY RING LEVEE

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

OCT 2012 PLATE 33



Criteria 1 residual floodplain shown if geotechnical probability of failue is greater than 5% at median top of levee or top of levee less than 3 feet above median water surface elevation.

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

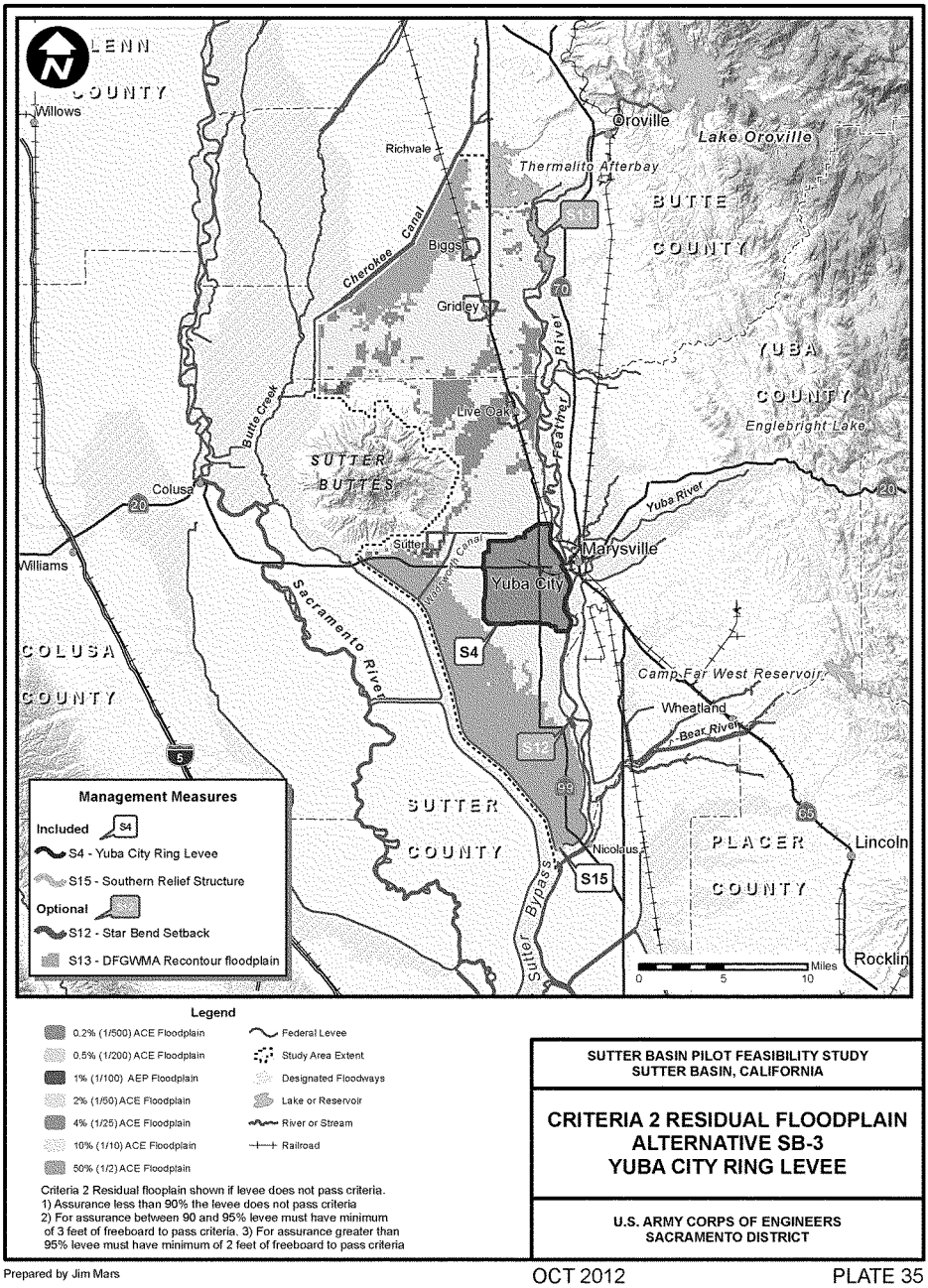
CRITERIA 1 RESIDUAL FLOODPLAIN ALTERNATIVE SB-3 YUBA CITY RING LEVEE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

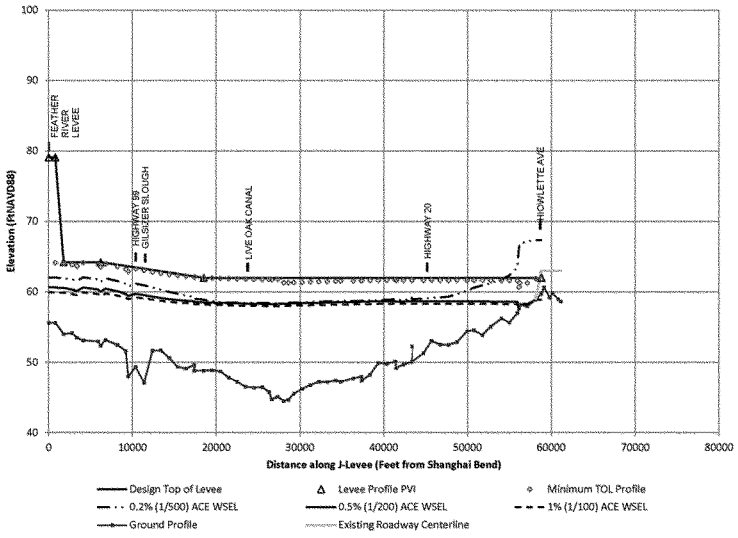
Prepared by Jim Mars

OCT 2012

PLATE 34



Prepared by Jim Mars OCT 2012 PLATE 35



Notes:

1) WSEL = Water Surface Elevation

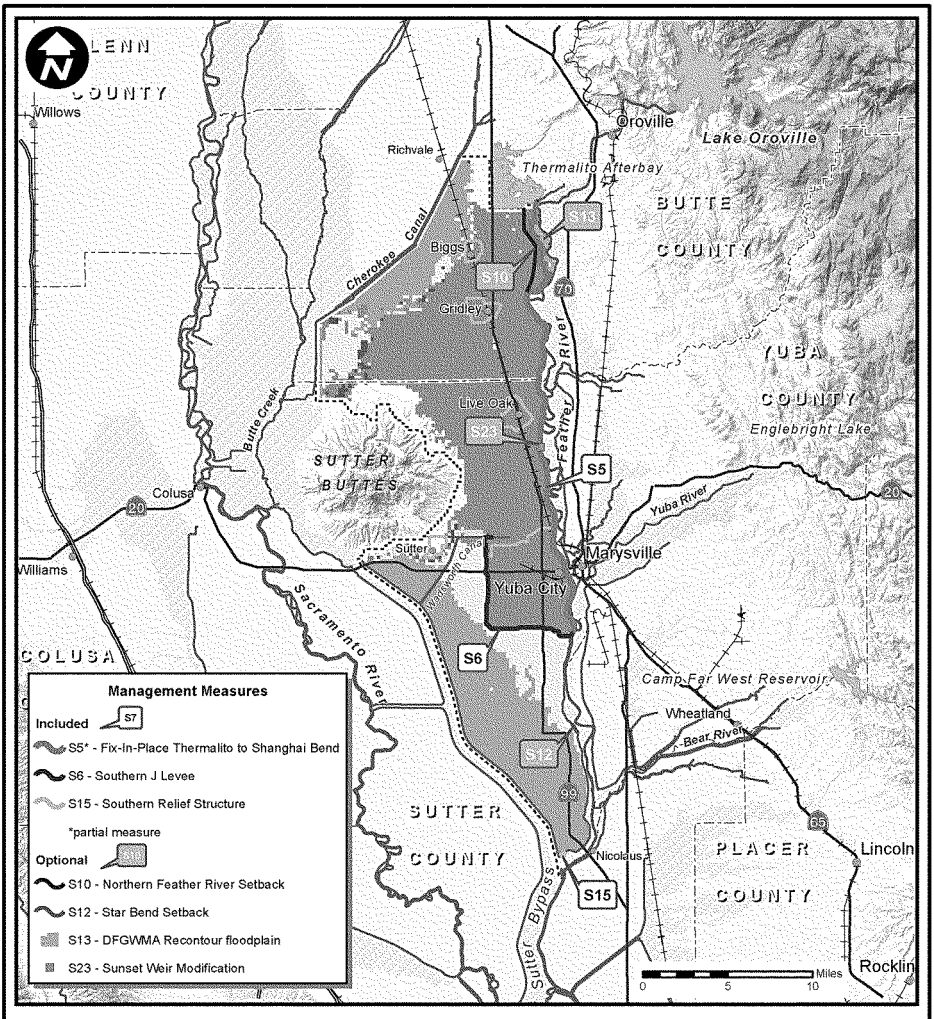
2) Water surface elevations based on maximum water surface from assumed levee breaches outside the ring levee.

SUTTER BASIN FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

LEVEE DESIGN PROFILE
ALTERNATIVE SB-4
LITTLE "J" LEVEE

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

OCT 2012 PLATE 36



Criteria 1 residual floodplain shown if geotechnical probability of failue is greater than 5% at median top of levee or top of levee less than 3 feet above median water surface elevation,

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

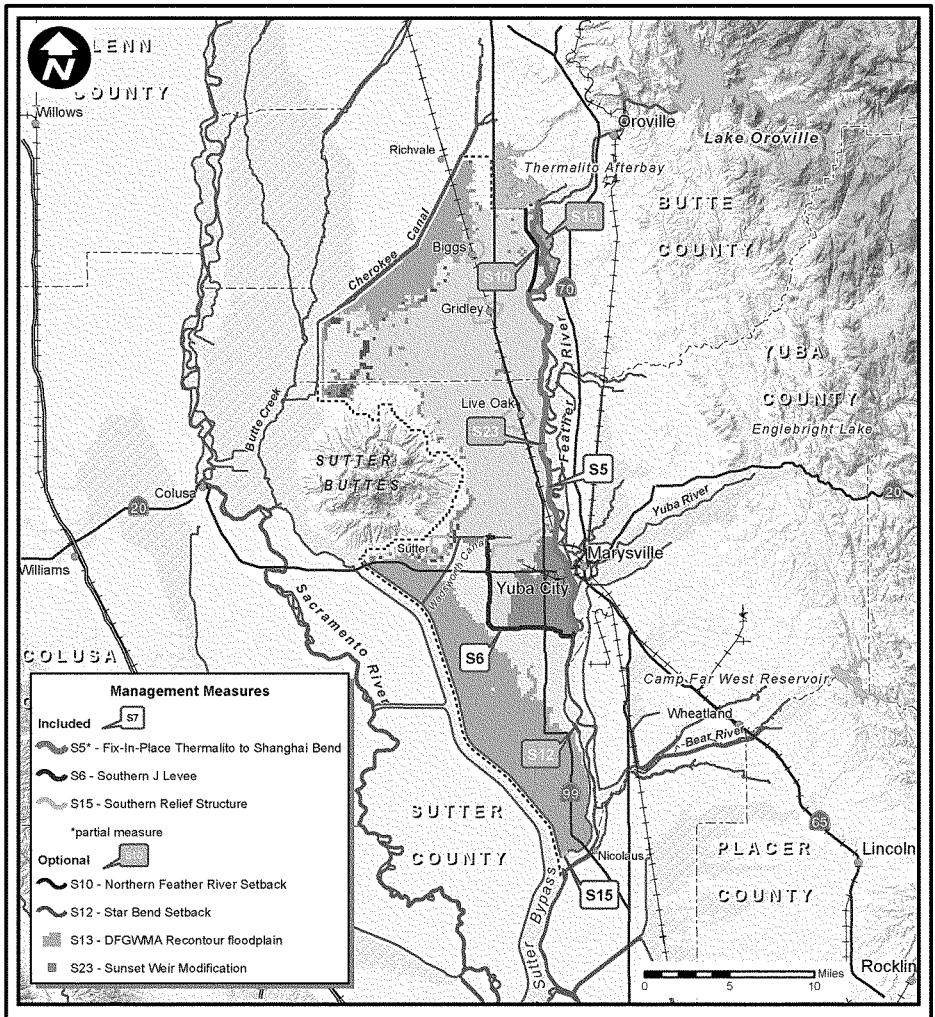
CRITERIA 1 RESIDUAL FLOODPLAIN ALTERNATIVE SB-4 LITTLE "J" LEVEE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012

PLATE 37



Criteria 2 Residual floodplain shown if levee does not pass criteria.
1) Assurance less than 90% the levee does not pass criteria
2) For assurance between 90 and 95% levee must have minimum of 3 feet of freeboard to pass criteria. 3) For assurance greater than 95% levee must have minimum of 2 feet of freeboard to pass criteria

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

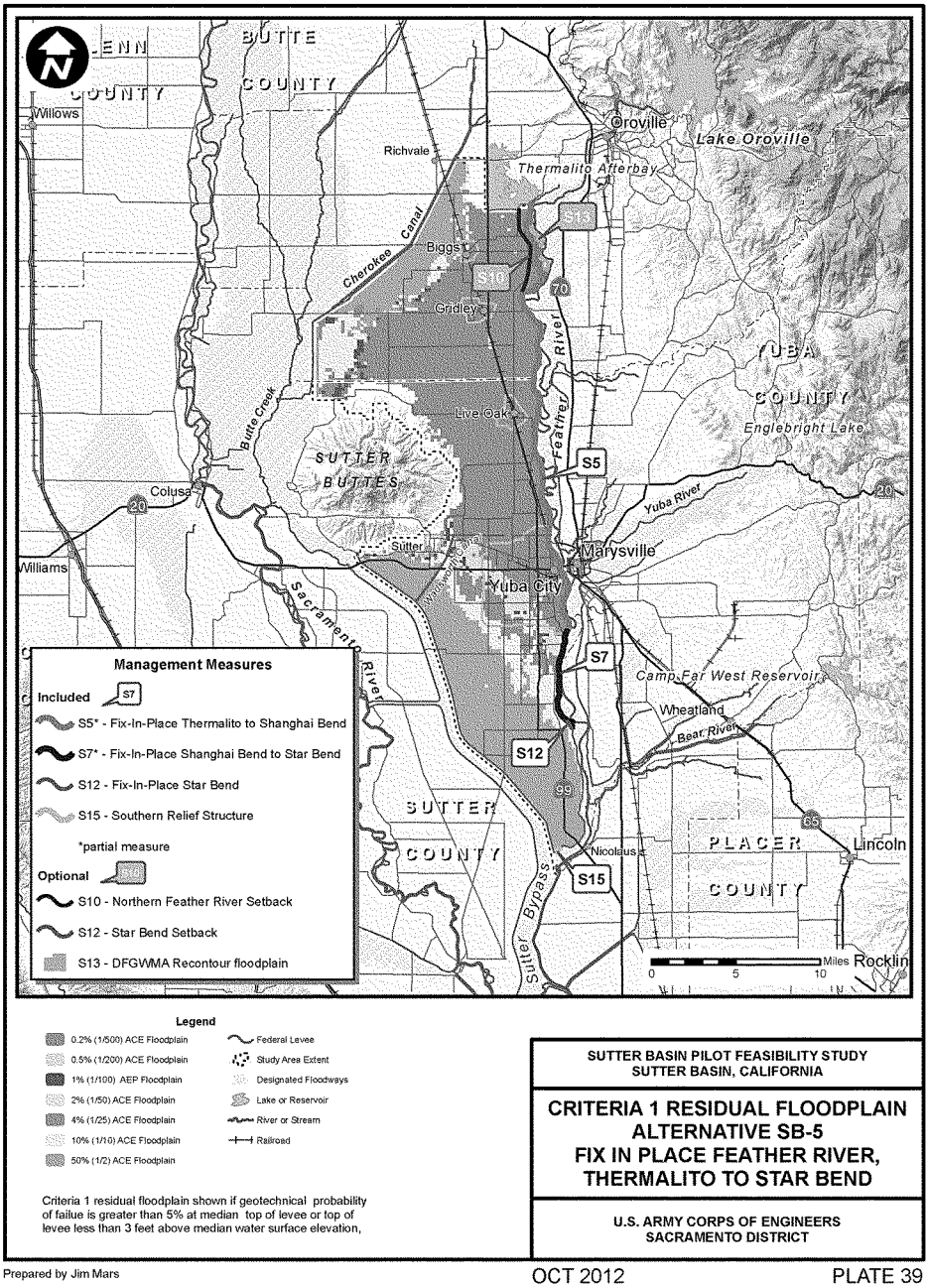
CRITERIA 2 RESIDUAL FLOODPLAIN ALTERNATIVE SB-4 LITTLE "J" LEVEE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012

PLATE 38



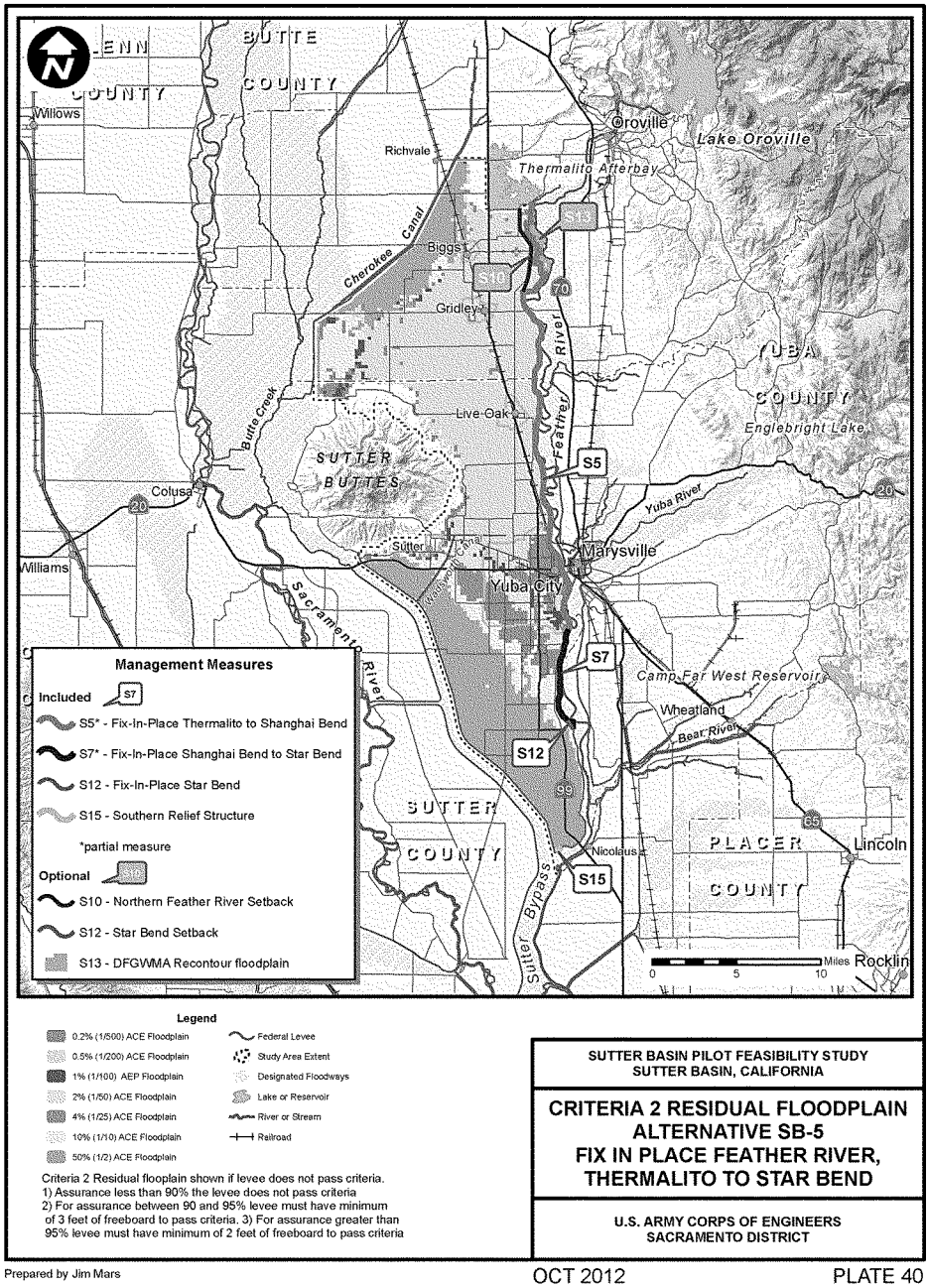
Criteria 1 residual floodplain shown if geotechnical probability of failue is greater than 5% at median top of levee or top of levee less than 3 feet above median water surface elevation,

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

CRITERIA 1 RESIDUAL FLOODPLAIN ALTERNATIVE SB-5 FIX IN PLACE FEATHER RIVER, THERMALITO TO STAR BEND

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars | OCT 2012 | PLATE 39



Criteria 2 Residual flooplain shown if levee does not pass criteria.
1) Assurance less than 90% the levee does not pass criteria
2) For assurance between 90 and 95% levee must have minimum of 3 feet of freeboard to pass criteria. 3) For assurance greater than 95% levee must have minimum of 2 feet of freeboard to pass criteria

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

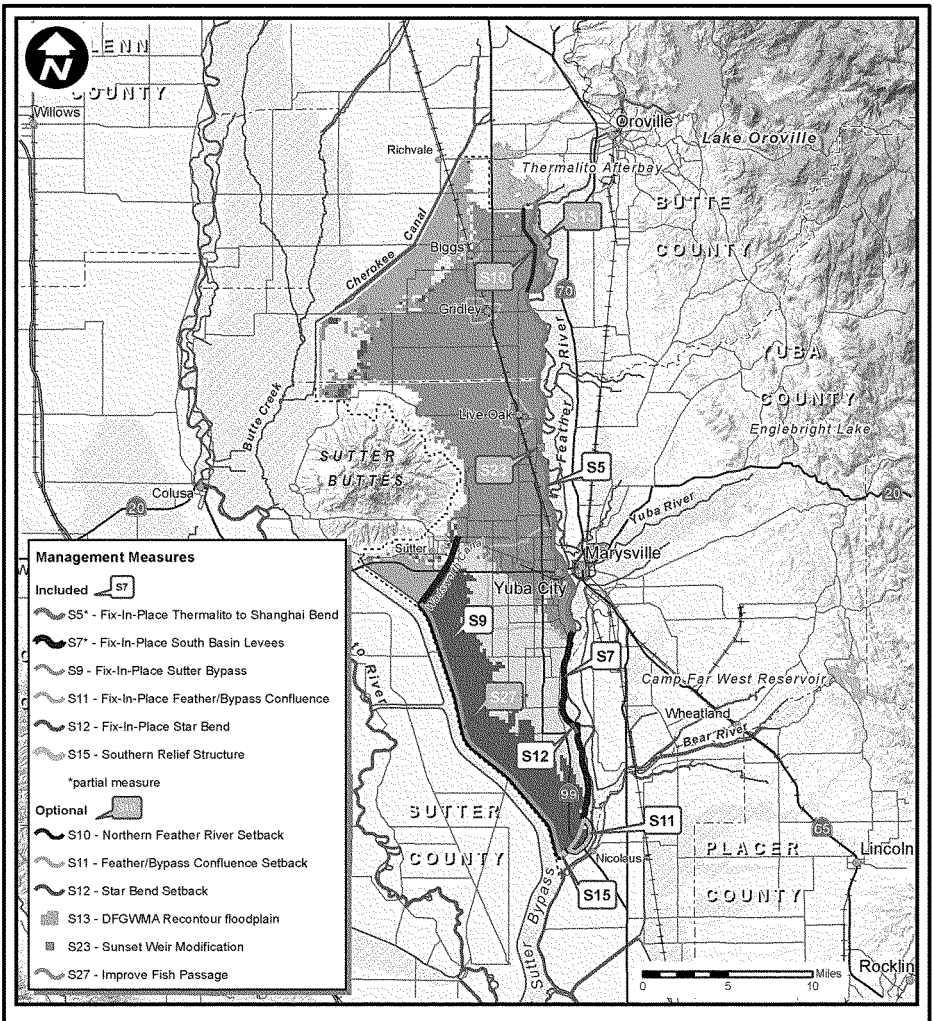
CRITERIA 2 RESIDUAL FLOODPLAIN ALTERNATIVE SB-5 FIX IN PLACE FEATHER RIVER, THERMALITO TO STAR BEND

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012

PLATE 40



Criteria 1 residual floodplain shown if geotechnical probability of failue is greater than 5% at median top of levee or top of levee less than 3 feet above median water surface elevation,

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

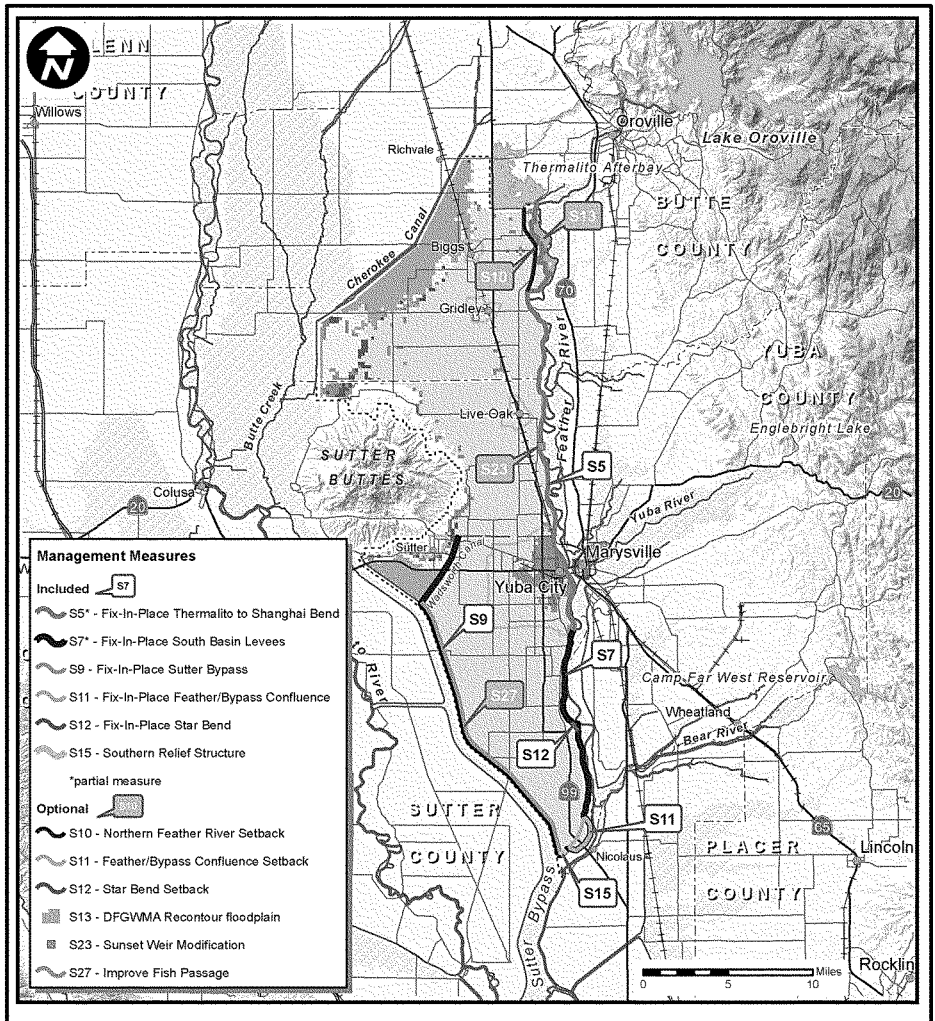
CRITERIA 1 RESIDUAL FLOODPLAIN ALTERNATIVE SB-6 FIX IN PLACE FEATHER RIVER, SUTTER BYPASS, AND WADSWORTH

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012

PLATE 41



Legend

- 0.2% (1/500) ACE Floodplain
- 0.5% (1/200) ACE Floodplain
- 1% (1/100) AEP Floodplain
- 2% (1/50) ACE Floodplain
- 4% (1/25) ACE Floodplain
- 10% (1/10) ACE Floodplain
- 50% (1/2) ACE Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad

Criteria 2 Residual floodplain shown if levee does not pass criteria.
1) Assurance less than 90% the levee does not pass criteria
2) For assurance between 90 and 95% levee must have minimum of 3 feet of freeboard to pass criteria. 3) For assurance greater than 95% levee must have minimum of 2 feet of freeboard to pass criteria

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

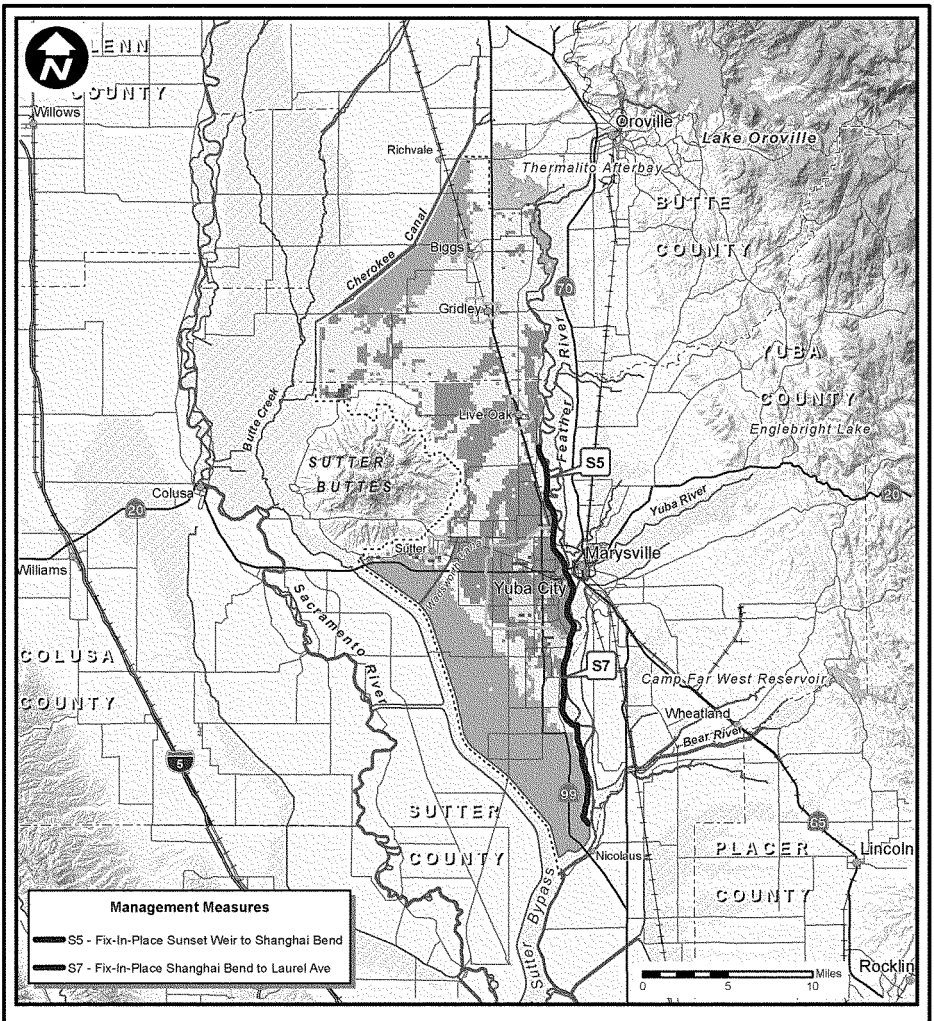
CRITERIA 2 RESIDUAL FLOODPLAIN ALTERNATIVE SB-6 FIX IN PLACE FEATHER RIVER, SUTTER BYPASS, AND WADSWORTH

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012

PLATE 42



Criteria 1 residual floodplain shown if geotechnical probability of failue is greater than 5% at median top of levee or top of levee less than 3 feet above median water surface elevation,

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

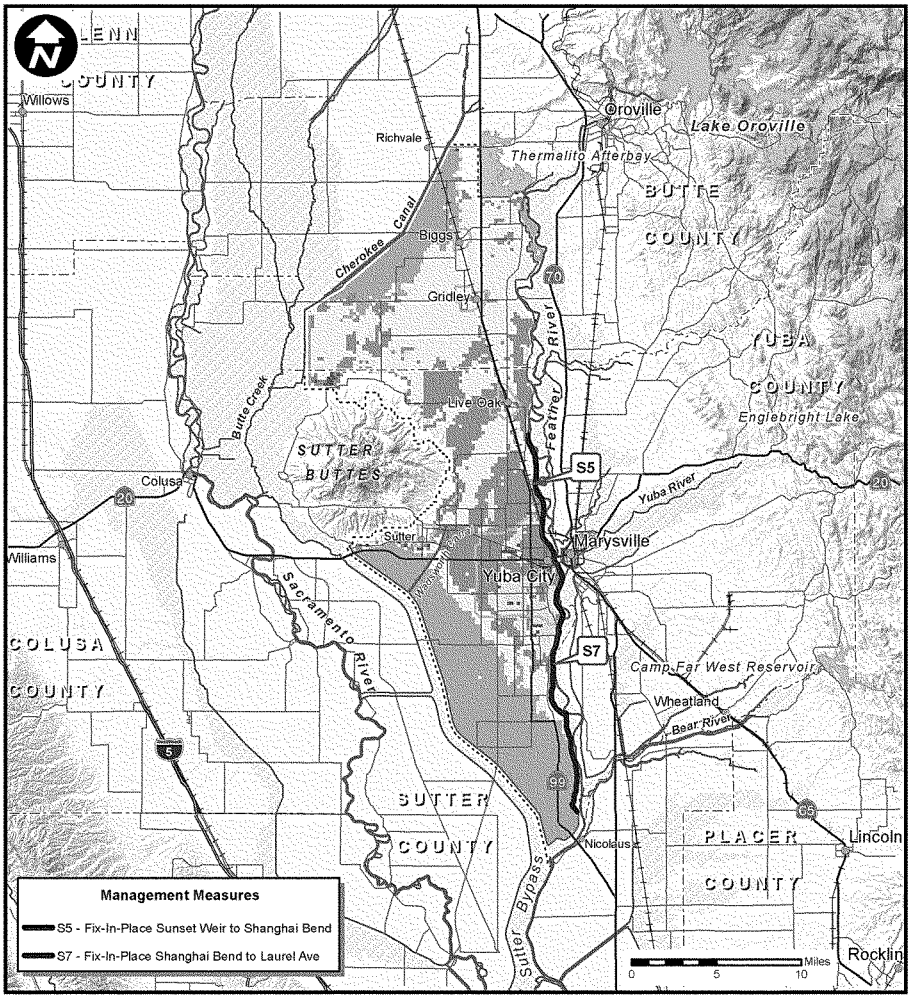
CRITERIA 1 RESIDUAL FLOODPLAIN ALTERNATIVE SB-7 FIX-IN-PLACE FEATHER RIVER SUNSET WEIR TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012

PLATE 43



Legend

- 0.2% (1/500) ACE Floodplain
- 0.5% (1/200) ACE Floodplain
- 1% (1/100) AEP Floodplain
- 2% (1/50) ACE Floodplain
- 4% (1/25) ACE Floodplain
- 10% (1/10) ACE Floodplain
- 50% (1/2) ACE Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad

Criteria 2 Residual floodplain shown if levee does not pass criteria.
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SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

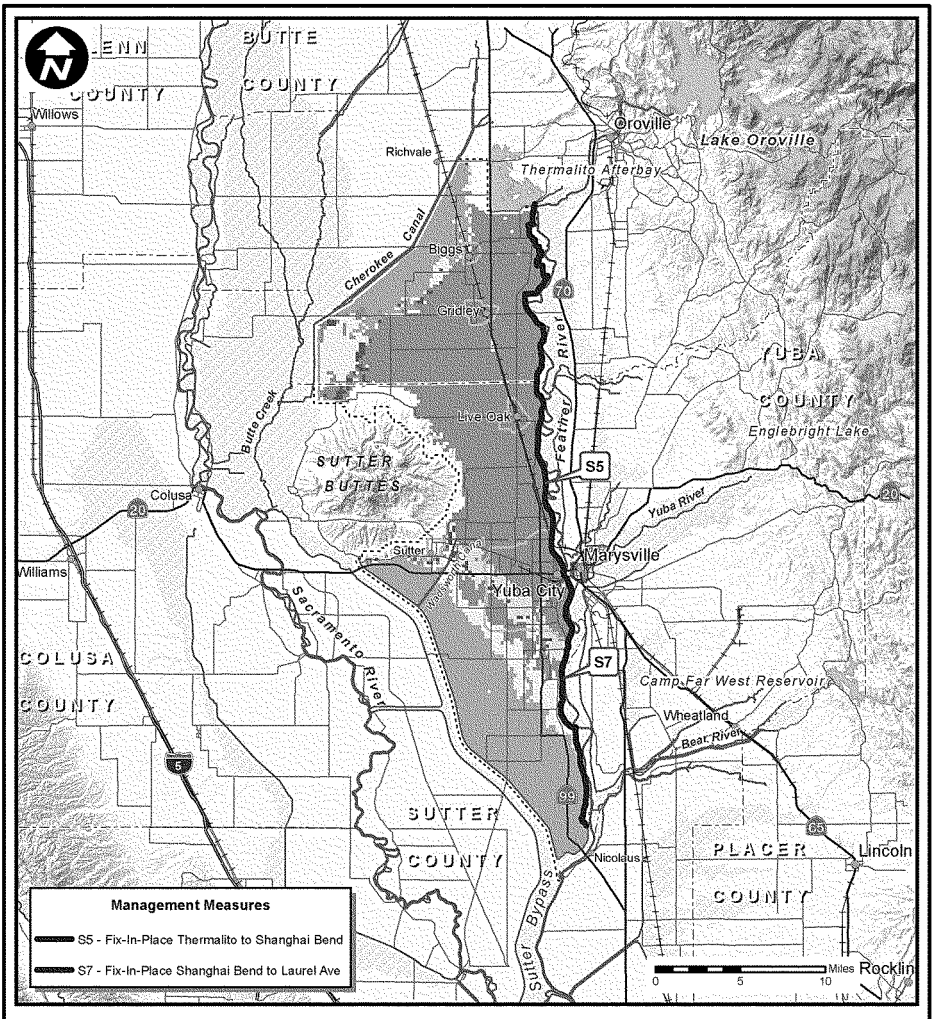
CRITERIA 2 RESIDUAL FLOODPLAIN ALTERNATIVE SB-7 FIX-IN-PLACE FEATHER RIVER SUNSET WEIR TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012

PLATE 44



Legend

- 0.2% (1/500) ACE Floodplain
- 0.5% (1/200) ACE Floodplain
- 1% (1/100) AEP Floodplain
- 2% (1/50) ACE Floodplain
- 4% (1/25) ACE Floodplain
- 10% (1/10) ACE Floodplain
- 50% (1/2) ACE Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad

Criteria 1 residual floodplain shown if geotechnical probability of failue is greater than 5% at median top of levee or top of levee less than 3 feet above median water surface elevation,

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

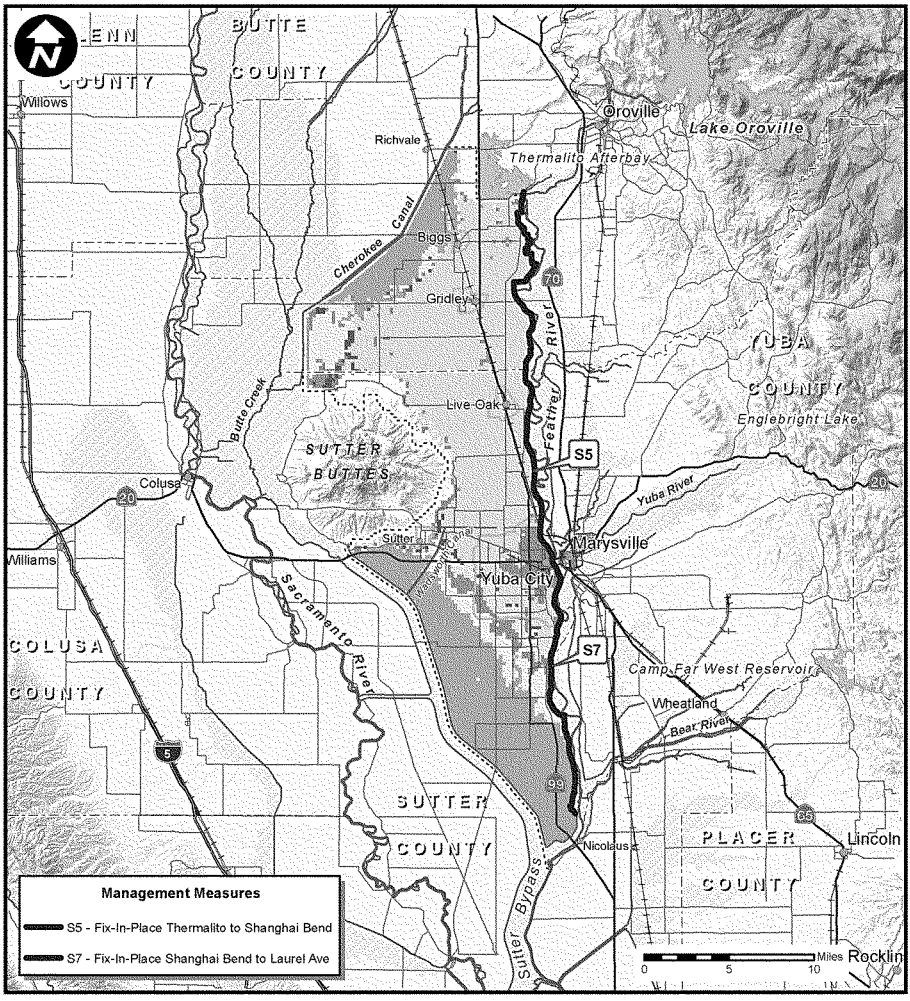
CRITERIA 1 RESIDUAL FLOODPLAIN ALTERNATIVE SB-8 FIX IN PLACE FEATHER RIVER, THERMALITO TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012

PLATE 45



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SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

CRITERIA 2 RESIDUAL FLOODPLAIN ALTERNATIVE SB-8 FIX IN PLACE FEATHER RIVER, THERMALITO TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars | OCT 2012 | PLATE 46

QUALITY CONTROL CERTIFICATE

Hydraulic Analysis Section, Engineering Division

PROJECT NAME: SUTTER BASIN, CALIFORNIA – PILOT FEASIBILITY STUDY
PRODUCT: MEMORANDUM FOR FILE: HYDRAULIC ANALYSIS OF REFINED ALTERNATIVES.
Actual Completion Date: 23-Oct-12

PROJECT MANAGER: LAURA WHITNEY

Background: [Include project description, technical products, and review methodology]

District Quality Control was performed on the 23 October revision to the memorandum originally dated 8 June 2012. The purpose of the revision was to include two additional alternatives SB-7 and SB-8.

HYDRAULIC LEAD

I have ensured that the above products were prepared in accordance with standard quality control practices. I have also incorporated or resolved all issues identified during District Quality Control (DQC) review.

Hydraulic Lead: Peter Blodgett	Title: Senior Hydraulic Engineer	
Print name	Signature	Date

REVIEWERS

I have reviewed the products noted above and find them to be in accordance with project requirements, standards of the profession, and USACE policies and standards.

DQC Reviewer: John Wiest	Title: Hydraulic Engineer	
JOHN C WIEST		10/26/12
Print name	Signature	Date

RESOURCE PROVIDER

I have reviewed and resolved all critical and technical issues. I agree that all project requirements, standards of the profession, and USACE policies and standards have been met.

Section Chief: Peter Blodgett		
Peter Blodgett		10/26/2012
Print name	Signature	Date

ATTACHMENT B

Final Geotechnical Fragility Curves
February 2013.

DRAFT

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

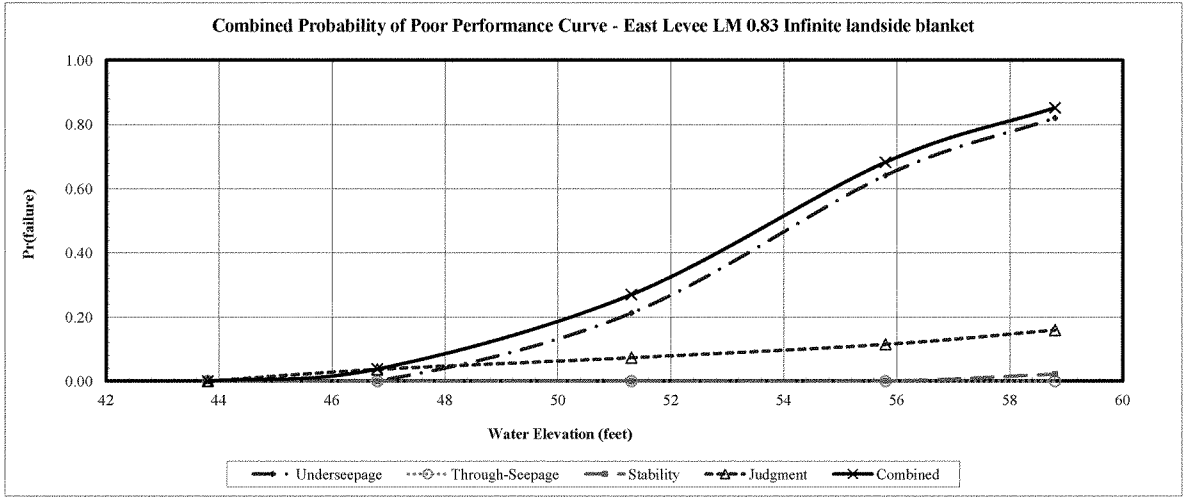
Project: Sutter Feasibility Study
Study Area: Wadsworth Canal
River Section: East Levee

Levee Mile: 0.83
River Mile: 2170954.86 N; (
Analysis Case: Infinite landside blanket

Crest Elev.: 58.80
L/S Toe Elev.: 43.80
W/S Toe Elev.: 41.80

Analysis By: T. Huynh
Checked By: E.W. James/J.M.
Date: Updated 9/13/20

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
43.80	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
46.80	0.0011	0.9989	0.0000	1.0000	0.0000	1.0000	0.0365	0.9635	0.0375	0.9625
51.30	0.2121	0.7879	0.0000	1.0000	0.0000	1.0000	0.0729	0.9271	0.2695	0.7305
55.80	0.6407	0.3593	0.0000	1.0000	0.0003	0.9997	0.1145	0.8855	0.6820	0.3180
58.80	0.8199	0.1801	0.0000	1.0000	0.0213	0.9787	0.1590	0.8410	0.8518	0.1482



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

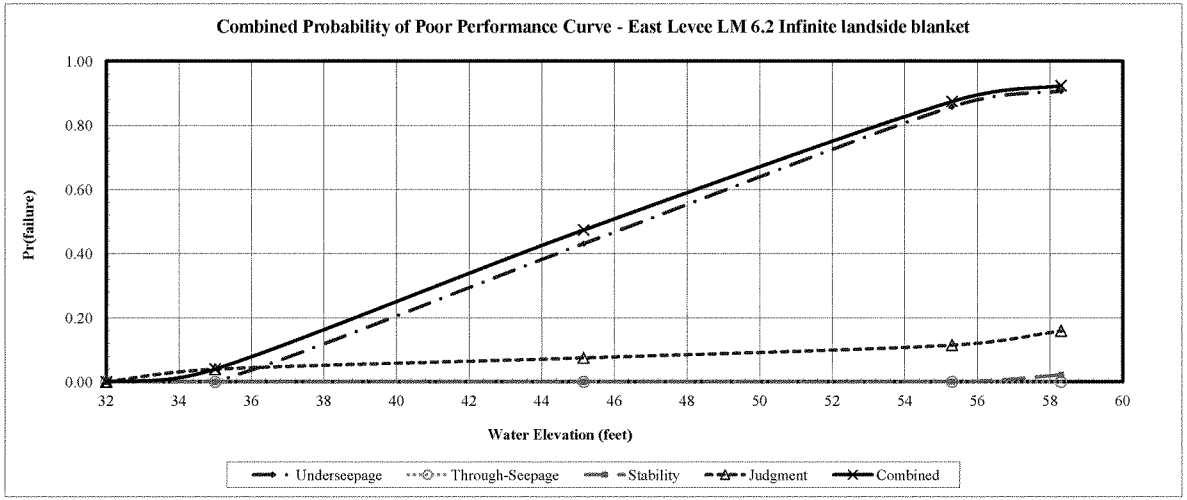
Project: Sutter Feasibility Study
Study Area: Sutter Bypass
River Section: East Levee

Levee Mile: 6.20
River Mile: 2158855 N; 663
Analysis Case: Infinite landside blanket

Crest Elev.: 58.30
L/S Toe Elev.: 32.00
W/S Toe Elev.: 32.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M.
Date: 9/13/2012

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
32.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
35.00	0.0004	0.9996	0.0000	1.0000	0.0000	1.0000	0.0394	0.9606	0.0398	0.9602
45.15	0.4311	0.5689	0.0000	1.0000	0.0000	1.0000	0.0747	0.9253	0.4736	0.5264
55.30	0.8583	0.1417	0.0000	1.0000	0.0003	0.9997	0.1145	0.8855	0.8746	0.1254
58.30	0.9076	0.0924	0.0000	1.0000	0.0213	0.9787	0.1590	0.8410	0.9239	0.0761



1851

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

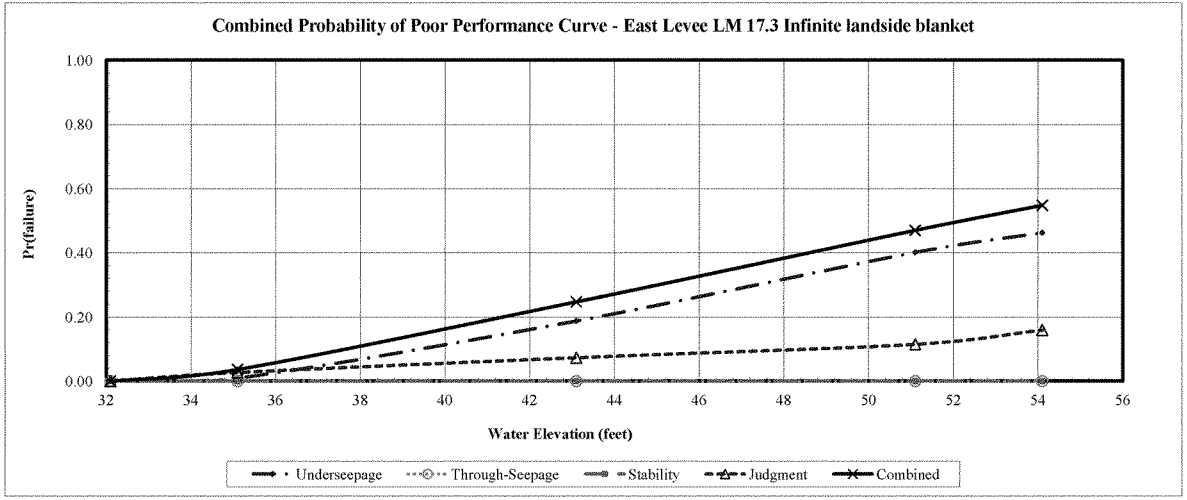
Project: Sutter Feasibility Study
Study Area: Sutter Bypass
River Section: East Levee

Levee Mile: 17.30
River Mile: 2113476.9763 N
Analysis Case: Infinite landside blanket

Crest Elev.: 54.10
L/S Toe Elev.: 32.10
W/S Toe Elev.: 37.78

Analysis By: T. Huynh
Checked By: E.W. James/J.M.
Date: Updated 13 Augu

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
32.10	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
35.10	0.0094	0.9906	0.0000	1.0000	0.0000	1.0000	0.0267	0.9733	0.0359	0.9641
43.10	0.1876	0.8124	0.0000	1.0000	0.0000	1.0000	0.0729	0.9271	0.2468	0.7532
51.10	0.4011	0.5989	0.0000	1.0000	0.0000	1.0000	0.1145	0.8855	0.4697	0.5303
54.10	0.4623	0.5377	0.0000	1.0000	0.0001	0.9999	0.1590	0.8410	0.5478	0.4522



1852

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

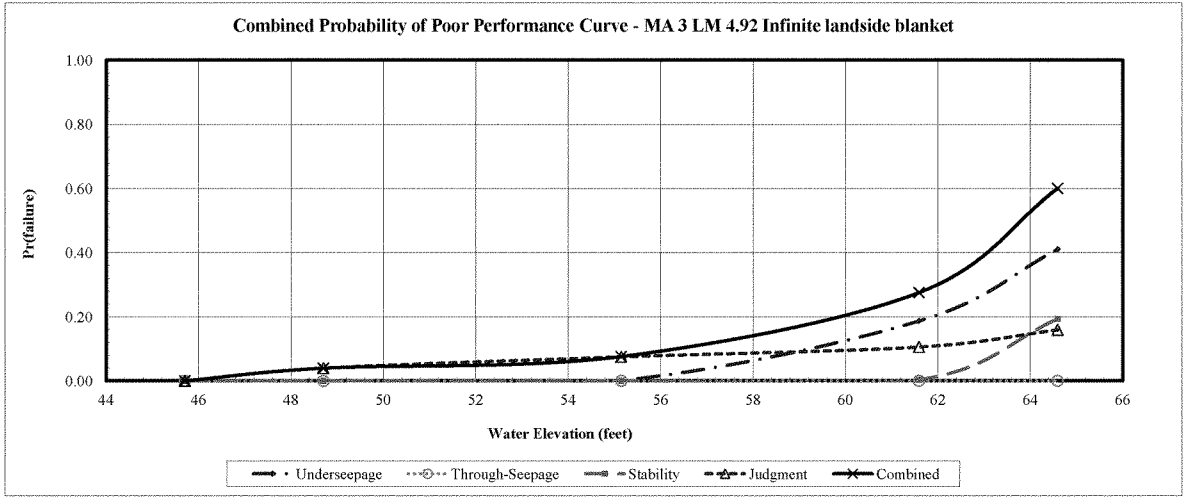
Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: MA 3

Levee Mile: 4.92
River Mile: 2106963.58 N; (
Analysis Case: Infinite landside blanket

Crest Elev.: 64.59
L/S Toe Elev.: 45.70
W/S Toe Elev.: 45.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M.
Date: Updated 09/12/2(

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
45.70	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
48.70	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0394	0.9606	0.0394	0.9606
55.15	0.0011	0.9989	0.0000	1.0000	0.0000	1.0000	0.0747	0.9253	0.0758	0.9242
61.59	0.1867	0.8133	0.0000	1.0000	0.0038	0.9962	0.1054	0.8946	0.2751	0.7249
64.59	0.4106	0.5894	0.0000	1.0000	0.1934	0.8066	0.1590	0.8410	0.6002	0.3998



1853

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

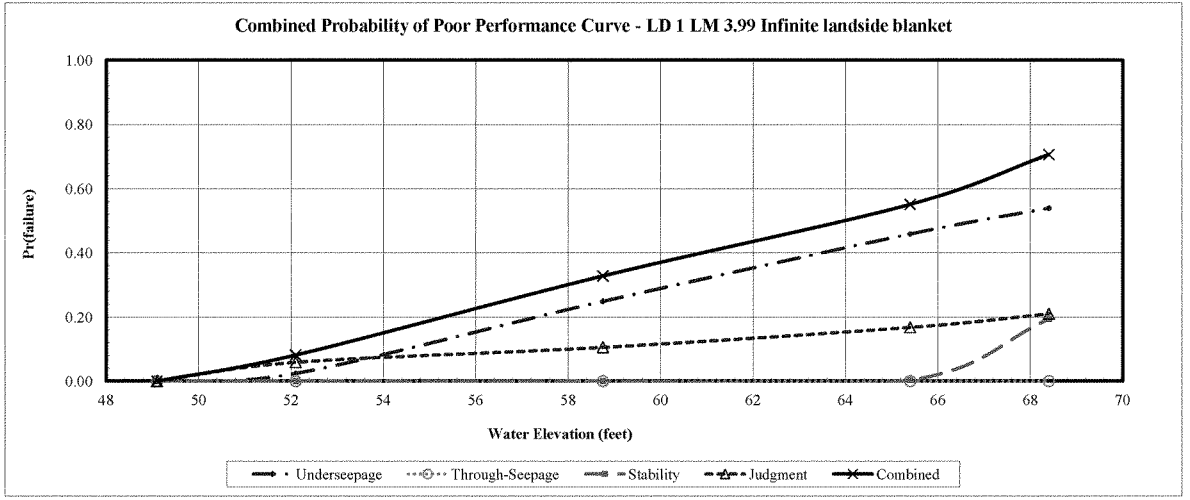
Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: LD 1

Levee Mile: 3.99
River Mile: 2127081.8143 N
Analysis Case: Infinite landside blanket

Crest Elev.: 68.40
L/S Toe Elev.: 49.10
W/S Toe Elev.: 40.00

Analysis By: T. Huynh
Checked By: E.W. James\J.M.
Date: Updated 09/26/2(

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
49.10	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
52.10	0.0240	0.9760	0.0000	1.0000	0.0000	1.0000	0.0586	0.9414	0.0812	0.9188
58.75	0.2485	0.7515	0.0000	1.0000	0.0000	1.0000	0.1053	0.8947	0.3276	0.6724
65.40	0.4584	0.5416	0.0000	1.0000	0.0038	0.9962	0.1676	0.8324	0.5509	0.4491
68.40	0.5390	0.4610	0.0000	1.0000	0.1934	0.8066	0.2098	0.7902	0.7062	0.2938



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

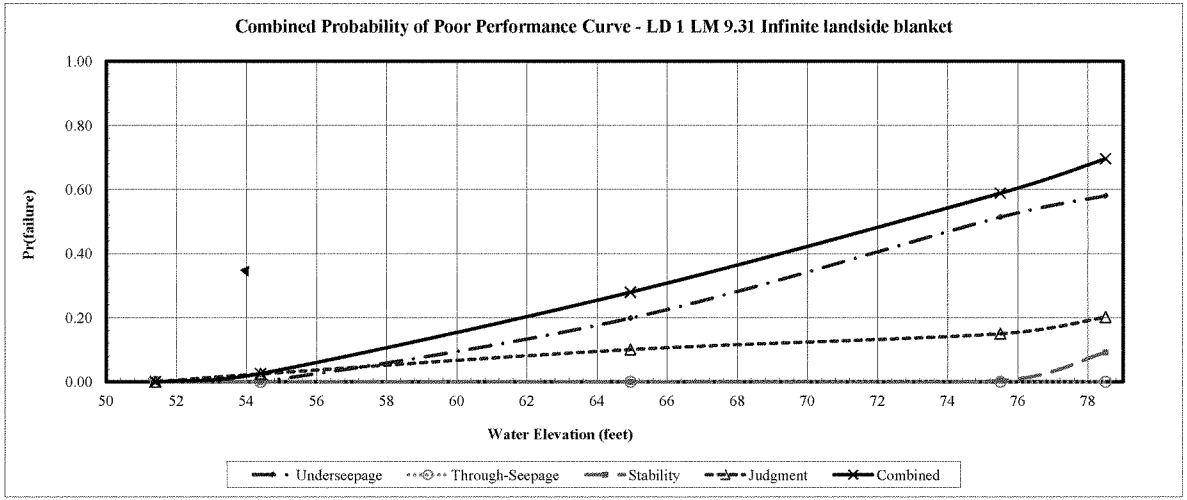
Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: LD 1

Levee Mile: 9.31
River Mile: 2156078.18 N; (
Analysis Case: Infinite landside blanket

Crest Elev.: 78.50
L/S Toe Elev.: 51.40
W/S Toe Elev.: 53.70

Analysis By: T. Huynh
Checked By: E.W. James/J.M.
Date: Updated 2/21/20

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
51.40	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
54.40	0.0008	0.9992	0.0000	1.0000	0.0000	1.0000	0.0248	0.9752	0.0255	0.9745
64.95	0.1986	0.8014	0.0000	1.0000	0.0000	1.0000	0.1007	0.8993	0.2793	0.7207
75.50	0.5140	0.4860	0.0000	1.0000	0.0038	0.9962	0.1501	0.8499	0.5885	0.4115
78.50	0.5805	0.4195	0.0000	1.0000	0.0917	0.9083	0.2015	0.7985	0.6958	0.3042



1855

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

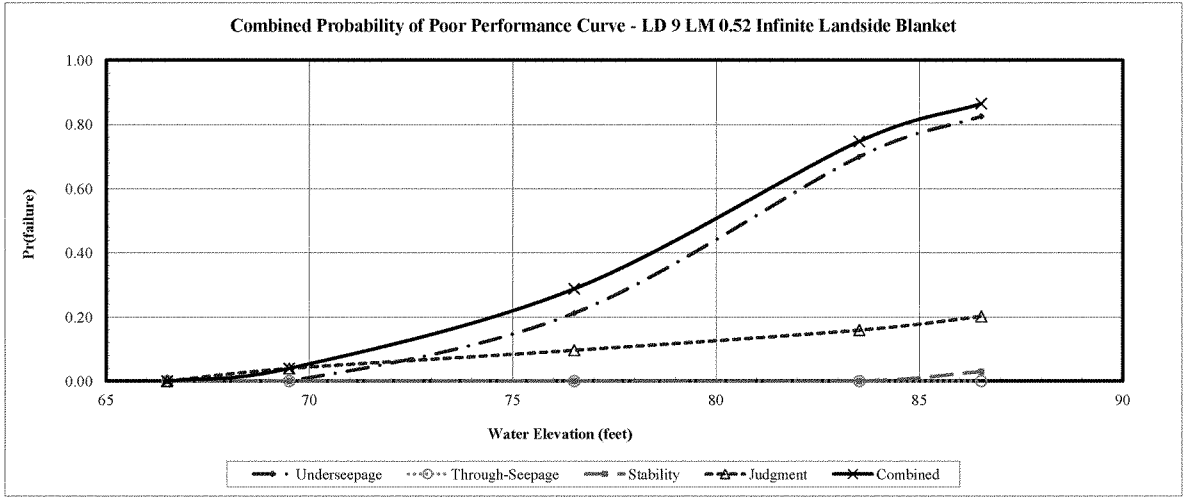
Project: Sutter Feasibility Study
Study Area: Feather River South
River Section: LD 9

Levee Mile: 0.52
River Mile: 2188213.88 N; (
Analysis Case: Infinite landside blanket

Crest Elev.: 86.52
L/S Toe Elev.: 66.50
W/S Toe Elev.: 58.90

Analysis By: T. Huynh
Checked By: E.W. James/J.M.
Date: Updated 9/12/20

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
66.50	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
69.50	0.0001	0.9999	0.0000	1.0000	0.0000	1.0000	0.0394	0.9606	0.0394	0.9606
76.51	0.2117	0.7883	0.0000	1.0000	0.0000	1.0000	0.0961	0.9039	0.2875	0.7125
83.52	0.6995	0.3005	0.0000	1.0000	0.0000	1.0000	0.1589	0.8411	0.7473	0.2527
86.52	0.8254	0.1746	0.0000	1.0000	0.0297	0.9703	0.2015	0.7985	0.8647	0.1353



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

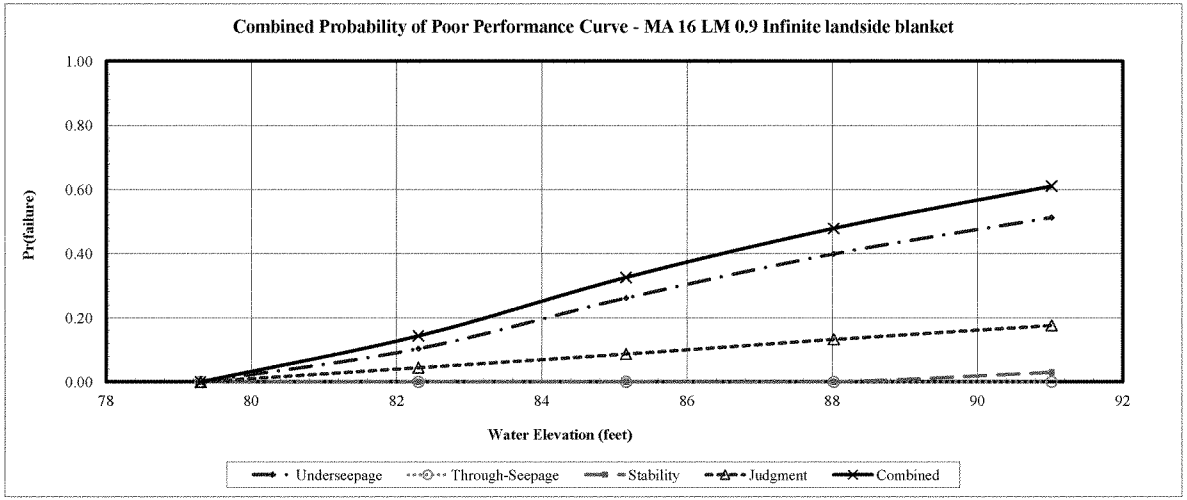
Project: Sutter Feasibility Study
Study Area: Feather River North
River Section: MA 16

Levee Mile: 0.90
River Mile: 2224154.37 N; (
Analysis Case: Infinite landside blanket

Crest Elev.: 91.02
L/S Toe Elev.: 79.30
W/S Toe Elev.: 77.30

Analysis By: T. Huynh
Checked By: E.W. James/J.M.
Date: Updated 9/12/20

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
79.30	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
82.30	0.1036	0.8964	0.0000	1.0000	0.0000	1.0000	0.0442	0.9558	0.1432	0.8568
85.16	0.2614	0.7386	0.0000	1.0000	0.0000	1.0000	0.0869	0.9131	0.3256	0.6744
88.02	0.3990	0.6010	0.0000	1.0000	0.0000	1.0000	0.1324	0.8676	0.4786	0.5214
91.02	0.5127	0.4873	0.0000	1.0000	0.0297	0.9703	0.1761	0.8239	0.6105	0.3895



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

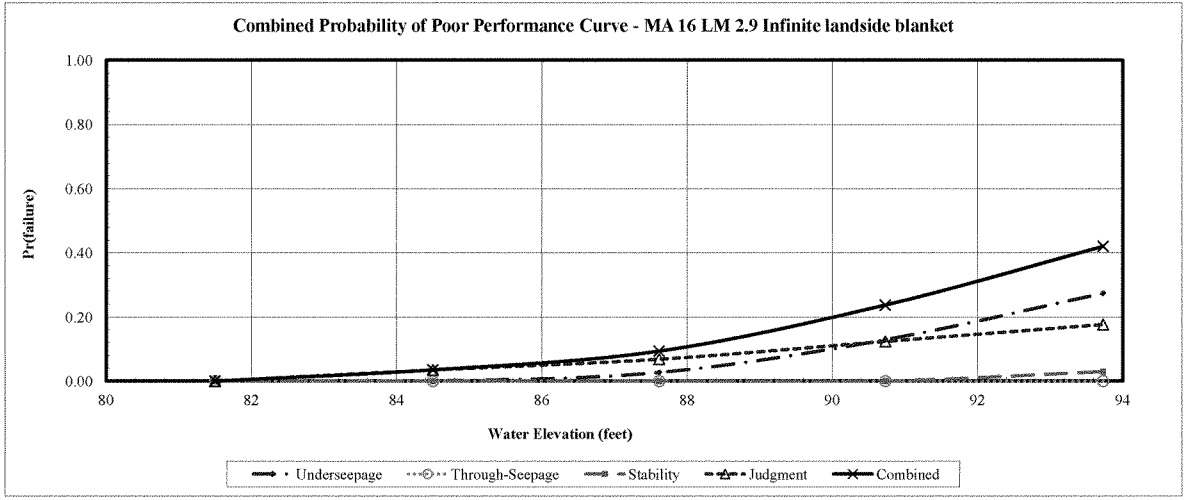
Project: Sutter Feasibility Study
Study Area: Feather River North
River Section: MA 16

Levee Mile: 2.90
River Mile: 2233626.25 N; (
Analysis Case: Infinite landside blanket

Crest Elev.: 93.73
L/S Toe Elev.: 81.50
W/S Toe Elev.: 79.40

Analysis By: T. Huynh
Checked By: E.W. James/J.M.
Date: Updated 9/12/20

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
81.50	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
84.50	0.0005	0.9995	0.0000	1.0000	0.0000	1.0000	0.0345	0.9655	0.0350	0.9650
87.62	0.0271	0.9729	0.0000	1.0000	0.0000	1.0000	0.0681	0.9319	0.0934	0.9066
90.73	0.1294	0.8706	0.0000	1.0000	0.0000	1.0000	0.1235	0.8765	0.2369	0.7631
93.73	0.2738	0.7262	0.0000	1.0000	0.0297	0.9703	0.1762	0.8238	0.4195	0.5805



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

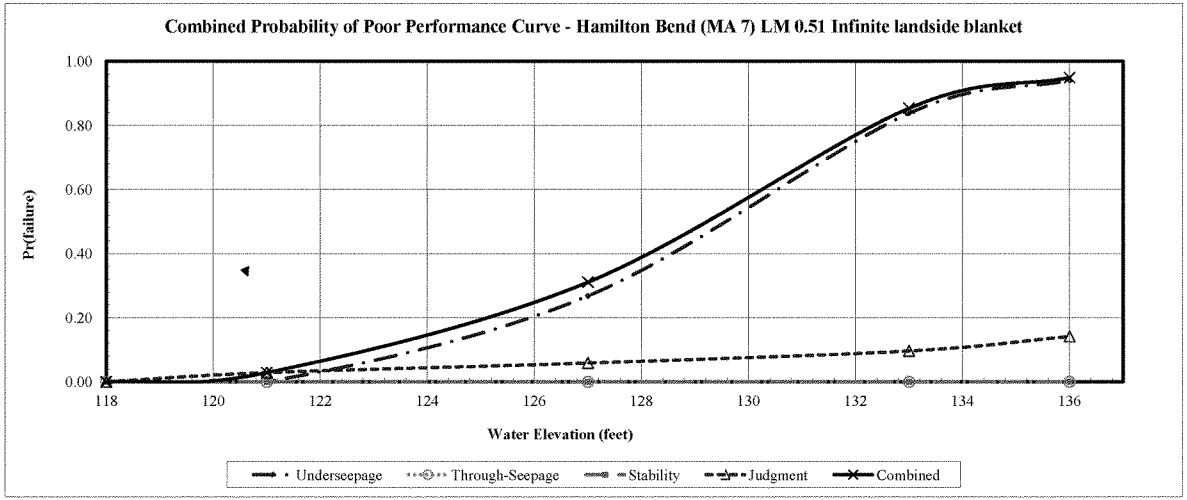
Project: Sutter Feasibility Study
Study Area: Feather River North
River Section: Hamilton Bend (MA 7)

Levee Mile: 0.51
River Mile: 2288660.96 N; (
Analysis Case: Infinite landside blanket

Crest Elev.: 136.00
L/S Toe Elev.: 118.00
W/S Toe Elev.: 118.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M.
Date: Updated 2/21/20

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
118.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
121.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0287	0.9713	0.0287	0.9713
127.00	0.2678	0.7322	0.0000	1.0000	0.0000	1.0000	0.0587	0.9413	0.3108	0.6892
133.00	0.8376	0.1624	0.0000	1.0000	0.0003	0.9997	0.0963	0.9037	0.8533	0.1467
136.00	0.9405	0.0595	0.0000	1.0000	0.0000	1.0000	0.1414	0.8586	0.9489	0.0511



1859

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

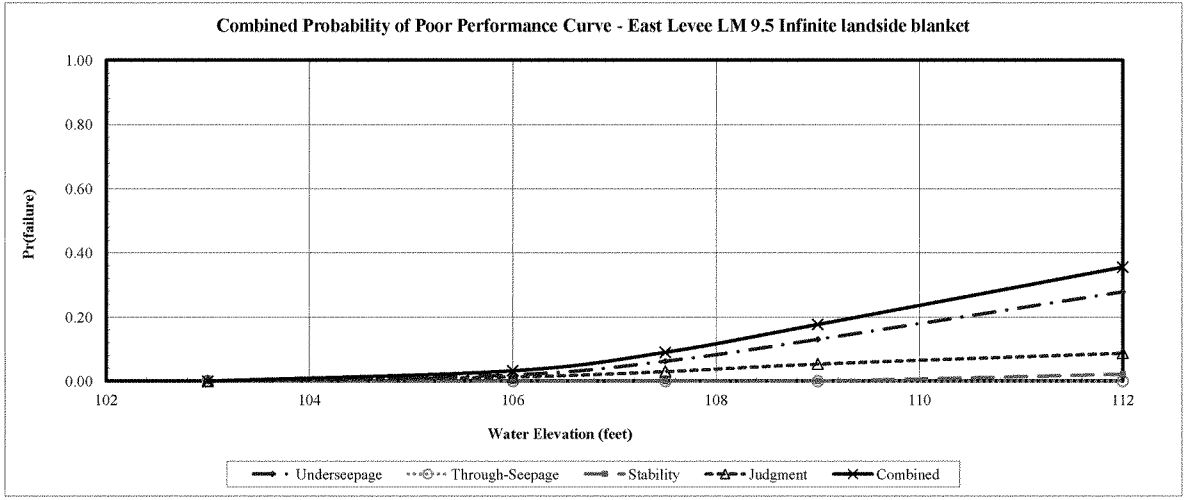
Project: Sutter Feasibility Study
Study Area: Cherokee Canal
River Section: East Levee

Levee Mile: 9.50
River Mile: 2301045.948 N:
Analysis Case: Infinite landside blanket

Crest Elev.: 112.00
L/S Toe Elev.: 103.00
W/S Toe Elev.: 104.00

Analysis By: T. Huynh
Checked By: E.W. James/J.M.
Date: Updated 9/13/12

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
103.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
106.00	0.0195	0.9805	0.0000	1.0000	0.0000	1.0000	0.0129	0.9871	0.0322	0.9678
107.50	0.0620	0.9380	0.0000	1.0000	0.0000	1.0000	0.0297	0.9703	0.0898	0.9102
109.00	0.1300	0.8700	0.0000	1.0000	0.0003	0.9997	0.0529	0.9471	0.1763	0.8237
112.00	0.2780	0.7220	0.0000	1.0000	0.0213	0.9787	0.0870	0.9130	0.3548	0.6452



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

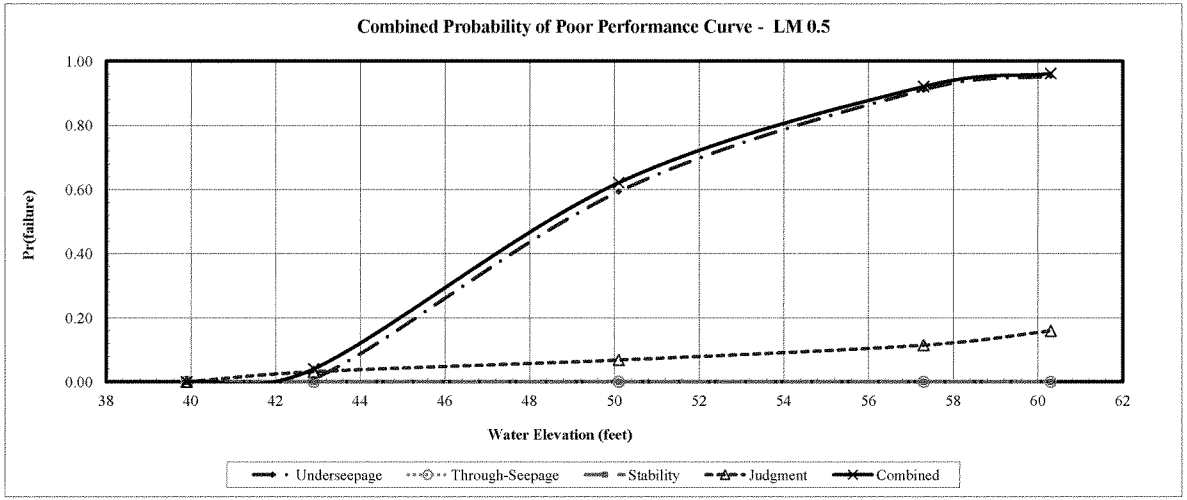
Project: Sutter Feasibility Study
Study Area: Wadsworth Canal - Right Bank
River Section:

Levee Mile: 0.50
River Mile: 2168750 N; 662
Analysis Case:

Crest Elev.: 60.30
L/S Toe Elev.: 39.90
W/S Toe Elev.: 41.50

Analysis By: E.W. James
Checked By: J.M. Bolton
Date: Updated 09/14/

Water Surface	Underseepage		Through-Seepage		Stability		Judgment		Combined	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
39.90	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
42.90	0.0088	0.9912	0.0000	1.0000	0.0000	1.0000	0.0316	0.9684	0.0402	0.9598
50.10	0.5935	0.4065	0.0000	1.0000	0.0000	1.0000	0.0682	0.9318	0.6212	0.3788
57.30	0.9112	0.0888	0.0000	1.0000	0.0000	1.0000	0.1145	0.8855	0.9213	0.0787
60.30	0.9547	0.0453	0.0000	1.0000	0.0000	1.0000	0.1590	0.8410	0.9619	0.0381



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

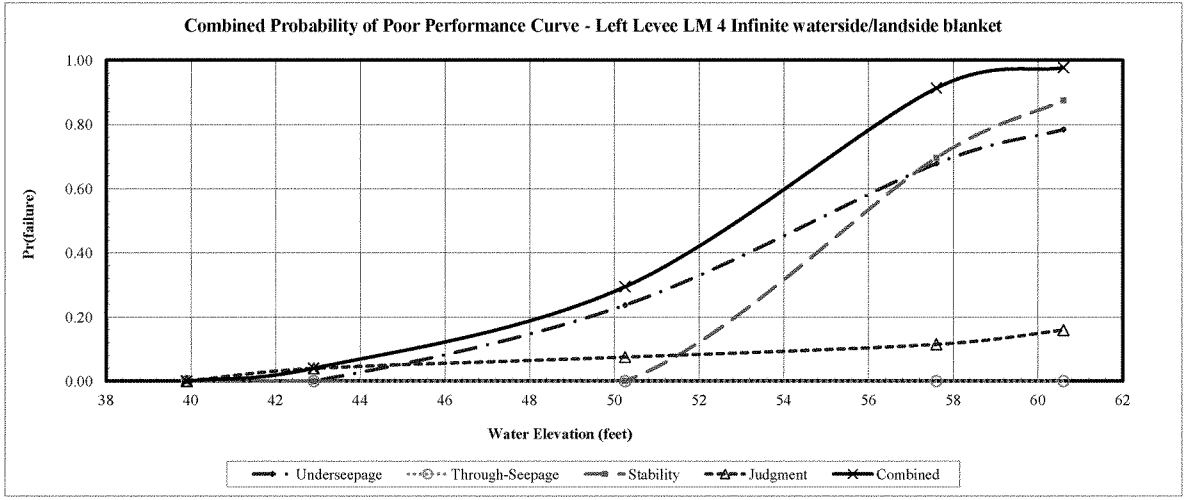
Project: Sutter Feasibility Study
Study Area: Sutter Bypass
River Section: Left Levee

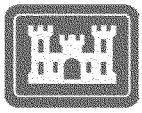
Levee Mile: 4.00
River Mile: 2168110 N; 662
Analysis Case: Infinite waterside/landside blanket

Crest Elev.: 60.60
L/S Toe Elev.: 39.90
W/S Toe Elev.: 41.50

Analysis By: T. Huynh
Checked By: E.W. James/J.M.
Date: Updated 9/14/20

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
39.90	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
42.90	0.0004	0.9996	0.0000	1.0000	0.0000	1.0000	0.0394	0.9606	0.0398	0.9602
50.25	0.2366	0.7634	0.0000	1.0000	0.0005	0.9995	0.0747	0.9253	0.2940	0.7060
57.60	0.6780	0.3220	0.0000	1.0000	0.6959	0.3041	0.1145	0.8855	0.9133	0.0867
60.60	0.7846	0.2154	0.0000	1.0000	0.8754	0.1246	0.1590	0.8410	0.9774	0.0226





US Army Corps
of Engineers.

Sacramento District
Engineering Division

Sutter Basin Pilot Feasibility Report - Environmental Impact Report / Supplemental Environmental Impacts Statement

Butte and Sutter Counties, California

COST ENGINEERING APPENDIX

Oct 2013

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SBFS Cost Engineering Appendix to the Feasibility Study

1. BASIS OF ESTIMATE

COST ESTIMATE FOR DRAFT ALTERNATIVE ARRAY

Cost estimates were developed to compare the draft array of alternatives presented in the Feasibility Study Report. These cost estimates were utilized to select the final array of alternatives and were based on a level 4 per requirement of ER 110-2-1302. In developing the reconnaissance level cost estimates of the various measures and alternatives (combined measures) for the Sutter Basin project, the Cost Engineering team utilized a methodology wherein costs for levee improvements or new levees (sans relocations) were developed using a parametric spreadsheet based on typical cross sections for differing types of levee improvements. Costs for relocations and construction other than that directly related to the levee were compiled based on either 1) historical costs - past levee projects in the vicinity of Sacramento, 2) estimating software MII (MCACES, 2nd Generation) or PACES, or 3) based on a percentage of construction costs. In lieu of the time constraints of the 24-month fast-track pilot study schedule, these methods were used for preparing costs for the purpose of selecting the final array of alternatives. Refer to Attachment A for further detail on the background and approach to developing cost estimates for the draft array of alternatives.

FEASIBILITY COST ESTIMATES FOR FINAL ALTERNATIVE ARRAY

The baseline feasibility cost estimates for the final array of alternatives (SB-1, SB-7 & SB-8) were developed using the design drawings provided by Civil Design. The quantities take-off calculations were provided by the Sacramento District's Civil Design section to produce the feasibility estimates. There are 41 Reaches spanning approximately 40 miles of levee. The breakdown of the alternatives by reach is further described in paragraph 2. Most of the geotechnical levee repair for the alternatives is to be accomplished with a soil-bentonite slurry wall constructed in the centerline of the levee. There are locations where jet grout, seepage berm or relief wells are also utilized but they are small in magnitude relative to the SB slurry wall. Of the 41 Reaches, there are several Reaches where no levee work is proposed (Reach 14, 15, 29, and 39).

Due to the large scope, the project is broken into construction contracts. To facilitate comparison to the local sponsor Early Implementation Project (EIP), similar contract reaches were utilized. These contracts have no impact on the total project cost. Based on the anticipated yearly funding availability, the reaches were combined in more manageable contracts, totaling approximately $40 million per contract per year for the feasibility study. Refer to tables in paragraph 5 for breakdown of contracts by reach.

2. PROJECT SCOPE/DESCRIPTION

There are three final Alternatives (SB-1, SB-7 & SB-8) to be evaluated for selection of the Recommended Plan. Alternative SB-1 is the No Action plan, which is to do nothing; hence a cost estimate was not created. It is assumed that Alternative SB-1 has no federal cost.

Alternative SB-7 is to Fix-in-Place the Feather River West Levee from the Sunset Weir to Laurel Avenue. The Alternative SB-7 project footprint extends from FRWL Reach 2 through 21. Alternative SB-8 is to Fix-in-Place the Feather River West Levee from Thermalito Afterbay to Laurel Avenue. The SB-8 project footprint extends from FRWL Reach 2 through 41. Alternative SB-8 is an incremental addition to Alternative SB-7 and all elements in Alternative SB-7 exist in Alternative SB-8.

Alternative SB-8 is almost equivalent to the Feather River West Levee Project (FRWLP) with the exception of Reach 6. At Reach 6, the Sponsor has constructed the Star Bend Setback Levee. However, during plan formulation the PDT proposed to have Reach 6 as a Fix-In-Place levee in lieu of Setback Levee because it is more cost effective. The Sponsor is seeking credit for work at this location. An estimate for the Star Bend Setback levee was created for cost comparison.

The designs for Alternatives SB-7 and SB-8 are similar in terms of levee remedial methods needed to reduce flood risk to the Sutter Basin. The vast majority of levee remediation is to reduce seepage by constructing a soil-bentonite slurry cutoff wall through the centerline of the levee and rebuild the levee to pre-project geometry. At some locations, seepage berms, relief wells, deep-soil-mixing, jet grout cutoff walls, canal relocations, and slight levee relocations to provide O&M access roads are included but they are minor relative to the soil-bentonite cutoff wall construction. Detail of the design remedial methods can be found in the Civil Design Appendix.

Along the FRWL, there are abandoned utilities that need to be removed. Active utilities such as pressure pipes, irrigation pipes, drainage pipes, electrical, sewer, gas, cable and water lines are to be removed and replaced in order to construct the soil-bentonite cutoff wall. Temporary utilities service is to be provided during the service outages. Roads on the levee crowns that must be removed in order to demolish or relocate utilities will be replaced.

3. MII COST ESTIMATE – NOTES & ASSUMPTIONS

The MII estimate used the QTO's provided by Civil Design. An estimate on the construction contracts and years for Alternatives SB-7 and SB-8 is presented below in paragraph 5.

MCACES PROGRAM & LIBRARIES

The program and libraries used for the MCACES cost estimate are as follows:

a. MII version 4.1 Build 4
b. 2010 Cost Book
c. 2011 EP1110-1-8 Equipment Library for Region VII.

OVERTIME

Overtime is included in the estimate. Assumption is 10 hour workdays, 6 days per week.

ACQUISITION PLAN

Construction contracts are assumed to be Invitation For Bid (IFB), Competitive, Unrestricted Full and Open Competition and all businesses may respond.

CONTRACTING PLAN

The prime contractor is expected to be an earthwork contractor responsible for site work, borrow site excavation, levee degradation, slurry wall construction, and levee embankment reconstruction. The utilities penetration relocation is expected to be done by a specialty subcontractor. Material hauling, hydroseeding, jet grouting, asphalt pavement, and other miscellaneous work are expected to be performed by subcontractors.

SITE ACCESS

The project footprint follows the existing levee along the west bank of the Feather River, northernmost from Thermalito Afterbay and extending southernmost to near the Sutter Bypass and Feather River confluence. The levee is assumed to be maintained by local Reclamation Districts (RD) and it is expected that the levee is accessible from the landside. Staging areas or stockpile areas are constructed every 2,500 lineal feet along or near the levee landside /waterside toes. Stripped topsoil material, aggregate base, and levee degrade material can be readily stockpiled in the staging areas. Haul routes for import/export material is expected to be on existing roads and highways (no barge transport). No new roadway for site access is expected to be constructed.

BORROW/DISPOSAL AREAS

Borrow sources identified by the sponsor are incorporated into the estimate. A material balance calculation was performed by SPK's Civil Design and Cost Engineering sections using sponsor QTO's for levee fill materials (Types 1, 2 & Random) available at each borrow site. It was concluded that there is enough material to satisfy the fill demand for Alternatives SB7 and SB8. The suitability of the borrow source/material has been evaluated by the SPK Geotech Section (please refer to Geotechnical Engineering Appendix for detail). Non-hazardous unsuitable fill material is assumed to be used to backfill the borrow pits. Other construction waste is assumed to be disposed of off-site in accordance with local, state, and federal regulations. HTRW waste is assumed to be absent from the project. Construction waste can be safely disposed of within a 30 mile radius of the site.

CONSTRUCTION METHODOLGY

The construction methodologies for the soil-bentonite slurry wall excavation and placement are considered to be standard, except for deep walls (greater than 85 feet). Below this depth a conventional long reach hydraulic excavator cannot be used. The method provided in the cost estimate opts for the contractor to utilize a deep-soil-mixing (DSM) method for a design depth of cutoff wall greater than 85 feet.

CONSTRUCTION WORK WINDOWS

Due to environmental and wildlife concerns (wildlife habitat, migratory season, mating season etc.) it is assumed that a normal construction season would typically span from the month of May through October. Typically, USACE and local flood agencies want the levee to be

reconstructed by October due to the beginning of the storm season. This is a flood safety measure. Depending on local jurisdiction and permitting weather, construction tasks such as hydroseeding, asphalt pavement repair of levee crown, and associated work that does not undermine the structural integrity of the levee during a storm event may be permissible beyond October. The irrigation canal that runs parallel to the levee landside toe is operational from April through February. The construction window for work in the canal is limited from February through April. One approach for working around this limitation is to obtain an encroachment permit for a variance to work outside the normal construction season prior to working in the canal. Another approach is to install sheet pile cutoff walls to insure that the work within the levee does not lead to excessive seepage or possible failure of the canal bank. This second approach does not require a variance. For the purposes of the feasibility report, the estimate assumes installation of a sheet pile cutoff wall. Depending on the scope of work and pipe crossing type, each approach is site specific and will be more closely dealt with on a case by case basis in the PED phase.

UNIQUE TECHNIQUES OF CONSTRUCTION
In close proximity to existing bridge abutments, underground utilities, or railroad tracks, a jet grout cutoff wall is to be constructed in lieu of the slurry cutoff wall.

EQUIPMENT AND LABOR AVAILABILITY AND DISTANCE TRAVELED
The project is in Yuba City, an urban city environment and equipment & labor is readily available within a 100 mile radius of the site. No labor shortage is anticipated.

ENVIRONMENTAL CONCERNS
Environmental protection requires consideration of air, water, and land, and involves noise management, solid-waste management and management of other pollutants. In order to prevent or provide for abatement and control of any environmental pollution arising from construction, the Prime Contractor and Subcontractors in the performance of the contract shall comply with all applicable Federal, State, and local laws, as well as regulations concerning environmental pollution control and abatement. The Contractor shall use best management practices at all times to minimize the potential for environmental impacts.

LABOR RATES
This estimate meets the Davis Bacon wage rates for Davis Bacon Wage Determination for the State of California, General Decision Number: CA130009 04/05/2013 CA9 .

EQUIPMENT RATES
Equipment rates were obtained from quotes or verbal/telephone conversations and the MII 2011 EP1110-1-8 Equipment Library for Region VII.

MATERIAL COST
Material prices are obtained from vendor quotes, supply catalogs, previous estimates and the MII Cost Book.

SALES TAX
California State Sales tax is applied at 8.00%.

OMRR&R
The proposed project reaches of Alternatives SB-7 and SB-8 are currently maintained as part of the Federal Sacramento River Flood Control Project. The OMRR&R for the proposed project would be similar as the existing project. Therefore, no OMRR&R cost are included in the estimate. A qualitative analysis of the OMRR&R costs was performed to validate this assumption. Both alternatives are comprised almost entirely of installation of a soil-bentonite cutoff wall within the structural section of the levee. The levee will be reconstructed to existing pre-project geometry and meet USACE standards. The slurry wall will reduce the short term maintenance cost due to a reduction in seepage. The reconstruction of the upper half of the levee (side slopes, vegetation removal, grass re-establishment, and crown road replacement) will also reduce the short term maintenance cost. With the installation of the slurry wall, many of the existing relief wells can be decommissioned or converted to other functions and this would reduce short term maintenance costs. The Levee Safety requirements for typical levee cross-sections (side slopes, crown and O&M road widths, etc.) will somewhat increase the current maintenance costs due to a larger footprint of vegetation management. The replacement of utility and drainage pipe crossings would reduce maintenance costs in the short term. Overall, the short term OMRR&R will decrease. However, in long term the OMRR&R cost is about the same because the commitments remain unchanged.

LIFE CYCLE COST
A life cycle cost estimate was not performed for the study.

4. CONTRACTOR MARKUPS
Prime Contractor's Markups – Below is the breakdown of the Prime CTR markups.

Prime Contractor	Own Work	Sub Work
JOOH	10.00%	10.00%
HOOH	10.00%	10.00%
Profit	9.00%	5.00%
Bond	1.50%	1.50%

Subcontractors' Markups – Below is the breakdown of the general subcontractors' markups.

Piping/Relocation	Own Work
JOOH	8.00%
HOOH	10.00%
Profit	8.00%

Jet Grout	Own Work
JOOH	10.00%
HOOH	11.00%
Profit	8.00%

Paving	Own Work
HOOH	8.00%
Profit	8.00%

The contractor markups presented in the tables above are representative of past civil works estimates performed in the Sacramento region. Depending on the bidding environment and

availability of work in the region, the contractor markups can be higher or lower but the markups are expected be near those shown above. It is assumed that the subcontractors will perform all of their own work and will not subcontract any portion of it.

In addition to the contractor markups, a direct cost markup for Small Tools is estimated at 1.50% of Labor costs.

5. CONSTRUCTION SCHEDULE (SEE ATTACHED)

Alternative SB-7 is expected to consist of five (5) construction contracts. Alternative SB-8 would consist of seven (7) construction contracts. With the exception of the Star Bend FIP contract, each contract is assumed to be completed in two construction season. Star Bend FIP is a relatively small contract and it is assumed it can be constructed concurrently in the same year with another contract. If funding permits, multiple contracts can be awarded in the same year. An approximation on the construction contracts and year(s) of construction is presented below. The schedule assumes the project gets authorized and appropriated through the construction window. This projection assumes that there is no funding shortage to implement the contract(s) in a given year. Other considerations in drafting the construction schedule includes public safety, availability of qualified contractors and special construction equipment, construction windows, funding constraints and acquisition of real estate.

SB-7

CONTRACT		FRWLP Reaches	Year for Construction
A		2–5	2020-2021
STAR BEND FIP		6	2019-2020
B		7–12	2019-2020
C	C1	13-18	2017-2018
	C2	19-21	2018-2019

SB-8

CONTRACT		FRWLP Reaches	Year for Construction
A		2–5	2022-2023
STAR BEND FIP		6	2021-2022
B		7–12	2021-2022
C	C1	13-18	2017-2018
	C2	19-25	2018-2019
D	D1	26-33	2019-2020
	D2	34-41	2020-2021

6. COST AND SCHEDULE RISK ANALYSIS (SEE ATTACHED)

The scope of the risk analysis was to calculate and present the cost and schedule contingencies at the 80 percent confidence level using the risk analysis processes, as mandated by U.S. Army Corps of Engineers (USACE) Engineer Regulation (ER) 1110-2-1150, Engineering and Design for Civil Works, ER 1110- 2-1302, Civil Works Cost Engineering, and Engineer Technical Letter

1110-2- 573, Construction Cost Estimating Guide for Civil Works. The contingency derived from the CSRA for Alternatives SB-7 and SB-8 is approximately 35% and 36% respectively.

7. TOTAL PROJECT COSTS (SEE ATTACHED)

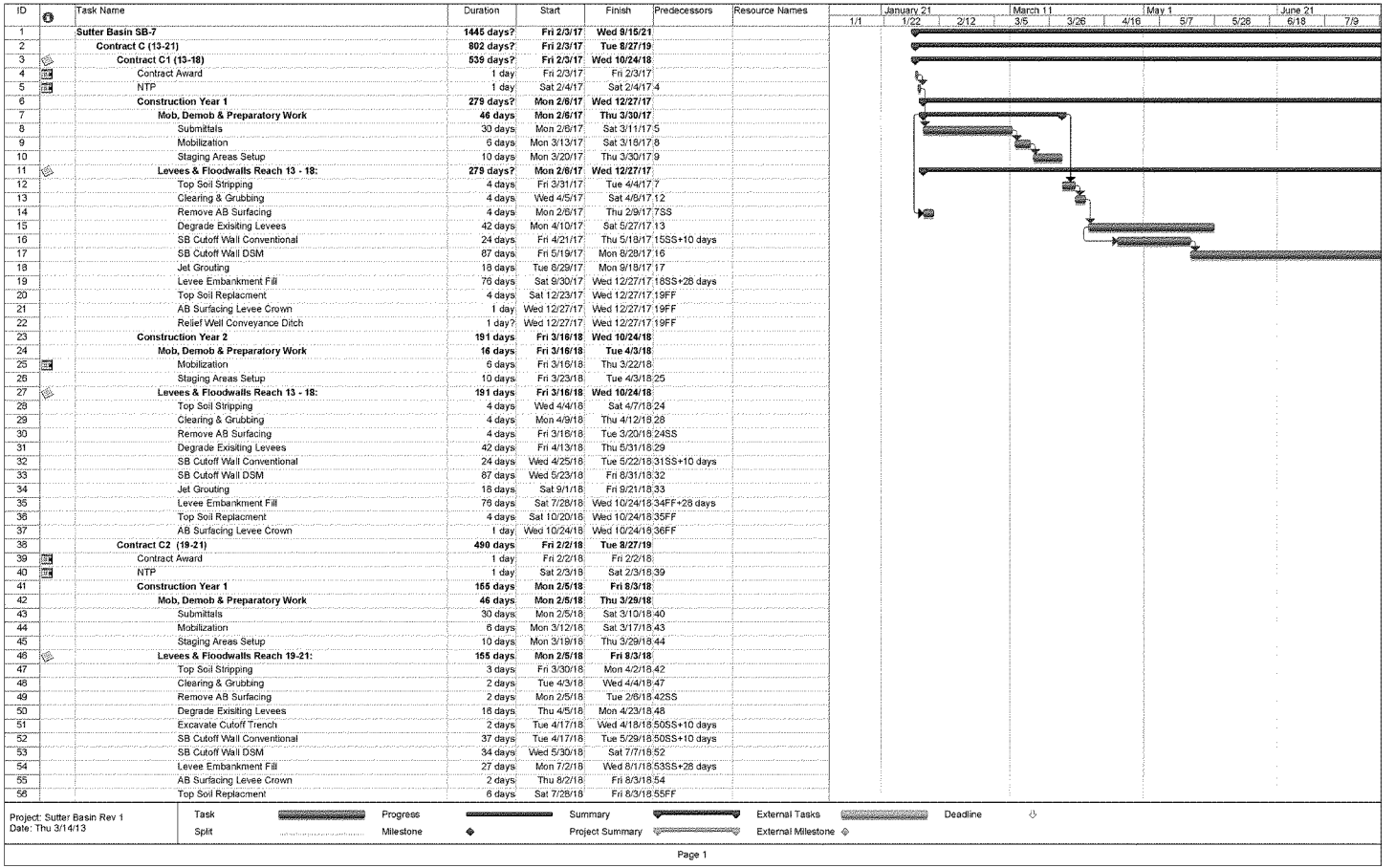
REAL ESTATE (01 and 02 Accounts)
The Real Estate cost estimate (01 Account Lands & Damages and Administrative costs) is performed by the SPK Real Estate Division and provided to the Cost Engineering section. The 01 Account Lands and Damages, Relocation Assistance Payment, and New Utility Easements cost estimates were appraised to include 50% incremental costs (please refer to the Real Estate Appendix for more detail). These technical Real Estate increments estimated by the appraiser are independent of the contingency derived though the Cost and Schedule Risk Analysis (CSRA). The contingency for the Federal and Non-Federal Real Estate Administrative costs is estimated at 5% was provided by the Real Estate Division. The CSRA identified no additional contingencies for the 01 Account. The overall contingency for the 01 Account is 33% and 28% for Alternative SB-7 and Alternative SB-8 respectively. For the 02 Account Relocations, the Real Estate Division assessed no contingencies. The CSRA evaluated the relocations and have applied contingencies of 35% and 36% for SB-7 and SB-8 respectively.

ENVIRONMENTAL MITIGATION (06 Account)
The Environmental Mitigation cost estimate is performed by SPK Environmental Planning and provided to Cost Engineering. It is understood that Environmental Planning included its own contingencies (20%) in the Environmental Mitigation estimate due to their experience and field of expertise. Environmental Mitigation includes costs for Riparian Forest, Oak Woodlands, Elderberry, Giant Garter Snake, Wetlands, Air Quality, and ETL Compliance (please refer to the Environmental Planning Appendix for more detail). Environmental Planning also provided costs for tree removal. Since this is a construction cost the contingency applied to this task will be that derived from the Cost and Schedule Risk Analysis.

CULTURAL RESOURCES PRESERVATION (18 Account)
The Cultural Resources Preservation costs estimate was developed by SPK Archeologist and provided to Cost Engineering. The contingency applied to this account will be that derived from the Cost and Schedule Risk Analysis.

PLANNING, ENGINEERING AND DESIGN (30 Account)
The cost for Planning, Engineering and Design (PED) was provided by the project manager.

CONSTRUCTION MANAGEMENT (31 Account)
The cost for Construction Management (CM) was provided by construction.



ID	Task Name	Duration	Start	Finish	Predecessors	Resource Names
1	**Sutter Basin SB-7**	**1445 days?**	**Fri 2/3/17**	**Wed 8/15/21**		
2	**Contract C (13-21)**	**802 days?**	**Fri 2/3/17**	**Tue 8/27/19**		
3	**Contract C1 (13-18)**	**539 days?**	**Fri 2/3/17**	**Wed 10/24/18**		
4	Contract Award	1 day	Fri 2/3/17	Fri 2/3/17		
5	NTP	1 day	Sat 2/4/17	Sat 2/4/17	4	
6	**Construction Year 1**	**279 days?**	**Mon 2/6/17**	**Wed 12/27/17**		
7	**Mob, Demob & Preparatory Work**	**46 days**	**Mon 2/6/17**	**Thu 3/30/17**		
8	Submittals	30 days	Mon 2/6/17	Sat 3/11/17	5	
9	Mobilization	6 days	Mon 3/13/17	Sat 3/18/17	8	
10	Staging Areas Setup	10 days	Mon 3/20/17	Thu 3/30/17	9	
11	**Levees & Floodwalls Reach 13 - 18:**	**279 days?**	**Mon 2/6/17**	**Wed 12/27/17**		
12	Top Soil Stripping	4 days	Fri 3/31/17	Tue 4/4/17	7	
13	Clearing & Grubbing	4 days	Wed 4/5/17	Sat 4/8/17	12	
14	Remove AB Surfacing	4 days	Mon 2/6/17	Thu 2/9/17	7SS	
15	Degrade Exisiting Levees	42 days	Mon 4/10/17	Sat 5/27/17	13	
16	SB Cutoff Wall Conventional	24 days	Fri 4/21/17	Thu 5/18/17	15SS+10 days	
17	SB Cutoff Wall DSM	87 days	Fri 5/19/17	Mon 8/28/17	16	
18	Jet Grouting	18 days	Tue 8/29/17	Mon 9/18/17	17	
19	Levee Embankment Fill	76 days	Sat 9/30/17	Wed 12/27/17	18SS+28 days	
20	Top Soil Replacment	4 days	Sat 12/23/17	Wed 12/27/17	19FF	
21	AB Surfacing Levee Crown	1 day	Wed 12/27/17	Wed 12/27/17	19FF	
22	Relief Well Conveyance Ditch	1 day?	Wed 12/27/17	Wed 12/27/17	19FF	
23	**Construction Year 2**	**191 days**	**Fri 3/16/18**	**Wed 10/24/18**		
24	**Mob, Demob & Preparatory Work**	**16 days**	**Fri 3/16/18**	**Tue 4/3/18**		
25	Mobilization	6 days	Fri 3/16/18	Thu 3/22/18		
26	Staging Areas Setup	10 days	Fri 3/23/18	Tue 4/3/18	25	
27	**Levees & Floodwalls Reach 13 - 18:**	**191 days**	**Fri 3/16/18**	**Wed 10/24/18**		
28	Top Soil Stripping	4 days	Wed 4/4/18	Sat 4/7/18	24	
29	Clearing & Grubbing	4 days	Mon 4/9/18	Thu 4/12/18	28	
30	Remove AB Surfacing	4 days	Fri 3/16/18	Tue 3/20/18	24SS	
31	Degrade Exisiting Levees	42 days	Fri 4/13/18	Thu 5/31/18	29	
32	SB Cutoff Wall Conventional	24 days	Wed 4/25/18	Tue 5/22/18	31SS+10 days	
33	SB Cutoff Wall DSM	87 days	Wed 5/23/18	Fri 8/31/18	32	
34	Jet Grouting	18 days	Sat 9/1/18	Fri 9/21/18	33	
35	Levee Embankment Fill	76 days	Sat 7/28/18	Wed 10/24/18	34FF+28 days	
36	Top Soil Replacment	4 days	Sat 10/20/18	Wed 10/24/18	35FF	
37	AB Surfacing Levee Crown	1 day	Wed 10/24/18	Wed 10/24/18	36FF	
38	**Contract C2 (19-21)**	**490 days**	**Fri 2/2/18**	**Tue 8/27/19**		
39	Contract Award	1 day	Fri 2/2/18	Fri 2/2/18		
40	NTP	1 day	Sat 2/3/18	Sat 2/3/18	39	
41	**Construction Year 1**	**155 days**	**Mon 2/5/18**	**Fri 8/3/18**		
42	**Mob, Demob & Preparatory Work**	**46 days**	**Mon 2/5/18**	**Thu 3/29/18**		
43	Submittals	30 days	Mon 2/5/18	Sat 3/10/18	40	
44	Mobilization	6 days	Mon 3/12/18	Sat 3/17/18	43	
45	Staging Areas Setup	10 days	Mon 3/19/18	Thu 3/29/18	44	
46	**Levees & Floodwalls Reach 19-21:**	**155 days**	**Mon 2/5/18**	**Fri 8/3/18**		
47	Top Soil Stripping	3 days	Fri 3/30/18	Mon 4/2/18	42	
48	Clearing & Grubbing	2 days	Tue 4/3/18	Wed 4/4/18	47	
49	Remove AB Surfacing	2 days	Mon 2/5/18	Tue 2/6/18	42SS	
50	Degrade Exisiting Levees	18 days	Thu 4/5/18	Mon 4/23/18	48	
51	Excavate Cutoff Trench	2 days	Tue 4/17/18	Wed 4/18/18	50SS+10 days	
52	SB Cutoff Wall Conventional	37 days	Tue 4/17/18	Tue 5/29/18	50SS+10 days	
53	SB Cutoff Wall DSM	34 days	Wed 5/30/18	Sat 7/7/18	52	
54	Levee Embankment Fill	27 days	Mon 7/2/18	Wed 8/1/18	53SS+28 days	
55	AB Surfacing Levee Crown	2 days	Thu 8/2/18	Fri 8/3/18	54	
56	Top Soil Replacment	6 days	Sat 7/28/18	Fri 8/3/18	55FF	

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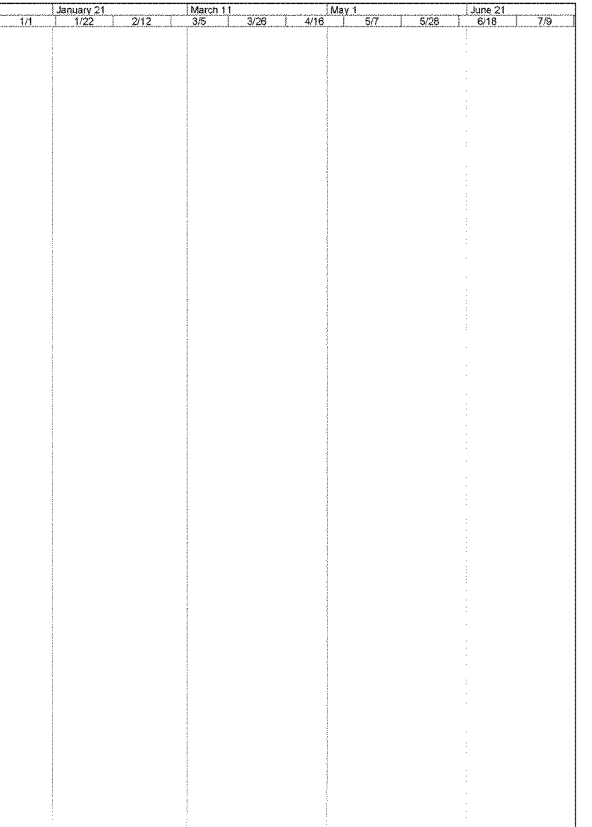
Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

ID	Task Name	Duration	Start	Finish	Predecessors	Resource Names
57	**Construction Year 2**	**155 days**	**Thu 2/28/19**	**Tue 8/27/19**		
58	**Mob, Demob & Preparatory Work**	**46 days**	**Thu 2/28/19**	**Mon 4/22/19**		
59	Submittals	30 days	Thu 2/28/19	Wed 4/3/19		
60	Mobilization	6 days	Thu 4/4/19	Wed 4/10/19	59	
61	Staging Areas Setup	10 days	Thu 4/11/19	Mon 4/22/19	60	
62	**Levees & Floodwalls Reach 19-21:**	**109 days**	**Tue 4/23/19**	**Tue 8/27/19**		
63	Top Soil Stripping	3 days	Tue 4/23/19	Thu 4/25/19	58	
64	Clearing & Grubbing	2 days	Fri 4/26/19	Sat 4/27/19	63	
65	Remove AB Surfacing	2 days	Tue 4/23/19	Wed 4/24/19	58	
66	Degrade Exisiting Levees	16 days	Mon 4/29/19	Thu 5/16/19	64	
67	Excavate Cutoff Trench	2 days	Fri 5/10/19	Sat 5/11/19	66SS+10 days	
68	SB Cutoff Wall Conventional	37 days	Fri 5/10/19	Fri 6/21/19	66SS+10 days	
69	SB Cutoff Wall DSM	34 days	Sat 6/22/19	Wed 7/31/19	68	
70	Levee Embankment Fill	27 days	Thu 7/25/19	Sat 8/24/19	68SS+28 days	
71	AB Surfacing Levee Crown	2 days	Mon 8/26/19	Tue 8/27/19	70	
72	Top Soil Replacment	6 days	Wed 8/21/19	Tue 8/27/19	71FF	
73	**Contract B (7-12)**	**504 days?**	**Tue 2/5/19**	**Mon 9/14/20**		
74	**Contract B (7-12)**	**504 days?**	**Tue 2/5/19**	**Mon 9/14/20**		
75	Contract Award	1 day	Tue 2/5/19	Tue 2/5/19		
76	NTP	1 day	Wed 2/6/19	Wed 2/6/19	75	
77	**Construction Year 1**	**187 days?**	**Thu 2/7/19**	**Thu 9/12/19**		
78	**Mob, Demob & Preparatory Work**	**46 days**	**Thu 2/7/19**	**Mon 4/1/19**		
79	Submittals	30 days	Thu 2/7/19	Wed 3/13/19	76	
80	Mobilization	6 days	Thu 3/14/19	Wed 3/20/19	79	
81	Staging Areas Setup	10 days	Thu 3/21/19	Mon 4/1/19	80	
82	**Levees & Floodwalls Reach 7-12**	**141 days?**	**Tue 4/2/19**	**Thu 9/12/19**		
83	Top Soil Stripping	6 days	Tue 4/2/19	Mon 4/8/19	78	
84	Clearing & Grubbing	5 days	Tue 4/9/19	Sat 4/13/19	83	
85	Remove AB Surfacing	3 days	Fri 6/7/19	Mon 6/10/19	78,86FF	
86	Degrade Exisiting Levees	49 days	Mon 4/15/19	Mon 6/10/19	84	
87	Excavate Cutoff Trench	4 days	Fri 4/26/19	Tue 4/30/19	86SS+10 days	
88	Excavate Inspection/Key Trench	1 day?	Wed 5/8/19	Wed 5/8/19	87SS+10 days	
89	SB Cutoff Wall Conventional	83 days	Fri 4/26/19	Wed 7/31/19	86SS+10 days	
90	Levee Embankment Fill	83 days	Wed 5/29/19	Mon 9/2/19	89SS+28 days	
91	AB Surfacing Levee Crown	9 days	Tue 9/3/19	Thu 9/12/19	90	
92	Top Soil Replacment	12 days	Fri 8/30/19	Thu 9/12/19	91FF	
93	**Construction Year 2**	**157 days?**	**Mon 3/16/20**	**Mon 9/14/20**		
94	**Mob, Demob & Preparatory Work**	**16 days**	**Mon 3/16/20**	**Thu 4/2/20**		
95	Mobilization	6 days	Mon 3/16/20	Sat 3/21/20		
96	Staging Areas Setup	10 days	Mon 3/23/20	Thu 4/2/20	95	
97	**Levees & Floodwalls Reach 7-12**	**141 days?**	**Fri 4/3/20**	**Mon 9/14/20**		
98	Top Soil Stripping	6 days	Fri 4/3/20	Thu 4/9/20	94	
99	Clearing & Grubbing	5 days	Fri 4/10/20	Wed 4/15/20	98	
100	Remove AB Surfacing	3 days	Tue 6/9/20	Thu 6/11/20	94,101FF	
101	Degrade Exisiting Levees	49 days	Thu 4/16/20	Thu 6/11/20	99	
102	Excavate Cutoff Trench	4 days	Tue 4/28/20	Fri 5/1/20	101SS+10 days	
103	Excavate Inspection/Key Trench	1 day?	Sat 5/9/20	Sat 5/9/20	102SS+10 days	
104	SB Cutoff Wall Conventional	83 days	Tue 4/28/20	Sat 8/1/20	101SS+10 days	
105	Levee Embankment Fill	83 days	Sat 5/30/20	Thu 9/3/20	104SS+28 days	
106	AB Surfacing Levee Crown	9 days	Fri 9/4/20	Mon 9/14/20	105	
107	Top Soil Replacment	12 days	Tue 9/1/20	Mon 9/14/20	106FF	
108	**Star Bend FIP (6)**	**425 days?**	**Tue 2/5/19**	**Sat 6/13/20**		
109	**Star Bend FIP (6)**	**425 days?**	**Tue 2/5/19**	**Sat 6/13/20**		
110	Contract Award	1 day	Tue 2/5/19	Tue 2/5/19		
111	NTP	1 day	Wed 2/6/19	Wed 2/6/19	110	
112	**Construction Year 1**	**108 days**	**Thu 2/7/19**	**Wed 6/12/19**		



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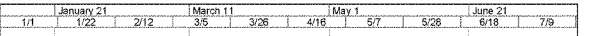
Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

ID	Task Name	Duration	Start	Finish	Predecessors	Resource Names
113	**Mob, Demob & Preparatory Work**	**46 days**	**Thu 2/7/19**	**Mon 4/1/19**		
114	Submittals	30 days	Thu 2/7/19	Wed 3/13/19	111	
115	Mobilization	6 days	Thu 3/14/19	Wed 3/20/19	114	
116	Staging Areas Setup	10 days	Thu 3/21/19	Mon 4/1/19	115	
117	**Levees & Floodwalls Reach 6**	**62 days**	**Tue 4/2/19**	**Wed 6/12/19**		
118	Top Soil Stripping	2 days	Tue 4/2/19	Wed 4/3/19	113	
119	Clearing & Grubbing	2 days	Thu 4/4/19	Fri 4/5/19	118	
120	Degrade Exisiting Levees	10 days	Sat 4/6/19	Wed 4/17/19	119	
121	Excavate Cutoff Trench	1 day	Thu 4/18/19	Thu 4/18/19	120SS+10 days	
122	SB Cutoff Wall Conventional	29 days	Thu 4/18/19	Tue 5/21/19	120SS+10 days	
123	Levee Embankment Fill	18 days	Tue 5/21/19	Mon 6/10/19	122SS+28 days	
124	AB Surfacing Levee Crown	2 days	Tue 6/11/19	Wed 6/12/19	123	
125	Top Soil Replacment	3 days	Mon 6/10/19	Wed 6/12/19	124FF	
126	**Construction Year 2**	**78 days?**	**Mon 3/16/20**	**Sat 6/13/20**		
127	**Mob, Demob & Preparatory Work**	**16 days**	**Mon 3/16/20**	**Thu 4/2/20**		
128	Mobilization	6 days	Mon 3/16/20	Sat 3/21/20		
129	Staging Areas Setup	10 days	Mon 3/23/20	Thu 4/2/20	128	
130	**Levees & Floodwalls Reach 8**	**62 days?**	**Fri 4/3/20**	**Sat 6/13/20**		
131	Top Soil Stripping	2 days	Fri 4/3/20	Sat 4/4/20	127	
132	Clearing & Grubbing	2 days	Mon 4/6/20	Tue 4/7/20	131	
133	Degrade Exisiting Levees	10 days	Wed 4/8/20	Sat 4/18/20	132	
134	Excavate Cutoff Trench	1 day	Mon 4/20/20	Mon 4/20/20	133SS+10 days	
135	Excavate Inspection/Key Trench	1 day?	Fri 5/1/20	Fri 5/1/20	134SS+10 days	
136	SB Cutoff Wall Conventional	29 days	Mon 4/20/20	Fri 5/22/20	133SS+10 days	
137	Levee Embankment Fill	18 days	Fri 5/22/20	Thu 6/11/20	136SS+28 days	
138	AB Surfacing Levee Crown	2 days	Fri 6/12/20	Sat 6/13/20	137	
139	Top Soil Replacment	3 days	Thu 6/11/20	Sat 6/13/20	138FF	
140	**Contract A (2-5)**	**506 days**	**Tue 2/4/20**	**Wed 9/15/21**		
141	**Contract A (2-5)**	**506 days**	**Tue 2/4/20**	**Wed 9/15/21**		
142	Contract Award	1 day	Tue 2/4/20	Tue 2/4/20		
143	NTP	1 day	Wed 2/5/20	Wed 2/5/20	142	
144	**Construction Year 1**	**188 days**	**Thu 2/6/20**	**Fri 9/11/20**		
145	**Mob, Demob & Preparatory Work**	**46 days**	**Thu 2/6/20**	**Mon 3/30/20**		
146	Submittals	30 days	Thu 2/6/20	Wed 3/11/20	143	
147	Mobilization	6 days	Thu 3/12/20	Wed 3/18/20	146	
148	Staging Areas Setup	10 days	Thu 3/19/20	Mon 3/30/20	147	
149	**Levees & Floodwalls Reach 2-5:**	**142 days**	**Tue 3/31/20**	**Fri 9/11/20**		
150	Top Soil Stripping	8 days	Tue 3/31/20	Wed 4/8/20	145	
151	Clearing & Grubbing	6 days	Thu 4/9/20	Wed 4/15/20	150	
152	Remove AB Surfacing	3 days	Tue 3/31/20	Thu 4/2/20	145	
153	Degrade Exisiting Levees	46 days	Thu 4/16/20	Mon 6/8/20	151	
154	Excavate Cutoff Trench	4 days	Tue 4/28/20	Fri 5/1/20	153SS+10 days	
155	Excavate Inspection/Key Trench	4 days	Sat 5/9/20	Wed 5/13/20	154SS+10 days	
156	SB Cutoff Wall Conventional	51 days	Tue 4/28/20	Thu 6/25/20	153SS+10 days	
157	SB Cutoff Wall DSM	67 days	Fri 6/26/20	Fri 9/11/20	156	
158	Levee Embankment Fill	82 days	Sat 5/30/20	Wed 9/2/20	156SS+28 days	
159	AB Surfacing Levee Crown	5 days	Thu 9/3/20	Tue 9/8/20	158	
160	Top Soil Replacment	8 days	Mon 8/31/20	Tue 9/8/20	159FF	
161	**Construction Year 2**	**159 days**	**Tue 3/16/21**	**Wed 9/15/21**		
162	**Mob, Demob & Preparatory Work**	**16 days**	**Tue 3/16/21**	**Fri 4/2/21**		
163	Mobilization	6 days	Tue 3/16/21	Mon 3/22/21		
164	Staging Areas Setup	10 days	Tue 3/23/21	Fri 4/2/21	163	
165	**Levees & Floodwalls Reach 2-5**	**142 days**	**Sat 4/3/21**	**Wed 9/15/21**		
166	Top Soil Stripping	8 days	Sat 4/3/21	Mon 4/12/21	162	
167	Clearing & Grubbing	6 days	Tue 4/13/21	Mon 4/19/21	166	
168	Remove AB Surfacing	3 days	Sat 4/3/21	Tue 4/6/21	162	



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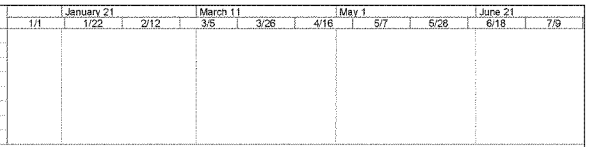
Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

ID	Task Name	Duration	Start	Finish	Predecessors	Resource Names
169	Degrade Exisiting Levees	46 days	Tue 4/20/21	Fri 6/11/21	167	
170	Excavate Cutoff Trench	4 days	Sat 5/1/21	Wed 5/5/21	169SS+10 days	
171	Excavate Inspection/Key Trench	4 days	Thu 5/13/21	Mon 5/17/21	170SS+10 days	
172	SB Cutoff Wall Conventional	51 days	Sat 5/1/21	Tue 6/29/21	169SS+10 days	
173	SB Cutoff Wall DSM	67 days	Wed 6/30/21	Wed 9/15/21	172	
174	Levee Embankment Fill	82 days	Thu 6/3/21	Mon 9/6/21	172SS+28 days	
175	AB Surfacing Levee Crown	5 days	Tue 9/7/21	Sat 9/11/21	174	
176	Top Soil Replacment	8 days	Fri 9/3/21	Sat 9/11/21	175FF	



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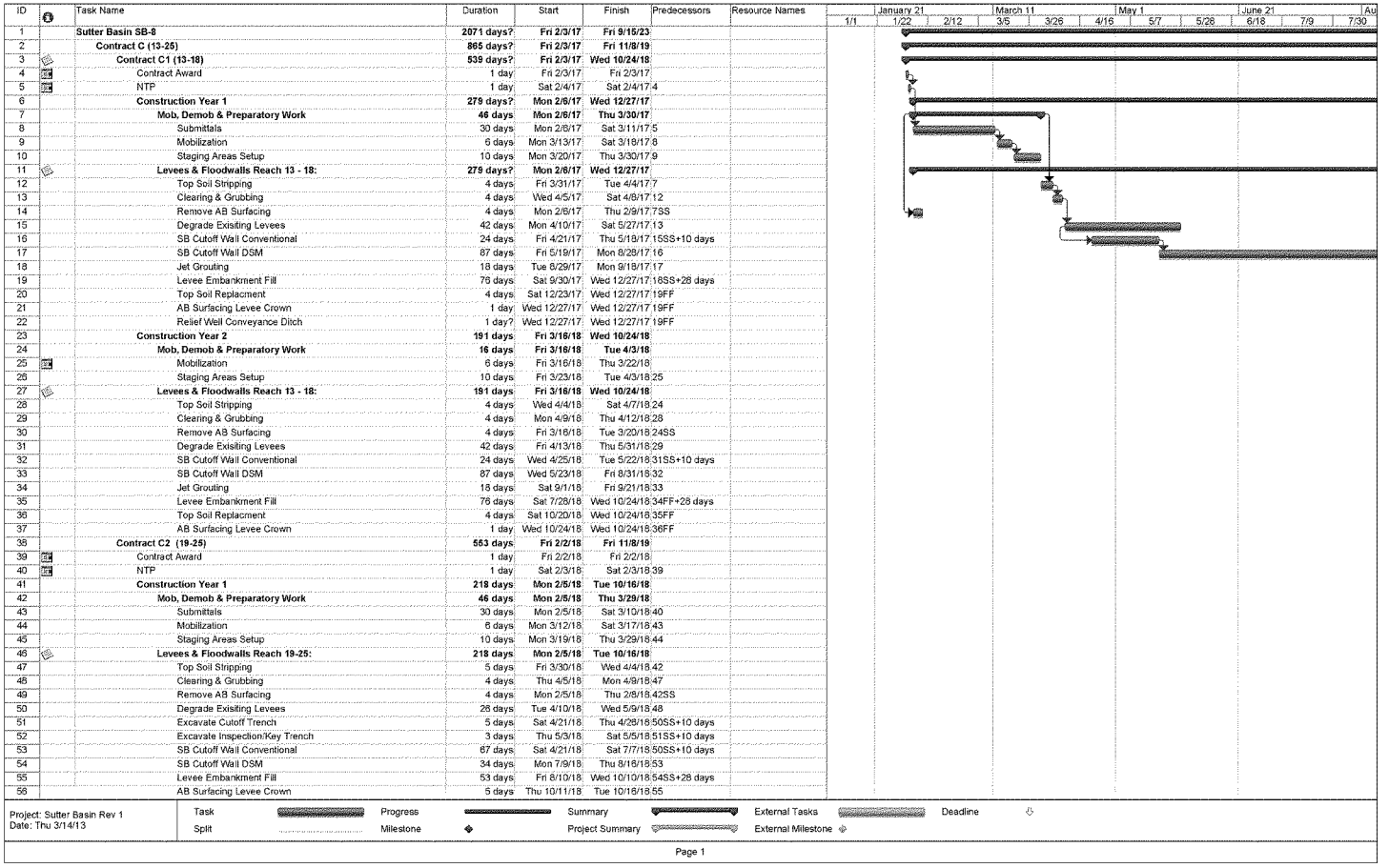
Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone



ID	Task Name	Duration	Start	Finish	Predecessors	Resource Names
1	**Sutter Basin SB-8**	**2071 days?**	**Fri 2/3/17**	**Fri 9/15/23**		
2	**Contract C (13-25)**	**865 days?**	**Fri 2/3/17**	**Fri 11/8/19**		
3	**Contract C1 (13-18)**	**539 days?**	**Fri 2/3/17**	**Wed 10/24/18**		
4	Contract Award	1 day	Fri 2/3/17	Fri 2/3/17		
5	NTP	1 day	Sat 2/4/17	Sat 2/4/17	4	
6	**Construction Year 1**	**279 days?**	**Mon 2/6/17**	**Wed 12/27/17**		
7	**Mob, Demob & Preparatory Work**	**46 days**	**Mon 2/6/17**	**Thu 3/30/17**		
8	Submittals	30 days	Mon 2/6/17	Sat 3/11/17	5	
9	Mobilization	6 days	Mon 3/13/17	Sat 3/18/17	8	
10	Staging Areas Setup	10 days	Mon 3/20/17	Thu 3/30/17	9	
11	**Levees & Floodwalls Reach 13 - 18:**	**279 days?**	**Mon 2/6/17**	**Wed 12/27/17**		
12	Top Soil Stripping	4 days	Fri 3/31/17	Tue 4/4/17	7	
13	Clearing & Grubbing	4 days	Wed 4/5/17	Sat 4/8/17	12	
14	Remove AB Surfacing	4 days	Mon 2/6/17	Thu 2/9/17	7SS	
15	Degrade Exisiting Levees	42 days	Mon 4/10/17	Sat 5/27/17	13	
16	SB Cutoff Wall Conventional	24 days	Fri 4/21/17	Thu 5/18/17	15SS+10 days	
17	SB Cutoff Wall DSM	87 days	Fri 5/19/17	Mon 8/28/17	16	
18	Jet Grouting	18 days	Tue 8/29/17	Mon 9/18/17	17	
19	Levee Embankment Fill	76 days	Sat 9/30/17	Wed 12/27/17	18SS+28 days	
20	Top Soil Replacment	4 days	Sat 12/23/17	Wed 12/27/17	19FF	
21	AB Surfacing Levee Crown	1 day	Wed 12/27/17	Wed 12/27/17	19FF	
22	Relief Well Conveyance Ditch	1 day?	Wed 12/27/17	Wed 12/27/17	19FF	
23	**Construction Year 2**	**191 days**	**Fri 3/16/18**	**Wed 10/24/18**		
24	**Mob, Demob & Preparatory Work**	**16 days**	**Fri 3/16/18**	**Tue 4/3/18**		
25	Mobilization	6 days	Fri 3/16/18	Thu 3/22/18		
26	Staging Areas Setup	10 days	Fri 3/23/18	Tue 4/3/18	25	
27	**Levees & Floodwalls Reach 13 - 18:**	**191 days**	**Fri 3/16/18**	**Wed 10/24/18**		
28	Top Soil Stripping	4 days	Wed 4/4/18	Sat 4/7/18	24	
29	Clearing & Grubbing	4 days	Mon 4/9/18	Thu 4/12/18	28	
30	Remove AB Surfacing	4 days	Fri 3/16/18	Tue 3/20/18	24SS	
31	Degrade Exisiting Levees	42 days	Fri 4/13/18	Thu 5/31/18	29	
32	SB Cutoff Wall Conventional	24 days	Wed 4/25/18	Tue 5/22/18	31SS+10 days	
33	SB Cutoff Wall DSM	87 days	Wed 5/23/18	Fri 8/31/18	32	
34	Jet Grouting	18 days	Sat 9/1/18	Fri 9/21/18	33	
35	Levee Embankment Fill	76 days	Sat 7/28/18	Wed 10/24/18	34FF+28 days	
36	Top Soil Replacment	4 days	Sat 10/20/18	Wed 10/24/18	35FF	
37	AB Surfacing Levee Crown	1 day	Wed 10/24/18	Wed 10/24/18	36FF	
38	**Contract C2 (19-25)**	**553 days**	**Fri 2/2/18**	**Fri 11/8/19**		
39	Contract Award	1 day	Fri 2/2/18	Fri 2/2/18		
40	NTP	1 day	Sat 2/3/18	Sat 2/3/18	39	
41	**Construction Year 1**	**218 days**	**Mon 2/5/18**	**Tue 10/16/18**		
42	**Mob, Demob & Preparatory Work**	**46 days**	**Mon 2/5/18**	**Thu 3/29/18**		
43	Submittals	30 days	Mon 2/5/18	Sat 3/10/18	40	
44	Mobilization	6 days	Mon 3/12/18	Sat 3/17/18	43	
45	Staging Areas Setup	10 days	Mon 3/19/18	Thu 3/29/18	44	
46	**Levees & Floodwalls Reach 19-25:**	**218 days**	**Mon 2/5/18**	**Tue 10/16/18**		
47	Top Soil Stripping	5 days	Fri 3/30/18	Wed 4/4/18	42	
48	Clearing & Grubbing	4 days	Thu 4/5/18	Mon 4/9/18	47	
49	Remove AB Surfacing	4 days	Mon 2/5/18	Thu 2/8/18	42SS	
50	Degrade Exisiting Levees	28 days	Tue 4/10/18	Wed 5/9/18	48	
51	Excavate Cutoff Trench	5 days	Sat 4/21/18	Thu 4/26/18	50SS+10 days	
52	Excavate Inspection/Key Trench	3 days	Thu 5/3/18	Sat 5/5/18	51SS+10 days	
53	SB Cutoff Wall Conventional	67 days	Sat 4/21/18	Sat 7/7/18	50SS+10 days	
54	SB Cutoff Wall DSM	34 days	Mon 7/9/18	Thu 8/16/18	53	
55	Levee Embankment Fill	53 days	Fri 8/10/18	Wed 10/10/18	54SS+28 days	
56	AB Surfacing Levee Crown	5 days	Thu 10/11/18	Tue 10/16/18	55	

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Task | Progress | Summary | External Tasks | Deadline
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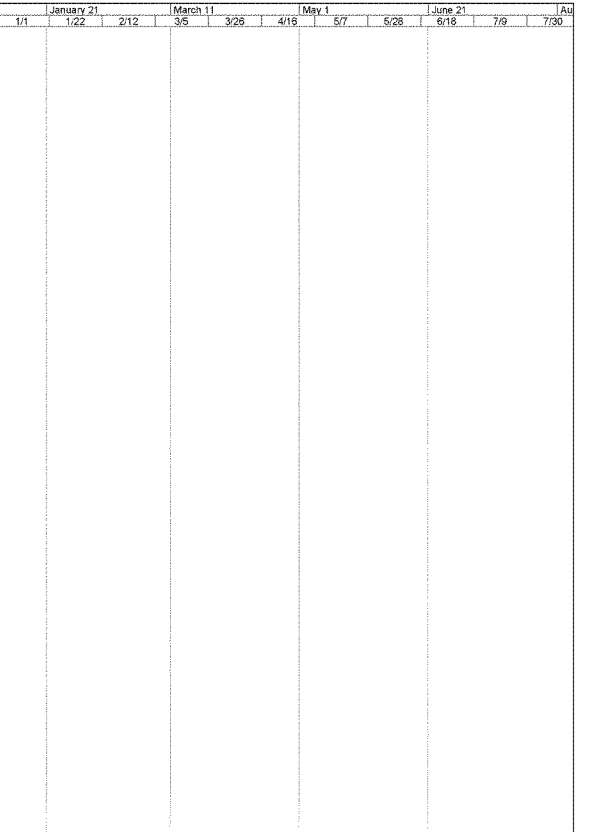
ID	Task Name	Duration	Start	Finish	Predecessors	Resource Names
57	Top Soil Replacment	10 days	Fri 10/5/18	Tue 10/16/18	56FF	
58	**Construction Year 2**	**218 days**	**Thu 2/28/19**	**Fri 11/8/19**		
59	**Mob, Demob & Preparatory Work**	**46 days**	**Thu 2/28/19**	**Mon 4/22/19**		
60	Submittals	30 days	Thu 2/28/19	Wed 4/3/19		
61	Mobilization	6 days	Thu 4/4/19	Wed 4/10/19	60	
62	Staging Areas Setup	10 days	Thu 4/11/19	Mon 4/22/19	61	
63	**Levees & Floodwalls Reach 19-25:**	**172 days**	**Tue 4/23/19**	**Fri 11/8/19**		
64	Top Soil Stripping	5 days	Tue 4/23/19	Sat 4/27/19	59	
65	Clearing & Grubbing	4 days	Mon 4/29/19	Thu 5/2/19	64	
66	Remove AB Surfacing	4 days	Tue 4/23/19	Fri 4/26/19	59	
67	Degrade Exisiting Levees	26 days	Fri 5/3/19	Sat 6/1/19	65	
68	Excavate Cutoff Trench	5 days	Wed 5/15/19	Mon 5/20/19	67SS+10 days	
69	Excavate Inspection/Key Trench	5 days	Mon 5/27/19	Fri 5/31/19	68SS+10 days	
70	SB Cutoff Wall Conventional	67 days	Wed 5/15/19	Wed 7/31/19	67SS+10 days	
71	SB Cutoff Wall DSM	34 days	Thu 8/1/19	Mon 9/9/19	70	
72	Levee Embankment Fill	53 days	Tue 9/3/19	Sat 11/2/19	71SS+28 days	
73	AB Surfacing Levee Crown	5 days	Mon 11/4/19	Fri 11/8/19	72	
74	Top Soil Replacment	10 days	Tue 10/29/19	Fri 11/8/19	73FF	
75	**Contract D (26-41)**	**793 days**	**Mon 2/4/19**	**Mon 8/16/21**		
76	**Contract D1 (26-33)**	**541 days**	**Mon 2/4/19**	**Mon 10/26/20**		
77	Contract Award	1 day	Mon 2/4/19	Mon 2/4/19		
78	NTP	1 day	Tue 2/5/19	Tue 2/5/19	77	
79	**Construction Year 1**	**228 days**	**Wed 2/6/19**	**Tue 10/29/19**		
80	**Mob, Demob & Preparatory Work**	**46 days**	**Wed 2/6/19**	**Sat 3/30/19**		
81	Submittals	30 days	Wed 2/6/19	Tue 3/12/19	78	
82	Mobilization	6 days	Wed 3/13/19	Tue 3/19/19	81	
83	Staging Areas Setup	10 days	Wed 3/20/19	Sat 3/30/19	82	
84	**Levees & Floodwalls Reach 26-33:**	**228 days**	**Wed 2/6/19**	**Tue 10/29/19**		
85	Top Soil Stripping	4 days	Mon 4/1/19	Thu 4/4/19	80	
86	Clearing & Grubbing	3 days	Fri 4/5/19	Mon 4/8/19	85	
87	Remove AB Surfacing	3 days	Wed 2/6/19	Fri 2/8/19	80SS	
88	Degrade Exisiting Levees	17 days	Tue 4/9/19	Sat 4/27/19	86	
89	Excavate Cutoff Trench	4 days	Sat 4/20/19	Wed 4/24/19	86SS+10 days	
90	Excavate Inspection/Key Trench	5 days	Thu 5/2/19	Tue 5/7/19	89SS+10 days	
91	SB Cutoff Wall Conventional	68 days	Sat 4/20/19	Mon 7/8/19	86SS+10 days	
92	SB Cutoff Wall DSM	60 days	Tue 7/9/19	Mon 9/16/19	91	
93	Jet Grouting	20 days	Sat 8/24/19	Mon 9/16/19	92FF	
94	Levee Embankment Fill	61 days	Fri 8/9/19	Fri 10/18/19	91SS+28 days,93I	
95	AB Surfacing Levee Crown	4 days	Sat 10/19/19	Wed 10/23/19	94	
96	Top Soil Replacment	7 days	Wed 10/16/19	Wed 10/23/19	95FF	
97	**Canal @ STA 1753+00**	**17 days**	**Thu 10/10/19**	**Tue 10/29/19**		
98	Construction New Canal	8 days	Thu 10/10/19	Fri 10/18/19	86,94FF	
99	Backfill Old Canal	9 days	Sat 10/19/19	Tue 10/29/19	98	
100	**Construction Year 2**	**193 days**	**Mon 3/16/20**	**Mon 10/26/20**		
101	**Mob, Demob & Preparatory Work**	**16 days**	**Mon 3/16/20**	**Thu 4/2/20**		
102	Mobilization	6 days	Mon 3/16/20	Sat 3/21/20		
103	Staging Areas Setup	10 days	Mon 3/23/20	Thu 4/2/20	102	
104	**Levees & Floodwalls Reach 26-33**	**193 days**	**Mon 3/16/20**	**Mon 10/26/20**		
105	Top Soil Stripping	4 days	Fri 4/3/20	Tue 4/7/20	101	
106	Clearing & Grubbing	3 days	Wed 4/8/20	Fri 4/10/20	105	
107	Remove AB Surfacing	3 days	Mon 3/16/20	Wed 3/18/20	101SS	
108	Degrade Exisiting Levees	17 days	Sat 4/11/20	Thu 4/30/20	106	
109	Excavate Cutoff Trench	4 days	Thu 4/23/20	Mon 4/27/20	108SS+10 days	
110	Excavate Inspection/Key Trench	5 days	Tue 5/5/20	Sat 5/9/20	109SS+10 days	
111	SB Cutoff Wall Conventional	68 days	Thu 4/23/20	Fri 7/10/20	108SS+10 days	
112	SB Cutoff Wall DSM	60 days	Sat 7/11/20	Fri 9/18/20	111	



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Task | Progress | Summary | External Tasks | Deadline
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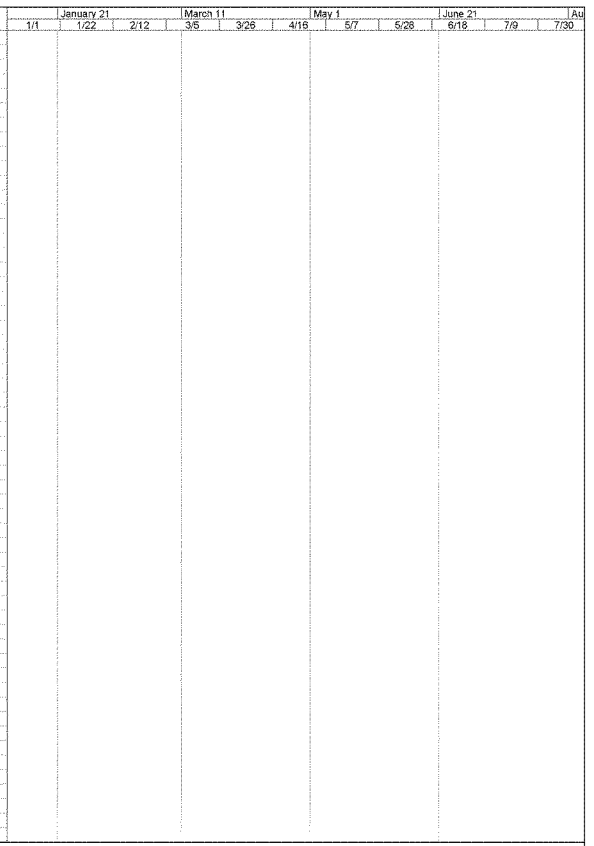
ID	Task Name	Duration	Start	Finish	Predecessors	Resource Names
113	Jet Grouting	20 days	Thu 8/27/20	Fri 9/18/20	112FF	
114	Levee Embankment Fill	61 days	Wed 8/12/20	Wed 10/21/20	111SS+28 days,1	
115	AB Surfacing Levee Crown	4 days	Thu 10/22/20	Mon 10/26/20	114	
116	Top Soil Replacment	7 days	Mon 10/19/20	Mon 10/26/20	115FF	
117	**Contract D2 (34-41)**	**481 days**	**Mon 2/3/20**	**Mon 8/16/21**		
118	Contract Award	1 day	Mon 2/3/20	Mon 2/3/20		
119	NTP	1 day	Tue 2/4/20	Tue 2/4/20	118	
120	**Construction Year 1**	**163 days**	**Wed 2/5/20**	**Wed 8/12/20**		
121	**Mob, Demob & Preparatory Work**	**46 days**	**Wed 2/5/20**	**Sat 3/28/20**		
122	Submittals	30 days	Wed 2/5/20	Tue 3/10/20	119	
123	Mobilization	6 days	Wed 3/11/20	Tue 3/17/20	122	
124	Staging Areas Setup	10 days	Wed 3/18/20	Sat 3/28/20	123	
125	**Levees & Floodwalls Reach 34-41**	**117 days**	**Mon 3/30/20**	**Wed 8/12/20**		
126	Top Soil Stripping	4 days	Mon 3/30/20	Thu 4/2/20	121	
127	Clearing & Grubbing	5 days	Fri 4/3/20	Wed 4/8/20	126	
128	Remove AB Surfacing	2 days	Sat 5/2/20	Mon 5/4/20	121,129FF	
129	Degrade Exisiting Levees	22 days	Thu 4/9/20	Mon 5/4/20	127	
130	Excavate Cutoff Trench	3 days	Tue 4/21/20	Thu 4/23/20	129SS+10 days	
131	SB Cutoff Wall Conventional	31 days	Tue 4/21/20	Tue 5/26/20	129SS+10 days	
132	SB Cutoff Wall DSM	67 days	Wed 5/27/20	Wed 8/12/20	131	
133	Levee Embankment Fill	23 days	Sat 5/23/20	Thu 6/18/20	131SS+28 days	
134	AB Surfacing Levee Crown	3 days	Fri 6/19/20	Mon 6/22/20	133	
135	Top Soil Replacment	7 days	Mon 6/15/20	Mon 6/22/20	134FF	
136	**Construction Year 2**	**133 days**	**Mon 3/15/21**	**Mon 8/16/21**		
137	**Mob, Demob & Preparatory Work**	**16 days**	**Mon 3/15/21**	**Thu 4/1/21**		
138	Mobilization	6 days	Mon 3/15/21	Sat 3/20/21		
139	Staging Areas Setup	10 days	Mon 3/22/21	Thu 4/1/21	138	
140	**Levees & Floodwalls Reach 34-41**	**117 days**	**Fri 4/2/21**	**Mon 8/16/21**		
141	Top Soil Stripping	4 days	Fri 4/2/21	Tue 4/6/21	137	
142	Clearing & Grubbing	5 days	Wed 4/7/21	Mon 4/12/21	141	
143	Remove AB Surfacing	2 days	Thu 5/6/21	Fri 5/7/21	137,144FF	
144	Degrade Exisiting Levees	22 days	Tue 4/13/21	Fri 5/7/21	142	
145	Excavate Cutoff Trench	3 days	Sat 4/24/21	Tue 4/27/21	144SS+10 days	
146	SB Cutoff Wall Conventional	31 days	Sat 4/24/21	Sat 5/29/21	144SS+10 days	
147	SB Cutoff Wall DSM	67 days	Mon 5/31/21	Mon 8/16/21	146	
148	Levee Embankment Fill	23 days	Thu 5/27/21	Tue 6/22/21	146SS+28 days	
149	AB Surfacing Levee Crown	3 days	Wed 6/23/21	Fri 6/25/21	148	
150	Top Soil Replacment	7 days	Fri 6/18/21	Fri 6/25/21	149FF	
151	**Contract B (7-12)**	**503 days?**	**Fri 2/5/21**	**Wed 9/14/22**		
152	**Contract B (7-12)**	**503 days?**	**Fri 2/5/21**	**Wed 9/14/22**		
153	Contract Award	1 day	Fri 2/5/21	Fri 2/5/21		
154	NTP	1 day	Sat 2/6/21	Sat 2/6/21	153	
155	**Construction Year 1**	**187 days?**	**Mon 2/8/21**	**Mon 9/13/21**		
156	**Mob, Demob & Preparatory Work**	**46 days**	**Mon 2/8/21**	**Thu 4/1/21**		
157	Submittals	30 days	Mon 2/8/21	Sat 3/13/21	154	
158	Mobilization	6 days	Mon 3/15/21	Sat 3/20/21	157	
159	Staging Areas Setup	10 days	Mon 3/22/21	Thu 4/1/21	158	
160	**Levees & Floodwalls Reach 7-12**	**141 days?**	**Fri 4/2/21**	**Mon 9/13/21**		
161	Top Soil Stripping	6 days	Fri 4/2/21	Thu 4/8/21	156	
162	Clearing & Grubbing	5 days	Fri 4/9/21	Wed 4/14/21	161	
163	Remove AB Surfacing	3 days	Tue 6/8/21	Thu 6/10/21	156,164FF	
164	Degrade Exisiting Levees	49 days	Thu 4/15/21	Thu 6/10/21	162	
165	Excavate Cutoff Trench	4 days	Tue 4/27/21	Fri 4/30/21	164SS+10 days	
166	Excavate Inspection/Key Trench	1 day?	Sat 5/8/21	Sat 5/8/21	165SS+10 days	
167	SB Cutoff Wall Conventional	83 days	Tue 4/27/21	Sat 7/31/21	164SS+10 days	
168	Levee Embankment Fill	83 days	Sat 5/29/21	Thu 9/2/21	167SS+28 days	



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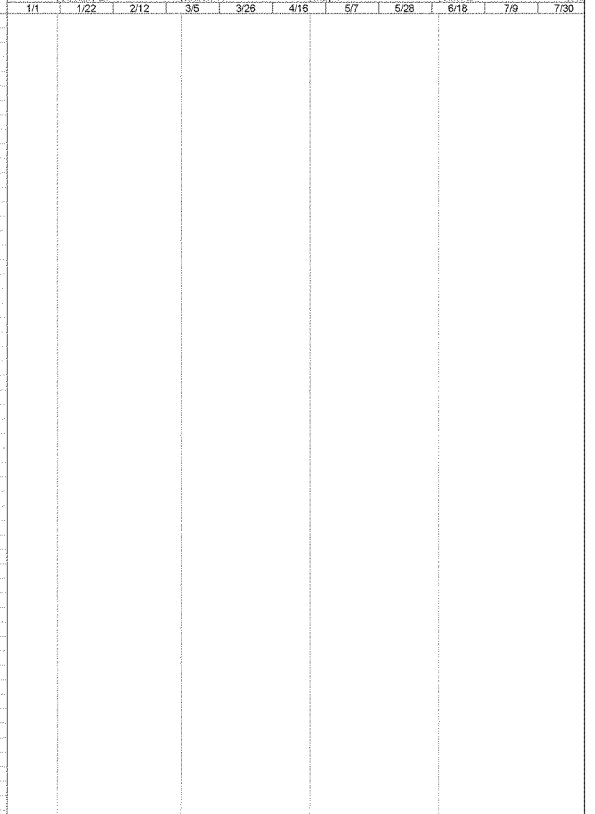
Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

ID	Task Name	Duration	Start	Finish	Predecessors	Resource Names
169	AB Surfacing Levee Crown	9 days	Fri 9/3/21	Mon 9/13/21	168	
170	Top Soil Replacment	12 days	Tue 8/31/21	Mon 9/13/21	169FF	
171	**Construction Year 2**	**157 days?**	**Wed 3/16/22**	**Wed 9/14/22**		
172	**Mob, Demob & Preparatory Work**	**16 days**	**Wed 3/16/22**	**Sat 4/2/22**		
173	Mobilization	6 days	Wed 3/16/22	Tue 3/22/22		
174	Staging Areas Setup	10 days	Wed 3/23/22	Sat 4/2/22	173	
175	**Levees & Floodwalls Reach 7-12**	**141 days?**	**Mon 4/4/22**	**Wed 9/14/22**		
176	Top Soil Stripping	6 days	Mon 4/4/22	Sat 4/9/22	172	
177	Clearing & Grubbing	5 days	Mon 4/11/22	Fri 4/15/22	176	
178	Remove AB Surfacing	3 days	Thu 6/9/22	Sat 6/11/22	172,179FF	
179	Degrade Exisiting Levees	49 days	Sat 4/16/22	Sat 6/11/22	177	
180	Excavate Cutoff Trench	4 days	Thu 4/28/22	Mon 5/2/22	179SS+10 days	
181	Excavate Inspection/Key Trench	1 day?	Tue 5/10/22	Tue 5/10/22	180SS+10 days	
182	SB Cutoff Wall Conventional	63 days	Thu 4/28/22	Tue 6/28/22	179SS+10 days	
183	Levee Embankment Fill	63 days	Tue 5/31/22	Sat 9/3/22	182SS+28 days	
184	AB Surfacing Levee Crown	9 days	Mon 9/5/22	Wed 9/14/22	183	
185	Top Soil Replacment	12 days	Thu 9/1/22	Wed 9/14/22	184FF	
186	**Star Bend FIP (6)**	**424 days?**	**Fri 2/5/21**	**Tue 6/14/22**		
187	**Star Bend FIP (6)**	**424 days?**	**Fri 2/5/21**	**Tue 6/14/22**		
188	Contract Award	1 day	Fri 2/5/21	Fri 2/5/21		
189	NTP	1 day	Sat 2/6/21	Sat 2/6/21	188	
190	**Construction Year 1**	**108 days**	**Mon 2/8/21**	**Sat 6/12/21**		
191	**Mob, Demob & Preparatory Work**	**46 days**	**Mon 2/8/21**	**Thu 4/1/21**		
192	Submittals	30 days	Mon 2/8/21	Sat 3/13/21	189	
193	Mobilization	6 days	Mon 3/15/21	Sat 3/20/21	192	
194	Staging Areas Setup	10 days	Mon 3/22/21	Thu 4/1/21	193	
195	**Levees & Floodwalls Reach 6**	**62 days**	**Fri 4/2/21**	**Sat 6/12/21**		
196	Top Soil Stripping	2 days	Fri 4/2/21	Sat 4/3/21	191	
197	Clearing & Grubbing	2 days	Mon 4/5/21	Tue 4/6/21	196	
198	Degrade Exisiting Levees	10 days	Wed 4/7/21	Sat 4/17/21	197	
199	Excavate Cutoff Trench	1 day	Mon 4/19/21	Mon 4/19/21	198SS+10 days	
200	SB Cutoff Wall Conventional	29 days	Mon 4/19/21	Fri 5/21/21	198SS+10 days	
201	Levee Embankment Fill	18 days	Fri 5/21/21	Thu 6/10/21	200SS+28 days	
202	AB Surfacing Levee Crown	2 days	Fri 6/11/21	Sat 6/12/21	201	
203	Top Soil Replacment	3 days	Thu 6/10/21	Sat 6/12/21	202FF	
204	**Construction Year 2**	**78 days?**	**Wed 3/16/22**	**Tue 6/14/22**		
205	**Mob, Demob & Preparatory Work**	**16 days**	**Wed 3/16/22**	**Sat 4/2/22**		
206	Mobilization	6 days	Wed 3/16/22	Tue 3/22/22		
207	Staging Areas Setup	10 days	Wed 3/23/22	Sat 4/2/22	206	
208	**Levees & Floodwalls Reach 6**	**62 days?**	**Mon 4/4/22**	**Tue 6/14/22**		
209	Top Soil Stripping	2 days	Mon 4/4/22	Tue 4/5/22	205	
210	Clearing & Grubbing	2 days	Wed 4/6/22	Thu 4/7/22	209	
211	Degrade Exisiting Levees	10 days	Fri 4/8/22	Tue 4/19/22	210	
212	Excavate Cutoff Trench	1 day	Wed 4/20/22	Wed 4/20/22	211SS+10 days	
213	Excavate Inspection/Key Trench	1 day?	Mon 5/2/22	Mon 5/2/22	212SS+10 days	
214	SB Cutoff Wall Conventional	29 days	Wed 4/20/22	Mon 5/23/22	211SS+10 days	
215	Levee Embankment Fill	18 days	Mon 5/23/22	Sat 6/11/22	214SS+28 days	
216	AB Surfacing Levee Crown	2 days	Mon 6/13/22	Tue 6/14/22	215	
217	Top Soil Replacment	3 days	Sat 6/11/22	Tue 6/14/22	216FF	
218	**Contract A (2-5)**	**505 days**	**Fri 2/4/22**	**Fri 9/15/23**		
219	**Contract A (2-5)**	**505 days**	**Fri 2/4/22**	**Fri 9/15/23**		
220	Contract Award	1 day	Fri 2/4/22	Fri 2/4/22		
221	NTP	1 day	Sat 2/5/22	Sat 2/5/22	220	
222	**Construction Year 1**	**188 days**	**Mon 2/7/22**	**Tue 9/13/22**		
223	**Mob, Demob & Preparatory Work**	**46 days**	**Mon 2/7/22**	**Thu 3/31/22**		
224	Submittals	30 days	Mon 2/7/22	Sat 3/12/22	221	



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Task | Progress | Summary | External Tasks | Deadline
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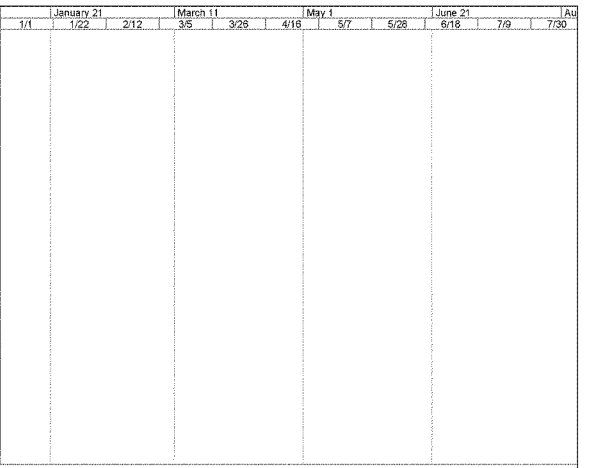
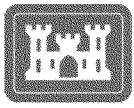
ID	Task Name	Duration	Start	Finish	Predecessors	Resource Names
225	Mobilization	6 days	Mon 3/14/22	Sat 3/19/22	224	
226	Staging Areas Setup	10 days	Mon 3/21/22	Thu 3/31/22	225	
227	**Levees & Floodwalls Reach 2-5:**	**142 days**	**Fri 4/1/22**	**Tue 9/13/22**		
228	Top Soil Stripping	8 days	Fri 4/1/22	Sat 4/9/22	223	
229	Clearing & Grubbing	6 days	Mon 4/11/22	Sat 4/16/22	228	
230	Remove AB Surfacing	3 days	Fri 4/1/22	Mon 4/4/22	223	
231	Degrade Exisiting Levees	46 days	Mon 4/18/22	Thu 6/9/22	229	
232	Excavate Cutoff Trench	4 days	Fri 4/29/22	Tue 5/3/22	231SS+10 days	
233	Excavate Inspection/Key Trench	4 days	Wed 5/11/22	Sat 5/14/22	232SS+10 days	
234	SB Cutoff Wall Conventional	51 days	Fri 4/29/22	Mon 6/27/22	231SS+10 days	
235	SB Cutoff Wall DSM	67 days	Tue 6/28/22	Tue 9/13/22	234	
236	Levee Embankment Fill	82 days	Wed 6/1/22	Sat 9/3/22	234SS+26 days	
237	AB Surfacing Levee Crown	5 days	Mon 9/5/22	Fri 9/9/22	236	
238	Top Soil Replacment	8 days	Thu 9/1/22	Fri 9/9/22	237FF	
239	**Construction Year 2**	**168 days**	**Thu 3/16/23**	**Fri 9/15/23**		
240	**Mob, Demob & Preparatory Work**	**16 days**	**Thu 3/16/23**	**Mon 4/3/23**		
241	Mobilization	6 days	Thu 3/16/23	Wed 3/22/23		
242	Staging Areas Setup	10 days	Thu 3/23/23	Mon 4/3/23	241	
243	**Levees & Floodwalls Reach 2-5**	**142 days**	**Tue 4/4/23**	**Fri 9/15/23**		
244	Top Soil Stripping	8 days	Tue 4/4/23	Wed 4/12/23	240	
245	Clearing & Grubbing	6 days	Thu 4/13/23	Wed 4/19/23	244	
246	Remove AB Surfacing	3 days	Tue 4/4/23	Thu 4/6/23	240	
247	Degrade Exisiting Levees	46 days	Thu 4/20/23	Mon 6/12/23	245	
248	Excavate Cutoff Trench	4 days	Tue 5/2/23	Fri 5/5/23	247SS+10 days	
249	Excavate Inspection/Key Trench	4 days	Sat 5/13/23	Wed 5/17/23	248SS+10 days	
250	SB Cutoff Wall Conventional	51 days	Tue 5/2/23	Thu 6/29/23	247SS+10 days	
251	SB Cutoff Wall DSM	67 days	Fri 6/30/23	Fri 9/15/23	250	
252	Levee Embankment Fill	82 days	Sat 6/3/23	Wed 9/6/23	250SS+26 days	
253	AB Surfacing Levee Crown	5 days	Thu 9/7/23	Tue 9/12/23	252	
254	Top Soil Replacment	8 days	Mon 9/4/23	Tue 9/12/23	253FF	



Project: Sutter Basin Rev 1
Date: Thu 3/14/13

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



US Army Corps of Engineers®

Sutter Basin Feasibility Study
Alternative Selection Plans
Project Cost and Schedule Risk Analysis Report

Prepared for:

U.S. Army Corps of Engineers,
Sacramento District

Prepared with:

U.S. Army Corps of Engineers
Cost Engineering Mandatory Center of Expertise, Walla Walla

August 1, 2013

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EXECUTIVE SUMMARY

The US Army Corps of Engineers (USACE), Sacramento District presents this cost and schedule risk analysis (CSRA) report regarding the risk findings and recommended contingencies for the Sutter Basin Feasibility Study for two Alternatives (SB7 and SB8). In compliance with Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008, a formal risk analysis study was conducted for the development of contingency on the total project cost. The purpose of this risk analysis study is to present the cost and schedule risks considered, those determined and respective project contingencies at a recommend 80% confidence level of successful execution to project completion.

The Sutter Basin Study consists of levee remediations necessary to reduce flood risk to the Sutter Basin. The vast majority of levee remediation consists of seepage prevention by constructing a soil-bentonite slurry cutoff wall through the centerline of the levee and rebuild the levee to pre-project geometry.

The Sutter Basin Feasibility Study considers three (3) Alternatives; Do Nothing; SB7, a Fix-in-Place alternative running for the Feather River West Levee from Sunset Weir to Laurel Avenue; and SB8, a Fix-in-Place alternative for the Feather River West Levee running from Thermalito Afterbay to Laurel Avenue (essentially SB7 plus the additional length from Thermalito Afterbay to Sunset Weir).

Specific to the Sutter Basin project, the base case construction cost for

- SB7 (excluding Accounts 01 Lands and Damages, 02 Fish and Wildlife Facilities, 30 Planning, Engineering and Design and 31 Construction Management) is estimated at approximately $194 Million. Based on the results of the analysis, the Cost Engineering Mandatory Center of Expertise for Civil Works (Walla Walla District) recommends a contingency value of approximately $70.5 Million, or 36%.

- SB8 (excluding Accounts 01 Lands and Damages, 02 Fish and Wildlife Facilities, 30 Planning, Engineering and Design and 31 Construction Management) is estimated at approximately $364 Million. Based on the results of the analysis, the Cost Engineering Mandatory Center of Expertise for Civil Works (Walla Walla District) recommends a contingency value of approximately $126.4 Million, or 35%.

In conjunction with the Sacramento team, the Cost Engineering Mandatory Center of Expertise (MCX) for Civil Works performed risk analysis by applying the *Monte Carlo* technique, producing the aforementioned contingencies and identifying key risk drivers.

The following tables ES-1 and ES-2portray the developed contingencies for both alternatives and resulting approximate project costs. The recommended contingencies are based on an 80% confidence level, as per USACE Civil Works guidance. The following tables are not an exact replica of the final reported Total Project costs due to rounding and late cost adjustments. The calculated contingencies are approximate and reflective of those items and cost studied. The following cost accounts were excluded for the risk study:

- The 01-Lands and Damages and the 06-Fish and Wildlife contingencies were established outside of the risk model.

- The 30-Preconstruction, Engineering and Design and the 31-Construction Management carry the same % of contingency value as construction; the theory being is that as constructions cost are impacted, so are these two respective accounts.

Table ES-1A. Contingency Analysis Table – Alternative SB7

Base Cost Estimate	**$194,048,000**	
Confidence Level	**Value ($$)**	**Contingency (%)**
5%	$33,495,693	17.26%
50%	$56,363,817	29.05%
80%	**$70,533,025**	**36.35%**
95%	$83,658,086	43.11%

Table ES-1B. Contingency Analysis Table – Alternative SB8

Base Cost Estimate	**$363,638,000**	
Confidence Level	**Value ($$)**	**Contingency (%)**
5%	$59,186,930	16.28%
50%	$100,985,958	27.77%
80%	**$126,390,500**	**34.76%**
95%	$149,857,593	41.21%

The risk analysis and resulting contingencies are presented as both a cost in dollars and a per cent of the base costs. The risk analysis was performed on a specific cost at a specific point in time. Subtle changes in the costs used to support the risk analysis do not have a significant bearing on contingency dollars or per cent when risk remains constant. As costs fluctuate to a slight degree and risks remain constant, greater emphasis is placed on the per cent value.

KEY FINDINGS/OBSERVATIONS RECOMMENDATIONS

The key cost risk drivers identified through sensitivity analysis for both Alternatives SB7 and SB8 are CA-3 (Availability of Qualified Contractors) and CA-1 (Multiple Construction Contracts), which together contribute some 69 percent of the statistical cost variance.

- Availability of Qualified Contractors. Captures the risk of limited competition. Multiple other contracts with similar seepage cutoff wall construction could be ongoing at time of contract award, potentially limiting the pool of contractors available to perform the work, impacting the ultimate contract costs.
- Multiple Construction Contracts. Captures the risk funding constraints will require multiple construction contracts, resulting in construction inefficiencies (multiple mob/demobs) and increasing contract oversight and administration costs.

Moderate cost risks, when combined, can also become a cost impact. The greater moderate risks include:

- Availability of suitable Borrow Sources.
- Potential Future Construction Claims and Modifications
- Potential System Wide Improvement Framework (SWIF) Requirements
- Funding Delays

The key schedule risk drivers identified through sensitivity analysis both Alternatives SB7 and SB8 are CA-1 (Multiple Construction Contracts) and PPM-2 (Vertical Team Review and Approval), which together contribute some 72 percent of the statistical schedule variance.

- Multiple Construction Contracts captures the risk funding constraints will require multiple non-concurrent construction contracts, extending the time required to complete the total project.
- Vertical Team Review and Approval captures the risk high time demands on vertical teams have created a backlog of projects and resulting in the potential for delays in the approval process and subsequent schedule slips.
- Funding Delays captures the possible delays in availability in Federal funds and the resulting issues that a protracted construction schedule can place the project at greater risks related to more stringent environmental restrictions, scope changes, political changes, escalation exceeding OMB projections, greater potential for extreme commodity availability and inflation.

Moderate schedule risks, when combined, can also become a time and resulting cost impact. The greater moderate risks include:

- Construction Windows for Endangered Species
- Potential Unknown HTRW Sites
- Potential Cultural Discoveries
- Project Competing with Other Priorities (Staffing)
- Potential Future Construction Claims and Modifications

Recommendations, as detailed within the main report, include the implementation of cost and schedule contingencies, further iterative study of risks throughout the project life-cycle, potential mitigation throughout the PED phase, and proactive monitoring and control of risk identified in this study.

MAIN REPORT

1.0 PURPOSE

The US Army Corps of Engineers (USACE), Sacramento District presents this cost and schedule risk analysis (CSRA) report regarding the risk findings and recommended contingencies for the Sutter Basin Feasibility Study for two Alternatives (SB7 and SB8).

2.0 BACKGROUND

The Sutter Basin Study consists of levee remediation necessary to reduce flood risk to the Sutter Basin. The vast majority of levee remediation consists of seepage prevention by constructing a soil-bentonite slurry cutoff wall through the centerline of the levee and rebuild the levee to pre-project geometry. At some locations, seepage berm, relief wells, deep-soil-mixing, jet grout cutoff wall, canal relocation, and slight levee relocation to provide O&M access roads are included but they are minor relative to the soil-bentonite cutoff wall construction.

The Sutter Basin Feasibility Study considers three (3) Alternatives; Do Nothing; SB7, a Fix-in-Place alternative running for the Feather River West Levee from Sunset Weir to Laurel Avenue; and SB8, a Fix-in-Place alternative for the Feather River West Levee running from Thermalito Afterbay to Laurel Avenue (essentially SB7 plus the additional length from Thermalito Afterbay to Sunset Weir).

The primary project sponsors are the Sutter Butte Flood Control Agency (SBFCA). and the California Department of Water Resources (DWR).The work will likely be complete in 5-7 phases due to funding increment limitations. It is likely that the contracts will be acquired using a RFP procurement. The current construction schedule is approximately 24 months in duration. Construction of the first phase (Star Bend) has been started by the Sponsor with additional phases to begin construction in late FY 3013.

As a part of study effort, Sacramento District has requested that the USACE Cost Engineering Mandatory Center of Expertise for Civil Works (Cost Engineering MCX) provide a risk analysis study to establish the resulting contingencies.

3.0 REPORT SCOPE

The scope of the risk analysis report is to identify cost and schedule risks with a resulting recommendation for contingencies at the 80 percent confidence level. This report is intended to serve as part of the risk management plan. The CSRA applies the principles mandated by U.S. Army Corps of Engineers (USACE) Engineer Regulation

(ER) 1110-2-1150, Engineering and Design for Civil Works, ER 1110-2-1302, Civil Works Cost Engineering, and Engineer Technical Letter 1110-2-573, Construction Cost Estimating Guide for Civil Works. The study and presentation does not include consideration for life cycle costs.

3.1 Project Scope

The formal process included extensive involvement of the PDT for risk identification and the development of the risk register. The analysis process evaluated the base case Micro Computer Aided Cost Estimating System (MCACES) cost estimate, schedule, and funding profiles using Crystal Ball software to conduct a *Monte Carlo* simulation and statistical sensitivity analysis, per the guidance in Engineer Technical Letter (ETL) CONSTRUCTION COST ESTIMATING GUIDE FOR CIVIL WORKS, dated September 30, 2008.

The project technical scope, estimates and schedules were developed and presented by the Sacramento District. Consequently, these documents serve as the basis for the risk analysis.

The scope of this study addresses the identification of problems, needs, opportunities and potential solutions that are viable from an economic, environmental, and engineering viewpoint.

3.2 USACE Risk Analysis Process

The risk analysis process for this study follows the USACE Headquarters requirements as well as the guidance provided by the Cost Engineering MCX. The risk analysis process reflected within this report uses probabilistic cost and schedule risk analysis methods within the framework of the Crystal Ball software. Furthermore, the scope of the report includes the identification and communication of important steps, logic, key assumptions, limitations, and decisions to help ensure that risk analysis results can be appropriately interpreted.

Risk analysis results are also intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes, as well as to provide tools to support decision making and risk management as the project progresses through planning and implementation. To fully recognize its benefits, cost and schedule risk analysis should be considered as an ongoing process conducted concurrent to, and iteratively with, other important project processes such as scope and execution plan development, resource planning, procurement planning, cost estimating, budgeting and scheduling.

In addition to broadly defined risk analysis standards and recommended practices, this risk analysis was performed to meet the requirements and recommendations of the following documents and sources:

- Cost and Schedule Risk Analysis Process guidance prepared by the USACE Cost Engineering MCX.
- Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008.
- Engineer Technical Letter (ETL) CONSTRUCTION COST ESTIMATING GUIDE FOR CIVIL WORKS, dated September 30, 2008.

4.0 METHODOLOGY / PROCESS

The risk analysis process for this study is intended to determine the probability of various cost outcomes and quantify the required contingency needed in the cost estimate to achieve the desired level of cost confidence. Per regulation and guidance, the P80 confidence level (80% confidence level) is the normal and accepted cost confidence level. District Management has the prerogative to select different confidence levels, pending approval from Headquarters, USACE.

In simple terms, contingency is an amount added to an estimate to allow for items, conditions or events for which the occurrence or impact is uncertain and that experience suggests will likely result in additional costs being incurred or additional time being required. The amount of contingency included in project control plans depends, at least in part, on the project leadership's willingness to accept risk of project overruns. The less risk that project leadership is willing to accept the more contingency should be applied in the project control plans. The risk of overrun is expressed, in a probabilistic context, using confidence levels.

The Cost MCX guidance for cost and schedule risk analysis generally focuses on the 80-percent level of confidence (P80) for cost contingency calculation. It should be noted that use of P80 as a decision criteria is a risk averse approach (whereas the use of P50 would be a risk neutral approach, and use of levels less than 50 percent would be risk seeking). Thus, a P80 confidence level results in greater contingency as compared to a P50 confidence level. The selection of contingency at a particular confidence level is ultimately the decision and responsibility of the project's District and/or Division management.

The risk analysis process uses *Monte Carlo* techniques to determine probabilities and contingency. The *Monte Carlo* techniques are facilitated computationally by a

commercially available risk analysis software package (Crystal Ball) that is an add-in to Microsoft Excel. Cost estimates are packaged into an Excel format and used directly for cost risk analysis purposes. The level of detail recreated in the Excel-format schedule is sufficient for risk analysis purposes that reflect the established risk register, but generally less than that of the native format.

The primary steps, in functional terms, of the risk analysis process are described in the following subsections. Risk analysis results are provided in Section 6.

4.1 Identify and Assess Risk Factors

Identifying the risk factors via the PDT is considered a qualitative process that results in establishing a risk register that serves as the document for the quantitative study using the Crystal Ball risk software. Risk factors are events and conditions that may influence or drive uncertainty in project performance. They may be inherent characteristics or conditions of the project or external influences, events, or conditions such as weather or economic conditions. Risk factors may have either favorable or unfavorable impacts on project cost and schedule.

The Walla Walla Cost Engineering MCX performed the Cost and Schedule Risk Analysis, relying on local Sacramento District staff to provide information gathering. The Walla Walla Cost Engineering MCX facilitated an on-site risk identification meeting on January 24, 2013 with the Sacramento District PDT to produce a risk register that served as the framework for the risk analysis. Participants in risk identification meeting included the following:

Name	Organization	Title
Peter Blodgett	USACE - SPK	Hydraulic Engineer
William Bolte	USACE - NWW	Cost Engineer (Risk Facilitator)
Jane Bolton	USACE - SPK	Geotechnical Engineer
Matt Davis	USACE - SPK	Environmental Engineer
Tri Duong	USACE - SPK	Cost Engineer
Mark Ellis	USACE - SPK	Project Manager
Miki Fujitsubo	USACE - SPK	Planner
Erik Gomez	USACE - SPK	Economist
S. Joe Griffin	USACE - SPK	Cultural Resources
Richard Kristof	USACE - SPK	Civil Engineer
Tung Le	USACE - SPK	Structural Engineer
Michael Musto	DWR	Sponsor Representative
Laurie Parker	USACE – SPK	Real Estate
David Peterson	PBI	Sponsor Representative

Representatives from Construction and Contracting were contacted after the on-site risk identification meeting and given the initial Risk Registry for their review. Their subsequent input has been incorporated into the final Risk Registry.

The initial formal meetings focused primarily on risk factor identification using brainstorming techniques, but also included some facilitated discussions based on risk factors common to projects of similar scope and geographic location. Subsequent meetings focused primarily on risk factor assessment and quantification.

Additionally, numerous conference calls and informal meetings were conducted throughout the risk analysis process on an as-needed basis to further facilitate risk factor identification, market analysis, and risk assessment.

4.2 Quantify Risk Factor Impacts

The quantitative impacts of risk factors on project plans were analyzed using a combination of professional judgment, empirical data and analytical techniques. Risk factor impacts were quantified using probability distributions (density functions) because risk factors are entered into the Crystal Ball software in the form of probability density functions.

Similar to the identification and assessment process, risk factor quantification involved multiple project team disciplines and functions. However, the quantification process relied more extensively on collaboration between cost engineering and risk analysis team members with lesser inputs from other functions and disciplines. This process used an iterative approach to estimate the following elements of each risk factor:

- Maximum possible value for the risk factor
- Minimum possible value for the risk factor
- Most likely value (the statistical mode), if applicable
- Nature of the probability density function used to approximate risk factor uncertainty
- Mathematical correlations between risk factors
- Affected cost estimate and schedule elements

The resulting product from the PDT discussions is captured within a risk register as presented in Appendix A for both cost and schedule risk concerns. Note that the risk register records the PDT's risk concerns, discussions related to those concerns, and potential impacts to the current cost and schedule estimates. The concerns and discussions support the team's decisions related to event likelihood, impact, and the resulting risk levels for each risk event.

4.3 Analyze Cost Estimate and Schedule Contingency

Contingency is analyzed using the Crystal Ball software, an add-in to the Microsoft Excel format of the cost estimate and schedule. *Monte Carlo* simulations are performed by applying the risk factors (quantified as probability density functions) to the appropriate estimated cost and schedule elements identified by the PDT. Contingencies are calculated by applying only the moderate and high level risks identified for each option (i.e., low-level risks are typically not considered, but remain within the risk register to serve historical purposes as well as support follow-on risk studies as the project and risks evolve).

For the cost estimate, the contingency is calculated as the difference between the P80 cost forecast and the baseline cost estimate. Each option-specific contingency is then allocated on a civil works feature level based on the dollar-weighted relative risk of each feature as quantified by *Monte Carlo* simulation. Standard deviation is used as the feature-specific measure of risk for contingency allocation purposes. This approach results in a relatively larger portion of all the project feature cost contingency being allocated to features with relatively higher estimated cost uncertainty.

5.0 PROJECT ASSUMPTIONS

The following data sources and assumptions were used in quantifying the costs associated with the Sutter Basin project.

a. The Sacramento District provided MII MCACES (Micro-Computer Aided Cost Estimating Software) files and a summary Excel spreadsheet detailing all project costs by contract and serves as the basis for the final cost and schedule risk analyses.

b. The cost comparisons and risk analyses performed and reflected within this report are based on design scope and estimates that are at the feasibility level.

c. The CSRA excludes

- The 01-Lands and Damages and the 06-Fish and Wildlife contingencies were established outside of the risk model.

- The 30-Preconstruction, Engineering and Design and the 31-Construction Management carry the same % of contingency value as construction; the theory being is that as constructions cost are impacted, so are these two respective accounts.

d. Schedules are analyzed for impact to the project cost in terms of both uncaptured escalation (variance from OMB factors and the local market) and unavoidable fixed contract costs and/or languishing federal administration costs incurred throughout delay.

Specific to the Sutter Basin project, the schedule was analyzed only for impacts due to residual fixed costs.

e. The risk analyses accounted for escalation over and above the projected Office of Management and Budget (OMB). Based on a detailed calculations for the Isabella Lake Project, Sacramento District has calculated California is 1.92% higher than the OMB rates.

f. Per the data in the estimate, the Overhead percentage for the Prime Contractor is 10%, and 10% for the Subcontractors. Thus, the assumed residual fixed cost rate for this project is 10%. For the P80 schedule, this comprises approximately 22% of the total contingency and 8% of the base cost estimate (9.2% for SB7 and 7.7% for SB8). This is due to the accrual of residual fixed costs associated with delay associated with the implementation schedule.

g. The Cost MCX guidance generally focuses on the eighty-percent level of confidence (P80) for cost contingency calculation. For this risk analysis, the eighty-percent level of confidence (P80) was used. It should be noted that the use of P80 as a decision criteria is a moderately risk averse approach, generally resulting in higher cost contingencies. However, the P80 level of confidence also assumes a small degree of risk that the recommended contingencies may be inadequate to capture actual project costs.

h. Only high and moderate risk level impacts, as identified in the risk register, were considered for the purposes of calculating cost contingency. Low level risk impacts should be maintained in project management documentation, and reviewed at each project milestone to determine if they should be placed on the risk "watch list".

6.0 RESULTS

The cost and schedule risk analysis results are provided in the following sections. In addition to contingency calculation results, sensitivity analyses are presented to provide decision makers with an understanding of variability and the key contributors to the cause of this variability.

6.1 Risk Register

A risk register is a tool commonly used in project planning and risk analysis. The actual risk register is provided in Appendix A. The complete risk register includes low level risks, as well as additional information regarding the nature and impacts of each risk.

It is important to note that a risk register can be an effective tool for managing identified risks throughout the project life cycle. As such, it is generally recommended that risk registers be updated as the designs, cost estimates, and schedule are further refined,

especially on large projects with extended schedules. Recommended uses of the risk register going forward include:

- Documenting risk mitigation strategies being pursued in response to the identified risks and their assessment in terms of probability and impact.
- Providing project sponsors, stakeholders, and leadership/management with a documented framework from which risk status can be reported in the context of project controls.
- Communicating risk management issues.
- Providing a mechanism for eliciting feedback and project control input.
- Identifying risk transfer, elimination, or mitigation actions required for implementation of risk management plans.

6.2 Cost Contingency and Sensitivity Analysis

The result of risk or uncertainty analysis is quantification of the cumulative impact of all analyzed risks or uncertainties as compared to probability of occurrence. These results, as applied to the analysis herein, depict the overall project cost at intervals of confidence (probability).

Table 1 provides the construction cost contingencies calculated for the P80 confidence level and rounded to the nearest thousand. The construction cost contingencies for the P50 and P95 confidence levels are also provided for illustrative purposes only.

Table 1A. Construction Cost Contingency Summary – SB7

Risk Analysis Forecast	Total Construction Cost	Total Contingency[1] ($)	Total Contingency (%)
50% Confidence Level			
Construction Cost	$250,411,817	$56,363,817	29.05%
80% Confidence Level			
Construction Cost	$264,581,025	$70,533,025	36.35%
95% Confidence Level			
Construction Cost	$277,706,086	$83,658,086	43.11%

Notes:
1) These figures combine uncertainty in the baseline cost estimates and schedule.

Table 1B. Construction Cost Contingency Summary – SB8

Risk Analysis Forecast	Total Construction Cost	Total Contingency[1] ($)	Total Contingency (%)
50% Confidence Level			
Construction Cost	$464,623,958	$100,985,958	27.77%
80% Confidence Level			
Construction Cost	$490,028,500	$126,390,500	34.76%
95% Confidence Level			
Construction Cost	$513,495,593	$149,857,593	41.21%

Notes:
1) These figures combine uncertainty in the baseline cost estimates and schedule.

6.2.1 Sensitivity Analysis

Sensitivity analysis generally ranks the relative impact of each risk/opportunity as a percentage of total cost uncertainty. The Crystal Ball software uses a statistical measure (contribution to variance) that approximates the impact of each risk/opportunity contributing to variability of cost outcomes during *Monte Carlo* simulation.

Key cost drivers identified in the sensitivity analysis can be used to support development of a risk management plan that will facilitate control of risk factors and their potential impacts throughout the project lifecycle. Together with the risk register, sensitivity analysis results can also be used to support development of strategies to eliminate, mitigate, accept or transfer key risks.

6.2.2 Sensitivity Analysis Results

The risks/opportunities considered as key or primary cost drivers are ranked in order of importance in contribution to variance bar charts. Opportunities that have a potential to reduce project cost and are shown with a negative sign; risks are shown with a positive sign to reflect the potential to increase project cost. A longer bar in the sensitivity analysis chart represents a greater potential impact to project cost.

Figure 1 presents a sensitivity analysis for cost growth risk from the high level cost risks identified in the risk register. Likewise, Figure 2 presents a sensitivity analysis for schedule growth risk from the high level schedule risks identified in the risk register.

Figure 1A. Cost Sensitivity Analysis – SB7

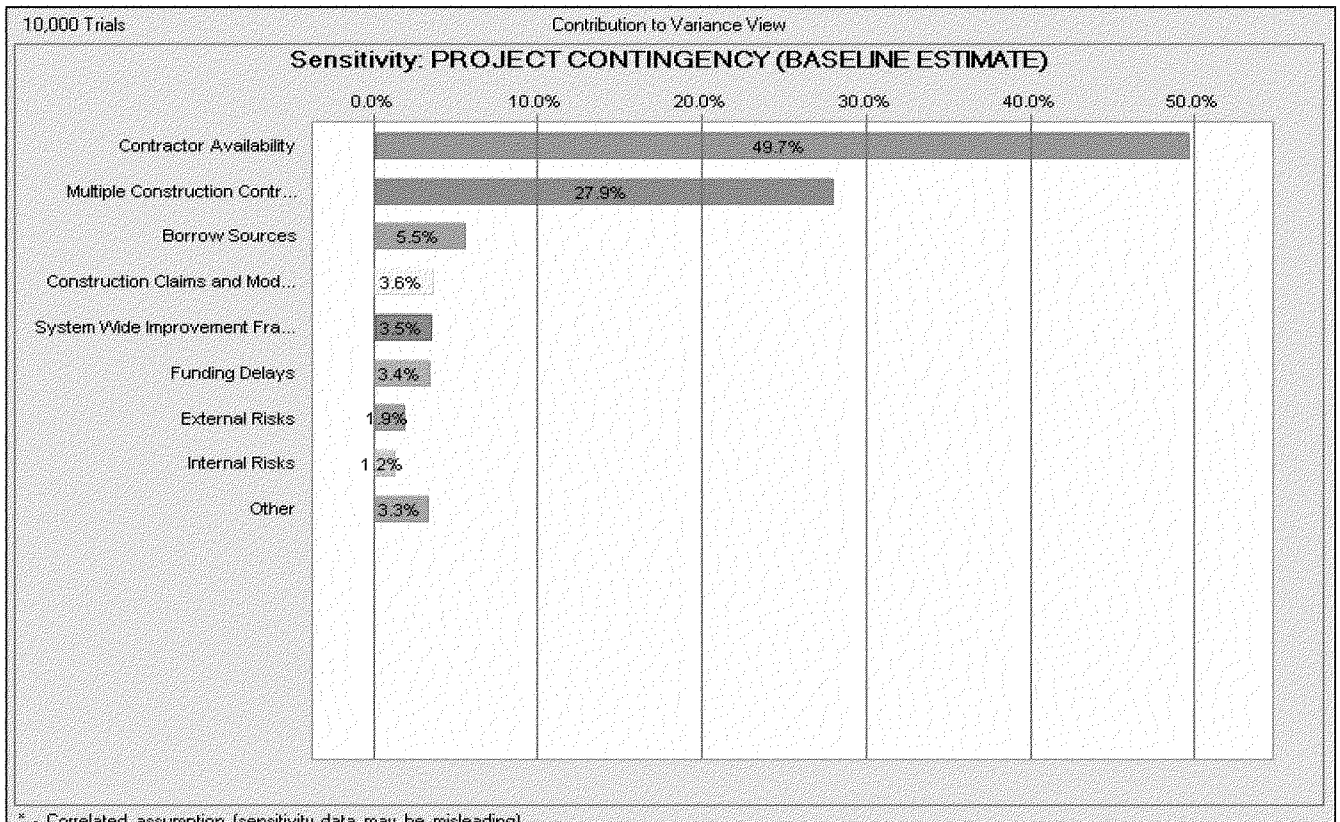
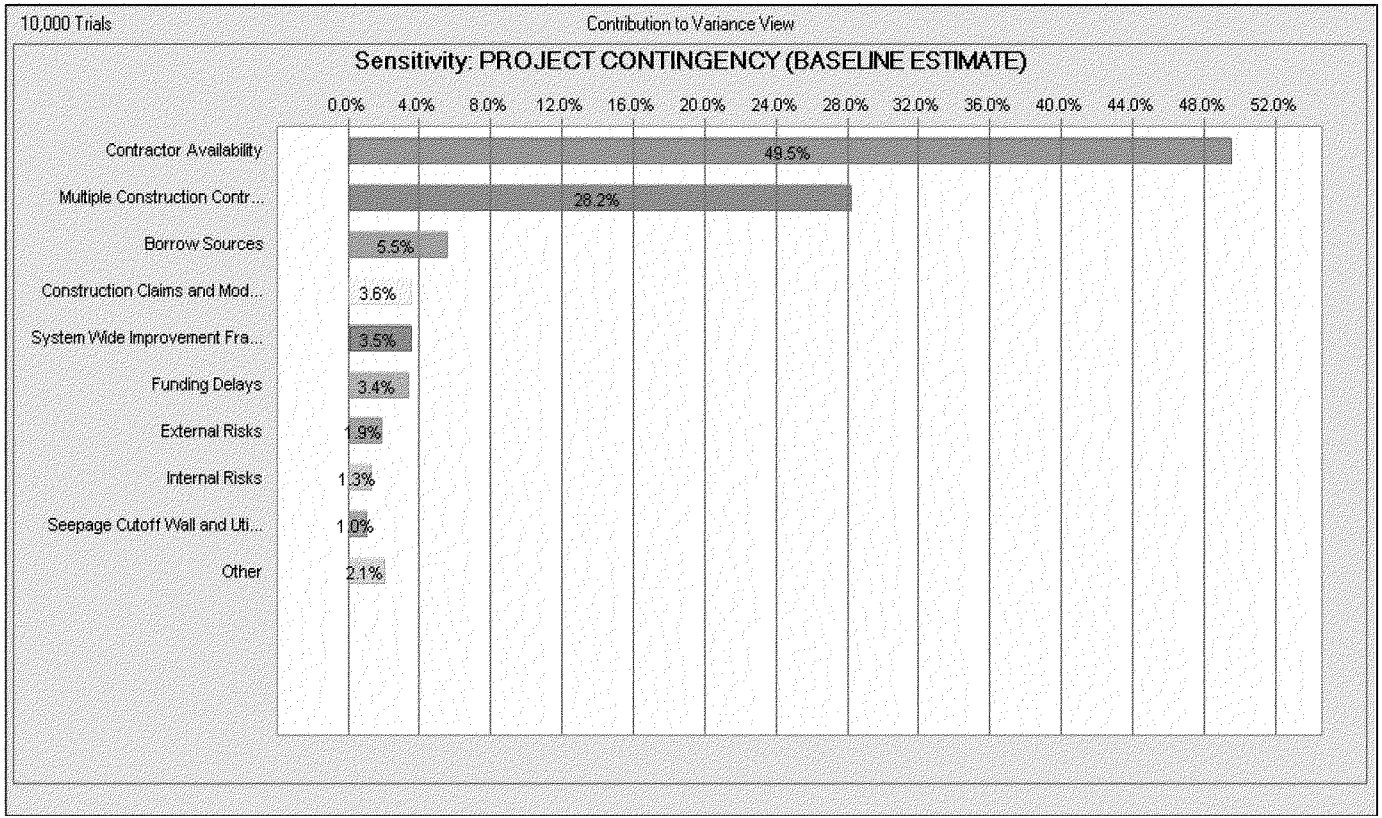


Figure 1B. Cost Sensitivity Analysis – SB8



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6.3 Schedule Contingency Risk Analysis

Table 2 provides the schedule duration contingencies calculated for the P80 confidence level. The schedule duration contingencies for the P50 and P95 confidence levels are also provided for illustrative purposes.

Schedule duration contingency was quantified as 37 months for SB7 and 41 months for SB8 based on the P80 level of confidence. These contingencies were used to calculate the projected residual fixed cost impact of project delays that are included in the Table 1 presentation of total cost contingency. The schedule contingencies were calculated by applying the high level schedule risks identified in the risk register for each option to the durations of critical path and near critical path tasks.

The schedule was not resource loaded and contained open-ended tasks and non-zero lags (gaps in the logic between tasks) that limit the overall utility of the schedule risk analysis. These issues should be considered as limitations in the utility of the schedule contingency data presented. Schedule contingency impacts presented in this analysis are based solely on projected residual fixed costs.

Table 2A. Schedule Duration Contingency Summary – SB7

Risk Analysis Forecast	Baseline Schedule Duration (months)	Contingency[1] (months)
50% Confidence Level		
Project Duration	60	28
80% Confidence Level		
Project Duration	60	37
95% Confidence Level		
Project Duration	60	45

Notes:
1) The schedule was not resource loaded and contained open-ended tasks and non-zero lags (gaps in the logic between tasks) that limit the overall utility of the schedule risk analysis. These issues should be considered as limitations in the utility of the schedule contingency data presented in Table 2.

Table 2A. Schedule Duration Contingency Summary – SB8

Risk Analysis Forecast	Baseline Schedule Duration (months)	Contingency[1] (months)
50% Confidence Level		
Project Duration	84	31
80% Confidence Level		
Project Duration	84	41
95% Confidence Level		
Project Duration	84	50

Notes:
1) The schedule was not resource loaded and contained open-ended tasks and non-zero lags (gaps in the logic between tasks) that limit the overall utility of the schedule risk analysis. These issues should be considered as limitations in the utility of the schedule contingency data presented in Table 2.

Figure 2A. Schedule Sensitivity Analysis – SB7

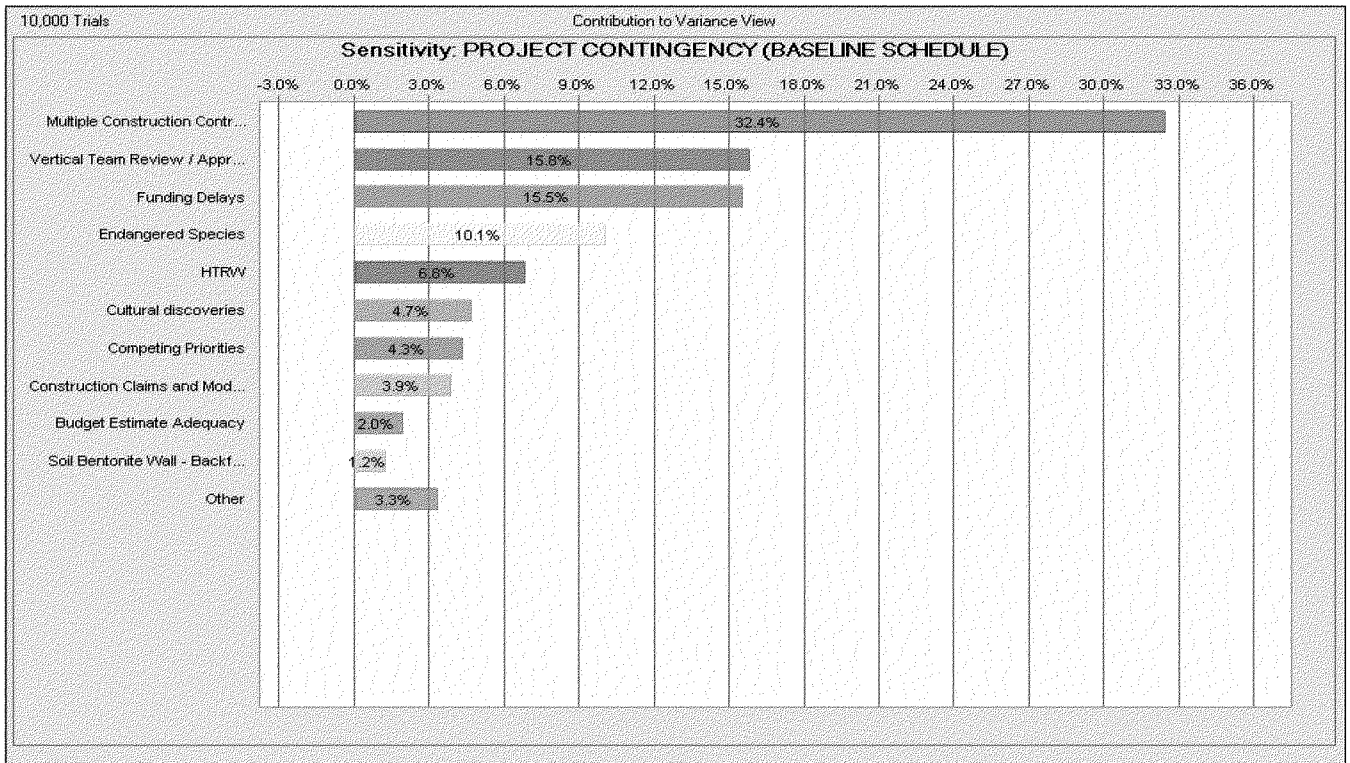

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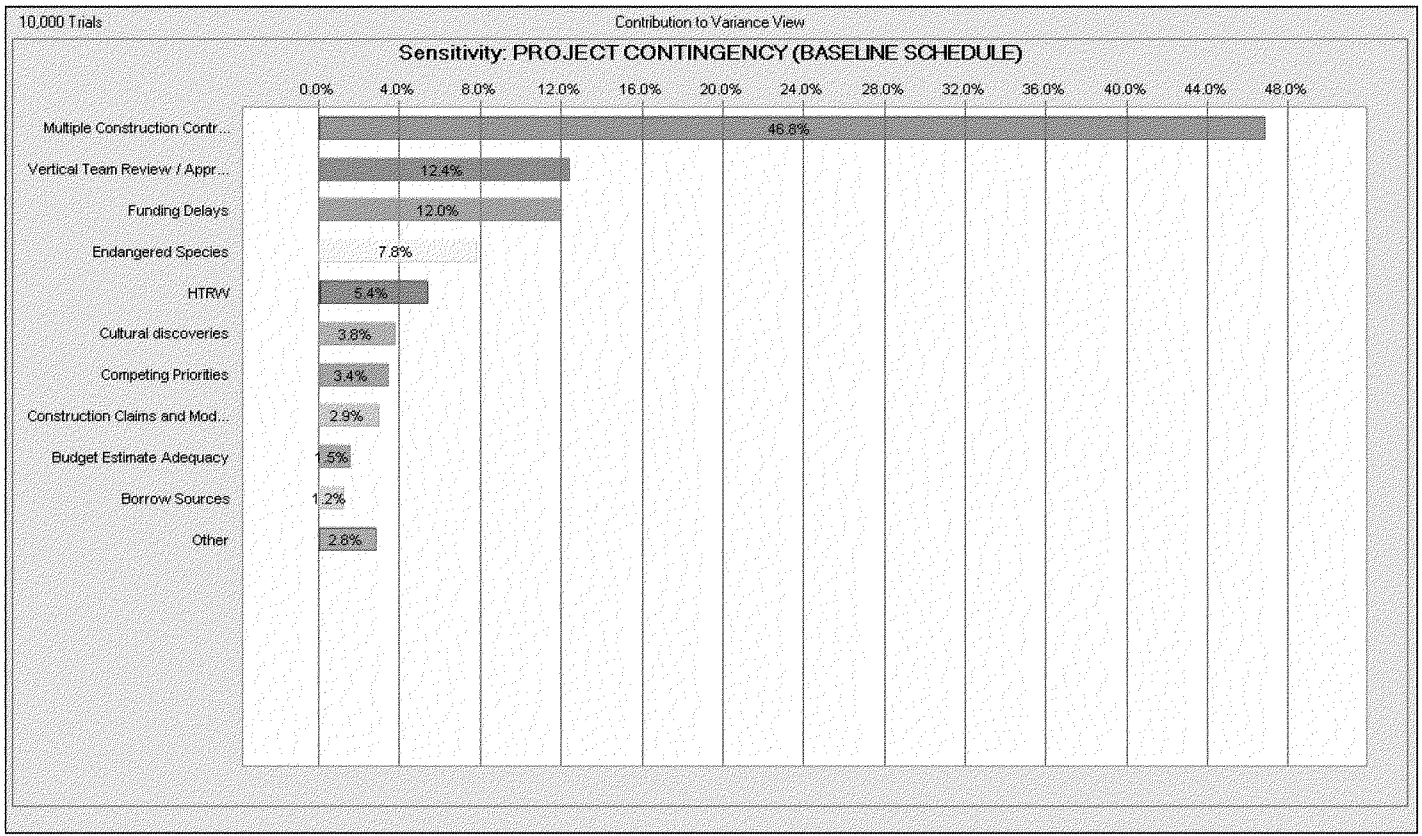
Figure 2B. Schedule Sensitivity Analysis – SB8



7.0 MAJOR FINDINGS/OBSERVATIONS/RECOMMENDATIONS

This section provides a summary of significant risk analysis results that are identified in the preceding sections of the report. Risk analysis results are intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes, as well as to provide tools to support decision making and risk management as projects progress through planning and implementation. Because of the potential for use of risk analysis results for such diverse purposes, this section also reiterates and highlights important steps, logic, key assumptions, limitations, and decisions to help ensure that the risk analysis results are appropriately interpreted.

7.1 Major Findings/Observations

Project cost comparison summaries are provided in Table 3 and Figure 3. Additional major findings and observations of the risk analysis are listed below.

1. The key cost risk drivers identified through sensitivity analysis for both Alternatives SB7 and SB8 are CA-3 (Availability of Qualified Contractors) and CA-1 (Multiple Construction Contracts), which together contribute 75 percent of the statistical cost variance.

2. The key schedule risk drivers identified through sensitivity analysis for both Alternatives SB7 and SB8 are CA-1 (Multiple Construction Contracts), PPM-2 (Vertical Team Review and Approval) and FL-1 (Funding Delays), which together contribute some 70 percent of the statistical schedule variance.

3. Operation and maintenance activities were not included in the cost estimate or schedules. Therefore, a full life cycle risk analysis could not be performed. Risk analysis results or conclusions could be significantly different if the necessary operation and maintenance activities were included.

Table 3A. SB7 - Construction Cost Comparison Summary (Uncertainty Analysis)

Confidence Level	Project Cost ($)	Contingency ($)	Contingency (%)
0%	$209,800,350	$15,752,350	8.12%
5%	$227,543,693	$33,495,693	17.26%
10%	$231,972,265	$37,924,265	19.54%
15%	$235,247,242	$41,199,242	21.23%
20%	$237,696,139	$43,648,139	22.49%
25%	$240,020,408	$45,972,408	23.69%
30%	$242,188,027	$48,140,027	24.81%
35%	$244,349,283	$50,301,283	25.92%
40%	$246,369,322	$52,321,322	26.96%
45%	$248,421,570	$54,373,570	28.02%
50%	$250,411,817	$56,363,817	29.05%
55%	$252,541,259	$58,493,259	30.14%
60%	$254,643,854	$60,595,854	31.23%
65%	$256,823,021	$62,775,021	32.35%
70%	$259,168,844	$65,120,844	33.56%
75%	$261,716,448	$67,668,448	34.87%
80%	$264,581,025	$70,533,025	36.35%
85%	$267,992,159	$73,944,159	38.11%
90%	$271,948,428	$77,900,428	40.14%
95%	$277,706,086	$83,658,086	43.11%
100%	$307,215,136	$113,167,136	58.32%

Table 3B. SB8 - Construction Cost Comparison Summary (Uncertainty Analysis)

Confidence Level	Project Cost ($)	Contingency ($)	Contingency (%)
0%	$391,772,116	$28,134,116	7.74%
5%	$422,824,930	$59,186,930	16.28%
10%	$431,001,798	$67,363,798	18.52%
15%	$436,624,564	$72,986,564	20.07%
20%	$441,020,979	$77,382,979	21.28%
25%	$445,349,931	$81,711,931	22.47%
30%	$449,430,772	$85,792,772	23.59%
35%	$453,213,236	$89,575,236	24.63%
40%	$456,886,402	$93,248,402	25.64%
45%	$460,663,258	$97,025,258	26.68%
50%	$464,623,958	$100,985,958	27.77%
55%	$468,139,081	$104,501,081	28.74%
60%	$472,170,410	$108,532,410	29.85%
65%	$475,882,381	$112,244,381	30.87%
70%	$480,241,481	$116,603,481	32.07%
75%	$484,956,781	$121,318,781	33.36%
80%	$490,028,500	$126,390,500	34.76%
85%	$496,174,529	$132,536,529	36.45%
90%	$503,436,210	$139,798,210	38.44%
95%	$513,495,593	$149,857,593	41.21%
100%	$565,245,374	$201,607,374	55.44%

7.2 Recommendations

Risk Management is an all-encompassing, iterative, and life-cycle process of project management. The Project Management Institute's (PMI) *A Guide to the Project Management Body of Knowledge (PMBOK® Guide), 4th edition*, states that "project risk management includes the processes concerned with conducting risk management planning, identification, analysis, responses, and monitoring and control on a project." Risk identification and analysis are processes within the knowledge area of risk management. Its outputs pertinent to this effort include the risk register, risk quantification (risk analysis model), contingency report, and the sensitivity analysis.

The intended use of these outputs is implementation by the project leadership with respect to risk responses (such as mitigation) and risk monitoring and control. In short, the effectiveness of the project risk management effort requires that the proactive management of risks not conclude with the study completed in this report.

The Cost and Schedule Risk Analysis (CSRA) produced by the PDT identifies issues that require the development of subsequent risk response and mitigation plans. This section provides a list of recommendations for continued management of the risks identified and analyzed in this study. Note that this list is not all inclusive and should not substitute a formal risk management and response plan.

1. Key Cost Risk Drivers: The key cost risk drivers identified through sensitivity analysis for both Alternatives SB7 and SB8 are CA-3 (Availability of Qualified Contractors) and CA-1 (Multiple Construction Contracts), which together contribute some 75 percent of the statistical cost variance.

a) Availability of Qualified Contractors: There is inherent risk that the ultimate bidding climate at the time of award of future contracts will be unfavorable to the price, as compared to the current working estimates of contract price. The PDT should continue to perform market research and analysis of trends within the construction industry. Ultimately, this uncertainty cannot be mitigated until more information is available. This should be communicated to management, and an adequate amount of contingency should be reserved to capture this risk.

b) Multiple Construction Contracts (Funding Constraints): Project leadership should take proactive measures to obtain decisions regarding funding and acquisition strategy, as well as communication to management regarding the impact of those decisions on cost performance.

2. Key Schedule Risk Drivers: The he key schedule risk drivers identified through sensitivity analysis for both Alternatives SB7 and SB8 are CA-1 (Multiple Construction Contracts), PPM-2 (Vertical Team Review and Approval) and FL-1 (Funding Delays), which together contribute some 70 percent of the statistical schedule variance.

a) Multiple Construction Contracts (Funding): Project leadership should take proactive measures to obtain decisions regarding funding and acquisition strategy, as well as communication to management regarding the impact of those decisions on schedule performance.

b) Vertical Team Review and Approval: Project leadership should proactively coordinate and communicate with Management (both at the District, Division and Headquarters). Ultimately, an amount and duration for this issue should be included and protected within the contingency and/or management reserve.

c) Funding Delays: Project leadership should proactively coordinate and communicate with Management (both at the District, Division and Headquarters) keeping all parties aware of probable funding and any subsequent impacts.

3. Risk Management: Project leadership should use of the outputs created during the risk analysis effort as tools in future risk management processes. The risk register should be updated at each major project milestone. The results of the sensitivity analysis may also be used for response planning strategy and development. These tools should be used in conjunction with regular risk review meetings.

4. Risk Analysis Updates: Project leadership should review risk items identified in the original risk register and add others, as required, throughout the project life-cycle. Risks should be reviewed for status and reevaluation (using qualitative measure, at a minimum) and placed on risk management watch lists if any risk's likelihood or impact significantly increases. Project leadership should also be mindful of the potential for secondary (new risks created specifically by the response to an original risk) and residual risks (risks that remain and have unintended impact following response).

APPENDIX A

Sutter Basin - SB7

Risk No.	Risk/Opportunity Event	Concerns	PDT Discussions & Conclusions	Project Cost			Project Schedule		
				Likelihood*	Impact*	Risk Level*	Likelihood*	Impact*	Risk Level*
	Contract Risks (Internal Risk Items are those that are generated, caused, or controlled within the PDT's sphere of influence.)								
	PROJECT & PROGRAM MGMT								
PPM-1	Project competing with other priorities	PDT Design Resources. District has assigned key personnel to various projects. Sutter Pilot study is one of two pilot studies in the nation, so has become a higher priority project. Project Feasibility Study is only funded through FY 13. The schedule currently reflects a Sept 30 Chiefs Report.	With time "priority" status has diminished. Competition for resources will remain an issue through completion of feasibility study. At this point, September 30 competition is likely but review process and unforeseen issues remain possible. A delay into next FY could significantly impact schedule due to unknown availability of future feasibility study funding after September 30.	Very Unlikely	Negligible	LOW	Unlikely	Critical	MODERATE
PPM-2	Vertical Team Review / Approval Process	Vertical Team review and approval (outside of District control) is required to meet critical milestones.	High demands on vertical teams have created a backlog of projects and pilot projects have lost much of their "priority" status.	Very Unlikely	Negligible	LOW	Likely	Critical	HIGH
PPM-3	PED Phase Staffing / Funding	Majority of design is being performed as in-kind work by the sponsor. Non-Federal Sponsor funding is in place and has not been an issue; minimal risks design will be delayed for funding or staffing issues.	Because the sponsor is funding much of the design as in-kind work, funding delays are not a concern.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW
PPM-4	Scope Changes	Given the inherient nature of Feasibility Studies, changes in the project scope can be anticipated.	The local sponsor's A/E is actively developing designs and is currently approaching the 90% level. The PDT has used the A/E's 65% plans in development of the NED and LPP plans and feels they are much better prepared than typical feasibility level designs.	Very Unlikely	Marginal	LOW	Very Unlikely	Marginal	LOW
	CONTRACT ACQUISITION RISKS								
CA-1	Multiple Construction Contracts	SB-8 Construction Contracts currently divided into 5 contracts with most ~$50-$60 Million. Contracts may need to be divided into smaller increments resulting in increased construction costs, government oversight and construction schedules.	Sponsor will proceed ahead with 221 Crediting agreement, working ahead of Federal Funding.	Likely	Significant	HIGH	Likely	Significant	HIGH
CA-2	Incremental Construction Schedule	Fixing the highest risk areas with long delays between projects (5 years or more) could result in last contracts not being completed due to B/C ratios no longer being beneficial.	Projects going beyond 5 years and subject to economic re-evaluation can become problematic.	Very Unlikely	Significant	LOW	Very Unlikely	Negligible	LOW
CA-3	Availability of qualified contractors.	Number of seepage cutoff wall contractors could be limited slowing either schedule (insufficient equipment) or increasing cost (limited competition).	It is the opinion of the PDT that equipment will be available, but limited qualified contractors could lead to moderately higher costs.	Likely	Marginal	MODERATE	Very Unlikely	Negligible	LOW

Risk No.	Risk/Opportunity Event	Concerns	PDT Discussions & Conclusions	Project Cost			Project Schedule		
				Likelihood*	Impact*	Risk Level*	Likelihood*	Impact*	Risk Level*
	TECHNICAL RISKS								
TL-1	Borrow Sources	It has been difficult to find willing landowners to acquire impermeable (clay) borrow material. Cost estimate assumes borrow sources are available and within 25-50miles round trip. Haul could be as much as 100 miles round trip or more. Sponsor may also require additional lengths of time finding "willing" borrow sites.	Real Estate estimate has included a relatively high contingency for procurement of borrow sites.	Likely	Significant	HIGH	Likely	Marginal	MODERATE
TL-2	Changes in Geomorphology	Riprap protection for scour issues has not been included in the current design.	It is assumed that any future scour issues, when they occur, will be covered with O&M funding and outside the scope of this project.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW
TL-3	Utility Crossings	Pipe penetrations will be removed and replaced but not necessarily to USACE current design guidance. For example, some large pump stations will not be remodeled to up-and-over type pipe penetrations.	Current project design is sufficient. Given the impracticality of meeting all criteria, design waivers will be acquired and USACE criteria will not dictate future design modifications.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW
TL-4	Utility Relocations	Time requirement for coordination of relocation of utility poles could be extensive.	Sponsor is confident relocations will not impact construction award schedules.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW
TL-5	O&M Access Road	Current design assumes a 10ft to 20ft land acquisition along the entire length of the toe of the levee for an O&M access road and vegetation free zone.	Real Estate estimate assumes a worst case cost (max land acquisition) but enough uncertainties remain that no potential cost savings will be included.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW
TL-6	Utility Corridor	Several areas will require relocation of existing utilities outside the flood critical areas.	Real Estate contingency accounts for additional reaches requiring utility corridor easements.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW
TL-7	Soil Bentonite Seepage Cutoff Wall	Design assumes Soil Bentonite Cutoff wall with jet grouting at bridge and railroad crossings. This design is robust enough that any changes in design methodology will not result in cost or schedule increases.	Cost estimate assumes long stick excavation for depths up to 75' design depth and Deep Soil mixing for deeper cutoff walls.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW

Risk No.	Risk/Opportunity Event	Concerns	PDT Discussions & Conclusions	Project Cost			Project Schedule		
				Likelihood*	Impact*	Risk Level*	Likelihood*	Impact*	Risk Level*
	LANDS AND DAMAGES RISKS								
LD-1	Real Estate - Utility Corridors	Majority of work is on existing levee already owned by the sponsor. Real Estate has assumed 10 ft to 20 ft permanent real estate acquisition (riverside and landside) for O&M access road and vegetation free zone. Real Estate estimate does not include baseline costs for utility relocation corridors.	Real Estate contingency accounts for additional reaches requiring utility corridor easements. REAL ESTATE CONTINGENCY HAS BEEN DEVELOPED INDEPENDENTLY AND WILL NOT BE INCLUDED IN THIS EVALUATION.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW
LD-2	Real Estate - Irrigation Canal and Levee Relocations	Real Estate estimate does not include baseline costs for irrigation canal relocation corridors.	Real Estate contingency accounts for additional relocations. REAL ESTATE CONTINGENCY HAS BEEN DEVELOPED INDEPENDENTLY AND WILL NOT BE INCLUDED IN THIS EVALUATION.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW
LD-3	Real Estate - Structural Relocations	Real Estate estimate does not include demolition costs for potential structural relocations.	There is a placeholder cost of $1,920,460 in the appraisal. When buildings are impacted it is not unusual for agencies to acquire the entire property (land/building) and make necessary changes---altering or raising the buildings and than resale the remainder. This helps to alleviate the time and cost associated with litigation or working with property owners. It is less costly to acquire the entire property when improvements will be impacted versus trying to modify the existing improvements and compensating property owners for damages. REAL ESTATE CONTINGENCY HAS BEEN DEVELOPED INDEPENDENTLY AND WILL NOT BE INCLUDED IN THIS EVALUATION.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW
LD-4	Real Estate - Temporary Construction Easements	Temporary construction easements have been assumed along the length of the levee construction.	Staging areas have been identified already in the project area. REAL ESTATE CONTINGENCY HAS BEEN DEVELOPED INDEPENDENTLY AND WILL NOT BE INCLUDED IN THIS EVALUATION.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW

No.			PDT Discussions & Conclusions	Likelihood*	Impact*	Risk Level*	Likelihood*	Impact*	Risk Level*
	REGULATORY AND ENVIRONMENTAL RISKS								
RE-1	Air quality	Contractor will require newer equipment to meet air quality requirement, but air quality credits aren't anticipated.	Anticipate qualified California contractor will have worked previous projects with appropriate equipment.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW
RE-2	Known cultural Sites	Estimate includes 1% for cultural impacts.	Historical structures downtown will require vibration monitoring.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW
RE-3	Cultural discoveries	Cost Estimate includes 1% for cultural investigations.	Majority of work will occur in existing levees, but it is still possible cultural discoveries could be made during construction. Cultural reconnaissance will occur prior to construction and limit possibility of discovery during construction. If cultural discoveries are made, construction must stop in that area. Cultural discovery must be resolved before construction can resume in that reach. IF discovery is made anticipate 3 to 6 month impact. Some 3 miles of Levee and Canal Realignment are required through new previously untouched regions; but greater cultural reconnaissance will be conducted in these areas minimizing potential schedule impacts.	Unlikely	Significant	MODERATE	Likely	Marginal	MODERATE
RE-4	Endangered Species	Construction windows are constrained by Federal and State endangered species windows. Work is currently scheduled outside most species windows but Swainson's Hawk will nest in early spring and fledge in early September.	There is the possibility work could be halted around any nesting areas. Bird surveys may be conducted the prior year to determine risk. (Construction schedule for Irrigation canal Jan-March and Levee April - October).	Very Unlikely	Negligible	LOW	Likely	Marginal	MODERATE
RE-5	Historic Structures	There are a number of historical structures that may or may not need to be relocated, specifically in Yuba City.	Cultural inventories will identify historic structures and assess possible adverse effects. If a historic structure is identified for relocation mitigation for that resources would be governed by a Memorandum of Agreement coordinated with SHPO.	Likely	Negligible	LOW	Very Unlikely	Negligible	LOW
RE-6	HTRW	There may be HTRW sites that are unknown	It is unlikely that HTRW waste be encounter. If HTRW waste is encountered in would not affect cost but the schedule may be affected.	Unlikely	Marginal	LOW	Unlikely	Significant	MODERATE

Risk No.	Risk/Opportunity Event	Concerns	PDT Discussions & Conclusions	Project Cost			Project Schedule		
				Likelihood*	Impact*	Risk Level*	Likelihood*	Impact*	Risk Level*
	CONSTRUCTION RISKS								
CON-1	Seepage Cutoff Wall and Utility Penetrations	Replacement construction of Utility Penetration can't begin until after seepage cutoff wall construction has been completed possibly resulting in long periods of temporary service. Costs have been included for temporary up-and-over services for a limited number of sites (4months each site) .	SB7 Levee has fewer gravity flow utilities (more up-and-over type levee crossings) so likely a marginal cost impact.	Likely	Marginal	MODERATE	Likely	Marginal	MODERATE
CON-2	Availability of Bentonite	There is risk of escalation on bentonite, pea gravel and course sand. There may be come shortages that could impact the costs and schedule.	In the past, contractor for Mayhew Levee raise encountered difficulties procuring sufficient supplies of bentonite. Bentonite has many applications, including in oil drilling. If multiple other projects also requiring bentonite are under construction concurrently, this could be an issue. Pea gravel and course sand have also presented acquisition issue in the past as well.	Likely	Marginal	MODERATE	Very Unlikely	Negligible	LOW
CON-3	Cobbles	Cobbles in the area can slow or even prevent the construction of seepage cutoff walls.	Seepage berms have been included in the design and cost estimate to account for these problematic areas but could anticipate greater numbers required with only a minimal cost/schedule impacts.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW
CON-4	Slurry Blowout During Construction	In the event of slurry blowout, would require greater levee degradation, suspension of work during cleanup and additional backfill required.	Worst case assume one blowout every 5 miles at a cost of $500,000 per blowout. The levee is far enough from the river that seepage into the river and potential environmental impacts is not anticipated.	Likely	Significant	HIGH	Very Unlikely	Negligible	LOW
CON-5	Vagrancy and Loitering Issues	There is the issue of vandalism and damage to the contractor, and there may be some risk transference to the contractor.	The likelihood of claims initiated by the contractor is negligible.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW
CON-6	Soil Bentonite Wall - Backfill Material	Consistence of backfill material gradations, specification are reasonable per the drill logs and existing conditions at each site	Historically these types of SB wall contracts include a provision that the KTR use on-site material with a mix of import to meet the backfill requirements. This mixing and subsequent testing of the mix are performed on-site with laboratory results to follow in 3 days. By the time laboratory results are provided backfill has been placed and it becomes a battle on if we remove and replace or give the KTR consideration.	Very Likely	Significant	HIGH	Likely	Marginal	MODERATE
CON-MOD	Modifications and Claims	There is inherent risk of construction modifications and claims that arise after contract award due to issues such as weather, schedules dictated by O&M cycles, differing site conditions, user directed changes or omissions, inaccurate surveys, and variations in estimated quantities (minor).	Post-award construction contract modifications and claims could impact the ultimate contract costs and delay the overall schedule.	Likely	Significant	HIGH	Likely	Significant	HIGH

Risk No.	Risk/Opportunity Event	Concerns	PDT Discussions & Conclusions	Project Cost			Project Schedule		
				Likelihood*	Impact*	Risk Level*	Likelihood*	Impact*	Risk Level*
	ESTIMATE AND SCHEDULE RISKS								
EST-1	Railroad Crossing	Railroad crossing is currently below crest of levee.	Estimate includes cost of stop log closure structure. May not include costs for establishing temporary railroad services or outages.	Likely	Marginal	MODERATE	Very Unlikely	Negligible	LOW
EST-2	Budget Estimate Adequacy	All feature codes are currently captured in the estimate. However, there may be some uncertainty in the disposition of some feature codes.	Crews, assemblies, productivities, and methodologies in the current PCE may not adequately capture ultimate actual contractor technique and costs.	Likely	Marginal	MODERATE	Likely	Marginal	MODERATE
	ECONOMICS RISKS								
FL-1	Funding Delays	With extended funding lags could be multiple years before funding arrives. Protracted construction places the project at greater risks related to more stringent environmental restrictions, scope changes, political changes, escalation exceeding OMB projections, greater potential for extreme commodity availability	Much of this issue exists outside of the scope of the PDT's control, but it is anticipated there will likely be schedule delays and cost increases due to funding lags.	Likely	Marginal	MODERATE	Likely	Marginal	MODERATE
INT-1	Internal Risk	There is inherent risk in all projects that could contribute to cost and schedule variance due to unknowns.	This could impact cost and schedule.	Likely	Marginal	MODERATE	Likely	Marginal	MODERATE
	Programmatic Risks	(External Risk Items are those that are generated, caused, or controlled exclusively outside the PDT's sphere of influence.)							
PR-1	System Wide Improvement Framework (SWIF)	Agreement on ETL vegetation requirements will require negotiation and agreement between three parties (USACE, State of California, and Levee Sponsor) in addition to third party entities.	Cost estimate does not include cost for additional vegetation removal. It may be possible it will be decided this removal will be a project cost (as opposed to O&M).	Likely	Critical	HIGH	Very Unlikely	Negligible	LOW
PR-2	Central Valley Flood Protection Plan	A statewide systemwide program that includes the Sacramento Flood Control Project (study project levees).	Affects all Central Valley studies. Future efforts or alternatives of current studies coordinated as "no regrets actions."	Unlikely	Negligible	LOW	Unlikely	Negligible	LOW
EXT-1	External Risk	There is inherent risk in all projects that could contribute to cost and schedule variance due to unknowns.	This could impact cost and schedule.	Likely	Marginal	MODERATE	Likely	Marginal	MODERATE

Sutter Basin - SB8

Risk No.	Risk/Opportunity Event	Concerns	PDT Discussions & Conclusions	Project Cost			Project Schedule		
				Likelihood*	Impact*	Risk Level*	Likelihood*	Impact*	Risk Level*
	Contract Risks (Internal Risk Items are those that are generated, caused, or controlled within the PDT's sphere of influence.)								
	PROJECT & PROGRAM MGMT								
PPM-1	Project competing with other priorities	PDT Design Resources. District has assigned key personnel to various projects. Sutter Pilot study is one of two pilot studies in the nation, so has become a higher priority project. Project Feasibility Study is only funded through FY 13. The schedule currently reflects a Sept 30 Chiefs Report.	With time "priority" status has diminished. Competition for resources will remain an issue through completion of feasibility study. At this point, September 30 competition is likely but review process and unforeseen issues remain possible. A delay into next FY could significantly impact schedule due to unknown availability of future feasibility study funding after September 30.	Very Unlikely	Negligible	LOW	Unlikely	Critical	MODERATE
PPM-2	Vertical Team Review / Approval Process	Vertical Team review and approval (outside of District control) is required to meet critical milestones.	High demands on vertical teams have created a backlog of projects and pilot projects have lost much of their "priority" status.	Very Unlikely	Negligible	LOW	Likely	Critical	HIGH
PPM-3	PED Phase Staffing / Funding	Majority of design is being performed as in-kind work by the sponsor. Non-Federal Sponsor funding is in place and has not been an issue; minimal risks design will be delayed for funding or staffing issues.	Because the sponsor is funding much of the design as in-kind work, funding delays are not a concern.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW
PPM-4	Scope Changes	Given the inherient nature of Feasibility Studies, changes in the project scope can be anticipated.	The local sponsor's A/E is actively developing designs and is currently approaching the 90% level. The PDT has used the A/E's 65% plans in development of the NED and LPP plans and feels they are much better prepared than typical feasibility level designs.	Very Unlikely	Marginal	LOW	Very Unlikely	Marginal	LOW
	CONTRACT ACQUISITION RISKS								
CA-1	Multiple Construction Contracts	SB-8 Construction Contracts currently divided into 7 contracts with most ~$50-$60 Million. Contracts may need to be divided into smaller increments resulting in increased construction costs, government oversight and construction schedules.	Sponsor will proceed ahead with 221 Crediting agreement, working ahead of Federal Funding.	Likely	Significant	HIGH	Likely	Significant	HIGH
CA-2	Incremental Construction Schedule	Fixing the highest risk areas with long delays between projects (5 years or more) could result in last contracts not being completed due to B/C ratios no longer being beneficial.	Projects going beyond 5 years and subject to economic re-evaluation can become problematic.	Very Unlikely	Significant	LOW	Very Unlikely	Negligible	LOW
CA-3	Availability of qualified contractors.	Number of seepage cutoff wall contractors could be limited slowing either schedule (insufficient equipment) or increasing cost (limited competition).	It is the opinion of the PDT that equipment will be available, but limited qualified contractors could lead to moderately higher costs.	Likely	Marginal	MODERATE	Very Unlikely	Negligible	LOW

Risk No.	Risk/Opportunity Event	Concerns	PDT Discussions & Conclusions	Project Cost			Project Schedule		
				Likelihood*	Impact*	Risk Level*	Likelihood*	Impact*	Risk Level*
	TECHNICAL RISKS								
TL-1	Borrow Sources	It has been difficult to find willing landowners to acquire impermeable (clay) borrow material. Cost estimate assumes borrow sources are available and within 25-50miles round trip. Haul could be as much as 100 miles round trip or more. Sponsor may also require additional lengths of time finding "willing" borrow sites.	Real Estate estimate has included a relatively high contingency for procurement of borrow sites.	Likely	Significant	HIGH	Likely	Marginal	MODERATE
TL-2	Changes in Geomorphology	Riprap protection for scour issues has not been included in the current design.	It is assumed that any future scour issues, when they occur, will be covered with O&M funding and outside the scope of this project.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW
TL-3	Utility Crossings	Pipe penetrations will be removed and replaced but not necessarily to USACE current design guidance. For example, some large pump stations will not be remodeled to up-and-over type pipe penetrations.	Current project design is sufficient. Given the impracticality of meeting all criteria, design waivers will be acquired and USACE criteria will not dictate future design modifications.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW
TL-4	Utility Relocations	Time requirement for coordination of relocation of utility poles could be extensive.	Sponsor is confident relocations will not impact construction award schedules.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW
TL-5	O&M Access Road	Current design assumes a 10ft to 20ft land acquisition along the entire length of the toe of the levee for an O&M access road and vegetation free zone.	Real Estate estimate assumes a worst case cost (max land acquisition) but enough uncertainties remain that no potential cost savings will be included.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW
TL-6	Utility Corridor	Several areas will require relocation of existing utilities outside the flood critical areas.	Real Estate contingency accounts for additional reaches requiring utility corridor easements.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW
TL-7	Soil Bentonite Seepage Cutoff Wall	Design assumes Soil Bentonite Cutoff wall with jet grouting at bridge and railroad crossings. This design is robust enough that any changes in design methodology will not result in cost or schedule increases.	Cost estimate assumes long stick excavation for depths up to 75' design depth and Deep Soil mixing for deeper cutoff walls.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW
TL-8	Abandoned Drainage penetrations	Cost included for removal of abandoned penetrations. Additional engineering effort will be required to justify no internal drainage issues will be caused.	Additional effort will have minimal impacts to design cost and schedule.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW

Risk No.	Risk/Opportunity Event	Concerns	PDT Discussions & Conclusions	Project Cost			Project Schedule		
				Likelihood*	Impact*	Risk Level*	Likelihood*	Impact*	Risk Level*
	LANDS AND DAMAGES RISKS								
LD-1	Real Estate - Utility Corridors	Majority of work is on existing levee already owned by the sponsor. Real Estate has assumed 10 ft to 20 ft permanent real estate acquisition (riverside and landside) for O&M access road and vegetation free zone. Real Estate estimate does not include baseline costs for utility relocation corridors.	Real Estate contingency accounts for additional reaches requiring utility corridor easements. REAL ESTATE CONTINGENCY HAS BEEN DEVELOPED INDEPENDENTLY AND WILL NOT BE INCLUDED IN THIS EVALUATION.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW
LD-2	Real Estate - Irrigation Canal and Levee Relocations	Real Estate estimate does not include baseline costs for irrigation canal relocation corridors.	Real Estate contingency accounts for additional relocations. REAL ESTATE CONTINGENCY HAS BEEN DEVELOPED INDEPENDENTLY AND WILL NOT BE INCLUDED IN THIS EVALUATION.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW
LD-3	Real Estate - Structural Relocations	Real Estate estimate does not include demolition costs for potential structural relocations.	There is a placeholder cost of $1,920,460 in the appraisal. When buildings are impacted it is not unusual for agencies to acquire the entire property (land/building) and make necessary changes--- altering or raising the buildings and than resale the remainder. This helps to alleviate the time and cost associated with litigation or working with property owners. It is less costly to acquire the entire property when improvements will be impacted versus trying to modify the existing improvements and compensating property owners for damages. REAL ESTATE CONTINGENCY HAS BEEN DEVELOPED INDEPENDENTLY AND WILL NOT BE INCLUDED IN THIS EVALUATION.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW
LD-4	Real Estate - Temporary Construction Easements	Temporary construction easements have been assumed along the length of the levee construction.	Staging areas have been identified already in the project area. REAL ESTATE CONTINGENCY HAS BEEN DEVELOPED INDEPENDENTLY AND WILL NOT BE INCLUDED IN THIS EVALUATION.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW

Risk No.	Risk/Opportunity Event	Concerns	PDT Discussions & Conclusions	Project Cost			Project Schedule		
				Likelihood*	Impact*	Risk Level*	Likelihood*	Impact*	Risk Level*
	REGULATORY AND ENVIRONMENTAL RISKS								
RE-1	Air quality	Contractor will require newer equipment to meet air quality requirement, but air quality credits aren't anticipated.	Anticipate qualified California contractor will have worked previous projects with appropriate equipment.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW
RE-2	Known cultural Sites	Estimate includes 1% for cultural impacts.	Historical structures downtown will require vibration monitoring.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW
RE-3	Cultural discoveries	Cost Estimate includes 1% for cultural investigations.	Majority of work will occur in existing levees, but it is still possible cultural discoveries could be made during construction. Cultural reconnaissance will occur prior to construction and limit possibility of discovery during construction. If cultural discoveries are made, construction must stop in that area. Cultural discovery must be resolved before construction can resume in that reach. IF discovery is made anticipate 3 to 6 month impact. Some 3 miles of Levee and Canal Realignment are required through new previously untouched regions; but greater cultural reconnaissance will be conducted in these areas minimizing potential schedule impacts.	Unlikely	Significant	MODERATE	Likely	Marginal	MODERATE
RE-4	Endangered Species	Construction windows are constrained by Federal and State endangered species windows. Work is currently scheduled outside most species windows but Swainson's Hawk will nest in early spring and fledge in early September.	There is the possibility work could be halted around any nesting areas. Bird surveys may be conducted the prior year to determine risk. (Construction schedule for Irrigation canal Jan-March and Levee April - October).	Very Unlikely	Negligible	LOW	Likely	Marginal	MODERATE
RE-5	Historic Structures	There are a number of historical structures that may or may not need to be relocated, specifically in Yuba City.	Cultural inventories will identify historic structures and assess possible adverse effects. If a historic structure is identified for relocation mitigation for that resources would be governed by a Memorandum of Agreement coordinated with SHPO.	Likely	Negligible	LOW	Very Unlikely	Negligible	LOW
RE-6	HTRW	There may be HTRW sites that are unknown	It is unlikely that HTRW waste be encounter. If HTRW waste is encountered in would not affect cost but the schedule may be affected.	Unlikely	Marginal	LOW	Unlikely	Significant	MODERATE

Risk No.	Risk/Opportunity Event	Concerns	PDT Discussions & Conclusions	Project Cost			Project Schedule		
				Likelihood*	Impact*	Risk Level*	Likelihood*	Impact*	Risk Level*
	CONSTRUCTION RISKS								
CON-1	Seepage Cutoff Wall and Utility Penetrations	Replacement construction of Utility Penetration can't begin until after seepage cutoff wall construction has been completed possibly resulting in long periods of temporary service. Costs have been included for temporary up-and-over services for a limited number of sites (4months each site).	SB8 Levee reach has multiple gravity flow lines that could be impacted.	Likely	Significant	HIGH	Likely	Marginal	MODERATE
CON-2	Availability of Bentonite	There is risk of escalation on bentonite, pea gravel and course sand. There may be come shortages that could impact the costs and schedule.	In the past, contractor for Mayhew Levee raise encountered difficulties procuring sufficient supplies of bentonite. Bentonite has many applications, including in oil drilling. If multiple other projects also requiring bentonite are under construction concurrently, this could be an issue. Pea gravel and course sand have also presented acquisition issue in the past as well.	Likely	Marginal	MODERATE	Very Unlikely	Negligible	LOW
CON-3	Cobbles	Cobbles in the area can slow or even prevent the construction of seepage cutoff walls. Seepage berms have been included in the design and cost estimate to account for these problematic areas but could anticipate greater numbers required.	Greater likelihood of encountering cobbles in SB8 regions, but larger numbers of seepage berms have also been included so assume minimal impacts.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW
CON-4	Slurry Blowout During Construction	In the event of slurry blowout, would require greater levee degradation, suspension of work during cleanup and additional backfill required.	Worst case assume one blowout every 5 miles at a cost of $500,000 per blowout. The levee is far enough from the river that seepage into the river and potential environmental impacts is not anticipated.	Likely	Significant	HIGH	Very Unlikely	Negligible	LOW
CON-5	Vagrancy and Loitering Issues	There is the issue of vandalism and damage to the contractor, and there may be some risk transference to the contractor.	The likelihood of claims initiated by the contractor is negligible.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW
CON-6	Soil Bentonite Wall - Backfill Material	Consistence of backfill material gradations, specification are reasonable per the drill logs and existing conditions at each site	Historically these types of SB wall contracts include a provision that the KTR use on-site material with a mix of import to meet the backfill requirements. This mixing and subsequent testing of the mix are performed on-site with laboratory results to follow in 3 days. By the time laboratory results are provided backfill has been placed and it becomes a battle on if we remove and replace or give the KTR consideration.	Very Likely	Significant	HIGH	Likely	Marginal	MODERATE
CON-MOD	Modifications and Claims	There is inherent risk of construction modifications and claims that arise after contract award due to issues such as weather, schedules dictated by O&M cycles, differing site conditions, user directed changes or omissions, inaccurate surveys, and variations in estimated quantities (minor).	Post-award construction contract modifications and claims could impact the ultimate contract costs and delay the overall schedule.	Likely	Significant	HIGH	Likely	Significant	HIGH

Risk No.	Risk/Opportunity Event	Concerns	PDT Discussions & Conclusions	Project Cost			Project Schedule		
				Likelihood*	Impact*	Risk Level*	Likelihood*	Impact*	Risk Level*
	ESTIMATE AND SCHEDULE RISKS								
EST-1	Railroad Crossing	Railroad crossing is currently below crest of levee.	Estimate includes cost of stop log closure structure. May not include costs for establishing temporary railroad services or outages.	Likely	Marginal	MODERATE	Very Unlikely	Negligible	LOW
EST-2	Budget Estimate Adequacy	All feature codes are currently captured in the estimate. However, there may be some uncertainty in the disposition of some feature codes.	Crews, assemblies, productivities, and methodologies in the current PCE may not adequately capture ultimate actual contractor technique and costs.	Likely	Marginal	MODERATE	Likely	Marginal	MODERATE
	ECONOMICS RISKS								
FL-1	Funding Delays	With extended funding lags could be multiple years before funding arrives. Protracted construction places the project at greater risks related to more stringent environmental restrictions, scope changes, political changes, escalation exceeding OMB projections, greater potential for extreme commodity availability.	Much of this issue exists outside of the scope of the PDT's control, but it is anticipated there will likely be schedule delays and cost increases due to funding lags.	Likely	Marginal	MODERATE	Likely	Marginal	MODERATE
INT-1	Internal Risk	There is inherent risk in all projects that could contribute to cost and schedule variance due to unknowns.	This could impact cost and schedule.	Likely	Marginal	MODERATE	Likely	Marginal	MODERATE
	Programmatic Risks	(External Risk items are those that are generated, caused, or controlled exclusively outside the PDT's sphere of influence.)							
PR-1	System Wide Improvement Framework (SWIF)	Agreement on ETL vegetation requirements will require negotiation and agreement between three parties (USACE, State of California, and Levee Sponsor) in addition to third party entities.	Cost estimate does not include cost for additional vegetation removal. It may be possible it will be decided this removal will be a project cost (as opposed to O&M).	Likely	Critical	HIGH	Very Unlikely	Negligible	LOW
PR-2	Central Valley Flood Protection Plan	A statewide systemwide program that includes the Sacramento Flood Control Project (study project levees).	Affects all Central Valley studies. Future efforts or alternatives of current studies coordinated as "no regrets actions."	Unlikely	Negligible	LOW	Unlikely	Negligible	LOW
EXT-1	External Risk	There is inherent risk in all projects that could contribute to cost and schedule variance due to unknowns.	This could impact cost and schedule.	Likely	Marginal	MODERATE	Likely	Marginal	MODERATE

WALLA WALLA COST ENGINEERING MANDATORY CENTER OF EXPERTISE

COST AGENCY TECHNICAL REVIEW

CERTIFICATION STATEMENT

Project No. 105638

SPK – Sutter Basin Project

Two Alternatives for the Sutter Basin Project, as presented by Sacramento District, have undergone a successful Cost Agency Technical Review (Cost ATR), performed by the Walla Walla District Cost Engineering Mandatory Center of Expertise (Cost MCX) team. The Cost ATR included study of the project scopes, report, cost estimates, schedules, escalation, and risk-based contingencies. This certification signifies the products meet the quality standards as prescribed in ER 1110-2-1150 Engineering and Design for Civil Works Projects and ER 1110-2-1302 Civil Works Cost Engineering.

As of October 10, 2013, the Cost MCX certifies the estimated total project cost of the two alternatives:

ALTERNATIVE SB-7
FY 2014 Price Level: $391,840,000
Fully Funded Amount: $440,530,000

ALTERNATIVE SB-8
FY 2014 Price Level: $688,930,000
Fully Funded Amount: $791,970,000

It remains the responsibility of the District to correctly reflect these cost values within the Final Report and to implement effective project management controls and implementation procedures including risk management throughout the life of the project.

CALLAN.KIM.C.1231558221

Digitally signed by CALLAN.KIM.C.1231558221
DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=USA, cn=CALLAN.KIM.C.1231558221
Date: 2013.10.11 07:30:26 -07'00'

Kim C. Callan, PE, CCE, PM1
Chief, Cost Engineering MCX
Walla Walla District

US Army Corps of Engineers®

****TOTAL PROJECT COST SUMMARY****

10/10/2013

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE DRAFT FEASIBILITY REPORT, ALT. SB-7
PROJECT: Sutter Basin TPCS
LOCATION: CALIFORNIA

U. S. ARMY CORPS OF ENGINEER, SACRAMENTO DISTRICT
P.O.C.: JEREMIAH A. FROST, CHIEF, COST ENGINEERING SECTION

Current MCACES Estimate Prepared: 25-Jul-2013
Effective Price Level (EPL): 1-Oct-2013

WB NO.	Civil Works FEATURE DESCRIPTION	ESTIMATED COST COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	PROGRAM YEAR(BUDGET EC) 2014 EFF. PRICE LEVEL DATE:1-Oct-2013 PROJECT FIRST COST ESC. (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	TOTAL PROJECT COST (FULLY FUNDED) SPENT THRU: 1-Oct-2013 COST ($K)	ESC. MIDPT(%)	COST ($K)	CNTG ($K)	FULLY FUNDED ($K)
Index Codes: 0 - no esc. applied; A - Administration; C - Combined Indexes; All other codes used coincides with the Code of Accounts.														
		Contingency Applied To Remaining Cost Only												
	FEDERAL COSTS													
6	FISH & WILDLIFE FACILITIES	5,032	1,006	20	6,038	0.00	5,032	1,006	6,038	0	12	5,611	1,122	6,733
11	LEVEES & FLOODWALLS	176,205	63,717	36	239,922	0.00	176,205	63,717	239,922	0	11	196,085	70,906	266,991
18	CULT. RESRC. PRESERV. (1	1,655	598		2,253		1,655	598	2,253	0		1,841	665	2,506
	Data Recovery	1,200	433		1,633	0.00	1,200	433	1,633	0		1,334	482	1,816
	Inventory/Evaluation/Mitigation Costs	455	165	36	620	0.00	455	165	620	0	11	507	183	690
	SUBTOTAL FEDERAL & NON-FEDERAL CONSTRUCTION COSTS	182,892	65,321		248,213		182,892	65,321	248,213	0		203,537	72,693	276,230
1	LANDS & DAMAGES, Admin (2	6,952	348	5	7,300	0.00	6,952	348	7,300	0	17	8,168	408	8,576
30	PLAN/ENGINEERING/DESIGN	32,622	11,797	36	44,419	0.00	32,622	11,797	44,419	0	18	38,534	13,934	52,468
31	CONSTRUCTION MANAGEMT	15,406	5,570	36	20,976	0.00	15,406	5,570	20,976	0	23	18,943	6,849	25,792
	SUBTOTAL FEDERAL & NON-FEDERAL CONTRIBUTION	237,872	83,036		320,908		237,872	83,036	320,908	0		269,182	93,884	363,066
	NON-FEDERAL CONTRIBUTION (-)	-48,533	-17,105		-65,638		-48,533	-17,105	-65,638	0		-56,289	-19,847	-76,136
	TOTAL FEDERAL COSTS	**$189,339**	**$65,931**		**$255,270**		**$189,339**	**$65,931**	**$255,270**	**$0**		**$212,893**	**$74,037**	**$286,930**
	NON-FEDERAL COSTS													
1	LANDS AND DAMAGES	31,811	10,579	33	42,390	0.00	31,811	10,579	42,390	0	8.5	34,523	11,481	46,004
2	RELOCATIONS	20,962	7,580		28,542		20,962	7,580	28,542	0		23,105	8,355	31,460
	Relocations Construction Cost	16,376	5,922	36	22,298	0.00	16,376	5,922	22,298	0	10	18,074	6,536	24,610
	Plan/Engineering/Design	2,948	1,066	36	4,014	0.00	2,948	1,066	4,014	0	8.8	3,209	1,160	4,369
	Construction Mangement	1,638	592	36	2,230	0.00	1,638	592	2,230	0	11	1,822	659	2,481
	SUBTOTAL NON-FEDERAL	52,773	18,159		70,932		52,773	18,159	70,932	0		57,628	19,836	77,464
	NON-FEDERAL CONTRIBUTION (+)	48,533	17,105		65,638		48,533	17,105	65,638	0		56,289	19,847	76,136
	TOTAL NON-FEDERAL COSTS	**$101,306**	**$35,264**		**$136,570**		**$101,306**	**$35,264**	**$136,570**	**$0**		**$113,917**	**$39,683**	**$153,600**
	TOTAL FEDERAL AND NON-FEDERAL COSTS	**$290,645**	**$101,195**		**$391,840**		**$290,645**	**$101,195**	**$391,840**	**$0**		**$326,810**	**$113,720**	**$440,530**

GENERAL NOTES

(1 Cultural Resources Preservation costs was provided by Cultural Resources Archaeologist.
(2 Federal administrative costs for non-Federal land acquisition.
(3 The Fully Funded cost estimate was prepared in compliance with Indexes used from CWCCIS reflecting OMB future rates Mar. 31, 2013
(4 01 Account for Land and Damages cost are from Real Estates.
(5 06 Account Fish and Wildlife Cost was provided by SPK Environmental Planning.
(6 30 Account Planning, Engineering and Design and 31 Account Construction Management cost was provided by its respective organizations.

CONTINGENCY RATIONALE

(A CONTINGENCIES USED WAS DERIVED BY THE COST RISK ANALYSIS PROCESS AND IS BASED ON A 80% CONFIDENCE LEVEL

_____ CHIEF, COST ENGINEERING

_____ PROJECT MANAGER

_____ CHIEF, REAL ESTATE

TOTAL FEDERAL COSTS	$286,930
TOTAL NON-FEDERAL COSTS	$153,600
THE MAXIMUM PROJECT COSTS	$440,530

******TOTAL PROJECT COST SUMMARY****** 10/10/2013

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE DRAFT FEASIBILITY REPORT, ALT. SB-8

PROJECT: Sutter Basin TPCS

LOCATION: CALIFORNIA

U. S. ARMY CORPS OF ENGINEER, SACRAMENTO DISTRICT

P.O.C.: JEREMIAH A. FROST, CHIEF, COST ENGINEERING SECTION

Current MCACES Estimate Prepared: 25-Jul-2013

Effective Price Level (EPL): 1-Oct-2013

PROGRAM YEAR(BUDGET EC) 2014

EFF. PRICE LEVEL DATE:1-Oct-2013

SPENT THRU: 1-Oct-2013

WB NO.	Civil Works FEATURE DESCRIPTION		ESTIMATED COST COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	PROJECT FIRST COST ESC. (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	TOTAL PROJECT COST (FULLY FUNDED) COST ($K)	ESC. MIDPT(%)		COST ($K)	CNTG ($K)	FULLY FUNDED ($K)
Index Codes: 0 - no esc. applied; A - Administration; C - Combined indexes; All other codes used coincides with the Code of Accounts.																
			Contingency Applied To Remaining Cost Only													
	FEDERAL COSTS															
6	FISH & WILDLIFE FACILITIES		6,330	1,265	20	7,595	0.00	6,330	1,265	7,595	0	14	7,226	1,445	8,671
11	LEVEES & FLOODWALLS		306,367	106,488	35	412,855	0.00	306,367	106,488	412,855	0	13	347,604	120,821	468,425
18	CULT. RESRC. PRESERV. (1		3,030	1,076		4,106		3,030	1,076	4,106			3,399	1,207	4,606
	Federal Obligations from NED Cost.		1,655	598		2,253		1,655	598	2,253			1,841	665	2,506
	Data Recovery		1,200	433		1,633		1,200	433	1,633	0		1,334	482	1,816
	Inventory/Evaluation/Mitigation Costs		455	165		620		455	165	620	0		507	183	690
	Cost Beyond NED Cost.		1,375	478		1,853		1,375	478	1,853	0		1,558	542	2,100
	Data Recovery	18	1,000	348	35	1,348	0.00	1,000	348	1,348	0	13	1,134	394	1,528
	Inventory/Evaluation/Mitigation Costs	18	375	130	35	505	0.00	375	130	505	0	13	424	148	572
	SUBTOTAL FEDERAL & NON-FEDERAL CONSTRUCTION COSTS		315,727	108,829		424,556		315,727	108,829	424,556	0		358,229	123,473	481,702
1	LANDS & DAMAGES, Admin (2		11,143	557	5	11,700	0.00	11,143	557	11,700	0	22	13,549	677	14,226
30	PLAN/ENGINEERING/DESIGN		56,285	19,565	35	75,850	0.00	56,285	19,565	75,850	0	22	68,804	23,916	92,720
31	CONSTRUCTION MANAGE'MT		26,580	9,239	35	35,819	0.00	26,580	9,239	35,819	0	27	33,791	11,746	45,537
	SUBTOTAL FEDERAL & NON-FEDERAL CONTRIBUTION		409,735	138,190		547,925		409,735	138,190	547,925	0		474,373	159,812	634,185
	NON-FEDERAL CONTRIBUTION(-)		-220,396	-72,259		-292,655		-220,396	-72,259	-292,655	0		-261,480	-85,775	-347,255
	TOTAL FEDERAL NED COSTS		**$189,339**	**$65,931**		**$255,270**		**$189,339**	**$65,931**	**$255,270**	**$0**		**$212,893**	**$74,037**	**$286,930**
	NON-FEDERAL COSTS															
1	LANDS AND DAMAGES		41,795	11,751	28	53,546	0.00	41,795	11,751	53,546	0	11	46,222	12,995	59,217
2	RELOCATIONS		64,900	22,559		87,459		64,900	22,559	87,459	0		73,143	25,425	98,568
	Relocations Construction Cost		50,703	17,624	35	68,327	0.00	50,703	17,624	68,327	0	13	57,271	19,907	77,178
	Plan/Engineering/Design		9,127	3,172	35	12,299	0.00	9,127	3,172	12,299	0	11	10,123	3,519	13,642
	Construction Management		5,070	1,763	35	6,833	0.00	5,070	1,763	6,833	0	13	5,749	1,999	7,748
	SUBTOTAL NON-FEDERAL		106,695	34,310		141,005		106,695	34,310	141,005	0		119,365	38,420	157,785
	NON-FEDERAL CONTRIBUTION (+)		220,396	72,259		292,655		220,396	72,259	292,655	0		261,480	85,775	347,255
	Non-Federal Contribution - NED		48,533	17,105		65,638		48,533	17,105	65,638	0		56,289	19,847	76,136
	Additional Cost Above NED		171,863	55,154		227,017		171,863	55,154	227,017	0		205,191	65,928	271,119
	TOTAL NON-FEDERAL COSTS		**$327,091**	**$106,569**		**$433,660**		**$327,091**	**$106,569**	**$433,660**	**$0**		**$380,845**	**$124,195**	**$505,040**
	TOTAL FEDERAL AND NON-FEDERAL COSTS		**$516,430**	**$172,500**		**$688,930**		**$516,430**	**$172,500**	**$688,930**	**$0**		**$593,738**	**$198,232**	**$791,970**

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(6 30 Account Planning, Engineering and Design and 31 Account Construction Management cost was provided by its respective organizations.

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	DOLLAR(K)
TOTAL FEDERAL COSTS	$286,930
TOTAL NON-FEDERAL COSTS	$505,040
THE MAXIMUM PROJECT COSTS	$791,970

_____ **CHIEF, COST ENGINEERING**

_____ **PROJECT MANAGER**

_____ **CHIEF, REAL ESTATE**

SUTTER & BUTTE COUNTIES, CA

SUTTER BASIN PILOT FEASIBILITY STUDY

DRAFT REPORT

ALTERNATIVE SB-7 STATION 180+00 TO STATION 1483+33
ALTERNATIVE SB-8 STATION 1483+83 TO STATION 2368+00

LOCATION MAP
NTS

NOT FOR CONSTRUCTION

US Army Corps of Engineers
Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
COVER SHEET

Sheet reference number:
G-1

1922

DWG NO.	SHT NO.	DESCRIPTION
		GENERAL
G-1	1	TITLE SHEET AND LOCATION MAP
G-2	2	SHEET INDEX
G-3	3	BASIN MAP
G-4	4	VICINITY MAP
G-5	5	PROJECT FEATURES, BORROW SITES AND HAUL ROUTES
G-6	6	GENERAL ABBREVIATIONS, LEGEND AND SYMBOLS
G-7	7	GENERAL NOTES
G-8	8	OVERALL SITE PLAN AND KEY MAP
		PLAN VIEW SHEETS
C-101	9	PLAN VIEW STA: 175+00 TO 225+00
C-102	10	PLAN VIEW STA: 225+00 TO 275+00
C-103	11	PLAN VIEW STA: 275+00 TO 325+00
C-104	12	PLAN VIEW STA: 325+00 TO 375+00
C-105	13	PLAN VIEW STA: 375+00 TO 425+00
C-106	14	PLAN VIEW STA: 425+00 TO 478+68
C-107	15	PLAN VIEW STA: 478+68 TO 512+00 (STAR BEND FIX IN PLACE)
C-108	16	PLAN VIEW STA: 512+00 TO 575+00
C-109	17	PLAN VIEW STA: 575+00 TO 625+00
C-110	18	PLAN VIEW STA: 625+00 TO 675+00
C-111	19	PLAN VIEW STA: 675+00 TO 725+00
C-112	20	PLAN VIEW STA: 725+00 TO 775+00
C-113	21	PLAN VIEW STA: 775+00 TO 825+00
C-114	22	PLAN VIEW STA: 825+00 TO 875+00
C-115	23	PLAN VIEW STA: 875+00 TO 925+00
C-116	24	PLAN VIEW STA: 925+00 TO 975+00
C-117	25	PLAN VIEW STA: 975+00 TO 1025+00
C-118	26	PLAN VIEW STA: 1025+00 TO 1075+00
C-119	27	PLAN VIEW STA: 1075+00 TO 1125+00
C-120	28	PLAN VIEW STA: 1125+00 TO 1175+00
C-121	29	PLAN VIEW STA: 1175+00 TO 1225+00
C-122	30	PLAN VIEW STA: 1225+00 TO 1275+00
C-123	31	PLAN VIEW STA: 1275+00 TO 1325+00
C-124	32	PLAN VIEW STA: 1325+00 TO 1375+00
C-125	33	PLAN VIEW STA: 1375+00 TO 1433+83
C-126	34	PLAN VIEW STA: 1433+83 TO 1475+00
C-127	35	PLAN VIEW STA: 1475+00 TO 1525+00
C-128	36	PLAN VIEW STA: 1525+00 TO 1575+00
C-129	37	PLAN VIEW STA: 1575+00 TO 1625+00
C-130	38	PLAN VIEW STA: 1625+00 TO 1675+00
C-131	39	PLAN VIEW STA: 1675+00 TO 1725+00
C-132	40	PLAN VIEW STA: 1725+00 TO 1775+00
C-133	41	PLAN VIEW STA: 1775+00 TO 1825+00
C-134	42	PLAN VIEW STA: 1825+00 TO 1875+00
C-135	43	PLAN VIEW STA: 1875+00 TO 1925+00
C-136	44	PLAN VIEW STA: 1925+00 TO 1975+00
C-137	45	PLAN VIEW STA: 1975+00 TO 2025+00
C-138	46	PLAN VIEW STA: 2025+00 TO 2075+00
C-139	47	PLAN VIEW STA: 2075+00 TO 2120+00
C-140	48	PLAN VIEW STA: 2125+00 TO 2175+00
C-141	49	PLAN VIEW STA: 2175+00 TO 2225+00
C-142	50	PLAN VIEW STA: 2225+00 TO 2275+00
C-143	51	PLAN VIEW STA: 2275+00 TO 2325+00
C-144	52	PLAN VIEW STA: 2325+00 TO 2368+00
C-145	53	PLAN VIEW STA: 478+68 TO 512+00 (STAR BEND SETBACK)

DWG NO.	SHT NO.	DESCRIPTION
		PROFILE VIEW SHEETS
C-201	54	PROFILE VIEW STA: 175+00 TO 225+00
C-202	55	PROFILE VIEW STA: 225+00 TO 275+00
C-203	56	PROFILE VIEW STA: 275+00 TO 325+00
C-204	57	PROFILE VIEW STA: 325+00 TO 375+00
C-205	58	PROFILE VIEW STA: 375+00 TO 425+00
C-206	59	PROFILE VIEW STA: 425+00 TO 478+68
C-207	60	PROFILE VIEW STA: 478+68 TO 512+00 (STAR BEND FIX IN PLACE)
C-208	61	PROFILE VIEW STA: 512+00 TO 575+00
C-209	62	PROFILE VIEW STA: 575+00 TO 625+00
C-210	63	PROFILE VIEW STA: 625+00 TO 675+00
C-211	64	PROFILE VIEW STA: 675+00 TO 725+00
C-212	65	PROFILE VIEW STA: 725+00 TO 775+00
C-213	66	PROFILE VIEW STA: 775+00 TO 825+00
C-214	67	PROFILE VIEW STA: 825+00 TO 875+00
C-215	68	PROFILE VIEW STA: 875+00 TO 925+00
C-216	69	PROFILE VIEW STA: 925+00 TO 975+00
C-217	70	PROFILE VIEW STA: 975+00 TO 1025+00
C-218	71	PROFILE VIEW STA: 1025+00 TO 1075+00
C-219	72	PROFILE VIEW STA: 1075+00 TO 1125+00
C-220	73	PROFILE VIEW STA: 1125+00 TO 1175+00
C-221	74	PROFILE VIEW STA: 1175+00 TO 1225+00
C-222	75	PROFILE VIEW STA: 1225+00 TO 1275+00
C-223	76	PROFILE VIEW STA: 1275+00 TO 1325+00
C-224	77	PROFILE VIEW STA: 1325+00 TO 1375+00
C-225	78	PROFILE VIEW STA: 1375+00 TO 1433+83
C-226	79	PROFILE VIEW STA: 1433+83 TO 1475+00
C-227	80	PROFILE VIEW STA: 1475+00 TO 1525+00
C-228	81	PROFILE VIEW STA: 1525+00 TO 1575+00
C-229	82	PROFILE VIEW STA: 1575+00 TO 1625+00
C-230	83	PROFILE VIEW STA: 1625+00 TO 1675+00
C-231	84	PROFILE VIEW STA: 1675+00 TO 1725+00
C-232	85	PROFILE VIEW STA: 1725+00 TO 1775+00
C-233	86	PROFILE VIEW STA: 1775+00 TO 1825+00
C-234	87	PROFILE VIEW STA: 1825+00 TO 1875+00
C-235	88	PROFILE VIEW STA: 1875+00 TO 1925+00
C-236	89	PROFILE VIEW STA: 1925+00 TO 1975+00
C-237	90	PROFILE VIEW STA: 1975+00 TO 2025+00
C-238	91	PROFILE VIEW STA: 2025+00 TO 2075+00
C-239	92	PROFILE VIEW STA: 2075+00 TO 2125+00
C-240	93	PROFILE VIEW STA: 2125+00 TO 2175+00
C-241	94	PROFILE VIEW STA: 2175+00 TO 2225+00
C-242	95	PROFILE VIEW STA: 2225+00 TO 2275+00
C-243	96	PROFILE VIEW STA: 2275+00 TO 2325+00
C-244	97	PROFILE VIEW STA: 2325+00 TO 2368+00
C-245	98	PROFILE VIEW STA: 478+68 TO 512+00 (STAR BEND SETBACK)

DWG NO.	SHT NO.	DESCRIPTION
		TYPICAL LEVEE IMPROVEMENT SECTIONS AND DETAILS
C-301	99	TYPICAL LEVEE IMPROVEMENT – CUTOFF WALL
C-302	100	TYPICAL LEVEE IMPROVEMENT – SEEPAGE BERM
C-303	101	TYPICAL LEVEE IMPROVEMENT – CUTOFF WALL WITH SEEPAGE BERM OR RELIEF WELLS
C-304	102	TYPICAL LEVEE IMPROVEMENT – CUTOFF WALL WITH FULL LEVEE DEGRADE AND RELIEF WELLS
C-305	103	TYPICAL LEVEE IMPROVEMENT – CUTOFF WALL WITH LEVEE RELOCATION
C-306	104	TYPICAL LEVEE IMPROVEMENT – CUTOFF WALL WITH CANAL RELOCATION
C-307	105	TYPICAL LEVEE IMPROVEMENT – TYPICAL CUTOFF WALL WITH LANDSIDE TOE FILL
C-308	106	TYPICAL LEVEE IMPROVEMENT – NEW LEVEE WITH CUTOFF WALL
C-309	107	TYPICAL LEVEE IMPROVEMENT – MISC. DETAILS
C-310	108	TYPICAL LEVEE IMPROVEMENT – STOP LOG STRUCTURE
		TYPICAL UTILITY IMPROVEMENT SECTIONS AND DETAILS
C-401	109	TYPICAL UTILITY IMPROVEMENT – REMOVAL & DISPOSAL OF ABANDONED RAISED PIPE
C-402	110	TYPICAL UTILITY IMPROVEMENT – REMOVAL & DISPOSAL OF ABANDONED THROUGH PIPE
C-403	111	TYPICAL UTILITY IMPROVEMENT – REMOVAL & REPLACEMENT OF RAISED PIPE
C-404	112	TYPICAL UTILITY IMPROVEMENT – REMOVAL & REPLACEMENT OF THROUGH PIPE
C-406	113	TYPICAL UTILITY IMPROVEMENT – REMOVAL & REPLACEMENT OF THROUGH PIPE WITH CANAL RELOCATION
C-405	114	TYPICAL UTILITY IMPROVEMENT – REMOVAL & REPLACEMENT OF RAISED PIPE W/CANAL RELOCATION
C-407	115	TYPICAL UTILITY IMPROVEMENT – REMOVAL & REPLACEMENT OF THROUGH PIPE ADJACENT TO CANAL
C-408	116	TYPICAL UTILITY IMPROVEMENT – REMOVAL & REPLACEMENT OF THROUGH PIPE UNDER CANAL
C-409	117	TYPICAL UTILITY IMPROVEMENT – REMOVAL & REPLACEMENT OF THROUGH PIPE UNDER CANAL WITH LEVEE RELOCATION

DWG NO.	SHT NO.	DESCRIPTION

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US Army Corps of Engineers
Sacramento District

58	20SEP2043	EXECUTIVE APPROVAL
57	20SEP2042	CHIEF APPROVAL
56	20SEP2041	DWR APPROVAL
55	20SEP2040	DWR APPROVAL
54	20SEP2039	DWR APPROVAL
53	20SEP2038	DWR APPROVAL
52	20SEP2037	DWR APPROVAL
51	20SEP2036	DWR APPROVAL
50	20SEP2035	DWR APPROVAL
No.	Date	Description

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

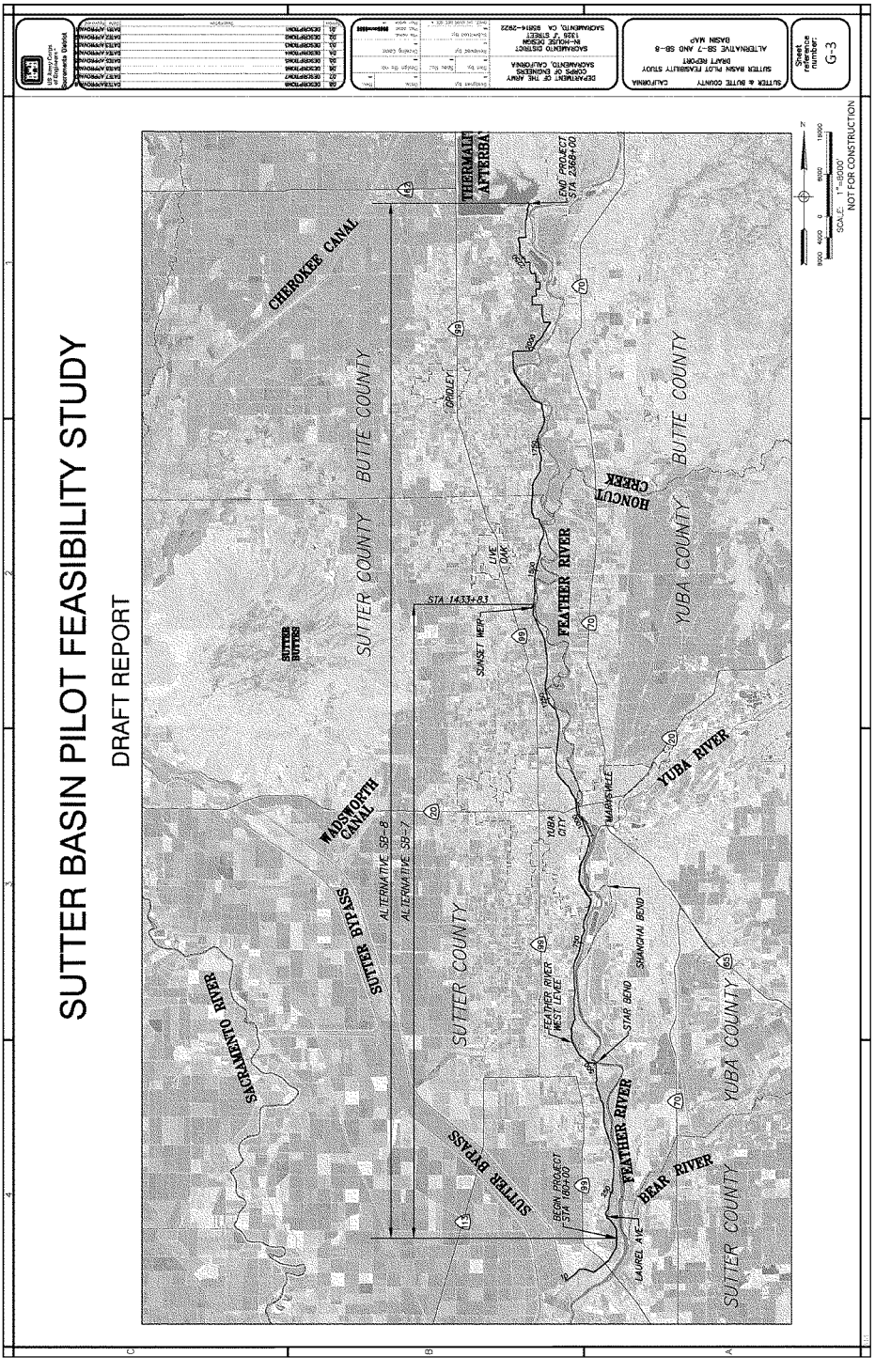
SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922

Designed by: | Date:
Drawn by: | Scale: 1
Checked by: | Drawing No.:
Approved by: | Tgt. elev.:
Submitted by: | Tgt. name:
Date Approved for Bid: | File name:

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
SHEET INDEX

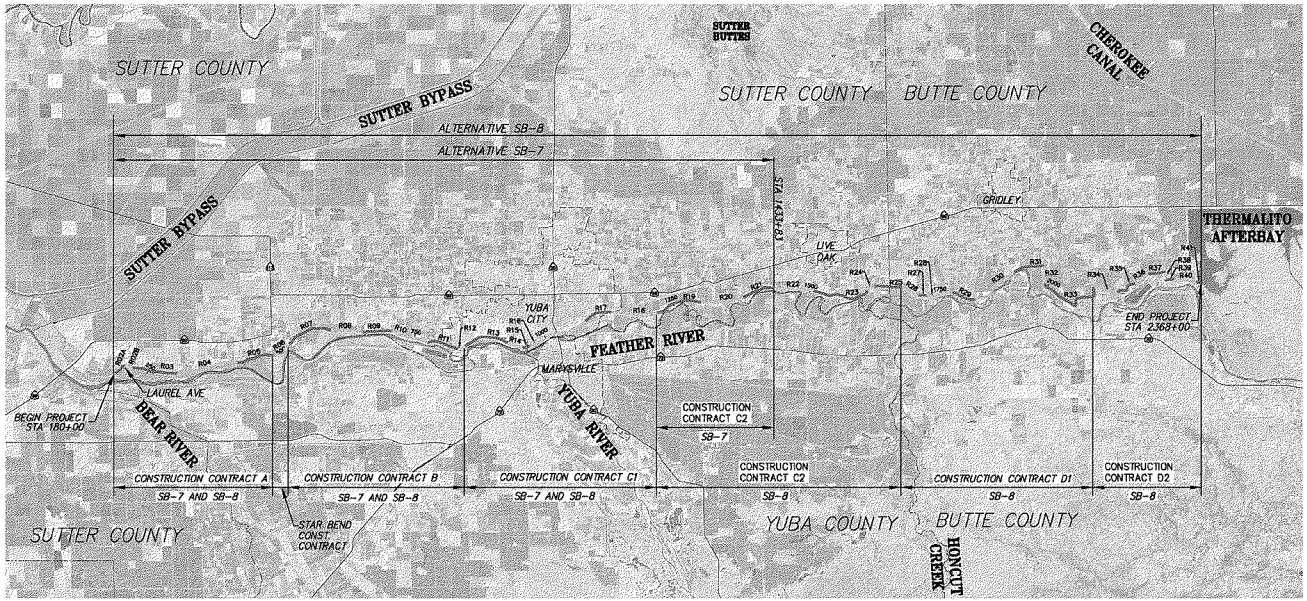
Sheet reference number:
G-2

1923


SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
SUTTER COUNTY
BUTTE COUNTY
YUBA COUNTY
CHEROKEE CANAL
WADSWORTH CANAL
SUTTER BYPASS
SACRAMENTO RIVER
FEATHER RIVER
HONCUT CREEK
YUBA RIVER
BEAR RIVER
SUTTER BUTTES
ALTERNATIVE SB-8
ALTERNATIVE SB-7
STA 1433+83
BEGIN PROJECT STA 160+00
END PROJECT STA 2368+00
THERMALITO AFTERBAY
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
ALTERNATIVE SB-7 AND SB-8 BASIN MAP
DRAFT REPORT
Sheet reference number: G-3
SCALE: 1"=8000'
NOT FOR CONSTRUCTION

SUTTER BASIN PILOT FEASIBILITY STUDY

DRAFT REPORT



REACH LEGEND

R09 REACH NAME

EVEN REACHES

ODD REACHES (EXCEPT REACH R02A)

SCALE: 1"=8000'

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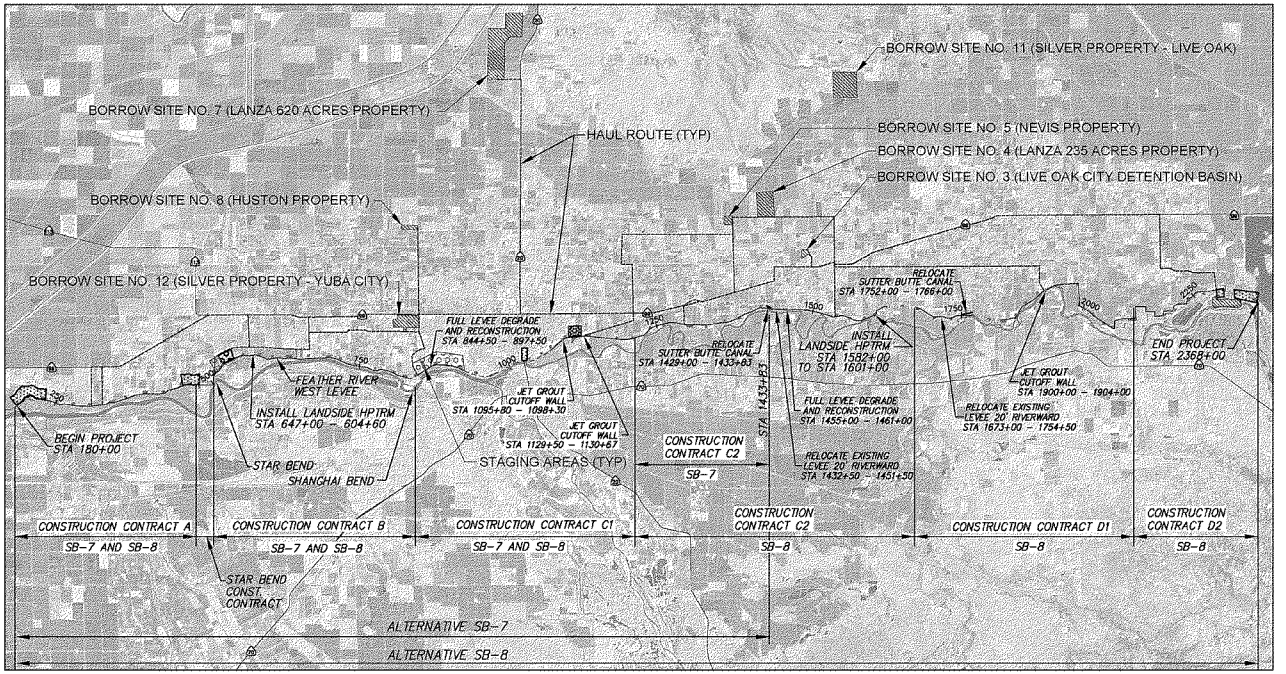
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
VICINITY MAP

Sheet reference number:
G-4

SUTTER BASIN PILOT FEASIBILITY STUDY

DRAFT REPORT



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SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PROJECT FEATURES, BORROW SITES AND HAUL ROUTES

Sheet reference number: G-5

1926

ABBREVIATIONS

APPROX	APPROXIMATE
ATOL	AUTHORIZED TOP OF LEVEE
AVE	AVENUE
AVG	AVERAGE
BLVD	BOULEVARD
BM	BENCHMARK
CL	CENTERLINE
CMP	CORREGATED METAL PIPE
CONST	CONSTRUCTION
DEMO	DEMOLITION
DIA	DIAMETER
DIST	DISTANCE
E	EASTING
EA	EACH
ELEV, EL	ELEVATION
ENGR	ENGINEER
EX	EXISTING
HPTRM	HIGH PERFORMANCE TURF REINFORCING MAT
IRR	IRRIGATION
MAX	MAXIMUM
MH	MANHOLE
MIN	MINIMUM
MISC	MISCELLANEOUS
MW	MONITORING WELL
NGS	NATIONAL GEODETIC SURVEY
NGVD	NATIONAL GEODETIC VERTICAL DATUM
NTS	NOT TO SCALE
OH	OVERHEAD
O&M	OPERATION AND MAINTENANCE
PL	PROPERTY LINE
PP	POWER POLE
PROP	PROPOSED
PS	PUMP STATION
QTY	QUANTITY
R/W, ROW	RIGHT OF WAY
RCP	REINFORCED CONCRETE PIPE
RD	ROAD
RM	RIVER MILE
RR	RAILROAD
RSP	ROCK SLOPE PROTECTION
RT	RELIEF WELL
ST	STREET
STA	STATION
STD	STANDARD
TEMP	TEMPORARY
TOPO	TOPOGRAPHY
TYP	TYPICAL
UTIL	UTILITY
VFZ	VEGETATION FREE ZONE
WSE	WATER SURFACE ELEVATION
WY	WAY

LEGEND AND SYMBOLS

EXISTING FEATURES		PROPOSED FEATURES
	CENTERLINE	
	PROPERTY LINE	N/A
	RIGHT OF WAY	N/A
N/A	O&M/VFZ/CONSTRUCTION LIMIT	
N/A	JET GROUT WALL (PLAN VIEW)	
N/A	JET GROUT WALL (PROFILE VIEW)	
	CUTOFF WALL (PLAN VIEW)	
	CUTOFF WALL (PROFILE VIEW)	
N/A	LEVEE DEGRADE/WORKING SURFACE	
	LEVEE/BERM TOE	
N/A	LEVEE CREST	
N/A	BERM TOP	
	1957 ATOL	N/A
N/A	STAGING AREA	
N/A	HIGH PERFORMANCE TURF REINFORCING MAT	
N/A	EARTH SLOPE	TOP / TOE
N/A	CONTROL LINE W/STATION	48+00
N/A	LEVEE EMBANKMENT FILL (SOIL TYPE 1)	
N/A	RANDOM FILL AREA	
	EXISTING STRUCTURE FOR DEMOLITION	N/A

NOTES:

1. THIS SHEET APPLIES TO THE ENTIRE SET OF DRAWINGS. THIS IS A STANDARD DRAWING LISTING SHOWING ABBREVIATIONS AND SYMBOLOGY. ALL ABBREVIATIONS AND SYMBOLOGY ARE NOT NECESSARILY USED ON THIS PROJECT.
2. SCREENING OR SHADING OF WORK IS USED TO INDICATE EXISTING COMPONENTS OR TO DE-EMPHASIZE PROPOSED IMPROVEMENTS TO HIGHLIGHT SELECTED TRADE WORK. REFER TO CONTEXT OF EACH DRAWING FOR USAGE.

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SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
GENERAL ABBREVIATIONS, LEGEND AND SYMBOLS

Sheet reference number:
G-6

ALTERNATIVE SB7

Measure	Typical Section (Sheet)	Segment	Contract	Beg. STA of Measure	End. STA of Measure	Length per Segment (LF)	Length per Contract (LF)	Length per Measure (LF)
No Rehabilitation Required	-	1	B	831+50	844+50	1,300	1,300	
No Rehabilitation Required	-	2	C1	923+75	1006+24	8,249		
No Rehabilitation Required	-	3	C1	1007+70	1024+00	1,630		
No Rehabilitation Required	-	4	C1	1027+50	1078+00	5,050	14,930	16,230
Cutoff Wall Only	C-301	1	A	231+00	453+00	22,200	22,200	
Cutoff Wall Only	C-301	2	SBFIP	478+68	512+00	3,332	3,340	
Cutoff Wall Only	C-301	3	B	570+00	831+50	26,150	26,150	
Cutoff Wall Only	C-301	4	C1	1078+00	1096+00	1,800		
Cutoff Wall Only	C-301	5	C1	1096+10	1107+00	690		
Cutoff Wall Only	C-301	6	C1	1125+70	1129+99	429		
Cutoff Wall Only	C-301	7	C1	1130+20	1213+85	8,365	11,480	
Cutoff Wall Only	C-301	7	C2	1213+85	1426+00	21,515	21,520	84,700
Jet Grouting Cutoff Wall Only	C-301	1	C1	1006+04	1007+90	186		
Jet Grouting Cutoff Wall Only	C-301	2	C1	1095+80	1096+30	250		
Jet Grouting Cutoff Wall Only	C-301	3	C1	1129+50	1130+67	117	560	560
Seepage Berm Only	C-302	1	C1	1024+00	1027+50	350	350	350
Cutoff Wall with Full Levee Degrade and Existing Relief Wells	C-304	1	C1	844+50	897+50	5,300	5,300	5,300
Cutoff Wall with Full Levee Degrade	C-304	-	-	0+00	0+00	0	0	0
Cutoff Wall with Existing Relief Wells	C-303	1	B	512+00	545+00	3,300	3,300	
Cutoff Wall with Existing Relief Wells	C-303	3	C1	897+50	923+75	2,625	2,630	5,930
Cutoff Wall with New Relief Wells	C-303	2	B	545+00	570+00	2,500	2,500	2,500
Cutoff Wall with Seepage Berm	C-303	1	A	180+00	231+00	5,100		
Cutoff Wall with Seepage Berm	C-303	2	A	453+00	478+68	2,568	7,670	7,670
Cutoff Wall with Levee Relocation	C-305	-	-	0+00	0+00	0	0	0
Cutoff Wall with Sutter Butte Canal Relocation	C-306	1	C2	1429+00	1432+70	370	370	370
Cutoff Wall with Landside Toe Fill	C-307	1	C1	1107+00	1125+70	1,870	1,870	1,870
DSM Cutoff Wall (already included in the Cutoff Wall Only section)	C-301	1	A	230+00	250+00	2,000	2,000	
DSM Cutoff Wall (already included in the Cutoff Wall Only section)	C-301	2	C1	1125+00	1129+99	499		
DSM Cutoff Wall (already included in the Cutoff Wall Only section)	C-301	3	C1	1130+20	1151+50	2,130	2,630	
DSM Cutoff Wall (already included in the Cutoff Wall Only section)	C-301	4	C2	1224+00	1248+00	2,400	2,400	7,030
Erosion Protection	-	1	B	547+00	604+50	5,750	5,750	5,750
Closure Structure (Stop Log)	-	1	C1	1130+00	1130+00	-	-	-

ALTERNATIVE SB8

Measure	Typical Section (Sheet)	Segment	Contract	Beg. STA of Measure	End. STA of Measure	Length per Segment (LF)	Length per Contract (LF)	Length per Measure (LF)
No Rehabilitation Required	-	1	B	831+50	844+50	1,300	1,300	
No Rehabilitation Required	-	2	C1	923+75	1006+24	8,249		
No Rehabilitation Required	-	3	C1	1007+70	1024+00	1,630		
No Rehabilitation Required	-	4	C1	1027+50	1078+00	5,050	14,930	
No Rehabilitation Required	-	5	C2	1925+00	1673+00	4,800	4,800	
No Rehabilitation Required	-	6	D1	1769+40	1813+30	4,390	4,390	
No Rehabilitation Required	-	7	D2	2303+00	2331+00	2,800	2,800	28,220
Cutoff Wall Only	C-301	1	A	231+00	453+00	22,200	22,200	
Cutoff Wall Only	C-301	2	SBFIP	478+68	512+00	3,332	3,340	
Cutoff Wall Only	C-301	3	B	570+00	831+50	26,150	26,150	
Cutoff Wall Only	C-301	4	C1	1078+00	1096+00	1,800		
Cutoff Wall Only	C-301	5	C1	1096+10	1107+00	690		
Cutoff Wall Only	C-301	6	C1	1125+70	1129+99	429		
Cutoff Wall Only	C-301	7	C1	1130+20	1213+85	8,365	11,480	
Cutoff Wall Only	C-301	7	C2	1213+85	1426+00	21,515		
Cutoff Wall Only	C-301	8	C2	1451+50	1455+00	350		
Cutoff Wall Only	C-301	9	C2	1461+00	1608+50	14,750		
Cutoff Wall Only	C-301	10	C2	1624+70	1625+00	30		
Cutoff Wall Only	C-301	11	C2	1673+00	1673+30	30	36,680	
Cutoff Wall Only	C-301	12	D1	1766+00	1769+40	340		
Cutoff Wall Only	C-301	13	D1	1813+30	1900+50	8,720		
Cutoff Wall Only	C-301	14	D1	1900+50	2122+00	21,950	30,910	
Cutoff Wall Only	C-301	14	D2	2122+00	2290+00	16,800	16,800	147,570
Jet Grouting Cutoff Wall Only	C-301	1	C1	1006+04	1007+90	186		
Jet Grouting Cutoff Wall Only	C-301	2	C1	1095+80	1096+30	250		
Jet Grouting Cutoff Wall Only	C-301	3	C1	1129+50	1130+67	117	560	
Jet Grouting Cutoff Wall Only	C-301	4	D1	1900+00	1904+00	400	400	960
Seepage Berm Only	C-302	1	C1	1024+00	1027+50	350	350	
Seepage Berm Only	C-302	2	D2	2299+00	2303+00	1,300		
Seepage Berm Only	C-302	3	D2	2331+00	2368+00	3,700	5,000	5,350
Cutoff Wall with Full Levee Degrade and Existing Relief Wells	C-304	1	C1	844+50	897+50	5,300	5,300	5,300
Cutoff Wall with Full Levee Degrade	C-304	2	C2	1455+00	1461+00	600	600	600
Cutoff Wall with Existing Relief Wells	C-303	1	B	512+00	545+00	3,300	3,300	
Cutoff Wall with Existing Relief Wells	C-303	3	C1	897+50	923+75	2,625	2,630	5,930
Cutoff Wall with New Relief Wells	C-303	2	B	545+00	570+00	2,500	2,500	2,500
Cutoff Wall with Seepage Berm	C-303	1	A	180+00	231+00	5,100		
Cutoff Wall with Seepage Berm	C-303	2	A	453+00	478+68	2,568	7,670	7,670
Cutoff Wall with Levee Relocation	C-305	1	C2	1432+70	1451+50	1,880		
Cutoff Wall with Levee Relocation	C-305	2	C2	1608+50	1624+70	1,620		
Cutoff Wall with Levee Relocation	C-305	3	C2	1673+30	1674+37	107	3,610	
Cutoff Wall with Levee Relocation	C-305	3	D1	1674+37	1754+30	7,993	8,000	11,610
Cutoff Wall with Sutter Butte Canal Relocation	C-306	1	C2	1429+00	1432+70	370	370	
Cutoff Wall with Sutter Butte Canal Relocation	C-306	2	D1	1754+30	1766+00	1,170	1,170	1,540
Cutoff Wall with Landside Toe Fill	C-307	1	C1	1107+00	1125+70	1,870	1,870	1,870
DSM Cutoff Wall (already included in the Cutoff Wall Only section)	C-301	1	A	230+00	250+00	2,000	2,000	
DSM Cutoff Wall (already included in the Cutoff Wall Only section)	C-301	2	C1	1125+00	1129+99	499		
DSM Cutoff Wall (already included in the Cutoff Wall Only section)	C-301	3	C1	1130+20	1151+50	2,130	2,630	
DSM Cutoff Wall (already included in the Cutoff Wall Only section)	C-301	4	C2	1224+00	1248+00	2,400	2,400	
DSM Cutoff Wall (already included in the Cutoff Wall Only section)	C-301	5	D1	1987+25	2002+00	1,475		
DSM Cutoff Wall (already included in the Cutoff Wall Only section)	C-301	6	D1	2016+75	2036+75	2,000		
DSM Cutoff Wall (already included in the Cutoff Wall Only section)	C-301	7	D1	2067+00	2083+00	2,100	5,580	
DSM Cutoff Wall (already included in the Cutoff Wall Only section)	C-301	8	D2	2137+00	2148+00	1,100		
DSM Cutoff Wall (already included in the Cutoff Wall Only section)	C-301	9	D2	2182+00	2196+50	1,450		
DSM Cutoff Wall (already included in the Cutoff Wall Only section)	C-301	10	D2	2245+75	2262+00	4,625	7,180	19,790
Erosion Protection	-	1	B	547+00	604+50	5,750	5,750	
Erosion Protection	-	2	C2	1582+00	1601+00	1,900	1,900	7,650
Closure Structure (Stop Log)	-	1	C1	1130+00	1130+00	-	-	-

NOTES REGARDING LAYOUT OF ALTERNATIVE SB-7 AND SB-8

1. SHEETS C-101 THROUGH C-125 ARE THE PLAN VIEW SHEETS FOR ALTERNATIVE SB-7; SHEETS C-201 THROUGH C-223 ARE THE PROFILE VIEW SHEETS FOR ALTERNATIVE SB-7.
2. SHEETS C-126 THROUGH C-144 ARE THE PLAN VIEW SHEETS FROM ALTERNATIVE SB-8; SHEETS C-226 THROUGH C-244 ARE THE PROFILE VIEW SHEET FOR ALTERNATIVE SB-8.
3. SHEETS C-145 AND C-245 ARE THE PLAN AND PROFILE VIEW SHEETS FOR THE STAR BEND SETBACK OPTION, RESPECTIVELY. THIS IS DONE SINCE THE RW-IN PLACE OPTION IS THE PREFERRED PLAN INCLUDED AS THE RECOMMENDED OPTION FOR ALTERNATIVES SB-7 & SB-8.

NOT FOR CONSTRUCTION

US Army Corps of Engineers
Sacramento District

DATE APPROVED
DATE APPROVED
DATE APPROVED
DATE APPROVED
DATE APPROVED
DATE APPROVED
DATE APPROVED
DATE APPROVED

08	25SEP2014	
07	25SEP2014	
06	25SEP2014	
05	25SEP2014	
04	25SEP2014	
03	25SEP2014	
02	25SEP2014	
01	25SEP2014	

DESIGNED by: Date:
DRAWN by: Date:
CHECKED by: Date:
APPROVED by: Date:
SUBMITTED by: Date:
Plot scale: 1 = 1
Plot units: Inches
Project Control No.: 916xx-xxxx

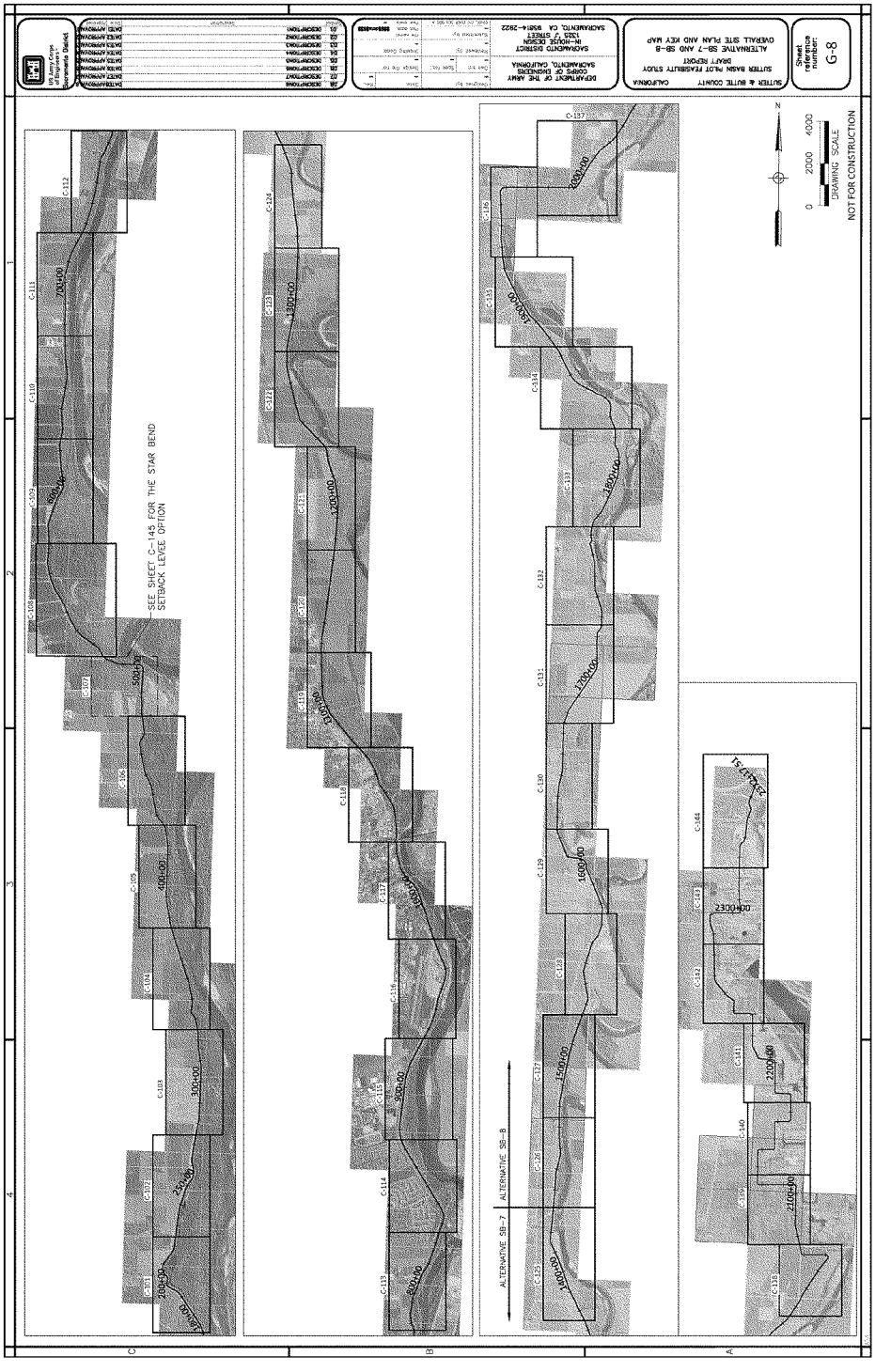
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

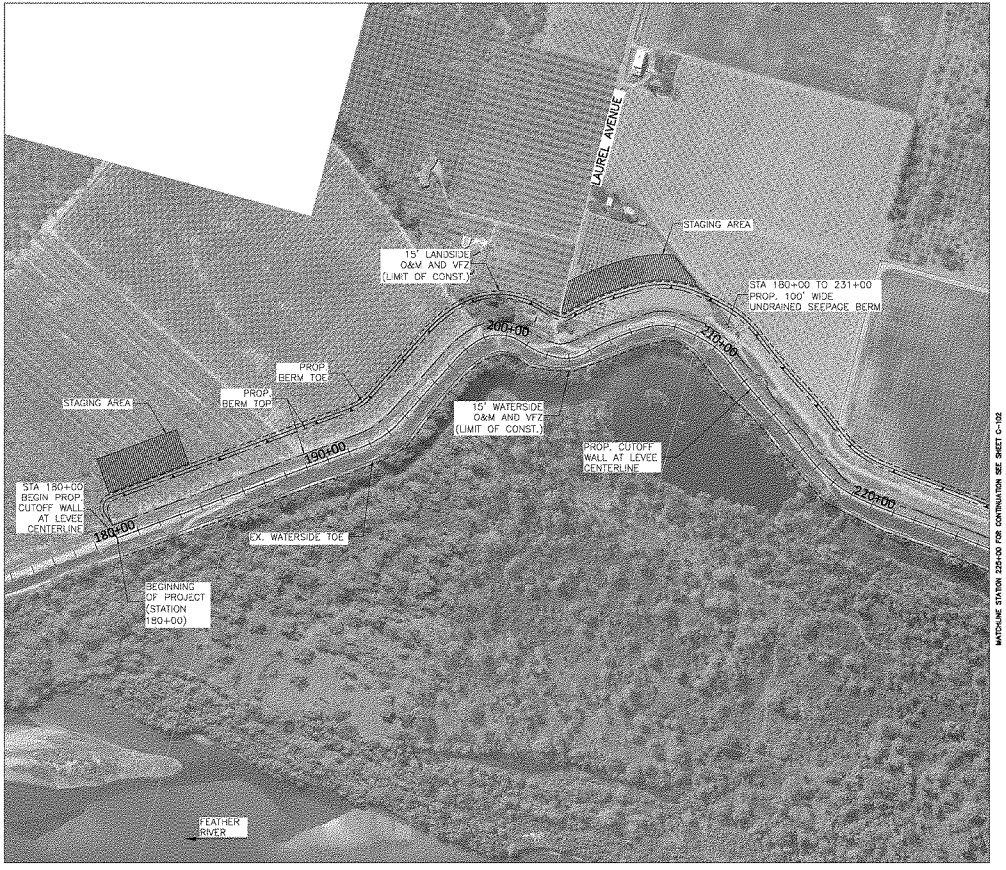
SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN FLOOD FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
GENERAL NOTES

Sheet reference number:
G-7

1928


SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
OVERALL SITE PLAN AND KEY MAP
Sheet reference number: G-8
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 J STREET
SACRAMENTO, CA 95814-2922
US Army Corps of Engineers Sacramento District
SEE SHEET C-145 FOR THE STAR BEND SETBACK LEVEE OPTION
ALTERNATIVE SB-7
ALTERNATIVE SB-8
N
0 2000 4000
DRAWING SCALE
NOT FOR CONSTRUCTION



HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

N

0 200 400
DRAWING SCALE

NOT FOR CONSTRUCTION

US Army Corps of Engineers
Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA 175+00 TO 225+00

Sheet reference number:
C-101

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

N

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DRAWING SCALE

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Sacramento District

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SACRAMENTO DISTRICT
IN-HOUSE DESIGN
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SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA 225+00 TO 275+00

Sheet reference number:
C-102

HORIZONTAL DATUM
THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).
N
0 200 400
DRAWING SCALE
NOT FOR CONSTRUCTION
MATCHLINE STATION 325+00 FOR CONTINUATION SEE SHEET C-104
MATCHLINE STATION 275+00 FOR CONTINUATION SEE SHEET C-102
CENTRAL STREET
320+00
310+00
300+00
290+00
280+00
STAGING AREA
STAGING AREA
PROP. CUTOFF WALL AT LEVEE CENTERLINE
15' LANDSIDE O&M AND VFZ (LIMIT OF CONST.)
15' WATERSIDE O&M AND VFZ (LIMIT OF CONST.)
EX. LANDSIDE TOE
EX. WATERSIDE TOE
FEATHER RIVER
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA 275+00 TO 325+00
Sheet reference number:
C-103
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922
US Army Corps of Engineers
Sacramento District

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

N

0 200 400
DRAWING SCALE

NOT FOR CONSTRUCTION

US Army Corps of Engineers
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DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA 325+00 TO 375+00

Sheet reference number:
C-104

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

N

0 200 400
DRAWING SCALE

NOT FOR CONSTRUCTION

US Army Corps of Engineers
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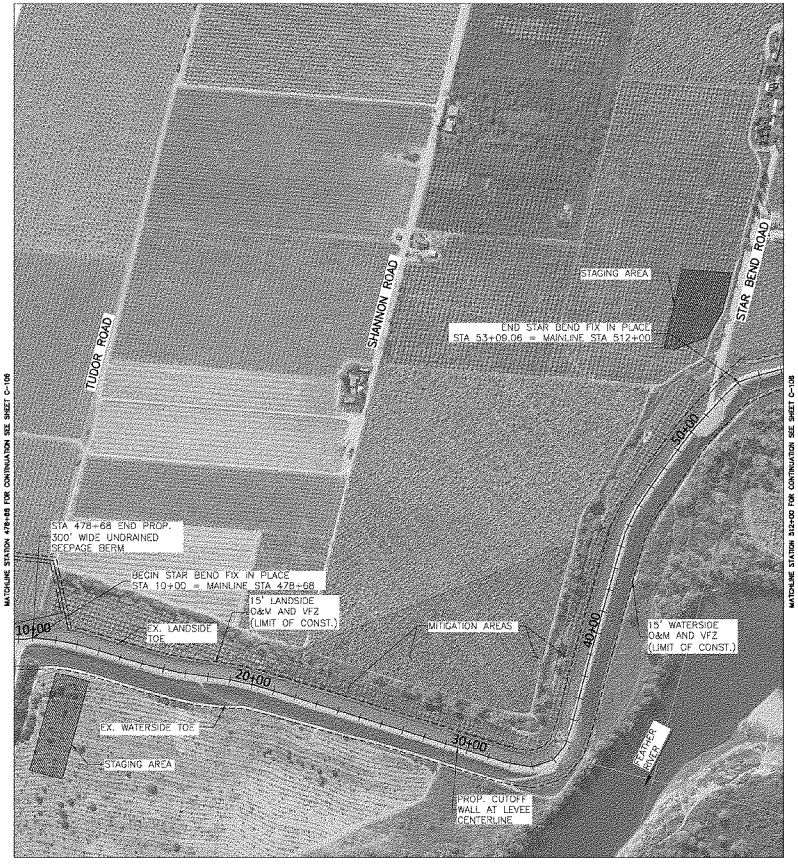
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA. 375+00 TO 425+00

Sheet reference number:
C-105

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
ALTERNATIVE SB-7 AND SB-8
DRAFT REPORT
PLAN VIEW
STA 425+00 TO 479+68
Sheet reference number: C-106
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
SACRAMENTO, CALIFORNIA
1325 J STREET
SACRAMENTO, CA 95814-2922
US Army Corps of Engineers Sacramento District
HORIZONTAL DATUM
THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) FOR THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).
N
0 200 400
DRAWING SCALE
NOT FOR CONSTRUCTION
MATCHLINE STATION 478+68 FOR CONTINUATION SEE SHEET C-107
SEE SHEET C-145 FOR STAR BEND SETBACK OPTION
MATCHLINE STATION 425+00 FOR CONTINUATION SEE SHEET C-105
ASHFORD AVENUE
PECK AVENUE
LYON AVENUE
STA 453+68 TO 478+68 PROP. 300' WIDE UNDRAINED SEEPAGE BERM
PROP. LANDSIDE TOE
PROP. BERM TOE
460+00
450+00
440+00
430+00
STAGING AREA
EX. LANDSIDE TOE
15' LANDSIDE O&M AND VFZ (LIMIT OF CONST.)
PROP. CUTOFF WALL AT LEVEE CENTERLINE
EX. WATERSIDE TOE
15' WATERSIDE O&M AND VFZ (LIMIT OF CONST.)
FEATHER RIVER



HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

N

NOTE: SEE SHEET C-145 FOR STAR BEND SETBACK OPTION

0 200 400
DRAWING SCALE

NOT FOR CONSTRUCTION

US Army Corps of Engineers
Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

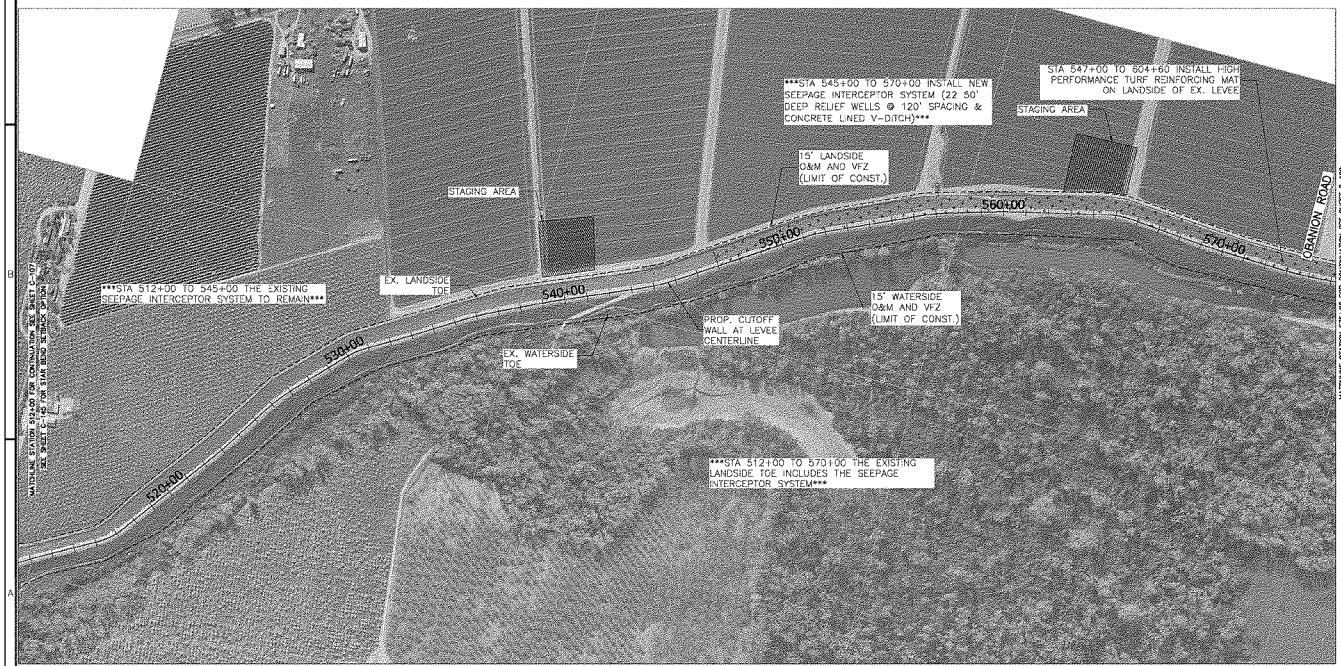
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA. 478+68 to STA. 512+00 (MAINLINE)

Sheet reference number:
C-107

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).



0 200 400
DRAWING SCALE

NOT FOR CONSTRUCTION

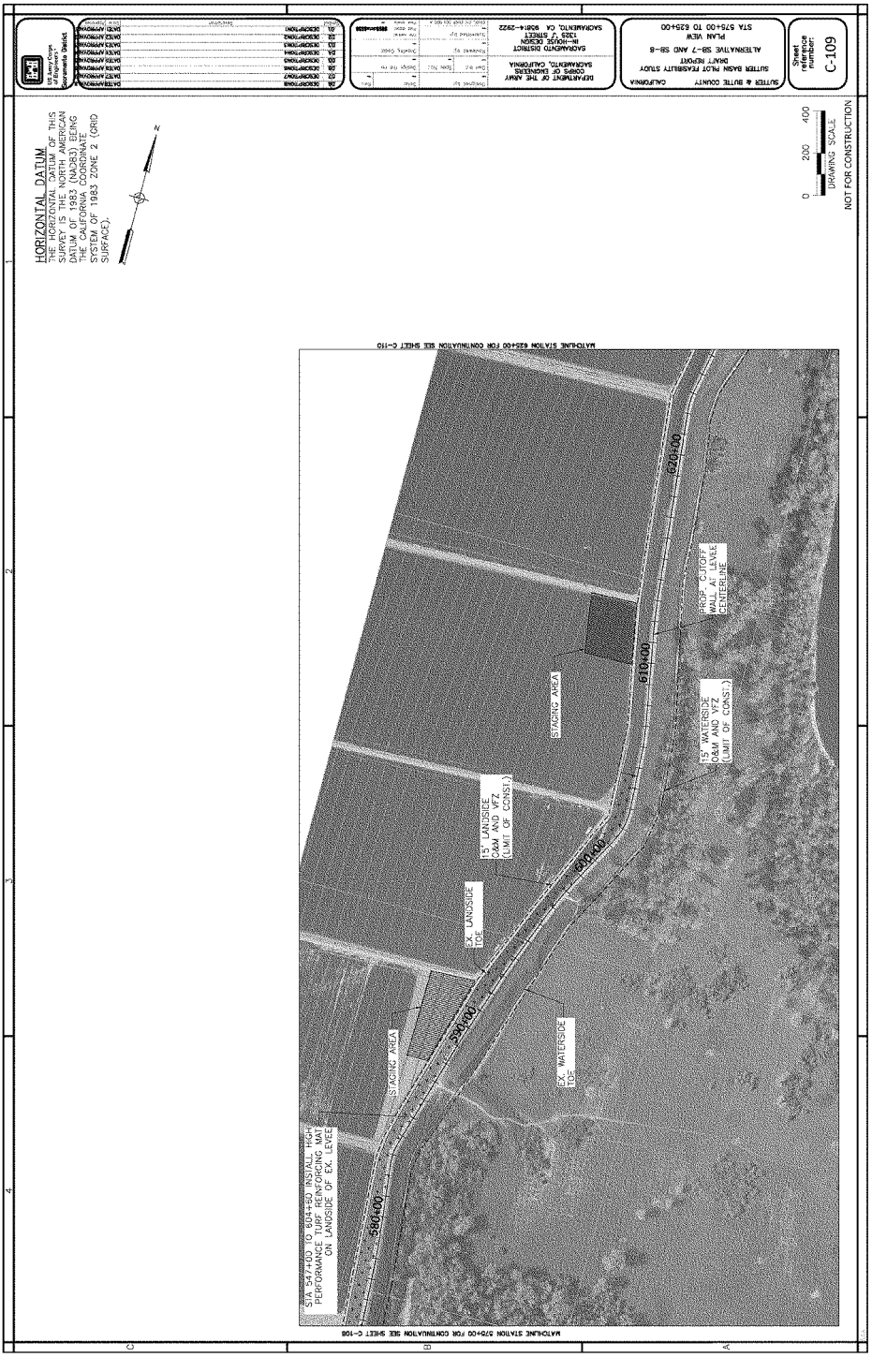
US Army Corps of Engineers
Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA 512+00 TO 575+00

Sheet reference number:
C-108


HORIZONTAL DATUM
THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).
N
0 200 400
DRAWING SCALE
NOT FOR CONSTRUCTION
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA 575+00 TO 625+00
Sheet number: C-109
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1329 'J' STREET
SACRAMENTO, CA 95814-2922
US Army Corps of Engineers Sacramento District
MATCHLINE STATION 575+00 FOR CONTINUATION SEE SHEET C-108
MATCHLINE STATION 625+00 FOR CONTINUATION SEE SHEET C-110
STAGING AREA
EX. LANDSIDE TOE
15' LANDSIDE O&M AND VFZ (LIMIT OF CONST.)
EX. WATERSIDE TOE
STAGING AREA
15' WATERSIDE O&M AND VFZ (LIMIT OF CONST.)
PROP. CUTOFF WALL ALIGNMENT CENTERLINE
560+00
580+00
610+00
630+00

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

0 200 400
DRAWING SCALE

NOT FOR CONSTRUCTION

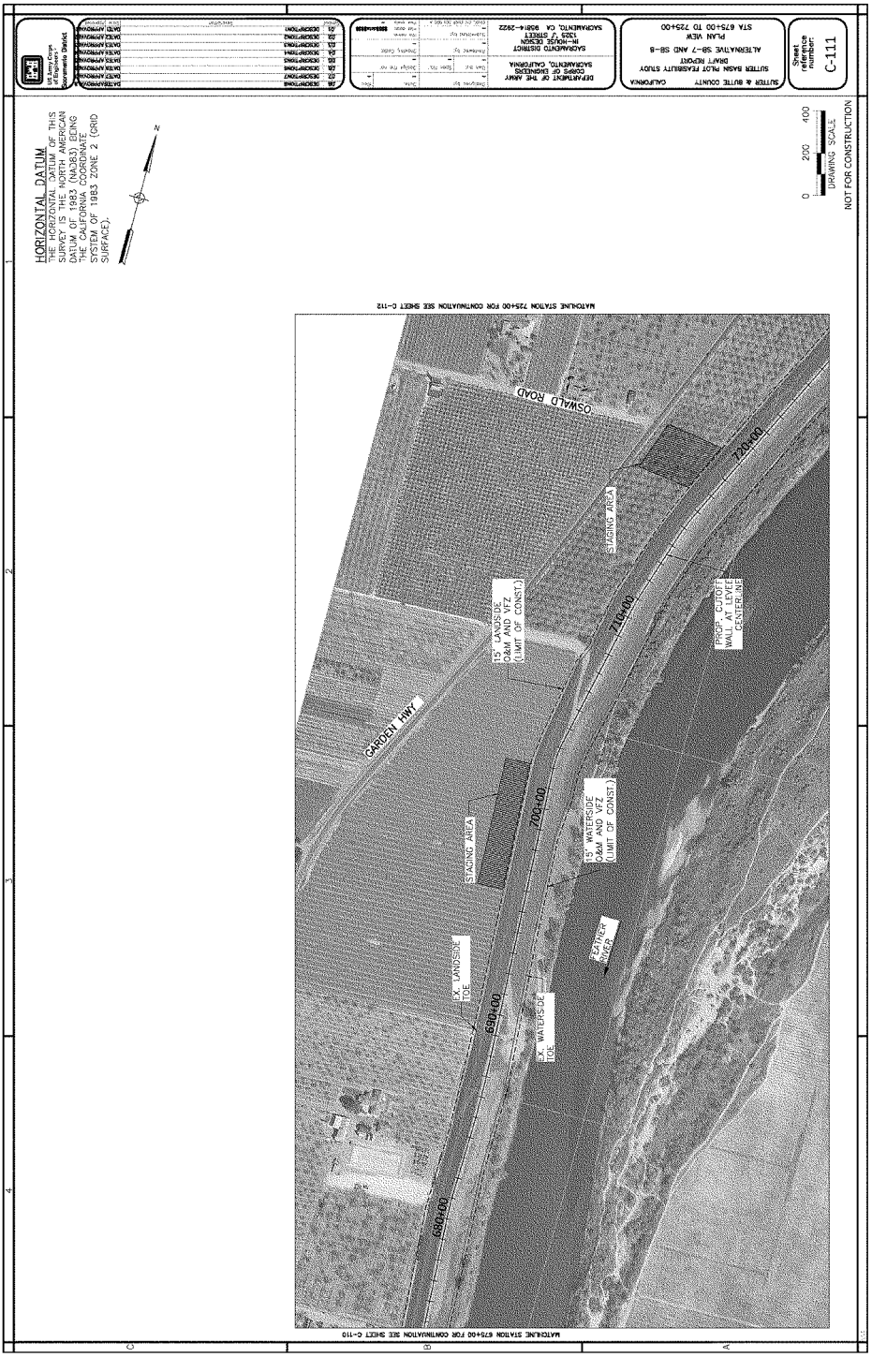
US Army Corps of Engineers®
Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA 625+00 TO 675+00

Sheet reference number:
C-110


SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA 675+00 TO 725+00
SUTTER & BUTTE COUNTY CALIFORNIA
Sheet number:
C-111
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
IN-HOUSE DESIGN
SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922
HORIZONTAL DATUM
THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA STATE PLANE COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).
N
0 200 400
DRAWING SCALE
NOT FOR CONSTRUCTION
MATCHLINE STATION 675+00 FOR CONTINUATION SEE SHEET C-110
MATCHLINE STATION 725+00 FOR CONTINUATION SEE SHEET C-112
OSWALD ROAD
GARDEN HWY
STAGING AREA
STAGING AREA
15' LANDSIDE O&M AND VFZ (LIMIT OF CONST)
15' WATERSIDE O&M AND VFZ (LIMIT OF CONST)
PROP. CUTOFF WALL AT LEVEE CROWN
EX. LANDSIDE TOE
EX. WATERSIDE TOE
EXISTING LEVEE
680+00
690+00
700+00
710+00
720+00

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

N

0 200 400
DRAWING SCALE
NOT FOR CONSTRUCTION

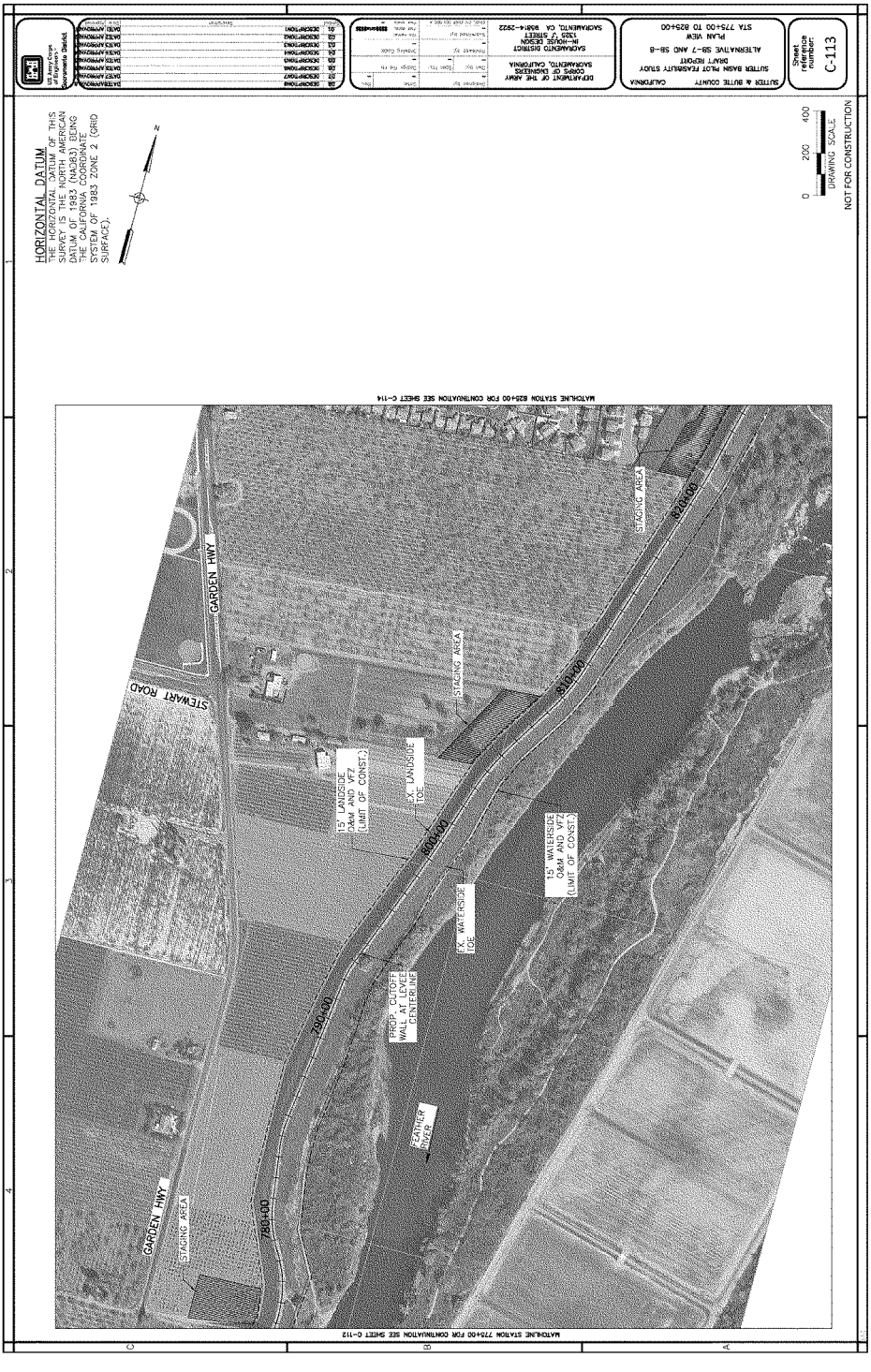
US Army Corps of Engineers®
Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA 725+00 TO 775+00

Sheet reference number:
C-112


HORIZONTAL DATUM
THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).
N
0 200 400
DRAWING SCALE
NOT FOR CONSTRUCTION
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA 775+00 TO 825+00
Sheet number: C-113
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 J STREET
SACRAMENTO, CA 95814-2922
US Army Corps of Engineers
Sacramento District
DATE APPROVED
DESCRIPTION
NO.
MATCHLINE STATION 775+00 FOR CONTINUATION SEE SHEET C-112
MATCHLINE STATION 825+00 FOR CONTINUATION SEE SHEET C-114
CARDEN HWY
STEWART ROAD
STAGING AREA
STAGING AREA
STAGING AREA
CARDEN HWY
15' LANDSIDE O&M AND VFZ (LIMIT OF CONST.)
15' WATERSIDE O&M AND VFZ (LIMIT OF CONST.)
PROP. CUTOFF WALL AT LEVEE CENTERLINE
EX. LANDSIDE TOE
EX. WATERSIDE TOE
FEATHER RIVER
750+00
800+00
850+00
900+00

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

N

0 200 400
DRAWING SCALE

NOT FOR CONSTRUCTION

US Army Corps of Engineers®
Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA 825+00 TO 875+00

Sheet reference number:
C-114

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

N

0 200 400
DRAWING SCALE

NOT FOR CONSTRUCTION

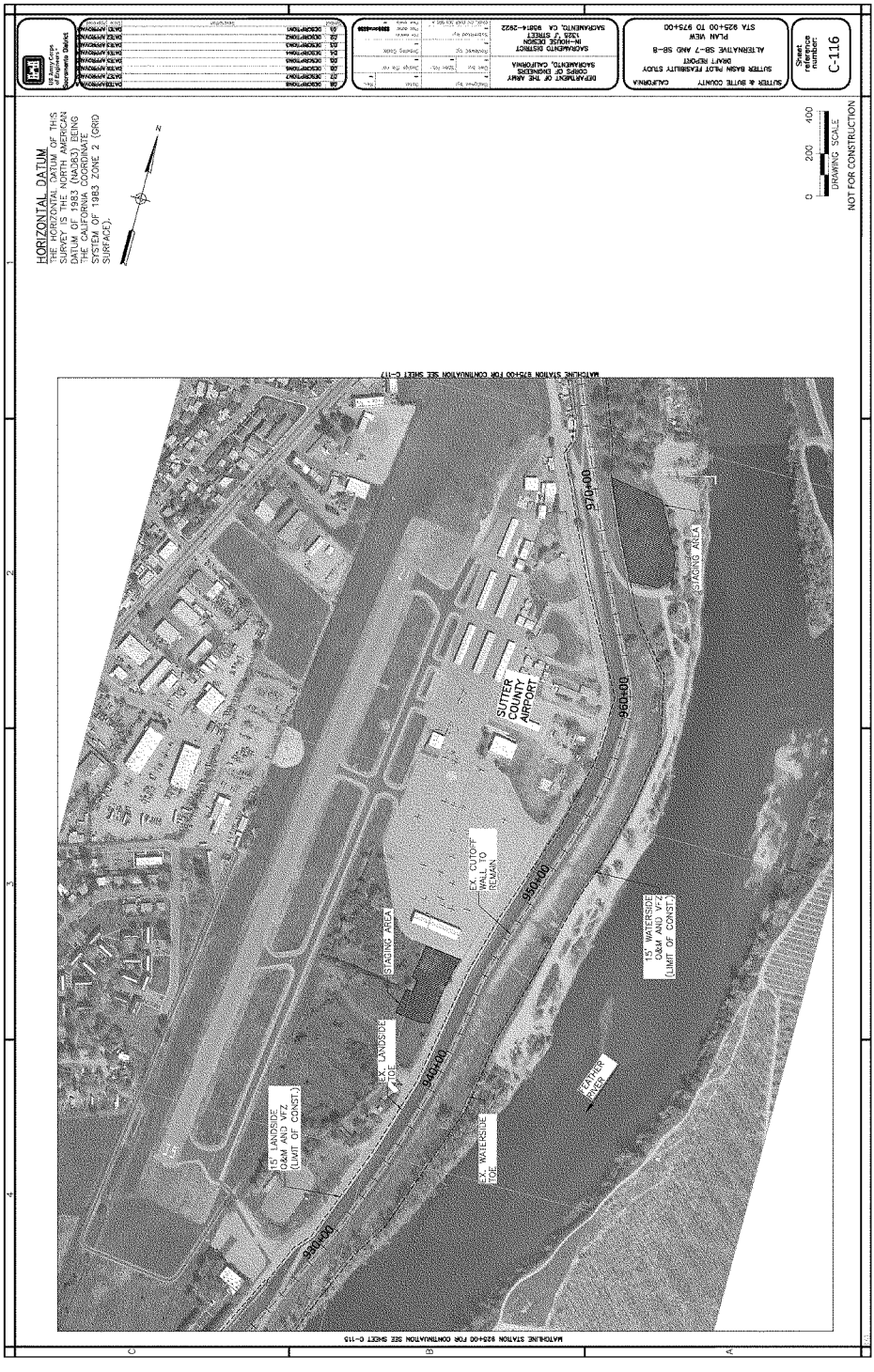
US Army Corps of Engineers
Sacramento District

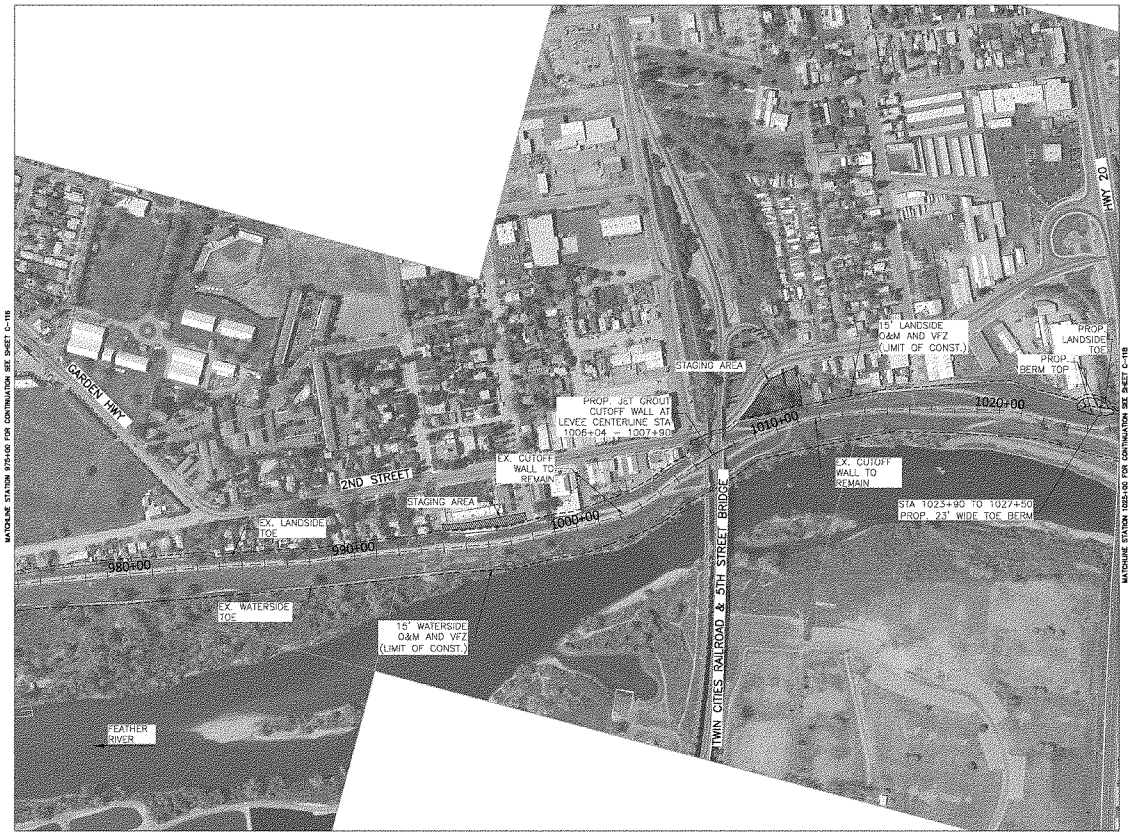
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA 875+00 TO 925+00

Sheet reference number:
C-115


SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
ALTERNATIVE SB-7 AND SB-8
DRAFT REPORT
PLAN VIEW
STA 925+00 TO 975+00
Sheet reference number: C-116
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 J STREET
SACRAMENTO, CA 95814-2922
US Army Corps of Engineers Sacramento District
HORIZONTAL DATUM
THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD 83) FOR THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).
N
0 200 400
DRAWING SCALE
NOT FOR CONSTRUCTION
MATCHLINE STATION 925+00 FOR CONTINUATION SEE SHEET C-115
MATCHLINE STATION 925+00 FOR CONTINUATION SEE SHEET C-117
970+00
960+00
950+00
940+00
SUTTER COUNTY AIRPORT
STAGING AREA
STAGING AREA
EX. CUTOFF WALL TO REMAIN
EX. LANDSIDE TOE
EX. WATERSIDE TOE
15' LANDSIDE O&M AND VTZ (LIMIT OF CONST.)
15' WATERSIDE O&M AND VTZ (LIMIT OF CONST.)
EXPEH AREA



HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

N

0 200 400
DRAWING SCALE

NOT FOR CONSTRUCTION

US Army Corps of Engineers
Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA 975+00 TO 1025+00

Sheet reference number:
C-117

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

N

0 200 400
DRAWING SCALE

NOT FOR CONSTRUCTION

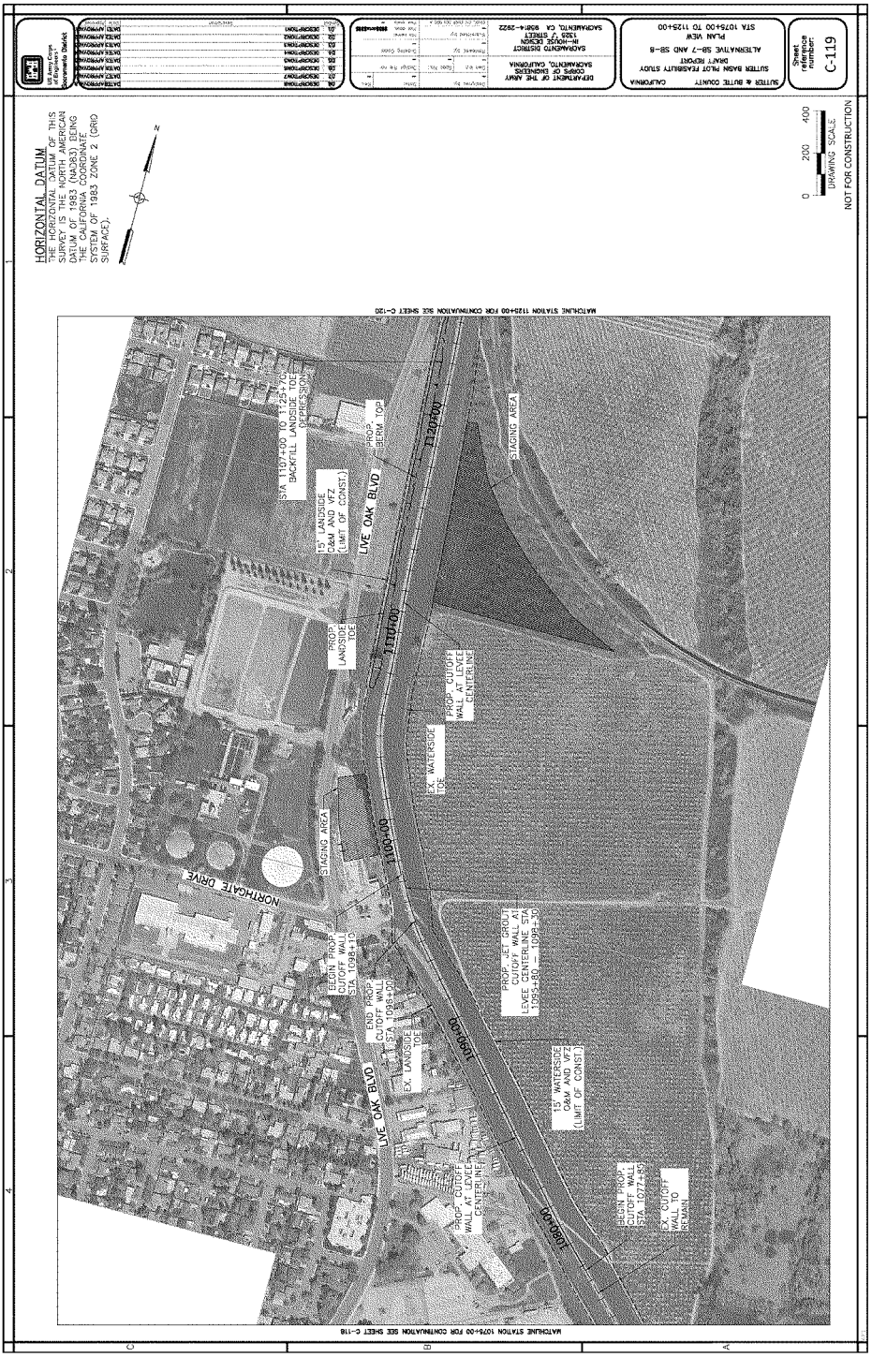
US Army Corps of Engineers
Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 J STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA 1025+00 TO 1075+00

Sheet reference number:
C-118


HORIZONTAL DATUM
THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83), BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983, ZONE 2 (GRID SURFACE).
N
0 200 400
DRAWING SCALE
NOT FOR CONSTRUCTION
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
SUTTER & BUTTE COUNTY CALIFORNIA
STA 1075+00 TO 1125+00
Sheet number:
C-119
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 J STREET
SACRAMENTO, CA 95814-2922
US Army Corps of Engineers
Sacramento District
MATCHLINE STATION 1125+00 FOR CONTINUATION SEE SHEET C-120
MATCHLINE STATION 1075+00 FOR CONTINUATION SEE SHEET C-118
LIVE OAK BLVD
NORTHGATE DRIVE
STAGING AREA
PROP. BERM TOP
PROP. LANDSIDE TOE
EX. LANDSIDE DAM AND VEZ (LIMIT OF CONST.)
EX. WATERSIDE TOE
PROP. CUTOFF WALL AT LEVEE CENTERLINE
PROP. CUTOFF WALL AT LEVEE CENTERLINE STA 1091+80 – 1098+50
BEGIN PROP. CUTOFF WALL STA 1098+10
END PROP. CUTOFF WALL STA 1098+50
BEGIN PROP. CUTOFF WALL STA 1077+85
EX. CUTOFF WALL TO REMAIN
STA 1107+00 TO 1125+00 BACKFILL LANDSIDE DEPRESSION
1120+00
1110+00
1100+00
1090+00
1080+00

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

N

0 200 400
DRAWING SCALE
NOT FOR CONSTRUCTION

US Army Corps of Engineers®
Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA 1125+00 TO 1175+00

Sheet reference number:
C-120

HORIZONTAL DATUM
THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).
N
0 200 400
DRAWING SCALE
NOT FOR CONSTRUCTION
SUTTER BASIN PILOT FEASIBILITY STUDY
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA 1175+00 TO 1225+00
SUTTER & BUTTE COUNTY CALIFORNIA
Sheet reference number:
C-121
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 J STREET
SACRAMENTO, CA 95814-2922
US Army Corps of Engineers Sacramento District
MATCHLINE STATION 1175+00 FOR CONTINUATION SEE SHEET C-120
MATCHLINE STATION 1225+00 FOR CONTINUATION SEE SHEET C-122
REDHALL ROAD
STAGING AREA
PROP. CUTOFF WALL AT LEVEE CENTERLINE
EX. WATERSIDE TOE
EX. LANDSIDE TOE
15' LANDSIDE O&M AND VFZ (LIMIT OF CONST.)
15' WATERSIDE O&M AND VFZ (LIMIT OF CONST.)
1180+00
1190+00
1200+00
1210+00
1220+00
FEATHER RIVER

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

N

0 200 400
DRAWING SCALE

NOT FOR CONSTRUCTION

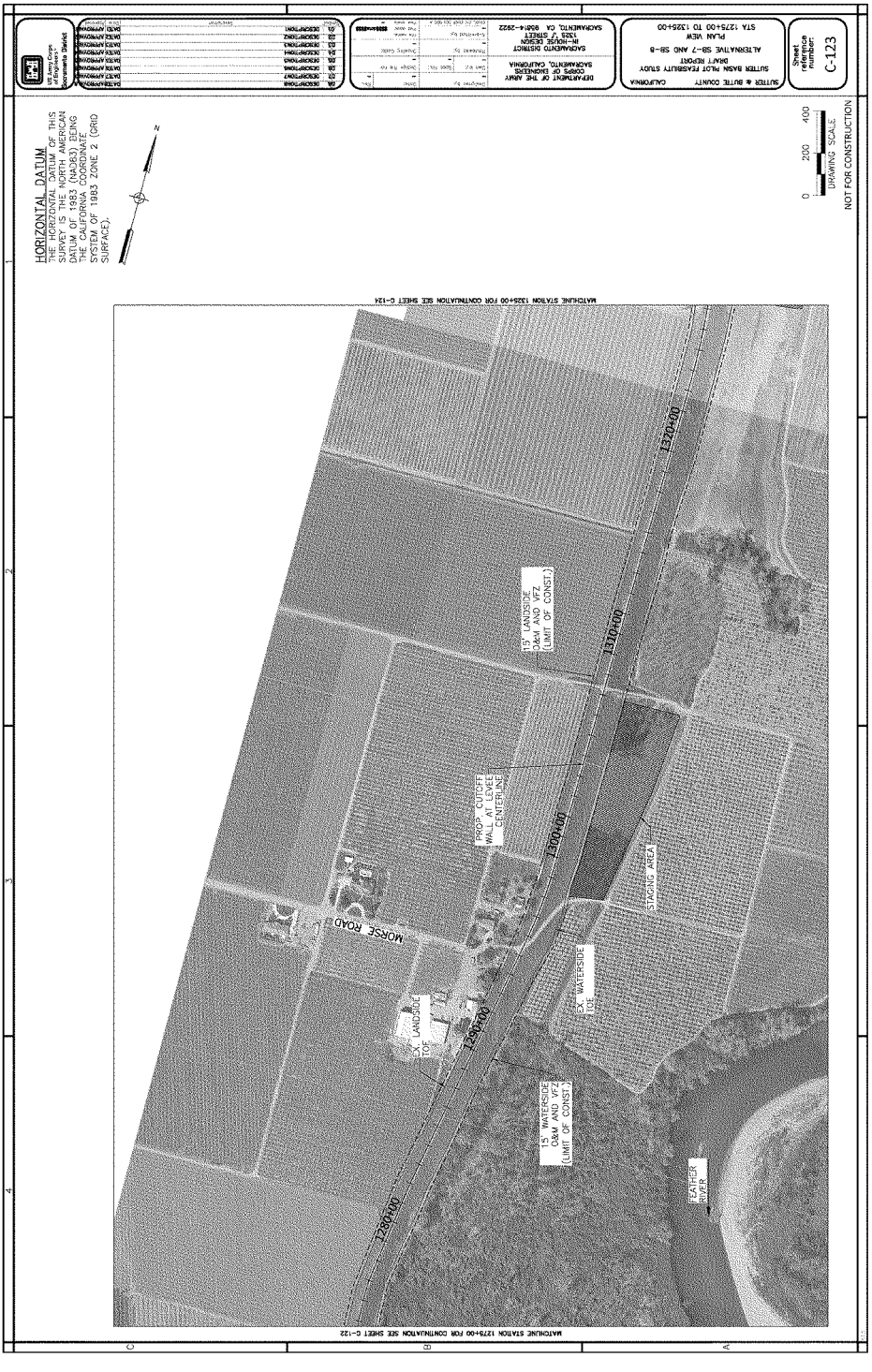
US Army Corps of Engineers
Sacramento District

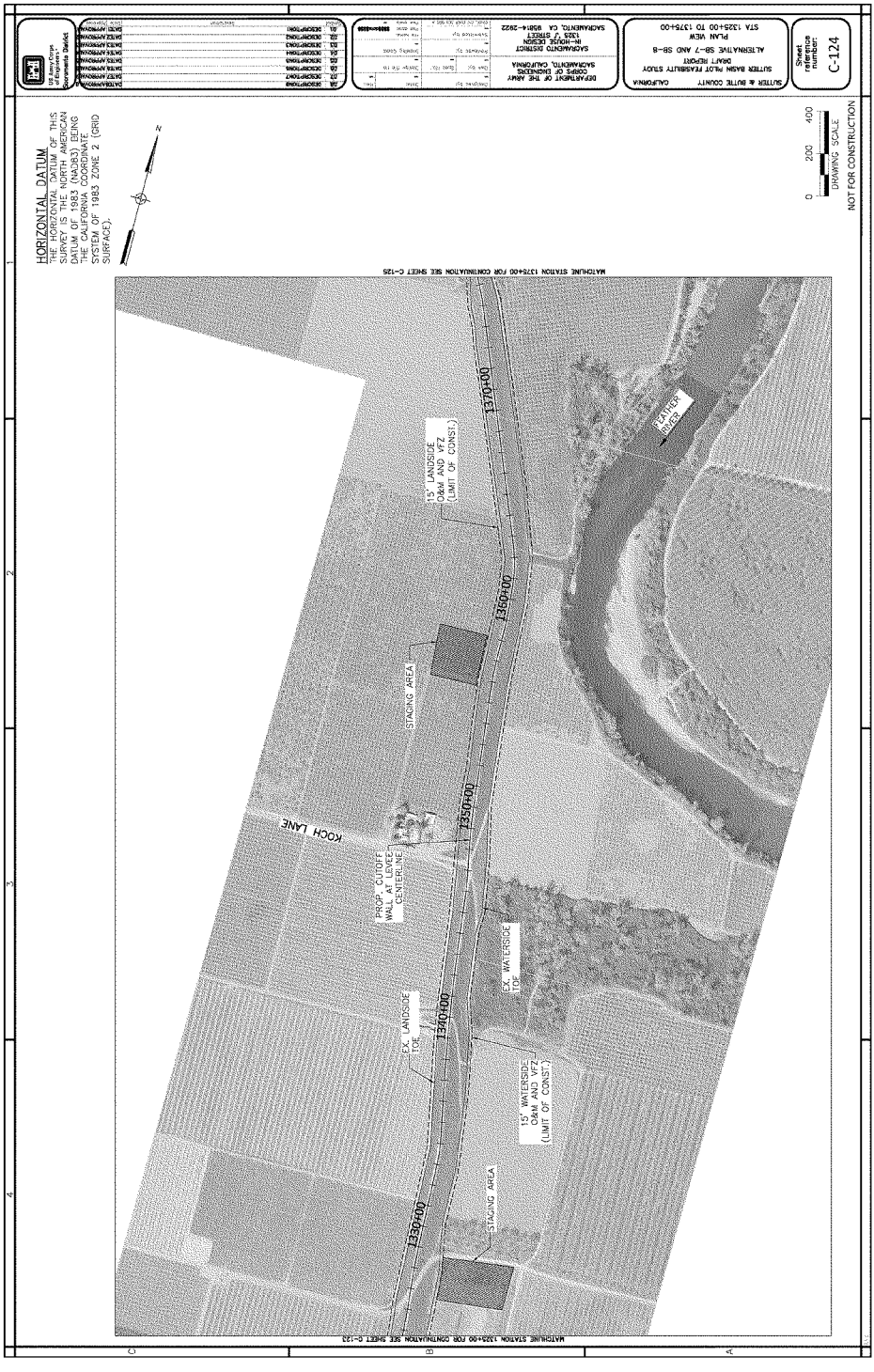
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

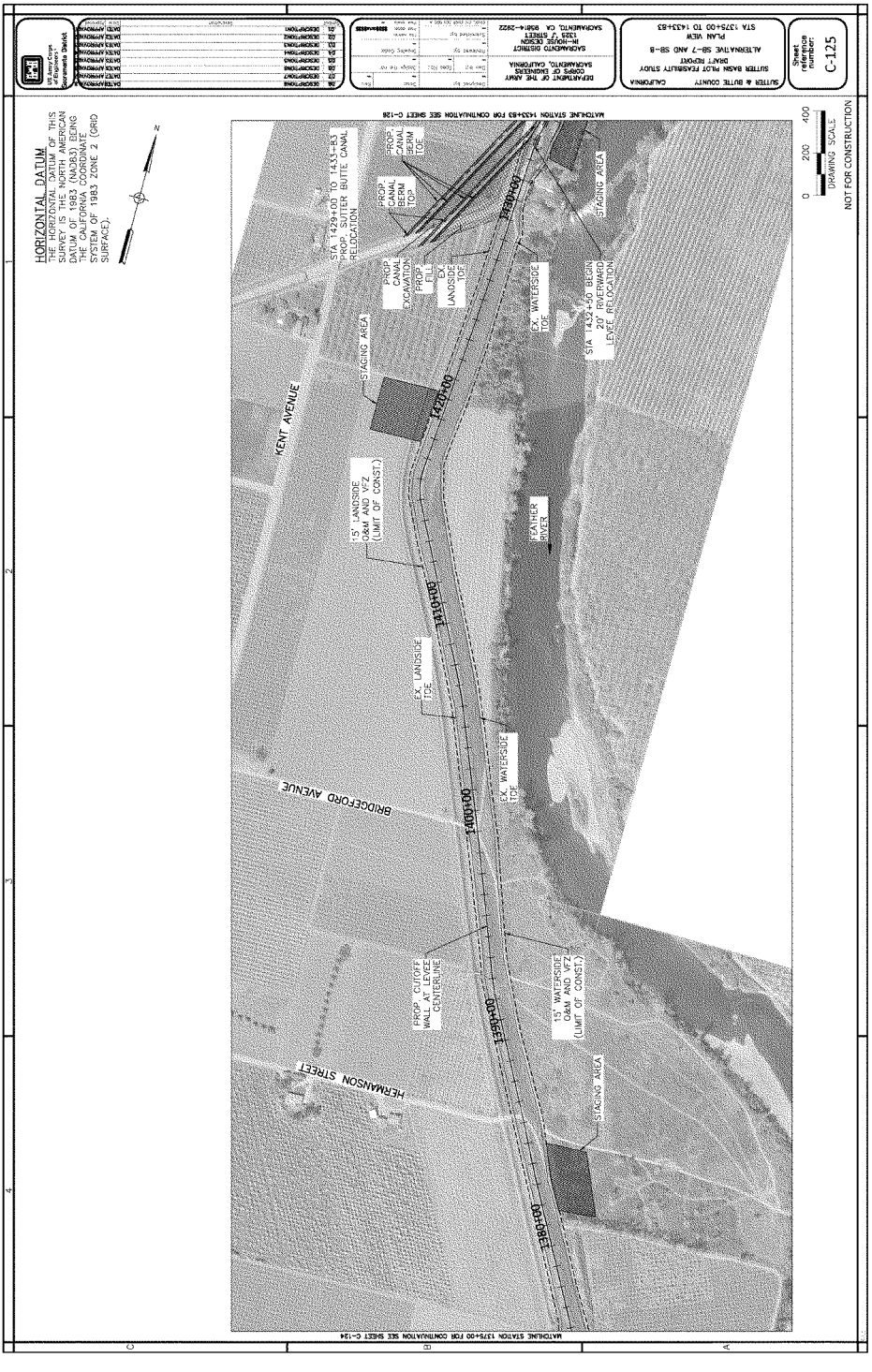
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

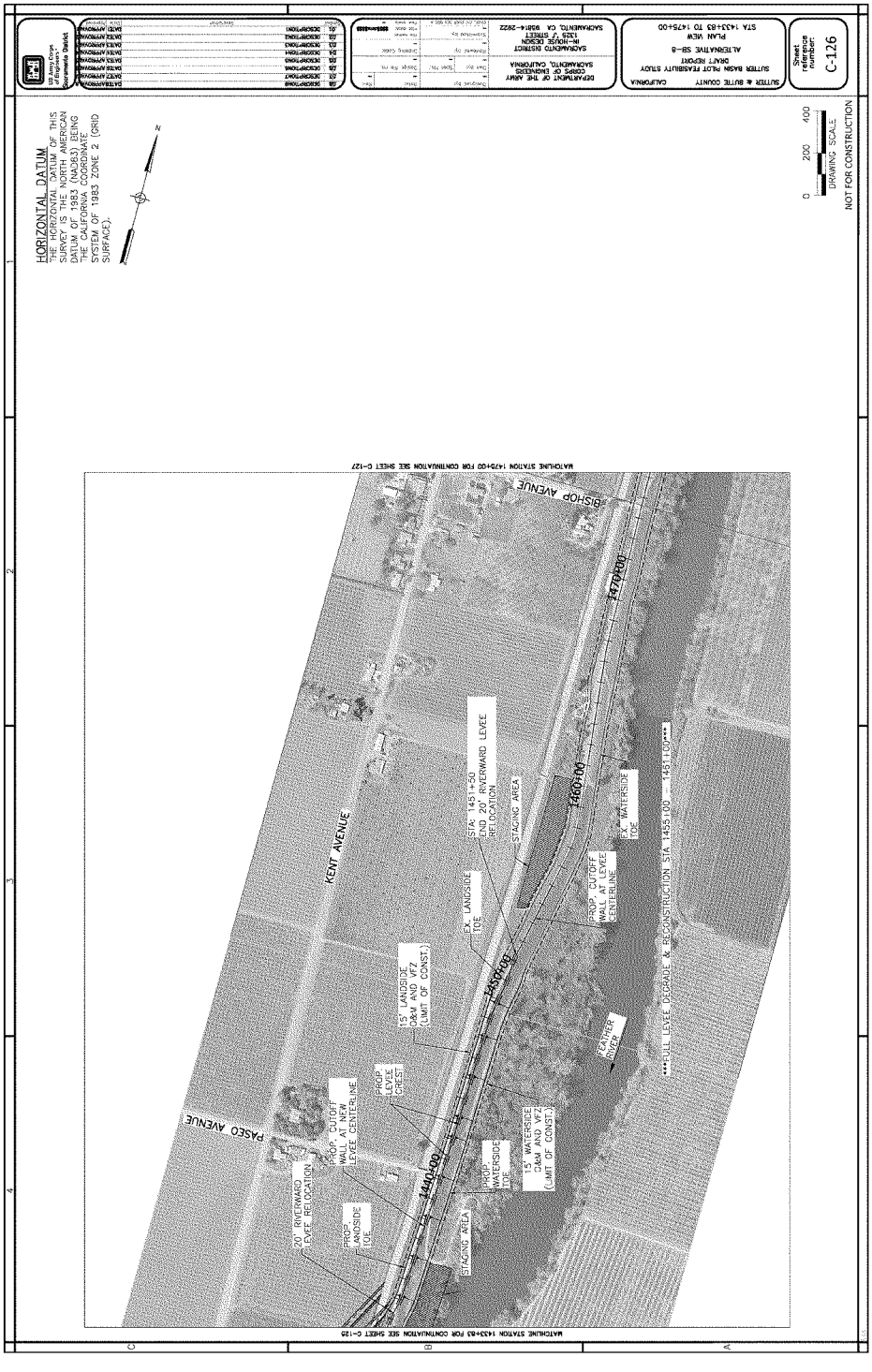
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA 1225+00 TO 1275+00

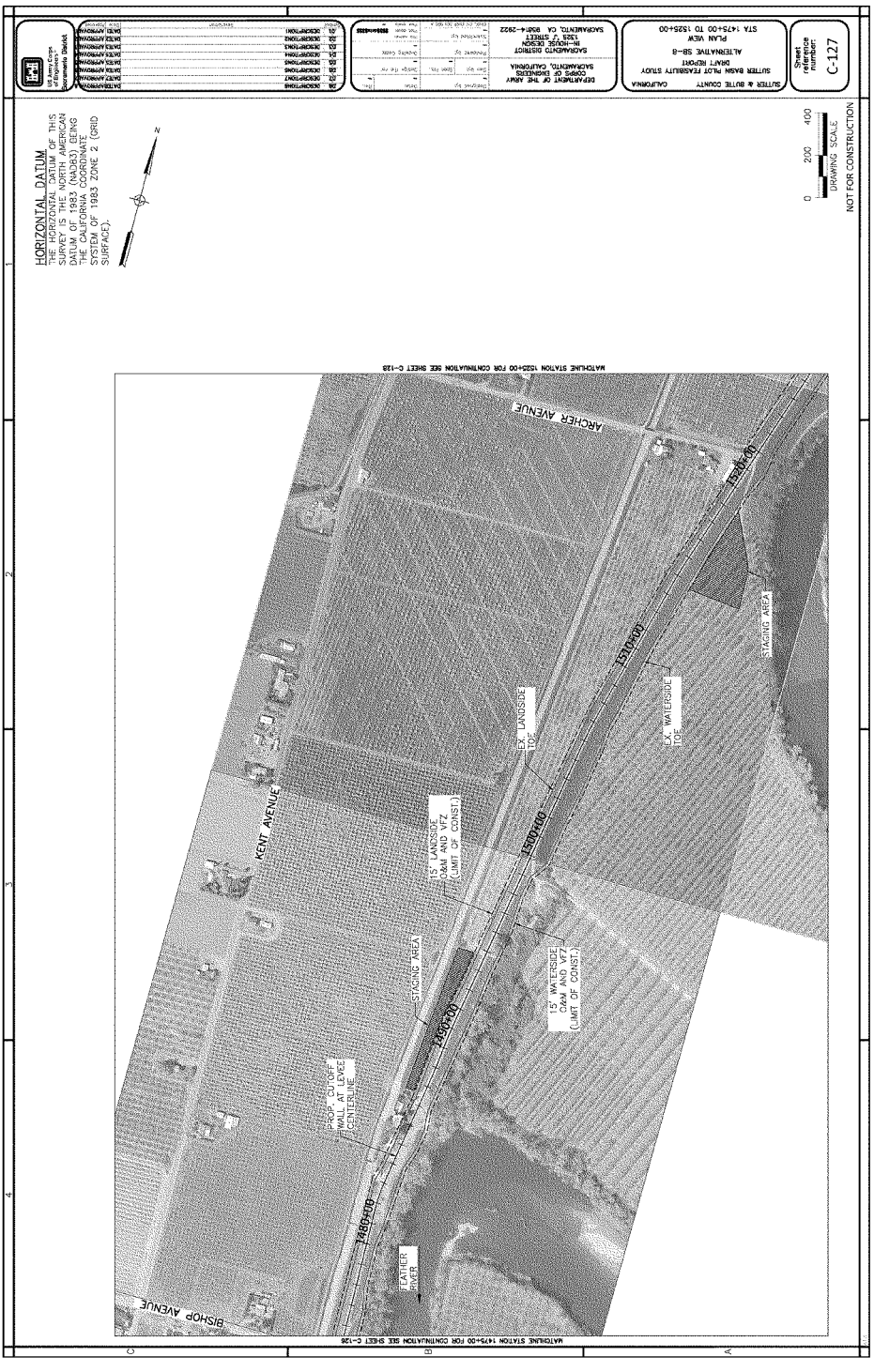
Sheet reference number:
C-122

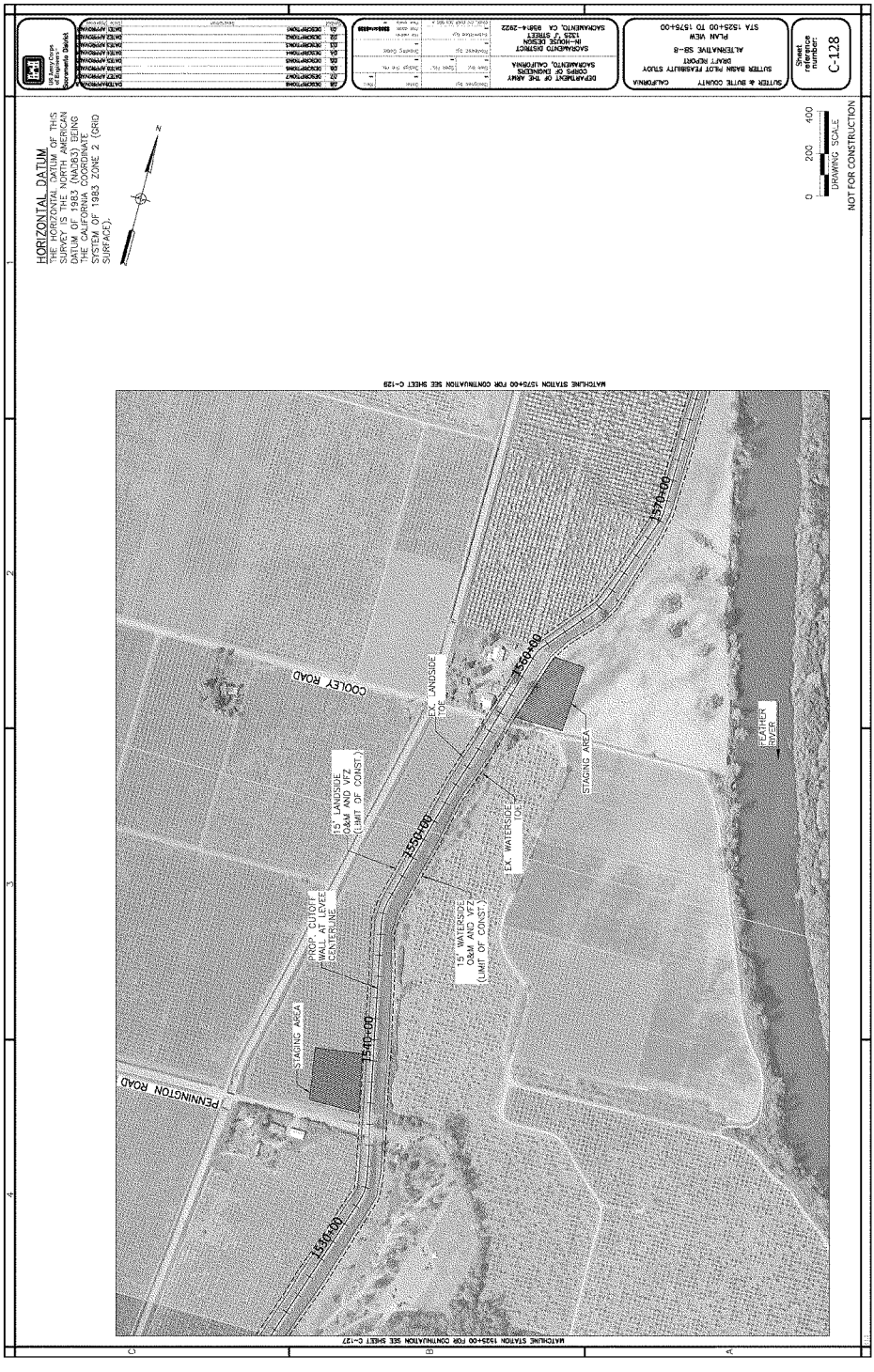

HORIZONTAL DATUM
THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).
N
0 200 400
DRAWING SCALE
NOT FOR CONSTRUCTION
MATCHLINE STATION 1325+00 FOR CONTINUATION SEE SHEET C-124
MATCHLINE STATION 1275+00 FOR CONTINUATION SEE SHEET C-122
1330+00
1310+00
1290+00
1270+00
MORSE ROAD
PROP. CUTOFF WALL ALIGNMENT CENTERLINE
EX. LANDSIDE TOE
EX. WATERSIDE TOE
15' LANDSIDE DSEM AND VFZ (LIMIT OF CONST.)
15' WATERSIDE DSEM AND VFZ (LIMIT OF CONST.)
STAGING AREA
FEATHER RIVER
SUTTER BASIN PILOT FEASIBILITY STUDY
ALTERNATIVE SB-7 AND SB-8
DRAFT REPORT
PLAN VIEW
STA 1275+00 TO 1325+00
SUTTER & BUTTE COUNTY CALIFORNIA
Sheet number: C-123
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 J STREET
SACRAMENTO, CA 95814-2922
US Army Corps of Engineers Sacramento District

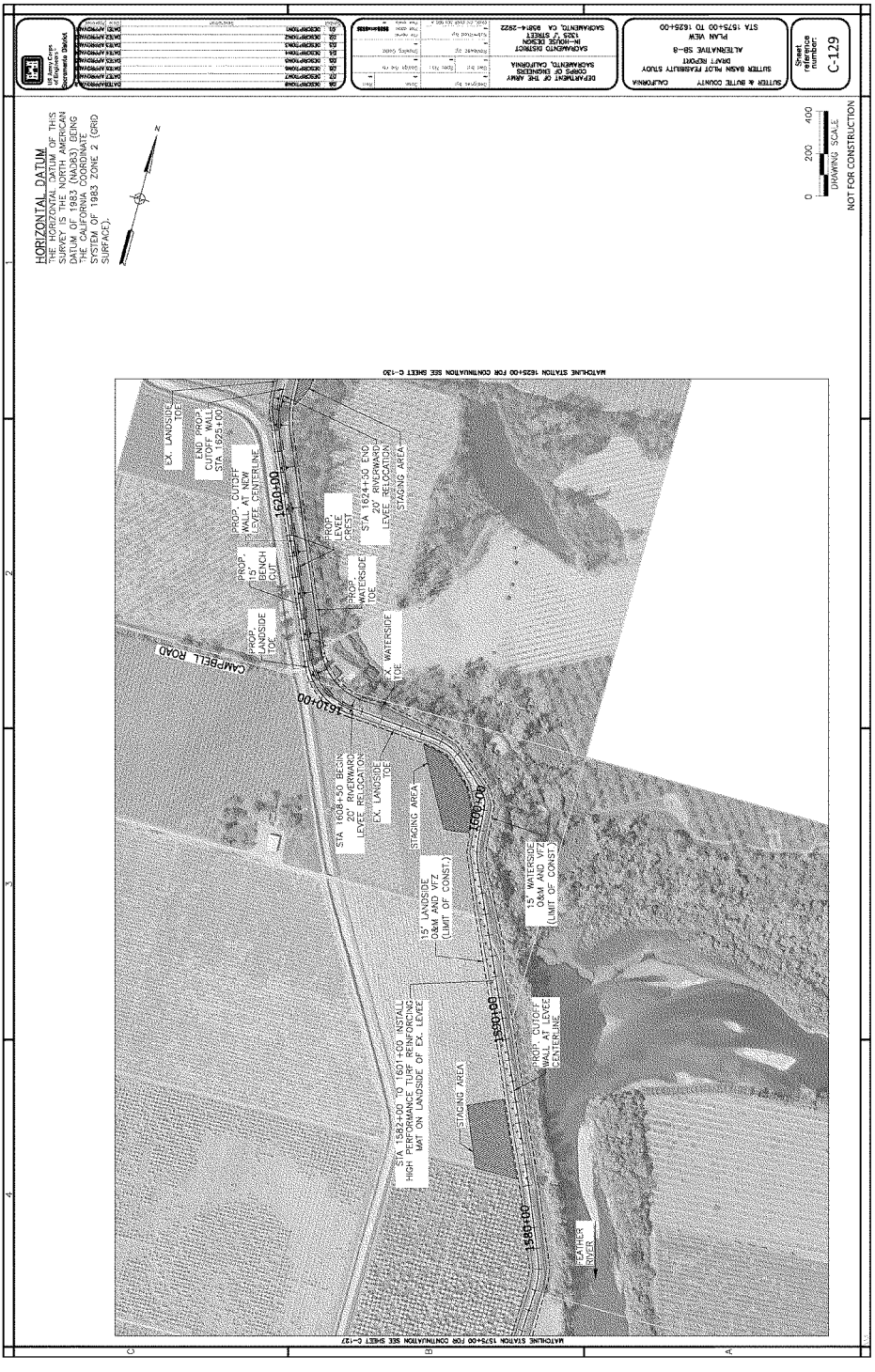

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
ALTERNATIVE SB-7 AND SB-8
DRAFT REPORT
PLAN VIEW
STA 1325+00 TO 1375+00
Sheet reference number: C-124
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
SACRAMENTO, CALIFORNIA
1325 J STREET
SACRAMENTO, CA 95814-2922
DRAWING SCALE
0 200 400
NOT FOR CONSTRUCTION
HORIZONTAL DATUM
THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) FOR THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).
N
MATCHLINE STATION 1325+00 FOR CONTINUATION SEE SHEET C-123
MATCHLINE STATION 1375+00 FOR CONTINUATION SEE SHEET C-125
1370+00
1360+00
1350+00
1340+00
1330+00
15' LANDSIDE BERM AND JPZ (LIMIT OF CONST.)
15' WATERSIDE BERM AND JPZ (LIMIT OF CONST.)
EX. LANDSIDE TOE
EX. WATERSIDE TOE
PROP. CUTOFF WALL & LEVEE CENTERLINE
STAGING AREA
STAGING AREA
KOCH LANE
FEATHER RIVER


SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PLAN VIEW
STA 1373+00 TO 1431+83
SUTTER & BUTTE COUNTY CALIFORNIA
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
SACRAMENTO, CALIFORNIA
1329 J STREET
SACRAMENTO, CA 95814-2922
Sheet number: C-125
HORIZONTAL DATUM
THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83), BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983, ZONE 2 (GRID SURFACE).
N
MATCHLINE STATION 1431+83 FOR CONTINUATION SEE SHEET C-124
MATCHLINE STATION 1373+00 FOR CONTINUATION SEE SHEET C-124
KENT AVENUE
BRIDGEFORD AVENUE
HERMANSON STREET
STA 1429+40 TO 1433+83 PROP. SUTTER BUTTE CANAL RELOCATION
PROP. CANAL BERM TOE
PROP. CANAL EXCAVATION
PROP. FILL
EX. LANDSIDE TOE
EX. WATERSIDE TOE
STAGING AREA
STA 1432+60 BEGIN 20' RIVERWARD LEVEE RELOCATION
15' LANDSIDE O&M AND VFZ (LIMIT OF CONST.)
EX. LANDSIDE TOE
FEATHER RIVER
PROP. CUTOFF WALL AT LEVEE CENTERLINE
15' WATERSIDE O&M AND VFZ (LIMIT OF CONST.)
1400+00
1410+00
1420+00
1430+00
1390+00
1380+00
0
200
400
DRAWING SCALE
NOT FOR CONSTRUCTION


SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
ALTERNATIVE SB-8
DRAFT REPORT
PLAN VIEW
STA 1433+83 TO 1475+00
Sheet reference number: C-126
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
SACRAMENTO, CALIFORNIA
1325 J STREET
SACRAMENTO, CA 95814-2922
US Army Corps of Engineers Sacramento District
HORIZONTAL DATUM
THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) FOR THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).
N
0 200 400
DRAWING SCALE
NOT FOR CONSTRUCTION
MATCHLINE STATION 1433+83 FOR CONTINUATION SEE SHEET C-125
MATCHLINE STATION 1475+00 FOR CONTINUATION SEE SHEET C-127
PASEO AVENUE
KENT AVENUE
BISHOP AVENUE
1440+00
1450+00
1460+00
1470+00
30' RIVERWARD LEVEE RELOCATION
PROP. LANDSIDE TOE
PROP. CUTOFF WALL AT NEW LEVEE CENTERLINE
PROP. LEVEE CREST
PROP. WATERSIDE TOE
15' WATERSIDE O&M AND VFZ (LIMIT OF CONST)
STAGING AREA
15' LANDSIDE O&M AND VFZ (LIMIT OF CONST)
EX. LANDSIDE TOE
STA. 1451+50 END 20' RIVERWARD LEVEE RELOCATION
STAGING AREA
PROP. CUTOFF WALL AT LEVEE CENTERLINE
EX. WATERSIDE TOE
FEATHER RIVER
****FULL LEVEE DEGRADE & RECONSTRUCTION STA 1455+00 - 1461+00****


HORIZONTAL DATUM
THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83), BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).
N
0 200 400
DRAWING SCALE
NOT FOR CONSTRUCTION
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PLAN VIEW
STA 1+75+00 TO 15+25+00
Sheet number: C-127
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 J STREET
SACRAMENTO, CA 95814-2922
US Army Corps of Engineers Sacramento District
MATCHLINE STATION 15+25+00 FOR CONTINUATION SEE SHEET C-128
MATCHLINE STATION 1+75+00 FOR CONTINUATION SEE SHEET C-126
KENT AVENUE
ARCHER AVENUE
BISHOP AVENUE
PROP. CUTOFF WALL AT LEVEE CENTERLINE
FEATHER RIVER
STAGING AREA
STAGING AREA
15' LANDSIDE O&M AND VFZ (LIMIT OF CONST.)
15' WATERSIDE O&M AND VFZ (LIMIT OF CONST.)
EX. LANDSIDE TOE
EX. WATERSIDE TOE
100+00ST
100+00ST
100+00ST
100+00ST
100+00ST


HORIZONTAL DATUM
THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).
N
0 200 400
DRAWING SCALE
NOT FOR CONSTRUCTION
MATCHLINE STATION 1575+00 FOR CONTINUATION SEE SHEET C-129
MATCHLINE STATION 1525+00 FOR CONTINUATION SEE SHEET C-127
COOLEY ROAD
PENNINGTON ROAD
1530+00
1540+00
1550+00
1560+00
1570+00
STAGING AREA
STAGING AREA
EX. LANDSIDE TOE
EX. WATERSIDE TOE
15' LANDSIDE O&M AND VFZ (LIMIT OF CONST.)
15' WATERSIDE O&M AND VFZ (LIMIT OF CONST.)
PROP. CUTOFF WALL AT LEVEE CENTERLINE
FEATHER RIVER
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PLAN VIEW
STA 1525+00 TO 1575+00
Sheet reference number:
C-128
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922
US Army Corps of Engineers Sacramento District


HORIZONTAL DATUM
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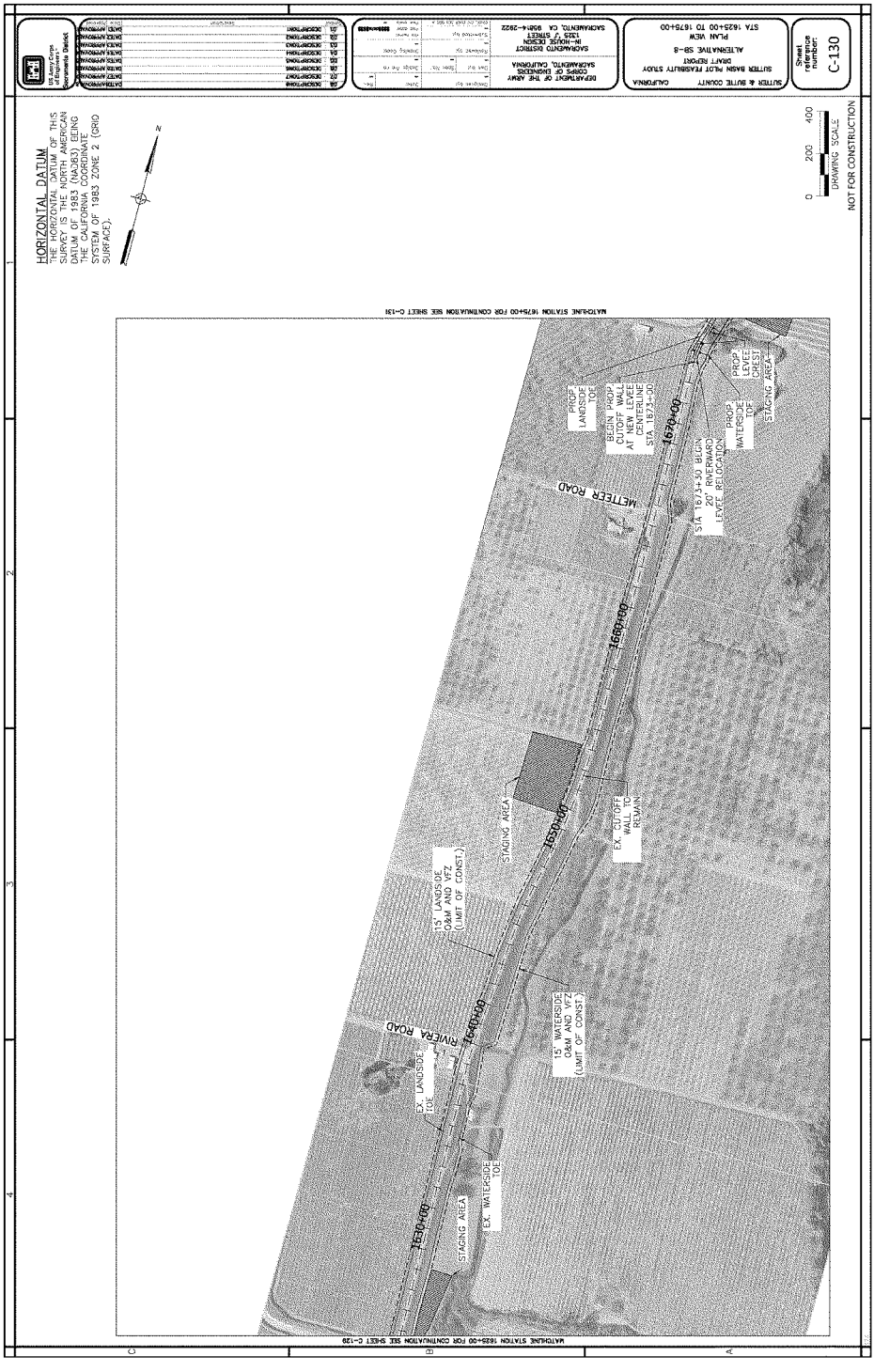
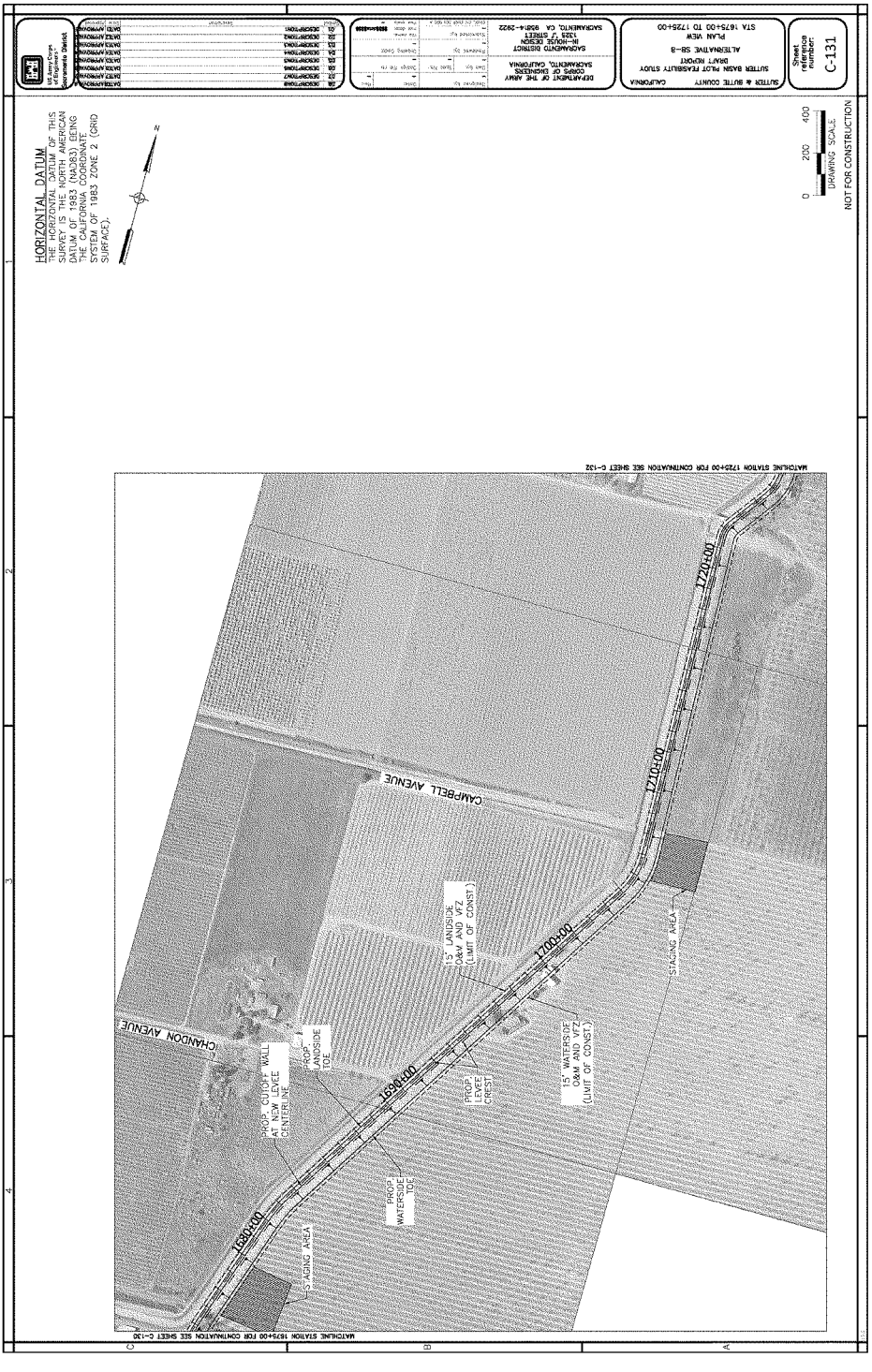
N
0 200 400
DRAWING SCALE
NOT FOR CONSTRUCTION
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PLAN VIEW
STA 1575+00 TO 1625+00
Sheet number: C-129
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
1325 J STREET
SACRAMENTO, CA 95814-2922
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
US Army Corps of Engineers
Sacramento District
MATCHLINE STATION 1625+00 FOR CONTINUATION SEE SHEET C-130
MATCHLINE STATION 1575+00 FOR CONTINUATION SEE SHEET C-127
CAMPBELL ROAD
EX. LANDSIDE TOE
END PROP. CUTOFF WALL STA 1625+00
PROP. CUTOFF WALL AT NEW LEVEE CENTERLINE
PROP. 15' BENCH CUT
PROP. LANDSIDE TOE
PROP. LEVEE CREST
PROP. WATERSIDE TOE
STA 1624+50 END 20' RIVERWARD LEVEE RELOCATION
STAGING AREA
EX. WATERSIDE TOE
1620+00
1610+00
STA 1608+50 BEGIN 20' RIVERWARD LEVEE RELOCATION
EX. LANDSIDE TOE
STAGING AREA
1600+00
15' LANDSIDE O&M AND VFZ (LIMIT OF CONST.)
15' WATERSIDE O&M AND VFZ (LIMIT OF CONST.)
1590+00
STA 1582+00 TO 1601+00 INSTALL HIGH PERFORMANCE TURF REINFORCING MAT ON LANDSIDE OF EX. LEVEE
STAGING AREA
PROP. CUTOFF WALL AT LEVEE CENTERLINE
1580+00
FEATHER RIVER


SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
ALTERNATIVE SB-8
DRAFT REPORT
PLAN VIEW
STA 1623+00 TO 1675+00
Sheet reference number: C-130
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 J STREET
SACRAMENTO, CA 95814-2922
US Army Corps of Engineers Sacramento District
HORIZONTAL DATUM
THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).
N
0 200 400
DRAWING SCALE
NOT FOR CONSTRUCTION
MATCHLINE STATION 1675+00 FOR CONTINUATION SEE SHEET C-131
MATCHLINE STATION 1623+00 FOR CONTINUATION SEE SHEET C-129
METTEER ROAD
RIVIERA ROAD
1680+00
1670+00
1650+00
1640+00
1630+00
PROP LANDSIDE TOE
BEGIN PROP CUTOFF WALL AT NEW LEVEE ALIGNMENT STA 1674+00
STA 1673+50 BEGIN 20' RIVERWARD LEVEE RELOCATION
PROP WATERSIDE TOE
PROP CREST
PROP STAGING AREA
STAGING AREA
EX. CUTOFF WALL TO REMAIN
15' LANDSIDE O&M AND VFZ (LIMIT OF CONST.)
15' WATERSIDE O&M AND VFZ (LIMIT OF CONST.)
EX. LANDSIDE TOE
EX. WATERSIDE TOE
STAGING AREA


HORIZONTAL DATUM
THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).
N
0 200 400
DRAWING SCALE
NOT FOR CONSTRUCTION
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PLAN VIEW
STA 1675+00 TO 1725+00
Sheet Number: C-131
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 J STREET
SACRAMENTO, CA 95814-2922
U.S. Army Corps of Engineers
Sacramento District
MATCHLINE STATION 1675+00 FOR CONTINUATION SEE SHEET C-132
MATCHLINE STATION 1725+00 FOR CONTINUATION SEE SHEET C-132
CHANDON AVENUE
CAMPBELL AVENUE
1690+00
1700+00
1710+00
1720+00
PROP. CUTOFF WALL AT NEW LEVEE CENTERLINE
PROP. LANDSIDE TOE
PROP. WATERSIDE TOE
PROP. LEVEE CREST
15' LANDSIDE O&M AND VFZ (LIMIT OF CONST.)
15' WATERSIDE O&M AND VFZ (LIMIT OF CONST.)
STAGING AREA
STAGING AREA

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

0 200 400
DRAWING SCALE

NOT FOR CONSTRUCTION

US Army Corps of Engineers
Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 J STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PLAN VIEW
STA 1725+00 TO 1775+00

Sheet reference number:
C-132

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

N

0 200 400
DRAWING SCALE

NOT FOR CONSTRUCTION

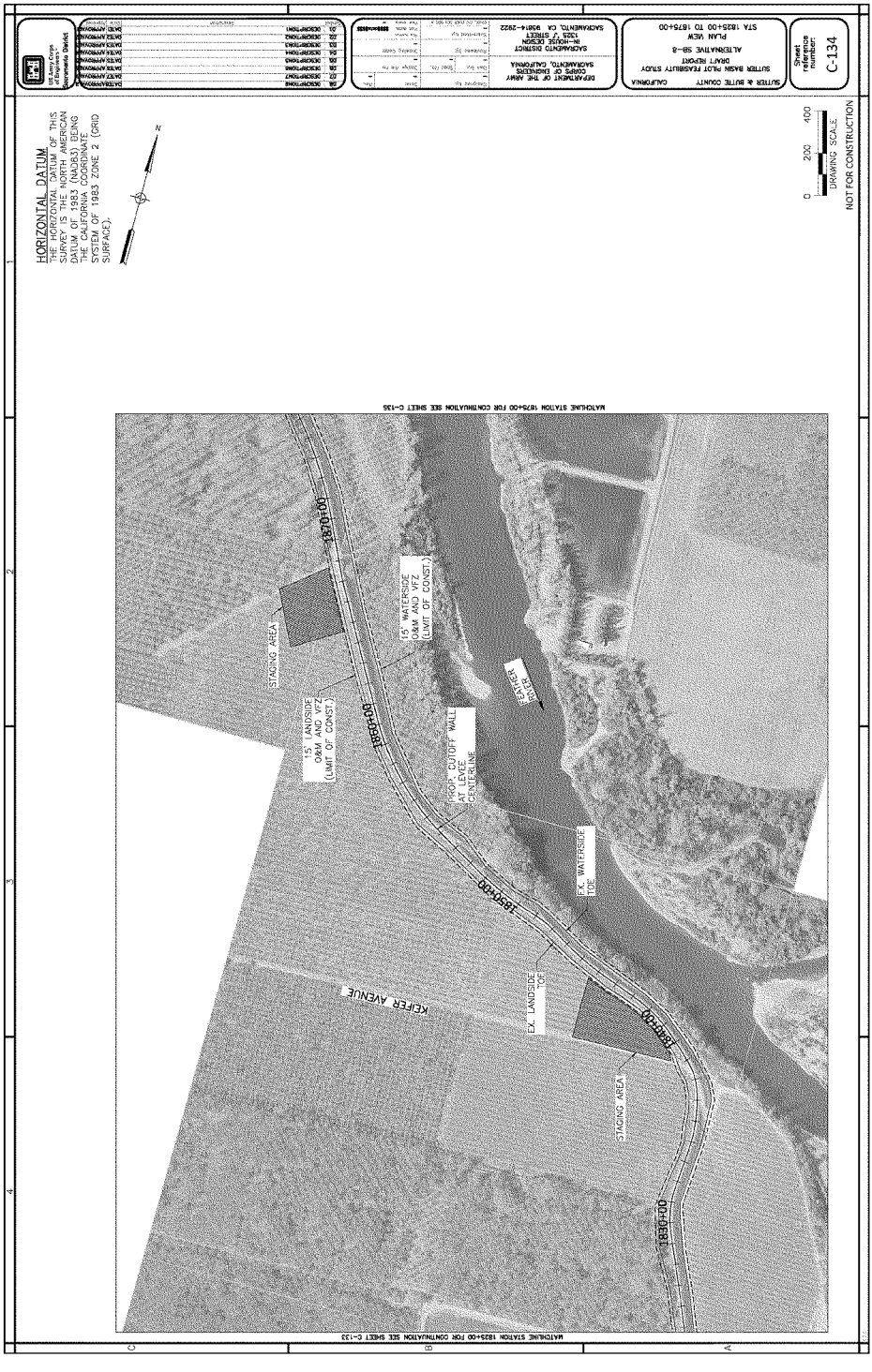
US Army Corps of Engineers
Sacramento District

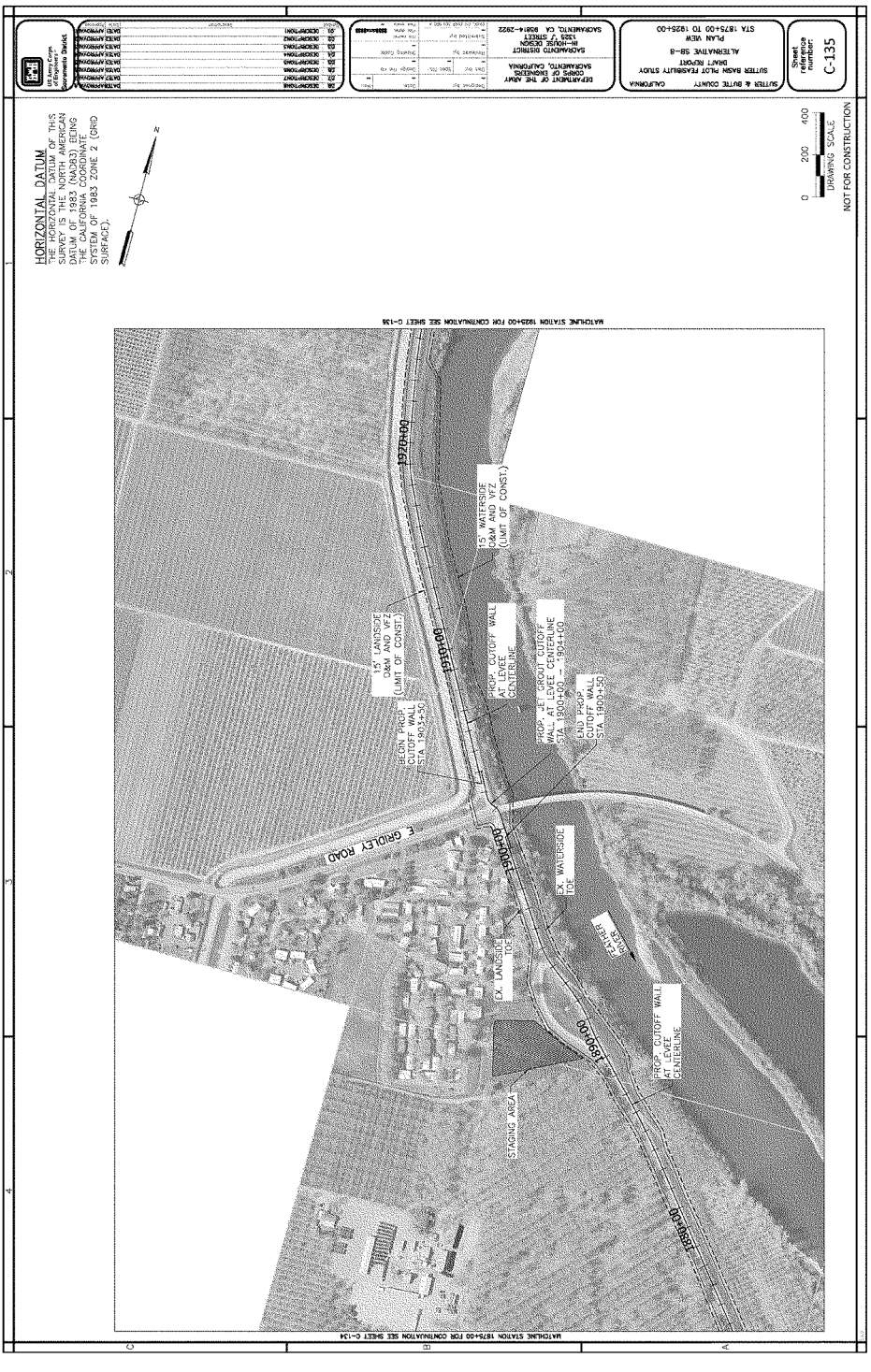
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PLAN VIEW
STA 1775+00 TO 1825+00

Sheet reference number:
C-133


SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
ALTERNATIVE SB-8
DRAFT REPORT
PLAN VIEW
STA 1825+00 TO 1875+00
Sheet reference number: C-134
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 J STREET
SACRAMENTO, CALIFORNIA 95814-2922
HORIZONTAL DATUM
THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD 83) FOR THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).
N
0 200 400
DRAWING SCALE
NOT FOR CONSTRUCTION
MATCHLINE STATION 1825+00 FOR CONTINUATION SEE SHEET C-133
MATCHLINE STATION 1875+00 FOR CONTINUATION SEE SHEET C-135
STAGING AREA
15' LANDSIDE O&M AND VFZ (LIMIT OF CONST.)
15' WATERSIDE O&M AND VFZ (LIMIT OF CONST.)
FEATHER RIVER
HDPE CUTOFF WALL AT LEVEE CENTERLINE
EX. WATERSIDE TOE
KEIFER AVENUE
EX. LANDSIDE TOE
1850+00
1900+00
1950+00
2000+00


HORIZONTAL DATUM
"THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83), BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).
N
0 200 400
DRAWING SCALE
NOT FOR CONSTRUCTION
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
ALTERNATIVE 2B-8
DRAFT REPORT
PLAN VIEW
STA 1875+00 TO 1925+00
Sheet number: C-135
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922
US Army Corps of Engineers Sacramento District
DESCRIPTION
DATE APPROVED
MATCHLINE STATION 1875+00 FOR CONTINUATION SEE SHEET C-134
MATCHLINE STATION 1925+00 FOR CONTINUATION SEE SHEET C-136
E GRIDLEY ROAD
1970+00
1940+00
1910+00
1880+00
1850+00
15' LANDSIDE O&M AND WE (LIMIT OF CONST.)
BEGIN PROP. CUTOFF WALL STA 1903+50
PROP CUTOFF WALL AT LEVEE CENTERLINE
15' WATERSIDE O&M AND WE (LIMIT OF CONST.)
PROP. JET GROUT CUTOFF WALL AT LEVEE CENTERLINE STA 1900+00 - 1904+00
LAND PROP. CUTOFF WALL STA 1900+50
EX. WATERSIDE TOE
EX. LANDSIDE TOE
STAGING AREA
PROP. CUTOFF WALL AT LEVEE CENTERLINE

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

N

0 200 400
DRAWING SCALE

NOT FOR CONSTRUCTION

US Army Corps of Engineers
Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PLAN VIEW
STA. 1925+00 TO 1975+00

Sheet reference number:
C-136

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

0 200 400
DRAWING SCALE

NOT FOR CONSTRUCTION

US Army Corps of Engineers
Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PLAN VIEW
STA 1975+00 TO 2025+00

Sheet reference number:
C-137

HORIZONTAL DATUM

THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).

N

0 200 400
DRAWING SCALE
NOT FOR CONSTRUCTION

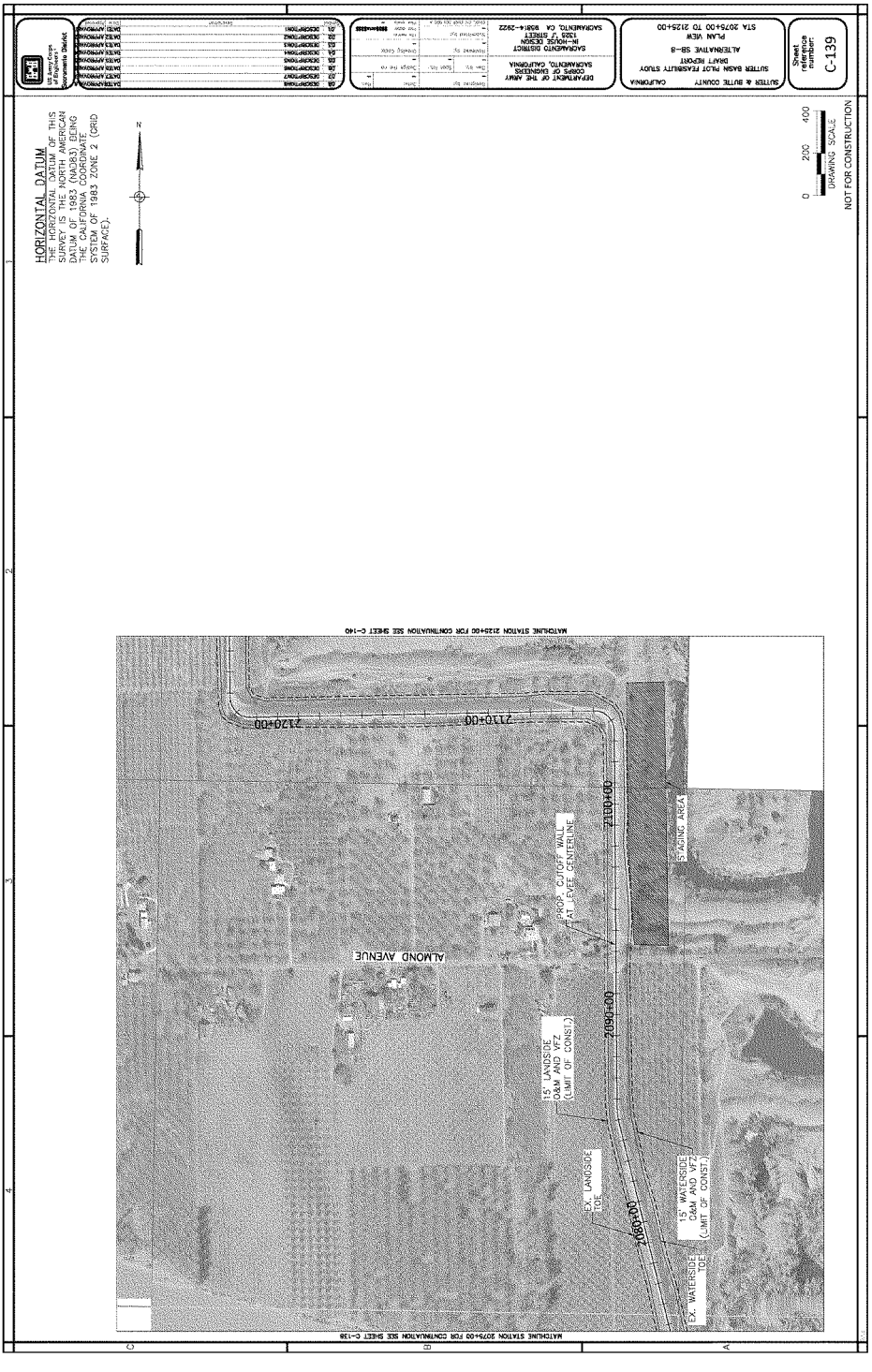
US Army Corps of Engineers®
Sacramento District

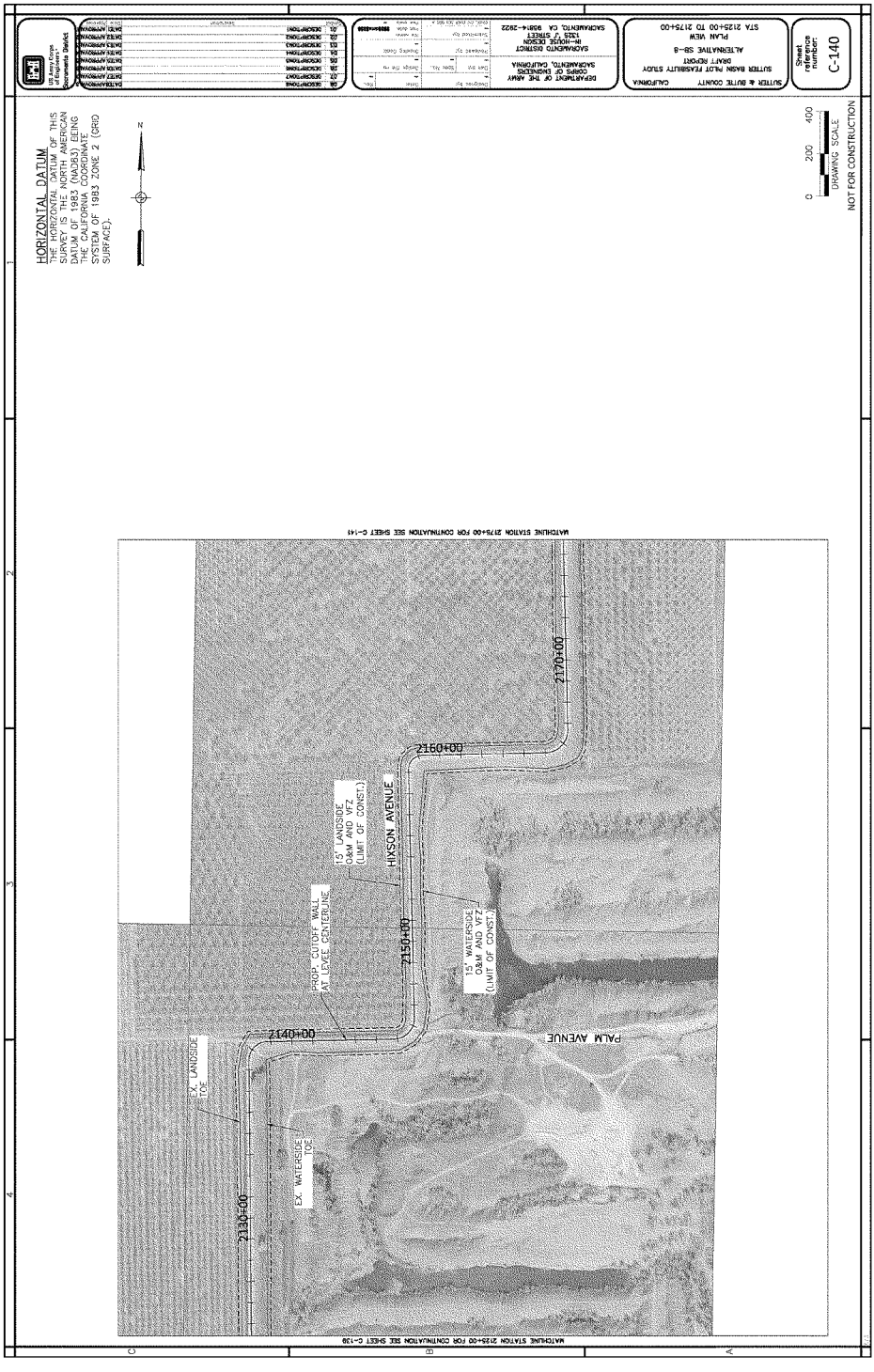
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

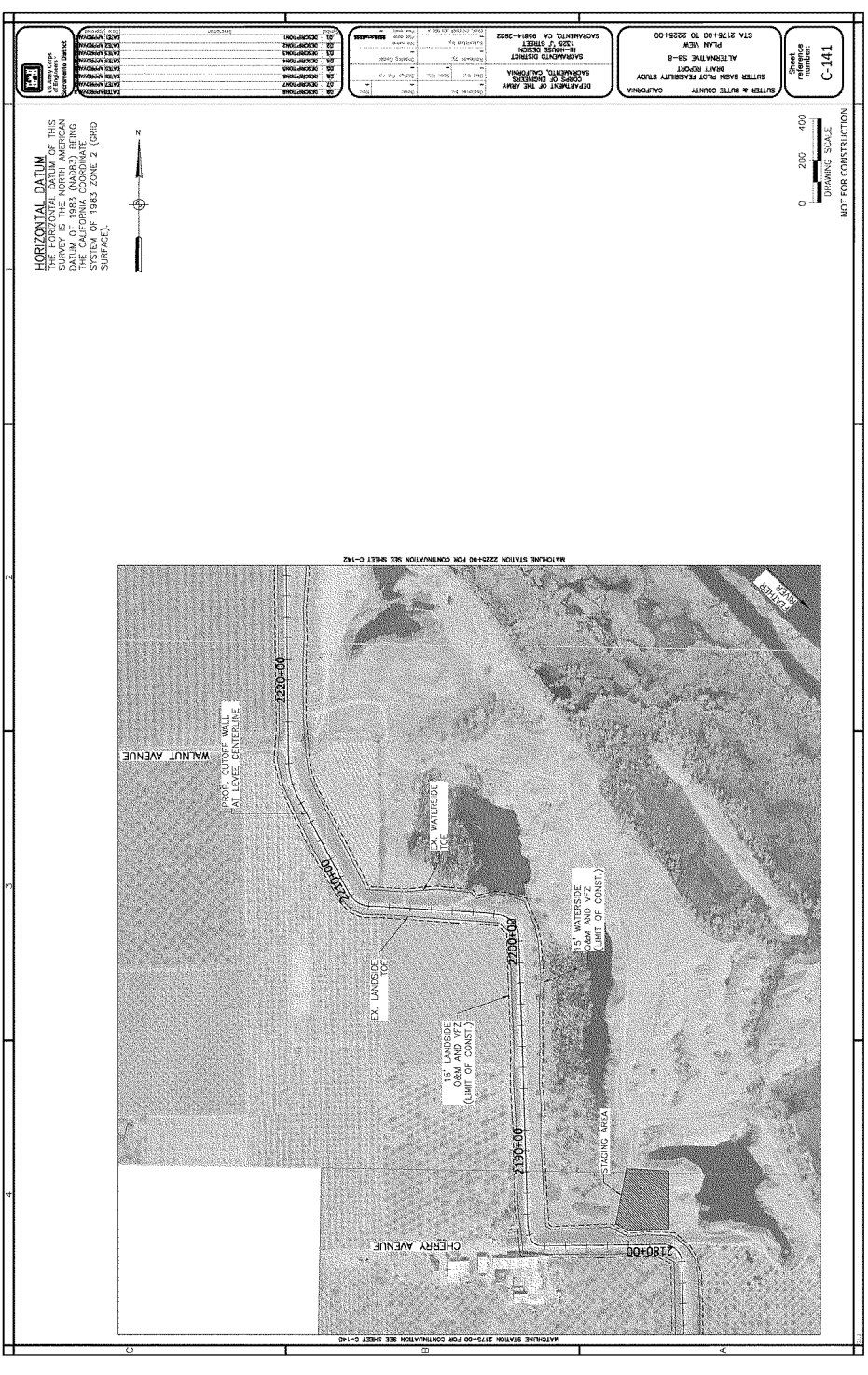
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PLAN VIEW
STA 2025+00 TO 2075+00

Sheet reference number:
C-138


HORIZONTAL DATUM
THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83), BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).
N
0 200 400
DRAWING SCALE
NOT FOR CONSTRUCTION
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER & BUTTE COUNTY CALIFORNIA
ALTERNATIVE SB-8
DRAFT REPORT
PLAN VIEW
STA 2075+00 TO 2125+00
Sheet reference number: C-139
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 J STREET
SACRAMENTO, CA 95814-2922
US Army Corps of Engineers
Sacramento District
MATCHLINE STATION 2125+00 FOR CONTINUATION SEE SHEET C-140
MATCHLINE STATION 2075+00 FOR CONTINUATION SEE SHEET C-138
ALMOND AVENUE
PROP. CUTOFF WALL
EX. LEVEE CENTERLINE
15' LANDSIDE O&M AND VFZ (LIMIT OF CONST)
EX. LANDSIDE TOE
15' WATERSIDE O&M AND VFZ (LIMIT OF CONST)
EX. WATERSIDE TOE
STAGING AREA
2110+00
2120+00
2090+00
2080+00


SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PLAN VIEW
STA 2125+00 TO 2175+00
Sheet reference number: C-140
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
IN-HOUSE DESIGN
SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922
US Army Corps of Engineers Sacramento District
HORIZONTAL DATUM
THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) FOR THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).
N
0 200 400
DRAWING SCALE
NOT FOR CONSTRUCTION
MATCHLINE STATION 2125+00 FOR CONTINUATION SEE SHEET C-139
MATCHLINE STATION 2175+00 FOR CONTINUATION SEE SHEET C-141
2130+00
2140+00
2150+00
2160+00
2170+00
EX. LANDSIDE TOE
EX. WATERSIDE TOE
PROP. CUTOFF WALL AT LEVEE CENTERLINE
15' LANDSIDE O&M AND VFZ (LIMIT OF CONST.)
15' WATERSIDE O&M AND VFZ (LIMIT OF CONST.)
HAXSON AVENUE
PALM AVENUE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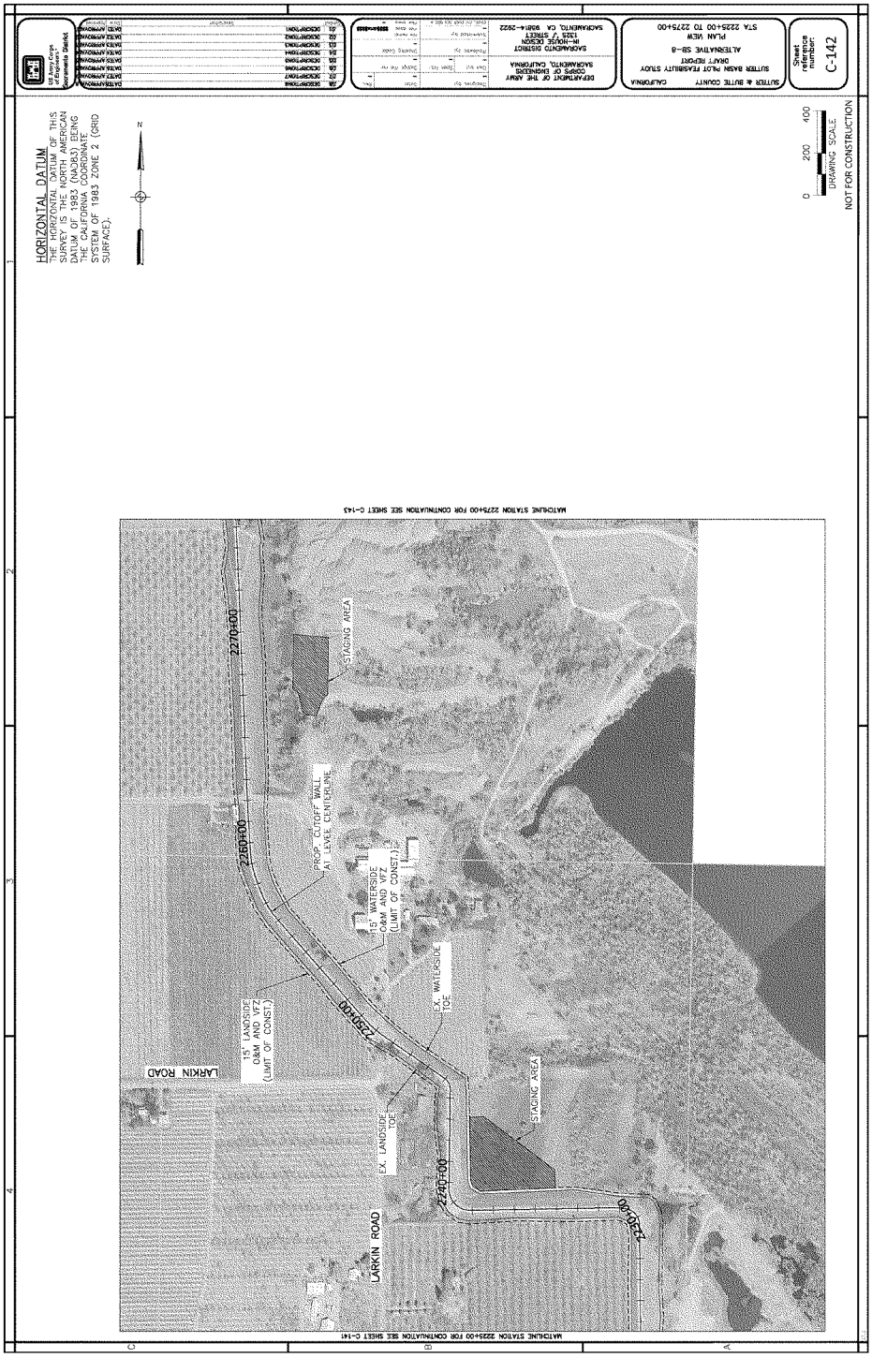
N
0 200 400
DRAWING SCALE
NOT FOR CONSTRUCTION
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PLAN VIEW
STA 2175+00 TO 2225+00
Sheet reference number: C-141
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
IN-HOUSE DESIGN
SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CALIFORNIA 95814-2922
US Army Corps of Engineers Sacramento District
WATERLINE STATION 2225+00 FOR CONTINUATION SEE SHEET C-142
WATERLINE STATION 2175+00 FOR CONTINUATION SEE SHEET C-140
WALNUT AVENUE
CHERRY AVENUE
P-SOD CUTOFF WALL AT LEVEE CENTERLINE
EX. WATERSIDE TOE
EX. LANDSIDE TOE
15' LANDSIDE O&M AND VFZ (LIMIT OF CONST.)
15' WATERSIDE O&M AND VFZ (LIMIT OF CONST.)
STAGING AREA
LEVEE
2220+00
2210+00
2200+00
2190+00
2180+00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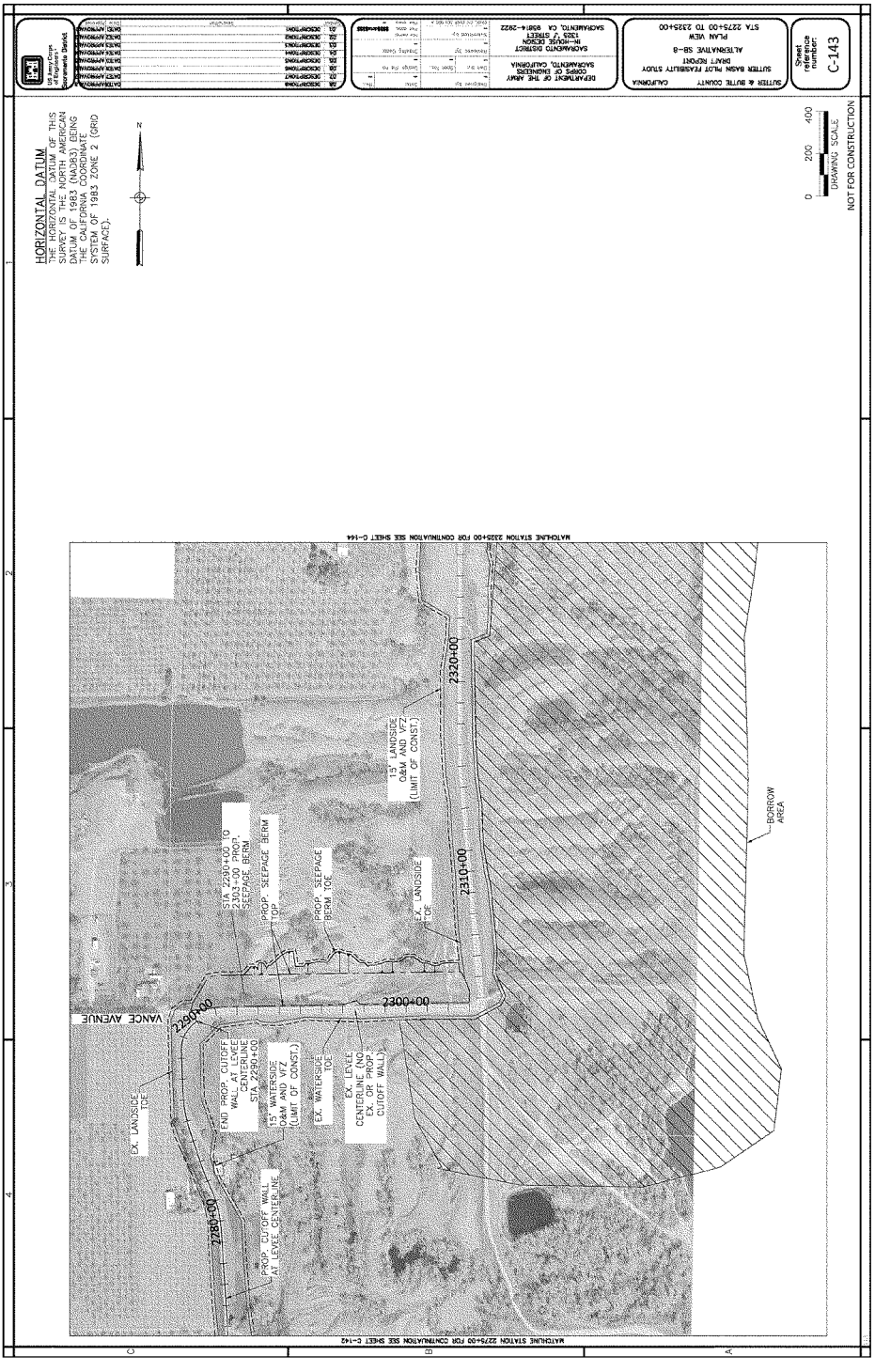
N
0 200 400
DRAWING SCALE
NOT FOR CONSTRUCTION
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PLAN VIEW
STA 2225+00 TO 2275+00
SUTTER & BUTTE COUNTY CALIFORNIA
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
IN-HOUSE DESIGN
SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922
Sheet reference number:
C-142
US Army Corps of Engineers Sacramento District
LARKIN ROAD
LARKIN ROAD
2275+00
2260+00
2270+00
2240+00
2230+00
EX. LANDSIDE TOE
EX. WATERSIDE TOE
PROP. CUTOFF WALL AT LEVEE CENTERLINE
15' LANDSIDE O&M AND VFZ (LIMIT OF CONST.)
15' WATERSIDE O&M AND VFZ (LIMIT OF CONST.)
STAGING AREA
STAGING AREA
MATCHLINE STATION 2225+00 FOR CONTINUATION SEE SHEET C-141
MATCHLINE STATION 2225+00 FOR CONTINUATION SEE SHEET C-141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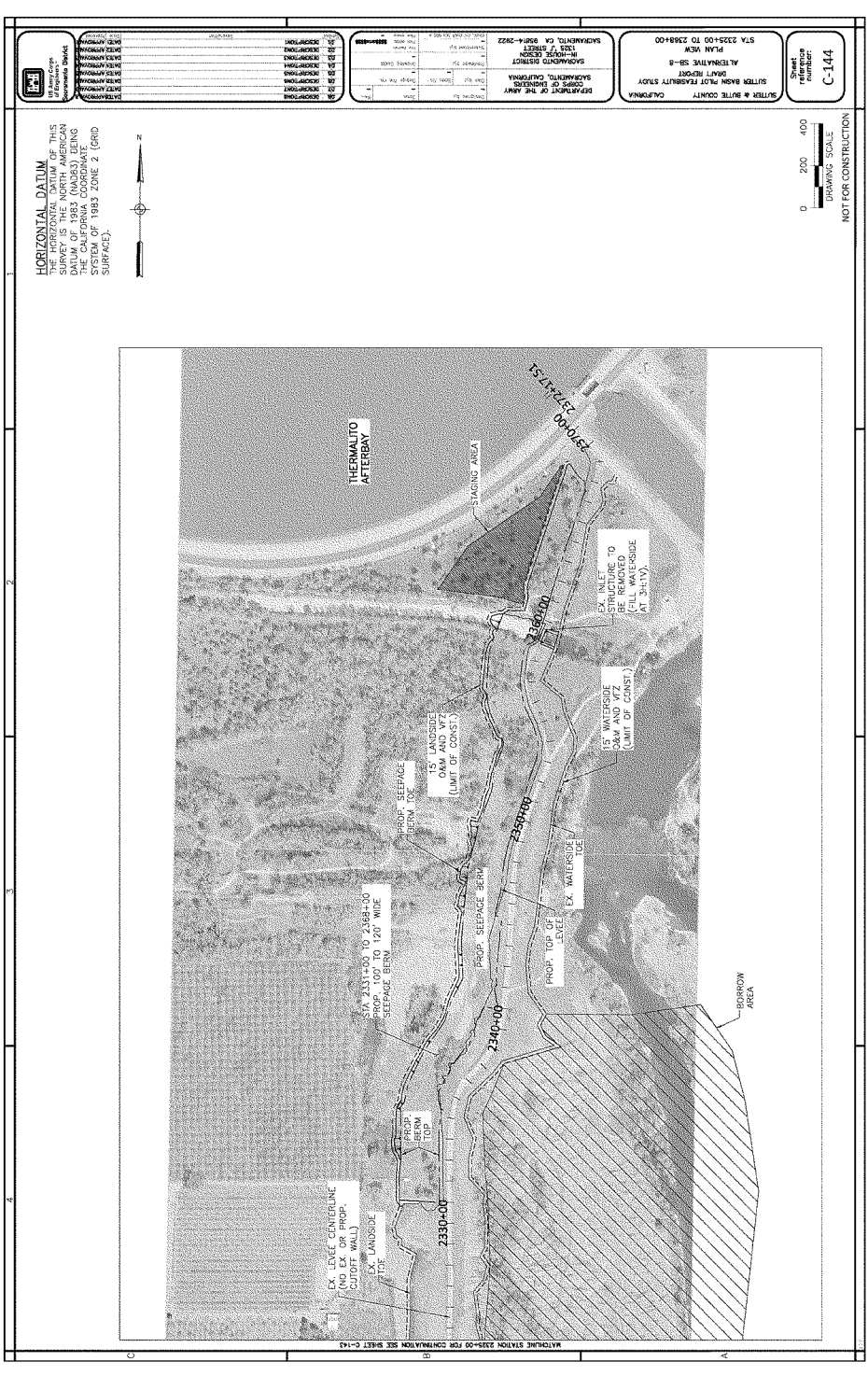
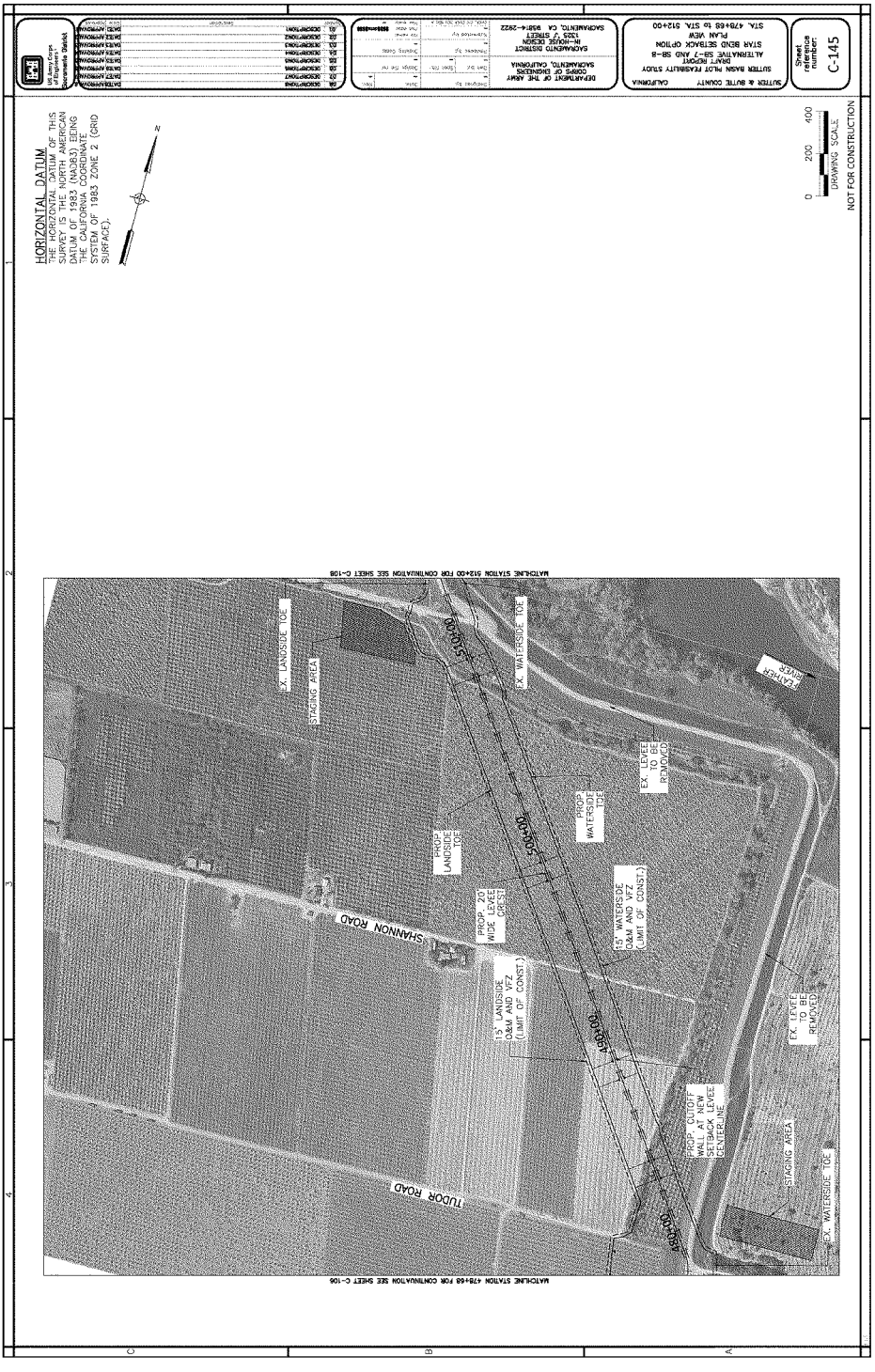
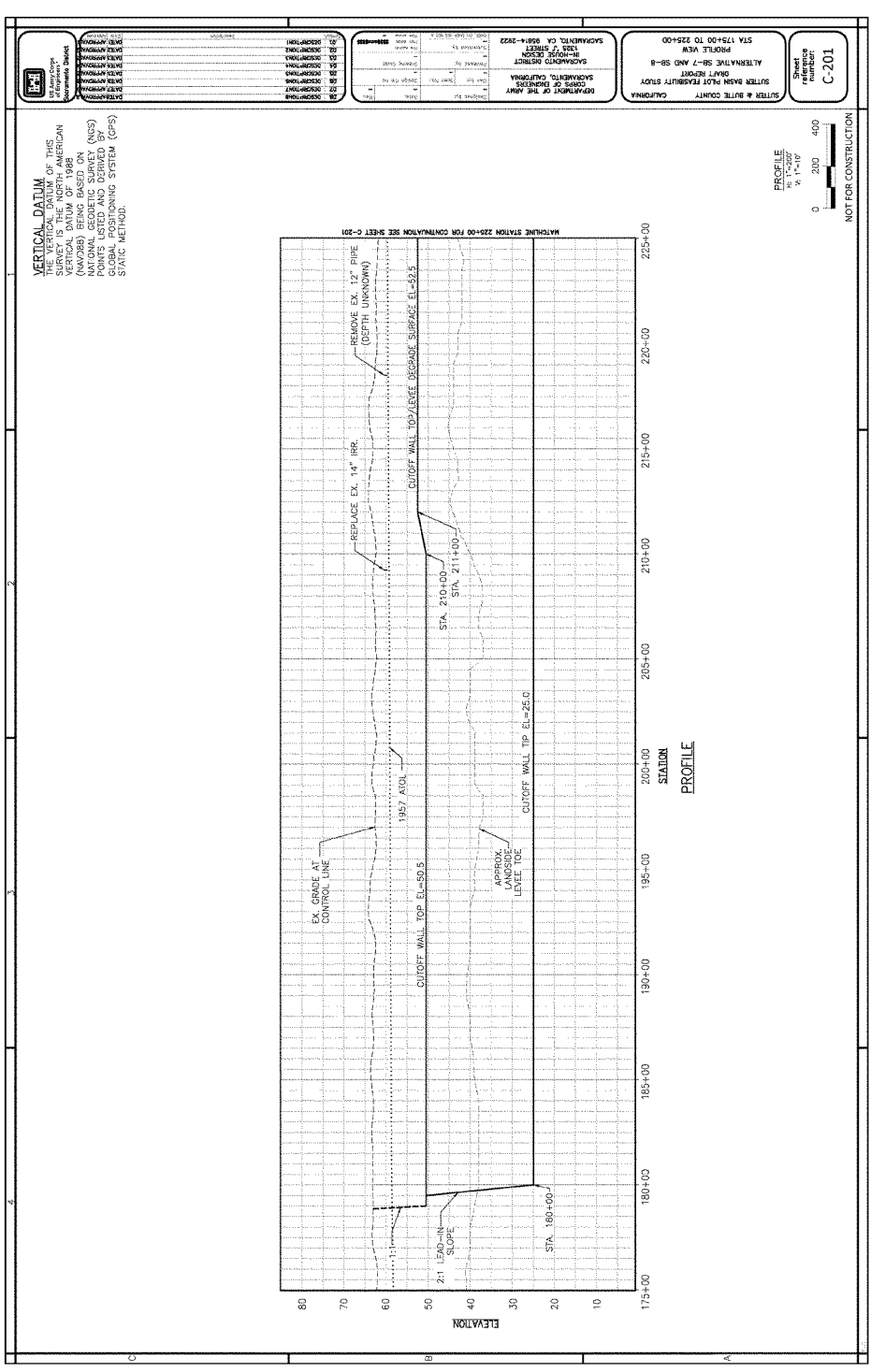
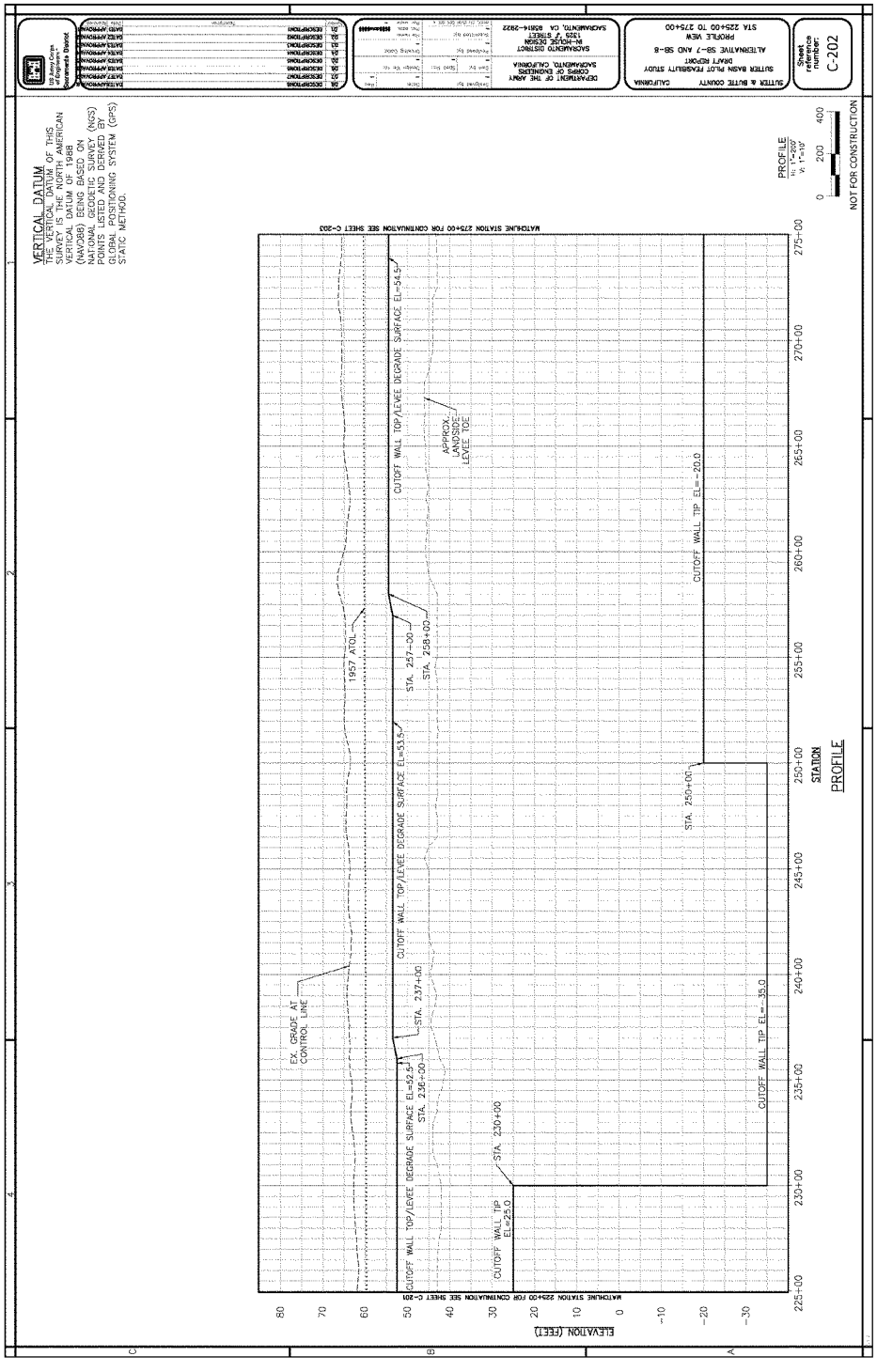
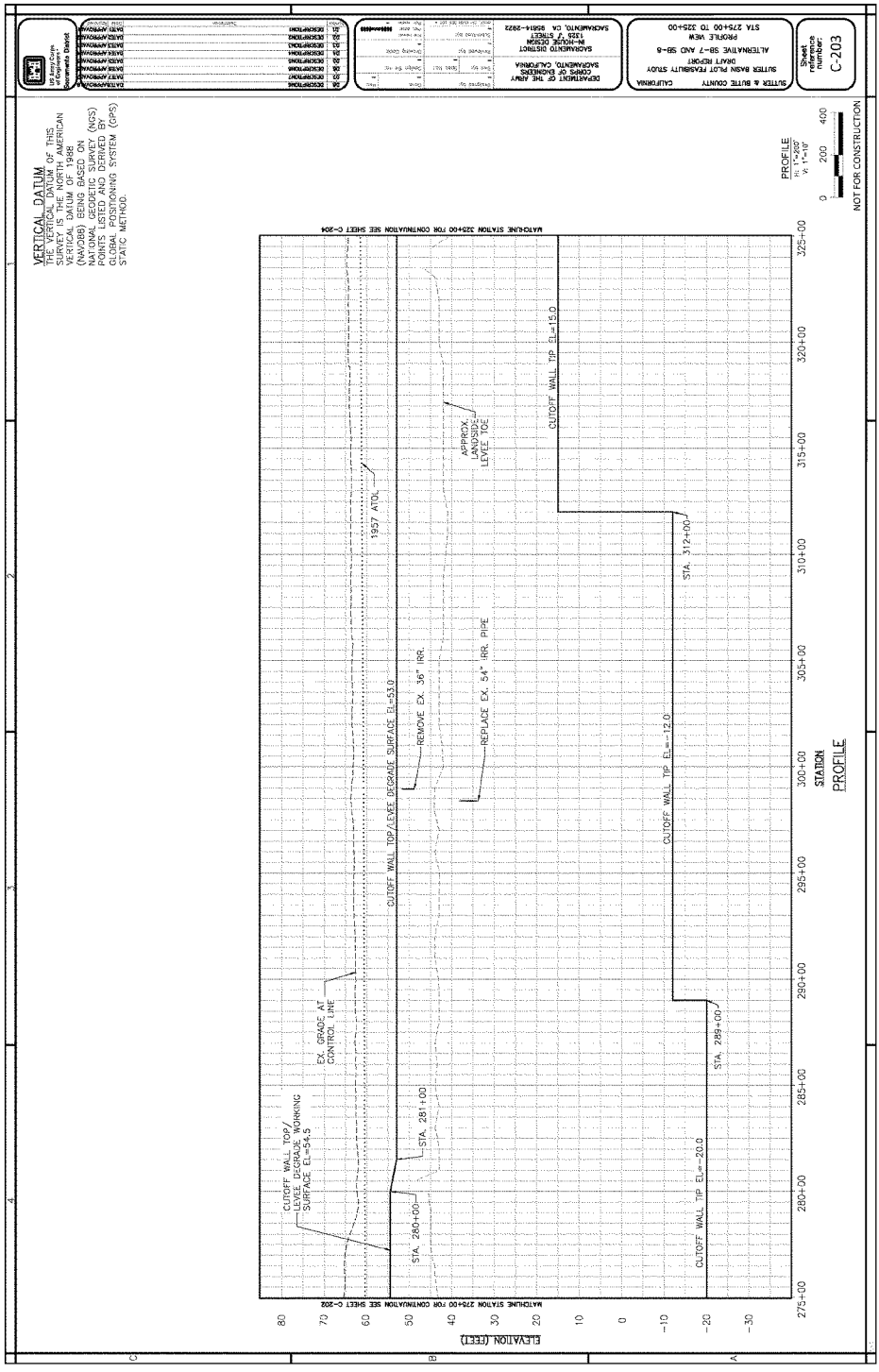
N
0 200 400
DRAWING SCALE
NOT FOR CONSTRUCTION
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 J STREET
SACRAMENTO, CA 95814-2922
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PLAN VIEW
STA 2275+00 TO 2325+00
Sheet number:
C-143
MATCHLINE STATION 2325+00 FOR CONTINUATION SEE SHEET C-144
MATCHLINE STATION 2275+00 FOR CONTINUATION SEE SHEET C-142
VANCE AVENUE
2280+00
2290+00
2300+00
2310+00
2320+00
EX. LANDSIDE TOE
END PROP. CUTOFF WALL AT LEVEE CENTERLINE STA 2284+00
PROP. CUTOFF WALL AT LEVEE CENTERLINE
15' WATERSIDE O&M AND VFZ (LIMIT OF CONST)
EX. WATERSIDE TOE
EX. LEVEE CENTERLINE (NO EX. OR PROP. CUTOFF WALL)
STA 2290+00 TO 2303+00 PROP. SEEPAGE BERM
PROP. SEEPAGE BERM TOP
PROP. SEEPAGE BERM TOE
EX. LANDSIDE TOE
15' LANDSIDE O&M AND VFZ (LIMIT OF CONST)
BORROW AREA


HORIZONTAL DATUM
THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) FOR THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).
N
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SA-8
PLAN VIEW
STA 2325+00 TO 2368+00
Sheet reference number:
C-144
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
SACRAMENTO, CALIFORNIA
1325 J STREET
SACRAMENTO, CA 95814-2922
0
200
400
DRAWING SCALE
NOT FOR CONSTRUCTION
THERMALITO AFTERBAY
STAGING AREA
EX. INLET STRUCTURE TO BE REMOVED (FILL WATERSIDE AT 3H:1V).
15' WATERSIDE O&M AND VFZ (LIMIT OF CONST.)
15' LANDSIDE O&M AND VFZ (LIMIT OF CONST.)
PROP. SEEPAGE BERM TOE
PROP. SEEPAGE BERM
PROP. TOP OF LEVEE
EX. WATERSIDE TOE
STA 2331+00 TO 2368+00 PROP. 100' TO 120' WIDE SEEPAGE BERM
PROP. BERM TOP
EX. LEVEE CENTERLINE (NO EX OR PROP. CUTOFF WALL)
EX. LANDSIDE TOE
BORROW AREA
2330+00
2340+00
2350+00
2360+00
2370+00
2372+17.51
MATCHLINE STATION 2329+00 FOR CONTINUATION SEE SHEET C-144

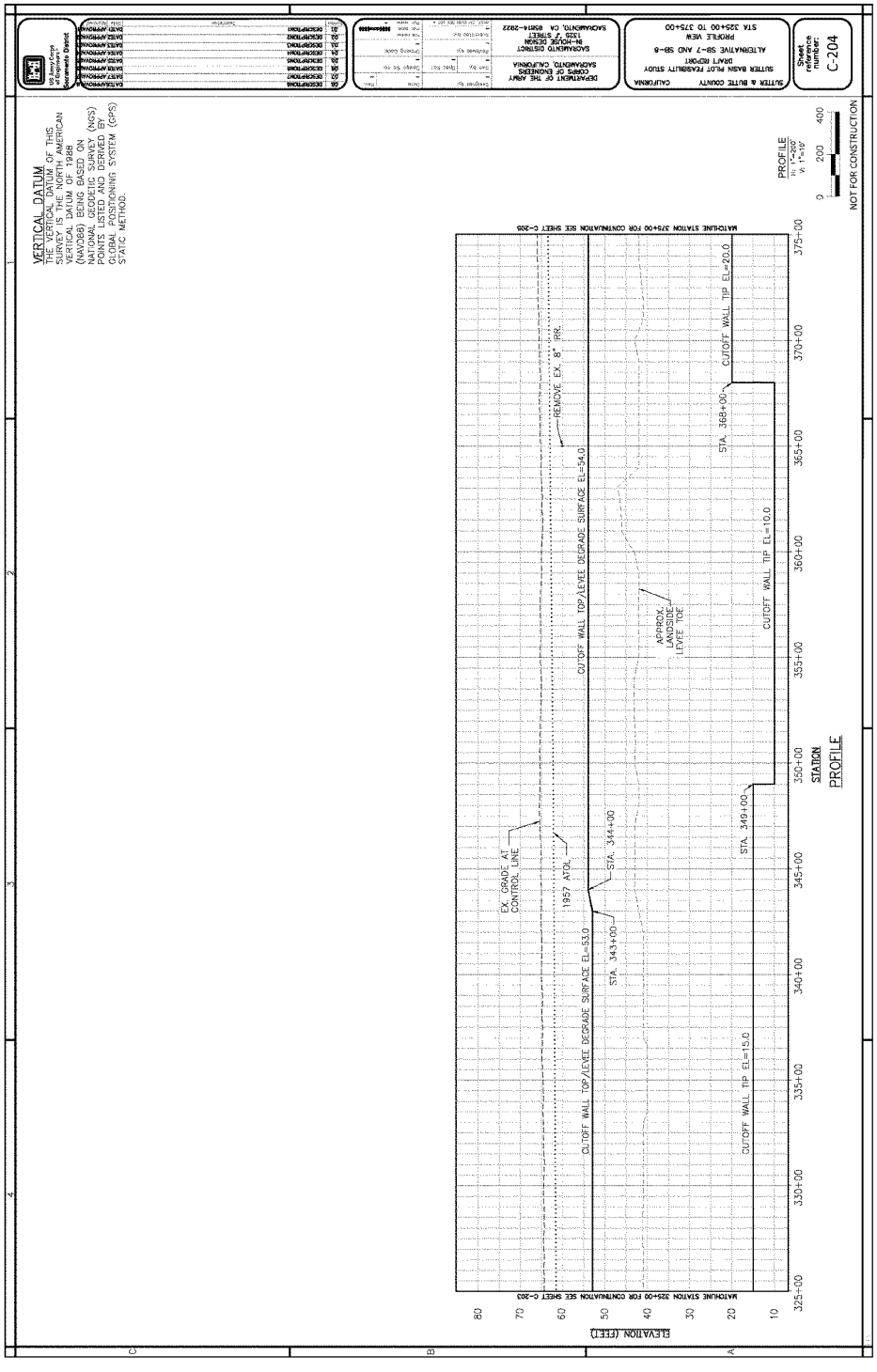

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
SMART REPORT
ALTERNATIVE SB-7 AND SB-8
STAR BEND SETBACK OPTION
PLAN VIEW
STA. 478+68 to STA. 512+00
Sheet number: C-145
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
1325 J STREET
SACRAMENTO, CA 95814-2922
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
SACRAMENTO, CALIFORNIA
US Army Corps of Engineers
Sacramento District
HORIZONTAL DATUM
THE HORIZONTAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) BEING THE CALIFORNIA COORDINATE SYSTEM OF 1983 ZONE 2 (GRID SURFACE).
N
0 200 400
DRAWING SCALE
NOT FOR CONSTRUCTION
MATCHLINE STATION 512+00 FOR CONTINUATION SEE SHEET C-106
MATCHLINE STATION 478+68 FOR CONTINUATION SEE SHEET C-106
EX. LANDSIDE TOE
STAGING AREA
EX. WATERSIDE TOE
PROP LANDSIDE TOE
PROP WATERSIDE TOE
EX. LEVEE TO BE REMOVED
FEATHER RIVER
SHANNON ROAD
TUDOR ROAD
PROP 20' WIDE LEVEE CREST
15' LANDSIDE O&M AND VFZ (LIMIT OF CONST)
15' WATERSIDE O&M AND VFZ (LIMIT OF CONST)
PROP CUTOFF WALL AT NEW SETBACK LEVEE CENTERLINE
550+00
500+00
450+00
400+00


VERTICAL DATUM
THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) PUBLISHED AND OBSERVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
ALTERNATIVE SB-7 AND SB-8
DRAFT REPORT
PROFILE
STA 175+00 TO 225+00
Sheet reference number: C-201
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
SACRAMENTO, CALIFORNIA
1325 J STREET
SACRAMENTO, CA 95814-2922
US Army Corps of Engineers Sacramento District
PROFILE
H: 1"=200'
V: 1"=10'
0 200 400
NOT FOR CONSTRUCTION
WATERLINE STATION 226+00 FOR CONTINUATION SEE SHEET C-201
REMOVE EX. 12" PIPE (DEPTH UNKNOWN)
REPLACE EX. 14" IRR.
CUTOFF WALL TOP/LEVEE DEGRADE SURFACE EL=52.5
STA. 210+00
STA. 211+00
1957 AXIS
EX. GRADE AT CONTROL LINE
CUTOFF WALL TOP EL=50.5
APPROX. LANDSIDE LEVEE TOE
CUTOFF WALL TIP EL=25.0
2:1 LEAD-IN SLOPE
STA. 180+00
ELEVATION
STATION
PROFILE
80 70 60 50 40 30 20 10
175+00 180+00 185+00 190+00 195+00 200+00 205+00 210+00 215+00 220+00 225+00


VERTICAL DATUM
THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.
SUTTER BASIN PLOT FEASIBILITY STUDY
ALTERNATIVE SB-7 AND SB-8
DRAFT REPORT
PROFILE VIEW
STA 225+00 TO 275+00
SUTTER & BUTTE COUNTY CALIFORNIA
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 J STREET
SACRAMENTO, CA 95814-2922
Sheet number: C-202
PROFILE
H: 1"=200'
V: 1"=10'
0 200 400
NOT FOR CONSTRUCTION
MATCHLINE STATION 225+00 FOR CONTINUATION SEE SHEET C-201
MATCHLINE STATION 275+00 FOR CONTINUATION SEE SHEET C-203
EX. GRADE AT CONTROL LINE
1957 ATOL
CUTOFF WALL TOP/LEVEE DEGRADE SURFACE EL=53.5
CUTOFF WALL TOP/LEVEE DEGRADE SURFACE EL=54.5
CUTOFF WALL TOP/LEVEE DEGRADE SURFACE EL=52.5
CUTOFF WALL TIP EL=25.0
CUTOFF WALL TIP EL=-35.0
CUTOFF WALL TIP EL=-20.0
STA. 230+00
STA. 236+00
STA. 237+00
STA. 250+00
STA. 257+00
STA. 258+00
APPROX. LANDSIDE LEVEE TOE
ELEVATION (FEET)
STATION
PROFILE



NOT FOR CONSTRUCTION


VERTICAL DATUM
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SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PROFILE VIEW
STA 325+00 TO 375+00
SUTTER & BUTTE COUNTY CALIFORNIA
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 J STREET
SACRAMENTO, CA 95814-2922
Sheet number: C-204
PROFILE
H: 1"=200'
V: 1"=10'
0 200 400
NOT FOR CONSTRUCTION
MATCHLINE STATION 325+00 FOR CONTINUATION SEE SHEET C-203
MATCHLINE STATION 375+00 FOR CONTINUATION SEE SHEET C-203
ELEVATION (FEET)
80 70 60 50 40 30 20 10
325+00 330+00 335+00 340+00 345+00 350+00 355+00 360+00 365+00 370+00 375+00
STATION
PROFILE
CUTOFF WALL TIP EL=15.0
CUTOFF WALL TOP/LEVEE DEGRADE SURFACE EL=53.0
CUTOFF WALL TOP/LEVEE DEGRADE SURFACE EL=54.0
CUTOFF WALL TIP EL=10.0
CUTOFF WALL TIP EL=20.0
EX. GRADE AT CONTROL LINE
1957 ATOL
STA. 343+00
STA. 344+00
STA. 349+00
STA. 368+00
APPROX. LANDSIDE LEVEE TOE
REMOVE EX. 81" PRP.

VERTICAL DATUM

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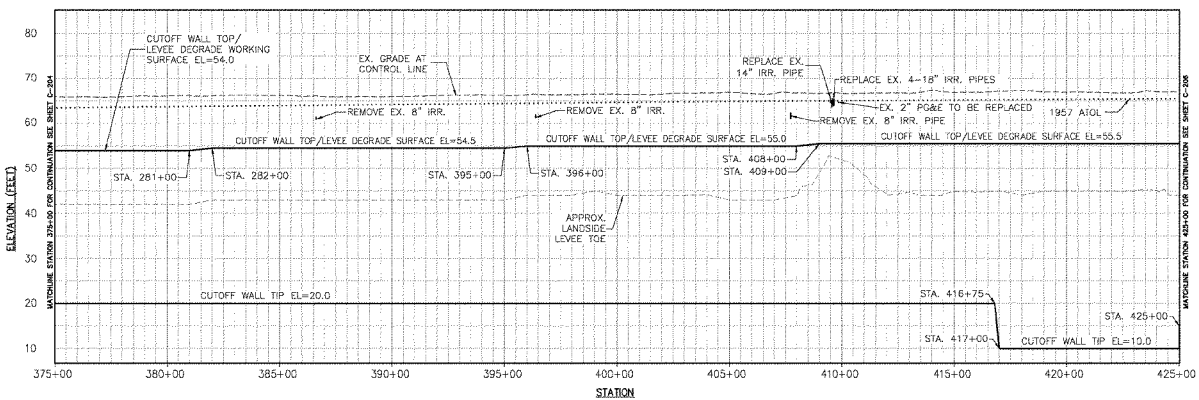


PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

NOT FOR CONSTRUCTION

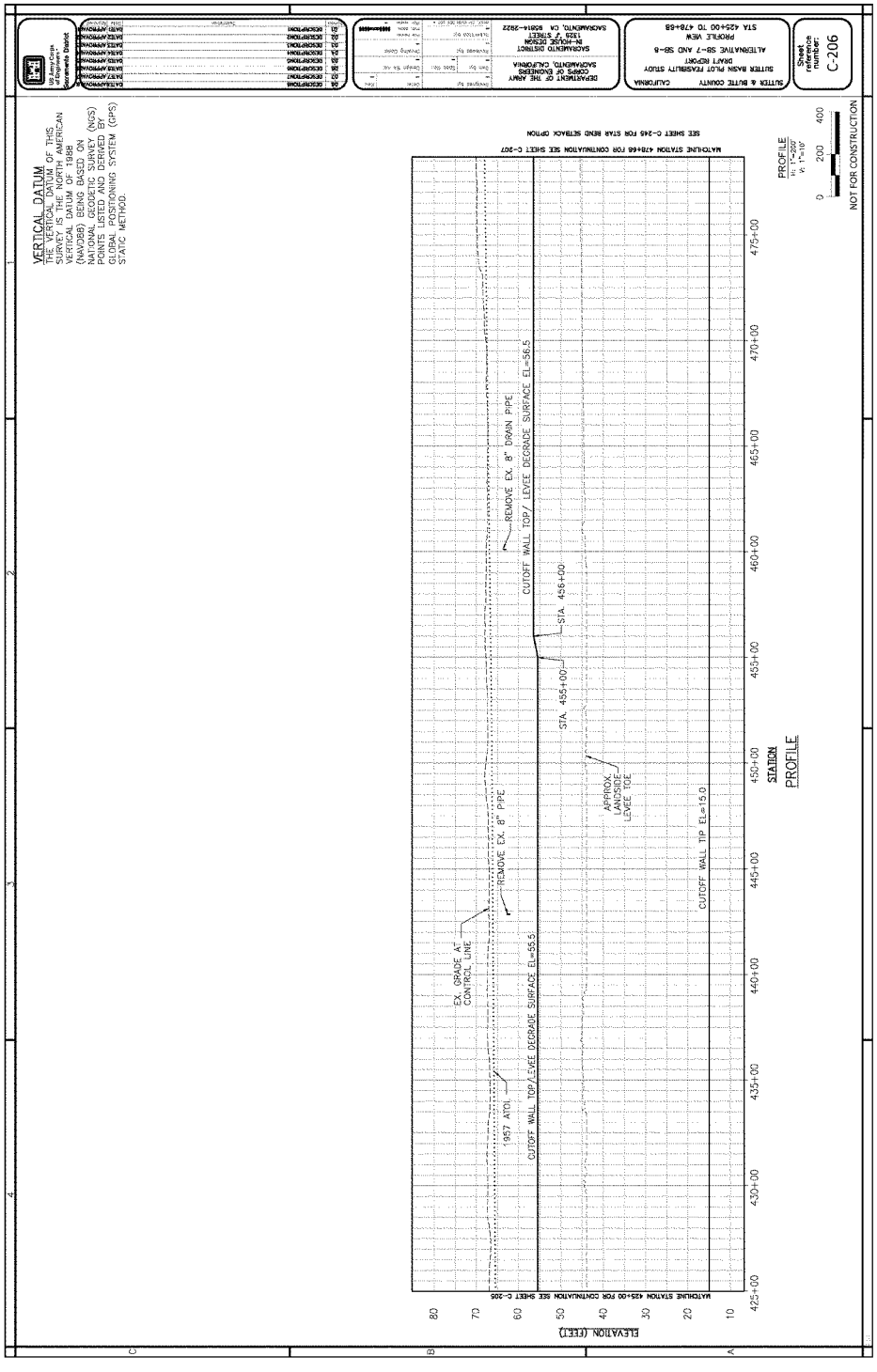
US Army Corps of Engineers
Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PROFILE VIEW
STA 375+00 TO 425+00

Sheet reference number:
C-205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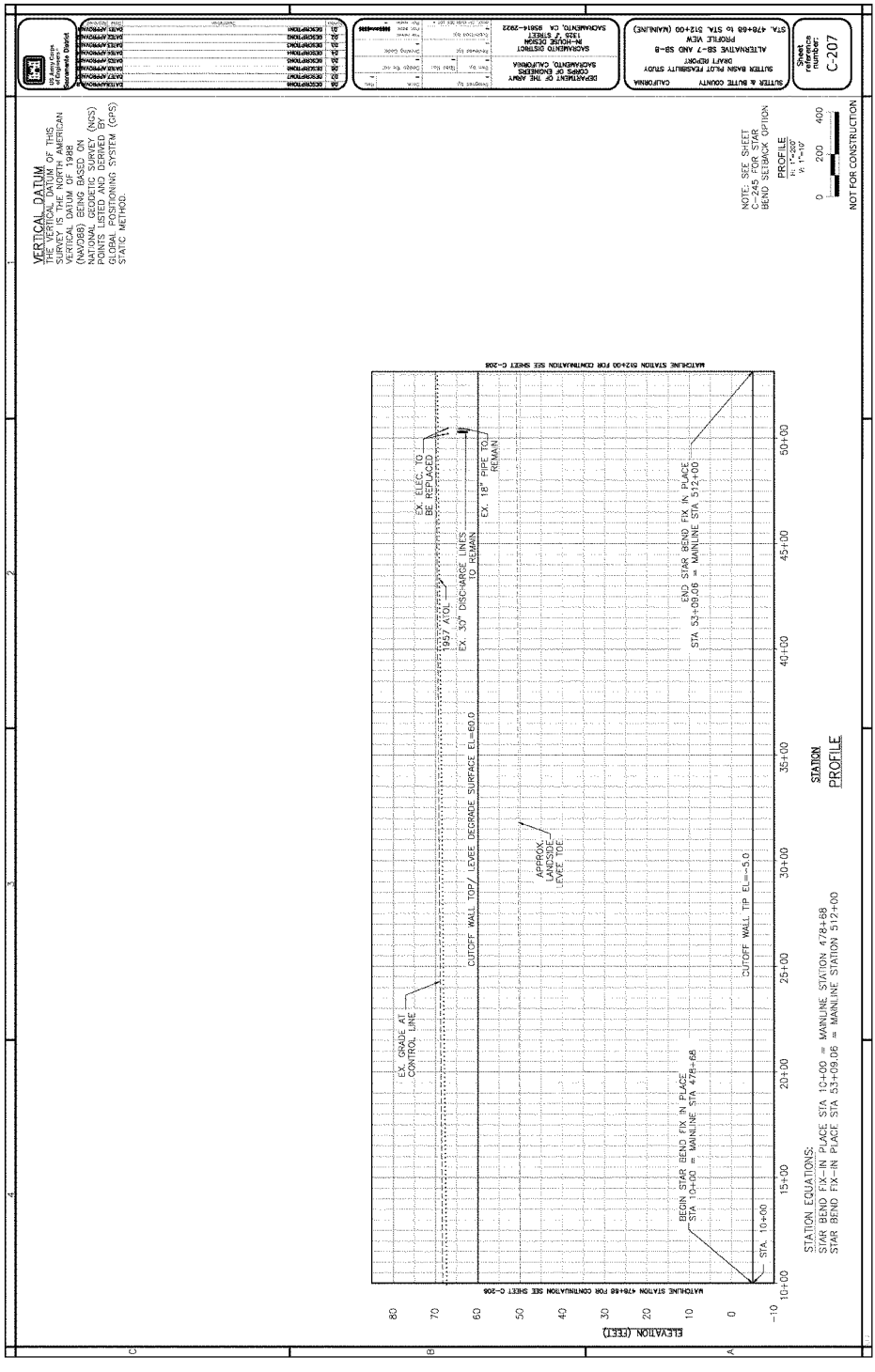
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PROFILE VIEW
STA 425+00 TO 478+58
DEPARTMENT OF THE ARMY CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT IN-HOUSE DESIGN
1325 J STREET SACRAMENTO, CA 95814-2922
Sheet number: C-206
PROFILE
H: 1"=200'
V: 1"=10'
0 200 400
NOT FOR CONSTRUCTION
STATION
PROFILE
ELEVATION (FEET)
MATCHLINE STATION 425+00 FOR CONTINUATION SEE SHEET C-205
MATCHLINE STATION 478+66 FOR CONTINUATION SEE SHEET C-207
SEE SHEET C-245 FOR STAR BEND SETBACK OPTION
EX. GRADE AT CONTROL LINE
1957 ATOL
REMOVE EX. 8" PIPE
CUTOFF WALL TOP / LEVEE DEGRADE SURFACE EL=55.5
STA. 455+00
STA. 456+00
APPROX. LANDSIDE LEVEE TOE
CUTOFF WALL TIP EL=15.0
REMOVE EX. 8" DRAIN PIPE
CUTOFF WALL TOP / LEVEE DEGRADE SURFACE EL=56.5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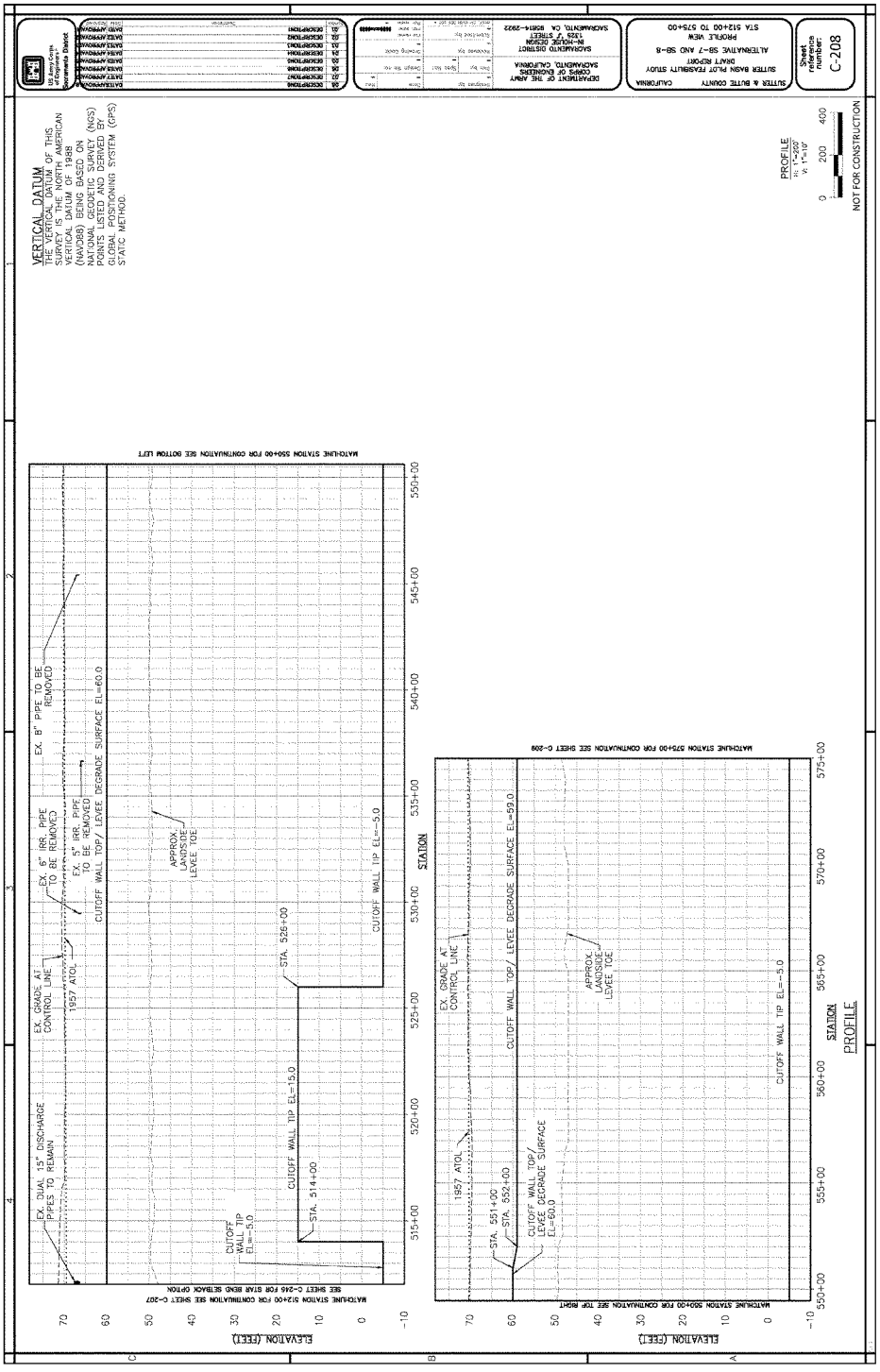
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER & BUTTE COUNTY CALIFORNIA
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
IN-HOUSE DESIGN
ALTERNATIVE SB-7 AND SB-8
PROFILE VIEW
STA 478+68 to STA 512+00 (MAINLINE)
Sheet reference number: C-207
NOTE: SEE SHEET C-245 FOR STAR BEND SETBACK OPTION
PROFILE
H: 1"=200'
V: 1"=10'
0 200 400
NOT FOR CONSTRUCTION
ELEVATION (FEET)
80 70 60 50 40 30 20 10 0 -10
10+00 15+00 20+00 25+00 30+00 35+00 40+00 45+00 50+00
MATCHLINE STATION 478+68 FOR CONTINUATION SEE SHEET C-206
MATCHLINE STATION 512+00 FOR CONTINUATION SEE SHEET C-208
EX. GRADE AT CONTROL LINE
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL+60.0
CUTOFF WALL TIP EL=-5.0
APPROX. LANDSIDE EXCAVATE
1957 AIOL
EX. 35" DISCHARGE LINES TO REMAIN
EX. ELEC. TO BE RELOCATED
EX. 18" PIPE TO REMAIN
BEGIN STAR BEND FIX IN PLACE STA 14+00 = MAINLINE STA 478+68
END STAR BEND FIX IN PLACE STA 53+09.06 = MAINLINE STA 512+00
STATION
PROFILE
STATION EQUATIONS:
STAR BEND FIX-IN PLACE STA 10+00 = MAINLINE STATION 478+68
STAR BEND FIX-IN PLACE STA 53+09.06 = MAINLINE STATION 512+00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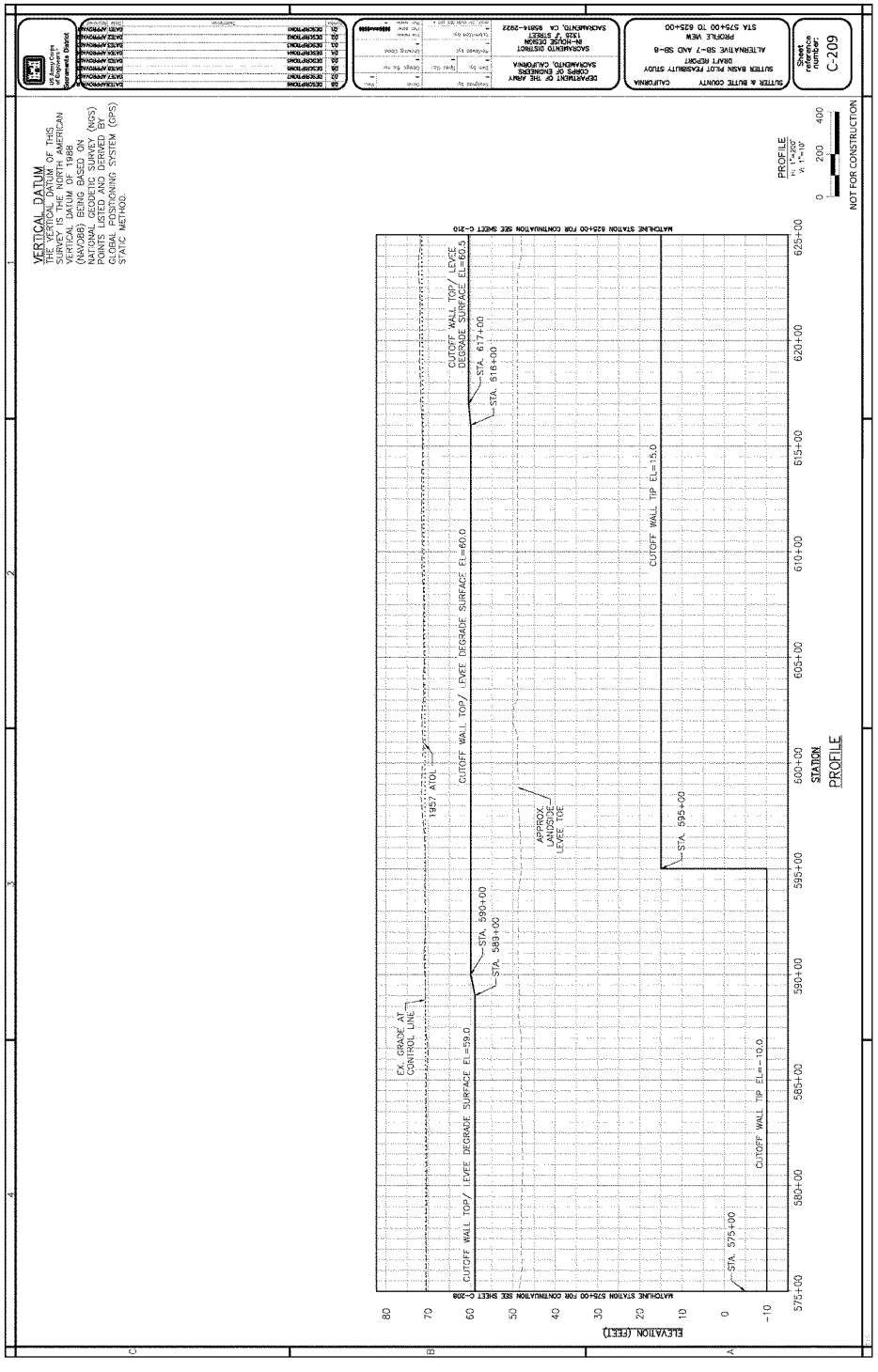
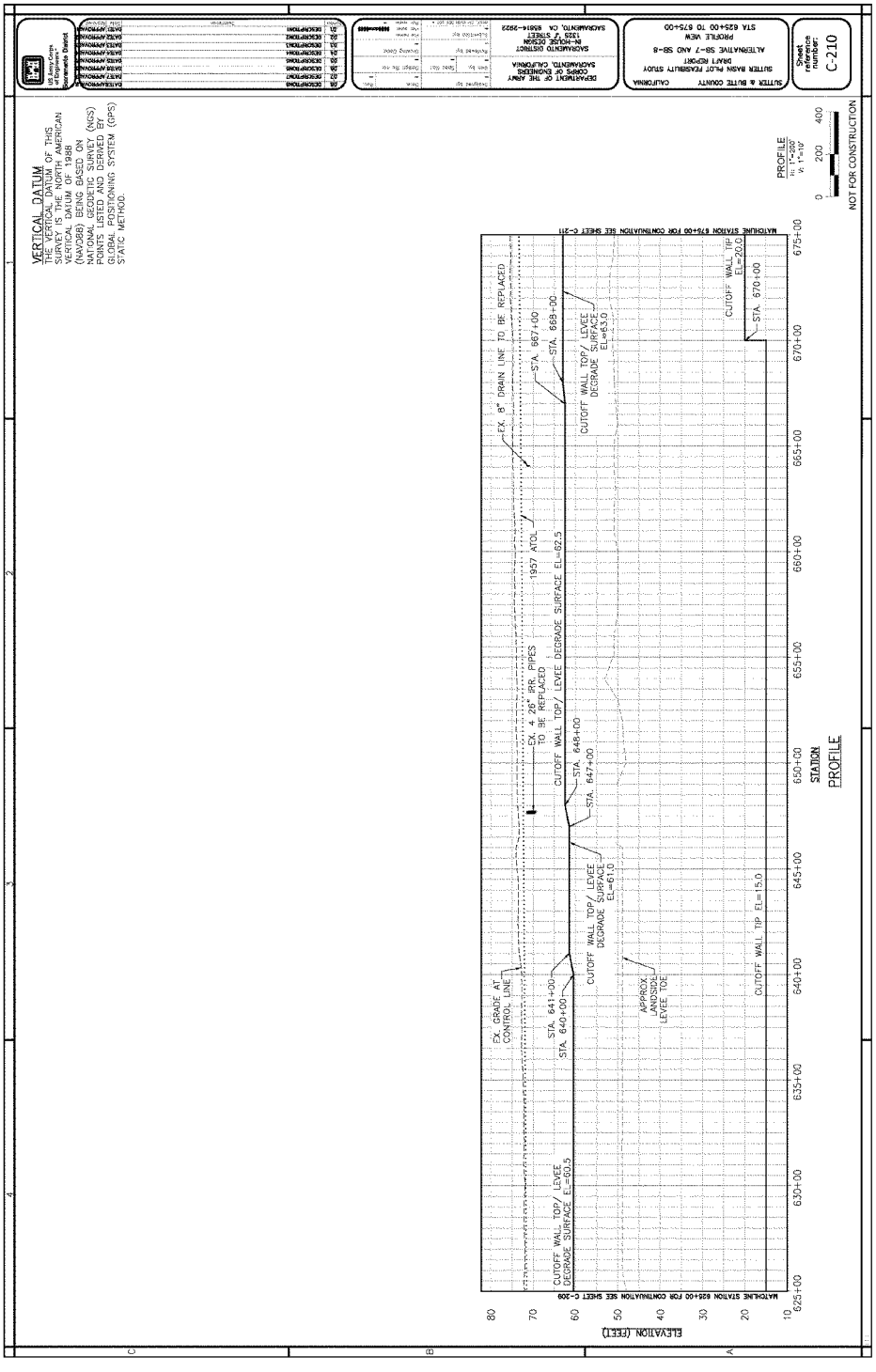
SUTTER BASIN PILOT FEASIBILITY STUDY
ALTERNATIVE SB-7 AND SB-8
DRAFT REPORT
PROFILE VIEW
STA 512+00 TO 575+00
SUTTER & BUTTE COUNTY CALIFORNIA
DEPARTMENT OF THE ARMY CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT IN-HOUSE DESIGN 1325 J STREET SACRAMENTO, CA 95814-2922
Sheet number: C-208
PROFILE
H: 1"=200'
V: 1"=10'
0 200 400
NOT FOR CONSTRUCTION
ELEVATION (FEET)
STATION
MATCHLINE STATION 512+00 FOR CONTINUATION SEE SHEET C-207
MATCHLINE STATION 550+00 FOR CONTINUATION SEE BOTTOM LEFT
EX. DUAL 15" DISCHARGE PIPES TO REMAIN
EX. GRADE AT CONTROL LINE
1957 ATOL
EX. 6" IRR. PIPE TO BE REMOVED
EX. 5" IRR. PIPE TO BE REMOVED
EX. 8" PIPE TO BE REMOVED
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=60.0
APPROX. LANDSIDE LEVEE TOE
CUTOFF WALL TIP EL=-5.0
CUTOFF WALL TIP EL=-15.0
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=60.0
STA. 514+00
STA. 526+00
STA. 551+00
STA. 552+00
MATCHLINE STATION 550+00 FOR CONTINUATION SEE TOP RIGHT
MATCHLINE STATION 575+00 FOR CONTINUATION SEE SHEET C-209
PROFILE


VERTICAL DATUM
THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS HELD AND OBSERVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PROFILE VIEW
STA 575+00 TO 625+00
Sheet reference number: C-209
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
SACRAMENTO, CALIFORNIA
1325 J STREET
SACRAMENTO, CA 95814-2922
PROFILE
H: 1"=200'
V: 1"=10'
0 200 400
NOT FOR CONSTRUCTION
MATCHLINE STATION 575+00 FOR CONTINUATION SEE SHEET C-208
MATCHLINE STATION 625+00 FOR CONTINUATION SEE SHEET C-210
EX. GRADE AT CONTROL LINE
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=59.0
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=60.0
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=60.5
CUTOFF WALL TIP EL=-10.0
CUTOFF WALL TIP EL=15.0
STA. 575+00
STA. 589+00
STA. 590+00
STA. 595+00
STA. 516+00
STA. 617+00
1957 ATOL
APPROX LANDSIDE LEVEE TOE
ELEVATION (FEET)
STATION
PROFILE
575+00
580+00
585+00
590+00
595+00
600+00
605+00
610+00
615+00
620+00
625+00
80
70
60
50
40
30
20
10
0
-10


VERTICAL DATUM
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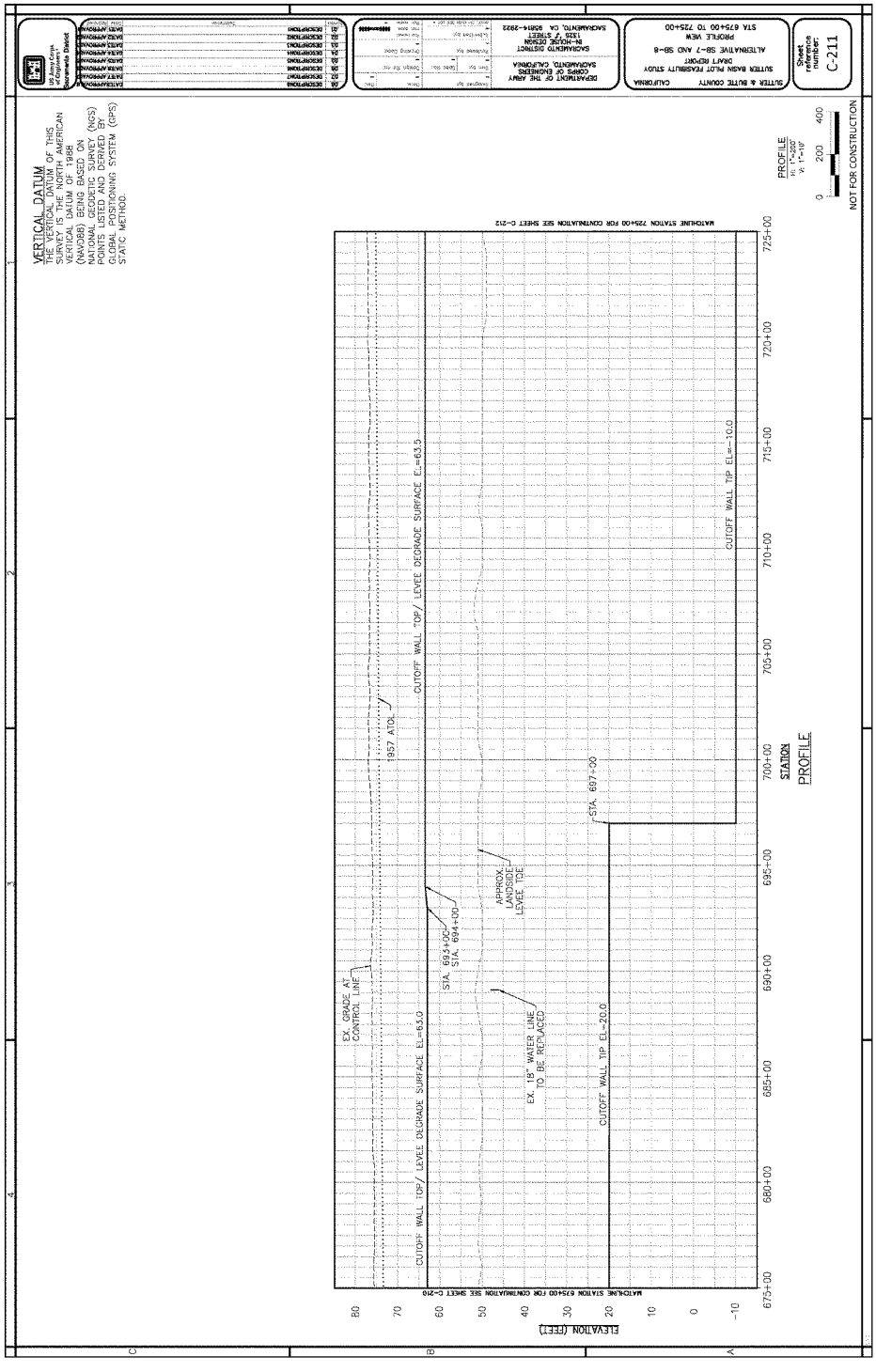
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PROFILE VIEW
STA 625+00 TO 675+00
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 J STREET
SACRAMENTO, CA 95814-2922
Sheet reference number:
C-210
PROFILE
H: 1"=200'
V: 1"=10'
0
200
400
NOT FOR CONSTRUCTION
ELEVATION (FEET)
STATION
PROFILE
MATCHLINE STATION 625+00 FOR CONTINUATION SEE SHEET C-209
MATCHLINE STATION 675+00 FOR CONTINUATION SEE SHEET C-211
EX. GRADE AT CONTROL LINE
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=60.5
STA. 640+00
STA. 641+00
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=61.0
APPROX. LANDSIDE LEVEE TOE
CUTOFF WALL TIP EL=15.0
EX. 4-28" IRR. PIPES TO BE REPLACED
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=62.5
STA. 647+00
STA. 648+00
1957 ATDL
EX. 8" DRAIN LINE TO BE REPLACED
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=63.0
STA. 667+00
STA. 668+00
CUTOFF WALL TIP EL=20.0
STA. 670+00


VERTICAL DATUM
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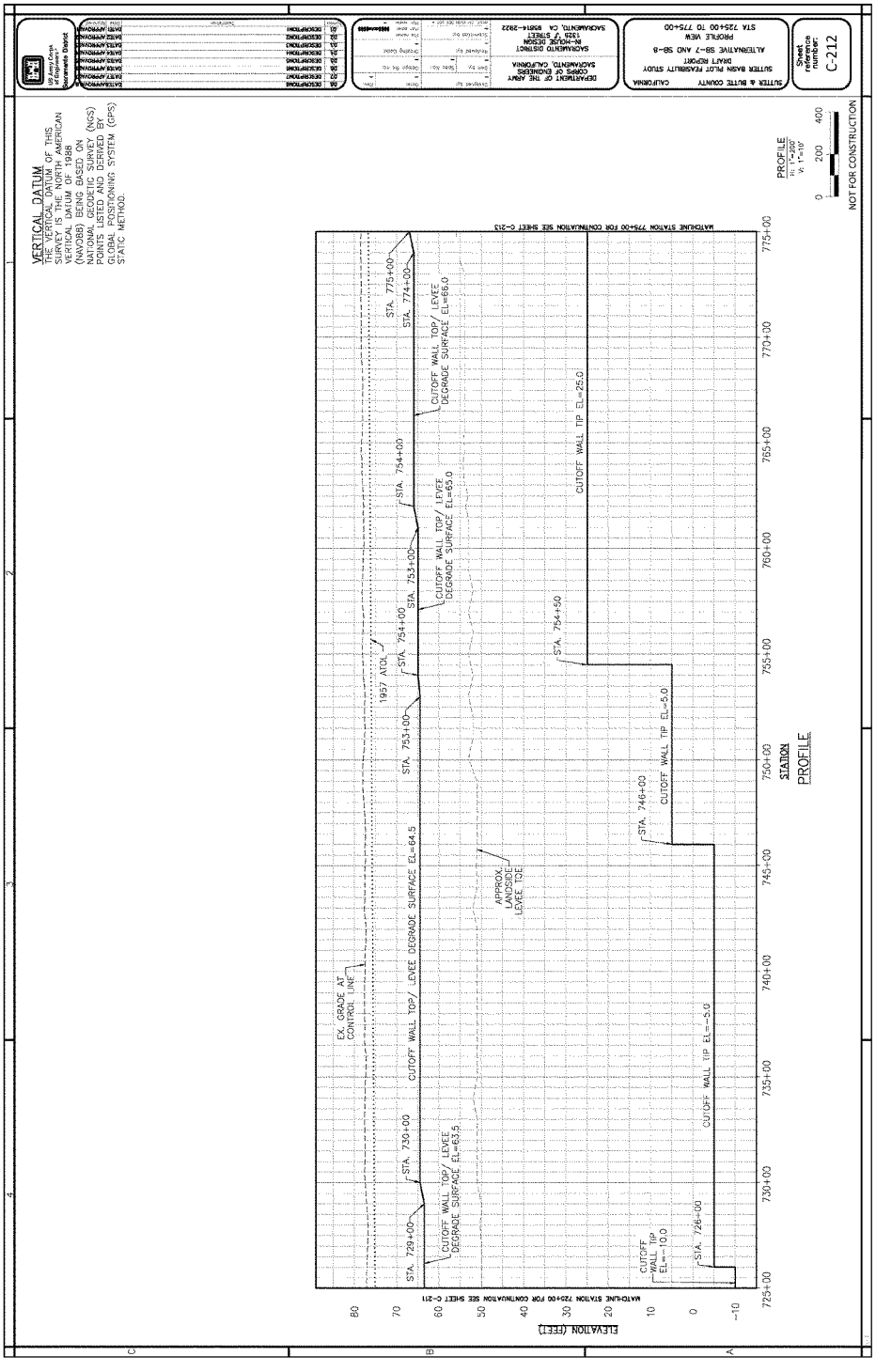
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PROFILE VIEW
STA 675+00 TO 725+00
Sheet reference number: C-211
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 J STREET
SACRAMENTO, CA 95814-2922
PROFILE
H: 1"=200'
V: 1"=10'
0 200 400
NOT FOR CONSTRUCTION
MATCHLINE STATION 725+00 FOR CONTINUATION SEE SHEET C-212
MATCHLINE STATION 675+00 FOR CONTINUATION SEE SHEET C-210
ELEVATION (FEET)
80 70 60 50 40 30 20 10 0 -10
675+00 680+00 685+00 690+00 695+00 700+00 705+00 710+00 715+00 720+00 725+00
STATION
PROFILE
CUTOFF WALL TOP / LEVEE DEGRADE SURFACE EL=63.0
EX. GRADE AT CONTROL LINE
STA. 694+00
STA. 694+00
APPROX. LANDSIDE LEVEE TOE
EX. 18" WATER LINE TO BE REPLACED
CUTOFF WALL TIP EL=-20.0
STA. 697+00
1957 ATOL
CUTOFF WALL TOP / LEVEE DEGRADE SURFACE EL=63.5
CUTOFF WALL TIP EL=-10.0


VERTICAL DATUM
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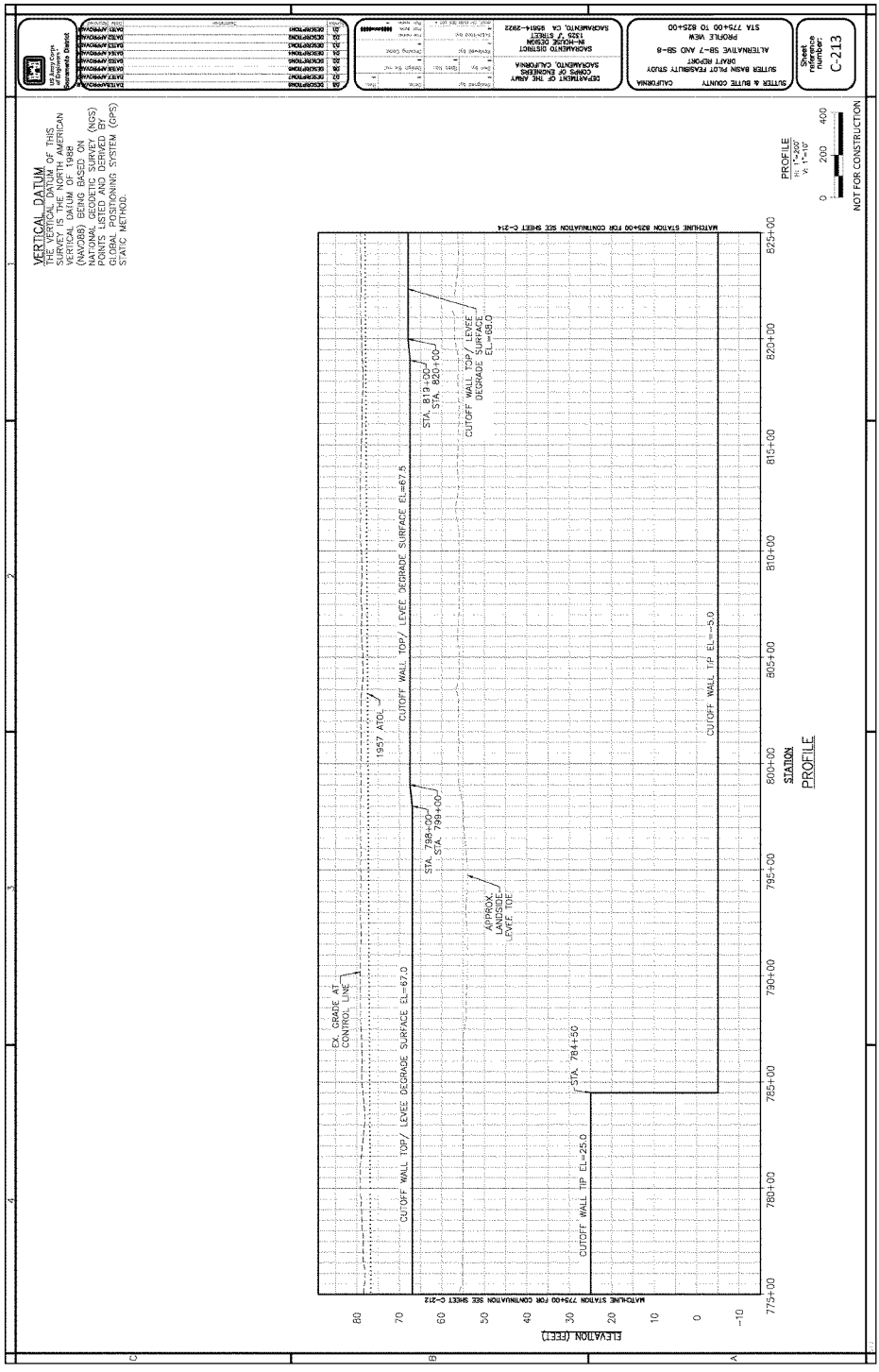
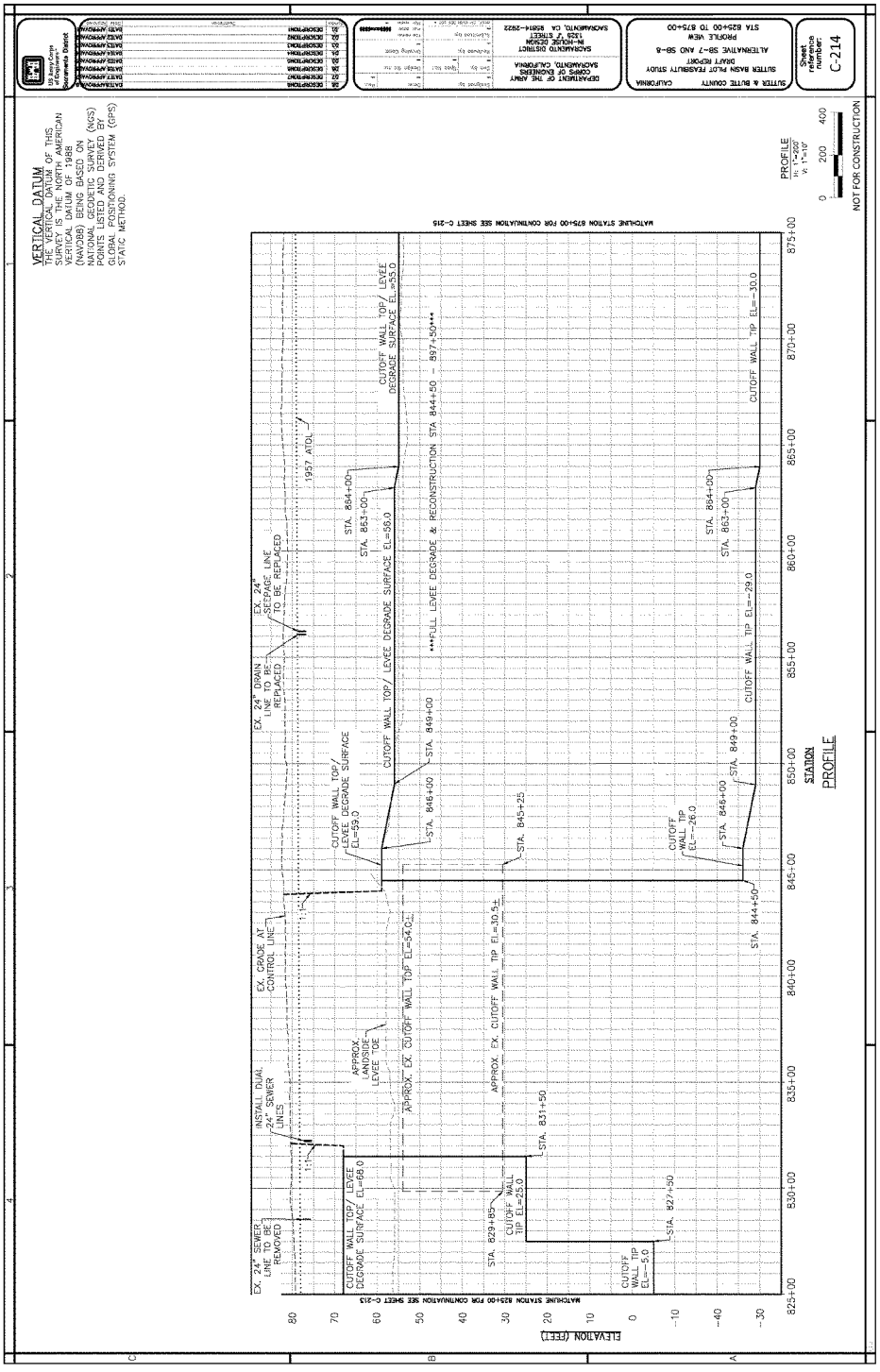
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
ALTERNATIVE SB-7 AND SB-8
DRAFT REPORT
PROFILE VIEW
STA 725+00 TO 775+00
DEPARTMENT OF THE ARMY CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT IN-HOUSE DESIGN 1325 J STREET SACRAMENTO, CA 95814-2922
Sheet number C-212
PROFILE
H: 1"=200'
V: 1"=10'
NOT FOR CONSTRUCTION
STATION
PROFILE
ELEVATION (FEET)
MATCHLINE STATION 725+00 FOR CONTINUATION SEE SHEET C-211
MATCHLINE STATION 775+00 FOR CONTINUATION SEE SHEET C-213
EX. GRADE AT CONTROL LINE
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=63.5
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=64.5
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=65.0
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=66.0
CUTOFF WALL TIP EL=-10.0
CUTOFF WALL TIP EL=-5.0
CUTOFF WALL TIP EL=25.0
APPROX. LANDSIDE LEVEE TOE
1957 ATOL
STA. 729+00
STA. 730+00
STA. 726+00
STA. 746+00
STA. 753+00
STA. 754+00
STA. 753+00
STA. 754+00
STA. 754+50
STA. 774+00
STA. 775+00


VERTICAL DATUM
THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) BENCH MARKS ESTABLISHED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PROFILE VIEW
STA 775+00 TO 825+00
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 J STREET
SACRAMENTO, CA 95814-2922
Sheet reference number:
C-213
PROFILE
H: 1"=200'
V: 1"=10'
0 200 400
NOT FOR CONSTRUCTION
ELEVATION (FEET)
80 70 60 50 40 30 20 10 0 -10
775+00 780+00 785+00 790+00 795+00 800+00 805+00 810+00 815+00 820+00 825+00
STATION
PROFILE
MATCHLINE STATION 775+00 FOR CONTINUATION SEE SHEET C-212
MATCHLINE STATION 825+00 FOR CONTINUATION SEE SHEET C-214
EX. GRADE AT CONTROL LINE
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=67.0
CUTOFF WALL TIP EL=-25.0
STA. 784+50
APPROX. LANDSIDE LEVEE TOE
STA. 798+00
STA. 799+00
1957 ATOL
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=67.5
CUTOFF WALL TIP EL=-5.0
STA. 819+00
STA. 820+00
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=68.0


VERTICAL DATUM
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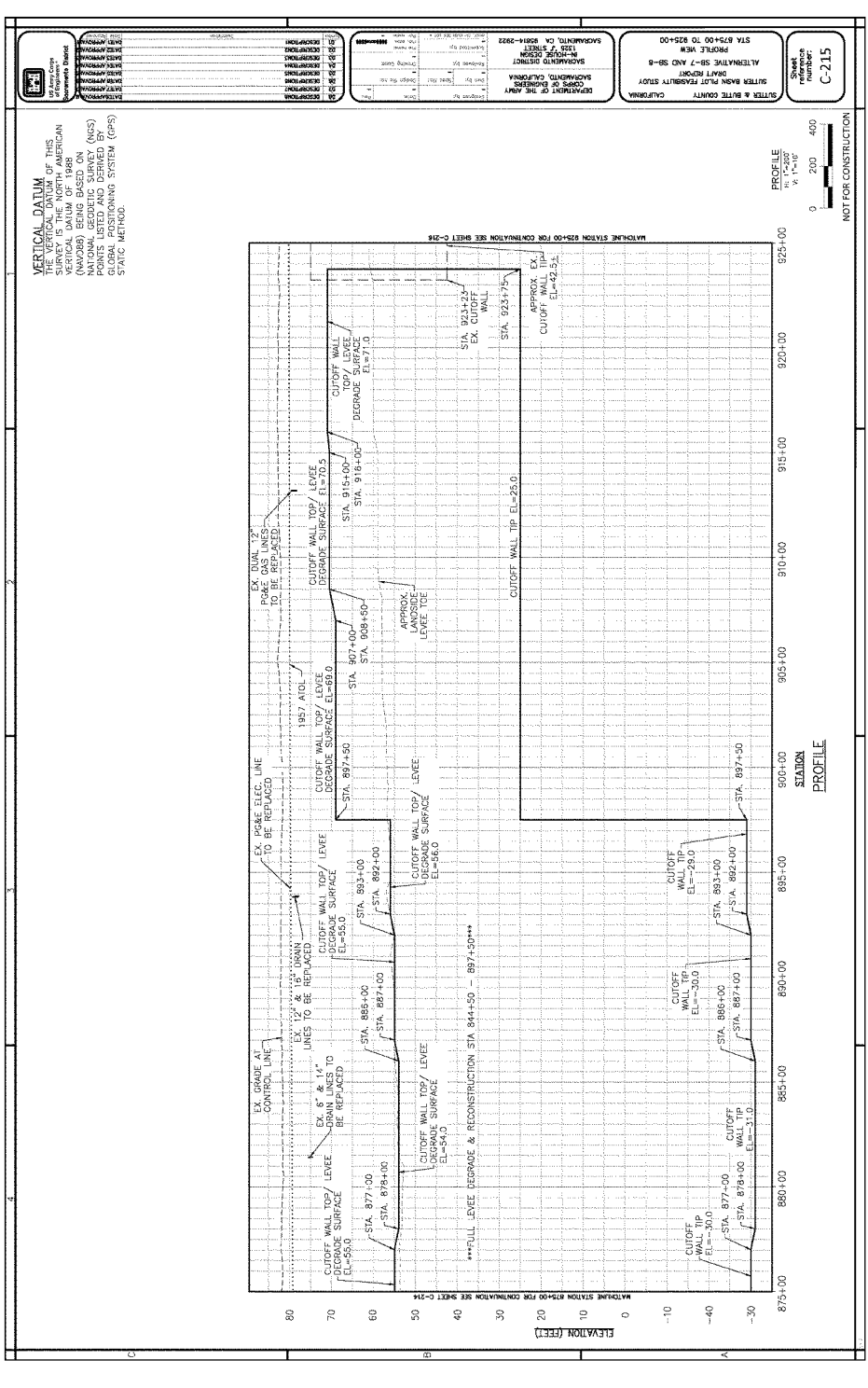
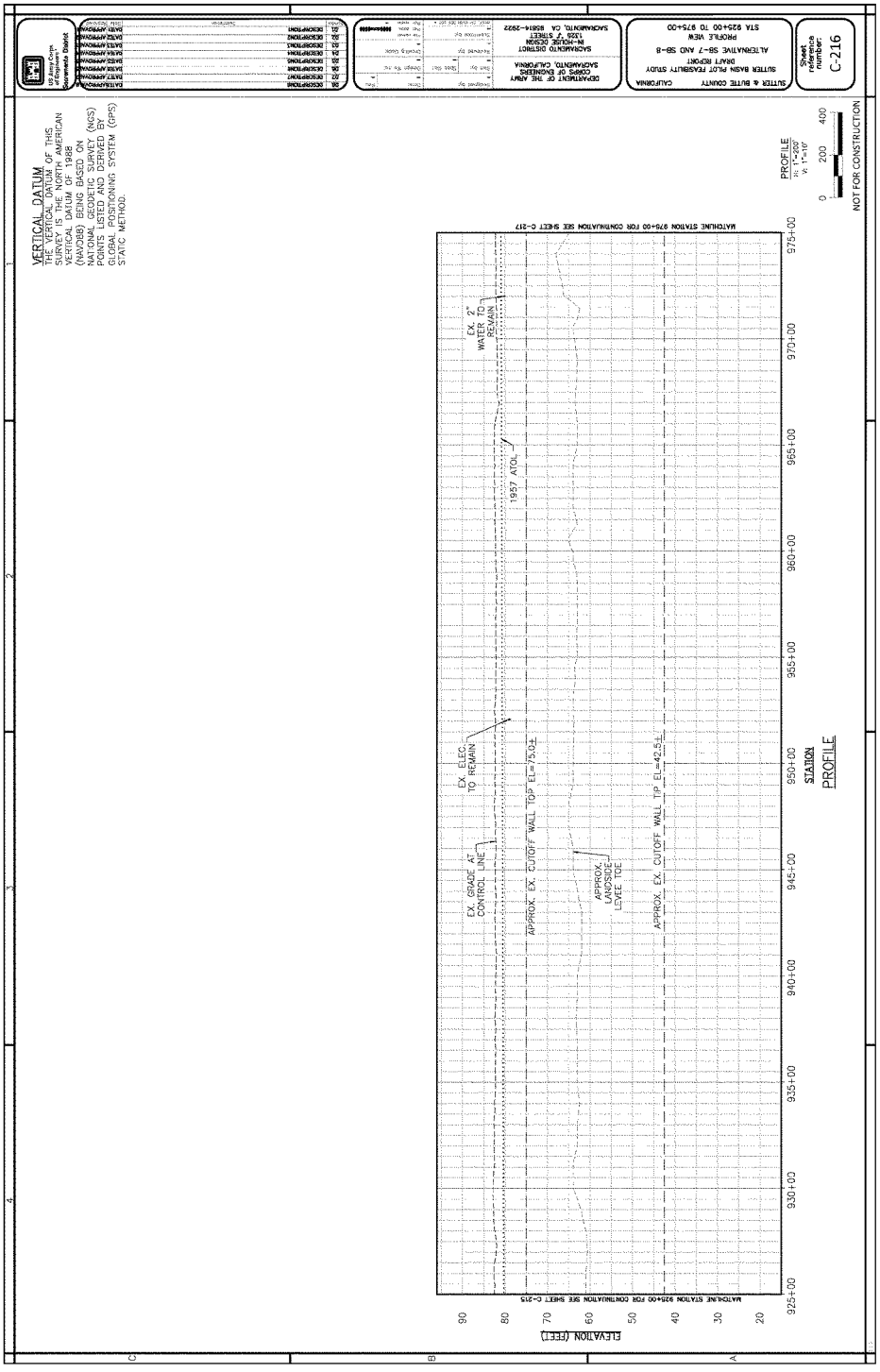
SUTTER BASIN PLOT FEASIBILITY STUDY
ALTERNATIVE SB-7 AND SB-8
DRAFT REPORT
PROFILE VIEW
STA 825+00 TO 875+00
SUTTER & BUTTE COUNTY CALIFORNIA
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 J STREET
SACRAMENTO, CA 95814-2922
Sheet number:
C-214
PROFILE
H: 1"=200'
V: 1"=10'
0 200 400
NOT FOR CONSTRUCTION
MATCHLINE STATION 825+00 FOR CONTINUATION SEE SHEET C-213
MATCHLINE STATION 875+00 FOR CONTINUATION SEE SHEET C-215
EX. 24" SEWER LINE TO BE REMOVED
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=68.0
INSTALL DUAL 24" SEWER LINES
EX. GROUE AT CONTROL LINE
APPROX. LANDSIDE LEVEE TOE
APPROX. EX. CUTOFF WALL TOP EL=54.0±
APPROX. EX. CUTOFF WALL TIP EL=30.0±
STA. 829+85
CUTOFF WALL TIP EL=-25.0
STA. 831+50
STA. 827+50
CUTOFF WALL TIP EL=-5.0
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=59.0
EX. 24" DRAIN LINE TO BE REPLACED
EX. 24" SEEPAGE LINE TO BE REPLACED
1957 ATOL
STA. 846+00
STA. 845+25
STA. 849+00
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=56.0
STA. 853+00
STA. 854+00
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=55.0
FULL LEVEE DEGRADE & RECONSTRUCTION STA 844+50 — 897+50
CUTOFF WALL TIP EL=-29.0
CUTOFF WALL TIP EL=-26.0
STA. 844+50
CUTOFF WALL TIP EL=-30.0
ELEVATION (FEET)
STATION
PROFILE


VERTICAL DATUM
THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) PUBLISHED CONTROL AND/OR GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
ALTERNATIVE SB-7 AND SB-8
DRAFT REPORT
PROFILE VIEW
STA 875+00 TO 925+00
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
SACRAMENTO, CALIFORNIA
1325 J STREET
SACRAMENTO, CA 95814-2922
Sheet reference number:
C-215
PROFILE
H: 1"=200'
V: 1"=10'
0 200 400
NOT FOR CONSTRUCTION
ELEVATION (FEET)
STATION
PROFILE
MATCHLINE STATION 875+00 FOR CONTINUATION SEE SHEET C-214
MATCHLINE STATION 925+00 FOR CONTINUATION SEE SHEET C-216
EX. GRADE AT CONTROL LINE
EX. 6" & 14" DRAIN LINES TO BE REPLACED
EX. 12" & 14" DRAIN LINES TO BE REPLACED
EX. PG&E ELEC. LINE TO BE REPLACED
EX. DUAL 12" PG&E GAS LINES TO BE REPLACED
1957 ATOL
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=55.0
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=69.0
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=70.5
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=71.0
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=54.0
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=56.0
CUTOFF WALL TOP/ DEGRADE SURFACE EL=59.0
CUTOFF WALL TIP EL=-30.0
CUTOFF WALL TIP EL=-31.0
CUTOFF WALL TIP EL=-25.0
CUTOFF WALL TIP EL=-28.0
APPROX. LANDSIDE LEVEE TOE
APPROX. EX. CUTOFF WALL EL=42.5±
EX. CUTOFF WALL
FULL LEVEE DEGRADE & RECONSTRUCTION STA 844+50 - 897+50
STA. 877+00
STA. 878+00
STA. 885+00
STA. 886+00
STA. 887+00
STA. 892+00
STA. 893+00
STA. 897+50
STA. 907+00
STA. 908+50
STA. 915+00
STA. 916+00
STA. 923+25
STA. 923+75


VERTICAL DATUM
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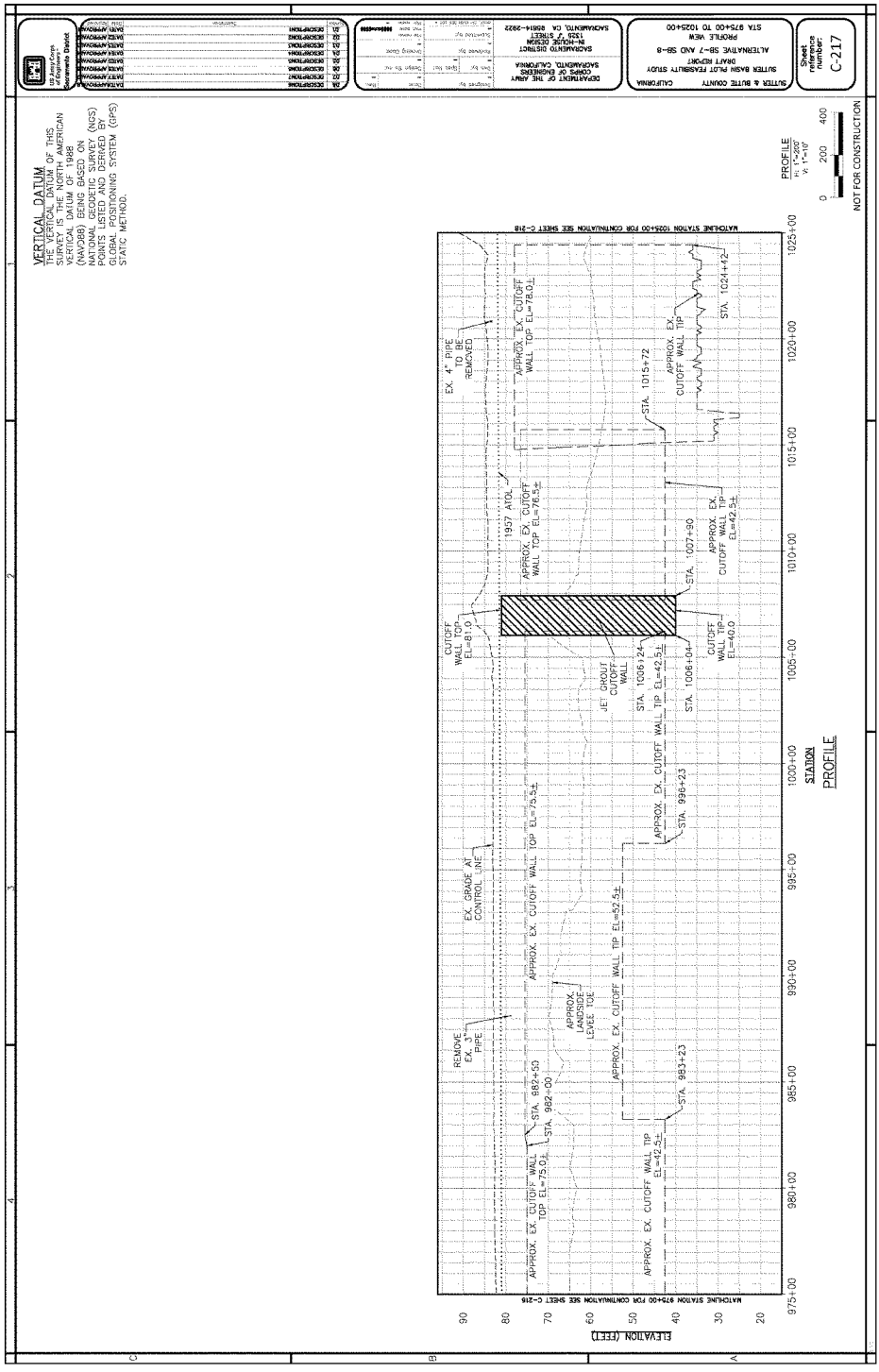
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
ALTERNATIVE SB-7 AND SB-8
DRAFT REPORT
PROFILE VIEW
STA 825+00 TO 975+00
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 J STREET
SACRAMENTO, CA 95814-2922
Sheet number: C-216
MATCHLINE STATION 975+00 FOR CONTINUATION SEE SHEET C-217
MATCHLINE STATION 925+00 FOR CONTINUATION SEE SHEET C-217
EX. 42" WATER TO REMAIN
1957 ATOL
EX. ELEC. TO REMAIN
EX. GRADE AT CONTROL LINE
APPROX. EX. CUTOFF WALL TOP EL=75.0±
APPROX. LANDSIDE LEVEE TOE
APPROX. EX. CUTOFF WALL TIP EL=42.5±
ELEVATION (FEET)
STATION
PROFILE
PROFILE
H: 1"=200'
V: 1"=10'
0 200 400
NOT FOR CONSTRUCTION


VERTICAL DATUM
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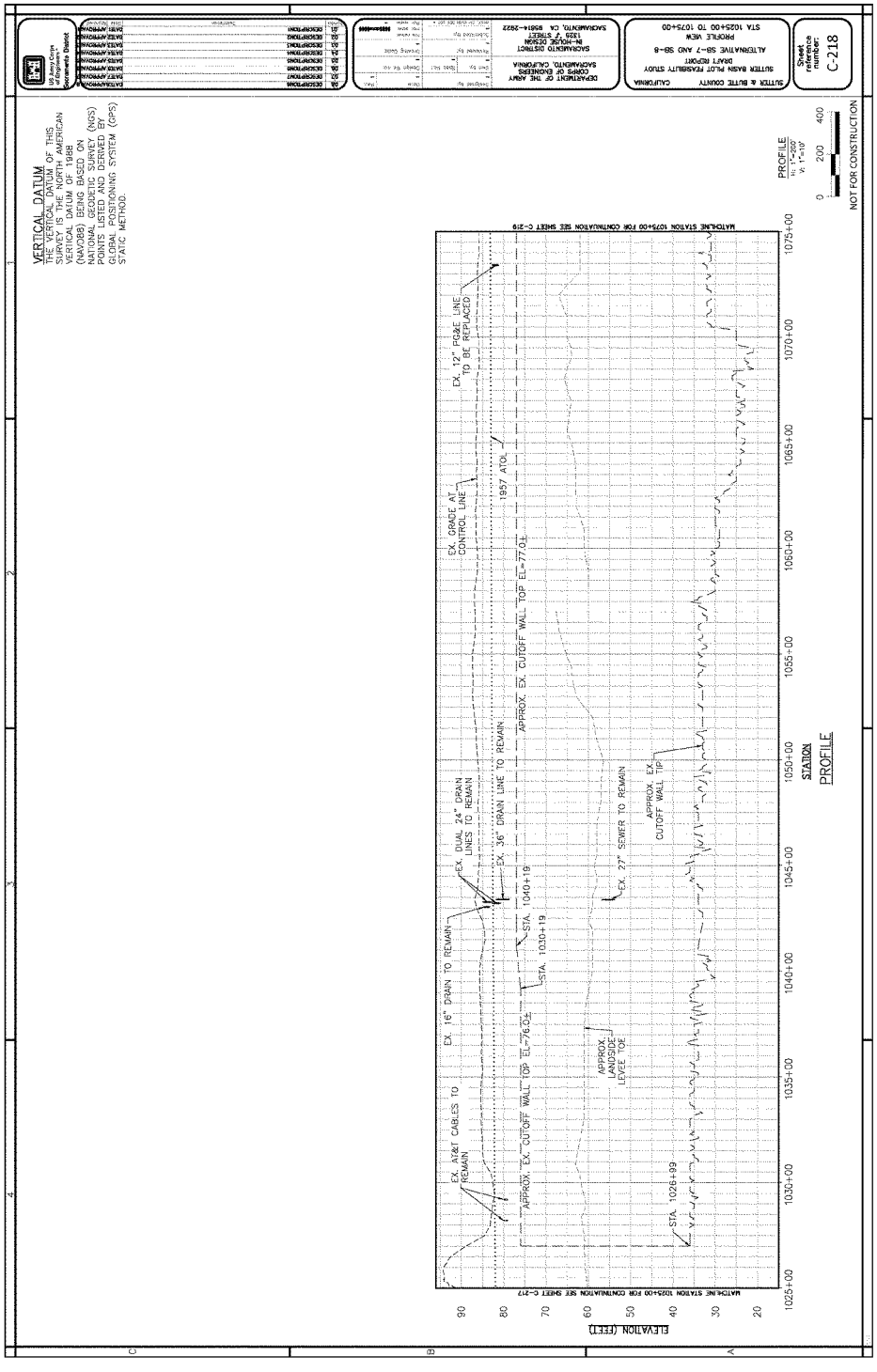
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PROFILE VIEW
STA 975+00 TO 1025+00
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 J STREET
SACRAMENTO, CALIFORNIA
SACRAMENTO, CA 95814-2922
Sheet reference number: C-217
PROFILE
H: 1"=200'
V: 1"=10'
0 200 400
NOT FOR CONSTRUCTION
ELEVATION (FEET)
STATION
PROFILE
MATCHLINE STATION 975+00 FOR CONTINUATION SEE SHEET C-216
MATCHLINE STATION 1025+00 FOR CONTINUATION SEE SHEET C-218
APPROX. EX. CUTOFF WALL TOP EL=75.0±
APPROX. EX. CUTOFF WALL TIP EL=42.5±
STA. 982+00
STA. 983+23
STA. 986+23
STA. 1006+04
STA. 1006+24
STA. 1007+90
STA. 1015+72
STA. 1024+12
REMOVE EX. 3" PIPE
APPROX. LANDSIDE TOE
EX. GRADE AT CONTROL LINE
APPROX. EX. CUTOFF WALL TOP EL=79.5±
APPROX. EX. CUTOFF WALL TIP EL=52.5±
JET GROUT CUTOFF WALL
CUTOFF WALL TOP EL=81.0
CUTOFF WALL TIP EL=42.5±
CUTOFF WALL TIP EL=40.0
1957 ATDL
APPROX. EX. CUTOFF WALL TOP EL=76.5±
APPROX. EX. CUTOFF WALL TOP EL=78.0±
EX. 4" PIPE TO BE REMOVED
APPROX. EX. CUTOFF WALL TIP
APPROX. EX. CUTOFF WALL TIP EL=42.5±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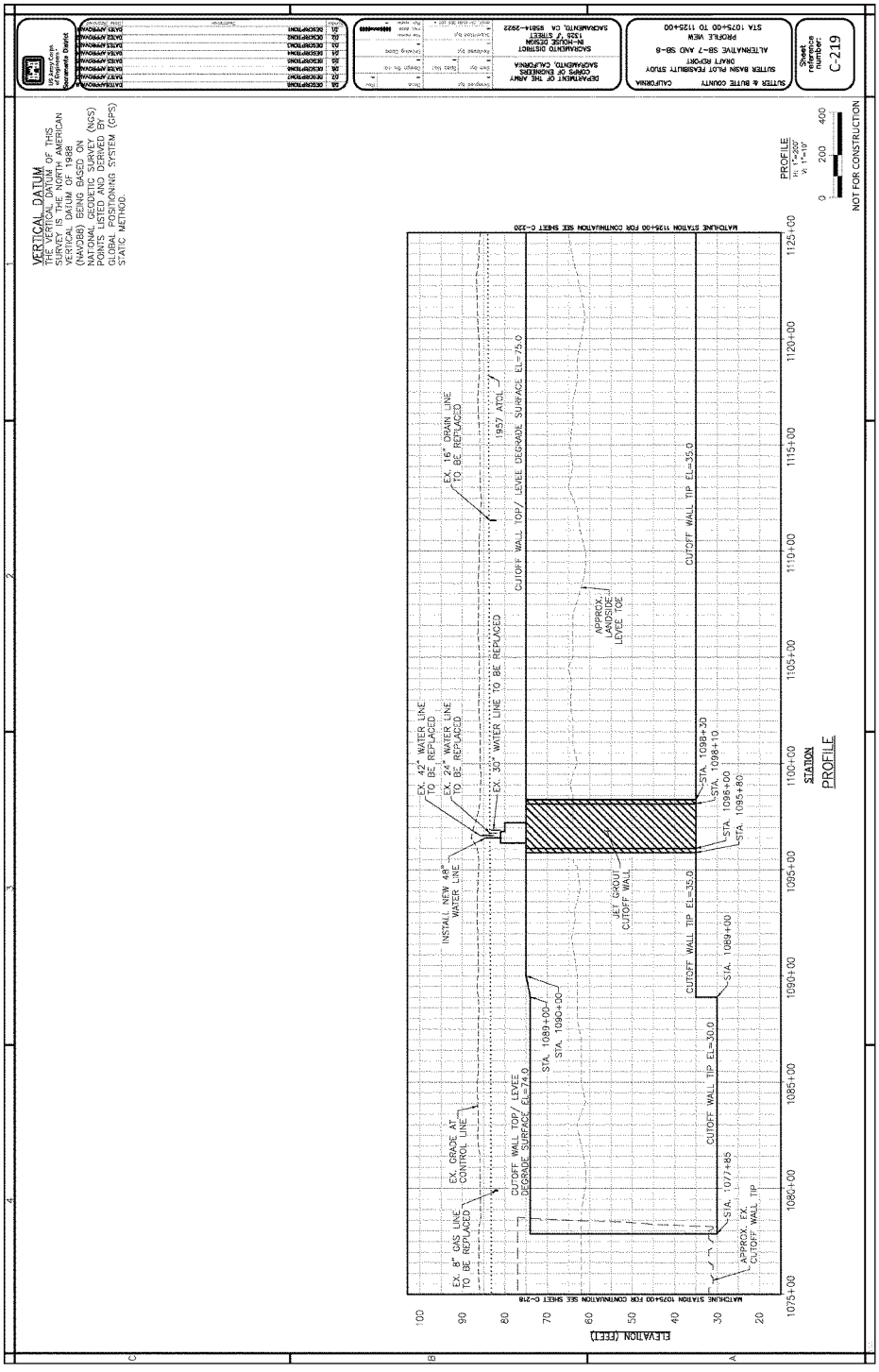
US Army Corps of Engineers Sacramento District
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
ALTERNATIVE SB-7 AND SB-8
DRAFT REPORT
PROFILE VIEW
STA 1025+00 TO 1075+00
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 J STREET
SACRAMENTO, CA 95814-2922
Sheet Number
C-218
PROFILE
H: 1"=200'
V: 1"=10'
0 200 400
NOT FOR CONSTRUCTION
ELEVATION (FEET)
STATION
PROFILE
MATCHLINE STATION 1025+00 FOR CONTINUATION SEE SHEET C-217
MATCHLINE STATION 1075+00 FOR CONTINUATION SEE SHEET C-219
EX. ARMY CABLES TO REMAIN
APPROX. EX. CUTOFF WALL TOP EL.=76.0±
EX. 16" DRAIN TO REMAIN
APPROX. LANDSIDE LEVEE TOE
STA. 1026+99
STA. 1030+19
STA. 1040+19
EX. DUAL 24" DRAIN LINES TO REMAIN
EX. 36" DRAIN LINE TO REMAIN
EX. 27" SEWER TO REMAIN
APPROX. EX. CUTOFF WALL TIP
APPROX. EX. CUTOFF WALL TOP EL.=77.0±
1957 ATOL
EX. GRADE AT CONTROL LINE
EX. 12" PROP. LINE TO BE REPLACED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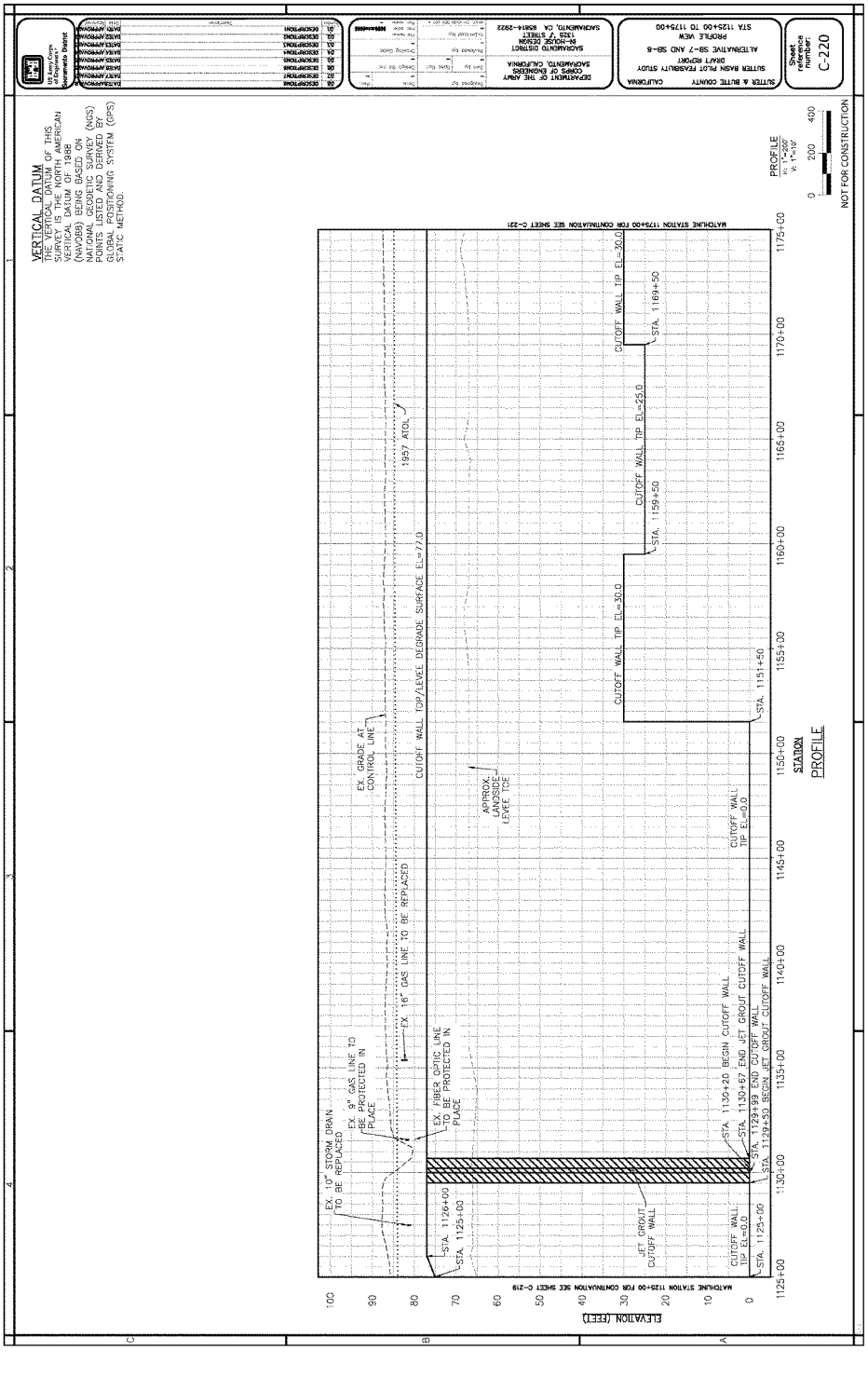
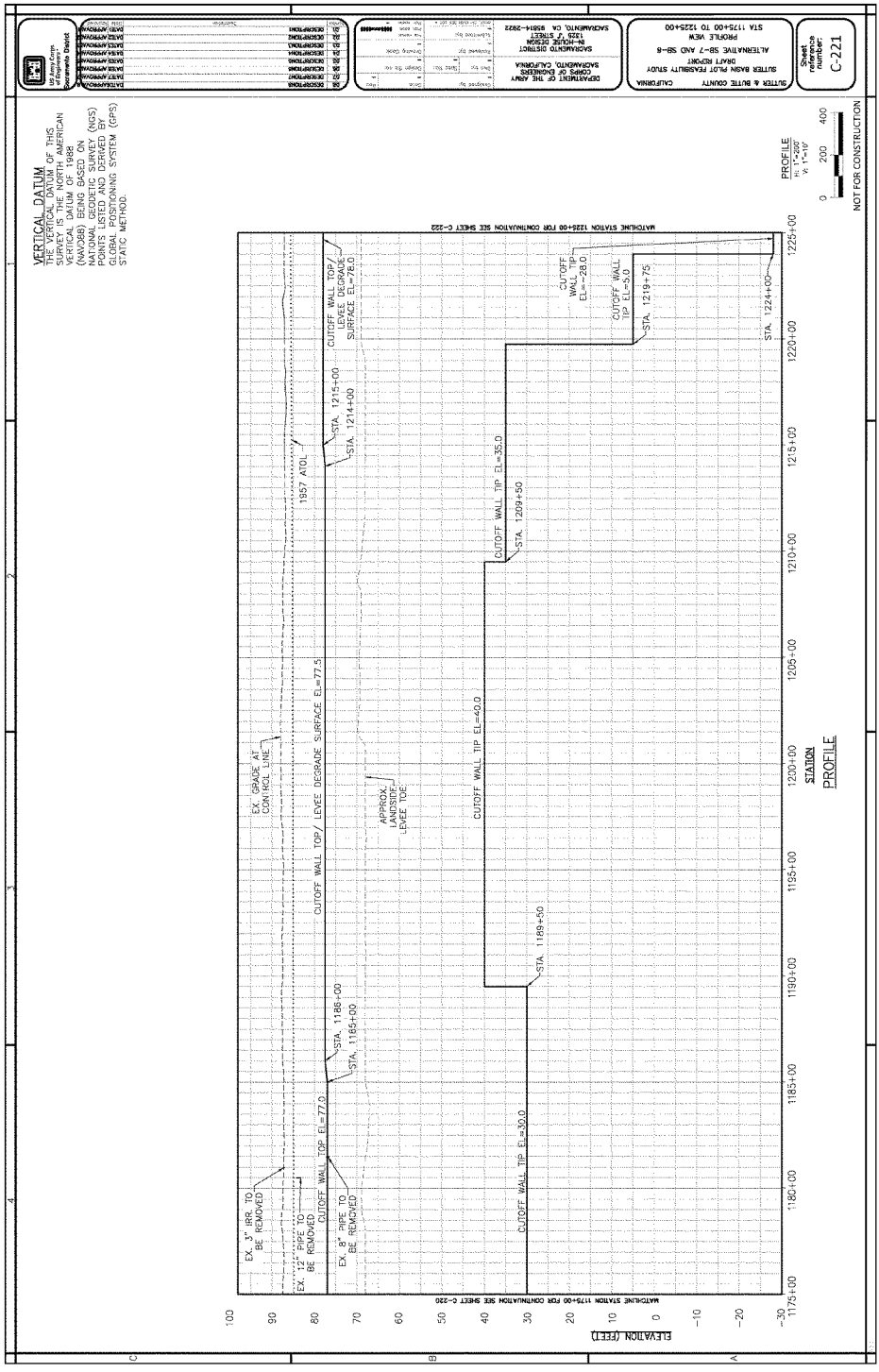
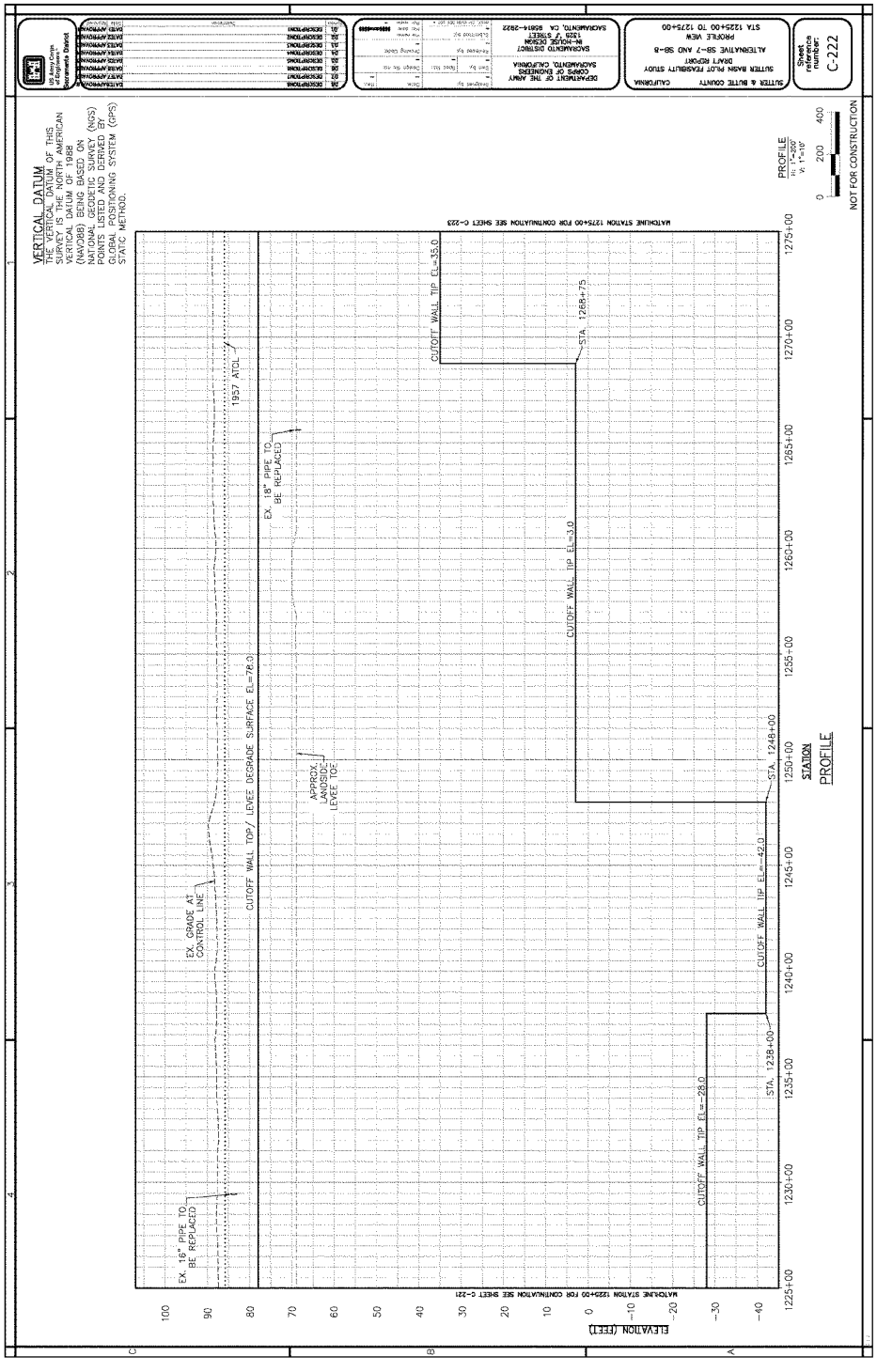
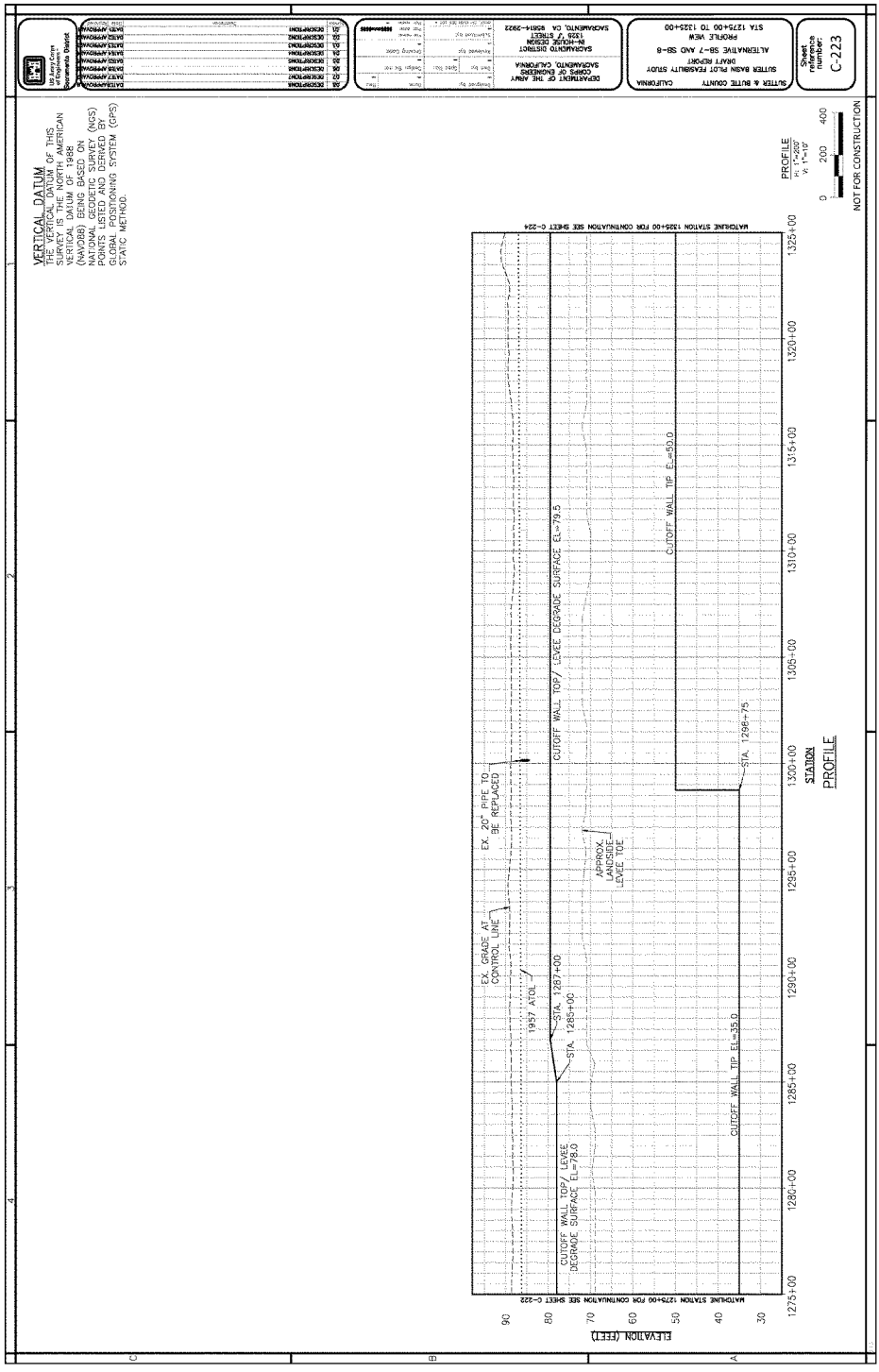
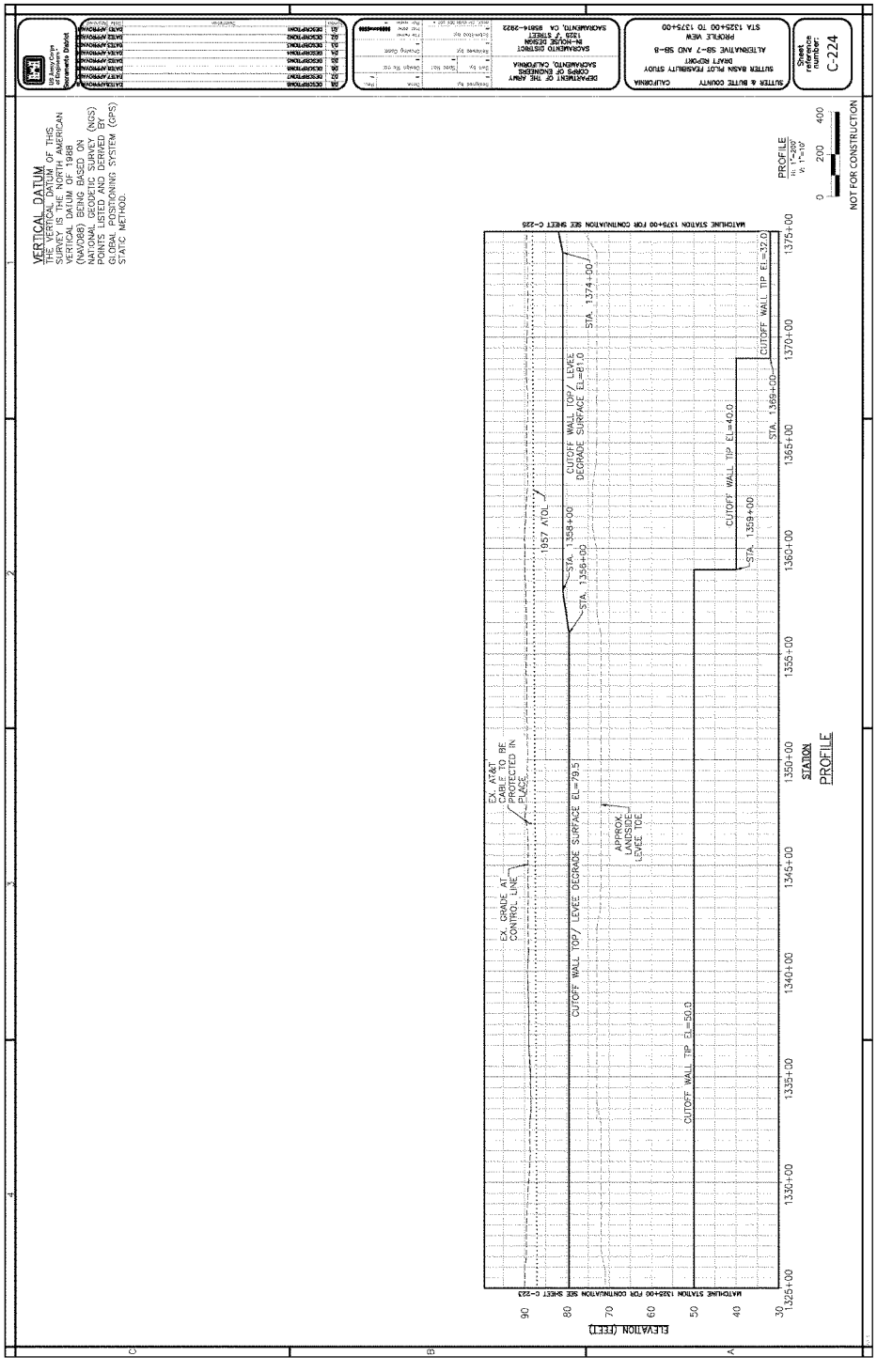
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PROFILE VIEW
STA 1075+00 TO 1125+00
Sheet reference number: C-219
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
SACRAMENTO, CALIFORNIA
1325 J STREET
SACRAMENTO, CA 95814-2922
US Army Corps of Engineers Sacramento District
PROFILE
H: 1"=200'
V: 1"=10'
0 200 400
NOT FOR CONSTRUCTION
ELEVATION (FEET)
STATION
PROFILE
MATCHLINE STATION 1075+00 FOR CONTINUATION SEE SHEET C-218
MATCHLINE STATION 1125+00 FOR CONTINUATION SEE SHEET C-220
EX. 8" GAS LINE TO BE REPLACED
EX. GRADE AT CONTROL LINE
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=74.0
STA. 1077+85
APPROX. EX. CUTOFF WALL TIP
CUTOFF WALL TIP EL=30.0
STA. 1089+00
STA. 1090+00
INSTALL NEW 48" WATER LINE
EX. 42" WATER LINE TO BE REPLACED
EX. 24" WATER LINE TO BE REPLACED
EX. 30" WATER LINE TO BE REPLACED
JET GROUT CUTOFF WALL
CUTOFF WALL TIP EL=35.0
STA. 1093+80
STA. 1096+00
STA. 1098+10
STA. 1098+30
APPROX. LANDSIDE LEVEE TOE
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=75.0
1957 ATCL
EX. 16" DRAIN LINE TO BE REPLACED
1075+00
1080+00
1085+00
1090+00
1095+00
1100+00
1105+00
1110+00
1115+00
1120+00
1125+00
100
90
80
70
60
50
40
30
20

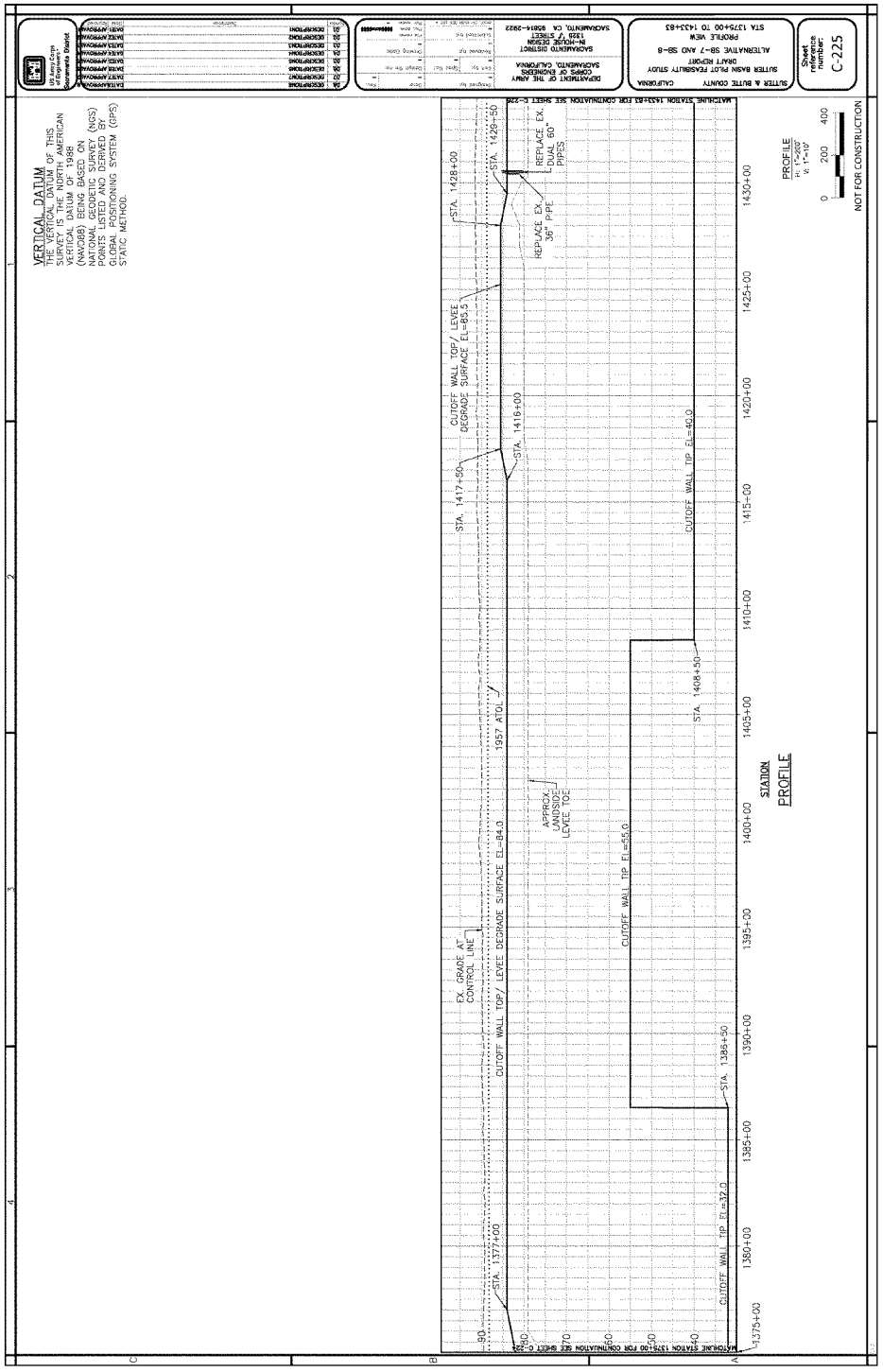

VERTICAL DATUM
THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.
SUTTER BASIN PILOT FEASIBILITY STUDY
ALTERNATIVE SB-7 AND SB-8
DRAFT REPORT
PROFILE VIEW
STA 1125+00 TO 1175+00
SUTTER & BUTTE COUNTY CALIFORNIA
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 J STREET
SACRAMENTO, CA 95814-2922
Sheet number:
C-220
PROFILE
H: 1"=200'
V: 1"=10'
0 200 400
NOT FOR CONSTRUCTION
ELEVATION (FEET)
STATION
PROFILE
MATCHLINE STATION 1125+00 FOR CONTINUATION SEE SHEET C-219
MATCHLINE STATION 1175+00 FOR CONTINUATION SEE SHEET C-221
EX. 10" STORM DRAIN TO BE REPLACED
EX. 9" GAS LINE TO BE PROTECTED IN PLACE
EX. FIBER OPTIC LINE TO BE PROTECTED IN PLACE
EX. 16" GAS LINE TO BE REPLACED
EX. GRADE AT CONTROL LINE
APPROX. LANDSIDE LEVEE TOE
CUTOFF WALL TOP/LEVEE DEGRADE SURFACE EL=77.0
1957 ATOL
JET GROUT CUTOFF WALL
CUTOFF WALL TIP EL=0.0
CUTOFF WALL TIP EL=30.0
CUTOFF WALL TIP EL=25.0
STA. 1125+00
STA. 1126+00
STA. 1129+50 BEGIN JET GROUT CUTOFF WALL
STA. 1129+99 END CUTOFF WALL
STA. 1130+67 END JET GROUT CUTOFF WALL
STA. 1130+20 BEGIN CUTOFF WALL
STA. 1151+50
STA. 1159+50
STA. 1169+50

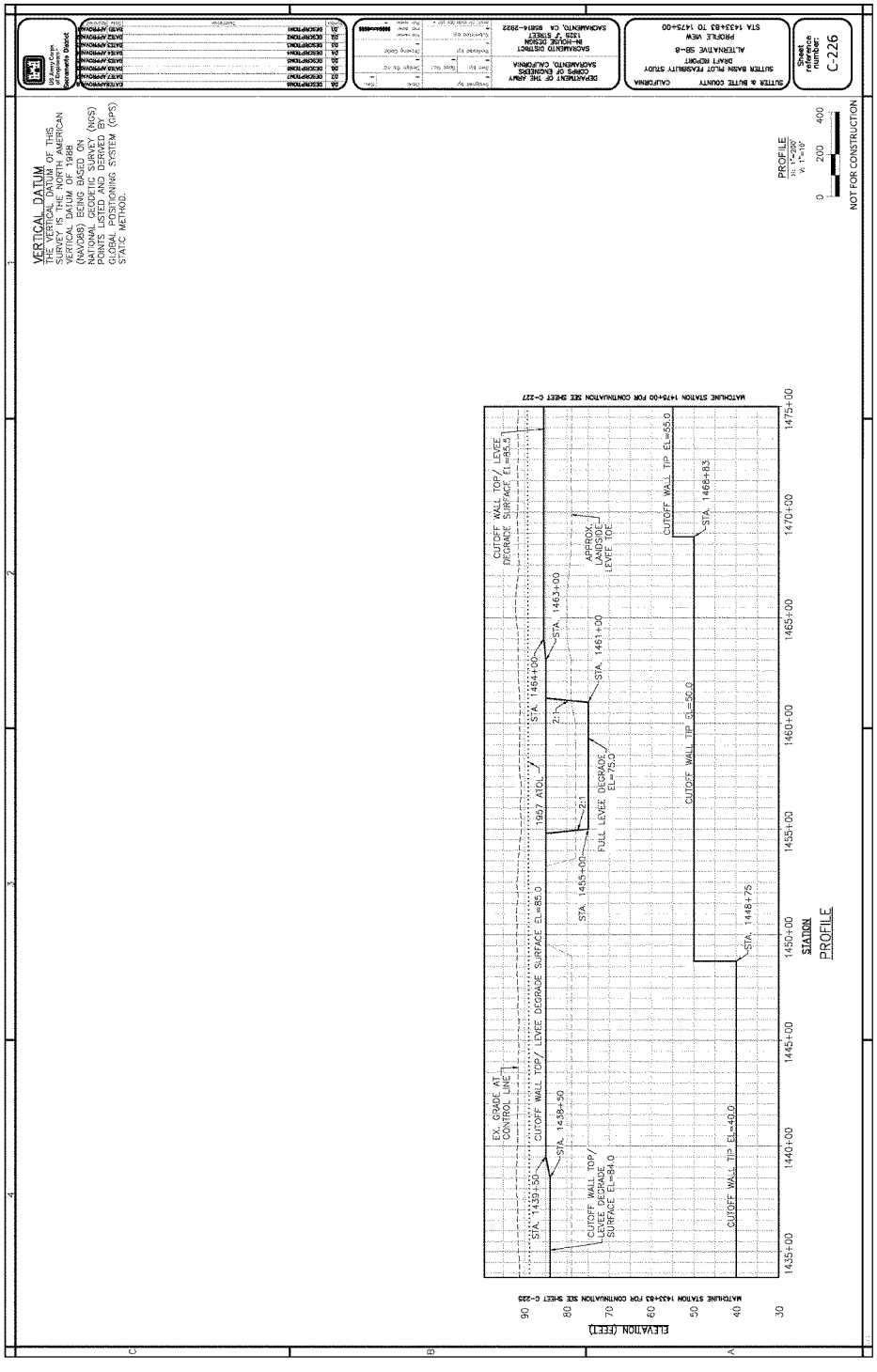

VERTICAL DATUM
THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POSITIONS AND ADJUSTED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PROFILE VIEW
STA 1175+00 TO 1225+00
Sheet reference number: C-221
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
IN-HOUSE DESIGN
PROFILE
STATION
ELEVATION (FEET)
MATCHLINE STATION 1175+00 FOR CONTINUATION SEE SHEET C-222
MATCHLINE STATION 1225+00 FOR CONTINUATION SEE SHEET C-222
EX. 3" IRR TO BE REMOVED
EX. 12" PIPE TO BE REMOVED
EX. 8" PIPE TO BE REMOVED
CUTOFF WALL TOP EL=77.0
CUTOFF WALL TIP EL=30.0
CUTOFF WALL TOP / LEVEE DEGRADE SURFACE EL=77.5
EX. GRADE AT CONTROL LINE
APPROX. LANDSIDE LEVEE TOE
CUTOFF WALL TIP EL=40.0
CUTOFF WALL TIP EL=35.0
CUTOFF WALL TOP / LEVEE DEGRADE SURFACE EL=76.0
CUTOFF WALL TIP EL=28.0
CUTOFF WALL TIP EL=5.0
1957 ATOL
STA. 1166+00
STA. 1186+00
STA. 1169+50
STA. 1209+50
STA. 1214+00
STA. 1215+00
STA. 1219+75
STA. 1224+00
PROFILE
H: 1"=200'
V: 1"=10'
0
200
400
NOT FOR CONSTRUCTION


VERTICAL DATUM
THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
ALTERNATIVE SB-7 AND SB-8
DRAFT REPORT
PROFILE VIEW
STA 1225+00 TO 1275+00
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 J STREET
SACRAMENTO, CA 95814-2922
Sheet number:
C-222
US Army Corps of Engineers Sacramento District
PROFILE
STATION
ELEVATION (FEET)
EX. 16" PIPE TO BE REPLACED
EX. GRADE AT CONTROL LINE
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=78.0
1957 ATOL
APPROX. LANDSIDE LEVEE TOE
EX. 18" PIPE TO BE REPLACED
CUTOFF WALL TIP EL=35.0
STA. 1286+75
CUTOFF WALL TIP EL=3.0
STA. 1248+00
CUTOFF WALL TIP EL=-42.0
STA. 1238+00
CUTOFF WALL TIP EL=-28.0
MATCHLINE STATION 1225+00 FOR CONTINUATION SEE SHEET C-221
MATCHLINE STATION 1275+00 FOR CONTINUATION SEE SHEET C-223
PROFILE
H: 1"=200'
V: 1"=10'
0 200 400
NOT FOR CONSTRUCTION


VERTICAL DATUM
THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) PUBLISHED CONTROL DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PROFILE VIEW
STA 1275+00 TO 1325+00
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 J STREET
SACRAMENTO, CA 95814-3922
Sheet reference number:
C-223
PROFILE
H: 1"=200'
V: 1"=10'
0 100 200 400
NOT FOR CONSTRUCTION
ELEVATION (FEET)
90 80 70 60 50 40 30
MATCHLINE STATION 1275+00 FOR CONTINUATION SEE SHEET C-224
MATCHLINE STATION 1325+00 FOR CONTINUATION SEE SHEET C-224
1275+00 1280+00 1285+00 1290+00 1295+00 1300+00 1305+00 1310+00 1315+00 1320+00 1325+00
STATION
PROFILE
EX. GRADE AT CONTROL LINE
EX. 20" PIPE TO BE REPLACED
1957 ATOL
STA. 1287+00
STA. 1285+00
APPROX. LANDSIDE LEVEE TOE
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=79.5
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=78.0
CUTOFF WALL TIP EL=35.0
CUTOFF WALL TIP EL=50.0
STA. 1296+75


VERTICAL DATUM
THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY CONTROL ESTABLISHING SYSTEM (GPS) STATIC METHOD.
SUTTER BASIN PILOT FEASIBILITY STUDY
ALTERNATIVE SB-7 AND SB-8
DRAFT REPORT
PROFILE VIEW
STA 1325+00 TO 1375+00
SUTTER & BUTTE COUNTY CALIFORNIA
DEPARTMENT OF THE ARMY CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT IN-HOUSE DESIGN
1325 J STREET SACRAMENTO, CA 95814-2922
Sheet reference number: C-224
PROFILE
H: 1"=200'
V: 1"=10'
0 200 400
NOT FOR CONSTRUCTION
ELEVATION (FEET)
90 80 70 60 50 40 30
STATION
1,325+00 1,330+00 1,335+00 1,340+00 1,345+00 1,350+00 1,355+00 1,360+00 1,365+00 1,370+00 1,375+00
MATCHLINE STATION 1325+00 FOR CONTINUATION SEE SHEET C-223
MATCHLINE STATION 1375+00 FOR CONTINUATION SEE SHEET C-225
EX. GRADE AT CONTROL LINE
EX. AT&T CABLE TO BE PROTECTED IN PLACE
APPROX. LANDSIDE LEVEE TOE
1957 ATOL
STA. 1358+00
STA. 1356+00
STA. 1374+00
STA. 1369+00
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=79.5
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=81.0
CUTOFF WALL TIP EL=40.0
CUTOFF WALL TIP EL=32.0
CUTOFF WALL TIP EL=50.0
PROFILE


VERTICAL DATUM
THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) PUBLISHED CONTROL DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
SACRAMENTO, CALIFORNIA
1239 'J' STREET
SACRAMENTO, CA 95814-2922
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
PROFILE VIEW
STA 1375+00 TO 1431+82
SUTTER & BUTTE COUNTY CALIFORNIA
Sheet reference number:
C-225
MATCHLINE STATION 1431+82 FOR CONTINUATION SEE SHEET C-226
MATCHLINE STATION 1375+00 FOR CONTINUATION SEE SHEET C-224
EX. GRADE AT CONTROL LINE
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=84.0
1957 ATOL
APPROX. LANDSIDE LEVEE TOE
CUTOFF WALL TIP EL=55.0
CUTOFF WALL TIP EL=32.0
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=86.5
CUTOFF WALL TIP EL=40.0
REPLACE EX. DUAL 60" PIPES
REPLACE EX. 36" PIPE
STA. 1377+00
STA. 1385+50
STA. 1390+00
STA. 1395+00
STA. 1400+00
STA. 1405+00
STA. 1408+50
STA. 1410+00
STA. 1415+00
STA. 1416+00
STA. 1417+60
STA. 1420+00
STA. 1425+00
STA. 1428+50
STA. 1430+00
STATION
PROFILE
PROFILE
H: 1"=200'
V: 1"=10'
0
200
400
NOT FOR CONSTRUCTION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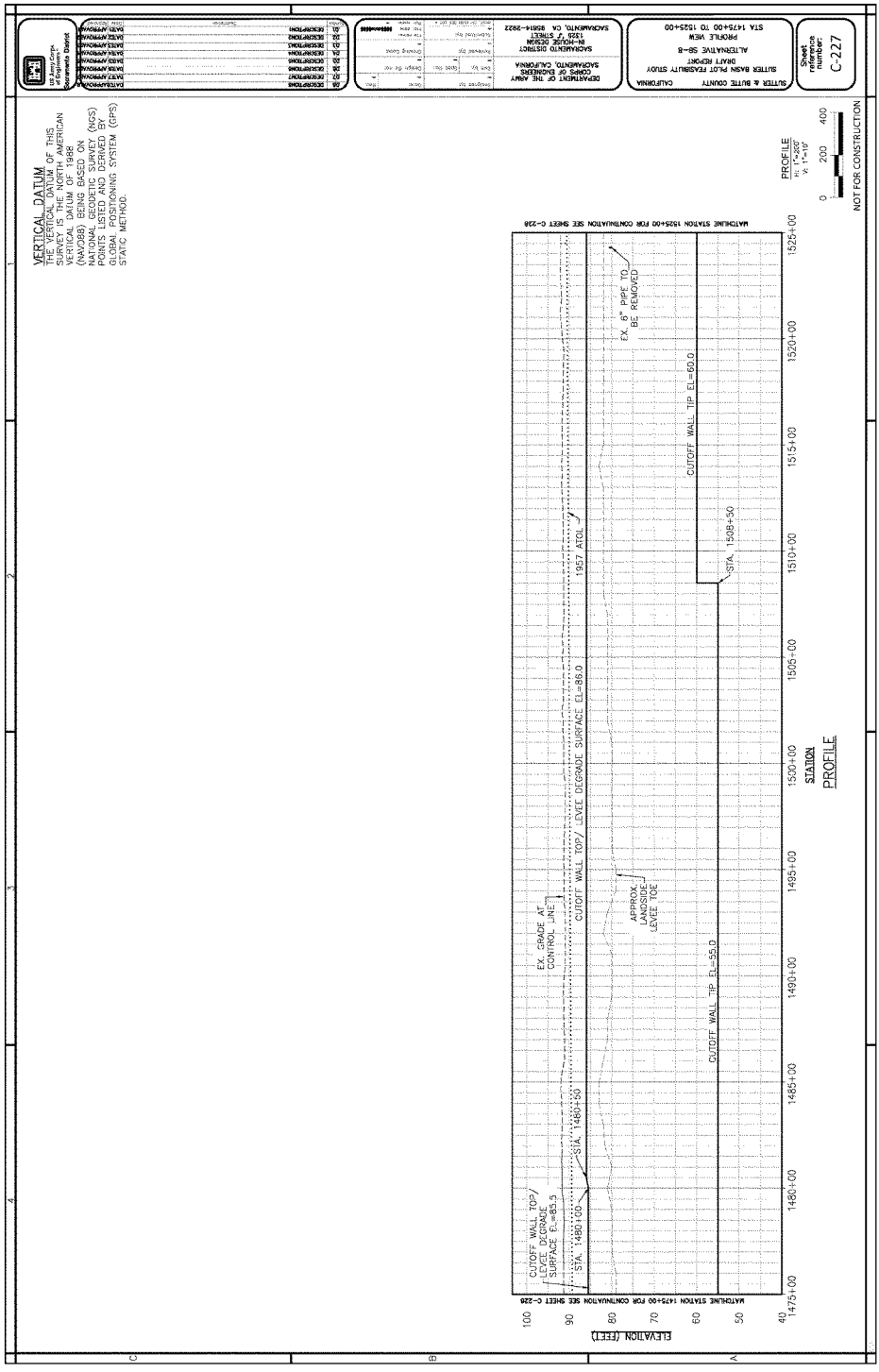
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER & BUTTE COUNTY CALIFORNIA
PROFILE VIEW
ALTERNATIVE 3B-8
STA 1433+83 TO 1475+00
DRAFT REPORT
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 J STREET
SACRAMENTO, CA 95814-2922
Sheet number: C-226
PROFILE
H: 1"=200'
V: 1"=10'
0 200 400
NOT FOR CONSTRUCTION
ELEVATION (FEET)
STATION
PROFILE
MATCHLINE STATION 1435+83 FOR CONTINUATION SEE SHEET C-225
MATCHLINE STATION 1475+00 FOR CONTINUATION SEE SHEET C-227
EX. GRADE AT CONTROL LINE
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=85.0
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=85.5
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=84.0
CUTOFF WALL TIP EL=40.0
CUTOFF WALL TIP EL=50.0
CUTOFF WALL TIP EL=55.0
FULL LEVEE DEGRADE EL=75.0
1957 ATOL
APPROX. LANDSIDE LEVEE TOE
STA. 14391+50
STA. 1439+50
STA. 1448+75
STA. 1455+00
STA. 1461+00
STA. 1463+00
STA. 1464+00
STA. 1468+83
2:1
2:1


VERTICAL DATUM
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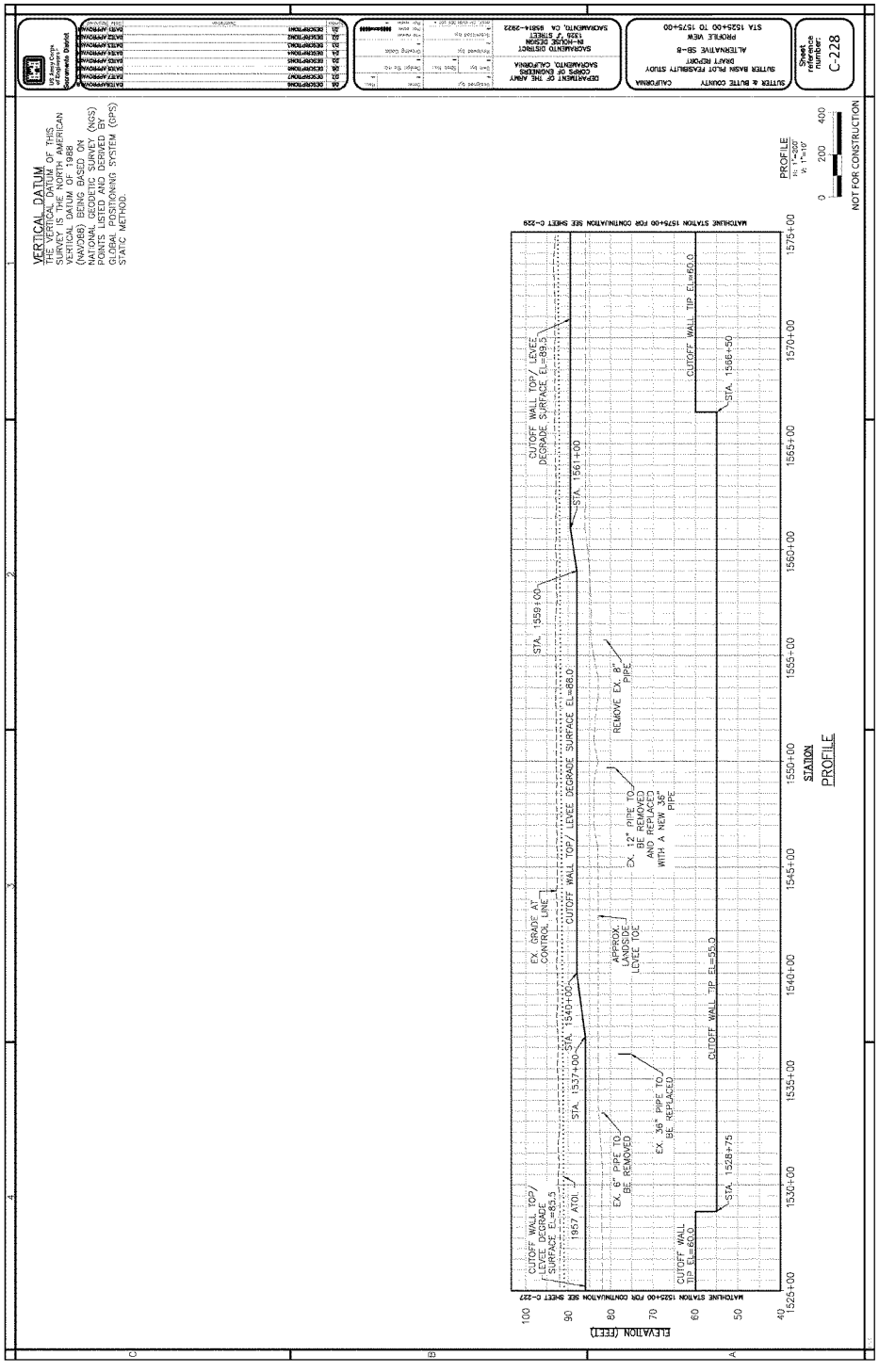
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
SACRAMENTO, CALIFORNIA
SACRAMENTO, CA 95814-2922
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PROFILE VIEW
STA 1475+00 TO 1525+00
SUTTER & BUTTE COUNTY CALIFORNIA
Sheet reference number: C-227
PROFILE
H: 1"=200'
V: 1"=10'
0 200 400
NOT FOR CONSTRUCTION
ELEVATION (FEET)
100 90 80 70 60 50 40
MATCHLINE STATION 1475+00 FOR CONTINUATION SEE SHEET C-228
MATCHLINE STATION 1525+00 FOR CONTINUATION SEE SHEET C-228
1475+00 1480+00 1485+00 1490+00 1495+00 1500+00 1505+00 1510+00 1515+00 1520+00 1525+00
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=85.5
STA. 1480+60
STA. 1489+50
EX. GRADE AT CONTROL LINE
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=85.0
APPROX. LANDSIDE LEVEE TOE
CUTOFF WALL TIP EL=55.0
1957 ATOL
STA. 1508+50
CUTOFF WALL TIP EL=60.0
EX. 6" PIPE TO BE REMOVED
STATION
PROFILE


VERTICAL DATUM
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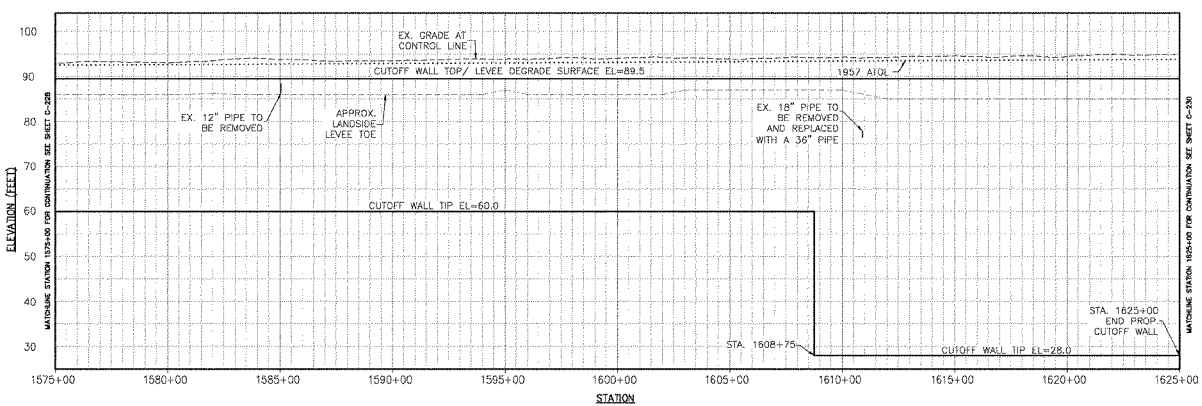
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER & BUTTE COUNTY CALIFORNIA
ALTERNATIVE SB-8
DRAFT REPORT
STA 1525+00 TO 1575+00
DEPARTMENT OF THE ARMY CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT IN-HOUSE DESIGN
1325 J STREET SACRAMENTO, CA 95814-2922
Sheet number: C-228
PROFILE
MATCHLINE STATION 1525+00 FOR CONTINUATION SEE SHEET C-227
MATCHLINE STATION 1575+00 FOR CONTINUATION SEE SHEET C-229
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=83.5
1957 ATOL
EX. 6" PIPE TO BE REMOVED
EX. 36" PIPE TO BE REPLACED
STA. 1528+75
CUTOFF WALL TIP EL=60.0
STA. 1537+00
STA. 1540+00
EX. GRADE AT CONTROL LINE
APPROX. LANDSIDE LEVEE TOE
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=88.0
EX. 12" PIPE TO BE REMOVED AND REPLACED WITH A NEW 36" PIPE
REMOVE EX. 8" PIPE
STA. 1559+00
STA. 1561+00
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=89.5
CUTOFF WALL TIP EL=60.0
STA. 1566+50
ELEVATION (FEET)
STATION
PROFILE
H: 1"=200'
V: 1"=10'
NOT FOR CONSTRUCTION

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

NOT FOR CONSTRUCTION

US Army Corps of Engineers
Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

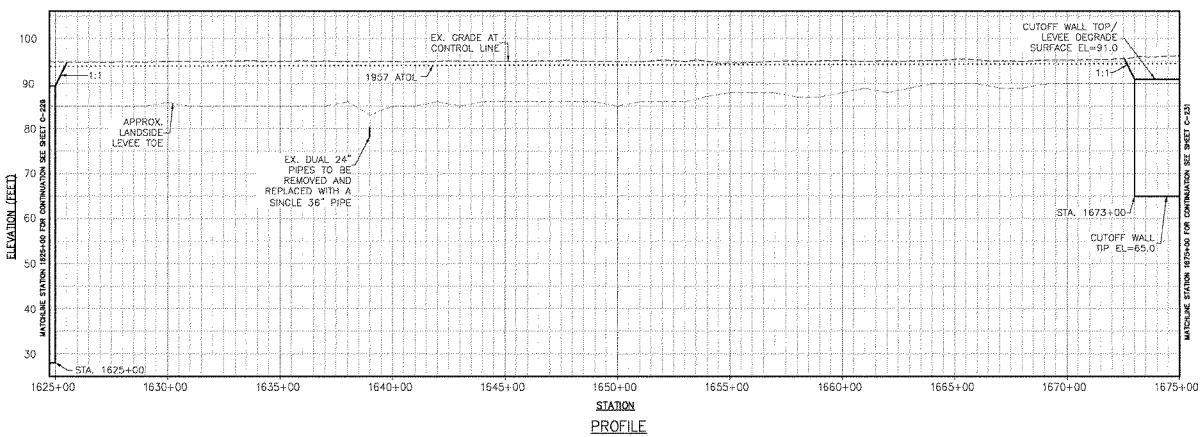
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PROFILE VIEW
STA 1575+00 TO 1625+00

Sheet reference number:
C-229

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

NOT FOR CONSTRUCTION

US Army Corps of Engineers
Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

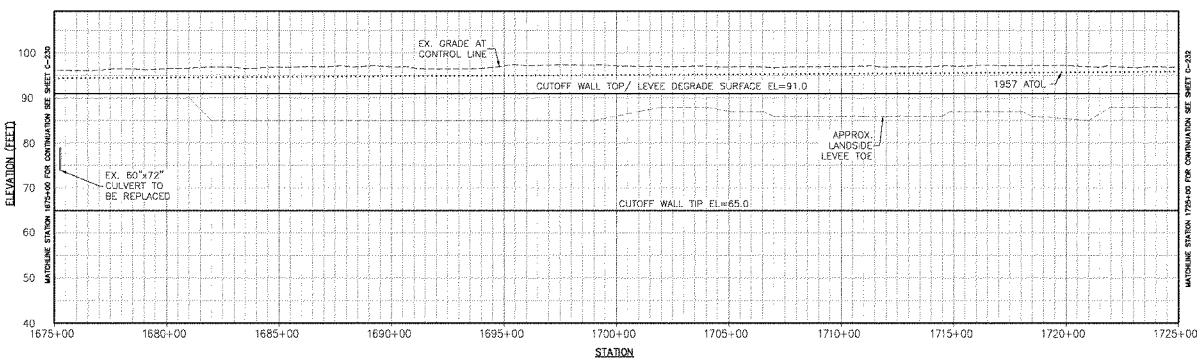
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PROFILE VIEW
STA 1625+00 TO 1675+00

Sheet reference number:
C-230

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

NOT FOR CONSTRUCTION

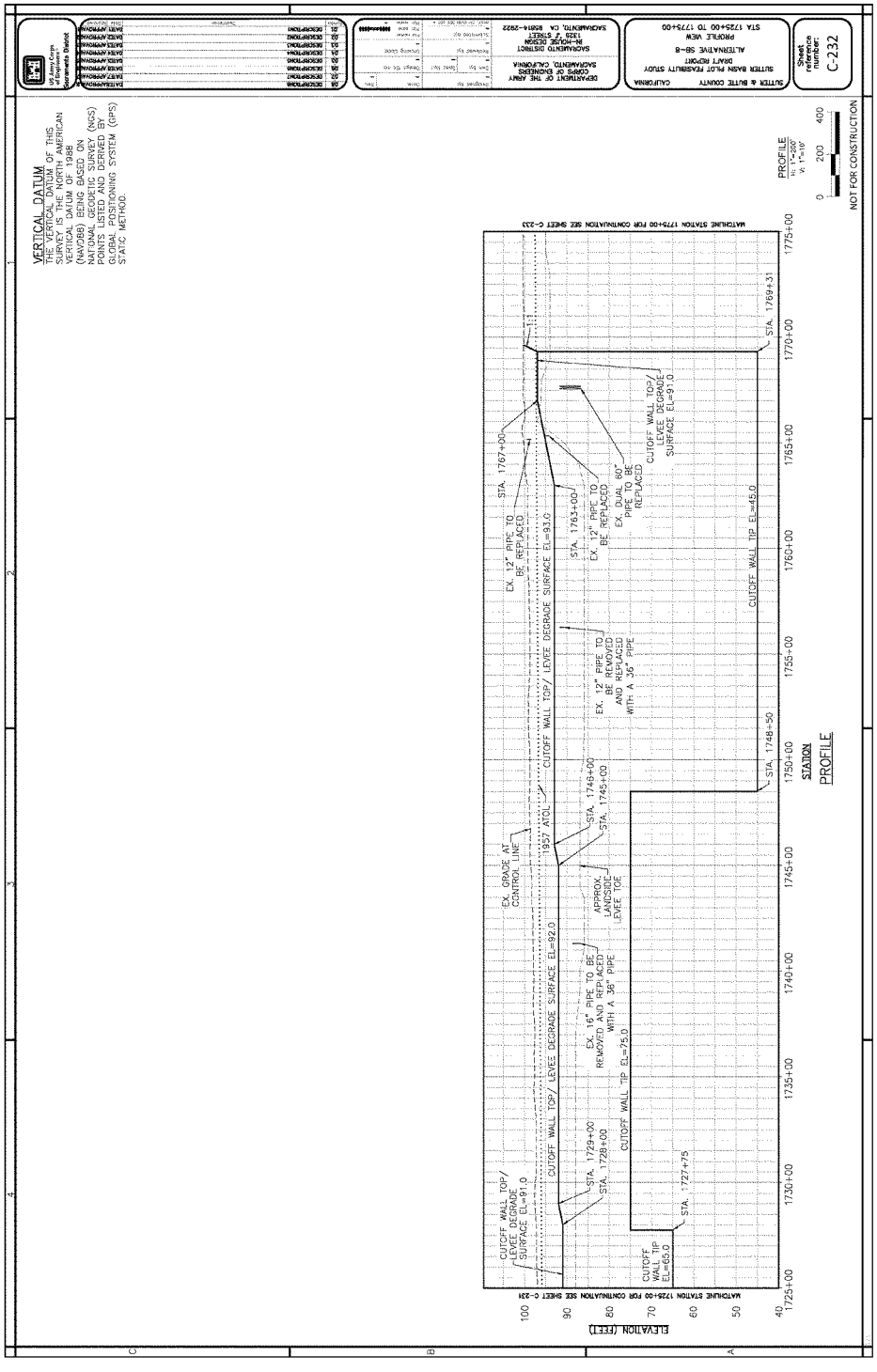
US Army Corps of Engineers
Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PROFILE VIEW
STA. 1675+00 TO 1725+00

Sheet reference number:
C-231


VERTICAL DATUM
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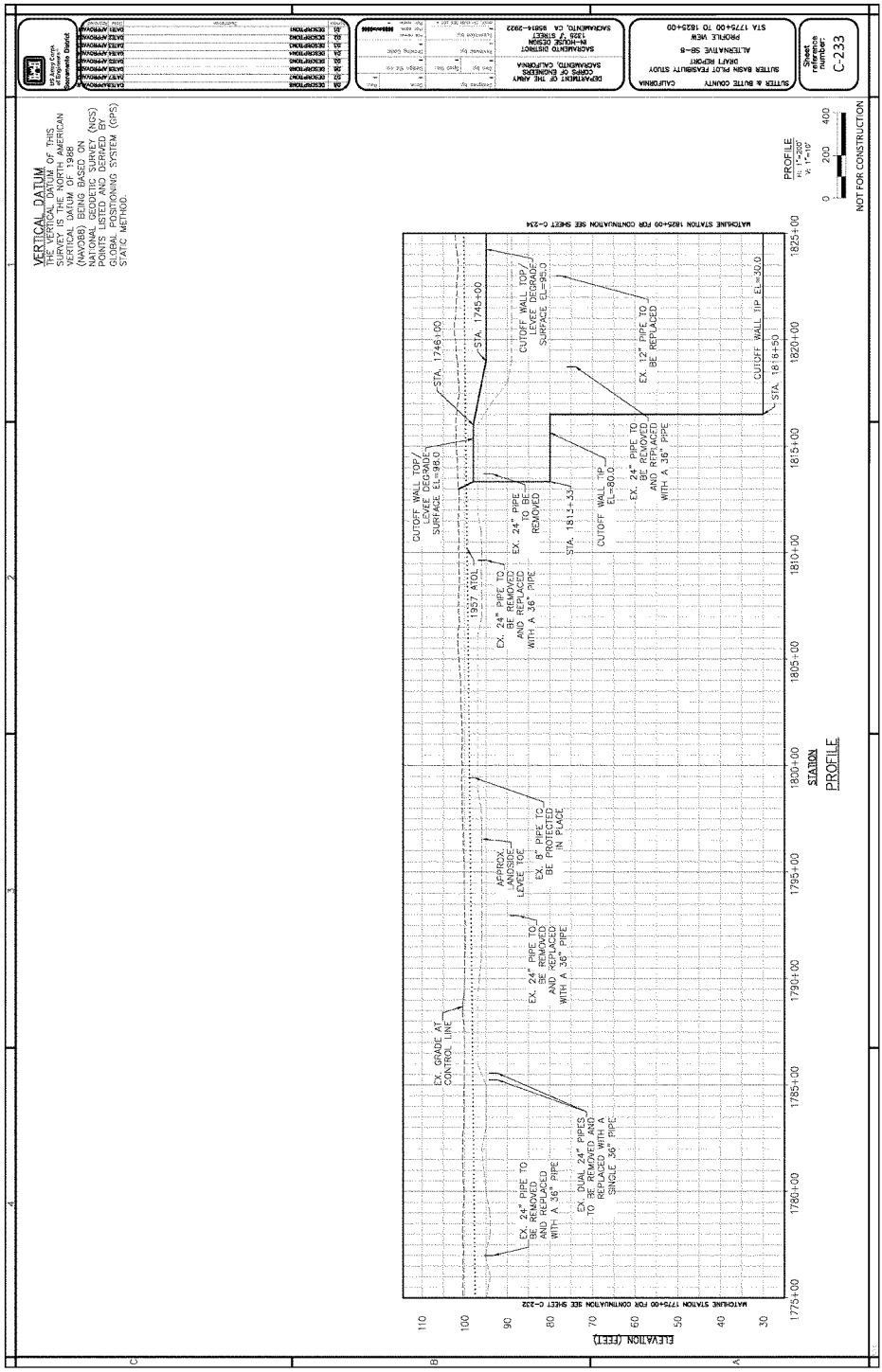
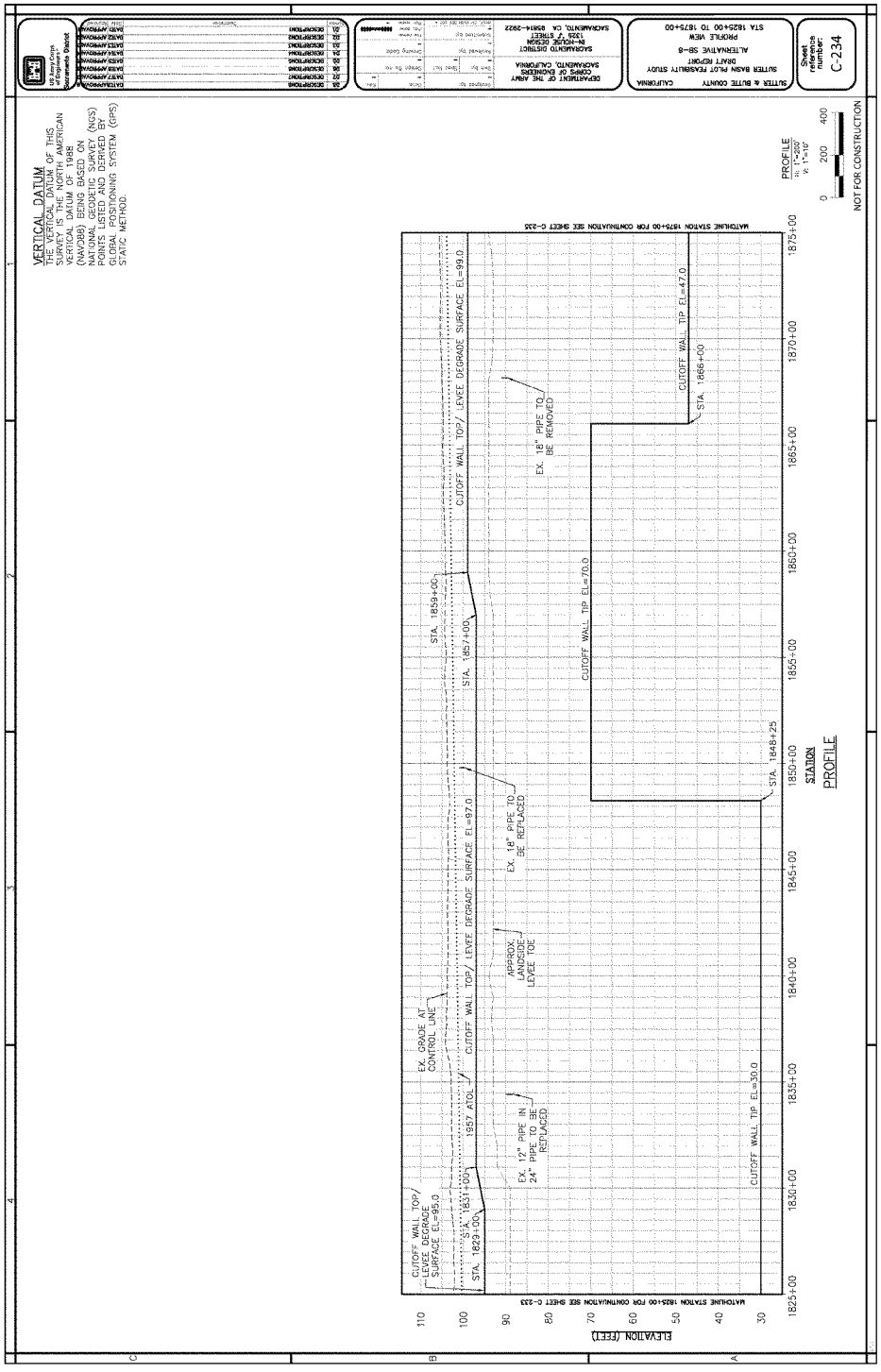
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PROFILE VIEW
STA 1725+00 TO 1775+00
Sheet number: C-232
DEPARTMENT OF THE ARMY CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT IN-HOUSE DESIGN
1325 J STREET SACRAMENTO, CA 95814-2922
US Army Corps of Engineers Sacramento District
PROFILE
H: 1"=200'
V: 1"=10'
0 200 400
NOT FOR CONSTRUCTION
ELEVATION (FEET)
STATION
MATCHLINE STATION 1725+00 FOR CONTINUATION SEE SHEET C-231
MATCHLINE STATION 1775+00 FOR CONTINUATION SEE SHEET C-233
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=91.0
CUTOFF WALL TIP EL=65.0
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=92.0
CUTOFF WALL TIP EL=75.0
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=93.0
CUTOFF WALL TIP EL=45.0
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=91.0
EX. GRADE AT CONTROL LINE
EX. 16" PIPE TO BE REMOVED AND REPLACED WITH A 36" PIPE
EX. 12" PIPE TO BE REMOVED AND REPLACED WITH A 36" PIPE
EX. 12" PIPE TO BE REPLACED
EX. 12" PIPE TO BE REPLACED
EX. DUAL 60" PIPE TO BE REPLACED
APPROX LANDSIDE LEVEE TOE
APPROX LANDSIDE LEVEE TOE
STA. 1727+75
STA. 1728+00
STA. 1729+00
STA. 1745+00
STA. 1743+00
STA. 1748+50
STA. 1763+00
STA. 1767+00
STA. 1769+31


VERTICAL DATUM
THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS HELD AND OBSERVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-6
PROFILE VIEW
STA 1775+00 TO 1825+00
Sheet reference number: C-233
DEPARTMENT OF THE ARMY CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT IN-HOUSE DESIGN 1325 J STREET SACRAMENTO, CA 95814-2922
US Army Corps of Engineers Sacramento District
DESCRIPTION DATE APPROVED
51 DESCRIPTION DATE APPROVED
50 DESCRIPTION DATE APPROVED
49 DESCRIPTION DATE APPROVED
48 DESCRIPTION DATE APPROVED
47 DESCRIPTION DATE APPROVED
46 DESCRIPTION DATE APPROVED
45 DESCRIPTION DATE APPROVED
44 DESCRIPTION DATE APPROVED
MATCHLINE STATION 1775+00 FOR CONTINUATION SEE SHEET C-232
MATCHLINE STATION 1825+00 FOR CONTINUATION SEE SHEET C-234
ELEVATION (FEET)
STATION
PROFILE
EX. GRADE AT CONTROL LINE
EX. 24" PIPE TO BE REMOVED AND REPLACED WITH A 36" PIPE
EX. DUAL 24" PIPES TO BE REMOVED AND REPLACED WITH A SINGLE 36" PIPE
APPROX. LANDSIDE LEVEE TOE
EX. 8" PIPE TO BE PROTECTED IN PLACE
EX. 24" PIPE TO BE REMOVED AND REPLACED WITH A 36" PIPE
1937' ATOL
EX. 24" PIPE TO BE REMOVED AND REPLACED WITH A 36" PIPE
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=95.0
STA. 1745+00
STA. 1746+00
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=95.0
STA. 1813+33
CUTOFF WALL TIP EL=-80.0
EX. 24" PIPE TO BE REMOVED AND REPLACED WITH A 36" PIPE
EX. 12" PIPE TO BE REPLACED
CUTOFF WALL TIP EL=-30.0
STA. 1818+50
PROFILE
H: 1"=200'
V: 1"=10'
0 200 400
NOT FOR CONSTRUCTION


VERTICAL DATUM
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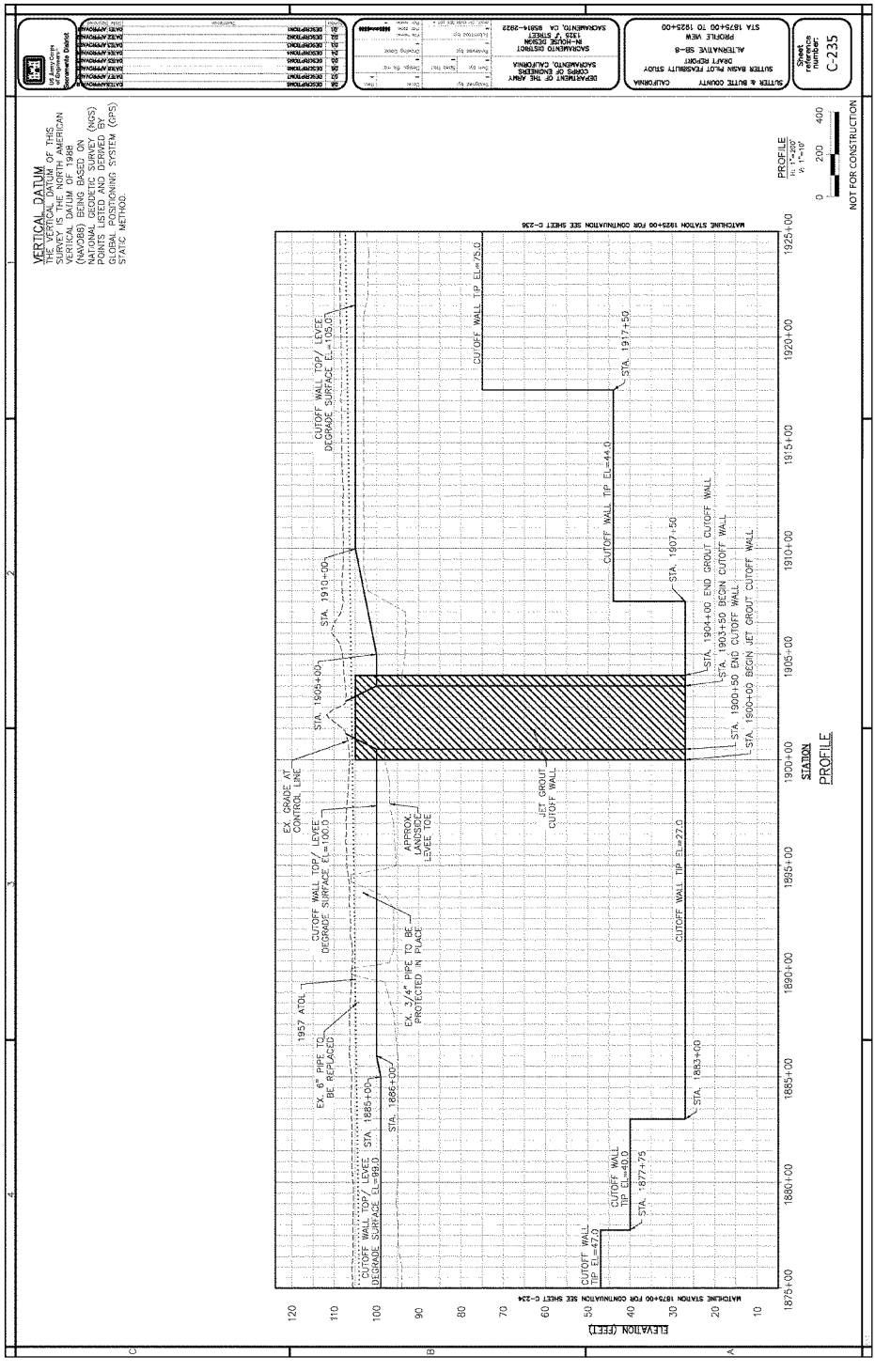
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-6
PROFILE VIEW
STA 1825+00 TO 1875+00
Sheet number: C-234
DEPARTMENT OF THE ARMY CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT IN-HOUSE DESIGN 1325 J STREET SACRAMENTO, CA 95814-2922
US Army Corps of Engineers Sacramento District
PROFILE
STATION
ELEVATION (FEET)
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=95.0
STA. 1829+00
STA. 1831+00
1857 ATOL
EX. GRADE AT CONTROL LINE
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=97.0
EX. 12" PIPE IN 24" PIPE TO BE REPLACED
APPROX. LANDSIDE LEVEE TOE
EX. 18" PIPE TO BE REPLACED
CUTOFF WALL TIP EL=30.0
CUTOFF WALL TIP EL=70.0
STA. 1848+25
STA. 1857+00
STA. 1859+00
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=99.0
EX. 18" PIPE TO BE REMOVED
CUTOFF WALL TIP EL=47.0
STA. 1866+00
MATCHLINE STATION 1825+00 FOR CONTINUATION SEE SHEET C-233
MATCHLINE STATION 1875+00 FOR CONTINUATION SEE SHEET C-233
PROFILE
H: 1"=200'
V: 1"=10'
0 200 400
NOT FOR CONSTRUCTION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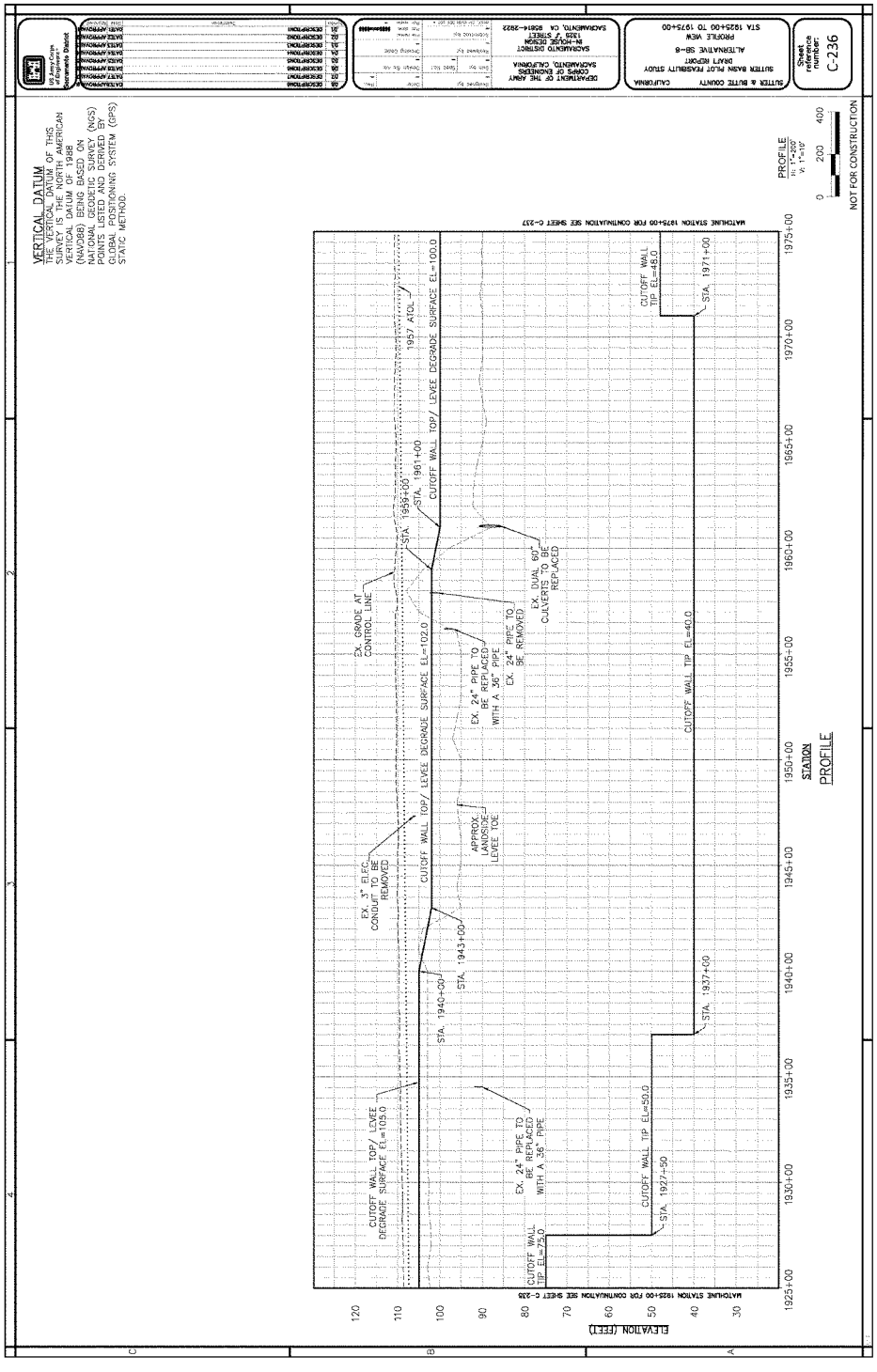
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
PROFILE REPORT
ALTERNATIVE SB-6
STA 1875+00 TO 1925+00
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
SACRAMENTO, CALIFORNIA
1325 J STREET
SACRAMENTO, CA 95814-2922
Sheet reference number
C-235
ELEVATION (FEET)
STATION
PROFILE
MATCHLINE STATION 1875+00 FOR CONTINUATION SEE SHEET C-234
MATCHLINE STATION 1925+00 FOR CONTINUATION SEE SHEET C-236
EX. GRADE AT CONTROL LINE
1957 ATOL
EX. 6" PIPE TO BE REPLACED
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=100.0
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=88.0
STA. 1865+00
STA. 1866+00
EX. 3/4" PIPE TO BE PROTECTED IN PLACE
APPROX. LANDSIDE LEVEE TOE
JET GROUT CUTOFF WALL
CUTOFF WALL TIP EL=47.0
CUTOFF WALL TIP EL=40.0
STA. 1877+75
CUTOFF WALL TIP EL=27.0
STA. 1883+00
STA. 1885+00
STA. 1890+00
STA. 1895+00
STA. 1900+00
STA. 1900+50 END CUTOFF WALL
STA. 1900+00 BEGIN JET GROUT CUTOFF WALL
STA. 1903+50 BEGIN CUTOFF WALL
STA. 1904+00 END GROUT CUTOFF WALL
STA. 1907+50
CUTOFF WALL TIP EL=44.0
STA. 1910+00
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=105.0
STA. 1905+00
CUTOFF WALL TIP EL=75.0
STA. 1917+50
STA. 1915+00
STA. 1920+00
STA. 1925+00
PROFILE
H: 1"=200'
V: 1"=10'
0 200 400
NOT FOR CONSTRUCTION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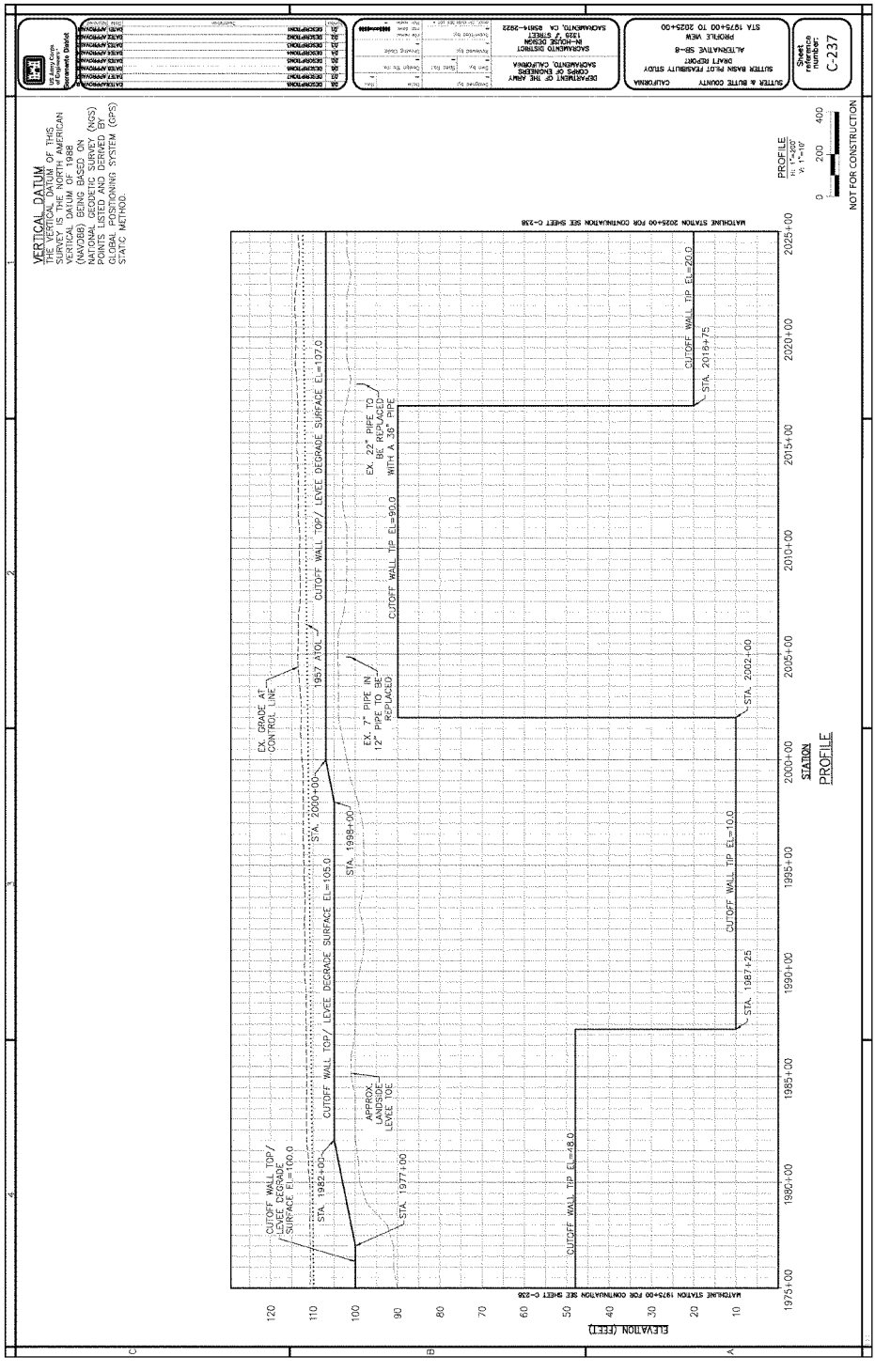
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
ALTERNATIVE SB-8
DRAFT REPORT
PROFILE, NEW
STA 1925+00 TO 1975+00
DEPARTMENT OF THE ARMY CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT IN-HOUSE DESIGN
1325 J STREET SACRAMENTO, CA 95814-2922
Sheet number: C-236
PROFILE
H: 1"=200'
V: 1"=10'
0 200 400
NOT FOR CONSTRUCTION
PROFILE
STATION
ELEVATION (FEET)
MATCHLINE STATION 1925+00 FOR CONTINUATION SEE SHEET C-235
MATCHLINE STATION 1975+00 FOR CONTINUATION SEE SHEET C-237
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=105.0
CUTOFF WALL TIP EL=75.0
CUTOFF WALL TIP EL=50.0
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=102.0
CUTOFF WALL TIP EL=40.0
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=100.0
CUTOFF WALL TIP EL=48.0
EX. 24" PIPE TO BE REPLACED WITH A 36" PIPE
EX. 24" PIPE TO BE REMOVED
EX. DUAL 60" CULVERTS TO BE REPLACED
EX. GRADE AT CONTROL LINE
EX. 3" ELEC. CONDUIT TO BE REMOVED
APPROX. LANDSIDE LEVEE TOE
STA. 1927+50
STA. 1937+00
STA. 1940+00
STA. 1943+00
STA. 1959+00
STA. 1961+00
STA. 1971+00
1957 ATOL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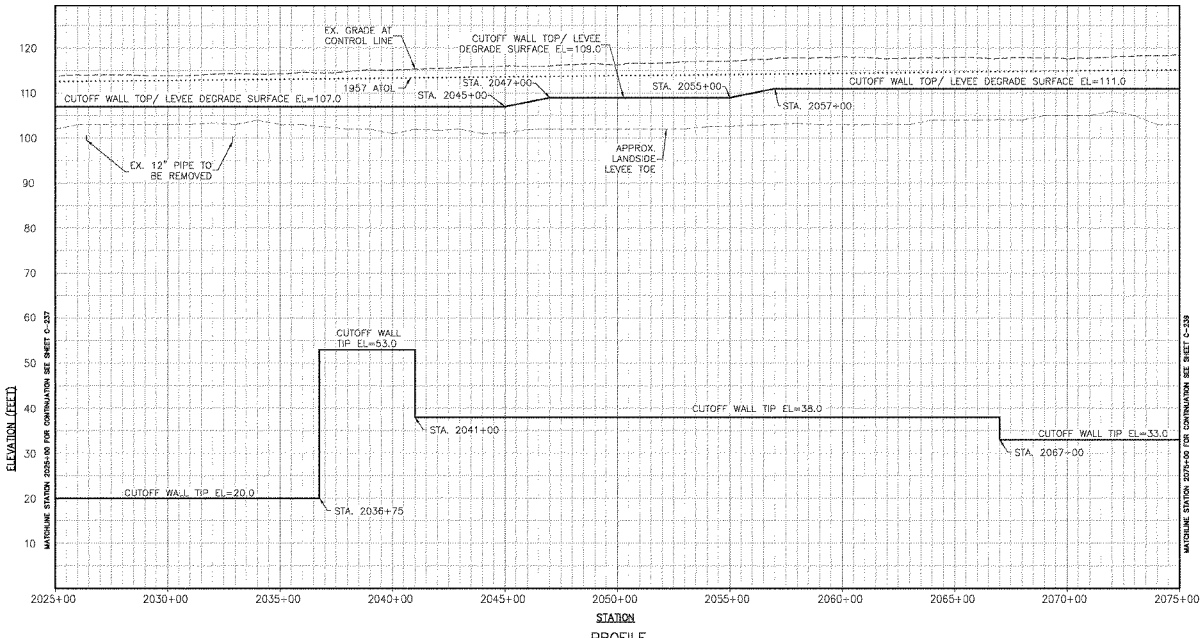
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PROFILE VIEW
STA 1975+00 TO 2025+00
Sheet reference number: C-237
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
SACRAMENTO, CALIFORNIA
1325 J STREET
SACRAMENTO, CA 95814-2922
US Army Corps of Engineers Sacramento District
PROFILE
H: 1"=200'
V: 1"=10'
0 200 400
NOT FOR CONSTRUCTION
ELEVATION (FEET)
STATION
MATCHLINE STATION 1975+00 FOR CONTINUATION SEE SHEET C-236
MATCHLINE STATION 2025+00 FOR CONTINUATION SEE SHEET C-236
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=100.0
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=105.0
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=107.0
CUTOFF WALL TIP EL=48.0
CUTOFF WALL TIP EL=10.0
CUTOFF WALL TIP EL=90.0
CUTOFF WALL TIP EL=20.0
STA. 1982+00
STA. 1977+00
STA. 2000+00
STA. 1998+00
STA. 1957 ATOL
STA. 1987+25
STA. 2002+00
STA. 2018+75
APPROX. LANDSIDE LEVEE TOE
EX. GRADE AT CONTROL LINE
EX. 7" PIPE IN 12" PIPE TO BE REPLACED
EX. 22" PIPE TO BE REPLACED WITH A 36" PIPE

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

NOT FOR CONSTRUCTION

US Army Corps of Engineers
Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

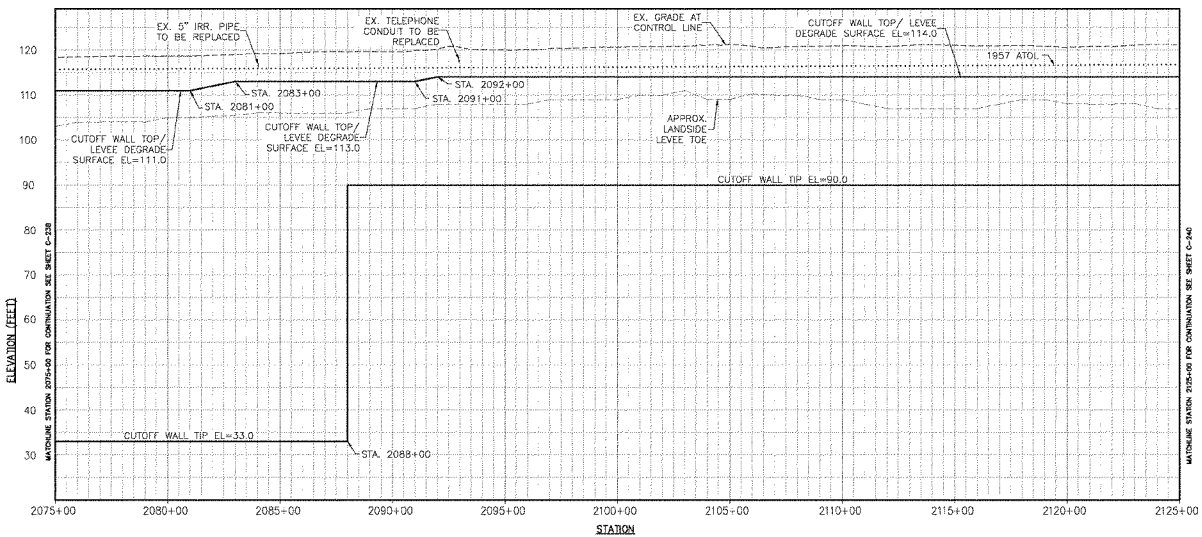
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PROFILE VIEW
STA 2025+00 TO 2075+00

Sheet reference number:
C-238

2012

VERTICAL DATUM

THE VERTICAL DATUM OF THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) BEING BASED ON NATIONAL GEODETIC SURVEY (NGS) POINTS LISTED AND DERIVED BY GLOBAL POSITIONING SYSTEM (GPS) STATIC METHOD.



PROFILE

PROFILE
H: 1"=200'
V: 1"=10'

0 200 400

NOT FOR CONSTRUCTION

US Army Corps of Engineers
Sacramento District

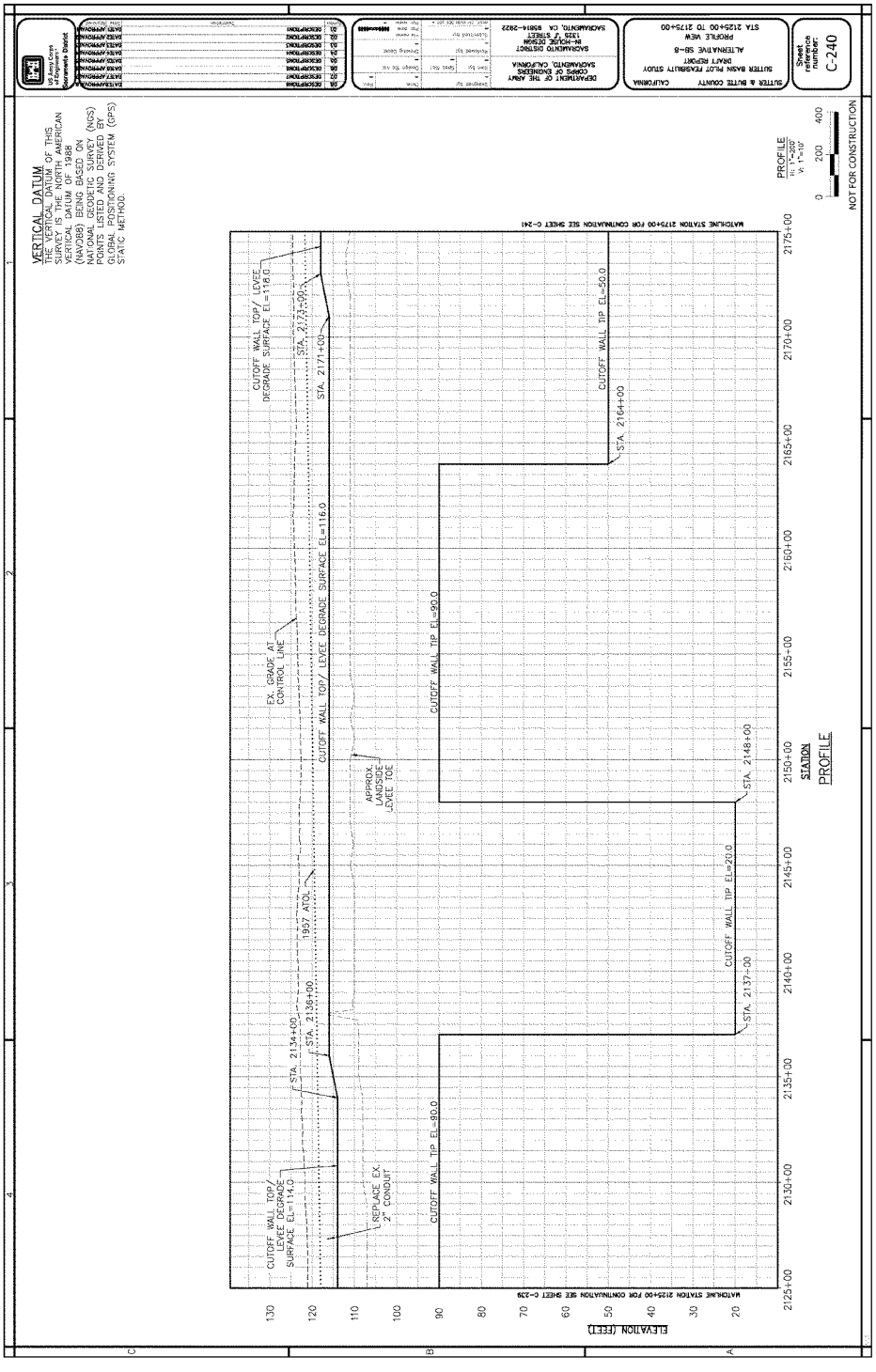
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PROFILE VIEW
STA. 2075+00 TO 2125+00

Sheet reference number:
C-239

2013


VERTICAL DATUM
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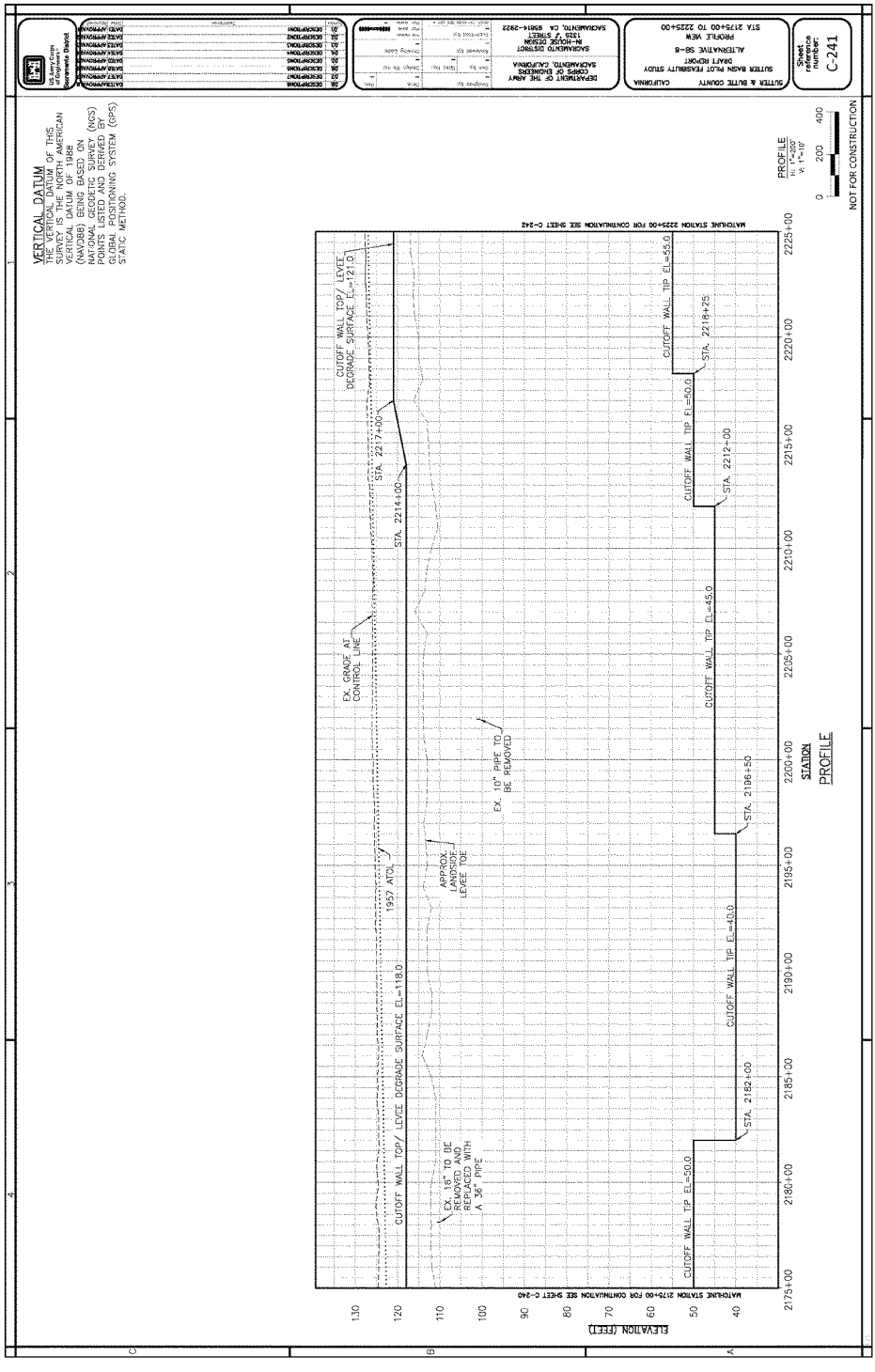
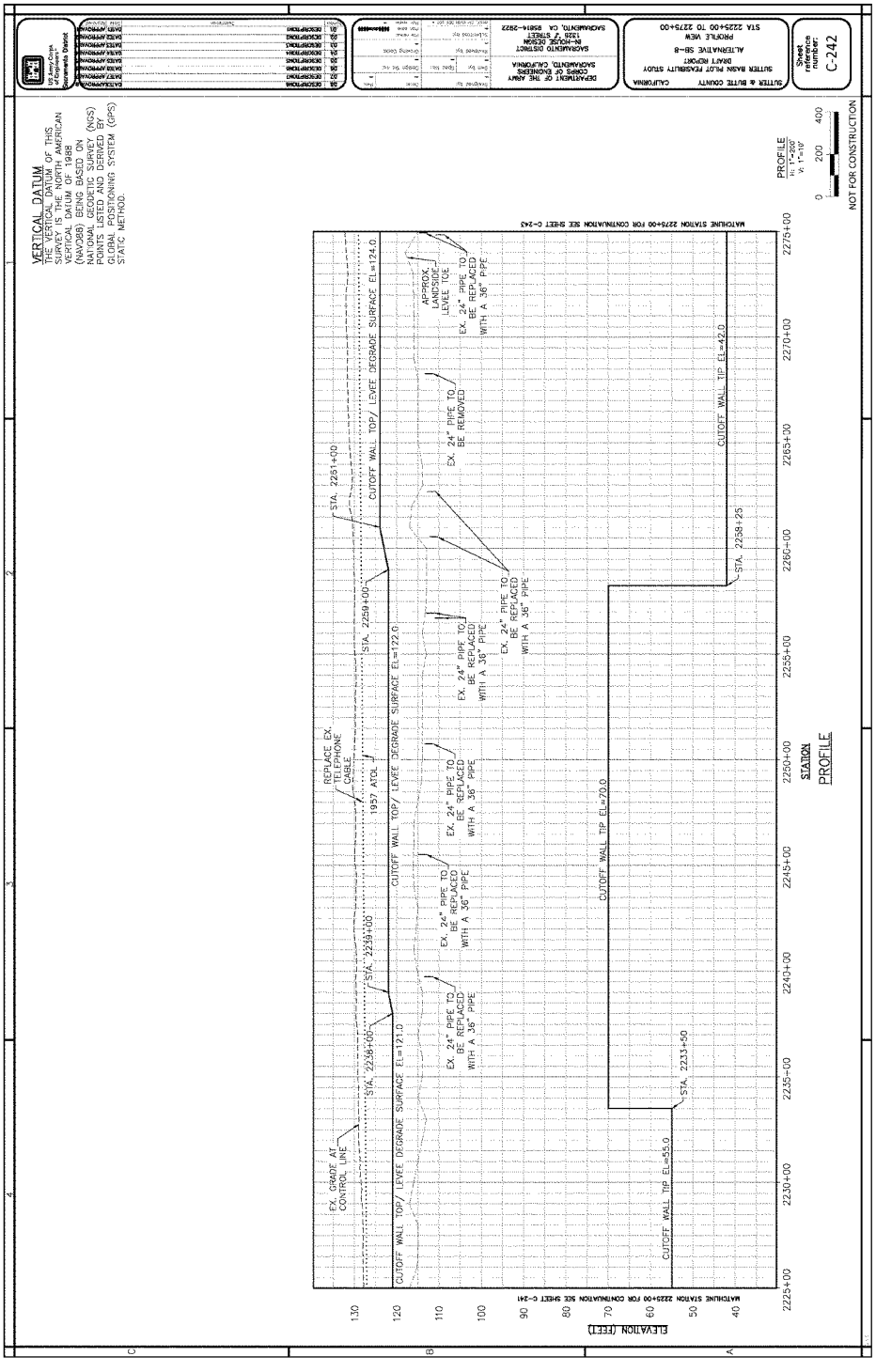
SUTTER BASIN PILOT FEASIBILITY STUDY
ALTERNATIVE SB-8
DRAFT REPORT
PROFILE VIEW
STA 2125+00 TO 2175+00
SUTTER & BUTTE COUNTY CALIFORNIA
Sheet Number
C-240
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922
US Army Corps of Engineers
Sacramento District
PROFILE
H: 1"=200'
V: 1"=10'
0
200
400
NOT FOR CONSTRUCTION
MATCHLINE STATION 2125+00 FOR CONTINUATION SEE SHEET C-239
MATCHLINE STATION 2175+00 FOR CONTINUATION SEE SHEET C-241
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=114.0
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=116.0
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=118.0
EX. GRADE AT CONTROL LINE
APPROX. LANDSIDE LEVEE TOE
REPLACE EX. 2" CONDUIT
CUTOFF WALL TIP EL=90.0
CUTOFF WALL TIP EL=50.0
CUTOFF WALL TIP EL=20.0
STA. 2134+00
STA. 2136+00
1957 ATD
STA. 2137+00
STA. 2148+00
STA. 2164+00
STA. 2171+00
STA. 2173+00
ELEVATION (FEET)
STATION
PROFILE



NOT FOR CONSTRUCTION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SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER & BUTTE COUNTY CALIFORNIA
ALTERNATIVE SB-8
DRAFT REPORT
PROFILE VIEW
STA 2225+00 TO 2275+00
DEPARTMENT OF THE ARMY CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 J STREET
SACRAMENTO, CA 95814-2922
Sheet number: C-242
PROFILE
H: 1"=200'
V: 1"=10'
0 200 400
NOT FOR CONSTRUCTION
ELEVATION (FEET)
STATION
PROFILE
MATCHLINE STATION 2225+00 FOR CONTINUATION SEE SHEET C-241
MATCHLINE STATION 2275+00 FOR CONTINUATION SEE SHEET C-243
EX. GRADE AT CONTROL LINE
REPLACE EX. TELEPHONE CABLE
1957 ATOL
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=121.0
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=122.6
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=124.0
CUTOFF WALL TIP EL=35.0
CUTOFF WALL TIP EL=70.0
CUTOFF WALL TIP EL=42.0
STA. 2236+00
STA. 2239+00
STA. 2233+50
STA. 2250+00
STA. 2251+00
STA. 2258+25
EX. 24" PIPE TO BE REPLACED WITH A 36" PIPE
EX. 24" PIPE TO BE REMOVED
APPROX. LANDSIDE LEVEE TOE
2225+00
2230+00
2235+00
2240+00
2245+00
2250+00
2255+00
2260+00
2265+00
2270+00
2275+00
130
120
110
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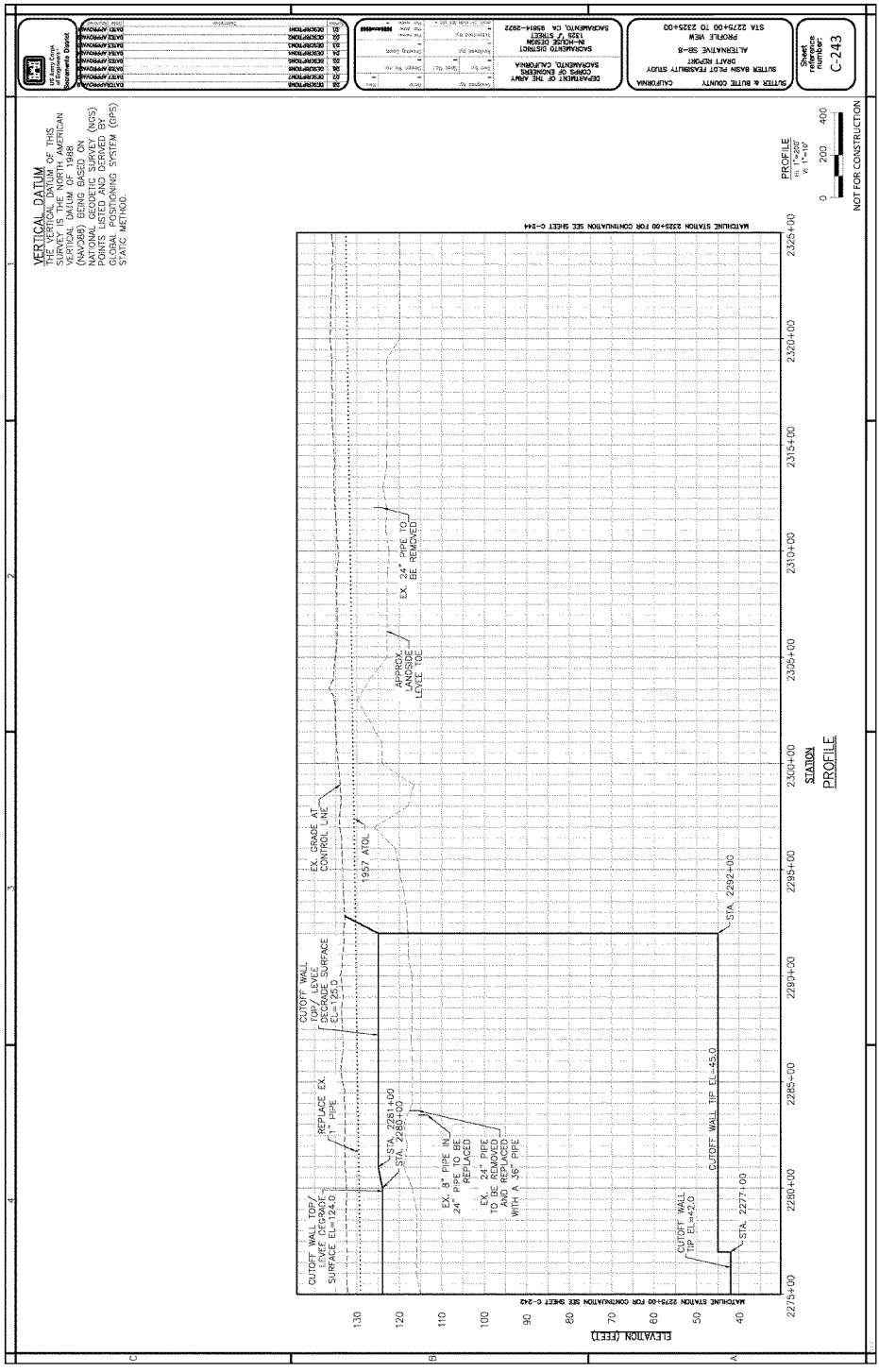
90
80
70
60
50
40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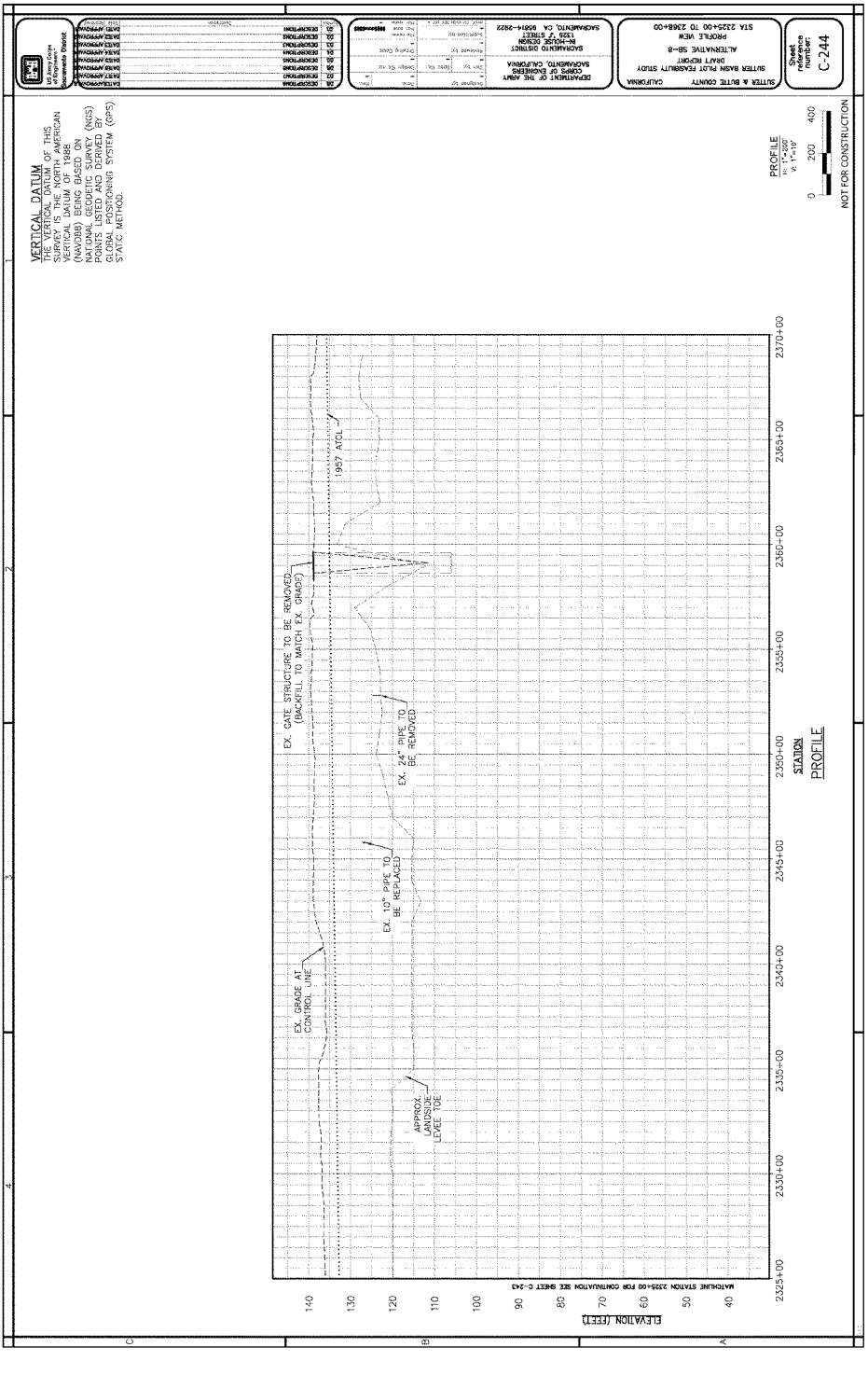
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-8
PROFILE VIEW
STA 2275+00 TO 2325+00
Sheet reference number: C-243
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO DISTRICT
SACRAMENTO, CALIFORNIA
IN-HOUSE DESIGN
SACRAMENTO, CA 95814-3922
1329 'J' STREET
ELEVATION (FEET)
MATCHLINE STATION 2325+00 FOR CONTINUATION SEE SHEET C-244
MATCHLINE STATION 2275+00 FOR CONTINUATION SEE SHEET C-242
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=124.0
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=125.0
REPLACE EX. 1" PIPE
STA. 2281+00
STA. 2280+00
EX. 8" PIPE IN 24" PIPE TO BE REPLACED
EX. 24" PIPE TO BE REMOVED AND REPLACED WITH A 36" PIPE
CUTOFF WALL TIP EL=42.0
STA. 2277+00
CUTOFF WALL TIP EL=45.0
STA. 2292+00
EX. GRADE AT CONTROL LINE
1957 ATOL
APPROX. LANDSIDE LEVEE TOE
EX. 24" PIPE TO BE REMOVED
STATION
PROFILE
PROFILE
H: 1"=200'
V: 1"=10'
0 200 400
NOT FOR CONSTRUCTION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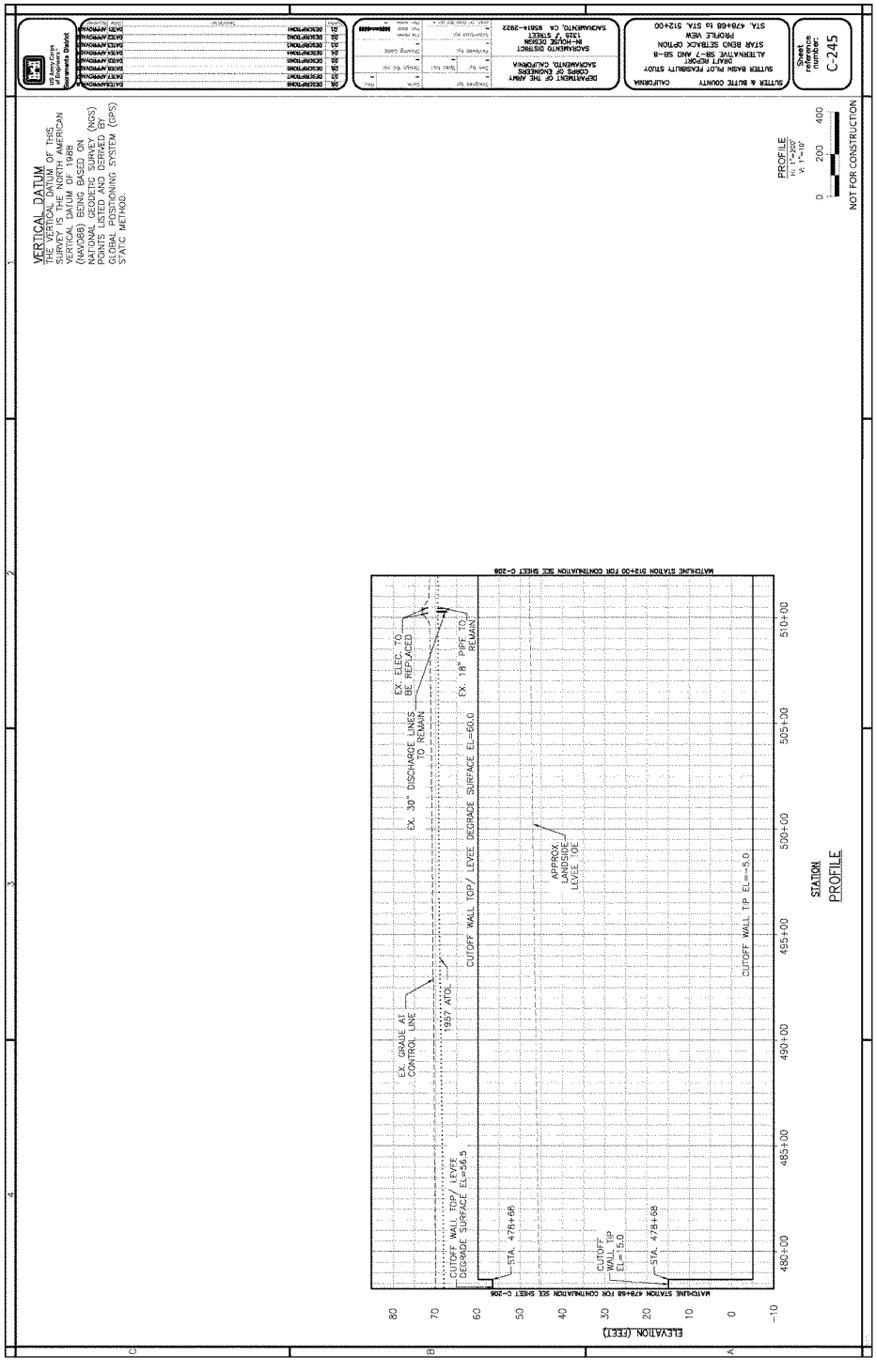
SUTTER BASIN PILOT FEASIBILITY STUDY
ALTERNATIVE SB-8
DRAFT REPORT
PROFILE
STA 2325+00 TO 2368+00
SUTTER & BUTTE COUNTY CALIFORNIA
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922
Sheet Number
C-244
PROFILE
H: 1"=200'
V: 1"=10'
0 200 400
NOT FOR CONSTRUCTION
EX. GATE STRUCTURE TO BE REMOVED (BACKFILL TO MATCH EX. GRADE)
1957 ATCL
EX. 24" PIPE TO BE REMOVED
EX. 10" PIPE TO BE REPLACED
EX. GRADE AT CONTROL LINE
APPROX. LANDSIDE LEVEE TOE
MATCHLINE STATION 2325+00 FOR CONTINUATION SEE SHEET C-243
ELEVATION (FEET)
STATION
PROFILE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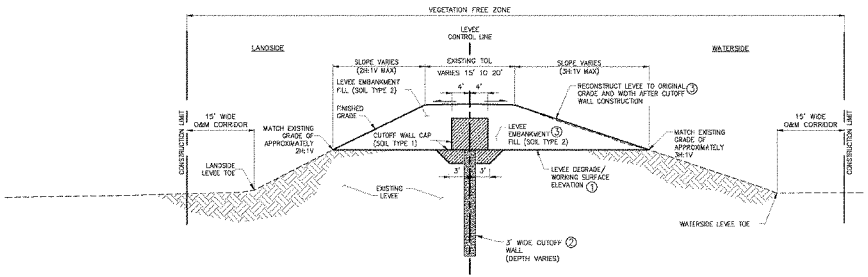
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
STAR BEND SETBACK OPTION
PROFILE NEW
STA. 478+68 to STA. 512+00
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 J STREET
SACRAMENTO, CA 95814-2922
Sheet reference number:
C-245
PROFILE
H: 1"=200'
V: 1"=10'
0 200 400
NOT FOR CONSTRUCTION
MATCHLINE STATION 478+68 FOR CONTINUATION SEE SHEET C-206
MATCHLINE STATION 512+50 FOR CONTINUATION SEE SHEET C-206
EX. GRADE AT CONTROL LINE
1957 ATOL
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=56.5
CUTOFF WALL TOP/ LEVEE DEGRADE SURFACE EL=60.0
EX. 30" DISCHARGE LINES TO REMAIN
EX. ELEC TO BE REPLACED
EX. 18" PIPE TO REMAIN
APPROX. LANDSIDE LEVEE TOE
CUTOFF WALL TIP EL=-5.0
CUTOFF WALL TIP El.=-5.0
STA. 478+68
STA. 478+68
STATION
PROFILE
ELEVATION (FEET)
480+00
485+00
490+00
495+00
500+00
505+00
510+00
80
70
60
50
40
30
20
10
0
-10



TYPICAL CUTOFF WALL
SCALE: NONE

CONSTRUCTION SEQUENCE:

1. DEGRADE EXISTING LEVEE.
2. CONSTRUCT CUTOFF WALL.
3. RECONSTRUCT LEVEE EMBANKMENT.

NOT FOR CONSTRUCTION

US Army Corps of Engineers
Sacramento District

A4	DESCRIPTION	DATE/APPROVAL
A3	DESCRIPTION	DATE/APPROVAL
A2	DESCRIPTION	DATE/APPROVAL
A1	DESCRIPTION	DATE/APPROVAL
A0	DESCRIPTION	DATE/APPROVAL

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

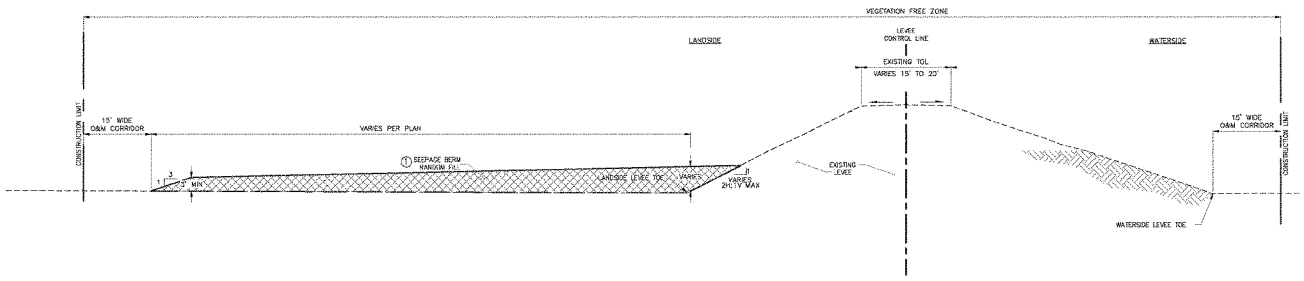
Designed by: Date:
Drawn by: Check by:
Approved by:
Scale: AS NOTED
Drawing Code:
File name:
Project No.

SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
TYPICAL LEVEE IMPROVEMENT-CUTOFF WALL

Sheet reference number:
C-301

2020



TYPICAL SEEPAGE BERM
SCALE: NONE

CONSTRUCTION SEQUENCE:

1 INSTALL RANDOM FILL FOR SEEPAGE BERM

NOT FOR CONSTRUCTION

US Army Corps of Engineers
Sacramento District

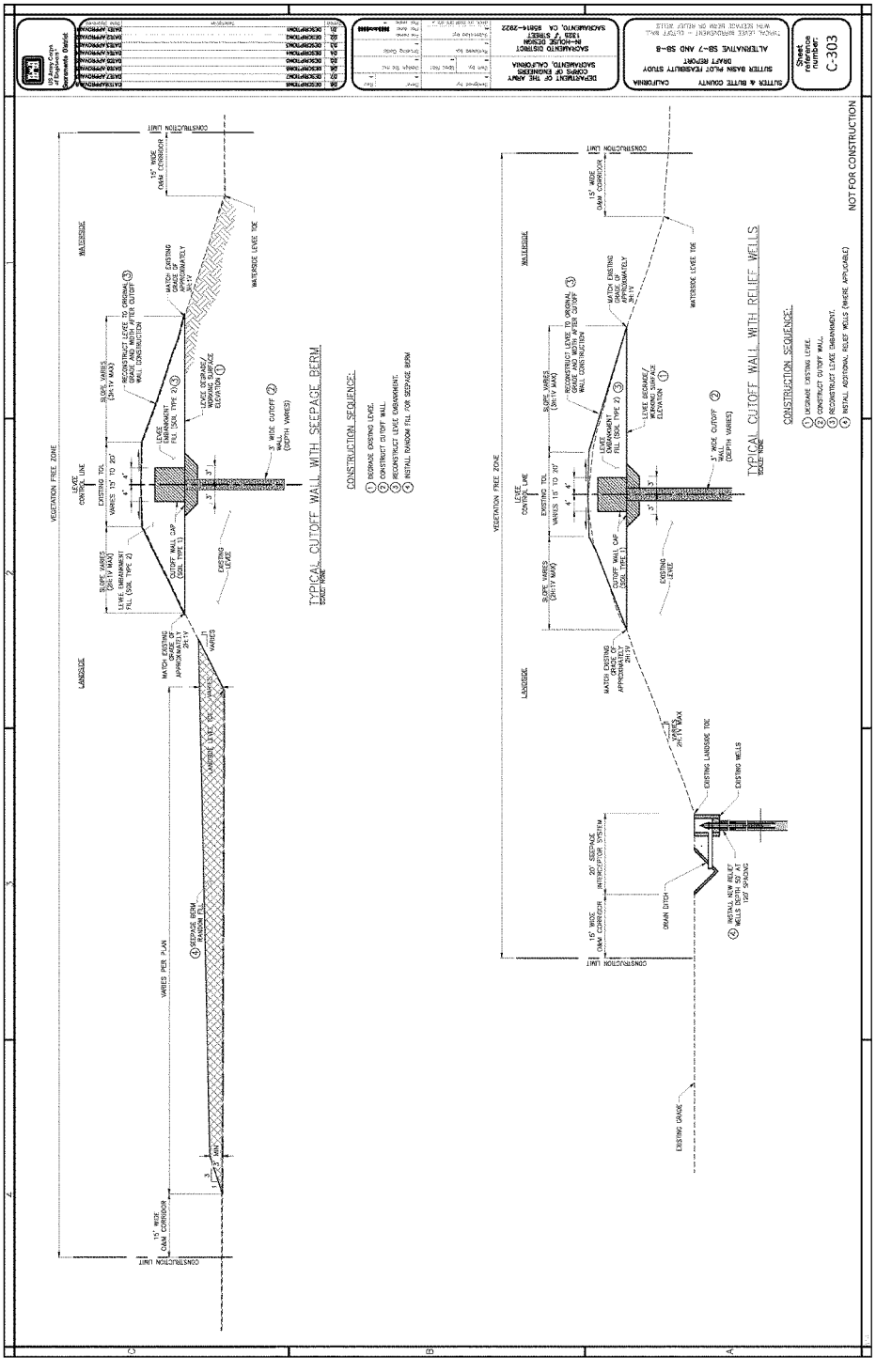
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 J STREET
SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
TYPICAL LEVEE IMPROVEMENT - SEEPAGE BERM

Sheet reference number:
C-302

2021


TYPICAL CUTOFF WALL WITH SEEPAGE BERM
CONSTRUCTION SEQUENCE:
1 SCARIFY EXISTING LEVEE.
2 CONSTRUCT CUTOFF WALL.
3 RECONSTRUCT LEVEE EMBANKMENT.
4 INSTALL RANDOM FILL FOR SEEPAGE BERM
TYPICAL CUTOFF WALL WITH RELIEF WELLS
CONSTRUCTION SEQUENCE:
1 SCARIFY EXISTING LEVEE.
2 CONSTRUCT CUTOFF WALL.
3 RECONSTRUCT LEVEE EMBANKMENT.
4 INSTALL ADDITIONAL RELIEF WELLS (WHERE APPLICABLE)
NOT FOR CONSTRUCTION
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CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
ALTERNATIVE SB-7 AND SB-8
DRAFT REPORT
DEPARTMENT OF THE ARMY
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SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
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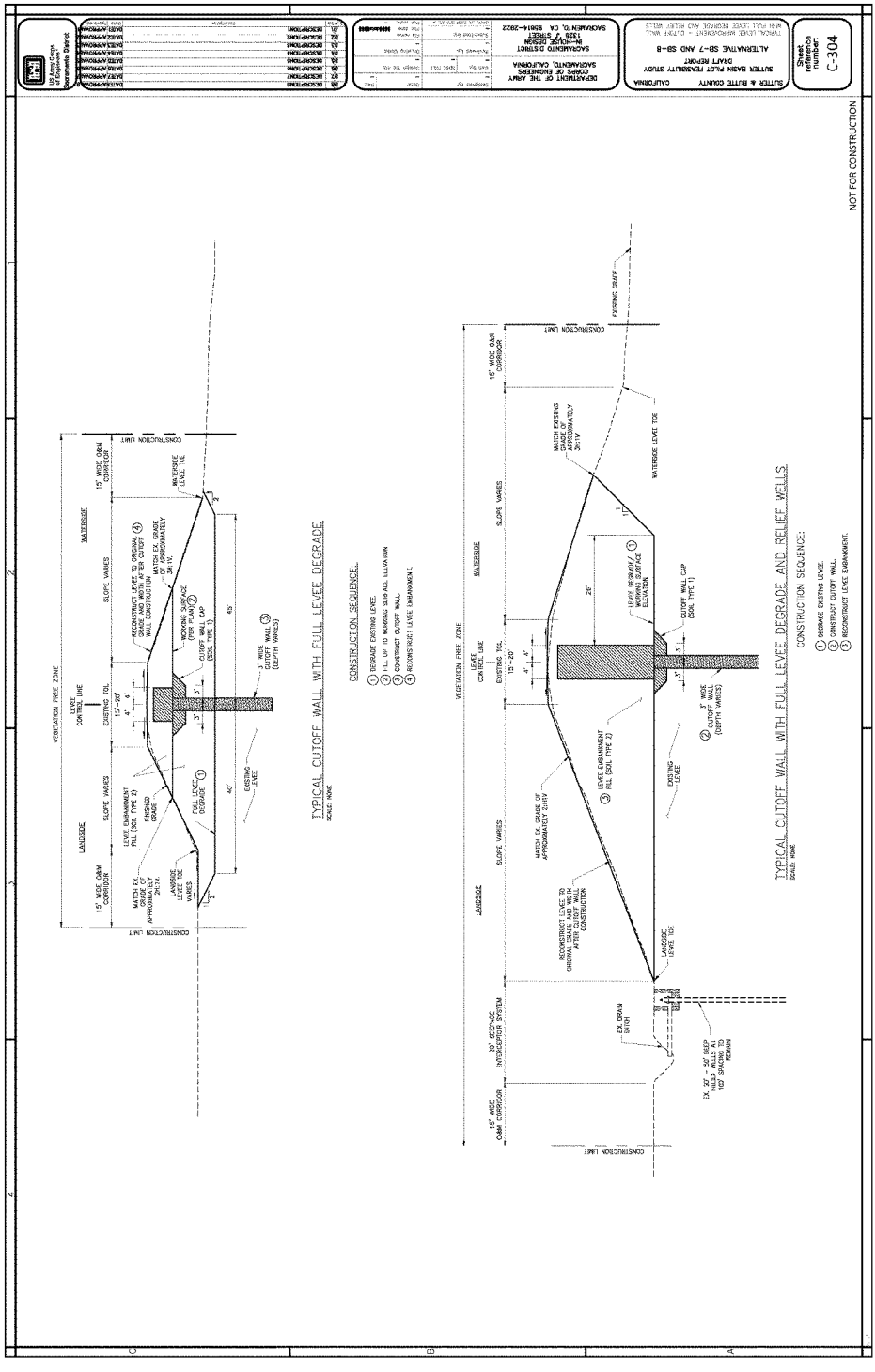
Sheet number
C-303


TYPICAL CUTOFF WALL WITH FULL LEVEE DEGRADE
SCALE: NONE
CONSTRUCTION SEQUENCE:
1 DEGRADE EXISTING LEVEE.
2 FILL UP TO WORKING SURFACE ELEVATION
3 CONSTRUCT CUTOFF WALL.
4 RECONSTRUCT LEVEE EMBANKMENT.
TYPICAL CUTOFF WALL WITH FULL LEVEE DEGRADE AND RELIEF WELLS
SCALE: NONE
CONSTRUCTION SEQUENCE:
1 DEGRADE EXISTING LEVEE.
2 CONSTRUCT CUTOFF WALL.
3 RECONSTRUCT LEVEE EMBANKMENT.
NOT FOR CONSTRUCTION
Sheet reference number: C-304
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
M-HOUSE DESIGN
1325 J STREET
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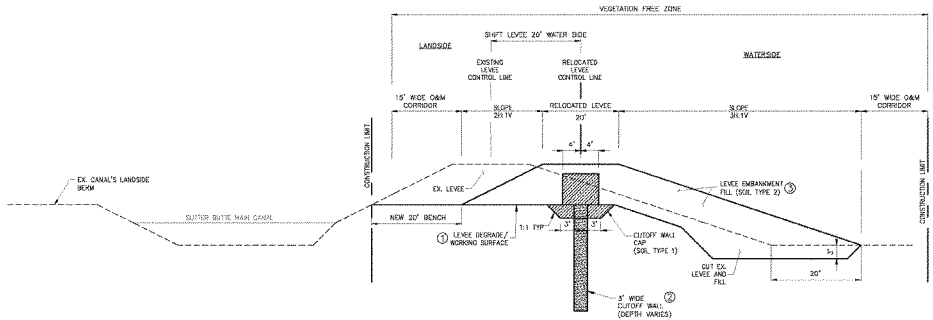
US Army Corps of Engineers
Sacramento District



TYPICAL CUTOFF WALL WITH LEVEE RELOCATION

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. DEGRADE EXISTING LEVEE.
2. CONSTRUCT CUTOFF WALL.
3. CONSTRUCT RELOCATED LEVEE EMBANKMENT.

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00	DESCRIPTION	DATE/APPROVAL
01	DESCRIPTION	DATE/APPROVAL
02	DESCRIPTION	DATE/APPROVAL
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Reviewed by: | Drawing Code:
Submitted by: | Dwg number:
Date: | Plot scale:
Plot date:

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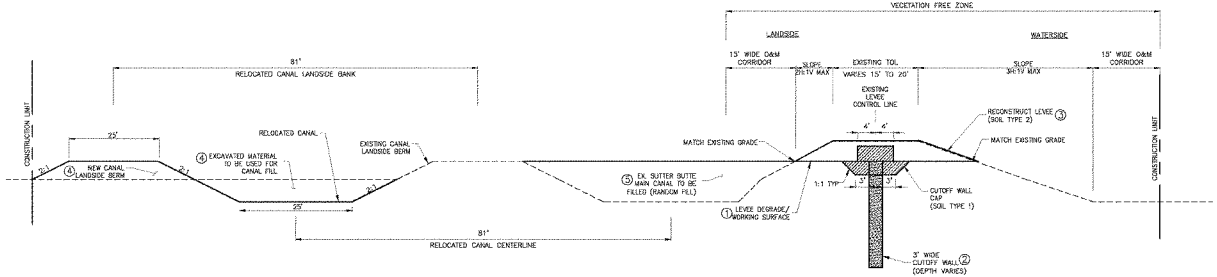
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
TYPICAL LEVEE IMPROVEMENT - CUTOFF WALL WITH LEVEE RELOCATION

Sheet reference number:
C-305

2024



TYPICAL CUTOFF WALL WITH CANAL RELOCATION

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. DEGRADE EXISTING LEVEE.
2. CONSTRUCT CUTOFF WALL.
3. RECONSTRUCT LEVEE EMBANKMENT.
4. EXCAVATE NEW SUTTER BUTTE CANAL AND CONSTRUCT NEW CANAL LANDSIDE BERM.
5. FILL SUTTER BUTTE CANAL WITH EXCAVATED MATERIAL

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Symbol	Description	Date	Approved
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99	DESCRIPTIONS	DATE	APPROVAL

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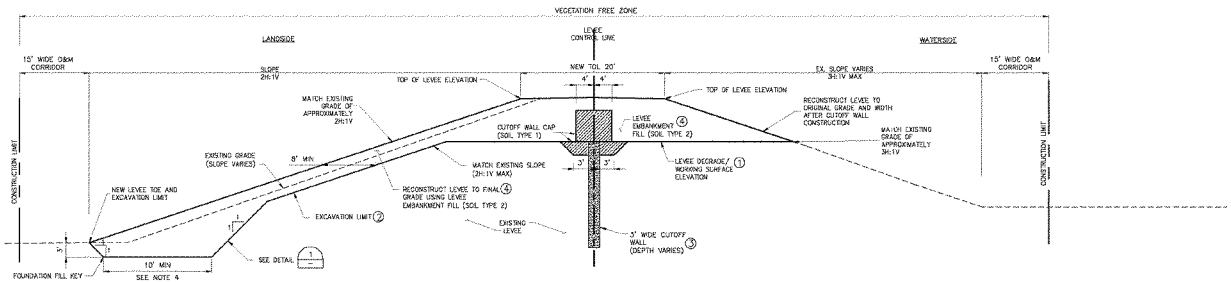
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
TYPICAL LEVEE IMPROVEMENT - CUTOFF WALL WITH CANAL RELOCATION

Sheet reference number:
C-306

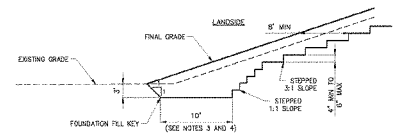


TYPICAL CUTOFF WALL WITH LANDSIDE TOE FILL

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. DEGRADE EXISTING LEVEE.
2. EXCAVATE LANDSIDE OF EXISTING LEVEE.
3. CONSTRUCT CUTOFF WALL.
4. RECONSTRUCT LEVEE EMBANKMENT.



1 FILL KEY AND BENCHING DETAIL

NTS

TYPICAL KEY & BENCHING NOTES:

1. PLACE FILL IN HORIZONTAL LIFTS AGAINST VERTICAL FACES CUT INTO EXISTING LEVEE MATERIAL.
2. THE BOTTOM OF THE KEY TRENCH SHALL BE SCARIFIED TO A DEPTH OF 8 INCHES AND RECOMPACTED TO 95% MAXIMUM DENSITY PER ASTM D698.
3. THE LEVEE KEY TRENCH SHALL BE INSPECTED BY THE AGENCY'S GEOTECHNICAL ENGINEER BEFORE PLACEMENT OF FILL.
4. WHERE EMBANKMENT FILL IS GREATER THAN 10' IN WIDTH, FOUNDATION KEY SHALL EXTEND FROM THE TOE OF THE NEW LEVEE TO THE TOE OF THE EXISTING LEVEE. IN NO CASE SHALL THE FOUNDATION KEY WIDTH BE LESS THAN 10'.

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01	DESCRIPTION	DATE	APPROVAL

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Dwn by: | Chkd by: | Design Sta. No.
Rev. by: | Date: | Drawing Code
Reviewed by: | Date: | Drawing No.
Approved by: | Date: | File name: | File size: | Plot scale: | Plot date:

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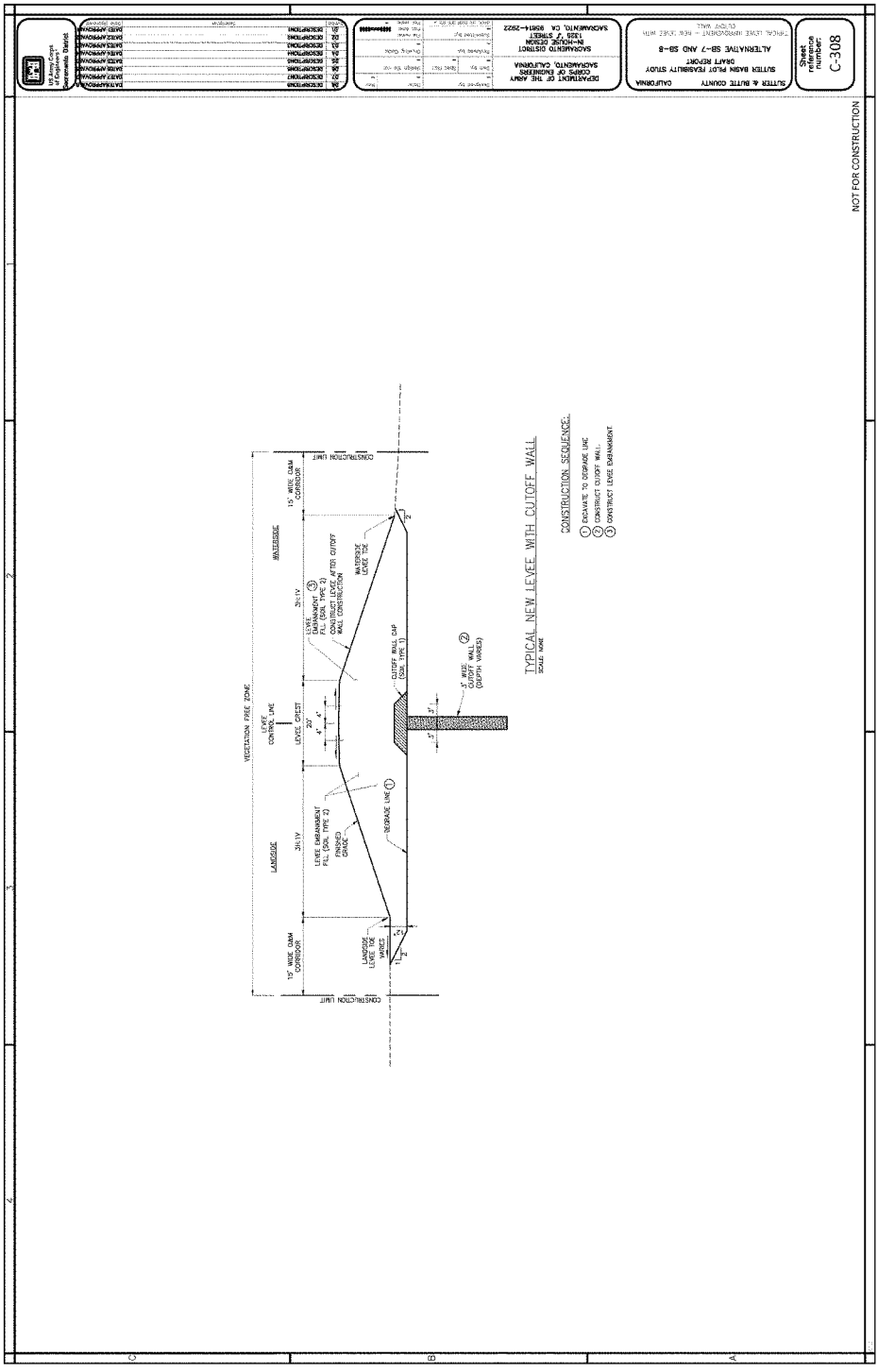
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
TYPICAL LEVEE IMPROVEMENT - TYPICAL CUTOFF WALL WITH LANDSIDE TOE FILL

Sheet reference number:
C-307


TYPICAL NEW LEVEE WITH CUTOFF WALL
SCALE: NONE
CONSTRUCTION SEQUENCE:
1 EXCAVATE TO SEEPAGE LINE
2 CONSTRUCT CUTOFF WALL
3 CONSTRUCT LEVEE EMBANKMENT
VEGETATION FREE ZONE
LANDSIDE
WATERSIDE
LEVEE CONTROL LINE
LEVEE CREST
20'
3H:1V
LEVEE EMBANKMENT FILL (SEE TYPE 2)
LANDSIDE LEVEE TOE VARIES
SEEPAGE LINE 1
LEVEE EMBANKMENT FILL (SEE TYPE 2) CONSTRUCT LEVEE AFTER CUTOFF WALL CONSTRUCTION
WATERSIDE LEVEE TOE
CUTOFF WALL CAP (SEE TYPE 1)
3' WIDE CUTOFF WALL (DEPTH VARIES)
15' WIDE O&M CORRIDOR
CONSTRUCTION LIMIT
NOT FOR CONSTRUCTION
SUTTER & BUTTE COUNTY CALIFORNIA
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ALTERNATIVE SB-7 AND SB-8
DRAFT REPORT
DEPARTMENT OF THE ARMY
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SACRAMENTO DISTRICT
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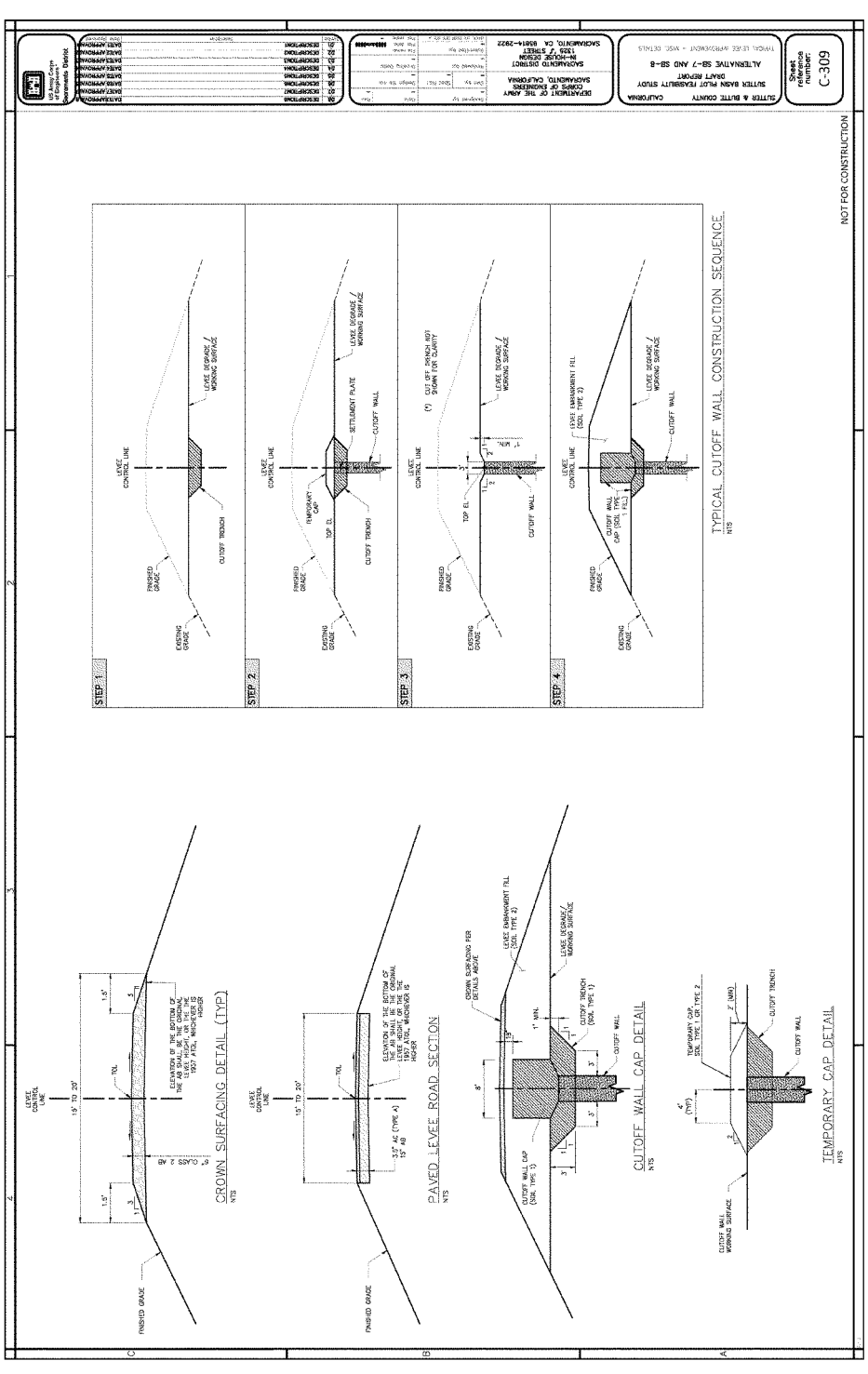
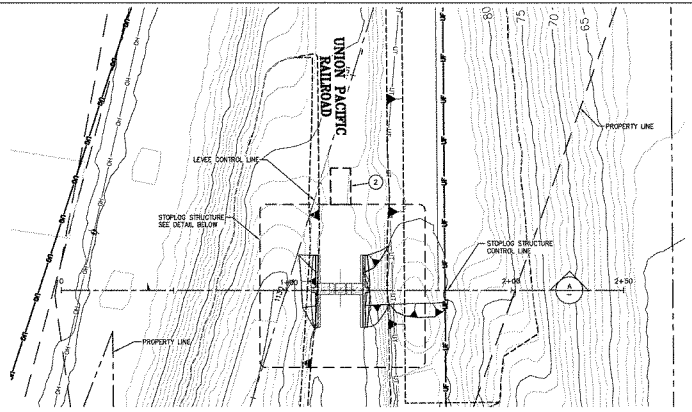
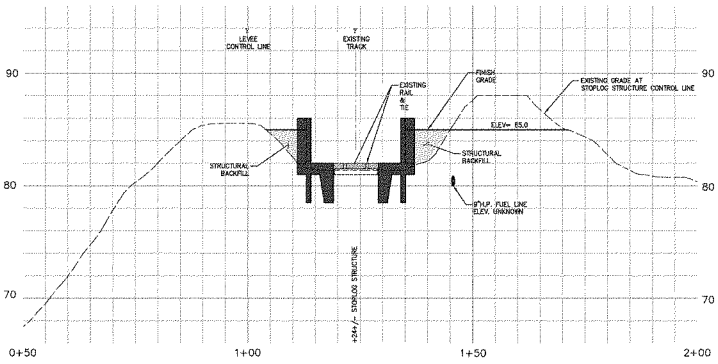
SACRAMENTO, CA 95814-2922
Sheet reference number:
C-308


CROWN SURFACING DETAIL (TYP)
PAVED LEVEE ROAD SECTION
CUTOFF WALL CAP DETAIL
TEMPORARY CAP DETAIL
TYPICAL CUTOFF WALL CONSTRUCTION SEQUENCE
STEP 1
STEP 2
STEP 3
STEP 4
NOT FOR CONSTRUCTION



STOPLOG STRUCTURE – PLAN
SCALE: 1"= 20'



STOPLOG STRUCTURE – ELEVATION

CONSTRUCTION NOTES:

1. CUTOFF WALL AND LEVEE DEGRADE NOT SHOWN. SEE DWG C-314 FOR WALL LOCATION AND LEVEE EXCAVATIONS.
2. EXISTING CONCRETE PANELS TO REMAIN.

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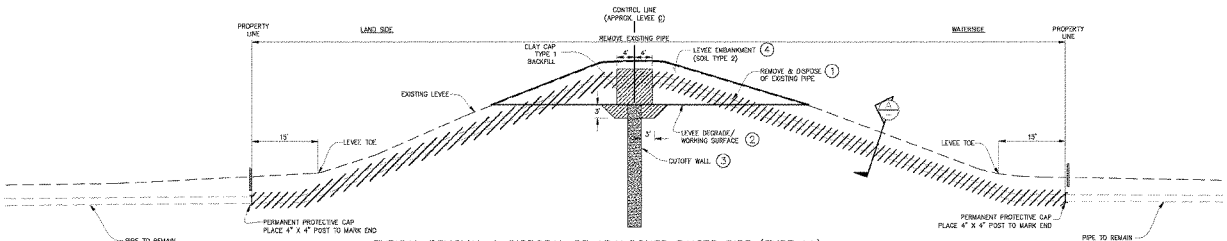
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
TYPICAL LEVEE IMPROVEMENT - STOP LOG STRUCTURE

Sheet reference number:
C-310

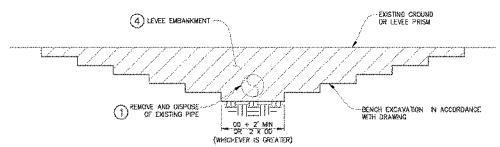


TYPICAL REMOVAL & DISPOSAL OF ABANDONED RAISED PIPE (TYPE 1A)

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. EXCAVATE, REMOVE AND DISPOSE OF EXISTING PIPE OFFSITE, AND BACKFILL UP TO WORKING SURFACE.
2. DEGRADE EXISTING LEVEE.
3. CONSTRUCT CUTOFF WALL.
4. RECONSTRUCT LEVEE EMBANKMENT.



SECTION A

SCALE: NONE

SCHEDULE OF RAISED PIPE REMOVALS		
EXISTING STATION	EXISTING PIPE DIA.	APPROX. DEPTH
219+00	12 IN	UNKNOWN
365+00	8 IN	4.8 FT
386+63	8 IN	4.6 FT
398+32	8 IN	4.1 FT
442+80	8 IN	4.1 FT
460+11	8 IN	4.1 FT
529+47	6 IN	4.0 FT
536+64	5 IN	2.0 FT
545+41	8 IN	3.1 FT
856+23	24 IN	5.2 FT
881+39	6 IN	5.1 FT
881+43	14 IN	5.1 FT
988+05	3 IN	UNKNOWN
1020+85	4 IN	UNKNOWN
1037+50	8 IN	UNKNOWN
1180+50	12 IN	UNKNOWN
1180+98	3 IN	UNKNOWN
1181+50	8 IN	UNKNOWN
1524+35	6 IN	UNKNOWN
1532+40	6 IN	UNKNOWN
1688+50	6 IN	5.2 FT
1893+60	1 IN	UNKNOWN

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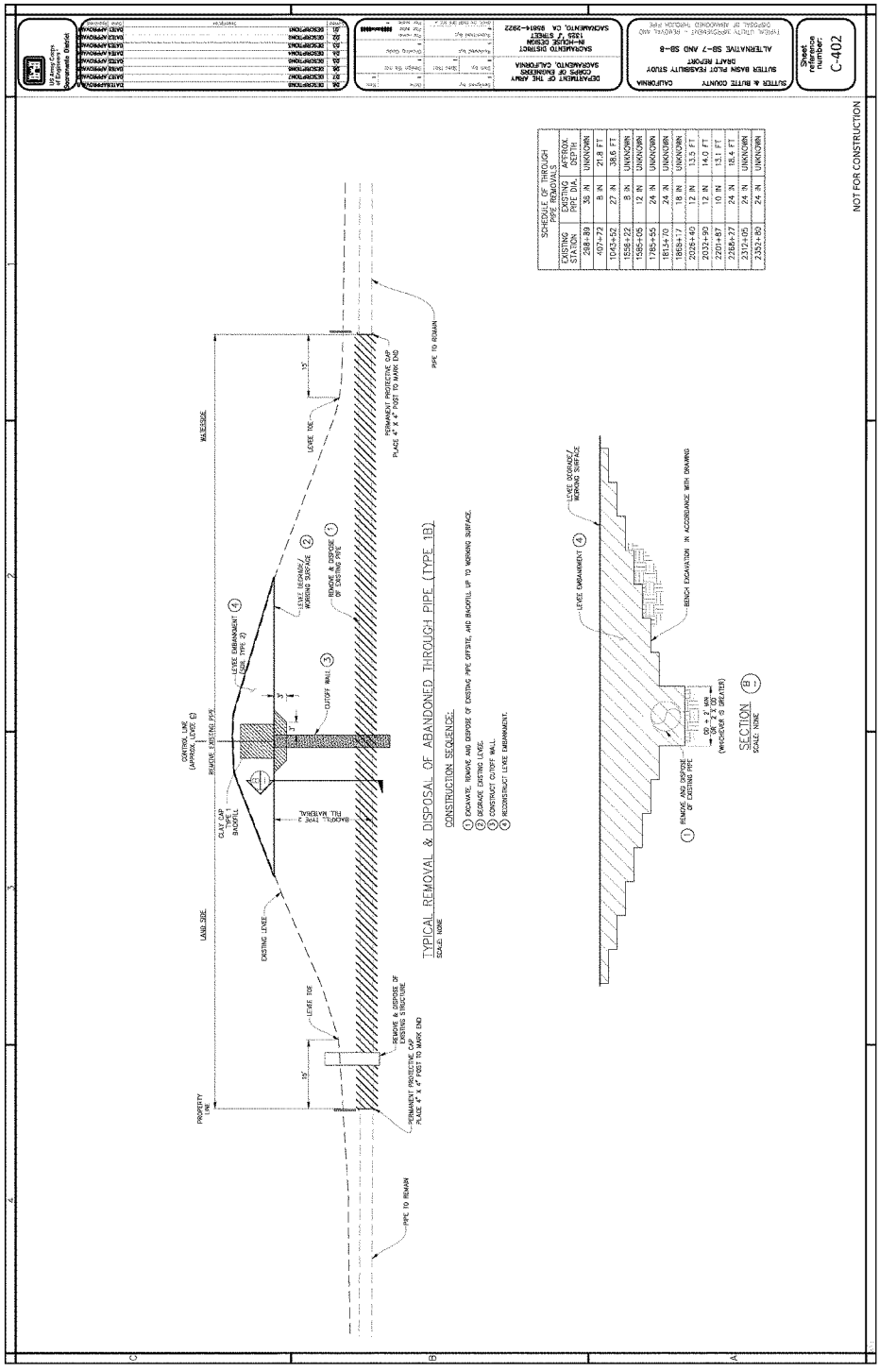
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
TYPICAL UTILITY APPROACHES - REMOVAL AND DISPOSAL OF ABANDONED RAISED PIPE

Sheet reference number:
C-401


SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
ALTERNATIVE SB-7 AND SB-8
DRAFT REPORT
DEPARTMENT OF THE ARMY
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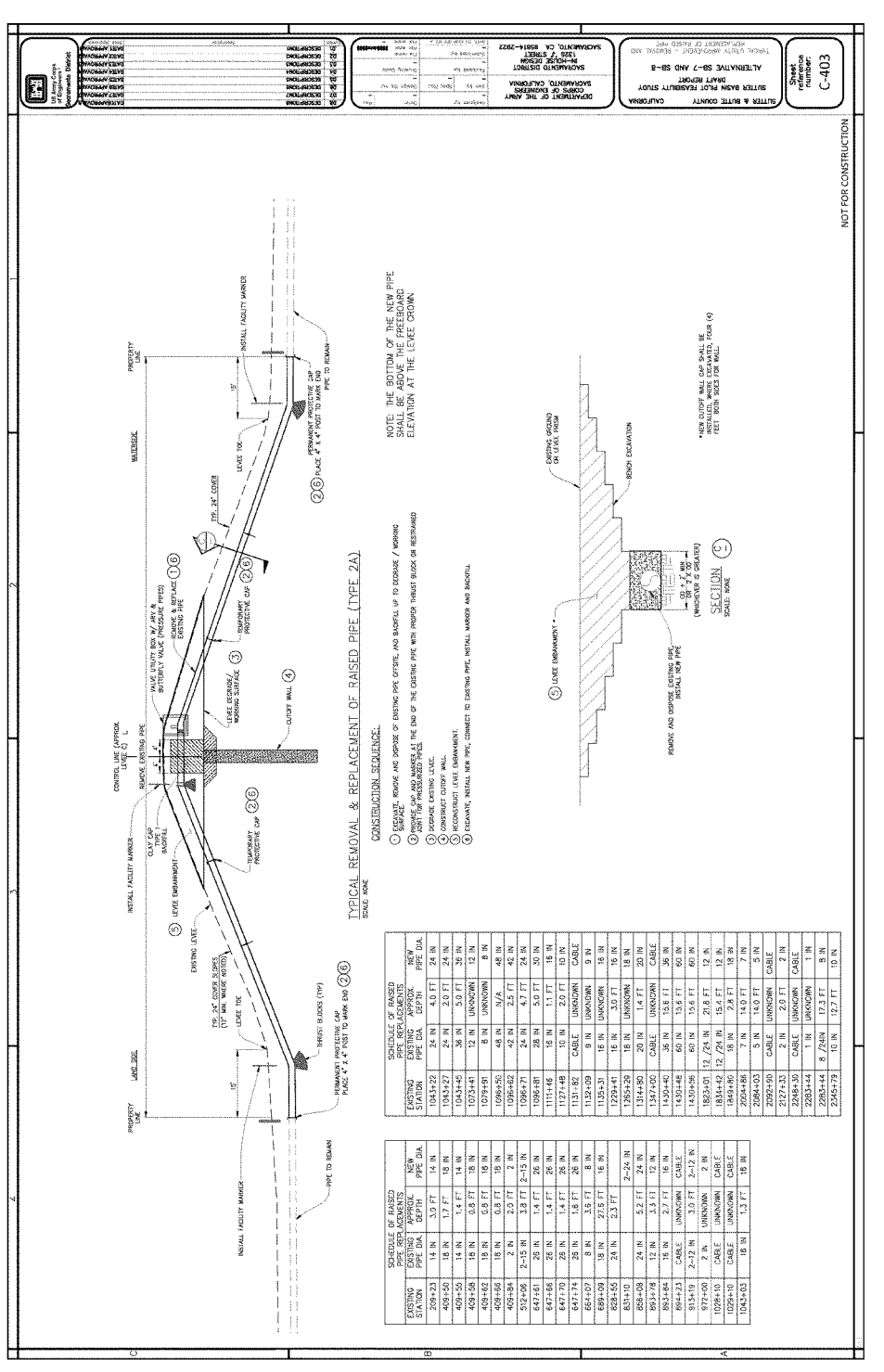
1325 J STREET
SACRAMENTO, CA 95814-2922
Sheet reference number: C-402
NOT FOR CONSTRUCTION
SCHEDULE OF THROUGH PIPE REMOVALS
EXISTING STATION
EXISTING PIPE DIA.
APPROX DEPTH
208+89 36 IN UNKNOWN
407+73 8 IN 21.8 FT
1043+52 27 IN 38.6 FT
1538+22 8 IN UNKNOWN
1585+05 12 IN UNKNOWN
1785+55 24 IN UNKNOWN
1814+70 24 IN UNKNOWN
1869+17 18 IN UNKNOWN
2026+40 12 IN 13.5 FT
2032+90 12 IN 14.0 FT
2201+87 10 IN 13.1 FT
2268+27 24 IN 18.4 FT
2312+05 24 IN UNKNOWN
2352+80 24 IN UNKNOWN
TYPICAL REMOVAL & DISPOSAL OF ABANDONED THROUGH PIPE (TYPE 1B)
SCALE: NONE
CONSTRUCTION SEQUENCE:
1 EXCAVATE, REMOVE AND DISPOSE OF EXISTING PIPE OFFSITE, AND BACKFILL UP TO WORKING SURFACE.
2 DEGRADE EXISTING LEVEE.
3 CONSTRUCT CUTOFF WALL.
4 RECONSTRUCT LEVEE EMBANKMENT.
SECTION
SCALE: NONE
LEVEE EMBANKMENT
LEVEE DOMAIN/ WORKING SURFACE
BENCH EXCAVATION IN ACCORDANCE WITH DRAWING
REMOVE AND DISPOSE OF EXISTING PIPE
PROPERTY LINE
LAND SIDE
WATERSIDE
EXISTING LEVEE
LEVEE TOE
15'
CONTROL LINE (APPROX. LOCE 0)
REMOVE EXISTING PIPE
CLAY CAP TYPE 1 BACKFILL
BACKFILL TYPE 'C' MATERIAL
LEVEE EMBANKMENT (SEE TYPE 2)
CUTOFF WALL
3'
LEVEE DOMAIN/ WORKING SURFACE
REMOVE & DISPOSE OF EXISTING PIPE
LEVEE TOE
PERMANENT PROTECTIVE CAP PLACE 4" X 4" POST TO MARK END
PIPE TO REMAIN
REMOVE & DISPOSE OF EXISTING STRUCTURE
PERMANENT PROTECTIVE CAP PLACE 4" X 4" POST TO MARK END
PIPE TO REMAIN



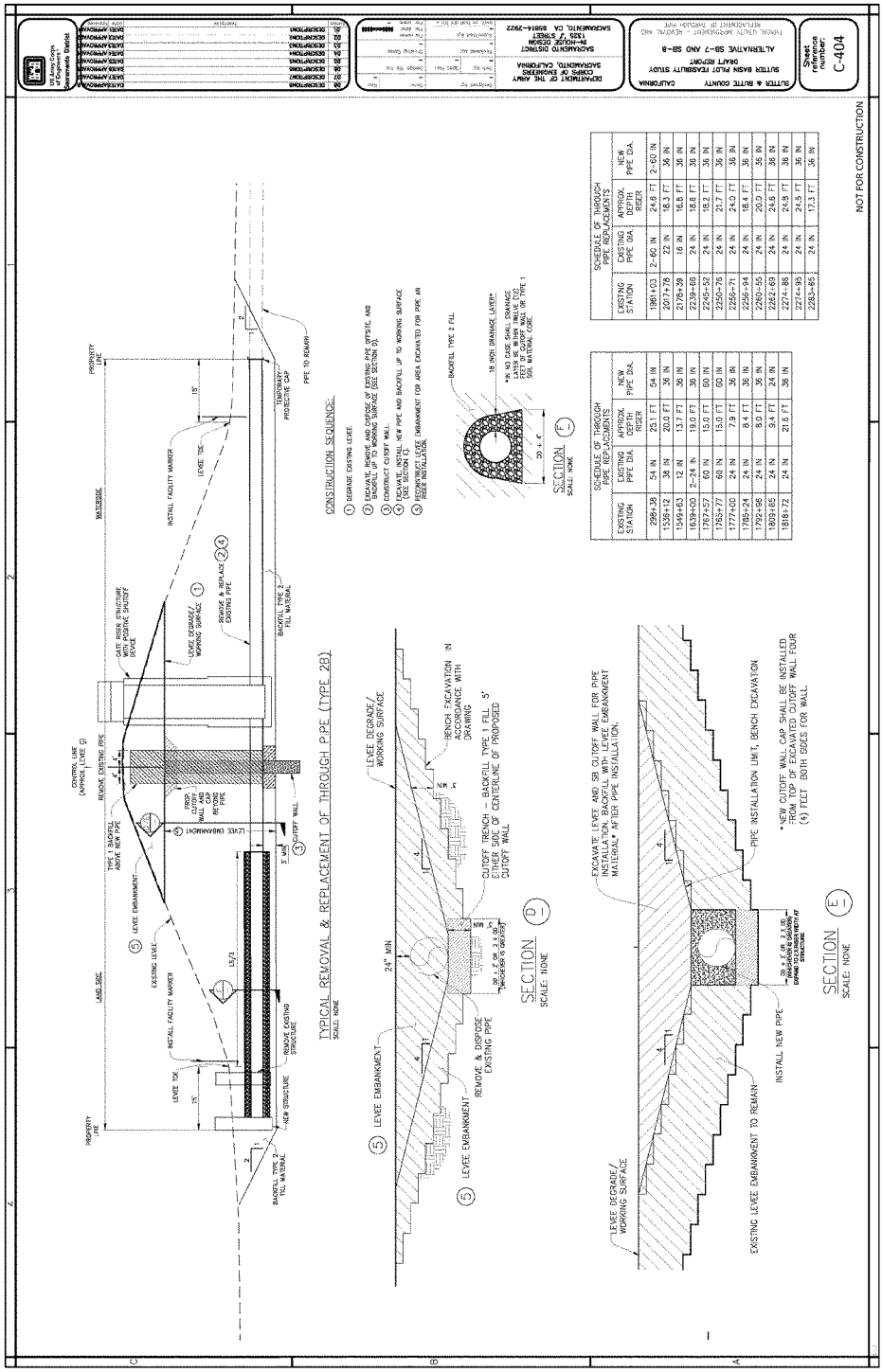
SCHEDULE OF RAISED PIPE REPLACEMENTS

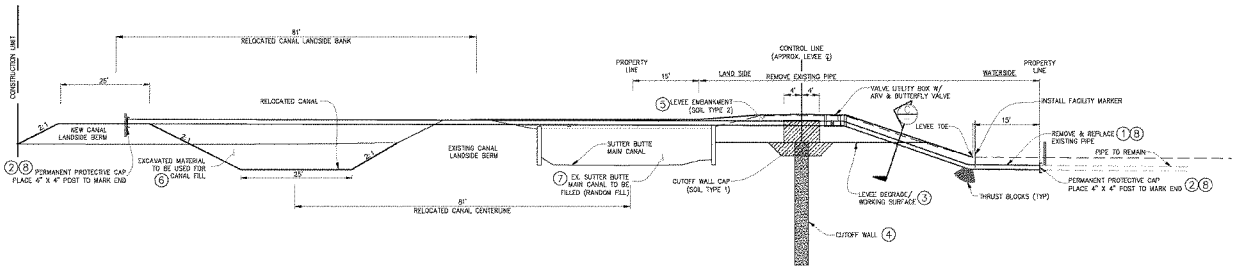
EXISTING STATION	EXISTING PIPE DIA.	APPROX. DEPTH	NEW PIPE DIA.
2094+23	14 IN	3.0 FT	14 IN
4059+50	18 IN	1.7 FT	18 IN
4059+55	14 IN	1.4 FT	14 IN
4059+58	18 IN	0.8 FT	18 IN
4059+62	18 IN	0.8 FT	18 IN
4059+66	18 IN	0.8 FT	18 IN
4059+84	2 IN	2.0 FT	2 IN
5124+06	2-15 IN	3.8 FT	2-15 IN
6447+61	26 IN	1.4 FT	26 IN
6447+66	26 IN	1.4 FT	26 IN
6447+70	26 IN	1.4 FT	26 IN
6447+74	26 IN	1.8 FT	26 IN
6664+07	8 IN	3.5 FT	8 IN
6689+09	18 IN	27.5 FT	16 IN
6828+55	24 IN	2.3 FT	2-24 IN
8314+10			
8656+08	24 IN	5.2 FT	24 IN
8693+78	12 IN	3.3 FT	12 IN
8893+64	16 IN	2.7 FT	16 IN
8944+23	CABLE	UNKNOWN	CABLE
9134+19	2-12 IN	3.0 FT	2-12 IN
9772+00	2 IN	UNKNOWN	2 IN
10298+10	CABLE	UNKNOWN	CABLE
10299+10	CABLE	UNKNOWN	CABLE
10433+03	16 IN	1.3 FT	16 IN

SCHEDULE OF RAISED PIPE REPLACEMENTS

EXISTING STATION	EXISTING PIPE DIA.	APPROX. DEPTH	NEW PIPE DIA.
10434+22	24 IN	4.0 FT	24 IN
10434+27	24 IN	2.0 FT	24 IN
10434+45	36 IN	5.0 FT	36 IN
10734+41	12 IN	UNKNOWN	12 IN
10779+91	8 IN	UNKNOWN	8 IN
10969+56	48 IN	N/A	48 IN
10986+62	42 IN	2.5 FT	42 IN
10987+71	24 IN	4.7 FT	24 IN
10988+81	28 IN	5.0 FT	30 IN
11114+46	16 IN	1.1 FT	16 IN
11274+48	10 IN	2.0 FT	10 IN
11311+82	CABLE	UNKNOWN	CABLE
11324+09	9 IN	UNKNOWN	9 IN
11354+31	16 IN	UNKNOWN	16 IN
12294+41	16 IN	3.0 FT	16 IN
12654+29	18 IN	UNKNOWN	18 IN
13144+80	20 IN	1.4 FT	20 IN
13474+00	CABLE	UNKNOWN	CABLE
14304+40	36 IN	15.6 FT	36 IN
14304+46	60 IN	13.6 FT	60 IN
14304+56	60 IN	15.6 FT	60 IN
18234+01	12, /24 IN	21.6 FT	12 IN.
18314+42	12, /24 IN	15.4 FT	12 IN.
18434+16	18 IN	2.8 FT	18 IN
20044+86	7 IN	14.0 FT	7 IN
20844+03	5 IN	14.0 FT	5 IN
20924+60	CABLE	UNKNOWN	CABLE
21274+33	2 IN	2.0 FT	2 IN
22464+30	CABLE	UNKNOWN	CABLE
22834+44	1 IN	UNKNOWN	1 IN
22854+44	8 /24IN	17.3 FT	8 IN
23454+79	10 IN	12.7 FT	10 IN

1st Army Corps of Engineers Sacramento District		DEPARTMENT OF THE ARMY CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA	SUTTER & BUTTE COUNTY CALIFORNIA
		SACRAMENTO DISTRICT 1325 J STREET SACRAMENTO, CA 95814-2922	SUTTER BASIN PILOT FEASIBILITY STUDY ALTERNATIVE SB-7 AND SB-8 DRAFT REPORT
			Sheet reference number: C-403


SUTTER BASIN PILOT FEASIBILITY STUDY
ALTERNATIVE SB-7 AND SB-8
DRAFT REPORT
SUTTER & BUTTE COUNTY CALIFORNIA
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
TYPICAL REMOVAL & REPLACEMENT OF THROUGH PIPE (TYPE 2B)
SCALE: NONE
CONSTRUCTION SEQUENCE:
1 DEGRADE EXISTING LEVEE.
2 EXCAVATE, REMOVE AND DISPOSE OF EXISTING PIPE (OPTION) AND BACKFILL UP TO WORKING SURFACE (SEE SECTION D)
3 CONSTRUCT CUTOFF WALL.
4 EXCAVATE, INSTALL NEW PIPE AND BACKFILL UP TO WORKING SURFACE (SEE SECTION E)
5 RECONSTRUCT LEVEE EMBANKMENT FOR AREA EXCAVATED FOR PIPE AN RISER INSTALLATION.
SECTION D
SCALE: NONE
SECTION E
SCALE: NONE
SECTION F
SCALE: NONE
SCHEDULE OF THROUGH PIPE REPLACEMENTS
SCHEDULE OF THROUGH PIPE REPLACEMENTS
SCHEDULE OF THROUGH PIPE REPLACEMENTS
NOT FOR CONSTRUCTION
Sheet reference number: C-404

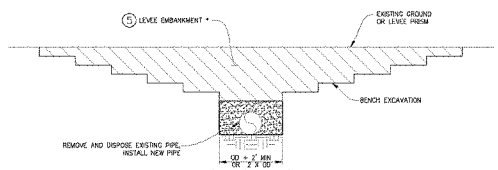


TYPICAL REMOVAL & REPLACEMENT OF RAISED PIPE WITH CANAL RELOCATION (TYPE 3A1)

SCALE: NONE

CONSTRUCTION SEQUENCE:

1. EXCAVATE, REMOVE AND DISPOSE OF EXISTING PIPE OFFSITE, AND BACKFILL UP TO DEGRADE / WORKING SURFACE.
2. PROVIDE CAP AND MARKER AT THE END OF THE EXISTING PIPE WITH PROPER THRUST BLOCK OR RESTRAINED JOINT FOR PRESSURIZED PIPES.
3. DEGRADE EXISTING LEVEE.
4. CONSTRUCT CUTOFF WALL.
5. RECONSTRUCT LEVEE EMBANKMENT.
6. EXCAVATE NEW SUTTER BUTTE CANAL AND CONSTRUCT NEW LANDSIDE BERM
7. FILL SUTTER BUTTE CANAL WITH EXCAVATED MATERIAL
8. EXCAVATE, INSTALL NEW PIPE, CONNECT TO EXISTING PIPE, INSTALL MARKER AND BACKFILL



SECTION C

SCALE: NONE

*NEW CUTOFF WALL CAP SHALL BE INSTALLED, WHERE EXCAVATED, FOUR (4) FEET BOTH SIDES FOR WALL.

SCHEDULE OF RAISED PIPE REPLACEMENTS W/ CANAL RELOCATION			
EXISTING STATION	EXISTING PIPE DIA.	APPROX. DEPTH	NEW PIPE DIA.
1765+15	12 IN	1.0 FT	12 IN

NOT FOR CONSTRUCTION

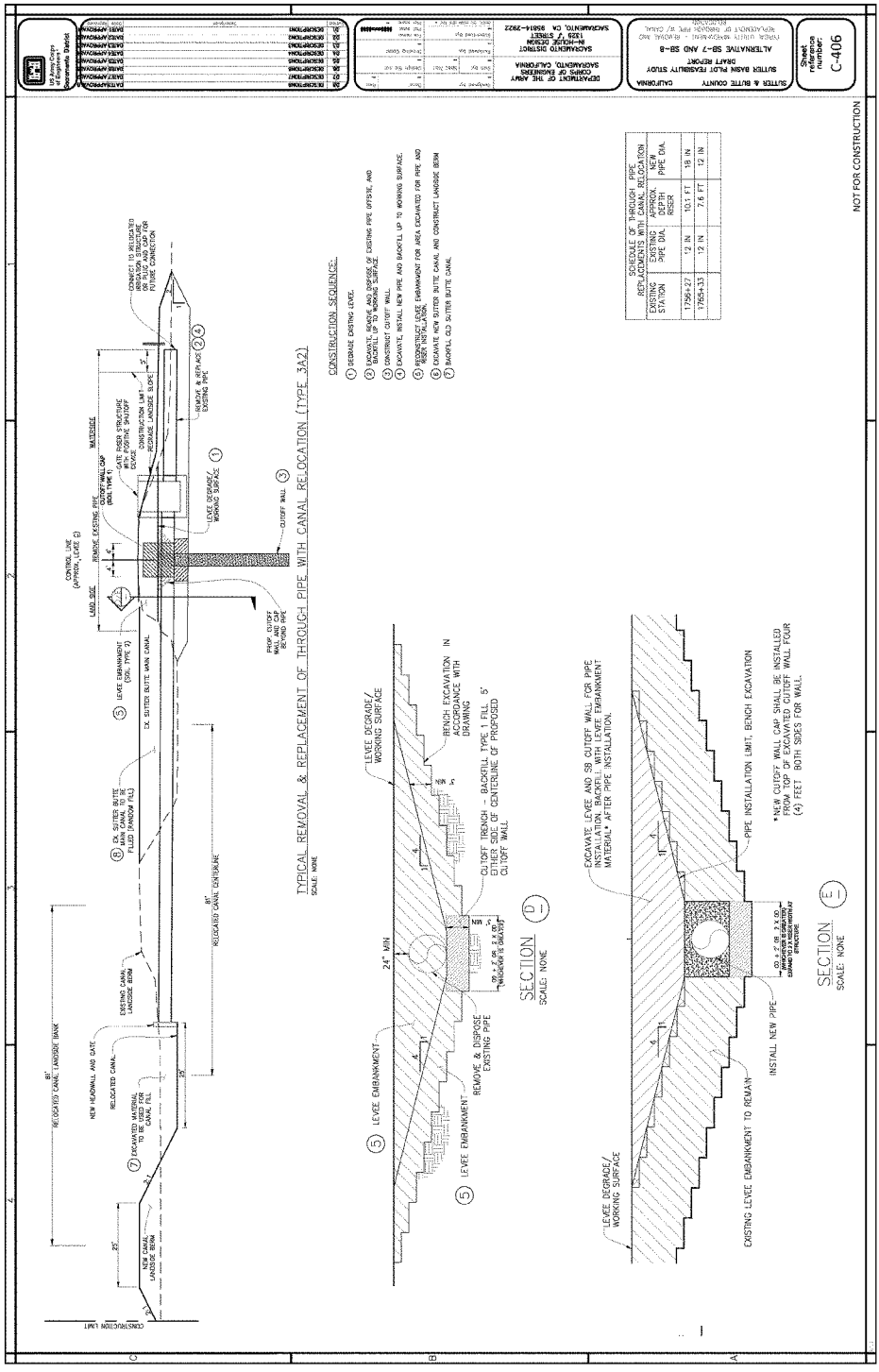
US Army Corps of Engineers
Sacramento District

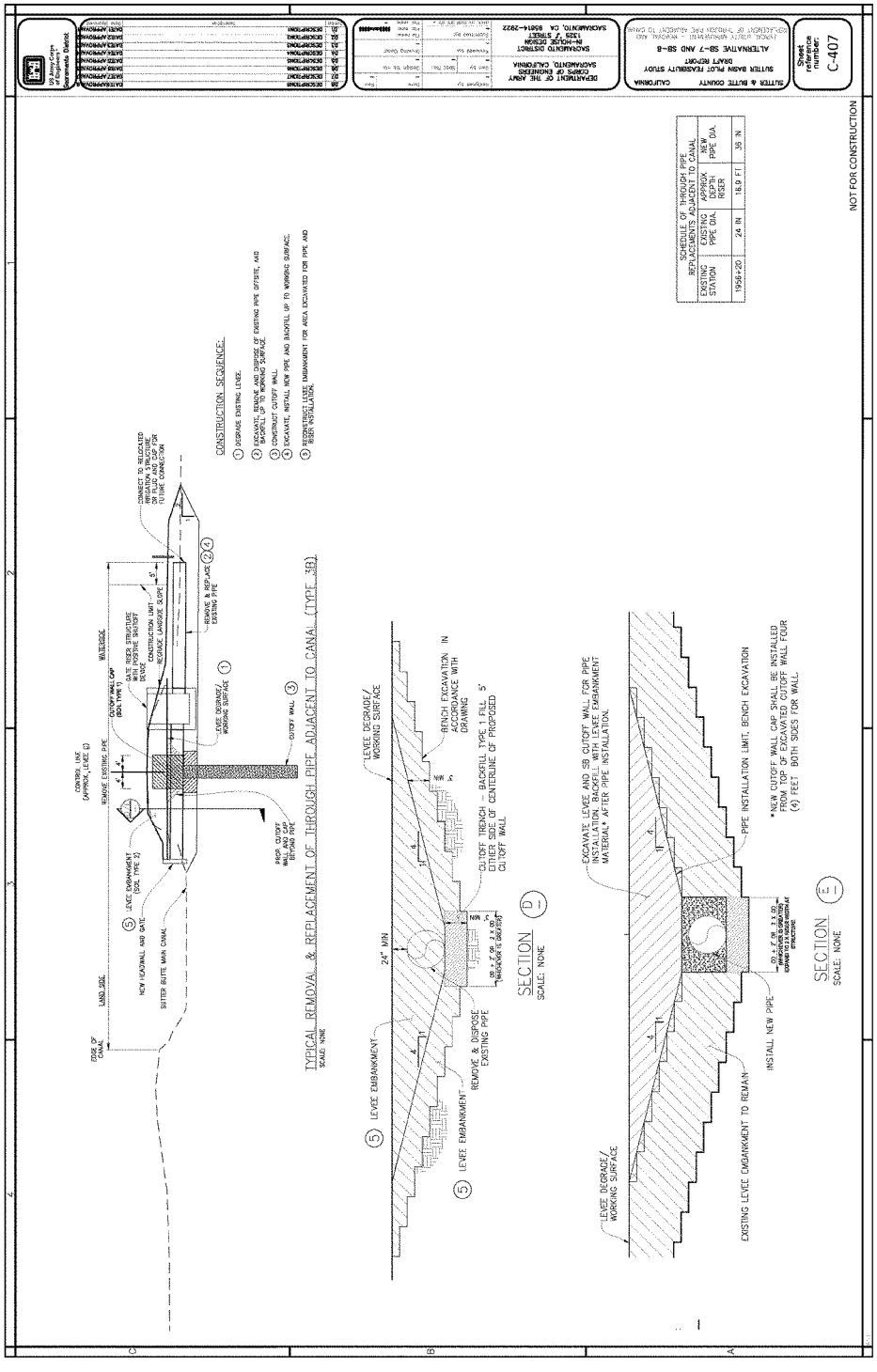
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

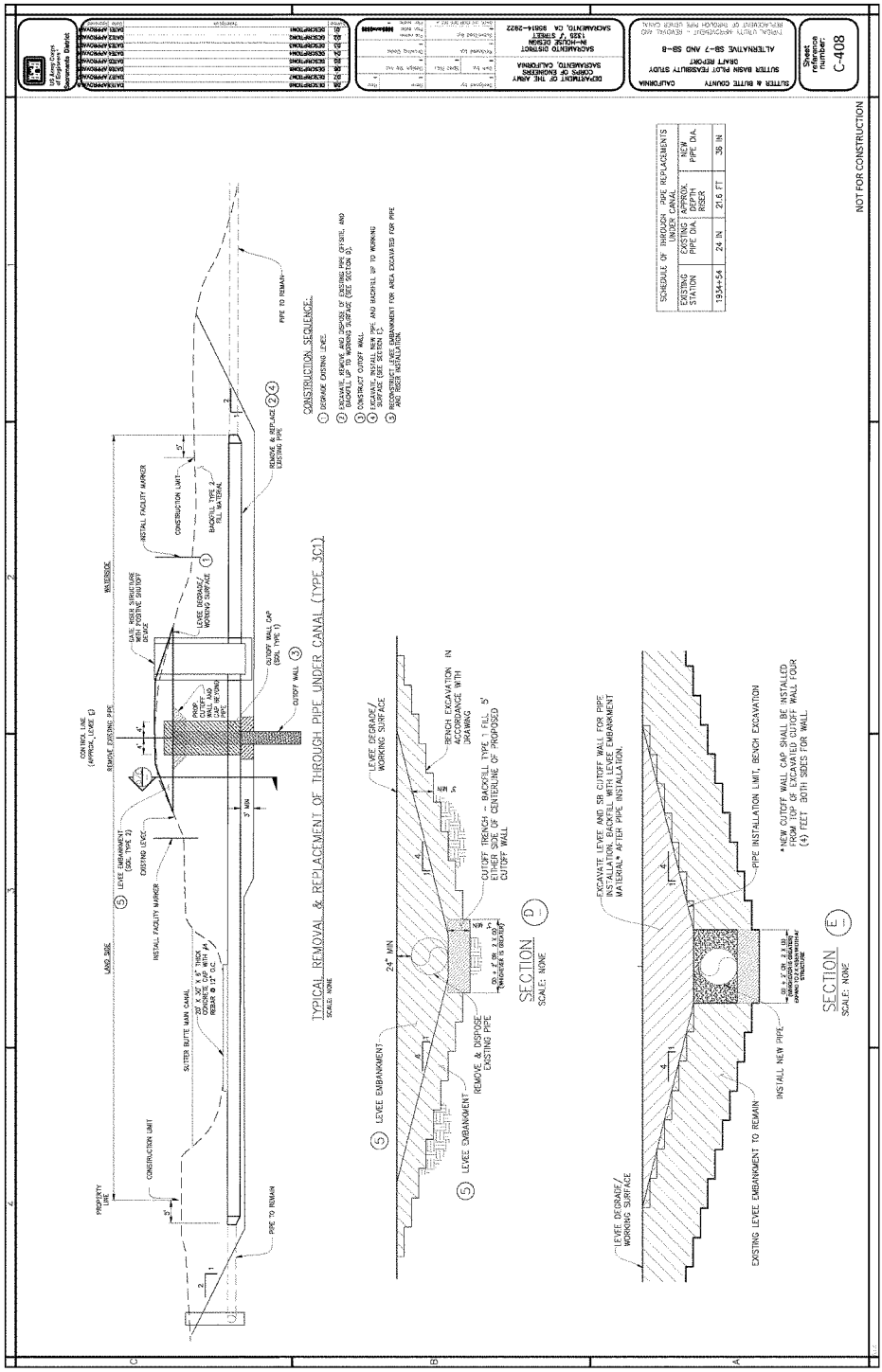
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 J STREET
SACRAMENTO, CA 95814-2922

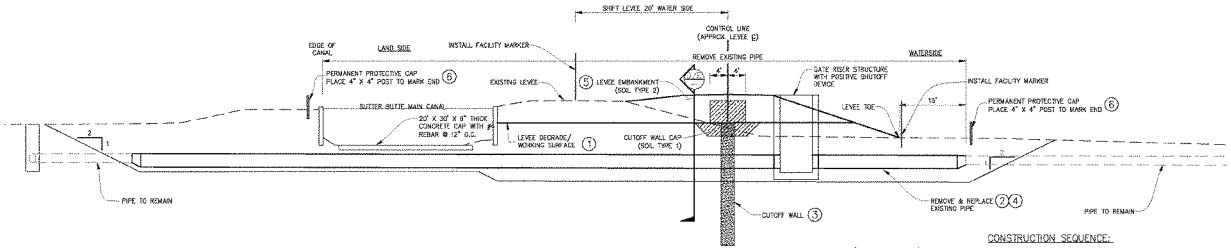
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
TYPICAL LIFTING OF RAISED PIPE W/ CANAL RELOCATION
REPLACEMENT OF RAISED PIPE W/ CANAL RELOCATION

Sheet reference number:
C-405


TYPICAL REMOVAL & REPLACEMENT OF THROUGH PIPE WITH CANAL RELOCATION (TYPE 3A2)
CONSTRUCTION SEQUENCE:
1. DEGRADE EXISTING LEVEE.
2. EXCAVATE, BACKFILL AND DISPOSE OF EXISTING PIPE OFFSITE, AND INSTALL NEW PIPE AS SHOWN ON PLANS.
3. CONSTRUCT CUTOFF WALL.
4. EXCAVATE, INSTALL NEW PIPE AND BACKFILL UP TO WORKING SURFACE.
5. RECONSTRUCT LEVEE EMBANKMENT FOR AREA EXCAVATED FOR PIPE AND USER INSTALLATION.
6. EXCAVATE NEW SUTTER BUTTE CANAL AND CONSTRUCT LANDSIDE BERM
7. BACKFILL OLD SUTTER BUTTE CANAL
SCHEDULE OF THROUGH PIPE REPLACEMENTS WITH CANAL RELOCATION
EXISTING STATION
EXISTING PIPE DIA.
APPROX. DEPTH RESER
NEW PIPE DIA.
17356+27
12 IN
10.1 FT
18 IN
17654+33
12 IN
7.6 FT
12 IN
SECTION D
SCALE: NONE
SECTION E
SCALE: NONE
NOT FOR CONSTRUCTION
SUTTER BASIN PILOT FEASIBILITY STUDY
ALTERNATIVE SB-7 AND SB-8
DRAFT REPORT
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
SACRAMENTO, CALIFORNIA
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CA 95814-2922
C-406


US Army Corps of Engineers Sacramento District
SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
DEPARTMENT OF THE ARMY CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT IN-HOUSE DESIGN 1325 J STREET SACRAMENTO, CA 95814-2922
Sheet number
C-407
CONSTRUCTION SEQUENCE:
1) DEGRADE EXISTING LEVEE.
2) EXCAVATE, REMOVE AND DISPOSE OF EXISTING PIPE OUTSIDE, AND BACKFILL UP TO WORKING SURFACE.
3) CONSTRUCT CUTOFF WALL.
4) EXCAVATE, INSTALL NEW PIPE AND BACKFILL UP TO WORKING SURFACE.
5) RECONSTRUCT LEVEE EMBANKMENT FOR AREA EXCAVATED FOR PIPE AND RISER INSTALLATION.
TYPICAL REMOVAL & REPLACEMENT OF THROUGH PIPE ADJACENT TO CANAL (TYPE 3B)
SCALE: NONE
SCHEDULE OF THROUGH PIPE REPLACEMENTS ADJACENT TO CANAL
EXISTING STATION
EXISTING PIPE DIA.
APPROX DEPTH RISER
NEW PIPE DIA.
1958+20
24 IN
18.9 FT
35 IN
SECTION
SCALE: NONE
SECTION
SCALE: NONE
NOT FOR CONSTRUCTION

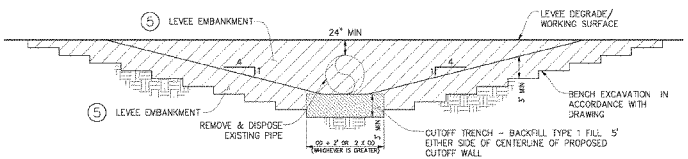

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
ALTERNATIVE SB-7 AND SB-8
DRAFT REPORT
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1939 'A' STREET
SACRAMENTO, CA 95814-2922
Sheet reference number: C-408
NOT FOR CONSTRUCTION
TYPICAL REMOVAL & REPLACEMENT OF THROUGH PIPE UNDER CANAL (TYPE 3C1)
SCALE: NONE
CONSTRUCTION SEQUENCE:
1 DEWATER EXISTING LEVEE.
2 EXCAVATE, REMOVE AND DISPOSE OF EXISTING PIPE (OPTION), AND BACKFILL UP TO WORKING SURFACE (SEE SECTION D).
3 CONSTRUCT CUTOFF WALL.
4 EXCAVATE, INSTALL NEW PIPE, AND BACKFILL UP TO WORKING SURFACE (SEE SECTION D).
5 RECONSTRUCT LEVEE EMBANKMENT FOR AREA EXCAVATED FOR PIPE AND RISER INSTALLATION.
SCHEDULE OF THROUGH PIPE REPLACEMENTS
EXISTING STATION
EXISTING PIPE DIA.
APPROX DEPTH RISER
NEW PIPE DIA.
1934+54
24 IN
21.5 FT
36 IN
SECTION D
SCALE: NONE
SECTION E
SCALE: NONE
LAND SIDE
WATERSIDE
CONSTRUCTION LIMIT
PROPERTY LINE
EXISTING LEVEE
REMOVE EXISTING PIPE
INSTALL FACILITY MARKER
LEVEE EMBANKMENT (SEAL TYPE 4)
GATE MISER SPRUCING WITH FLAP GATE
DEVICE
LEVEE DEGRADE/ WORKING SURFACE
CONSTRUCTION LIMIT
BACKFILL TYPE 2 TO WORKING SURFACE
REMOVE & REPLACE EXISTING PIPE
PIPE TO REMAIN
CUTOFF WALL CAP (SEAL TYPE 1)
CUTOFF WALL
SUTTER BUTTE MAIN CANAL
24" MIN
5' MIN
LEVEE EMBANKMENT
REMOVE & DISPOSE EXISTING PIPE
CUTOFF TRENCH - BACKFILL TYPE 1 FILL 5' EITHER SIDE OF CENTERLINE OF PROPOSED CUTOFF WALL
BENCH EXCAVATION IN ACCORDANCE WITH DRAWING
EXCAVATE LEVEE AND SB CUTOFF WALL FOR PIPE INSTALLATION. BACKFILL WITH LEVEE EMBANKMENT MATERIAL AFTER PIPE INSTALLATION.
PIPE INSTALLATION LIMIT, BENCH EXCAVATION
EXISTING LEVEE EMBANKMENT TO REMAIN
INSTALL NEW PIPE
* NEW CUTOFF WALL CAP SHALL BE INSTALLED FROM TOP OF EXCAVATED CUTOFF WALL FOUR (4) FEET BOTH SIDES FOR WALL.



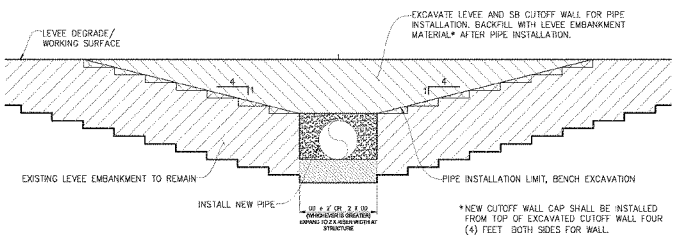
TYPICAL REMOVAL & REPLACEMENT OF THROUGH PIPE UNDER CANAL WITH LEVEE RELOCATION (TYPE 3C2)
SCALE: NONE

CONSTRUCTION SEQUENCE:

1. DEGRADE EXISTING LEVEE.
2. EXCAVATE, REMOVE AND DISPOSE OF EXISTING PIPE OFFSITE, AND BACKFILL UP TO WORKING SURFACE (SEE SECTION D).
3. CONSTRUCT CUTOFF WALL.
4. EXCAVATE, INSTALL NEW PIPE AND BACKFILL UP TO WORKING SURFACE (SEE SECTION E).
5. RECONSTRUCT LEVEE EMBANKMENT FOR AREA EXCAVATED FOR PIPE AN RISER INSTALLATION.
6. EXCAVATE, INSTALL NEW PIPE, CONNECT TO EXISTING PIPE, INSTALL MARKER AND BACKFILL.



SECTION D
SCALE: NONE



*NEW CUTOFF WALL CAP SHALL BE INSTALLED FROM TOP OF EXCAVATED CUTOFF WALL FOUR (4) FEET BOTH SIDES FOR WALL.

SECTION E
SCALE: NONE

SCHEDULE OF THROUGH PIPE REPLACEMENTS UNDER CANAL W/ LEVEE RELOCATION

EXISTING STATION	EXISTING PIPE DIA.	APPROX. DEPTH RISER	NEW PIPE DIA.
1610+92	18 IN	18.9 FT	36 IN
1675+27	60x72 IN	17.0 FT	60x72 IN
1741+32	16 IN	14.8 FT	18 IN

NOT FOR CONSTRUCTION

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Sacramento District

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SACRAMENTO, CALIFORNIA

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SACRAMENTO, CA 95814-2922

SUTTER & BUTTE COUNTY CALIFORNIA
SUTTER BASIN PILOT FEASIBILITY STUDY
DRAFT REPORT
ALTERNATIVE SB-7 AND SB-8
TYPICAL UNDER CANAL PIPE REPLACEMENT AND REPLACEMENT OF THROUGH PIPE UNDER CANAL WITH LEVEE RELOCATION

Sheet reference number:
C-409

APPENDIX D - ENVIRONMENTAL

Appendix A

Scoping Report

Memorandum

Date:	July 29, 2011
To:	Matt Davis, U.S. Army Corps of Engineers
Cc:	Chris Elliott, ICF International, Jennifer Rogers, ICF International
From:	Ingrid Norgaard, ICF International
Subject:	**Public Scoping Meeting Summary for the Sutter Basin Project and Feather River West Levee Project Environmental Scoping Meetings—June 27 and 28, 2011**

Introduction

Two efforts are presently underway to study flood risk reduction improvements in Sutter and Butte Counties, one known as the Sutter Basin Feasibility Study, sponsored by the U.S. Army Corps of Engineers (USACE) to determine federal interest in flood risk reduction project(s), and one known as the Feather River West Levee Project (FRWLP), sponsored by the Sutter Butte Flood Control Agency (SBFCA) as a locally driven flood risk reduction project.

The two projects are being studied in close coordination because they at least partially overlap in their study areas, purpose, potential improvements, potential effects, and involved parties. Therefore, a joint scoping process is being conducted for the two projects to explain the relationship between the two efforts and obtain public input in a manner that is convenient, efficient, and integrated. It is anticipated that the two planning efforts will result in a separate Environmental Impact Study/Environmental Impact Report (EIS/EIR) for each project, in accordance with the National Environmental Policy Act (NEPA) and California Environmental Quality Act (CEQA).

Sutter Basin Feasibility Study

USACE initiated the Sutter Basin project in 2001 and is conducting a feasibility study to evaluate flood damage reduction, ecosystem restoration, and recreation opportunities within the study area. The Central Valley Flood Protection Board (CVFPB) and SBFCA, in their roles as non-federal local sponsors, are coordinating with USACE on the feasibility study. USACE, acting as the federal lead agency under NEPA, and SBFCA, acting as the state lead agency under CEQA, have determined that an EIS/EIR will be prepared to describe alternatives, potential environmental effects, and mitigation measures.

FRWLP

SBFCA is planning the FRWLP to address levee deficiencies in the west levee of the Feather River from Thermalito Afterbay to the Sutter Bypass confluence to meet federal, state, and local flood protection criteria and goals. In 2010, an assessment district was enacted to provide local funding toward flood management improvements. These funds will be matched with those from the Disaster Preparedness and Flood Prevention Bond Act of 2006 (Proposition 1E) administered by the California Department of Water Resources (DWR). The purpose of the FRWLP would be to construct improvements as quickly as possible in advance of and compatible with the Sutter Basin Feasibility Study. USACE, acting as the federal lead agency under NEPA, and SBFCA, acting as the state lead agency under the CEQA, have determined that an EIS/EIR will be prepared to describe alternatives, potential environmental effects, and mitigation measures.

Development of the draft EIS/EIR to evaluate the FRWLP is underway and scheduled for public release in early 2012. A public release date for the Sutter Basin Project draft EIS/EIR has yet to be determined.

SBFCA and USACE have been carrying out scoping activities to assist them in determining the scope, and content of the environmental information for these two projects. SBFCA and USACE have had ongoing inter-agency consultation with responsible and interested agencies such as the Central Valley Flood Protection Board, Department of Fish and Game, Department of Water Resources (DWR), and California Regional Water Quality Control Board to name a few. In addition, SBFCA and USACE conducted a total of four public scoping meetings for the public and for federal and state agency staff on June 27th and June 28th, 2011. The following summarizes the outreach conducted to inform responsible and interested agencies and the public of the proposed projects, the scoping meetings, and the public comment received.

Noticing

Notice of Intent/Preparation

In compliance with the requirements set forth in CEQA, SBFCA and USACE prepared a Notice of Preparation (NOP). The NOP contained a brief description of the proposed project, project date, probable environmental effects, the date, time and place of the public scoping meetings, and contact information. The NOP solicited participation in determining the scopes and content of the environmental information of the EIS/EIRs. On May 20, 2011 the NOP was sent to Responsible and Trustee Agencies and involved federal agencies, to the State Clearinghouse, and parties previously requesting notice in writing. The comment period on the NOP was May 20, 2011 to July 08, 2011.

In compliance with the requirements set forth in NEPA, USACE prepared a Notice of Intent (NOI) describing its intent to prepare an EIS/EIR, the proposed action, the possible alternatives, and relevant scoping meeting and contact information. The NOI was posted in the Federal Register, the United States Government's official noticing and reporting publication, on May 20, 2011. The official comment period for the NOI was May 20, 2011 to July 08, 2011.

Mailings

SBFCA utilized a previously developed mailing list of interested stakeholders to send an email notification encouraging attendance at the scoping meetings.

Notifications

Advertisements briefly introducing the lead agencies, the proposed projects and associated environmental review processes, and publicizing the scoping meetings were placed in the Appeal Democrat and the Gridley Herald newspapers. Both newspapers are intended to reach a local and regional public audience that residents routinely rely upon to keep them abreast of Sutter and Butte county issues. The advertisements were published in the Appeal Democrat on June 20 and June 27, 2011. The advertisements were published in the Gridley Herald on June 22 and June 24, 2011. A media release was also emailed out to a number media contacts within the region on June 22, 2011.

Attachment A contains copies of the following:

- Notice of Preparation
- Notice of Intent
- Email Notification
- Appeal Democrat and Gridley Herald Ledger Advertisements
- Media Release

Public Meetings

Four public scoping meetings were held to inform the public of the proposed projects and seek feedback on the range of alternatives, environmental effects, and issues of concern related to the Sutter Basin Project and the FRWLP. The four meetings were held at two different times for two days. On June 27, 2011 the meeting times were from 3:30 to 5:30 p.m. and 6:30 to 8:30 p.m., at the Yuba City Veterans Memorial Community Center. On June 28, 2011 the meeting times were from 3:30 to 5:30 p.m. and 6:30 to 8:30 p.m., at the Gridley Veterans Memorial Hall. The meeting locations were chosen as they are central to the region. The meeting times were chosen to accommodate both the work day schedules of public agency representatives and the general public, including residents and business owners.

The meetings were open-house style workshops in which attendees could read and view the information about the two projects and interact with project staff including SBFCA, USACE, DWR, HDR Engineering consultant staff, and ICF International (ICF) environmental consulting staff.

Twenty-six graphic display boards were on display for attendees to review. The boards described and illustrated the Sutter Basin Project and FRWLP history, purpose, need and objectives, study area, levee deficiencies and potential improvements, environmental considerations, the CEQA/NEPA process and project timeline and were on display for attendees to review. SBFCA, USACE, HDR and

ICF staff were stationed at display boards to interact with public attendees and provide additional detail or answer any questions.

A Power Point presentation was given to provide a brief introduction to the Sutter Basin Project and the FRWLP including objectives, schedule, environmental compliance, and related flood control work in the region.

A fact sheet, providing an overview of the Sutter Basin Project and the FRWLP including purpose and goals, maps of the corresponding study areas, an overview of the environmental compliance process and timeline, was also made available.

Comment cards were prepared so that meeting attendees could provide feedback on the projects. These cards could be filled out during the meeting and given to a project team member.

Attachment B contains copies of the following:

- Display boards
- Power Point presentation
- Fact sheet
- Comment card templates

Public Feedback

There were 36 people in total who attended the two meetings. Twelve people attended the meeting from 3:30 to 5:00 p.m. and four people attended the meeting from 6:30 to 8:00 p.m. on June 27, 2011. Fifteen people attended the meeting from 3:30 to 5:00 p.m. and five people attended the meeting from 6:30 to 8:00 p.m. on June 28, 2011.

Five comments were received from the public regarding the EIS/EIRs during the scoping period. Below is a list summarizing the comments received.

- A request was made to keep the process for the Sutter Basin Feasibility Study on schedule so the state will be able to release EIP funding for the FRWLP.
- A comment was received regarding the importance of coordinating with the Lower Feather River Corridor Management Project so not to have to duplicate efforts on environmental studies.
- A comment was received in favor of the option of putting in a levee setback in the Nelson Slough area.
- A comment was received in opposition of the project.
- A comment addressed two issues. The first comment pertains to the lack of attention to the east levee of the Sutter Bypass. The second comment suggested using a perimeter levee around Yuba City, or a J levee on the south and west side.

Attachment C contains copies of the following:

- Comments received from all interested parties (including those transcribed by court reporter)
- Attendee sign-in sheet templates

Next Steps

The comments received during the scoping period will assist in determining which issues are evaluated in detail in both the Sutter Basin Project and FRWLP EIS/EIRs. Once alternatives have been developed based on the scoping process and preexisting information, they will be analyzed, and draft EIS/EIRs will be developed. Upon the release of the draft EIR/EIS, the public will have 45 days to comment on the document. Additionally, at least one public hearing will be held so the public and agencies can learn more about both of the draft EIR/EISs, ask questions regarding the analysis, and provide comments. At these meetings, the alternatives will be presented and explained.

Development of the draft EIS/EIR to evaluate the FRWLP is underway and scheduled for public release in early 2012. A public release date for the Sutter Basin Project draft EIS/EIR has yet to be determined.

Attachment A

- Notice of Preparation
- Notice of Intent
- Email Notification
- Appeal Democrat and Gridley Herald Ledger Advertisements
- Media Release

JERRY BROWN
GOVERNOR

STATE OF CALIFORNIA
GOVERNOR'S OFFICE *of* PLANNING AND RESEARCH
STATE CLEARINGHOUSE AND PLANNING UNIT

Notice of Preparation

May 20, 2011

To: Reviewing Agencies

Re: Sutter Basin Feasibility Study and Feather River West Levee Project
SCH# 2011052062

Attached for your review and comment is the Notice of Preparation (NOP) for the Sutter Basin Feasibility Study and Feather River West Levee Project draft Environmental Impact Report (EIR).

Responsible agencies must transmit their comments on the scope and content of the NOP, focusing on specific information related to their own statutory responsibility, within 30 days of receipt of the NOP from the Lead Agency. This is a courtesy notice provided by the State Clearinghouse with a reminder for you to comment in a timely manner. We encourage other agencies to also respond to this notice and express their concerns early in the environmental review process.

Please direct your comments to:

Ingrid Norgaard
Sutter Butte Flood Control Agency
c/o ICF International
630 K Street, Suite 400
Sacramento, CA 95814

with a copy to the State Clearinghouse in the Office of Planning and Research. Please refer to the SCH number noted above in all correspondence concerning this project.

If you have any questions about the environmental document review process, please call the State Clearinghouse at (916) 445-0613.

Sincerely,

Scott Morgan
Director, State Clearinghouse

Attachments
cc: Lead Agency

Document Details Report
State Clearinghouse Data Base

SCH# 2011052062
Project Title Sutter Basin Feasibility Study and Feather River West Levee Project
Lead Agency Sutter Butte Flood Control Agency

Type NOP Notice of Preparation

Description Two efforts are presently underway to study flood risk reduction improvements in Sutter and Butte Counties, one known as the Sutter Basin Feasibility Study, sponsored by the U.S. Army Corps of Engineers (USACE) to determine federal interest in flood risk reduction project(s), and one known as the Feather River West Levee Project (FRWLP), sponsored by the Sutter Butte Flood Control Agency (SBFCA) as a locally driven flood risk reduction project.

Lead Agency Contact

Name Ingrid Norgaard
Agency Sutter Butte Flood Control Agency
Phone 916 737-3000 **Fax**
email inorgaard@icfi.com
Address c/o ICF International
630 K Street, Suite 400
City Sacramento **State** CA **Zip** 95814

Project Location

County Sutter, Butte
City
Region
Cross Streets
Lat / Long
Parcel No.
Township **Range** **Section** **Base**

Proximity to:

Highways
Airports
Railways
Waterways
Schools
Land Use

Project Issues Aesthetic/Visual; Agricultural Land; Air Quality; Biological Resources; Archaeologic-Historic; Geologic/Seismic; Toxic/Hazardous; Water Quality; Landuse; Other Issues; Minerals; Noise; Population/Housing Balance; Public Services; Recreation/Parks; Economics/Jobs; Traffic/Circulation

Reviewing Agencies Resources Agency; Department of Conservation; Central Valley Flood Protection Board; Office of Historic Preservation; Department of Parks and Recreation; Department of Water Resources; Department of Fish and Game, Region 2; Office of Emergency Management Agency, California; Native American Heritage Commission; State Lands Commission; Caltrans, District 3; State Water Resources Control Board, Division of Water Quality; Regional Water Quality Control Bd., Region 5 (Sacramento); Regional Water Quality Control Bd., Region 5 (Redding)

Date Received 05/20/2011 **Start of Review** 05/20/2011 **End of Review** 06/20/2011

County: [illegible] SCH# [illegible]

ources Agency

Resources Agency
Nadell Gayou

Dept. of Boating & Waterways
Mike Sotelo

California Coastal Commission
Elizabeth A. Fuchs

Colorado River Board
Gerald R. Zimmerman

Dept. of Conservation
Rebecca Salazar

California Energy Commission
Eric Knight

Cal Fire
Allen Robertson

Central Valley Flood Protection Board
James Herota

Office of Historic Preservation
Ron Parsons

Dept of Parks & Recreation
Environmental Stewardship Section

California Department of Resources, Recycling & Recovery
Sue O'Leary

S.F. Bay Conservation & Dev't. Comm.
Steve McAdam

Dept. of Water Resources
Resources Agency
Nadell Gayou

Conservancy

and Game

Depart. of Fish & Game
Scott Flint
Environmental Services Division

Fish & Game Region 1
Donald Koch

- [ ] **Fish & Game Region 1E**
  Laurie Harnsberger
- [x] **Fish & Game Region 2**
  Jeff Drongesen
- [ ] **Fish & Game Region 3**
  Charles Armor
- [ ] **Fish & Game Region 4**
  Julie Vance
- [ ] **Fish & Game Region 5**
  Don Chadwick
  Habitat Conservation Program
- [ ] **Fish & Game Region 6**
  Gabrina Gatchel
  Habitat Conservation Program
- [ ] **Fish & Game Region 6 I/M**
  Brad Henderson
  Inyo/Mono, Habitat Conservation Program
- [ ] **Dept. of Fish & Game M**
  George Isaac
  Marine Region

Other Departments

- [ ] **Food & Agriculture**
  Steve Shaffer
  Dept. of Food and Agriculture
- [ ] **Depart. of General Services**
  Public School Construction
- [ ] **Dept. of General Services**
  Anna Garbeff
  Environmental Services Section
- [ ] **Dept. of Public Health**
  Bridgette Binning
  Dept. of Health/Drinking Water

Independent Commissions,Boards

- [ ] **Delta Protection Commission**
  Linda Flack
- [x] **Cal EMA (Emergency Management Agency)**
  Dennis Castrillo
- [ ] **Governor's Office of Planning & Research**
  State Clearinghouse
- [x] **Native American Heritage Comm.**
  Debbie Treadway
- [ ] **Public Utilities Commission**
  Leo Wong
- [ ] **Santa Monica Bay Restoration**
  Guangyu Wang
- [x] **State Lands Commission**
  Marina Brand
- [ ] **Tahoe Regional Planning Agency (TRPA)**
  Cherry Jacques

Business, Trans & Housing

- [ ] **Caltrans - Division of Aeronautics**
  Philip Crimmins
- [ ] **Caltrans - Planning**
  Terri Pencovic
- [ ] **California Highway Patrol**
  Scott Loetscher
  Office of Special Projects
- [ ] **Housing & Community Development**
  CEQA Coordinator
  Housing Policy Division

Dept. of Transportation

- [ ] **Caltrans, District 1**
  Rex Jackman
- [ ] **Caltrans, District 2**
  Marcelino Gonzalez
- [x] **Caltrans, District 3**
  Bruce de Terra
- [ ] **Caltrans, District 4**
  Lisa Carboni
- [ ] **Caltrans, District 5**
  David Murray
- [ ] **Caltrans, District 6**
  Michael Navarro
- [ ] **Caltrans, District 7**
  Elmer Alvarez
- [ ] **Caltrans, District 8**
  Dan Kopulsky
- [ ] **Caltrans, District 9**
  Gayle Rosander
- [ ] **Caltrans, District 10**
  Tom Dumas
- [ ] **Caltrans, District 11**
  Jacob Armstrong
- [ ] **Caltrans, District 12**
  Chris Herre

Cal EPA

Air Resources Board

- [ ] Airport Projects
  Jim Lerner
  - [ ] Transportation Projects
    Douglas Ito
  - [ ] Industrial Projects
    Mike Tollstrup
- [ ] **State Water Resources Control Board**
  Regional Programs Unit
  Division of Financial Assistance
- [x] **State Water Resources Control Board**
  Student Intern, 401 Water Quality Certification Unit
  Division of Water Quality
- [ ] **State Water Resouces Control Board**
  Steven Herrera
  Division of Water Rights
- [ ] **Dept. of Toxic Substances Control**
  CEQA Tracking Center
- [ ] **Department of Pesticide Regulation**
  CEQA Coordinator

Regional Water Quality Control Board (RWQCB)

- [ ] **RWQCB 1**
  Cathleen Hudson
  North Coast Region (1)
- [ ] **RWQCB 2**
  Environmental Document Coordinator
  San Francisco Bay Region (2)
- [ ] **RWQCB 3**
  Central Coast Region (3)
- [ ] **RWQCB 4**
  Teresa Rodgers
  Los Angeles Region (4)
- [x] **RWQCB 5S**
  Central Valley Region (5)
  - [ ] **RWQCB 5F**
    Central Valley Region (5)
    Fresno Branch Office
  - [x] **RWQCB 5R**
    Central Valley Region (5)
    Redding Branch Office
- [ ] **RWQCB 6**
  Lahontan Region (6)
  - [ ] **RWQCB 6V**
    Lahontan Region (6)
    Victorville Branch Office
- [ ] **RWQCB 7**
  Colorado River Basin Region (7)
- [ ] **RWQCB 8**
  Santa Ana Region (8)
- [ ] **RWQCB 9**
  San Diego Region (9)

- [ ] **Other** _____

Last Updated on 01/10/11

POLICY JUSTIFICATION

Kingdom of Saudi Arabia – Night Vision Equipment

The Government of the Kingdom of Saudi Arabia has requested a possible sale of 200 High-performance In-Line Sniper Sight (HISS) Thermal Weapon Sights - 1500 meter, 200 MilCAM Recon III LocatIR Long Range, Light Weight Thermal Binoculars with Geo Location, 7,000 Dual Beam Aiming Lasers (DBAL A2), 6000 AN/PVS-21 Low Profile Night Vision Goggles (LPNVG), spare and repair parts, support equipment, technical documentation and publications, translation services, training, U. S. government and contractor technical and logistics support services, and other related elements of logistical and program support. The estimated cost is $330 million.

This proposed sale will contribute to the foreign policy and national security of the United States by helping to improve the security of a friendly country which has been, and continues to be, an important force for political stability and economic progress in the Middle East.

The proposed sale will augment Saudi Arabia's capability to meet current and future threats from potential adversaries during operations conducted at night and during low visibility conditions. The Royal Saudi Land Forces (RSLF) are responsible for regional, perimeter, and border security operations. This proposed sale meets their defense and counter-terrorism requirements to deter current insurgent activity along their southern border and contributes to their overall military posture. The RSLF already has night vision devices in its inventory and will have no difficulty absorbing this night vision equipment into its inventory.

The proposed sale of this equipment will not alter the basic military balance in the region.

The prime contractors will be FLIR Inc. in Boston, Massachusetts and Laser Devices, Inc. in Monterey, California. There are no known offset agreements proposed in connection with this potential sale.

Implementation of this sale will not require the assignment of any U.S. Government or contractor representatives to recipient.

There will be no adverse impact on U.S. defense readiness as a result of this proposed sale.

[FR Doc. 2011–12405 Filed 5–19–11; 8:45 am]
BILLING CODE 5001–06–C

DEPARTMENT OF DEFENSE

Department of the Army; Corps of Engineers

Notice of Intent To Prepare Draft Environmental Impact Statements/ Environmental Impact Reports for the Sutter Basin Feasibility Study and the Section 408 Permission for the Feather River West Levee Project, Sutter and Butte Counties, CA

AGENCY: Department of the Army, U.S. Army Corps of Engineers; DoD.

ACTION: Notice of intent.

SUMMARY: Pursuant to the National Environmental Policy Act of 1969, as amended, and the California Environmental Quality Act (CEQA), the U.S. Army Corps of Engineers (USACE) intends to prepare a separate Environmental Impact Statement/ Environmental Impact Report (EIS/EIR) for each of the following related flood risk management study efforts in north-central California: a Feasibility Study of flood risk management and related water resources problems in the Sutter Basin conducted by USACE under the authority of the Flood Control Act of 1962 (Pub. L. 87–874); and under Section 14 of the Rivers and Harbors Act

of 1899 (as amended) (33 U.S.C. 408), and Section 404 of the Clean Water Act (33 U.S.C. 1344), the proposed Feather River West Levee Project (FRWLP), sponsored by the Sutter Butte Flood Control Agency (SBFCA) as a locally driven flood management improvement project. The two projects are being studied in close coordination because they partially overlap in their study areas, purpose, potential improvements, potential effects, and involved parties. Therefore, a joint scoping process is being conducted for the two projects to explain the relationship between the two efforts and obtain public input in a manner that is convenient, efficient, and integrated. Figures of the two project areas can be viewed at the SBFCA *Web site at: http://www.sutterbutteflood.org/index.php/notices_documents.*

Sutter Basin Feasibility Study. On March 20, 2000, the State of California entered into a feasibility cost-sharing agreement (FCSA) with USACE to initiate a feasibility study. An amendment to the FCSA was signed in 2010, which included SBFCA as a non-Federal sponsor. The purpose of the study is to address flood risk, ecosystem restoration and recreation-related issues in the study area. If a Federal interest is determined, the study would result in a decision document, a General Investigation Feasibility Study report and EIS/EIR, which would be the basis for a recommendation to Congress for authorization. The Central Valley Flood Protection Board (CVFPB) and SBFCA are coordinating with USACE on the feasibility study. USACE, as the Federal lead agency under NEPA, and SBFCA, as the state lead agency under CEQA in coordination with CVFPB, have determined that an EIS/EIR will be prepared to describe alternatives, potential environmental effects, and mitigation measures.

FRWLP. SBFCA is planning the FRWLP to construct improvements to the west levee of the Feather River from Thermalito Afterbay to the Sutter Bypass confluence to meet Federal, state, and local flood protection criteria and goals. In 2010, an assessment district was enacted to provide local funding toward flood management improvements. These funds may be matched with those from the Early Implementation Program (funded through previous state bonds) administered by the California Department of Water Resources (DWR). In order to implement the project, the sponsor must acquire permission from USACE to alter the Federal project under Section 14 of the Rivers and Harbors Act of 1899 (as amended) (33 U.S.C. 408 or, Section 408). USACE also has authority under Section 404 of the Clean Water Act (33 U.S.C. 1344) over activities involving the discharge of dredged or fill material to waters of the United States, which are known to be in the project area. The purpose of the FRWLP would be to construct improvements as quickly as possible in advance of and compatible with the Sutter Basin Project. USACE, acting as the Federal lead agency under NEPA, and SBFCA, acting as the state lead agency under the CEQA in coordination with CVFPB, have determined that an EIS/EIR will be prepared to describe alternatives, potential environmental effects, and mitigation measures.

DATES: Public scoping meetings will be held on Monday, June 27 at 3:30 p.m. and 6:30 p.m. at the Veterans Memorial Community Building, 1425 Veterans Memorial Circle, Yuba City, CA and on Tuesday, June 28 at 3:30 p.m. and 6:30 p.m. at the Veterans Memorial Hall, 245 Sycamore Street, Gridley, CA. Send written comments by July 8, 2011 (see **ADDRESSES**).

ADDRESSES: Written comments and suggestions concerning the scope and content of the environmental information may be submitted to Mr. Matt Davis, U.S. Army Corps of Engineers, Sacramento District, Attn: Planning Division (CESPK–PD–R), 1325 J Street, Sacramento, CA 95814. Requests to be placed on the mailing list also should be sent to this address.

FOR FURTHER INFORMATION CONTACT: Questions about the proposed actions and environmental review process should be addressed to Matt Davis at (916) 557–6708, *e-mail: Matthew.G.Davis@usace.army.mil* (see **ADDRESSES**).

SUPPLEMENTARY INFORMATION:

1. *Proposed Action. Sutter Basin Feasibility Study.* USACE is conducting a feasibility study to evaluate structural and non-structural flood-risk-management measures, including re-operation of existing reservoirs; improvements to existing levees; construction of new levees; and other storage, conveyance, and non-structural options. The Sutter Basin study area covers approximately 285 square miles and is roughly bounded by the Feather River, Sutter Bypass, Wadsworth Canal, Sutter Buttes, and Cherokee Canal. Flood waters potentially threatening the study area originate from the Feather River watershed and/or the upper Sacramento River watershed, above Colusa Weir. The study area is essentially encircled by project levees and the high ground of Sutter Buttes. Geotechnical analysis and historical performance during past floods indicates the project levees are at risk of failure due to underseepage. The risk of levee failure coupled with the consequence of deep flooding presents a threat to public safety and property. Considering the collective changes to riparian and aquatic ecosystems brought about by agriculture, urbanization, mining, and flood risk management and water supply infrastructure, and the national concern for environmental quality and protection, every opportunity to restore and protect natural resources should be taken whenever changes in the water management system are being contemplated. Ecosystem restoration measures likely would include restoration of floodplain function and habitat. Recreation measures include those outdoor recreation opportunities associated with sustainable water resource development. The feasibility phase of this project is cost-shared 50% Federal, 50% non-Federal with the project sponsors, the State of California CVFPB and the SBFCA. The study will focus on alternatives in the study area that comprise flood risk management, ecosystem restoration, and recreation management measures. As part of the study, an EIS/EIR will be prepared with USACE as the lead agency under NEPA and SBFCA in cooperation with CVFPB as the lead agency under CEQA.

FRWLP. SBFCA is proposing a levee improvement project along the Feather River west levee under the California DWR's Early Implementation Program to expeditiously complete flood-risk reduction measures in advance of the Sutter Basin Feasibility Study. Known as the FRWLP, the project proposes to construct levee improvements between the Thermalito Afterbay and the Feather River/Sutter Bypass confluence. Primary deficiencies of the levee include through-seepage, under-seepage, and embankment instability (*e.g.,* overly steepened slopes). Alternatives considered may include measures such as slurry cutoff walls, seepage berms, stability berms, internal drains, relief wells, sheet-pile walls, slope flattening, and potential new levee alignments. As part of the project, an EIS/EIR is being prepared. USACE has authority under Section 14 of the Rivers and Harbors Act of 1899 (as amended) (33 U.S.C. 408), over alterations to Federal flood control project levees and any such alterations as proposed by SBFCA are subject to approval by USACE. USACE also has authority under Section 404 of the Clean Water Act (33 U.S.C. 1344) over activities involving the discharge of dredged or fill material to waters of the United States, which are known to be in

the project area. Due to these authorities, USACE is acting as the lead agency for the EIS pursuant to NEPA. SBFCA will be acting as the lead agency for the EIR according to CEQA as an agency of the State of California with delegated authority to approve the project.

2. *Alternatives.* The EIS/EIRs will consider several alternatives for reducing flood damage. Alternatives analyzed during the investigation will consist of a combination of one or more measures to reduce the risk of flooding. These measures include installing cutoff walls, and constructing seepage berms.

3. *Scoping Process.*

a. A series of public scoping meetings will be held on June 27 and 28, 2011, to present information to the public and to receive comments from the public on both the feasibility study and the FRWLP. These meetings are intended to initiate the process to involve concerned individuals, and local, state, and Federal agencies.

b. Significant issues to be analyzed in depth in the environmental documents include effects on hydraulics, wetlands and other waters of the U.S., vegetation and wildlife resources, special-status species, aesthetics, cultural resources, recreation, land use, fisheries, water quality, air quality, transportation, and socioeconomics; and cumulative effects of related projects in the study area.

c. USACE is consulting with the State Historic Preservation Officer to comply with the National Historic Preservation Act and with the U.S. Fish and Wildlife Service and National Marine Fisheries Service to comply with the Endangered Species Act. USACE also is coordinating with the U.S. Fish and Wildlife Service to comply with the Fish and Wildlife Coordination Act.

d. A 45-day public review period will be provided for individuals and agencies to review and comment on the draft environmental documents. All interested parties are encouraged to respond to this notice and provide a current address if they wish to be notified of the draft EIS/EIR circulation.

4. *Availability.* The draft EIS/EIR for the FRWLP is scheduled to be available for public review and comment in late 2011. The draft EIS/EIR for the Sutter Basin Feasibility Study is scheduled to be available for public review and comment in mid 2012.

Dated: May 12, 2011.

Andrew B. Kiger,

LTC, EN, Commanding.

[FR Doc. 2011–12510 Filed 5–19–11; 8:45 am]

BILLING CODE 3720–58–P

DEPARTMENT OF DEFENSE

Department of the Army; Corps of Engineers

Notice of Availability of the Final Programmatic Environmental Impact Statement for the Mechanical and Artificial Creation and Maintenance of Emergent Sandbar Habitat in the Riverine Segments of the Upper Missouri River, Missouri River Basin, United States

AGENCY: Department of the Army, U.S. Army Corps of Engineers, DoD.

ACTION: Notice of Availability.

SUMMARY: In accordance with the National Environmental Policy Act of 1969, as amended, the U.S. Army Corps of Engineers intends to file a Final Programmatic Environmental Impact Statement (FPEIS) for the Mechanical and Artificial Creation and Maintenance of Emergent Sandbar Habitat on the Riverine Segments of the Upper Missouri River with the U.S. Environmental Protection Agency. The FEIS is available for final public review. Details on the proposed action, location and areas of environmental concern addressed in the FPEIS are provided below under **SUPPLEMENTARY INFORMATION.**

DATES: The review period will be open 30 days from the date of this notice. The Record of Decision is anticipated to be issued in August, 2011.

ADDRESSES: Written comments should be sent to: Department of the Army; Corps of Engineers, Omaha District; CENWO–PM–AC; ATTN: Emergent Sandbar Habitat Programmatic EIS; 1616 Capitol Avenue; Omaha, NE 68102–4901, or e-mailed to: *Cynthia.s.upah@usace.army.mil.* Comments must be postmarked, e-mailed, or otherwise submitted no later than June 13, 2011. Copies of the FPEIS have been sent to all agencies and individuals who participated in the scoping process or public hearings and to those requesting copies. The FEIS is available online at: *http://www.moriverrecovery.org/mrrp/MRRP_PUB_DEV.download_documentation_peis.* To obtain a copy, please contact Ms. Cynthia Upah.

FOR FURTHER INFORMATION CONTACT: Ms. Cynthia Upah, Project Manager, by telephone: (402) 995–2672, by mail: 1616 Capitol Avenue, Omaha, NE 68102–4901, or by e-mail: *Cynthia.s.upah@usace.army.mil.* For inquires from the media, please contact the USACE Omaha District Public Affairs Officer (PAO), Ms. Monique Farmer by telephone: (402) 995–2416, by mail: 1616 Capitol Avenue, Omaha, NE 68102, or by e-mail: *Monique.l.farmer@usace.army.mil.*

SUPPLEMENTARY INFORMATION: 1. *Background.* The Emergent Sandbar Habitat (ESH) program is being implemented by the U.S. Army Corps of Engineers (Corps) for the benefit of the interior population of the Interior least tern (least tern) and the northern Great Plains piping plover (piping plover). This implementation program resulted from a Biological Opinion (BiOp) issued by the U.S. Fish and Wildlife Service (USFWS) in which the Reasonable and Prudent Alternative (RPA) called for the Corps to provide sufficient ESH acreage in order to meet biological metrics (fledge ratios) to avoid jeopardizing continued existence of the species, as defined by the Endangered Species Act (ESA).

The FPEIS is needed to provide National Environmental Policy Act (NEPA) coverage for the mechanical and artificial construction of ESH in the riverine segments of the Upper Missouri River, pursuant to the 2003 BiOp Amendment RPA IV(b) 3, and to compare impacts among a range of alternatives. The goal is to inform the selection of a preferred alternative that allows for the creation and replacement of sufficient habitat to support tern and plover populations on the Missouri River in a safe, efficient and cost-effective manner that minimizes negative environmental consequences.

Alternatives to the proposed project that are considered in the FPEIS include (1) no action, including existing program activities and no action; (2) and 6 action alternatives of various acreage creation. Environmental issues addressed in the FPEIS include hydrology, water quality, aggradation and degradation, biological resources, air quality, noise and recreation.

After detailed consideration of the environmental and social impacts, and cumulative effects, of the Alternatives, the Corps has identified an Adaptive Management Implementation Process (AMIP) as the preferred alternative, and not one of the specific acreage alternatives. The key aspect of the AMIP is that, rather than selecting a specific acreage alternative and pursuing such construction, actions would be progressively implemented with the focus on monitoring a combination of biological and physical metrics (measurements). Implementation of progressively larger acreage amounts of habitat would continue until the desired biological response is attained and sustained.

Join Us To Learn More About Local Flood Risk Reduction Efforts

Join the U.S. Army Corps of Engineers (USACE) and the Sutter Butte Flood Control Agency (SBFCA) for a public scoping meeting to learn about two proposed flood risk reduction efforts in Sutter and Butte counties. USACE's Sutter Basin Feasibility Study will look at potential improvements throughout the Sutter Basin, while SBFCA's Feather River West Levee Project is proposing to repair 44 miles of the river's west levee.

The public is encouraged to attend these meetings to comment on the scope of the proposed projects and the preparation of related environmental documents.

Meeting Dates & Times

June 27 at 3:30 p.m. and 6:30 p.m.
Veterans Memorial Community Building
1425 Veterans Memorial Circle, Yuba City

June 28 at 3:30 p.m. and 6:30 p.m.
Gridley Veterans Memorial Hall
249 Sycamore Street, Gridley

A presentation will begin 30 minutes after the start of each meeting. The same information will be presented at each meeting.

If you have questions or need special assistance or accommodations at a meeting, call 916-231-9618 at least 72 hours in advance of the meeting you plan to attend.

US Army Corps of Engineers, Sacramento District

www.sutterbutteflood.org • www.spk.usace.army.mil

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US Army Corps of Engineers.
Sacramento District

www.sutterbutteflood.org • www.spk.usace.army.mil

FOR IMMEDIATE RELEASE
CONTACT: INGRID NORGAARD
EMAIL: inorgaard@icfi.com
PHONE: 916-737-3000

Agencies Hosting Public Meetings Related to Proposed Flood Improvements in Sutter and Butte Counties

The public is invited to attend to provide input on environmental process

Yuba City, June 22, 2011—The U.S. Army Corps of Engineers' (USACE) Sacramento District and the Sutter Butte Flood Control Agency (SBFCA) will hold four public scoping meetings on June 27 and 28 to provide the public an opportunity to comment on proposed regional flood risk management projects.

The purpose of the USACE's Sutter Basin Project is to address flood risk management, ecosystem restoration, and recreation issues in the Sutter Basin study area. The project is currently in the feasibility study phase. The study area covers approximately 285 square miles and is roughly bounded by the Feather River, Sutter Bypass, Wadsworth Canal, Sutter Buttes and Cherokee Canal.

SBFCA is planning the Feather River West Levee Project (FRWLP) to address levee deficiencies found along 44 miles of the west levee of the Feather River from the Thermalito Afterbay south to the Sutter Bypass. The west levee provides flood risk management benefits to the cities of Yuba City, Gridley, Live Oak, and Biggs and portions of unincorporated areas of Butte and Sutter counties. Measures are being evaluated to meet Federal, state, and local flood protection criteria and goals.

The Sutter Basin Project and FRWLP are being studied in close coordination because of related study areas, purpose, potential measures and potential effects. It is anticipated that two separate environmental impact statements/environmental impact reports (EIS/EIR) will be developed—one for the Sutter Basin Project and one for FRWLP. The public release of the draft EIS/EIR to evaluate FRWLP is scheduled for early 2012. The release of the Sutter Basin Project's draft EIS/EIR has yet to be determined. The California Department of Water Resources and Central Valley Flood Protection Board are also involved in these two efforts.

Combined and coordinated scoping for the two efforts is being conducted to ensure an efficient process for interested stakeholders. Public input will be solicited about the content of the environmental documents. Please join us at one of four scoping meetings to provide input.

City of Yuba City
June 27 at 3:30 p.m. *and* 6:30 p.m.
Veteran's Memorial Community Bldg.
1425 Veterans Memorial Circle,
Yuba City

City of Gridley
June 28 at 3:30 p.m. *and* 6:30 p.m.
Gridley Veteran's Memorial Hall
249 Sycamore Street, Gridley

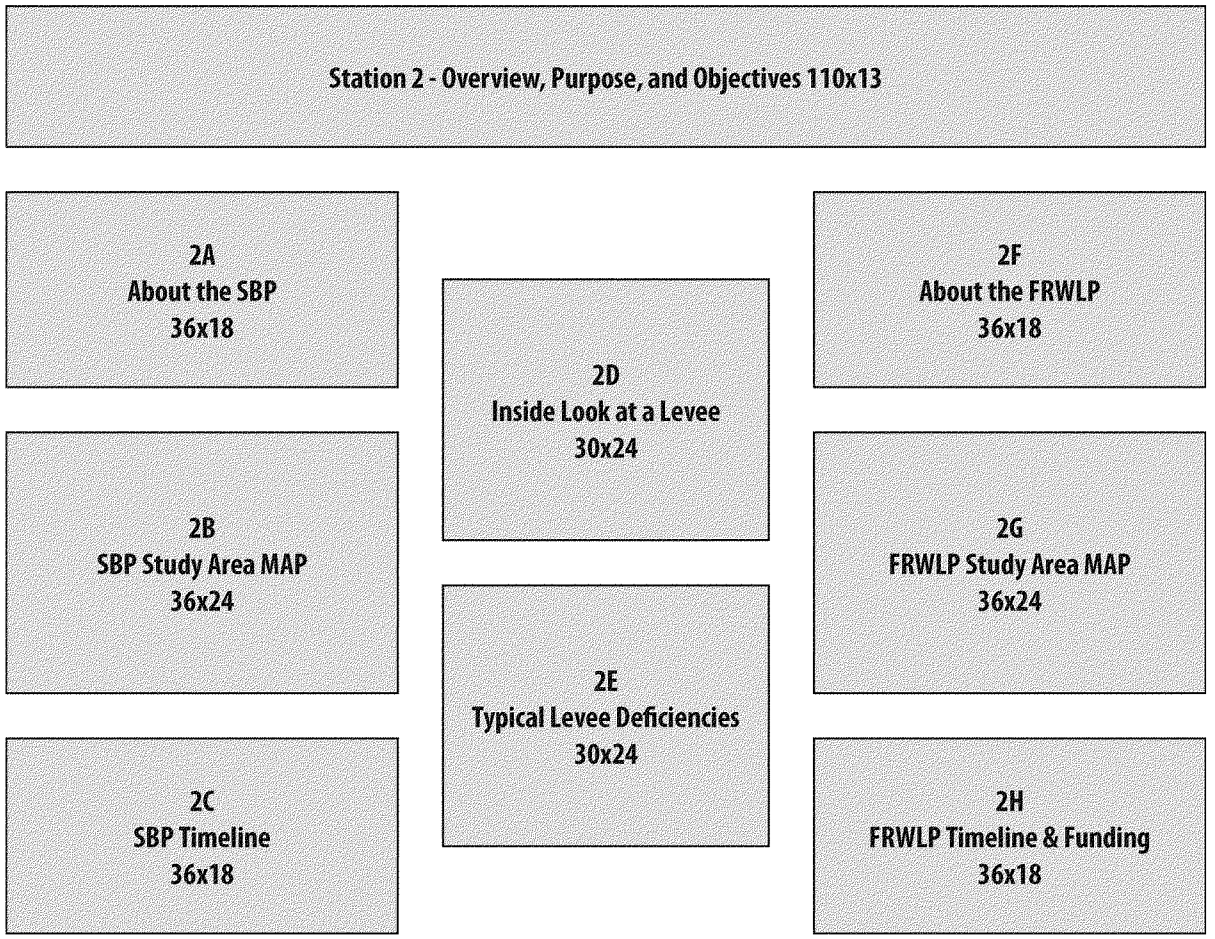
-MORE-

A presentation will be given 30 minutes after each meeting begins. The content of all four meetings will be the same. For questions about the meetings or to make special accommodations for attendees, contact Ms. Norgaard at 916-737-3000 or via email at inorgaard@icfi.com.

Learn more about the Sutter Basin Project at www.spk.usace.army.mil and about the FRWLP at www.sutterbutteflood.org.

###

- Display boards
- Power Point presentation
- Fact sheet
- Comment card templates


Station 2 - Overview, Purpose, and Objectives 110x13
2A
About the SBP
36x18
2B
SBP Study Area MAP
36x24
2C
SBP Timeline
36x18
2D
Inside Look at a Levee
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2E
Typical Levee Deficiencies
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2F
About the FRWLP
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2G
FRWLP Study Area MAP
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2H
FRWLP Timeline & Funding
36x18

Station 3 - Potential Measures 110x13
3A
Slurry Wall
25x20
3B
Stability Berm
25x20
3C
Seepage Berm
25x20
3D
Relief Well
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3E
Sheet-Pile Wall
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Slope Flattening
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3G
Internal Drain
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New/Relocated Levee
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Re-Operation
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Station 4 - Environmental Process 110x13
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About NEPA/CEQA
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Regulatory Compliance
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SBP Photo
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4F
FRWLP Photo
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Welcome to the Sutter Basin Project & Feather River West Levee Project Environmental Scoping Meeting

US Army Corps of Engineers
Sacramento District

Overview, Purpose, and Objectives

About the Sutter Basin Project

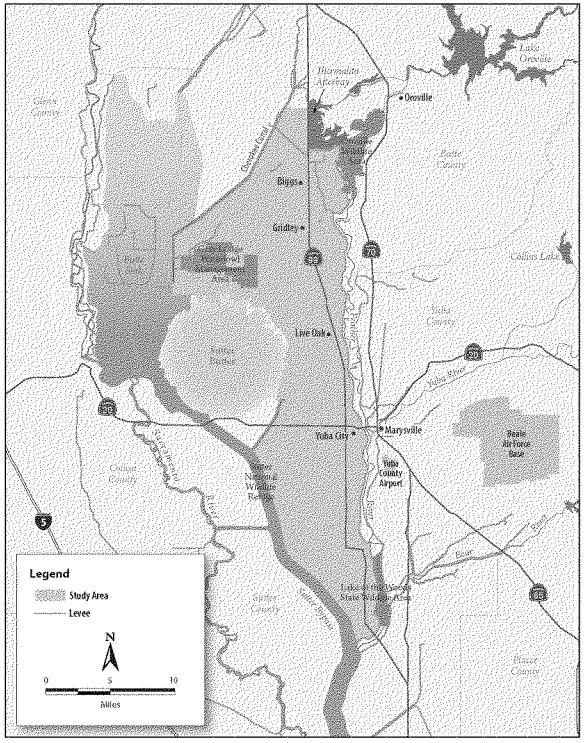
In 2000, the State of California and USACE entered into a cost-sharing agreement to initiate a feasibility study within the Sutter Basin. An amendment of the cost-sharing agreement was signed in July 2010 to include SBFCA as a non-Federal sponsor. The purpose of the feasibility study is to address flood risk management, ecosystem restoration, and recreation issues in the study area.

The Sutter Basin Project feasibility study evaluates approximately 285 square miles that are roughly bounded by the Feather River, Sutter Bypass, Wadsworth Canal, Sutter Buttes, and Cherokee Canal. The study area is essentially encircled by project levees and the high ground of the Sutter Buttes. Past flood events and geotechnical analysis show these levees have a higher probability of failure related to through-and under-seepage than levees designed to meet current standards. Additionally, the levees are at risk of overtopping from floods greater than they are designed to withstand.

As part of the Sutter Basin Project feasibility study, USACE is evaluating a variety of flood risk management measures that could include re-operation of reservoirs; improvements to existing levees; construction of new levees; other storage, conveyance, and non-structural options; and measures that could potentially restore the ecosystem within the study area and develop or expand recreation facilities.

This study will be the basis for a recommendation to Congress to address water resources and related issues within the study area.

Sutter Basin Project Area

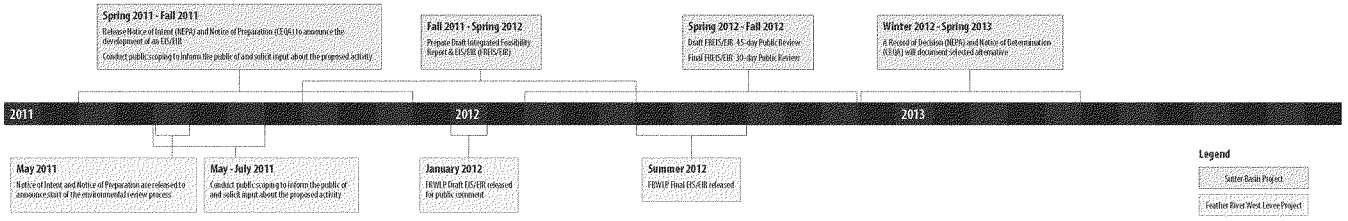


Sutter Basin Project Funding and Timeline

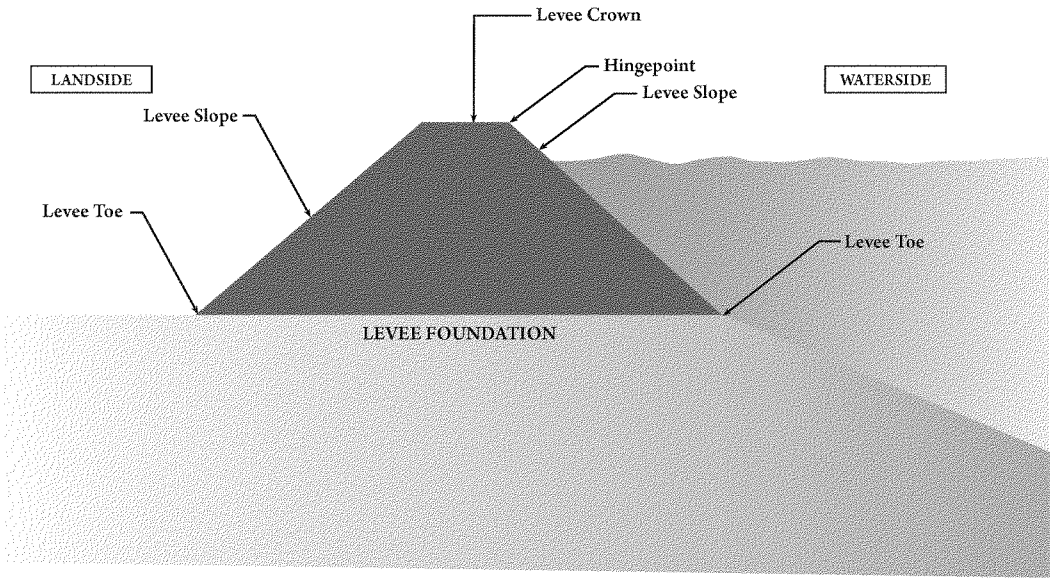
Funding

The feasibility study phase of this project is cost-shared; USACE will fund 50% and SBFCA and the State of California will fund the remaining 50% of the project.

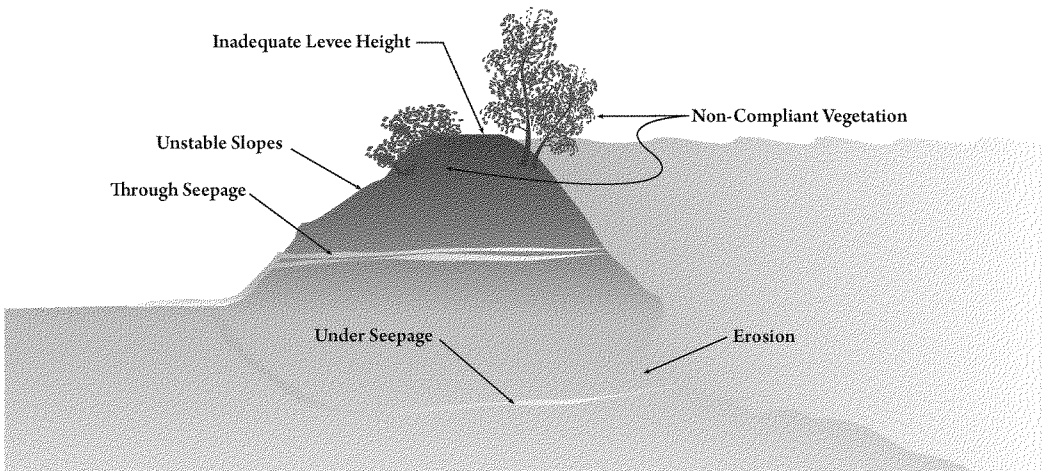
Timeline



An "Inside" Look at a Levee



Typical Levee Deficiencies



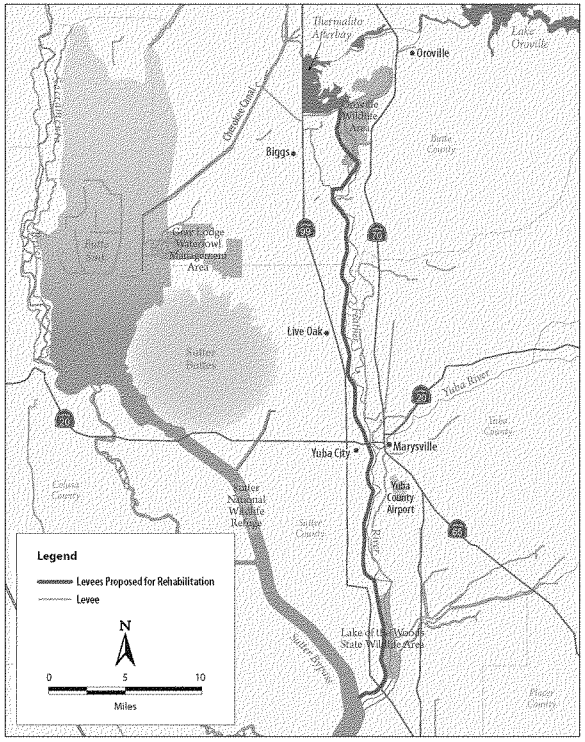
- Unstable Slopes - irregular or overly steep slopes compromise the levee structure
- Inadequate levee height - levee height may be too low relative to predicted water levels
- Non-Compliant Vegetation - can lead to levee instability and hinder levee monitoring and maintenance
- Erosion - water flow, wakes and waves, remove soil material, damaging the levee
- Seepage

About the Feather River West Levee Project

Communities in both Butte and Sutter Counties have an unfortunate historical knowledge of devastating flood events within the region. Sutter Butte Flood Control Agency (SBFCA) is planning the Feather River West Levee Project (FRWLP) to address levee deficiencies found along 44 miles of the west levee of the Feather River from the Thermalito Afterbay south to the Sutter Bypass. Measures are being evaluated to meet Federal, state, and local flood protection criteria and goals. The FRWLP is expected to:

- Increase public safety by providing 200-year flood protection from Yuba City north to the Thermalito Afterbay, and the appropriate level of flood protection south of Yuba City (in conjunction with repairs to the Sutter Bypass, which are the responsibility of the state).
- Save property owners millions of dollars annually in flood insurance costs by delaying, preventing, or cutting short FEMA floodplain mapping.
- Allow cities and counties to implement general plans, which will soon be restricted for any urban or urbanizing community without 200-year flood protection. This would not apply to areas with fewer than 10,000 residents.
- Sustain and grow the local economy by creating construction jobs, protecting property values, and allowing for responsible development.

Feather River West Levee Project Area



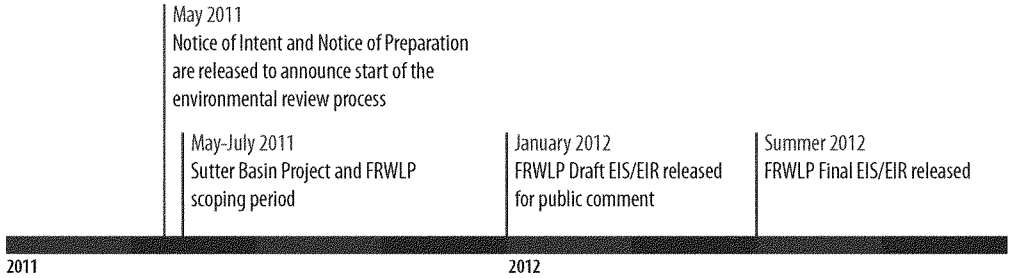
Feather River West Levee Project Funding and Timeline

Funding

The FRWLP is estimated at $250 million for construction. A local assessment district enacted in 2010 will pay 29% of the project cost and the State of California is expected to pay the remaining share.

Timeline

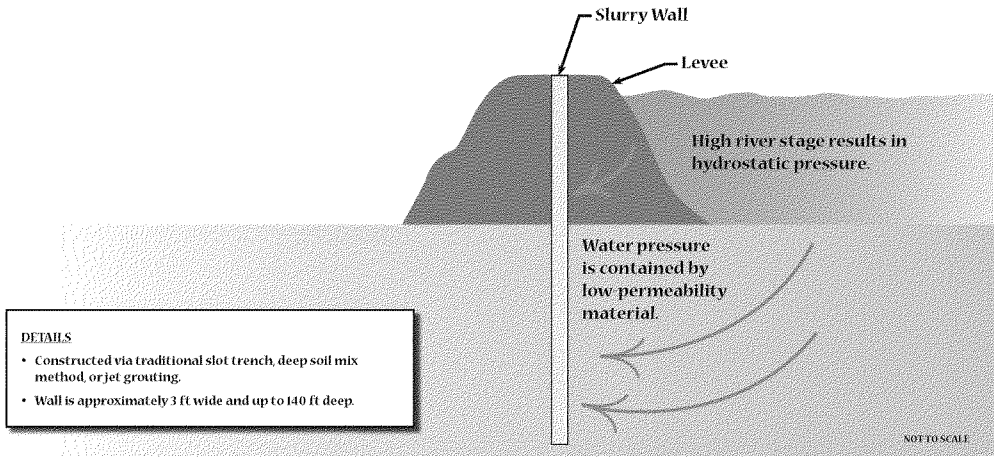
Environmental specialists are currently analyzing the effects the FRWLP could have if implemented, to comply with the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA). This analysis will help engineers finalize the project design, and request Federal and state permits. The goal is to construct the FRWLP as quickly as possible in advance of and compatible with the Sutter Basin Project, potentially beginning construction in 2013.



Potential Measures

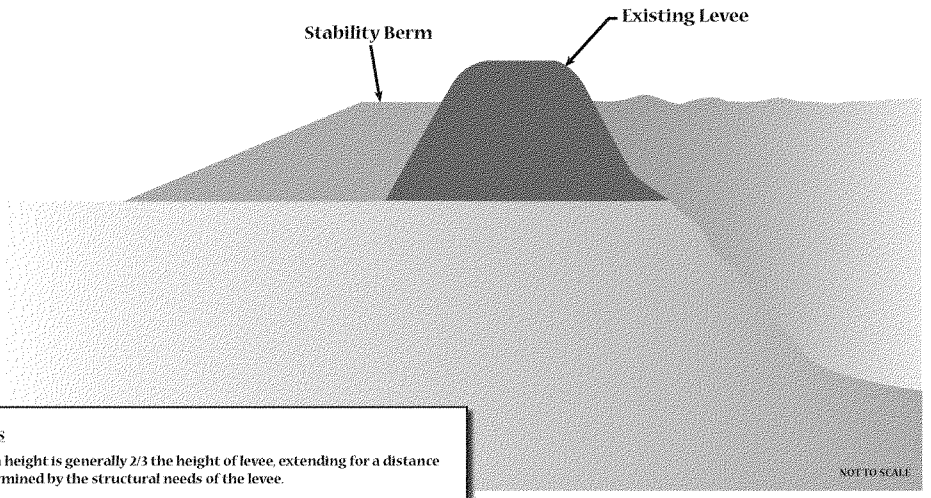
Slurry Cut-off Wall

Concept:
Water-seepage and through-seepage
are controlled by a low-permeability wall
constructed within the levee cross section.



Stability Berm

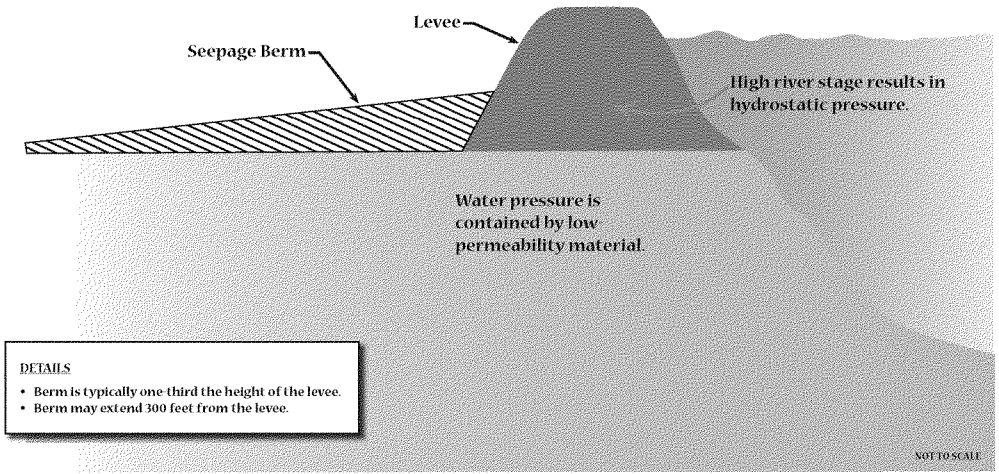
Concept:
Provides additional support to levee
to increase strength.



2073

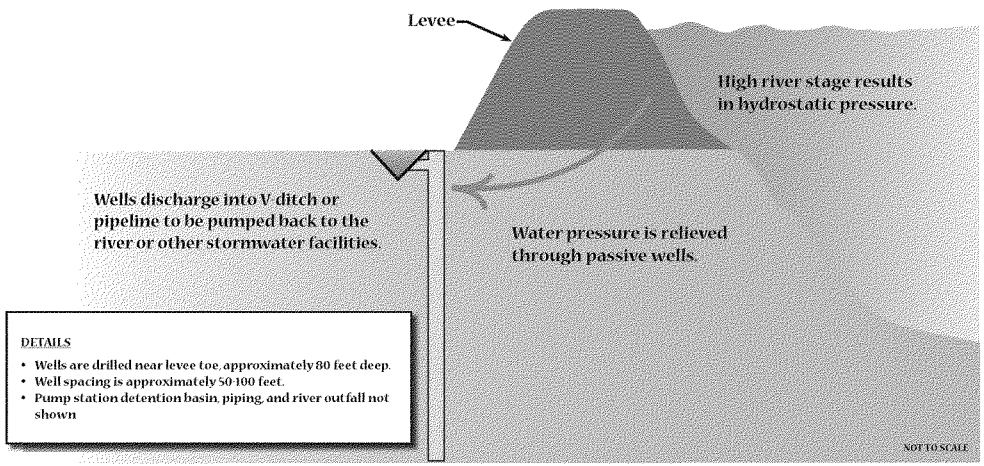
Seepage Berm

Concept:
Water pressure is contained and dispersed by a thickened soil layer.



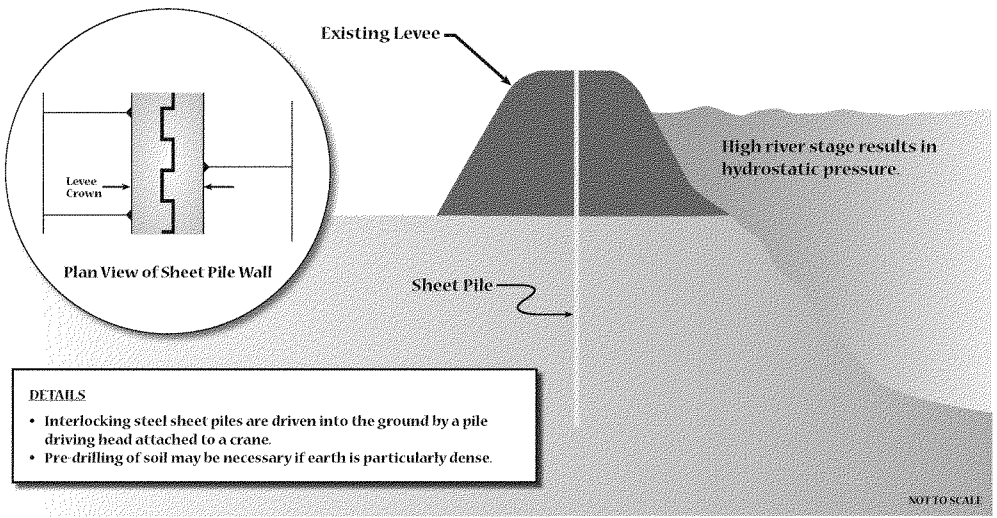
Relief Well

Concept:
Water pressure is relieved via passive wells, which direct water discharge into a collection system.



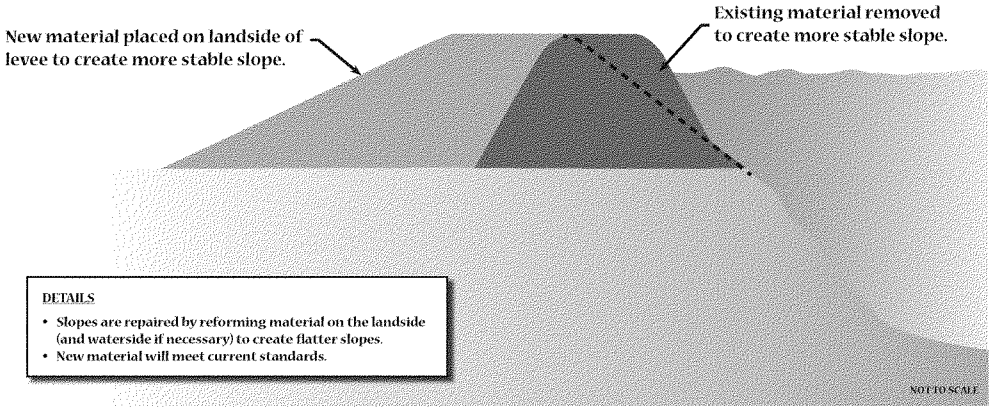
Sheet Pile Wall

Concept:
Steel panels are driven into the levee core to provide a seepage barrier.



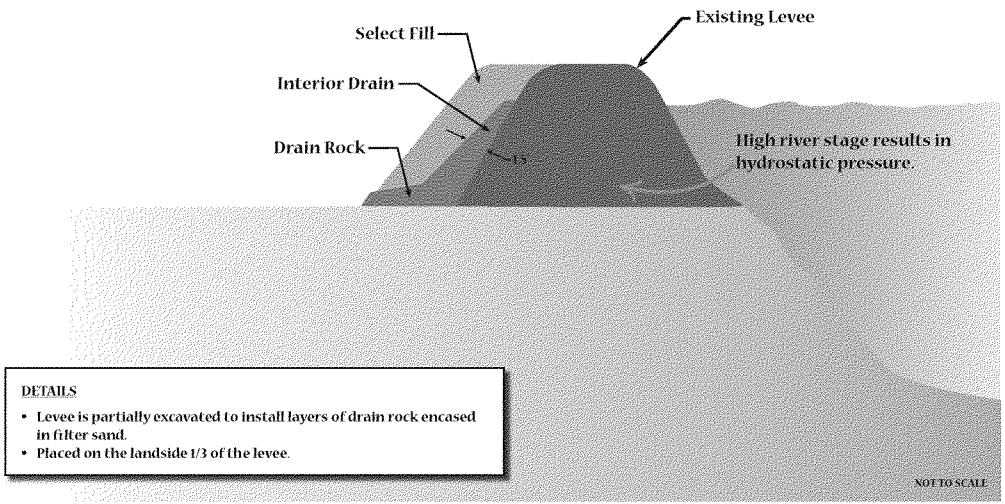
Slope Flattening

Concept:
Flatter slopes are more stable and less susceptible to erosion.



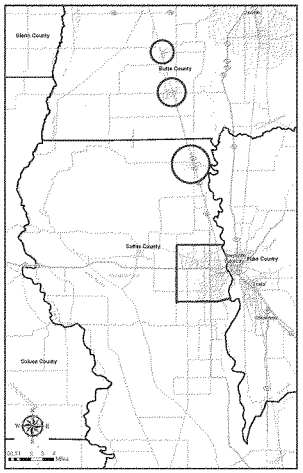
Internal Drain

Concept:
Capture any through-seepage and
direct it away from the face of the levee.

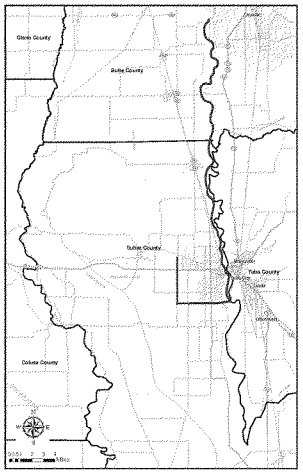


New Levee Location

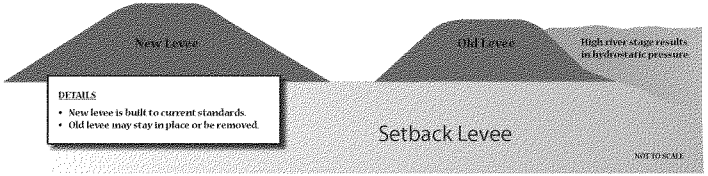
Concept:
A new levee is built where the existing levee is not readily repairable or where a change in the floodplain is an option (such as setback levees, ring levees, J-levees or similar concepts).



Ring Levees



J-Levees



Reservoir Reoperation Flood Risk Management

Reduce flood risk by improving a reservoir's ability to store peak flood flows through a variety of operational or physical modifications.

Examples:

- Reallocate storage for flood risk management purposes.
- Utilize flood forecast based operations to release storage in anticipation of a flood event.

Non-Structural Flood Risk Management

Non-structural measures reduce flood risk without significantly altering the nature or extent of the flooding. They do this by changing the use made of the floodplains, or by accommodating existing uses to the flood hazard.

Examples:

- Flood proofing
- Relocation of structures
- Flood warning/preparedness systems
- Regulation of floodplain uses

Ecosystem Restoration

Existing levees have isolated the floodplains from waterways, thereby eliminating significant floodplain habitats for native species, including Federally-listed species and other special-status species. There is potential to restore these areas in conjunction with flood risk management measures.

Examples:

- Realign levees to restore floodplains and river function
- Establish riparian/wetland habitat in conjunction with detention basins and other storage facilities
- Modify water inflow to select ponds to restore fish production and riparian/wetland habitats
- Convert nonnative habitats to native riparian/wetland habitats
- Eradicate exotic invasive plant species and establish native habitat

Recreation

An opportunity exists to create or enhance recreation features consistent with flood damage reduction and ecosystem restoration project features.

Examples:

- Multi-purpose paved trail on levee crown with access points, highway under crossings, public safety facilities, and appropriate signage
- Provide wildlife viewing platforms
- Picnic areas with associated parking and facilities
- Provide increased river access points

Environmental Process

About NEPA & CEQA

It is anticipated the Sutter Basin Project and FRWLP will result in two separate environmental impact statements/environmental impact reports (EIS/EIR)—one for each project. Both documents will disclose an activity's potential alternatives, potential effects, and proposed mitigation measures in compliance with the National Environmental Policy Act (NEPA) and California Environmental Quality Act (CEQA), respectively.

A joint EIS/EIR is prepared when there is both a Federal and state agency interest in an activity, and/or when a state agency needs permission to perform an action under Federal jurisdiction. The development of the draft joint EIS/EIR to evaluate the FRWLP is underway and scheduled for release in early 2012. The release date of USACE's draft joint EIS/EIR for the Sutter Basin Project has yet to be determined.

Scoping and Other Public Engagement

Scoping is a process used to inform the public of a proposed activity and provide an opportunity to give comment, insight, and local information related to the range of alternatives, environmental effects, and/or issues of concern related to the proposed activity.

Because the agencies are working to create two joint, albeit separate, environmental documents for these two projects, a joint scoping period is also being held. During the scoping process public input will be solicited about the scope of the environmental documents and the agencies will communicate with the public about the two efforts.

Scoping is particularly informative in a flood risk management project because the citizens of the effected community could have insight into the performance of a levee that the agencies are unaware of (think locations of under-seepage or boils or areas of general poor levee performance).

The comments received from public scoping will be used to inform development of the alternatives; defining the environment and resources potentially affected by the alternatives; and analysis of effects resulting from the alternatives. The affected environment broadly includes physical, biological, and social topic areas. Effects are identified and analyzed both for project construction and long-term operations and maintenance.

Potential Environmental Issues

The effect of a proposed activity on natural and built resources will be evaluated in the environmental documents for the Sutter Basin Project and the FRWLP. Resources analyzed in the EIS/EIRs will include, but are not limited to:

- Transportation and Navigation
- Vegetation and Wetlands
- Socioeconomics and Environmental Justice
- Wildlife
- Fisheries and Aquatics
- Cultural Resources
- Air Quality, GHG and Climate Change
- Public Health and Environmental Hazards
- Land Use and Agriculture

Other Regulatory Compliance

USACE and SBFCA will need to comply with several regulations to complete the environmental process. Those could include:

Section 404: Establishes regulation of discharges of pollutants

- USACE grants 404 permits. The compliance mechanism is an Individual Permit, including 404(b)(1) alternatives analysis to identify least environmentally damaging practicable alternative (LEDPA)

Section 401: Requires certification that the project will not adversely affect water quality

- Administered by State of California through the Regional Water Quality Control Board

Rivers and Harbors Act

- Section 14 of the Rivers and Harbors Act requires permission from USACE for alterations to Federal flood control projects
  - More commonly referred to as Section 408

Endangered Species Act

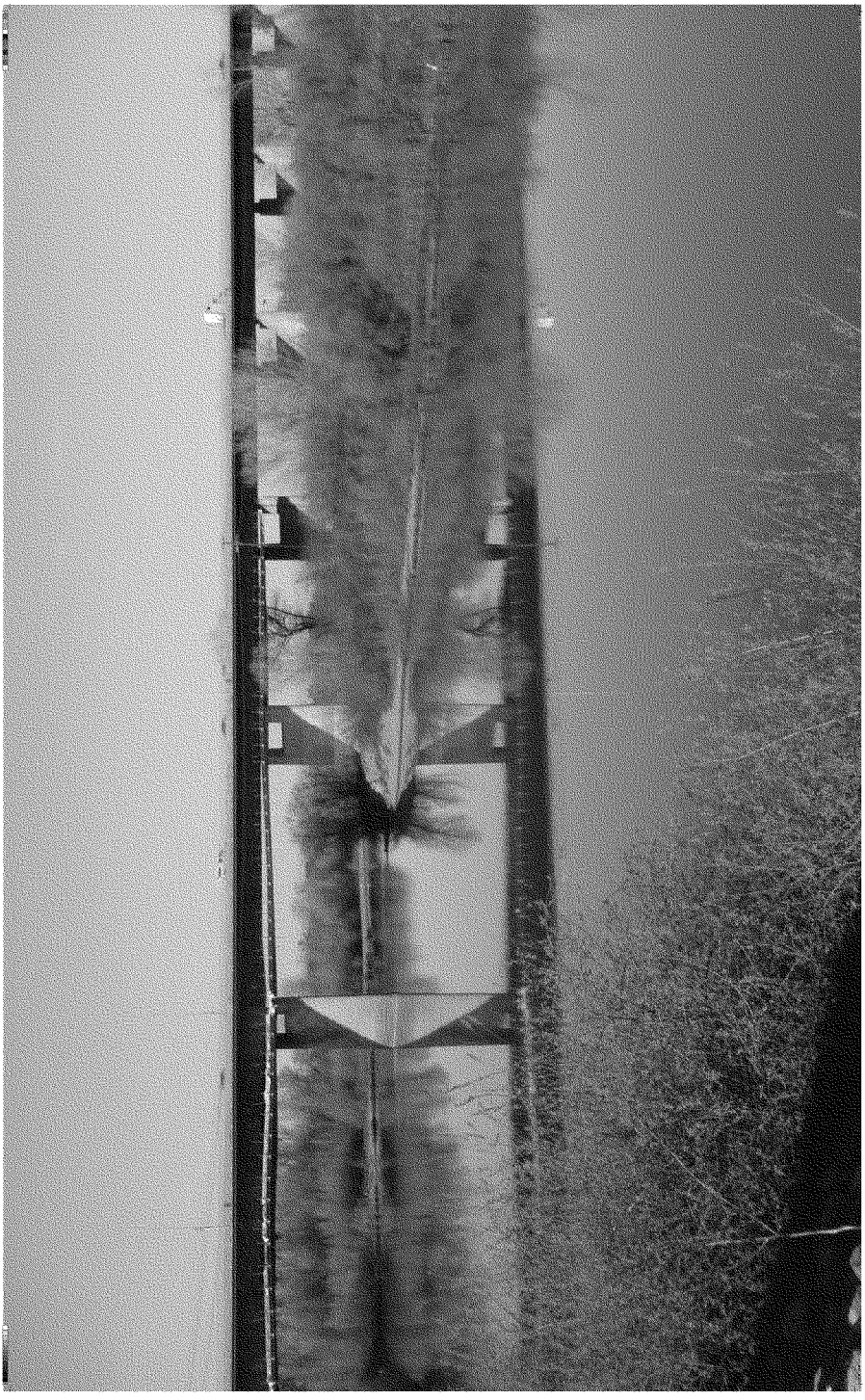
- Purpose is to protect species and the ecosystems upon which they depend
- Administered by two Federal agencies: NMFS and USFWS
- Section 7 requires Federal agencies to ensure any action authorized, funded, or carried out is not likely to jeopardize the continued existence of a listed species or modify their habitat
- If a listed species may be present, the agency must conduct a biological assessment (BA)
  - Analyzes the potential effects of the project on listed species and critical habitat
- NMFS/USFWS then determines a need for a biological opinion (BO) or letter of concurrence

National Historic Preservation Act

- Section 106: Requires consideration of resources eligible or potentially eligible for the National Register of Historic Places
  - Administered by California State Historic Preservation Officer (SHPO)

Fish and Game Code

- Section 1600 et seq.: Work on the waterside of the levee will require Streambed Alteration Agreement
- Section 2050 et seq.: Potential effects on listed species will require demonstration that effects have been fully mitigated or incidental take permit



Thank you for your interest in these two public safety projects. Please provide us with your input on the scope of the projects and the environmental analysis here.

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Sacramento District

2091

Welcome to the

SUTTER BASIN PROJECT FEASIBILITY STUDY
&
FEATHER RIVER WEST LEVEE PROJECT

PUBLIC SCOPING MEETING

JUNE 27 & 28, 2011

US Army Corps
of Engineers
Sacramento District

2092

PRESENTATION OUTLINE

1. Coordinated Flood Management Efforts
2. How Did We Get Here?
3. A Closer Look at Each Project
4. The Environmental Process

2093

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Coordinated Flood Management Efforts

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SUTTER BASIN PROJECT FEASIBILITY STUDY

- Led by U.S. Army Corps of Engineers (USACE)
- Initiated in 2001
- Purpose is to evaluate a Federal interest in flood risk management, ecosystem restoration, and recreation projects in study area
- Coordinating with Sutter Butte Flood Control Agency (SBFCA), Central Valley Flood Protection Board (CVFPB), and California Department of Water Resources (DWR)

2005

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FEATHER RIVER WEST LEVEE PROJECT (FRWLP)

- Led by local agency SBFCA
- Initiated upon approval of annual property assessment in 2010
- Purpose is to address levee deficiencies in the Feather River's west levee from Thermalito Afterbay to Sutter Bypass
- Construction start targeted for 2013
- SBFCA is coordinating with USACE, CVFPB, and DWR

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A JOINT APPROACH

- Studied in coordination due to similar study areas, purpose, potential improvements, effects, and parties involved
- Separate but coordinated EIS/EIRs will be developed for each project
- USACE is NEPA lead and SBFCA is CEQA lead agency for environmental process, jointly coordinating with CVFPB and DWR

2097

How Did We Get Here?

2098

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A Brief Local History

- Before 1850, the Feather and Sacramento Rivers overflowed their banks in high-water periods every few years
- Sediment from hydraulic mining in the mid-1800s caused river beds to rise
- Levees were consequently privately constructed in late 1800s and early 1900s to combat primarily overtopping
- Levees were improved and incorporated under the Sacramento River Flood Control Project by USACE in early 1900s

A Brief Local History (cont.)

- Oroville Dam and Reservoir were completed in 1967, adding substantial flood storage
- New Bullards Bar Dam and Reservoir completed in 1970, adding substantial flood storage
- Flood risk is still present, with major events
- In 1955, breach on Feather River near Shanghai Bend (38 people killed)
- In 1986, break on Yuba River and slump on Sutter Bypass
- In 1997, breaches on Feather River and Sutter Bypass

Recent Flood Management Efforts

- Levee evaluation studies by USACE, DWR, and SBFCA have documented deficiencies in the system
- In 2010, property owners of Sutter and Butte Counties approved the formation of an assessment district to provide local funds for flood risk management

Through-seepage
High river levels lead to through-seepage in sandy soils. Through-seepage can dislocate soil material and cause sloughing and failure on the land-side of the levee slope.
Water level near flood stage
Levee
Water seepage
Sand boil
CLAY BLANKET
INTERMIXED SAND AND GRAVELS
Under-seepage
High river levels lead to under-seepage through sandy and gravelly soils. An area of high water pressure beneath the clay blanket at the land-side levee toe can cause water seepage and sand boils.
SILTS AND SANDS

A Closer Look at Each Project

SUTTER BASIN PROJECT FEASIBILITY STUDY: STUDY AREA

- Study area encompasses ~284 sq. miles and is nearly encircled by Federal Project levees
- Includes portions of Sutter and Butte Counties
- About 44 miles long and 9 miles wide
- Feather River to the east and the Cherokee Canal, Wadsworth Canal, Sutter Buttes, and Sutter Bypass to the west

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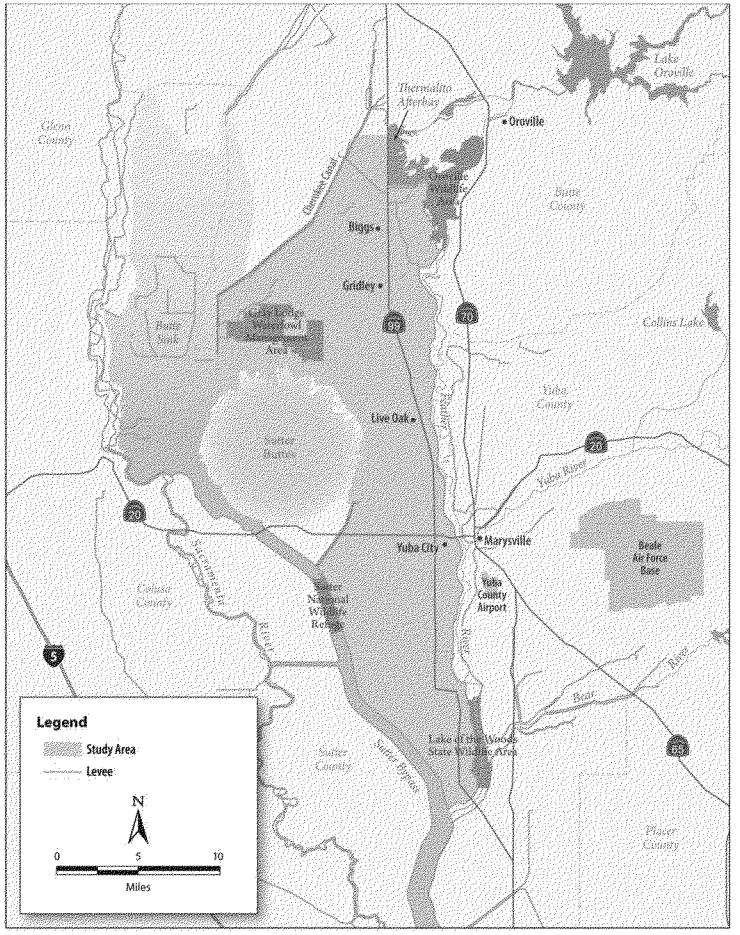
Sutter Basin Project Study Area



SUTTER BASIN PROJECT FEASIBILITY STUDY: PROBLEMS AND POTENTIAL MEASURES

- Levees are at risk due to under- and through-seepage and overtopping
- Study will evaluate measures including: re-operation of reservoirs, improvements to existing levees, building new levees, and other storage & conveyance options
- Ecosystem restoration would include restoration of floodplain function and habitat

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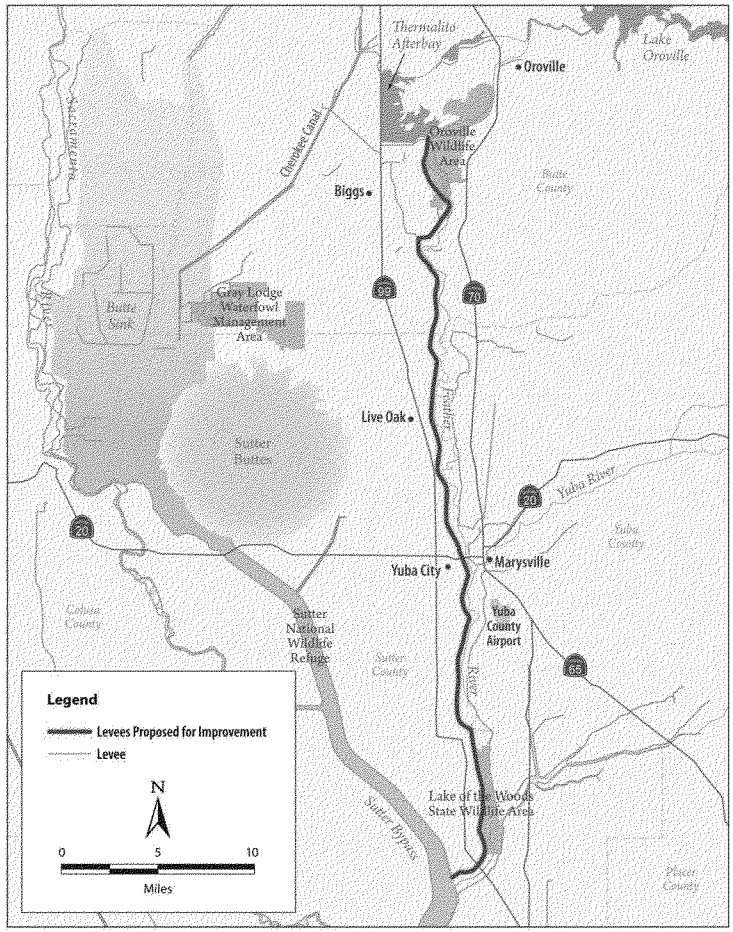
SUTTER BASIN PROJECT FEASIBILITY STUDY: POTENTIAL ALTERNATIVES & FUNDING

- Potential alternatives include those that comprise flood risk management, ecosystem restoration, and recreation measures
- Funding for the feasibility study phase only is cost-shared, 50% Federal (USACE) and 50% non-Federal (SBFCA and CVFPB)

Feather River West Levee Project: Study Area

- Will improve 44-miles of levees from the Thermalito Afterbay to the Sutter Bypass
- Provides flood risk management benefits to Live Oak, Biggs, Gridley, and Yuba City and unincorporated areas

FEATHER RIVER WEST LEVEE PROJECT STUDY AREA



Feather River West Levee Project: Problems and Potential Measures

- Primary deficiencies include through-seepage and under-seepage
- Measures may include slurry walls, seepage berms, stability berms, internal drains, relief wells, sheet-pile walls, slope flattening, and new levee alignments

Feather River West Levee Project: Funding

- The project cost is estimated at $300 million
- The state is expected to pay as much as 76% of project costs
- Locals (within assessment district) will pay the remaining share through annual assessment (anticipated to be in effect for 33 years)

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THE ENVIRONMENTAL PROCESS

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NEPA & CEQA

- NEPA (Federal) and CEQA (state) are both processes that require:
  - Analysis and disclosure of an activity's potential effect on the natural and built environments
  - Identification of alternatives and mitigation measures to reduce effects
- Processes may necessitate an EIS and EIR depending on potential effects (type and degree)

JOINT EIS/EIR

- Prepared when there is both a Federal and state agency interest in an activity, and/or
- When a state lead agency needs permission to perform an action under Federal jurisdiction (Section 408 permission & Section 404 permit)
- Agencies partner to analyze effects in a joint EIS/EIR and disclose an activity's potential effects

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WHAT IS *SCOPING*?

- Scoping is a process used to inform the public of the proposed activity and provide an opportunity to give input on the range of alternatives, potential environmental effects, and any issues of concern related to the proposed activity

SCOPING PERIOD

- May 20, 2011 to July 8, 2011
- Comments will be accepted via e-mail, fax, and USPS
- Comments must be postmarked, faxed, or time-stamped (email) before or on July 8, 2011

WAYS TO COMMENT

- Via E-mail
- Facsimile
- Via U.S. Postal Service
- Today via written comment (see comment cards)
- Provide oral comments to court reporter

CONTACT INFORMATION

Mail or E-mail comments to:

Matt Davis
U.S Army Corps of Engineers
1325 J Street
Sacramento, CA 95814

Phone: 916-557-6708
Fax: 916-557-7856

Matthew.G.Davis@usace. army.mil

Ingrid Norgaard
Sutter Butte Flood Control Agency
c/o ICF International
630 K Street, Suite 400
Sacramento, CA 95814

Phone: 916-737-3000
Fax: 916-737-3030

inorgaard@icfi.com

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Sacramento District

THANK YOU FOR ATTENDING

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Coordinated Environmental Analysis

It is anticipated the Sutter Basin Project and FRWLP will result in two separate environmental impact statements/environmental impact reports (EIS/EIR)—one for each project. Both documents will disclose alternatives, potential effects, and proposed mitigation measures in compliance with the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA), respectively. A joint EIS/EIR is prepared when there is both a Federal and state agency interest in an activity, and/or when a state agency needs permission to perform an action under Federal jurisdiction.

Development of the draft EIS/EIR to evaluate the FRWLP is underway and scheduled for public release in early 2012. A public release date for the Sutter Basin Project draft EIS/EIR has yet to be determined.

The Scoping Process

USACE and SBFCA are working together to combine and coordinate this public scoping process for their two separate environmental documents.

Scoping is a process in which agencies inform the public of a proposed activity and provide an opportunity for public input on the range of alternatives, environmental effects, and issues of concern related to the proposed activity. It also allows agencies to gather insights and local information from the public related to the activity.

Comments received from this public scoping period will be used to inform development of the alternatives; define the environment and resources potentially affected by the alternatives; and analyze effects resulting from the alternatives. The affected environment broadly includes physical, biological, and social topic areas. Effects will be identified and analyzed both for project construction and long-term operations and maintenance. The scoping period is from May 20, 2011 to July 8, 2011.

For more information on these efforts, visit www.spk.usace.army.mil or www.sutterbutteflood.org.

6/23/11

Sutter Basin Project and Feather River West Levee Project

The U.S. Army Corps of Engineers (USACE) and the Sutter Butte Flood Control Agency (SBFCA), in coordination with the California Department of Water Resources (DWR) and the California Central Valley Flood Protection Board (CVFPB), are undertaking two related efforts to study flood risk management measures in Sutter and Butte Counties. USACE is leading a feasibility study for the Sutter Basin Project to determine Federal interest in flood risk management in conjunction with other related purposes in the Sutter Basin study area, while SBFCA is leading the Feather River West Levee Project (FRWLP) to address deficiencies in 44 miles along the west levee of the Feather River.

USACE and SBFCA are studying these two projects in close coordination because they are related in their study areas, purpose, potential measures, and potential effects.

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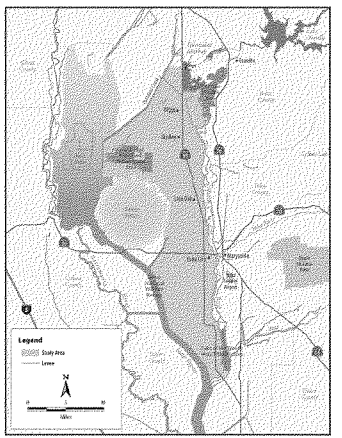
2120

A Closer Look at the Two Projects

The Sutter Basin Project Feasibility Study

In 2000, the State of California and USACE entered into a cost-sharing agreement to initiate a feasibility study within the Sutter Basin. An amendment of the cost-sharing agreement was signed in July 2010 to include SBFCA as a non-Federal sponsor. The purpose of the feasibility study is to address flood risk management, ecosystem restoration, and recreation issues in the study area.

The Sutter Basin Project feasibility study evaluates approximately 285 square miles that are roughly bounded by the Feather River, Sutter Bypass, Wadsworth Canal, Sutter Buttes, and Cherokee Canal. The study area is essentially encircled by project levees and the high ground of the Sutter Buttes. Past flood events and geotechnical analysis show these levees have a higher probability of failure related to through-and under-seepage than levees designed to meet current standards. Additionally, the levees are at risk of overtopping from floods greater than they are designed to withstand.

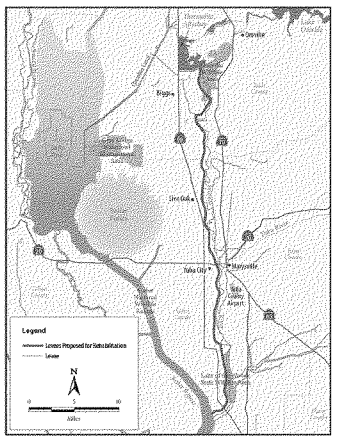


As part of the Sutter Basin Project feasibility study, USACE is evaluating a variety of flood risk management measures that could include re-operation of reservoirs; improvements to existing levees; construction of new levees; other storage, conveyance, and non-structural options; and measures that could potentially restore the ecosystem within the study area and develop or expand recreation facilities. This study will be the basis for a recommendation to Congress to address water resources and related issues within the study area. The feasibility study phase of this project is cost-shared: USACE will fund 50%, and SBFCA and the State of California will fund the remaining 50%.

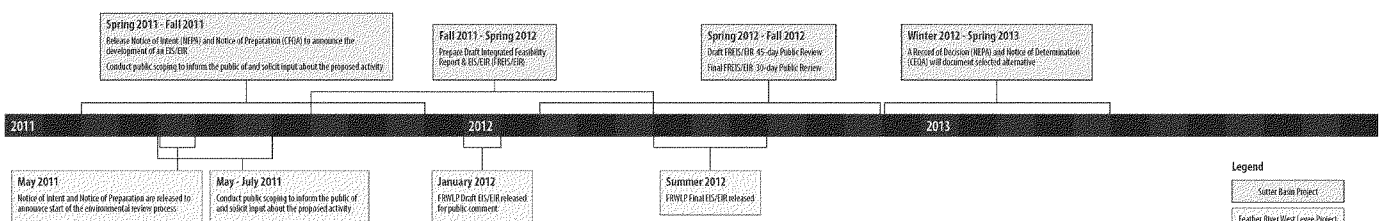
The Feather River West Levee Project

SBFCA is planning the FRWLP to address levee deficiencies found along 44 miles of the Feather River's west levee from the Thermalito Afterbay south to the Sutter Bypass. The west levee provides flood risk management benefits to the cities of Yuba City, Gridley, Live Oak, and Biggs, and portions of Butte and Sutter Counties. Measures are being evaluated to meet Federal, state, and local flood protection criteria and goals.

The west levee is at risk of failure from through- and under-seepage and from overtopping caused by floods greater than the levee is designed to withstand. Alternatives to repair these deficiencies could include slurry walls, seepage berms, stability berms, internal drains, relief wells, sheet-pile walls, slope flattening, and new levee alignments. The goal is to construct the FRWLP as quickly as possible, in advance of and compatible with the Sutter Basin Project, potentially in 2013.



Environmental Review Process Timeline for the Sutter Basin Project and FRWLP



Sutter Basin Project & Feather River West Levee Project

US Army Corps of Engineers
Sacramento District

June 27, 2011 Scoping Meeting Comment Card

Date:_____

Name:_____ Title:_____

Phone:_____ Fax:_____ Affiliation:_____

Email:_____ Street Address_____

City:_____ State:_____ Zip:_____

☐ Please add me to the mailing list to receive future updates.

Thank you for attending the Sutter Basin Project and Feather River West Levee Project (FRWLP) scoping meeting. Please provide your input in the space below about the content of the environmental impact statement/environmental impact report (EIS/EIR) for the Sutter Basin Project and/or for the EIS/EIR for the FRWLP. After you've written your comments in the space below, place this card in one of the designated baskets around the room or hand it to a project team member. Please write legibly.

Sutter Basin Project
& Feather River West Levee Project

US Army Corps of Engineers
Sacramento District

June 28, 2011 Scoping Meeting
Comment Card

Date:_____

Name:_____ Title:_____

Phone:_____ Fax:_____ Affiliation:_____

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Attachment C

- Comments received from all interested parties (including those transcribed by court reporter)
- Attendee sign-in sheet templates

Sutter Basin Project
& Feather River West Levee Project

US Army Corps of Engineers.
Sacramento District

June 27, 2011 Scoping Meeting
Comment Card

Date: 6/27/11

Name: Douglas Gault Title: Director of Public Works, Sutter County

Phone: Fax: Affiliation:

Email: Street Address

City: State: Zip:

☐ Please add me to the mailing list to receive future updates.

Thank you for attending the Sutter Basin Project and Feather River West Levee Project (FRWLP) scoping meeting. Please provide your input in the space below about the content of the environmental impact statement/environmental impact report (EIS/EIR) for the Sutter Basin Project and/or for the EIS/EIR for the FRWLP. After you've written your comments in the space below, place this card in one of the designated baskets around the room or hand it to a project team member. Please write legibly.

Meet Spring 2013 ~~scheduled~~ completion. of USACE Feasibility study. Do not delay. 104 certification must be issued at that time to allow state to release EIP funding for West Levee Project.

Keep the process for feasibility study on schedule.

ORIGINAL

SUTTER BASIN PROJECT FEASIBILITY STUDY & FEATHER RIVER WEST LEVEE PROJECT PUBLIC SCOPING MEETING û YUBA CITY, CA

DATE: June 27, 2011

TIME: 3:30 p.m. and 6:30 p.m.

REPORTED BY: Jillian Bassett
Certified Shorthand Reporter No. 13619

NCCR
Northern California Court Reporters
Certified Shorthand Reporters & Legal Photocopy
(916) 485-4949 ■ Fax (916) 485-1323 ■ (888) 600-NCCR
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nccr@norcalreporters.com ■ www.norcalreporters.com

STAN CLEVELAND, COUNTY SUPERVISOR:

I was told to repeat the comment I made regarding including the DWR Corridor Management Project, which is called The Lower Feather River Corridor Management Project. And there's a management group, and then there's -- I forgot what the other one is; there's two groups. And Aecom, they're the project, I guess, engineer group for that. And making sure that that is coordinated with this here. Because in that corridor of the Feather River, they're doing a lot of environmental planning and setting a foundation, or a level base, to where everybody won't have to come back and start from scratch on any of their studies -- environmental studies.

Certificate

of

Certified Shorthand Reporter

The undersigned certified shorthand reporter of the state of California does hereby certify:

That the foregoing deposition was taken before me at the time and place therein set forth, at which time the witness was duly sworn by me;

That the testimony of the witness and all objections made at the time of the examination were recorded stenographically by me and thereafter transcribed, said transcript being a true copy of my shorthand notes thereof.

In witness whereof, I have subscribed my name this date July 25 2011.

Jill Bellotti

Certificate number 13619

ORIGINAL

SUTTER BASIN PROJECT FEASIBILITY STUDY & FEATHER RIVER WEST LEVEE PROJECT PUBLIC SCOPING MEETING û GRIDLEY, CA

DATE: June 28, 2011

TIME: 3:30 p.m. and 6:30 p.m.

REPORTED BY: Jillian Bassett
Certified Shorthand Reporter No. 13619

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DAVID NEUBERT:

I live in Sutter County. I was speaking with your colleagues, and they mentioned one of the options they're looking at is a levee setback in the area of Nelson slough along Sacramento Avenue in Sutter County. And this would be the area between the Sacramento bypass and the Feather River, right where the Feather River enters the bypass. There's, I don't know, maybe 900,000 acres there that they could sort of cut the corner on the levee the way it exists now, and pick up 1,000 acres of floodplain.

And I'm just -- I think that's a great idea. There's -- I think there might be one house, and it's probably just a rental in that area. So you probably wouldn't have a lot of homeowners that would be hopping mad. And you'd probably pick up 10 or 15,000 acre-feet of flood storage. So it would be something, I think, that would -- engineering-wise, it would be an interesting levee setback to look at.

So the other thing that I think that as a resident of Sutter County, and I live in the LD-1 area -- I'm not sure if LD-1 has the capacity -- management capacity to pull something like that off. You know, maybe setting up something like

trilla (phonetic) like they did in Yuba County. Or maybe this super agency, the Sutter Butte Agency, could do it.

But I just -- I just don't think management capacity, or I should say the planning capacity of the board level -- I think the management, the managers of LD-1 are fine. But the board, I don't think, has vision for projects like this. So hopefully they do.

RICHARD KUCEK:

I guess it goes back to the building of the levee was our first project for the taxpayers to protect everybody from flooding. Okay. They knew after '55 when they finished the levee and had to break in Yuba City, that that wouldn't solve the problem. So they took -- and I wouldn't say they use -- it had scare tactic. But they got the taxpayers to fund another project which was get the dam at Lake Oroville. And the state of California, at that time, from what I understand, did not have enough money to build it. But the taxpayers voted it in, so it went on their tax board. But Southern California funded most of the money for building that in return for surplus water out at the lake.

And somewhere down the line it got turned around that I guess the water's worth more than the people in the houses. So they keep the lake elevation too high. But if they would keep it down, we would never need these projects that they're proposing today, which would be the third ones the taxpayers are going to pay for just for protection.

And like, the slurry would be the right way to fix this right now. If they went with the berm, that would cause a lot of problems, because there would be

maintenance, and they can't maintain the levees that there are right now. You can go out there and look at it; kids drive up and down on it, there's gophers and squirrels on it and everything else. And they don't spray it. They don't kill the weeds. They don't do nothing. So if they do, I guess that setback levee, that wouldn't cause a lot more problems on the east side of it, and then what do you do with that? Because you got to be in the floodplain. But the berm, to me, would be too expensive to keep in 33 years.

So I don't know how they got as far as they did with this project. But it should never happen because the taxpayers shouldn't have to pay three times for flood protection.

So I don't know. I guess we'll just go to the meetings and see how it comes out and, you know, if they're going to do all this, and Southern California has the right to all that water, why don't they pay the bills? I mean, why should we have to pay it? If they want to keep that lake full enough so it enables us from flooding, they should have to pay the bill if it does flood. Not raise our taxes and everything else, and our flood insurance, and they get all the water, and we got the bill.

BOB BARKHOUSE:

Two concerns I have is the east levee of the Sutter bypass, because, in my lifetime, on the west side -- I've had to live through two floods -- farmland on the other side -- major floods. Those levees on the west side -- east side are no better than west side, yet we're trying to contain the overflow from the Sacramento River between bypass. And we certainly are subject to flooding if the right condition --

And then my second concern was the maps continuously show a perimeter levee around Yuba City, or a J levee on the south and west side. And I'm concerned about building a levee around Yuba City and putting the city of Yuba City in the same parallel as the city of Marysville. Although Marysville has never flooded, but it's always -- the bowl is likely to fill up someday, and it would be a catastrophe.

But I am concerned about that part. They have a strong levee on the Feather River, and let that take care of itself. So that was my two concerns.

Certificate

of

Certified Shorthand Reporter

The undersigned certified shorthand reporter of the state of California does hereby certify:

That the foregoing deposition was taken before me at the time and place therein set forth, at which time the witness was duly sworn by me;

That the testimony of the witness and all objections made at the time of the examination were recorded stenographically by me and thereafter transcribed, said transcript being a true copy of my shorthand notes thereof.

In witness whereof, I have subscribed my name this date July 25 2011.

Jill Bassett

Certificate number 13419

Sutter Basin Project & Feather River West Levee Project

June 27, 2011 Scoping Meeting

Sign-in Sheet

US Army Corps of Engineers
Sacramento District

Name	Title	Affiliation	Street Address	City	Zip Code	How did you hear about the meeting?

Sutter Basin Project & Feather River West Levee Project

June 28, 2011 Scoping Meeting

Sign-in Sheet

US Army Corps of Engineers
Sacramento District

Name	Title	Affiliation	Street Address	City	Zip Code	How did you hear about the meeting?

Road Construction Emissions Model, Version 6.3.2

Emission Estimates for -> Contract A Project Phases (English Units)	ROG (lbs/day)	CO (lbs/day)	NOx (lbs/day)	Total PM10 (lbs/day)	Exhaust PM10 (lbs/day)	Fugitive Dust PM10 (lbs/day)	Total PM2.5 (lbs/day)	Exhaust PM2.5 (lbs/day)	Fugitive Dust PM2.5 (lbs/day)	CO2 (lbs/day)
Grubbing/Land Clearing	14.3	80.4	117.7	9.7	4.7	5.0	5.1	4.1	1.0	19,633.2
Grading/Excavation	53.2	321.2	419.5	20.8	15.8	5.0	15.0	13.9	1.0	67,500.9
Drainage/Utilities/Sub-Grade	11.8	67.9	93.9	9.0	4.0	5.0	4.5	3.5	1.0	16,672.6
Paving	9.3	57.0	70.6	3.3	3.3	-	2.8	2.8	-	13,616.9
Maximum (pounds/day)	53.2	321.2	419.5	20.8	15.8	5.0	15.0	13.9	1.0	67,500.9
Total (tons/construction project)	1.9	11.2	14.7	0.9	0.6	0.3	0.6	0.5	0.1	2,434.8

Notes:

Project Start Year ->	2013
Project Length (months) ->	6
Total Project Area (acres) ->	183
Maximum Area Disturbed/Day (acres) ->	1
Total Soil Imported/Exported (yd^3/day)->	3054

PM10 and PM2.5 estimates assume 50% control of fugitive dust from watering and associated dust control measures if a minimum number of water trucks are specified.

Total PM10 emissions shown in column F are the sum of exhaust and fugitive dust emissions shown in columns H and I. Total PM2.5 emissions shown in Column J are the sum of exhaust and fugitive dust emissions shown in columns K and L.

Emission Estimates for -> Contract A Project Phases (Metric Units)	ROG (kgs/day)	CO (kgs/day)	NOx (kgs/day)	Total PM10 (kgs/day)	Exhaust PM10 (kgs/day)	Fugitive Dust PM10 (kgs/day)	Total PM2.5 (kgs/day)	Exhaust PM2.5 (kgs/day)	Fugitive Dust PM2.5 (kgs/day)	CO2 (kgs/day)
Grubbing/Land Clearing	6.5	36.5	53.5	4.4	2.1	2.3	2.3	1.9	0.5	8,924.2
Grading/Excavation	24.2	146.0	190.7	9.5	7.2	2.3	6.8	6.3	0.5	30,682.2
Drainage/Utilities/Sub-Grade	5.4	30.8	42.7	4.1	1.8	2.3	2.1	1.6	0.5	7,578.5
Paving	4.2	25.9	32.1	1.5	1.5	-	1.3	1.3	-	6,189.5
Maximum (kilograms/day)	24.2	146.0	190.7	9.5	7.2	2.3	6.8	6.3	0.5	30,682.2
Total (megagrams/construction project)	1.7	10.1	13.4	0.8	0.5	0.3	0.5	0.5	0.1	2,208.5

Notes:

Project Start Year ->	2013
Project Length (months) ->	6
Total Project Area (hectares) ->	74
Maximum Area Disturbed/Day (hectares) ->	0
Total Soil Imported/Exported ($meters^3$/day)->	2335

PM10 and PM2.5 estimates assume 50% control of fugitive dust from watering and associated dust control measures if a minimum number of water trucks are specified.

Total PM10 emissions shown in column F are the sum of exhaust and fugitive dust emissions shown in columns H and I. Total PM2.5 emissions shown in Column J are the sume of exhaust and fugitive dust emissions shown in columns K and L.

Road Construction Emissions Model, Version 6.3.2

Emission Estimates for -> Contract B Project Phases (English Units)	ROG (lbs/day)	CO (lbs/day)	NOx (lbs/day)	Total PM10 (lbs/day)	Exhaust PM10 (lbs/day)	Fugitive Dust PM10 (lbs/day)	Total PM2.5 (lbs/day)	Exhaust PM2.5 (lbs/day)	Fugitive Dust PM2.5 (lbs/day)	CO2 (lbs/day)
Grubbing/Land Clearing	13.3	74.9	107.5	9.3	4.3	5.0	4.8	3.7	1.0	19,516.4
Grading/Excavation	49.2	289.3	372.3	19.1	14.1	5.0	13.4	12.4	1.0	66,559.2
Drainage/Utilities/Sub-Grade	10.9	63.1	85.5	8.7	3.7	5.0	4.2	3.2	1.0	16,555.8
Paving	8.5	52.8	64.3	3.0	3.0	-	2.5	2.5	-	13,462.0
Maximum (pounds/day)	49.2	289.3	372.3	19.1	14.1	5.0	13.4	12.4	1.0	66,559.2
Total (tons/construction project)	1.7	10.1	13.2	0.8	0.5	0.3	0.5	0.5	0.1	2,405.0

Notes:
- Project Start Year -> 2014
- Project Length (months) -> 6
- Total Project Area (acres) -> 272
- Maximum Area Disturbed/Day (acres) -> 1
- Total Soil Imported/Exported (yd^3/day)-> 2925

PM10 and PM2.5 estimates assume 50% control of fugitive dust from watering and associated dust control measures if a minimum number of water trucks are specified.

Total PM10 emissions shown in column F are the sum of exhaust and fugitive dust emissions shown in columns H and I. Total PM2.5 emissions shown in Column J are the sum of exhaust and fugitive dust emissions shown in columns K and L.

Emission Estimates for -> Contract B Project Phases (Metric Units)	ROG (kgs/day)	CO (kgs/day)	NOx (kgs/day)	Total PM10 (kgs/day)	Exhaust PM10 (kgs/day)	Fugitive Dust PM10 (kgs/day)	Total PM2.5 (kgs/day)	Exhaust PM2.5 (kgs/day)	Fugitive Dust PM2.5 (kgs/day)	CO2 (kgs/day)
Grubbing/Land Clearing	6.0	34.0	48.9	4.2	2.0	2.3	2.2	1.7	0.5	8,871.1
Grading/Excavation	22.3	131.5	169.2	8.7	6.4	2.3	6.1	5.6	0.5	30,254.2
Drainage/Utilities/Sub-Grade	5.0	28.7	38.9	4.0	1.7	2.3	1.9	1.4	0.5	7,525.4
Paving	3.9	24.0	29.2	1.4	1.4	-	1.2	1.2	-	6,119.1
Maximum (kilograms/day)	22.3	131.5	169.2	8.7	6.4	2.3	6.1	5.6	0.5	30,254.2
Total (megagrams/construction project)	1.6	9.2	11.9	0.7	0.5	0.3	0.5	0.4	0.1	2,181.4

Notes:
- Project Start Year -> 2014
- Project Length (months) -> 6
- Total Project Area (hectares) -> 110
- Maximum Area Disturbed/Day (hectares) -> 0
- Total Soil Imported/Exported ($meters^3$/day)-> 2236

PM10 and PM2.5 estimates assume 50% control of fugitive dust from watering and associated dust control measures if a minimum number of water trucks are specified.

Total PM10 emissions shown in column F are the sum of exhaust and fugitive dust emissions shown in columns H and I. Total PM2.5 emissions shown in Column J are the sume of exhaust and fugitive dust emissions shown in columns K and L.

Road Construction Emissions Model, Version 6.3.2

Emission Estimates for -> Contract C1 Project Phases (English Units)	ROG (lbs/day)	CO (lbs/day)	NOx (lbs/day)	Total PM10 (lbs/day)	Exhaust PM10 (lbs/day)	Fugitive Dust PM10 (lbs/day)	Total PM2.5 (lbs/day)	Exhaust PM2.5 (lbs/day)	Fugitive Dust PM2.5 (lbs/day)	CO2 (lbs/day)
Grubbing/Land Clearing	12.9	71.4	100.5	9.3	4.3	5.0	4.7	3.7	1.0	19,632.9
Grading/Excavation	41.1	214.6	300.0	16.6	11.6	5.0	11.3	10.2	1.0	59,060.7
Drainage/Utilities/Sub-Grade	10.4	60.2	78.9	8.6	3.6	5.0	4.1	3.1	1.0	16,672.3
Paving	8.1	50.5	59.7	3.0	3.0	-	2.5	2.5	-	13,615.6
Maximum (pounds/day)	41.1	214.6	300.0	16.6	11.6	5.0	11.3	10.2	1.0	59,060.7
Total (tons/construction project)	1.5	8.0	11.0	0.7	0.4	0.3	0.4	0.4	0.1	2,212.0

Notes:

Project Start Year ->	2015
Project Length (months) ->	6
Total Project Area (acres) ->	150
Maximum Area Disturbed/Day (acres) ->	1
Total Soil Imported/Exported (yd^3/day)->	1719

PM10 and PM2.5 estimates assume 50% control of fugitive dust from watering and associated dust control measures if a minimum number of water trucks are specified.

Total PM10 emissions shown in column F are the sum of exhaust and fugitive dust emissions shown in columns H and I. Total PM2.5 emissions shown in Column J are the sum of exhaust and fugitive dust emissions shown in columns K and L.

Emission Estimates for -> Contract C1 Project Phases (Metric Units)	ROG (kgs/day)	CO (kgs/day)	NOx (kgs/day)	Total PM10 (kgs/day)	Exhaust PM10 (kgs/day)	Fugitive Dust PM10 (kgs/day)	Total PM2.5 (kgs/day)	Exhaust PM2.5 (kgs/day)	Fugitive Dust PM2.5 (kgs/day)	CO2 (kgs/day)
Grubbing/Land Clearing	5.9	32.5	45.7	4.2	1.9	2.3	2.2	1.7	0.5	8,924.0
Grading/Excavation	18.7	97.5	136.4	7.5	5.3	2.3	5.1	4.6	0.5	26,845.8
Drainage/Utilities/Sub-Grade	4.7	27.4	35.8	3.9	1.6	2.3	1.9	1.4	0.5	7,578.3
Paving	3.7	22.9	27.1	1.3	1.3	-	1.1	1.1	-	6,188.9
Maximum (kilograms/day)	18.7	97.5	136.4	7.5	5.3	2.3	5.1	4.6	0.5	26,845.8
Total (megagrams/construction project)	1.4	7.3	10.0	0.7	0.4	0.3	0.4	0.4	0.1	2,006.3

Notes:

Project Start Year ->	2015
Project Length (months) ->	6
Total Project Area (hectares) ->	61
Maximum Area Disturbed/Day (hectares) ->	0
Total Soil Imported/Exported ($meters^3$/day)->	1314

PM10 and PM2.5 estimates assume 50% control of fugitive dust from watering and associated dust control measures if a minimum number of water trucks are specified.

Total PM10 emissions shown in column F are the sum of exhaust and fugitive dust emissions shown in columns H and I. Total PM2.5 emissions shown in Column J are the sume of exhaust and fugitive dust emissions shown in columns K and L.

Road Construction Emissions Model, Version 6.3.2

Emission Estimates for -> Contract C2 Project Phases (English Units)	ROG (lbs/day)	CO (lbs/day)	NOx (lbs/day)	Total PM10 (lbs/day)	Exhaust PM10 (lbs/day)	Fugitive Dust PM10 (lbs/day)	Total PM2.5 (lbs/day)	Exhaust PM2.5 (lbs/day)	Fugitive Dust PM2.5 (lbs/day)	CO2 (lbs/day)
Grubbing/Land Clearing	12.1	67.8	93.0	9.0	4.0	5.0	4.4	3.4	1.0	19,631.8
Grading/Excavation	40.1	216.4	279.4	15.8	10.8	5.0	10.5	9.5	1.0	61,466.5
Drainage/Utilities/Sub-Grade	9.8	57.2	73.2	8.3	3.3	5.0	3.9	2.8	1.0	16,671.2
Paving	7.6	47.9	55.9	2.8	2.8	-	2.3	2.3	-	13,614.1
Maximum (pounds/day)	40.1	216.4	279.4	15.8	10.8	5.0	10.5	9.5	1.0	61,466.5
Total (tons/construction project)	1.4	8.0	10.2	0.7	0.4	0.3	0.4	0.4	0.1	2,275.5

Notes:	
Project Start Year ->	2016
Project Length (months) ->	6
Total Project Area (acres) ->	105
Maximum Area Disturbed/Day (acres) ->	1
Total Soil Imported/Exported (yd^3/day)->	2095

PM10 and PM2.5 estimates assume 50% control of fugitive dust from watering and associated dust control measures if a minimum number of water trucks are specified.

Total PM10 emissions shown in column F are the sum of exhaust and fugitive dust emissions shown in columns H and I. Total PM2.5 emissions shown in Column J are the sum of exhaust and fugitive dust emissions shown in columns K and L.

Emission Estimates for -> Contract C2 Project Phases (Metric Units)	ROG (kgs/day)	CO (kgs/day)	NOx (kgs/day)	Total PM10 (kgs/day)	Exhaust PM10 (kgs/day)	Fugitive Dust PM10 (kgs/day)	Total PM2.5 (kgs/day)	Exhaust PM2.5 (kgs/day)	Fugitive Dust PM2.5 (kgs/day)	CO2 (kgs/day)
Grubbing/Land Clearing	5.5	30.8	42.3	4.1	1.8	2.3	2.0	1.5	0.5	8,923.5
Grading/Excavation	18.2	98.3	127.0	7.2	4.9	2.3	4.8	4.3	0.5	27,939.3
Drainage/Utilities/Sub-Grade	4.5	26.0	33.3	3.8	1.5	2.3	1.8	1.3	0.5	7,577.8
Paving	3.5	21.8	25.4	1.3	1.3	-	1.1	1.1	-	6,188.2
Maximum (kilograms/day)	18.2	98.3	127.0	7.2	4.9	2.3	4.8	4.3	0.5	27,939.3
Total (megagrams/construction project)	1.3	7.2	9.3	0.6	0.4	0.3	0.4	0.3	0.1	2,063.9

Notes:	
Project Start Year ->	2016
Project Length (months) ->	6
Total Project Area (hectares) ->	42
Maximum Area Disturbed/Day (hectares) ->	0
Total Soil Imported/Exported ($meters^3$/day)->	1602

PM10 and PM2.5 estimates assume 50% control of fugitive dust from watering and associated dust control measures if a minimum number of water trucks are specified.

Total PM10 emissions shown in column F are the sum of exhaust and fugitive dust emissions shown in columns H and I. Total PM2.5 emissions shown in Column J are the sume of exhaust and fugitive dust emissions shown in columns K and L.

Road Construction Emissions Model, Version 6.3.2

Emission Estimates for -> Contract D1 Project Phases (English Units)	ROG (lbs/day)	CO (lbs/day)	NOx (lbs/day)	Total PM10 (lbs/day)	Exhaust PM10 (lbs/day)	Fugitive Dust PM10 (lbs/day)	Total PM2.5 (lbs/day)	Exhaust PM2.5 (lbs/day)	Fugitive Dust PM2.5 (lbs/day)	CO2 (lbs/day)
Grubbing/Land Clearing	11.4	64.5	85.9	8.7	3.7	5.0	4.2	3.1	1.0	19,630.5
Grading/Excavation	36.3	185.7	247.0	14.7	9.7	5.0	9.5	8.4	1.0	60,502.7
Drainage/Utilities/Sub-Grade	9.2	54.4	67.8	8.1	3.1	5.0	3.7	2.6	1.0	16,670.0
Paving	7.2	45.4	52.3	2.6	2.6	-	2.2	2.2	-	13,612.6
Maximum (pounds/day)	36.3	185.7	247.0	14.7	9.7	5.0	9.5	8.4	1.0	60,502.7
Total (tons/construction project)	1.3	7.0	9.2	0.7	0.4	0.3	0.4	0.3	0.1	2,250.0

Notes:

Project Start Year ->	2017
Project Length (months) ->	6
Total Project Area (acres) ->	160
Maximum Area Disturbed/Day (acres) ->	1
Total Soil Imported/Exported (yd^3/day)->	1460

PM10 and PM2.5 estimates assume 50% control of fugitive dust from watering and associated dust control measures if a minimum number of water trucks are specified.

Total PM10 emissions shown in column F are the sum of exhaust and fugitive dust emissions shown in columns H and I. Total PM2.5 emissions shown in Column J are the sum of exhaust and fugitive dust emissions shown in columns K and L.

Emission Estimates for -> Contract D1 Project Phases (Metric Units)	ROG (kgs/day)	CO (kgs/day)	NOx (kgs/day)	Total PM10 (kgs/day)	Exhaust PM10 (kgs/day)	Fugitive Dust PM10 (kgs/day)	Total PM2.5 (kgs/day)	Exhaust PM2.5 (kgs/day)	Fugitive Dust PM2.5 (kgs/day)	CO2 (kgs/day)
Grubbing/Land Clearing	5.2	29.3	39.0	3.9	1.7	2.3	1.9	1.4	0.5	8,923.0
Grading/Excavation	16.5	84.4	112.3	6.7	4.4	2.3	4.3	3.8	0.5	27,501.2
Drainage/Utilities/Sub-Grade	4.2	24.7	30.8	3.7	1.4	2.3	1.7	1.2	0.5	7,577.3
Paving	3.3	20.7	23.8	1.2	1.2	-	1.0	1.0	-	6,187.5
Maximum (kilograms/day)	16.5	84.4	112.3	6.7	4.4	2.3	4.3	3.8	0.5	27,501.2
Total (megagrams/construction project)	1.2	6.4	8.3	0.6	0.3	0.3	0.3	0.3	0.1	2,040.8

Notes:

Project Start Year ->	2017
Project Length (months) ->	6
Total Project Area (hectares) ->	65
Maximum Area Disturbed/Day (hectares) ->	0
Total Soil Imported/Exported ($meters^3$/day)->	1116

PM10 and PM2.5 estimates assume 50% control of fugitive dust from watering and associated dust control measures if a minimum number of water trucks are specified.

Total PM10 emissions shown in column F are the sum of exhaust and fugitive dust emissions shown in columns H and I. Total PM2.5 emissions shown in Column J are the sume of exhaust and fugitive dust emissions shown in columns K and L.

Road Construction Emissions Model, Version 6.3.2

Emission Estimates for -> Contract D2				Total	Exhaust	Fugitive Dust	Total	Exhaust	Fugitive Dust	
Project Phases (English Units)	**ROG (lbs/day)**	**CO (lbs/day)**	**NOx (lbs/day)**	**PM10 (lbs/day)**	**PM10 (lbs/day)**	**PM10 (lbs/day)**	**PM2.5 (lbs/day)**	**PM2.5 (lbs/day)**	**PM2.5 (lbs/day)**	**CO2 (lbs/day)**
Grubbing/Land Clearing	11.4	64.5	85.9	8.7	3.7	5.0	4.2	3.1	1.0	19,630.5
Grading/Excavation	34.9	180.5	229.8	14.0	9.0	5.0	8.9	7.9	1.0	55,338.2
Drainage/Utilities/Sub-Grade	9.2	54.4	67.8	8.1	3.1	5.0	3.7	2.6	1.0	16,670.0
Paving	7.2	45.4	52.3	2.6	2.6	-	2.2	2.2	-	13,612.6
Maximum (pounds/day)	34.9	180.5	229.8	14.0	9.0	5.0	8.9	7.9	1.0	55,338.2
Total (tons/construction project)	1.3	6.9	8.7	0.6	0.4	0.3	0.4	0.3	0.1	2,113.6

Notes:
Project Start Year -> 2017
Project Length (months) -> 6
Total Project Area (acres) -> 90
Maximum Area Disturbed/Day (acres) -> 1
Total Soil Imported/Exported (yd^3/day)-> 1601

PM10 and PM2.5 estimates assume 50% control of fugitive dust from watering and associated dust control measures if a minimum number of water trucks are specified.

Total PM10 emissions shown in column F are the sum of exhaust and fugitive dust emissions shown in columns H and I. Total PM2.5 emissions shown in Column J are the sum of exhaust and fugitive dust emissions shown in columns K and L.

Emission Estimates for -> Contract D2				Total	Exhaust	Fugitive Dust	Total	Exhaust	Fugitive Dust	
Project Phases (Metric Units)	**ROG (kgs/day)**	**CO (kgs/day)**	**NOx (kgs/day)**	**PM10 (kgs/day)**	**PM10 (kgs/day)**	**PM10 (kgs/day)**	**PM2.5 (kgs/day)**	**PM2.5 (kgs/day)**	**PM2.5 (kgs/day)**	**CO2 (kgs/day)**
Grubbing/Land Clearing	5.2	29.3	39.0	3.9	1.7	2.3	1.9	1.4	0.5	8,923.0
Grading/Excavation	15.9	82.1	104.5	6.3	4.1	2.3	4.0	3.6	0.5	25,153.7
Drainage/Utilities/Sub-Grade	4.2	24.7	30.8	3.7	1.4	2.3	1.7	1.2	0.5	7,577.3
Paving	3.3	20.7	23.8	1.2	1.2	-	1.0	1.0	-	6,187.5
Maximum (kilograms/day)	15.9	82.1	104.5	6.3	4.1	2.3	4.0	3.6	0.5	25,153.7
Total (megagrams/construction project)	1.2	6.3	7.9	0.6	0.3	0.3	0.3	0.3	0.1	1,917.1

Notes:
Project Start Year -> 2017
Project Length (months) -> 6
Total Project Area (hectares) -> 36
Maximum Area Disturbed/Day (hectares) -> 0
Total Soil Imported/Exported ($meters^3$/day)-> 1224

PM10 and PM2.5 estimates assume 50% control of fugitive dust from watering and associated dust control measures if a minimum number of water trucks are specified.

Total PM10 emissions shown in column F are the sum of exhaust and fugitive dust emissions shown in columns H and I. Total PM2.5 emissions shown in Column J are the sume of exhaust and fugitive dust emissions shown in columns K and L.

U.S. Fish & Wildlife Service
Sacramento Fish & Wildlife Office

Federal Endangered and Threatened Species that Occur in or may be Affected by Projects in the Counties and/or U.S.G.S. 7 1/2 Minute Quads you requested

Document Number: 130814121815

Database Last Updated: September 18, 2011

No quad species lists requested.

County Lists

Butte County

Listed Species

Invertebrates

Branchinecta conservatio
- Conservancy fairy shrimp (E)
- Critical habitat, Conservancy fairy shrimp (X)

Branchinecta lynchi
- Critical habitat, vernal pool fairy shrimp (X)
- vernal pool fairy shrimp (T)

Desmocerus californicus dimorphus
- valley elderberry longhorn beetle (T)

Lepidurus packardi
- Critical habitat, vernal pool tadpole shrimp (X)
- vernal pool tadpole shrimp (E)

Fish

Acipenser medirostris
- green sturgeon (T) (NMFS)

Hypomesus transpacificus
- delta smelt (T)

Oncorhynchus mykiss
- Central Valley steelhead (T) (NMFS)
- Critical habitat, Central Valley steelhead (X) (NMFS)

Oncorhynchus tshawytscha
- Central Valley spring-run chinook salmon (T) (NMFS)
- Critical Habitat, Central Valley spring-run chinook (X) (NMFS)
- Critical habitat, winter-run chinook salmon (X) (NMFS)

winter-run chinook salmon, Sacramento River (E) (NMFS)

Amphibians

Ambystoma californiense
California tiger salamander, central population (T)

Rana draytonii
California red-legged frog (T)
Critical habitat, California red-legged frog (X)

Rana sierrae
Mountain yellow legged frog (PX)

Reptiles

Thamnophis gigas
giant garter snake (T)

Plants

Chamaesyce hooveri
Critical habitat, Hoover's spurge (X)
Hoover's spurge (T)

Limnanthes floccosa ssp. californica
Butte County (Shippee) meadowfoam (E)
Critical habitat, Butte County (Shippee) meadowfoam (X)

Orcuttia pilosa
Critical habitat, hairy Orcutt grass (X)
hairy Orcutt grass (E)

Orcuttia tenuis
Critical habitat, slender Orcutt grass (X)
slender Orcutt grass (T)

Senecio layneae
Layne's butterweed (=ragwort) (T)

Tuctoria greenei
Critical habitat, Greene's tuctoria (=Orcutt grass) (X)
Greene's tuctoria (=Orcutt grass) (E)

Candidate Species

Amphibians

Rana muscosa
mountain yellow-legged frog (C)

Birds

Coccyzus americanus occidentalis
Western yellow-billed cuckoo (C)

Mammals

Martes pennanti
fisher (C)

Key:

(E) *Endangered* - Listed as being in danger of extinction.

(T) *Threatened* - Listed as likely to become endangered within the foreseeable future.

(P) *Proposed* - Officially proposed in the Federal Register for listing as endangered or threatened.

(NMFS) Species under the Jurisdiction of the National Oceanic & Atmospheric Administration Fisheries Service. Consult with them directly about these species.

Critical Habitat - Area essential to the conservation of a species.

(PX) *Proposed Critical Habitat* - The species is already listed. Critical habitat is being proposed for it.

(C) *Candidate* - Candidate to become a proposed species.

(V) Vacated by a court order. Not currently in effect. Being reviewed by the Service.

(X) *Critical Habitat* designated for this species

Important Information About Your Species List

How We Make Species Lists

We store information about endangered and threatened species lists by U.S. Geological Survey 7½ minute quads. The United States is divided into these quads, which are about the size of San Francisco.

The animals on your species list are ones that occur within, **or may be affected by** projects within, the quads covered by the list.

- Fish and other aquatic species appear on your list if they are in the same watershed as your quad or if water use in your quad might affect them.
- Amphibians will be on the list for a quad or county if pesticides applied in that area may be carried to their habitat by air currents.
- Birds are shown regardless of whether they are resident or migratory. Relevant birds on the county list should be considered regardless of whether they appear on a quad list.

Plants

Any plants on your list are ones that have actually been observed in the area covered by the list. Plants may exist in an area without ever having been detected there. You can find out what's in the surrounding quads through the California Native Plant Society's online Inventory of Rare and Endangered Plants.

Surveying

Some of the species on your list may not be affected by your project. A trained biologist and/or botanist, familiar with the habitat requirements of the species on your list, should determine whether they or habitats suitable for them may be affected by your project. We

recommend that your surveys include any proposed and candidate species on your list. See our Protocol and Recovery Permits pages.

For plant surveys, we recommend using the Guidelines for Conducting and Reporting Botanical Inventories. The results of your surveys should be published in any environmental documents prepared for your project.

Your Responsibilities Under the Endangered Species Act

All animals identified as listed above are fully protected under the Endangered Species Act of 1973, as amended. Section 9 of the Act and its implementing regulations prohibit the take of a federally listed wildlife species. Take is defined by the Act as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect" any such animal.

> Take may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or shelter (50 CFR §17.3).

Take incidental to an otherwise lawful activity may be authorized by one of two procedures:

- If a Federal agency is involved with the permitting, funding, or carrying out of a project that may result in take, then that agency must engage in a formal consultation with the Service.

  During formal consultation, the Federal agency, the applicant and the Service work together to avoid or minimize the impact on listed species and their habitat. Such consultation would result in a biological opinion by the Service addressing the anticipated effect of the project on listed and proposed species. The opinion may authorize a limited level of incidental take.

- If no Federal agency is involved with the project, and federally listed species may be taken as part of the project, then you, the applicant, should apply for an incidental take permit. The Service may issue such a permit if you submit a satisfactory conservation plan for the species that would be affected by your project.

  Should your survey determine that federally listed or proposed species occur in the area and are likely to be affected by the project, we recommend that you work with this office and the California Department of Fish and Game to develop a plan that minimizes the project's direct and indirect impacts to listed species and compensates for project-related loss of habitat. You should include the plan in any environmental documents you file.

Critical Habitat

When a species is listed as endangered or threatened, areas of habitat considered essential to its conservation may be designated as critical habitat. These areas may require special management considerations or protection. They provide needed space for growth and normal behavior; food, water, air, light, other nutritional or physiological requirements; cover or shelter; and sites for breeding, reproduction, rearing of offspring, germination or seed dispersal.

Although critical habitat may be designated on private or State lands, activities on these lands are not restricted unless there is Federal involvement in the activities or direct harm to listed wildlife.

If any species has proposed or designated critical habitat within a quad, there will be a separate line for this on the species list. Boundary descriptions of the critical habitat may be found in the Federal Register. The information is also reprinted in the Code of Federal Regulations (50 CFR 17.95). See our Map Room page.

Candidate Species

We recommend that you address impacts to candidate species. We put plants and animals

on our candidate list when we have enough scientific information to eventually propose them for listing as threatened or endangered. By considering these species early in your planning process you may be able to avoid the problems that could develop if one of these candidates was listed before the end of your project.

Species of Concern

The Sacramento Fish & Wildlife Office no longer maintains a list of species of concern. However, various other agencies and organizations maintain lists of at-risk species. These lists provide essential information for land management planning and conservation efforts. More info

Wetlands

If your project will impact wetlands, riparian habitat, or other jurisdictional waters as defined by section 404 of the Clean Water Act and/or section 10 of the Rivers and Harbors Act, you will need to obtain a permit from the U.S. Army Corps of Engineers. Impacts to wetland habitats require site specific mitigation and monitoring. For questions regarding wetlands, please contact Mark Littlefield of this office at (916) 414-6520.

Updates

Our database is constantly updated as species are proposed, listed and delisted. If you address proposed and candidate species in your planning, this should not be a problem. However, we recommend that you get an updated list every 90 days. That would be November 12, 2013.

U.S. Fish & Wildlife Service
Sacramento Fish & Wildlife Office

Federal Endangered and Threatened Species that Occur in or may be Affected by Projects in the Counties and/or U.S.G.S. 7 1/2 Minute Quads you requested

Document Number: 130814122014

Database Last Updated: September 18, 2011

No quad species lists requested.

County Lists

Sutter County

Listed Species

Invertebrates

Branchinecta conservatio
Conservancy fairy shrimp (E)

Branchinecta lynchi
Critical habitat, vernal pool fairy shrimp (X)
vernal pool fairy shrimp (T)

Desmocerus californicus dimorphus
valley elderberry longhorn beetle (T)

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Central Valley steelhead (T) (NMFS)
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Oncorhynchus tshawytscha
Central Valley spring-run chinook salmon (T) (NMFS)
Critical Habitat, Central Valley spring-run chinook (X) (NMFS)
Critical habitat, winter-run chinook salmon (X) (NMFS)
winter-run chinook salmon, Sacramento River (E) (NMFS)

Amphibians

Ambystoma californiense
California tiger salamander, central population (T)

Rana draytonii
California red-legged frog (T)

Reptiles

Thamnophis gigas
giant garter snake (T)

Birds

Charadrius alexandrinus nivosus
western snowy plover (T)

Plants

Cordylanthus palmatus
palmate-bracted bird's-beak (E)

Pseudobahia bahiifolia
Hartweg's golden sunburst (E)

Candidate Species

Birds

Coccyzus americanus occidentalis
Western yellow-billed cuckoo (C)

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United States Department of the Interior

FISH AND WILDLIFE SERVICE
Sacramento Fish and Wildlife Office
2800 Cottage Way, Room W-2605
Sacramento, California 95825-1846

In Reply Refer To
08ESMF00-2013-CPA-0012

MAY 08 2013

Alicia E. Kirchner
Chief, Planning Division
Corps of Engineers, Sacramento District
1325 J Street
Sacramento, California 95825-2922

Dear Ms. Kirchner:

The U.S. Army Corps of Engineers has requested coordination under the Fish and Wildlife Coordination Act (FWCA) for the Sutter Basin Feasibility Study and the Feather River West Levee Project. The proposed levee modifications would occur on the west levee of the Feather River, in Sutter and Butte Counties, California. This report has been prepared under the authority of, and in accordance with, the provisions of section 2(b) of the FWCA (48 stat.401, as amended; 16 U.S.C. 661 et seq.).

By copy of this letter, this report is being circulated to the agencies and offices listed below for review and comment. We would appreciate receipt of any comments on this report within 30 days of receipt of this report.

If you have any questions regarding this report, please contact Jennifer Hobbs at (916) 414-6541.

Sincerely,

Daniel Welsh
Assistant Field Supervisor

Enclosure

cc:
Mike Hendrick, NMFS, Sacramento, California
Brad Johnson, Corps of Engineers, Sacramento, California
Jeff Koschak, Corps of Engineers, Sacramento, California
Kursten Sheridan, CDFW, Region 2, Rancho Cordova, California
Jenny Marr, CDFW Region 2, Chico, California

FISH AND WILDLIFE COORDINATION ACT REPORT
SUTTER BASIN FEASIBILITY STUDY/ FEATHER RIVER WEST LEVEE PROJECT

This is the U.S. Fish and Wildlife Service's (Service) Fish and Wildlife Coordination Act report on the effects of the proposed Sutter Basin Feasibility Study/Feather River West Levee Project, Sutter and Butte Counties, California. This report has been prepared under the authority of, and in accordance with, the provisions of the Fish and Wildlife Coordination Act (48 stat. 401, as amended: 16 U.S.C. 661 et seq.).

INTRODUCTION

The information presented in this report is based primarily upon project planning information made available by the Sutter Butte Flood Control Agency (SBFCA) and the U.S. Army Corps of Engineers (Corps). The Corps, Central Valley Flood Protection Board, and SBFCA are coordinating on the feasibility study to reduce flood risk within the study area. In a parallel but separate action, SBFCA is planning the Feather River West Levee Project (FRWLP) which would construct improvements along the Feather River from Thermalito Afterbay downstream to Laurel Avenue. The FRWLP is scheduled to begin construction in 2013, prior to the Sutter Basin Feasibility Study being authorized. In order to implement the FRWLP, SBFCA must obtain permission from the Corps to alter the Federal project under Section 14 of the Rivers and Harbors Act of 1899 (as amended) (33 USC §408 or Section 408). Consequently, two environmental impact statement/environmental impact reports (EIS/EIR) are being prepared, one for the feasibility study and one for the FRWLP. Both projects are being closely coordinated as they involve similar actions and the same participants. This FWCA report analyzes the effects to fish and wildlife and their habitats due to each of the projects, recognizing that only one of the alternatives discussed would be constructed and that this report will be used for both the Sutter Basin Feasibility EIS/EIR and the FRWLP EIS/EIR.

Major flood events have occurred along the Feather River, with the more significant events that caused levee failures and flooding occurring in 1955, 1986, and 1997. In December of 1955, the most significant flood event along the Feather River is reported to have occurred. Several levee embankment failures caused major flooding of nearly all of Yuba City, as well as flooding in Nicolaus. About 156 square miles were flooded during this event. In February of 1986, heavy snow pack and warm rains elevated water levels and caused a levee embankment failure on the adjacent segment of the Yuba River near Linda, flooding nearly 30 square miles including Linda and Olivehurst. The winter of 1996/1997, heavy snow pack and warm rains again elevated water levels. All citizens in Yuba City, Marysville, Linda, and Olivehurst were ordered to evacuate. Ultimately, in January of 1997, a levee embankment failure occurred south of Olivehurst flooding nearly 50 square miles including Olivehurst and Arboga.

Over the past two decades, several studies have been conducted by the Department of Water Resources (DWR), the Corps, and more recently SBFCA to evaluate the condition of the levees protecting the planning area relative to criteria for stability, seepage, erosion, geometry, and levee height. These studies have indicated that the levee system deficiencies include seepage,

slope instability, erosion, and encroachment, and that the consequences of levee failure from a major flood event would be significant. An emergency preparedness mapping study analyzed hypothetical levee failures and determined the rate and depth at which water would flood SBFCA's planning area if a levee failure occurred in the studied reaches. This study predicted flooding depths that could range from about 1-foot to more than 20 feet in some areas.

Further evaluation has demonstrated that much of the existing system does not provide protection from the 100-year flood event, the commonly accepted minimum level of flood protection per the Federal Emergency Management Agency's (FEMA's) National Flood Insurance Program as well as being less than the 200-year level targeted by the State of California for urban areas. The Corps' and SBFCA's goal is to reduce the risk of flooding on the population, property, and critical infrastructure. SBFCA's goal is to achieve a minimum of 200-year flood protection for the more urbanized areas and 100-year for the remaining rural agricultural parts of the planning area.

AREA DESCRIPTION

The Sutter Basin is part of the Sacramento River Flood Control Project, located in north-central California in Sutter and Butte Counties. The elongated, irregularly shaped basin covers about 300 square miles and is about 43 miles long north to south, and up to 14 miles wide east to west. The Sutter Basin is roughly bounded by the Feather River, Cherokee Canal, the Sutter Buttes, and Sutter Bypass. Floodwaters potentially threatening the basin originate from the Feather River watershed or the upper Sacramento River watershed, upstream of the Colusa Weir. These waterways have drainage areas of 5,921 and 12,090 square miles, respectively. In addition to Yuba City, communities in the basin include Biggs, Gridley, Live Oak, and Sutter.

The Corps and SBFCA have determined that flood risk can be reduced by focusing on the Feather River west levee. Consequently, all of the alternatives that they are pursuing deal with remediation of that levee. This portion of the west Feather River Levee extends from Thermalito Afterbay on the north to where the Feather River enters the Sutter Bypass on the south. This corridor is roughly 500 feet from the land side of the existing levees and 100 feet from the water side. The corridor is about 41 miles long.

PROJECT DESCRIPTION

The Sutter Basin Feasibility Study (SBFS) is evaluating two flood-risk reduction alternatives, while the FRWLP is evaluating three flood-risk reduction alternatives. The no-action alternative describes the project without flood-risk reduction measures. All of the alternatives for the SBFS and FRWLP use very similar flood risk-reduction measures. Rather than restate the entire alternatives for SB-7 and SB-8, the FRWLP alternatives will be discussed first and then the SBFS alternative will follow with the differences between these alternatives defined rather than restating the entire alternative.

No Action Alternative

Under the No Action Alternative, the Corps and SBFCA would not implement flood risk-reduction measures. The levees protecting the Sutter Basin would continue to require risk-reduction measures to meet current levee standards, FEMA's minimum acceptable level of flood protection, and State requirements for 200-year for urbanized areas. In addition, the associated risk to human health and safety, property, and the adverse economic impact that serious flooding could cause would continue, and the risk of a catastrophic flood would remain high.

Because of uncertainties in local, State, and federal funding; future state and federal authorization; and other approvals, it is not reasonable to predict construction of levee improvements in the foreseeable future would be completed in a reasonable timeframe. Therefore, for the purpose of evaluating effects under the No Action Alternative, it is assumed that no levee repair or strengthening would be implemented, the purpose and objectives would not be met, and the current level of flood risk would continue.

Alternative 1 (FRWLP)

This alternative would construct a cutoff wall along the centerline of the existing levee to varying depths and a seepage berm along a portion of the landside levee toe. This alternative would predominately keep within the existing footprint of the levee.

For Reaches 2 through 5, Alternative 1 would construct a cutoff wall ranging between 30 feet and 127 feet deep along the centerline of the levee. The levee would be degraded about 50% of its overall height with 2,900 feet of the levee being fully degraded. In addition to the cutoff wall, Alternative 1 would construct a 200-foot-wide seepage berm for 2,268 feet.

For Reaches 7 through 11, Alternative 1 would construct a cutoff wall ranging between 39 feet and 124 feet deep along the centerline of the levee. The levee would be degraded about 50% of its overall height with 1,900 feet of the levee being fully degraded.

SBFCA would acquire a temporary construction easement equal to 50 feet from the existing levee toe or toe of the proposed seepage berm for construction of the levee improvements. An additional 20-foot easement would be obtained where required for the relocation of existing utilities.

For Reaches 13 through 24, Alternative 1 would construct a cutoff wall ranging between 21 and 105 feet deep along the centerline of the levee. The levee would be degraded about 50% of its overall height with about 2,600 feet of the levee being fully degraded. In addition to the cutoff wall, Alternative 1 would include about 11,150 feet of waterside slope flattening, about 5,100 feet of depression infill, and about 1,500 feet of ditch lining.

For Reaches 26 through 41, a cutoff wall ranging between 18 feet and 97 feet deep along the centerline of the levee would be constructed. The levee would be degraded by about 50% of its overall height.

Materials imported to the project site would include water, bentonite, cement, incidental construction support materials, aggregate base rock, hydroseed, and up to 4,343,800 cubic yards of embankment fill material for the new levee surfaces from off-site commercial borrow sites. For backfill of new pipelines crossing the levee, Controlled Low Strength Material (CLSM) (otherwise known as light-weight concrete) is required to be placed to the pipeline's spring line.

Levee improvements are not required for Reaches 6, 14, 15, 29, and 39.

Alternative 2 (FRWLP)

Alternative 2 would construct seepage and stability berms along the landside toe of the levee and a shallow cutoff wall along a portion of the centerline of the levee. The seepage and stability berms would substantially extend beyond the footprint of the current levee, requiring real estate acquisition. In addition, Alternative 2 would include the filling of the existing canal adjacent to the levee in Reaches 26, 27, and 28 with water during periods of high water surface elevation in the river. This would require the construction of regulating structures within the canal to maintain the water level within the canal and create a resistive force against any under-seepage flows.

For Reaches 2 through 5, Alternative 2 would construct an undrained seepage berm ranging between 100 feet and 300 feet wide along the landside toe of the levee. Additionally, an 8-foot high stability berm would be constructed along 20,817 feet of the project. Also, a shallow cutoff wall 20 feet deep would be constructed along the levee centerline for 1,616 feet of the project. The levee would be degraded about 50% of its overall height.

For Reaches 7 through 11, Alternative 2 would construct an undrained seepage berm ranging between 110 feet and 300 feet wide along the landside toe of the levee. A stability berm about 9.5 feet tall would be constructed along 14,163 feet of the project. Also, a shallow cutoff wall ranging between 23 feet and 35 feet deep would be constructed along the levee centerline for 17,800 feet of the project. A portion of the existing Garden Highway would need to be removed and reconstructed to allow construction of the seepage berm.

For Reaches 13 through 24, Alternative 2 would construct an undrained seepage berm ranging between 70 feet and 300 feet wide along the landside toe of the levee. An 8- to 10-foot high stability berm would be constructed along about 24,200 feet of the project. A shallow cutoff wall 20 feet deep would be constructed along the levee centerline for about 14,700 feet of the project. Relief wells would be installed for about 37,400 feet of the project. To facilitate construction of the cutoff wall and to maintain stability of the levee, the levee would be degraded by about 50% of its overall height.

For Reaches 26 through 41, Alternative 2 would construct an undrained seepage berm ranging between 50 feet and 300 feet wide along the landside toe of the levee. A 4- to 10-foot-tall stability berm would be constructed along about 38,600 feet of the project. About 1,300 feet of the existing levee would need to be removed and reconstructed with a zoned filter at the base in combination with a seepage berm. About 15,100 feet of canal would be in-filled.

Materials imported to the project site would include water, bentonite, cement, incidental construction support materials, aggregate base rock, hydroseed, and up to 7,661,100 cubic yards of embankment fill material for the new levee surfaces from off-site commercial borrow sites. For backfill of new pipelines crossing the levee, CLSM is required to be placed to the pipeline's spring line.

Levee improvements are not required for Reaches 6, 14, 15, 29, and 39.

Alternative 3 (FRWLP)

Alternative 3 is the applicant-preferred alternative, combining measures from both Alternative 1 and Alternative 2 to produce the optimized alternative based on screening criteria. This alternative is optimal due to its effectiveness in addressing levee deficiencies, compatibility with land use, minimization of real estate acquisition, avoidance of effects, and cost.

For Reaches 2 through 5, Alternative 3 would construct a cutoff wall ranging between 20 feet and 127 feet deep along the centerline of the levee. The levee would be degraded by about 50% of its overall height. In addition to the cutoff wall, Alternative 3 would construct a 100-foot wide seepage berm for 1,616 feet and a 200-foot wide seepage berm for 2,268 feet.

For Reaches 7 through 11, Alternative 3 would construct a cutoff wall ranging between 39 feet and 124 feet deep along the centerline of the levee. Relief wells with 60 feet spacing and 50 feet deep would be distributed at various locations in Reach 7.

For Reaches 12 through 24, Alternative 3 would construct a cutoff wall ranging between 21 and 105 feet deep along the centerline of the levee. The levee would be degraded by about 50% of its overall height with about 2,600 feet of the levee being fully degraded. In addition to the cutoff wall, Alternative 3 would include relief wells for about 8,200 feet, about 11,150 feet of waterside slope flattening, about 5,100 feet of depression infill and about 1,500 feet of ditch lining. Reach 16 includes waterside slope flattening or other remedial measures.

At Reach 17, a seepage berm 7 feet tall and about 50 feet wide would be constructed beneath the Highway 20 crossing. It extends through the existing abandoned railroad tunnel at the levee landside toe. Pedestrian access through the tunnel will remain after the berms construction.

For Reaches 26 through 41, Alternative 3 would construct a cutoff wall ranging between 18 feet and 97 feet deep along the centerline of the levee. The levee would be degraded by about 50% of its overall height. About 1,300 feet of levee would be degraded and reconstructed with a 5 to 1 slope (horizontal to vertical). Reach 31 includes cutoff walls in addition to waterside slope flattening or other remedial measures. In Reach 38 an adjacent levee with a 20-ft wide crown will be constructed using the tailings materials located along the landside of the existing levee. In Reach 41, a 150-feet wide drained seepage berm will be constructed with a 1-ft thick filter drain along the bottom. The filter drain would provide drainage for seepage through the levee. The existing concrete outfall structure located at the south end of this reach would remain in place and would be backfilled with earth materials. This alternative would also include filling of the waterside pit located at the south end of this reach. A 30-foot wide construction access area

would be provided at the toe of the seepage berm. About 9,500 feet of canal would be monitored with a Flood Safety Plan.

Materials imported to the project site would include water, bentonite, cement, incidental construction support materials, aggregate base rock, hydroseed, and up to 1,150,000 cubic yards of embankment fill material for the new levee surfaces from off-site commercial borrow sites. For backfill of new pipelines crossing the levee, CLSM is required to be placed to the pipeline's spring line.

Levee improvements are not required for Reaches 6, 14, 15, 29, and 39.

SB-7

This alternative for the feasibility study closely aligns with the FRWLP Alternative 3 alternative description except for the easement that would be acquired and the length of levee that would be repaired. The Corps would only acquire a 20-foot easement on the landside of the levee and a 15-foot easement on the waterside. The Corps would require full compliance with the Corps policy regarding woody vegetation on levees (Engineering Technical Letter 1110-2-571 "Guidelines for Landscape Planting and Vegetation Management on Levees, Floodwalls, Embankment Dams, and Appurtenant Structures") which would result in more vegetation removal with this alternative than with Alternative 3.

SB-7 would only extend through reach 21 of the project area, resulting in a proposed repair length of about 24 miles long. Of this length, 2,250 feet of levee improvement would be made downstream of Laurel Avenue and consist of a 100-foot-wide undrained seepage berm (5-foot thick at berm toe) in combination with a cutoff wall extending to an elevation of 25 feet deep. The additional work is proposed because this area is located in an area that is highly conducive to seepage distress.

SB-8

This alternative for the feasibility study closely aligns with the FRWLP Alternative 3 alternative description. Differences include the reduced easement compared to the FRWLP, as described in SB-7 and the full compliance with Corps' vegetation management standards. Relocation of either the levee or the Sutter-Butte Irrigation Canal (SBIC) would occur where the SBIC is adjacent to the levee. This would provide space for an operations and maintenance road between the canal and levee. The relocation of either the SBIC or levee is described below:

a. Area 1a (Reach 21) would involve 483 linear feet of canal relocation landward into adjacent agricultural land to provide space between the canal and the levee for a landside operations and maintenance road.
b. Area 1b (Reach 22) would move 1,900 linear feet of levee waterward into the floodplain to provide sufficient space for the landside operations and maintenance road.
c. Area 2 (Reach 24) would move 1,200 linear feet of levee waterward into the floodplain to provide sufficient space for the landside operations and maintenance road.
d. Area 3a (Reach 28) would move 7,900 linear feet of levee waterward into the floodplain to provide sufficient space for the landside operations and maintenance road.

e. Area 3b (Reach 28) would move 1,200 linear feet of canal landward into adjacent agricultural area to provide space for the operations and maintenance road.

Canal relocation would occur during the regular construction season. The new canal is offset from the old canal and a berm would separate the two. The greatest distance between the old and new canal would be 81 feet. Plugs would remain at each end of the canal where it ties into the existing canal. In the winter following construction, when the irrigators no longer send water through the canal and it is dry for 2 months, the plugs would be removed and the abandoned canal section would be filled. The small relocation of the canal at the sunset pump station can be accomplished by simply excavating the opposite side of the canal (widening the canal) when the canal is dry and filling the opposite side of the canal.

An additional 2,250 feet of levee improvement would be made downstream of Laurel Avenue and consist of a 100-foot wide undrained seepage berm (5-foot thick at berm toe) in combination with a cutoff wall extending to an elevation of 25 feet deep. The additional work is proposed because this area is located in an area that is highly conducive to seepage distress.

To provide protection in the event of water overtopping the levee the Corps is proposing to use Anchored High Performance Turf Reinforced Mat along two levee sections. This would occur for 5,760 linear feet in Reaches 7 and 8 and 1,900 linear feet in Reach 23.

EXISTING BIOLOGICAL RESOURCES

Vegetation

Seven land cover category types can currently be found in the project area: riparian forest, riparian scrub-shrub, oak woodland, wetland, agricultural lands, ruderal, and developed/disturbed areas.

Riparian Forest habitat occurs along the Feather River and its tributaries, and supports an overstory dominated by mature native and nonnative trees. The dominant overstory species are valley oak, Fremont cottonwood, and Gooding's black willow. Other trees commonly observed within the riparian habitat were box elder, arroyo willow, Oregon ash and western sycamore. Understory species include horsetails, mugwort and curly dock.

California grape covers many of the trees and shrubs in the riparian forest and several patches of the invasive giant reed were found to occur along the edges of the riparian areas.

Riparian Scrub-Shrub habitat within the biological study area consists of shrubs such as willows, blue elderberry, coyote brush, Himalayan blackberry, and button bush.

Oak Woodland habitat is found in two small patches just south of Almond and Laurel Avenues in the study area. The oak woodland are dominated by valley oak and have an understory that includes wild oat, soft chess, ripgut brome, field hedge parsley and invasive yellow starthistle.

Wetland habitat in the study area consists of natural and agricultural waterbodies: irrigation ditches, open water, seasonal wetlands, streams, and tailing wetlands. Irrigation and drainage

canals typically occur along the landside of the levee and service the agricultural fields. There tends to be sparse vegetation growing along the edge of the canals. Seasonal wetlands and tailing wetlands typically have aquatic and/or emergent vegetation such as common duckweed, primrose, or narrowleaf cattail. The tailing wetlands are typically bounded by trees and shrubs. Open water areas consist of standing water with little vegetation. These occur at the northern and southern portions of the project area.

Agricultural lands are a predominant habitat in the project area and are made up largely of orchards and field and row crops. Orchards are the dominant land cover-type and occur throughout the study area. The majority of the orchards consist of walnut, plum and peach trees that are actively maintained. Herbaceous ground cover under the tree rows is highly variable and depends on the type and frequency of maintenance. When present, the herbaceous vegetation is mostly nonnative weedy species. Field and row crops can largely be found in the southern portion of the study area. Both active and fallow fields that showed indicators of tillage were included in this habitat type. Common field and row crops in the area include sweet corn, alfalfa, wheat, and tomatoes.

Developed areas within the study area consist of urban (residential and commercial) centers, ranchettes, rural neighborhoods, agricultural outbuildings, farm equipment storage areas, pumping stations, and a plant nursery.

Ruderal areas within the study area occur as swaths on both sides of the centerline of the levee where the native soil has been substantially altered. The largest ruderal areas are located between Vance Avenue and the northern terminus of the study area. These areas represent past and ongoing disturbance associated with agriculture, levee construction and maintenance, and excavation.

Trees found in ruderal areas include valley oak, Fremont cottonwood, and black willow. Common shrubs found consist of coyote bush, tree tobacco, Himalayan blackberry, and blue elderberry. Herbaceous vegetation is dominated by annual grasses such as wild oat, soft chess, ripgut brome, and foxtail barley. Non-native forbs such as yellow star-thistle, prickly lettuce, field hedge parsley, mustard, and rose clover occur in the study site as well as native forbs, Spanish lotus, California poppy, fireweed, and western verbena.

Wildlife

Riparian habitat communities provide wildlife with dispersal and migration corridors, foraging areas, cover, and breeding habitat. Riparian trees provide nesting habitat for a variety of raptors, egrets, herons, songbirds, and bats. Riparian forest also provides foraging habitat for numerous species of migratory and wintering birds. Typical mammal species that can be found in riparian areas include deer, raccoons, beavers, coyotes, and skunks. Reptiles and amphibians are also associated with a riparian habitat. Species of reptiles and amphibians include the giant garter snake, western fence lizard, western pond turtle, Pacific tree frog, western toad, and bullfrog.

Oak Woodland provides nesting habitat for a variety of raptors and other tree nesting migratory birds. Additionally, great-horned owl, barn owl, and yellow-billed magpie are known to utilize

this habitat as well. Reptiles and mammals that occur in the riparian habitat may also utilize oak woodlands for foraging and cover habitat.

Wetland habitats in the affected area include riverine areas, ponds, canals, and small ditches. In addition to providing habitat for fish, open water habitat provides foraging, cover and reproductive sites for a variety of wildlife species. Open water areas provide foraging habitat for raptors, herons, egrets, waterfowl, water birds, and land birds. Many of the reptiles and amphibians that use riparian habitat use open water habitat for breeding, foraging, and cover.

Canals and ditches that contain water through mid-fall, have suitable prey, and adequate cover have the potential to support giant garter snake. Mammals that use the open water habitats include different species of bats that forage for insects over open water. Terrestrial mammals such as deer, raccoon, skunk, and opossum, use open water habitat for water sources. Semi-aquatic and aquatic mammals that are found within open water habitat include beaver, river otter, mink, and muskrat.

Orchards have limited value for wildlife, although certain birds, such as the red-shouldered hawk, American crow, yellow-billed magpie, mourning dove, European starling, and rock pigeon may nest or forage in these areas.

Row and field crops provide foraging opportunities for a variety of raptors and other migratory and resident birds such as sandhill crane, blackbirds, western meadowlark, and rock pigeon. Similar species are known to use irrigated fields for foraging, and birds such as burrowing owl, northern harrier, and western meadowlark are known to nest in these areas.

Developed lands provide limited habitat for wildlife but are known to support common "urban-dwelling species" such as northern mockingbird, rock pigeon, mourning dove, house sparrow, house finch, western scrub jay, Botta's pocket gopher, California ground squirrel, house mouse, black rat, and coyote. Semi-developed areas with grass, trees, and a water source can provide habitat for additional wildlife species.

Ruderal areas in the project site have a variety of native and non-native trees, shrubs, grasses, and forbs like described in the vegetation section. Similar to developed lands, these areas support mostly common wildlife species, although some elderberry bushes, which support valley elderberry longhorn beetle, were found scattered in the area.

Fisheries

The study area includes over 40 miles of the Feather River's western bank, and the various water bodies in the study area provide spawning, rearing, and migratory habitat for a diverse assemblage of native and non-native fish species. Native species present in these streams can be separated into anadromous and resident species. Native anadromous species include two runs of Chinook salmon, steelhead, green and white sturgeon, Pacific and river lamprey. Native resident species include Sacramento pikeminnow, Sacramento splittail, Sacramento sucker, hardhead, California roach, and rainbow trout. Non-native anadromous species include striped bass and American shad. There are numerous non-native resident species such as catfish, black bass, crappie, sunfish and minnows.

There are many factors affecting the abundance of fish species on the Feather River and its tributaries. Riparian and shaded riverine aquatic habitat has decreased significantly with the building of dams, levees, and water diversions, and floodplain access for spawning and rearing has been diminished from what it once was. In addition to habitat alterations, other factors that limit fish species abundance include non-native fish introductions, food availability, entrainment due to water diversions, and water temperature.

Endangered Species

Appendix A provides the Service's biological opinion for the FRWLP, dated May 2, 2013, pursuant to section 7(a) and (c) of the Endangered Species Act (Act) of 1973, as amended.

In addition, the western yellow-billed cuckoo, a candidate species, may occur in the project area. Although candidate species are not protected under the Act, the 1988 amendments require the Service or NOAA Fisheries to monitor their status. If this species declines precipitously during the planning of this project, it could be listed on an emergency basis.

NOAA Fisheries has responsibility for most marine fish and wildlife, including anadromous salmonids, and should be consulted on activities which may affect any such listed or proposed species in the project area. The Service has consultation responsibility for the remaining species.

The California Department of Fish and Wildlife (CDFW) has responsibility for State listed species and species of concern. The CDFW should be contacted regarding any State listed species or species of concern that may be impacted by project activities.

FUTURE CONDITIONS WITH THE NO ACTION ALTERNATIVE

Vegetation

The No Action Alternative represents the continuation of the existing deficiencies in the levee along the west bank of the Feather River between the Sutter Bypass and Thermalito Afterbay. No levee improvements would be made and no construction related effects on vegetation or wetland would occur. Compliance with the Corps levee vegetation policy could lead to permanent loss of woody vegetation which would result in a significant effect on riparian habitat.

Wildlife

Under the No Action Alternative, the aquatic resources of the project area are not expected to change significantly from existing conditions. Since current levee operations and maintenance activities would continue as is, and there would be no change in the geomorphic or flood control regimes, resident and migratory wildlife would continue to use the area as they do today.

Because no levee improvements would be made under the No Action Alternative, the risk that the levees along the west bank of the Feather River could fail due to seepage or slope stability/geometry issues would continue. A catastrophic levee failure would result in flooding and inundation that could significantly affect wildlife and their upland or wetland habitats. A

major flood event could result in damage to the riparian forest, and given the importance of the riparian corridor to numerous special-status species, loss or fragmentation of this habitat would be a significant effect. Given the uncertainty of the occurrence or magnitude of such an event, potential effects on wildlife and their habitats cannot be quantified based on the available information.

Fisheries

Under the No Action Alternative, the aquatic resources of the project area are not expected to change significantly from existing conditions. Since current levee operations and maintenance activities would continue as is, and there would be no change in the geomorphic or flood control regimes, resident and migratory fishes would continue to use the area as they do today. Compliance with the Corps levee vegetation policy could lead to permanent loss of woody vegetation which would result in a significant effect on riparian habitat.

Because no levee improvements would be made under the No Action Alternative, the risk that the Feather River levee could fail and cause major damage would be greater. If the levees were to fail, it could result in the displacement of fish into flooded areas where the potential for stranding and mortality is high. In addition, flooding could cause adverse water conditions due to hazardous materials being released, which could adversely affect fish populations.

FUTURE CONDITIONS WITH THE PROJECT

Vegetation and Wildlife

Given the similarities in all the alternatives the following discussion on vegetation and wildlife applies to all the alternatives. Where there are substantial differences in the alternatives they are discussed below.

Habitat losses would occur linearly along the 41 miles of levee. Currently the position of the levee varies in distance from the river, with a minimum of the levee and bank of the river being the same to a maximum of about 5,000 feet. Using a GIS layer of the footprint of the various alternatives and measuring the lengths of the levee, the Service calculated that about 11 discontinuous miles of levee would be constructed within 300 feet of the Feather River's edge. Because Alternatives 1, 2, and 3 footprints are almost exactly the same on the waterside of the levee the above number applies to all of these alternatives. The SB-8 alternative is longer by 2,250 linear feet; however, the above number would also apply to this alternative because the additional length of levee is more than 300 feet from the edge of the river. The SB-7 alternative is the shortest of all the alternatives with the total length of levee being about 23 miles. Of this about 7 discontinuous miles of riparian habitat would be removed within 300 feet of the edge of the Feather River. The majority of the riparian forest and riparian scrub shrub that would be removed due to any of the alternatives occurs on the waterside. Removing trees and shrubs along these discontinuous segments of riparian habitat where the stand widths are already narrow is a greater loss of the habitat and therefore a larger effect on the wildlife species that would be using this habitat. Narrowing of riparian corridors decreases the diversity of species and vegetative layers that wildlife species can use. Narrowing of riparian habitat could isolate some species that may require contiguous vegetated areas to move up and down the river course.

All of the alternatives address deficiencies in the levees primarily using cutoff walls and seepage berms which result in potential adverse effects on wildlife resources. Effects of construction on wildlife in the area include disturbance from construction activity and noise. Amphibian and reptile species typically are not as mobile as other types of wildlife. Consequently they have a greater chance of being killed during construction activities. Wildlife such as birds and mammals, typically respond to this type of activity by leaving the construction area. It is likely they would move into adjacent habitat outside of the zone of construction noise and disturbance. However they may be forced to move to less than optimal habitat conditions as other animals may have established territories in the surrounding habitat. Pre-construction nesting bird surveys would avoid disturbing or destroying any nests within the vegetation removal area and comply with the Migratory Bird Treaty Act.

Oak woodland would be minimally affected with SB-8 affecting, at most, 1.3 acres. Effects to species from the loss of this habitat would be similar to what is described above during construction. The loss of wetland types varies with alternative. Small farm canals would be filled for all alternatives due to the construction of the seepage berm adjacent to agricultural lands. The majority of these are small (about 3 feet wide) and only have water in them when the farmers irrigate their fields. While some bird species such as herons and egrets can use this habitat for foraging, the inconsistent water regime and yearly disturbance by the farmers keeps most vegetation out of the canals, thus they tend to not provide much habitat value for wildlife species. Alternative 2 is the only alternative affecting pond habitat. There is a privately owned pond at the lower end of the project area which would be filled due to construction of a seepage berm. The loss of this habitat would likely affect bird species such as herons, egrets, and waterfowl, and amphibian species such as toads and frogs. Given the location is on the landside of the levee and the surrounding landuse is predominately agricultural, this habitat type is not common in the area and would adversely affect native wildlife species.

Seasonal wetlands, open water, and tailing wetlands are affected in almost every alternative. This habitat is scattered along the project area, though the tailing wetlands are at the upper end of the project area near Thermalito Afterbay. These areas typically have frequent bird use as well as serve as habitat for native amphibians such as chorus frogs and spadefoot toad. Construction within and around these areas would adversely affect these wildlife species through the direct loss of habitat as well as effects to species using surrounding areas due to noise and construction activity.

Because the construction would be accomplished over a 4-year period and along a long linear footprint and adjacent habitat in the form of riparian forest and scrub shrub would remain unaffected due to the project, it is likely the birds and mammals not dependent on woody vegetation would move back into the area once construction is completed. Species which rely on riparian vegetation would experience a loss of habitat within the corridor. The Corps and SBFCA would mitigate for the loss of riparian habitat by creating the Star Bend Conservation Area. However, there would be a temporal loss of habitat for all of the alternatives until the habitat grows mature enough to be habitat for certain species. For example raptors require large trees to build nests in; the trees at the Conservation Area may not reach a suitable size until 20 or more years post-planting. Species such as woodpeckers which require snags would not have that habitat available to them for a longer period of time. Once established and maturing, new

riparian habitat at Star Bend Conservation Area would connect existing riparian habitat within the corridor providing better connectivity and dispersal corridors than what currently exist.

Effects to ruderal habitat would be primarily temporary, with the habitat disturbed and replaced within a year. However; with SB-7 and SB-8, the Corps is proposing to place 5,760 linear feet and 7,660 linear feet respectively of erosion protection on the landside of the levee face. This would prevent erosion in the event of a levee overtopping. Placement of this material would prevent this area from being used by ground burrowing animals such as ground squirrels. While much of the surrounding area would still be available for these animals, the animals that depend on these burrows may find this loss detrimental since species such as giant garter snakes and burrowing owls do not create burrows themselves, but rely on other species to create them.

Table 1 summarizes the affected habitat types by Alternative.

Table 1. Acreages of Habitat Types Affected by Alternative

Habitat Type	Alternative 1	Alternative 2	Alternative 3	SB-7	SB-8
Riparian Forest	17.83	26.67	22.19	24.40	42.00
Riparian Scrub Shrub	0.39	3.09	1.29	0.02	0.50
Oak Woodland	0.22	0.24	0.22	1.00	1.30
Canal/Ditch	24.96	27.54	.21	1.4	7.1
Pond/Basin	0.00	1.91	0.00	0.00	0.00
Stream/River	0.00	0.00	0.00	0.02	1.9
Tailing Wetlands	0.14	0.58	0.13	0.00	0.13
Seasonal Wetlands	0.18	0.19	0.03	0.18	0.18
Open Water	0.17	0.62	0.04	0.19	0.19
Orchards	223.38	666.70	101.71	37.80	85.80
Field and Row Crops	17.42	92.03	4.76	0.70	3.80
Ruderal	522.01	559.87	550.80	395.50	552.00
Developed	222.40	259.56	196.00	125.00	199.00

Fisheries

Riparian habitat provides nutrients to the water which supports the feeding of many fish species. When immediately adjacent to the water, riparian habitat can provide shade and structure for fish to use for escaping higher velocity flows and predators. The loss of this type of habitat would adversely affect fish species. Other effects include increases in turbidity and suspended sediment due to construction activities, possible contaminant discharge from the construction equipment, and adverse effects caused by construction noise and vibration. Only certain reaches of the project are immediately adjacent to the river. Over the course of the 41 miles, about 11 miles of levee come within 300 feet of the Feather River. It is at these locations where vegetation loss

and its effects to fishes are most critical. In the other locations the remaining riparian vegetation can serve as a buffer and minimize effects to sediment making its way into the river. Where the buffer is lacking, the loss of vegetation would affect the addition of nutrients through leaf drop to the water. In these locations the vegetation loss would not be replaced by creating habitat at Star Bend Conservation Area. However, Star Bend Conservation area is adjacent to the river and a wider band of riparian habitat would be planted along the 1,250 linear feet which borders the Feather River. Ultimately, at the widest point, a 1,250 wide band of riparian habitat would be created at the Star Bend Conservation Area.

Endangered Species

The Corps and SBFCA have completed section 7 consultation with the Service on Alternative 3 of the FRWLP (Appendix A). Consultation with CDFW under California Endangered Species Act (CESA) needs to be completed to determine the effects of this project on State listed species.

DISCUSSION

The Service would like to comment on the lack of incorporating a setback levee into any of the alternatives. All of the current alternatives consist of fixing the existing levee in place. Setting the levee back in strategic locations would benefit both fish and wildlife species, by creating more floodplain habitat, as well as the flood system by increasing channel capacity and decreasing maintenance by lessening levee erosion. While the Service appreciates the attempts to minimize effects to existing habitat, we would like to see active movement toward creating a sustainable, reliable, and resilient flood and riparian system. Would the current levee alignment that is being improved in place be able to withstand changing future conditions such as climate change? While the EIS/EIR addresses climate change it does not address the ability of the flood control system to adapt to climate change and potentially the different precipitation patterns which may occur. DWR's Central Valley Flood Protection Plan also outlines the goals for flood control projects that DWR participates in. One of the secondary goals is promoting ecosystem restoration. Inclusion of setback levees into this project would help DWR progress on that goal as well as meet DWR's Environmental Stewardship Policy. Both SBFCA and the Corps should consider looking at opportunities to expand the floodway and include these within the selected alternative.

The Service's primary concern with the effects to fish and wildlife is the loss of riparian and wetland habitats. These habitat types would have the largest native habitat loss in each alternative. SBFCA completed section 7 consultation on Alternative 3 for species listed under the Service's jurisdiction. This Alternative avoids as much vegetation removal as possible by working around vegetation when possible. Additionally, it minimizes temporary effects to habitats such as canals/ditches and various waters by limiting the amount of time they are disturbed and restoring them once the construction in the area is completed. Any permanent effects to native habitats, riparian, oak woodland, and seasonal wetlands should be mitigated. To mitigate effects to wetlands SBFCA has proposed to buy credits at a wetland mitigation bank at a ratio of 2:1. The Service concurs this would mitigate the effects to wildlife species due to the loss of wetland habitat.

To offset the loss of riparian forest, riparian scrub, and oak woodland, SBFCA has calculated the total diameter at breast height (dbh) of all native trees which would be removed due to the project. They have proposed to plant a variety of native seedlings at the Star Bend Conservation Area to create a diverse riparian habitat which would restore 28 acres of ruderal floodplain habitat to riparian habitat. Restoration of this area would expand riparian habitat within the area because it is immediately upstream of the O'Connor Lakes Unit of the Feather River Wildlife Area which has had riparian habitat planted within the last 10 years. The Service believes the restoration of this area would mitigate for some of the effects to the loss of riparian and oak woodlands; however, the Service does not agree that the 28 acres adequately mitigates for the entire loss. Many large trees would be removed as a result of the project. The trees planted to mitigate this impact would not reach the size of the some of the affected oak, cottonwood, and sycamore trees for 50 years. To mitigate the loss of this habitat for wildlife species the Service believes that a ratio of at least 2:1 should be used to mitigate the loss of riparian forest, riparian scrub shrub, and oak woodland. Even with the increase in riparian habitat within the Feather River Corridor with the Starbend Conservation Area there will still be a temporal loss to species that use large trees for nesting, foraging, or sheltering. The additional acreages should be found within the 41 mile proposed project area in order to maintain or benefit connectivity of the riparian corridor along the Feather River.

The Service also has concerns about effects to wildlife and fish due to ongoing operation and maintenance (O&M) of the flood control facility. Under the SBFS, the Corps has included O&M as part of the project description. The FRWLP is not proposing to change existing O&M activities and therefore they have not covered these activities in their project description. Currently, effects to federally threatened and endangered species due to O&M activities have not been analyzed. As the Corps is a federal agency that requires DWR and the local maintaining agencies to operate and maintain the flood control structures according to the federal guidelines, the Corps should initiate section 7 on these activities if there are effects to listed species. The Service feels that some of the ongoing O&M activities are likely to adversely affect the valley elderberry longhorn beetle and giant garter snake in this area. Should the Corps reinitiate section 7 consultation for the SBFS, they should include O&M activities in the reinitiation. Additionally, the Corps should provide information regarding O&M to the Service so we can update this Fish and Wildlife Coordination Act report and include effects to fish and wildlife due to O&M activities. Should the Corps not reinitiate section 7 consultation under the SBFS they should initiate section 7 consultation with the Service for ongoing O&M activities given their role as a federal agency and their discretion over the O&M manual.

RECOMMENDATIONS

If the project is constructed, the Service recommends that the Corps implement the following:

1) Mitigate the loss of any natural habitat types (riparian forest, riparian scrub shrub, oak woodland, wetland, pond, canal, stream) at a ratio of at least 2:1.

2) Should the Feasibility Study move forward the Corps should work with DWR and SBFCA to develop a variance to allow vegetation within the Corps' vegetation free zone to remain in place.

3) Work with the Service on the development of the mitigation area.

4) Lands disturbed by construction activities, including the staging areas, should be reseeded with native grasses and forbs. Reseeding should be conducted just prior to the rainy season to enhance germination and plant establishment.

5) Conduct pre-construction surveys for breeding birds including the State listed Swainson's hawk and burrowing owl.

6) Develop and implement a vegetation monitoring program as part of the project. Monitoring the riparian restoration effort should focus on (a) recording tree survival rates, (b) the quantification of improved habitat values for wildlife (primarily bird species) by measuring percent tree and shrub cover, average height of overstory trees, canopy layering, and total woody riparian vegetation, and (c) developing recommendations for alternative methods of riparian restoration should initial efforts fail. A vegetation monitoring report should be submitted annually for the first 5 years after planting activities, and on the 10th, 15th, and 20th year after planting. The monitoring reports should also identify any shortcomings in the restoration effort and include remedial actions on how to improve restoration efforts. All phases of the revegetation, and monitoring programs should be coordinated with, and approved by, the Service, CDFW, and NOAA Fisheries.

7) Comply with the Conservation Measures and Terms and Conditions in the biological opinion (Appendix A).

8) Complete the appropriate consultation with the CDFW regarding impacts to State listed species, and NOAA Fisheries, as required under section 7 of the Endangered Species Act, for potential impacts to anadromous fish under NOAA Fishery's jurisdiction.

9) SB-7 or SB-8 (depending on the alternative selected) should mitigate for the loss of upland habitat lost due to erosion protection. Effects resulting from this action should be discussed both under the FWCA as well as the federal and State endangered species acts.

10) Initiate section 7 consultation with the Service on the effects of O&M activities to federally listed species.

Appendix A

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Sacramento Fish and Wildlife Office
2800 Cottage Way, Room W-2605
Sacramento, California 95825-1846

In Reply Refer To:
08ESMF00-2013-F-0342-1

MAY 02 2013

Ms. Alicia Kirchner
Chief, Planning Division
U.S. Army Corps of Engineers, Sacramento District
1325 J Street
Sacramento, California 95814

Subject: Formal Consultation on the Feather River West Levee Project, Sutter County, California

Dear Ms. Kirchner:

This is in response to your March 22, 2013, request for formal consultation with the U.S. Fish and Wildlife Service (Service) on the Feather River West Levee Project (FRWLP) (proposed project) in Sutter County, California. Your request was received on March 28, 2013. You requested our concurrence that the proposed project may affect, and is likely to adversely affect the federally-listed as threatened valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*)(beetle) and the giant garter snake (*Thamnophis gigas*)(snake). The Service concurs with your determination and this biological opinion addresses the effects of the proposed projec: on these two species. Critical habitat has been designated for the beetle; however, the proposed project is not located within any designated or proposed critical habitat. Critical habitat has not been designated for the snake; therefore, none will be affected. This response is in accordance with section 7(a)(2) of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*) (Act).

This biological opinion is based on information provided in the U.S. Army Corps of Engineers' (Corps) letter requesting consultation and their biological assessment. A complete administrative record is on file at the Sacramento Fish and Wildlife Office.

CONSULTATION HISTORY

July 13, 2012. The Service, ICF International, HDR Inc., consultants to Sutter Butte Flood Control Agency (SBFCA), SBFCA, California Department of Fish and Wildlife (CDFW), California Department of Water Resources, and the Corps participated in a site visit to the proposed project. Potential effects to giant garter snake were discussed on the trip.

September 27, 2012. The Service, Corps, HDR, and ICF met to discuss the biological opinion and the level of detail that will be available in order to initiate consultation. The applicant determined that they will have sufficient information to initiate consultation at the project level.

December 18, 2012. The Service, Corps, SBFCA, ICF, and HDR met to discuss effects to giant garter snake. Permanent and temporary effects were discussed as well as the Service providing suggestions on conservation measures that could be incorporated.

February 12, 2013. The Service, Corps, ICF, CDFW, and HDR met to discuss long-term operations and maintenance (O&M). The outcome of this meeting was that the SBFCA FRWLP will not include operations and maintenance in their project description because their project will not be changing O&M. However, the Corps will be initiating consultation on the Sutter Feasibility Study in the next 6 months and this project description will include O&M activities.

March 22, 2013. The Corps initiated section 7 consultation with the Sacramento Fish and Wildlife Office.

BIOLOGICAL OPINION

DESCRIPTION OF ACTION AREA

North to south, the Action Area consists of the 41-mile corridor along the west levee of the Feather River from the Thermalito Afterbay to a point about 4 miles north of the Sutter Bypass. The Action Area includes the project construction area and a 100-foot buffer around this area which includes staging and spoils areas. The project construction area was defined as the area in which levee improvements—such as seepage berms, stability berms, relief wells, sheet-pile walls, and slurry cutoff walls—are likely to be constructed. All direct and indirect effects will occur within this area and the 100-foot buffer around this area.

The corridor is divided into 41 relatively homogeneous reaches for ease of describing existing conditions, project components, land cover-types, and potential effects (note that this number is coincidental and one reach does not correspond to a length of 1 mile; additionally, Reach 1 is not part of the FRWLP) (Figure 1).

The Action Area also includes six potential borrow sites that could supply the borrow material necessary for levee construction and upgrades, and routes from the project construction area to the borrow sites. It is not anticipated that all six sites will be used over the multi-year phased construction period, but until additional geotechnical and soil samplings are completed, all sites will be available for use and are included in the Action Area.

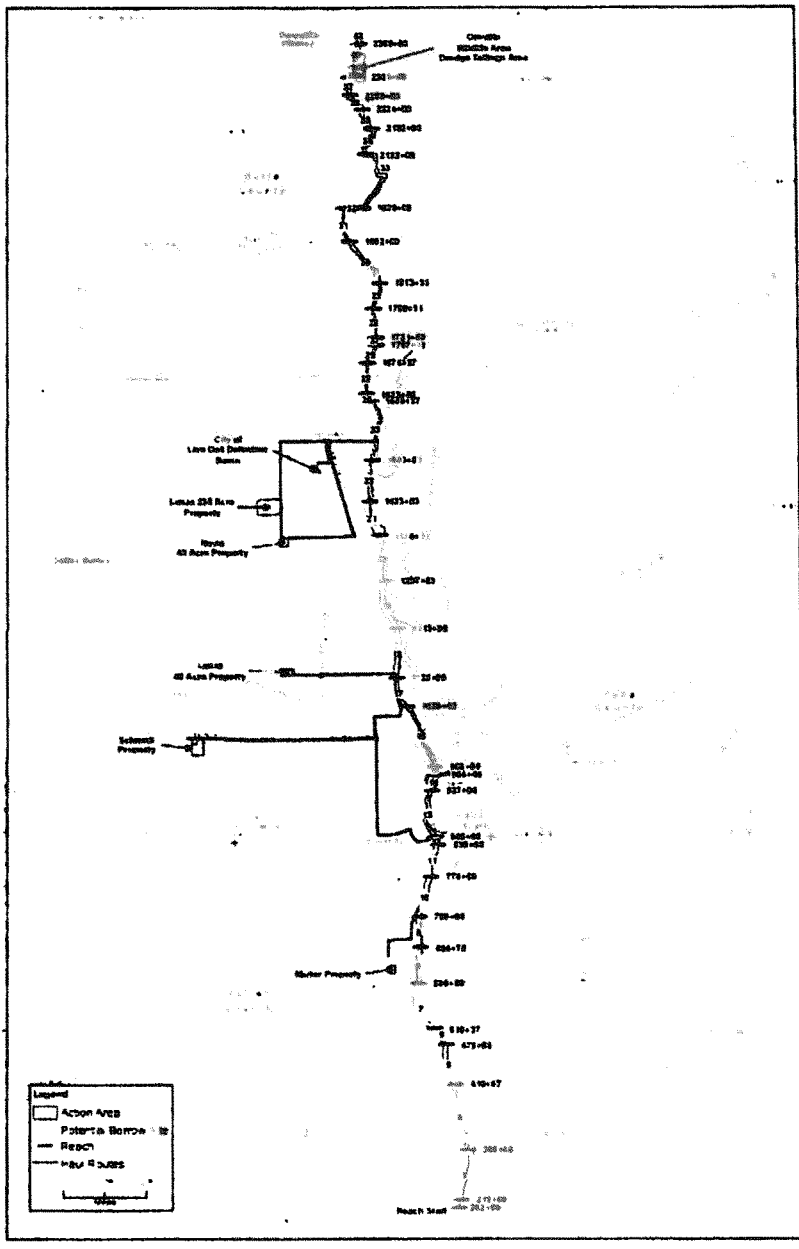

Figure 1. Proposed Project

Finally, the Action Area includes the existing 48.5-acre Star Bend Conservation Area, located on the west levee of the Feather River, about 6 miles south of Yuba City. Compensation for the Proposed Action's effects on the beetle is proposed to occur in a portion of this conservation area, which is discussed below under Conservation Measure 5.

Description of Proposed Action

The primary purpose of the FRWLP is to reduce flood risk in the Sutter Basin by addressing known levee deficiencies along the Feather River West Levee from Thermalito Afterbay downstream to a point about 4 miles upstream of the Feather River's confluence with the Sutter Bypass. While the FRWLP will not by itself reduce all flood risks affecting the Sutter Basin, it will address the most immediate risks based on the following.

- The proximity of the Feather River to population centers and key infrastructure.
- The nature of the Feather River West Levee being the longest and most contiguous portion of the planning area perimeter.
- The location of known levee deficiencies and the clarity and feasibility of available measures to address them.

The construction of the FRWLP will be divided into four separate construction contracts. Contract A begins near the intersection of the Feather River West Levee and Laurel Road. It continues north to the beginning of the improvements constructed as part of the Star Bend Setback Levee Project. The total length of the levee in this portion of the FRWLP is 27,618 linear feet. Contract B begins at the end of the improvements constructed as part of the Star Bend Setback Levee Project, and continues north for 31,963 linear feet. Contract C begins near the north end of the Shanghai Bend Setback Levee, and continues north for a total of 77,886 linear feet. Contract D then begins and continues north for 69,363 linear feet.

For Contract A, a cutoff wall ranging between 10 and 35 feet deep will be constructed along the centerline of the levee for the entire length of levee. The overall height of the levee will be degraded by about 50%. In addition to the cutoff wall, a portion of the levee will have a 9,816-foot-long; 100-foot-wide seepage berm installed.

For Contract B, a cutoff wall ranging between 5 and 25 feet deep will be constructed along the centerline of the levee for 31,600 linear feet. The overall height of the levee will be degraded by about 50%. Relief wells 60 feet apart and 50 feet deep will be installed along a 2,500 linear foot section. Finally, two small sections will involve pipe crossing work.

For Contract C, a cutoff wall ranging between 5 and 65 feet deep will be constructed along the centerline of the levee for 62,117 linear feet. The overall height of the levee will be degraded by about 50%, with about 5,900 linear feet of the levee needing to be fully degraded. A 7-foot tall

and 50-foot-wide seepage berm will be placed near the 10th Street bridge and extend through the existing abandoned railroad tunnel. Finally, there will be a few storm drain pipes replaced within the levee.

For Contract D, a cutoff wall ranging between 10 and 90 feet deep will be constructed along the centerline of the levee for 57,361 linear feet. For all but 317 linear feet of levee, the levee will be degraded by about 50%. The remaining 317 linear feet will have a full levee degrade and reconstruction. A canal runs adjacent to the landside of the levee for 4,723 feet. The landside levee will require reconstruction to the bottom of the canal. Six storm drain and irrigation pipes will need to be replaced along a section of the levee. About 4,800 linear feet of seepage berm will be constructed at the northern end of the proposed project. The berm will very in width between 100 and 170 feet. Additionally, a waterside pit located in this area will be filled.

Materials imported to the construction site will include water, bentonite, cement, incidental construction support materials, aggregate base rock, hydroseed, and up to 1,500,000 cubic yards of embankment fill material for the new levee surfaces from offsite commercial borrow sites or local landowners willing to sell borrow material. For backfill of new pipelines crossing the levee, controlled low strength material (CLSM) (otherwise known as lightweight concrete) will be placed to the pipeline's spring line.

Construction methods for the flood management measures are described in detail below.

Slurry Cutoff Wall

A slurry cutoff wall consists of impermeable material that is placed parallel to the levee, typically through the center of the levee crown. There are three methods for constructing a slurry cutoff wall: (1) conventional slot trench, (2) deep soil mixing (DSM), and (3) jet grouting. The first two are the primary methods for application over longer areas, while jet grouting is a spot application based on limiting conditions. A slurry cutoff wall addresses the deficiency of seepage (through- and under-seepage).

Conventional Slot Trench Method - To begin construction, the construction site and any necessary construction staging or slurry mixing areas are cleared, grubbed, and stripped. In the conventional slot trench method, a trench is excavated at the top center of the levee and into subsurface materials. The size of the trench is based on the severity of the seepage but can be typically 3 feet wide and up to 80–90 feet deep. As the trench is excavated, it is filled temporarily with bentonite water slurry to prevent cave-in. The soil from the excavated trench is hauled to a nearby location where it is mixed with hydrated bentonite to reduce permeability and cement in some applications where increased strength is desired. The soil-bentonite mixture then is returned to the levee and backfilled into the trench. This mixture hardens and creates the impermeable barrier wall in the levee.

In most cases, degradation of the levee crown is necessary to create a large enough working platform to reduce the risk of hydraulic fracturing from the insertion of slurry fluids, and allowing greater depths to be reached. Dependent on the conditions of the particular levee, it may be necessary to degrade the levee by one- to two-thirds its existing height. The material

from degrading the levee is hauled to a nearby stockpile area. Following completion of the slurry cutoff wall, the material is hauled back to the levee to restore the levee to its original dimensions. The material may need to be hauled offsite to a local landfill, and borrow material may need to be imported if the in-situ levee material is found to be unsuitable for current levee standards.

One construction crew typically is able to construct 75–100 linear feet of slurry wall (about 70–80 feet deep) in an 8-hour shift. Equipment needed for the crew includes a long-reach track hoe, three or four dump trucks (15 cubic yard capacity each), two loaders at the mixing location, bulldozers, excavators, loaders, a rough terrain forklift, compactors, maintainers, and a water truck. Vertical clearance of about 40 feet is needed for the excavator boom. Horizontal clearance of about 30 feet beyond the levee crest may be required for excavator swing when loading dump trucks.

A mixing area is located at the construction staging area. The mixing area is to prepare the soil-bentonite mixture and supply bentonite-water slurry. The mixing area is contained to avoid inadvertent dispersal of the mixing materials. Dump trucks haul material between the excavator and the mixing area along the levee.

An access road made of aggregate base rock is constructed on the levee crown to enable regular levee inspections. Post-construction, areas used for construction staging, mixing, the levee crown, slopes, and any other disturbed areas are hydroseeded.

Deep Soil Mixing Method - The DSM method of constructing a slurry cutoff wall uses a crane-supported set of two to four mixing augers (typically 36 inches in diameter) set side by side. These augers are drilled through the levee crown and foundation to the required depth (capable of a maximum depth of about 200 feet). As the augers are inserted and withdrawn, a soil-bentonite grout is injected through the augers and mixed with the native soil. An overlapping series of mixed columns is drilled to create a continuous seepage cutoff barrier.

To provide a wide enough working platform on the levee crown, the upper portion of some segments of the levee requires excavation with a paddle wheel scraper. Material is scraped and stockpiled at a nearby stockpile area. Dependent on the depth of the wall required, vertical clearance for the crane also may be needed. An excavator manipulates injector return spoils near the DSM rig, and transport trucks are used to haul spoils offsite. A crane is used for in-place sampling of DSM material and also for loading bentonite into the batch plant hopper. A mobile batch plant (diesel-powered) is required near each DSM rig at the work area to prepare the cement-bentonite grout. The grout is transported to the DSM rig through flexible hoses. Each batch plant requires a pad of 50 by 100 feet. Hauling at the work area involves scraper runs along the levee to the staging area and cement and bentonite deliveries to the batch plant.

During DSM slurry wall construction, one DSM rig typically can construct 50 linear feet of DSM wall per 8-hour shift (for wall depths up to 135 feet). Post-construction, areas used for construction staging, the levee slopes, and any other disturbed areas are hydroseeded.

Jet Grouting Method - Jet grouting involves injecting fluids or binders into the soil at very high pressure. The injected fluid can be grout; grout and air; or grout, air, and water. Jet grouting breaks up soil and, with the aid of a binder, forms a homogenous mass that solidifies over time to create a mass of low permeability. Jet grouting typically is used in constructing a slurry cutoff wall to access areas other methods cannot. In this regard, it is typically a spot application rather than a treatment to be applied on a large scale along an entire reach.

Equipment required for jet grouting consists of a drill rig fitted with a special drill string; a high pressure, high flow pump; and an efficient batching plant with sufficient capacity for the required amount of grout and water. The high-pressure pump conveys the grout, air, and/or water through the drill string to a set of nozzles located just above the drill bit. The diameter of the jet grout column is dependent on site-specific variables such as soil conditions, grout mix, nozzle diameter, rotation speed, withdrawal rate, and grout pressure. Jet grouted columns range from 1 to 16 feet in diameter and are typically interconnected to form cutoff barriers or structural sections. Under ideal conditions, one construction crew—consisting of a site supervisor, pump operator, batch plant operator, chuck tender, and driller—can construct two 6-foot diameter, 50-foot columns per day consisting of about 100 cubic yards of grout injected per 8-hour shift. Ideal conditions will be characterized by no technical issues occurring at either the batch plant or the drilling site, such as loss of fluid pressure, breakdown of equipment, or subsurface obstructions to drilling operations.

To initiate jet grouting, a borehole is drilled through the levee crown and foundation to the required depth (to a maximum depth of about 130 feet) by rotary or rotary-percussive methods using water, compressed air, bentonite, or a binder as the flushing medium. When the required depth is reached, the grout is injected at a very high pressure as the drill string is rotated and slowly withdrawn. Use of the double, triple, and superjet systems create eroded spoil materials that are expelled out of the top of the borehole, this material is frequently used as a construction fill.

To provide a wide enough working platform on the levee crown, the upper portion of some segments of the levee may require degradation with a paddle wheel scrapper. Material is scraped and stockpiled at a nearby stockpile area. Hauling at the work area involves scraper runs along the levee to the staging area and grout, bentonite, and water deliveries to the batch plant.

Batch plants are typically centrally located to the injection site, with pipelines for mixed grout that run the length of the work. Grout mixing and injection equipment consists of grout mixers, high powered grout pumps and supporting generators and air compressors, holding tanks, and water tanks, with bulk silos of grout typically used to feed large mixers. Smaller equipment can be used in combination with the single phase-fluid system and can be permanently trailer-mounted to permit efficient mobilization and easy movement at the job site.

Prior to commencing production jet grouting, a field test program is typically completed to evaluate injection parameters and to assess jet grout column geometries, and mechanical and permeability properties. Where possible, jet grout test elements are exposed by excavation and properties are obtained by direct measurement. Where excavation is not possible, core drilling is employed to obtain samples from the jet grout test columns for strength testing.

Areas used for construction staging, the levee slope, and any other disturbed areas are restored and hydroseeded following construction.

Slope Flattening

Slope flattening is a mechanical method to repair or reshape slopes that do not meet standards for geometry and stability. Levee slopes are typically subject to a standard of 3:1 (horizontal to vertical), but this may vary based on site-specific conditions and supporting engineering analysis. Slope flattening addresses the deficiency of slope stability and geometry. To begin slope flattening activities, the area is cleared, grubbed, and stripped to provide space for construction and reshaping of slopes. Additional embankment fill material may be necessary to achieve slope flattening—if so, bulldozers excavate and stockpile borrow material from a nearby permitted borrow site. Front-end loaders load haul trucks with the borrow material. The haul trucks transport the material to slope flattening site. Motor graders spread material evenly according to levee design plans, and sheepsfoot rollers compact the material. Water trucks distribute water over the material to ensure proper moisture for compaction.

To reshape a waterside slope, the existing crown of the levee is shifted farther landward and the waterside slope is trimmed and reshaped to a 3:1 slope. The shifted levee crown will be a minimum of 20 feet wide, with a 3:1 slope on the landward side. An access road made of aggregate base rock is constructed on the levee crown. Post-construction, the construction staging areas, levee slopes, and any other disturbed areas will be hydroseeded.

Stability Berm

A stability berm will be constructed against the landside slope of the existing levee with the purpose of supplying support as a buttress. The height of the stability berm is generally two-thirds the height of the levee; the structural needs of the levee determine the distance it extends along that reach. A stability berm addresses the deficiency of stability. To begin the construction of a stability berm, the site is cleared, grubbed, and stripped to provide space for construction and shaping of the berm. Embankment fill material necessary to construct the berm is excavated by a bulldozer from a nearby borrow site. Front-end loaders load haul trucks with the borrow material, and the haul trucks transport the material to the stability berm site. Motor graders spread the material evenly according to design specifications, and a sheepsfoot roller compacts the material. Water trucks distribute water over the material to ensure proper moisture for compaction.

Stability berms may be drained or undrained. An undrained berm consists of embankment fill only. A drained berm includes a layer of drain rock placed along the ground surface underneath the fill material, separated by a casing of filter fabric. Drainage water seeping from the berm will sheetflow on the adjacent landside surface.

Levee Reconstruction

Levee reconstruction will be necessary where a levee has been degraded to facilitate implementation of another measure (such as a slurry cutoff wall), where a substantial

encroachment has been removed from within the levee prism, or otherwise where the levee is found to be deficient and needs to be replaced with materials and methods that meet current engineering standards. The existing levee is first cleared, grubbed, and stripped to the desired surface to allow a working platform for other measures (such as a slurry cutoff wall), to remove an encroachment, or to remove substandard material. Embankment fill material necessary to construct the new levee is excavated by a bulldozer from a nearby borrow site. Front-end loaders load haul trucks with the borrow material and the haul trucks transport the material to the stability berm site. Motor graders spread the material evenly according to design specifications, and a sheepsfoot roller compacts the material. Water trucks distribute water over the material to ensure proper moisture for compaction. The new levee will be built in cross section to meet current engineering standards.

Sheet-Pile Wall

A sheet-pile wall is a series of vertical panels of interlocking steel that is placed parallel to the levee, typically through the center of the levee crown to provide an impermeable barrier. A sheet-pile wall addresses the deficiencies of seepage and will be used only as a site-specific treatment (rather than applied on a reach-wide basis) such as at roadway or railroad crossings. The site where sheet piles are to be installed is cleared, grubbed, and stripped to allow for construction activities, including removal of the roadway or railroad. A hydraulic- or pneumatically-operated pile-driving head attached to a crane drives the sheet pile into the levee crown to the desired depth (up to 135 feet). If the levee material is particularly solid, pre-drilling may be necessary. The conditions of the site and the desired life of the project determine the thickness and configuration of the sheet piles.

Post-construction, construction staging areas, the levee crown, slopes, and any other disturbed areas are hydroseeded and the roadway or railroad will be replaced in-kind to the pre-project condition.

Seepage Berm

Seepage berms are wide embankment structures made up of low-permeability materials that resist accumulated water pressure and safely release seeping water. A seepage berm is typically one-third the height of the levee, extending outward from the landside levee toe for 300–400 feet, and laterally along the levee as needed relative to the seepage conditions. A seepage berm addresses the deficiency of under-seepage. A seepage berm can vary in width, from a minimum of four times the levee height to a maximum of 300 feet. Berm heights can also vary but are typically a minimum of 5 feet tall at the landside toe of the levee and generally taper down to 3 feet at the end of the berm.

Construction consists of clearing, grubbing, and stripping the ground surface. Bulldozers then excavate and stockpile borrow material from a nearby borrow site. Front-end loaders load haul trucks, and the haul trucks subsequently transport the borrow material to the berm site. The haul trucks dump the material and motor graders spread it evenly, placing 3–5 feet of embankment fill material. Sheepsfoot rollers compact the material, and water trucks distribute water over the material to ensure proper moisture for compaction.

Seepage berms may have an optional feature of a drainage relief trench under the toe of the berm. Drained seepage berms include the installation of a drainage layer (gravel or clean sand) beneath the seepage berm backfill and above the native material at the levee landside toe. A drained seepage berm does not increase the overall footprint of the berm. Post-construction, areas used for construction staging, the levee, the berm, and any other disturbed areas are hydroseeded.

Relief Wells

Relief wells are passive systems that are constructed near the levee landside toe to provide a low-resistance pathway for under-seepage to exit to the ground surface in a controlled and observable manner. A low-resistance pathway allows under-seepage to exit without creating sand boils or piping levee foundation materials. Relief wells are an option only in reaches where geotechnical analyses have identified continuous sand and gravel layers. Relief wells are constructed using soil-boring equipment to drill a hole vertically through the fine-grained blanket layer (sand) into the coarse-grained aquifer layer (gravel) beneath. Pipe casings and gravel/sand filters are installed to allow water to flow freely to the ground surface, relieving the pressure beneath the clay blanket without transporting fine materials to the surface, which can undermine the levee foundation. Relief wells will be designed to discharge onto a cobble splash, and the water will then sheet flow into adjacent agricultural fields. In areas where sheet flow is not feasible, a swale will be excavated and connected to a drainage canal.

Relief wells generally are spaced at 50- to 100-foot intervals, dependent upon the amount of under-seepage, and extend to depths of 150 feet. Areas for relief well construction are cleared, grubbed, and stripped. During relief well construction, a typical well-drilling rig is used to drill to the required depth and construct the well (including well casing, gravel pack material, and well seal) beneath the ground surface. The drill rig likely will be an all-terrain, track-mounted rig that could access the well locations from the levee toe.

Piezometers, also called monitoring wells, could be installed between relief wells to allow monitoring of groundwater levels to ensure the wells are relieving the pressure within the aquifer.

Areas along the levee toe may be used to store equipment and supplies during construction of each well. Construction of each well and the lateral drainage system typically takes 10–20 days. Additional time may be required for site restoration. Post-construction, areas used for construction staging, the levee slopes, and any other disturbed areas are hydroseeded.

Depression/Ditch Infilling

Landside depressions and ditches can contribute to risk of levee failure if a seepage pathway forms under the levee and the water then surfaces through the depression or ditch, exploiting its less resistive nature compared to surrounding soil mass. This measure involves placing fill soil in such depressions and ditches to remove localized susceptibility to seepage. Construction consists of clearing, grubbing, and stripping the ditch or depression surface to remove vegetative material. Bulldozers then excavate and stockpile borrow material from a nearby borrow site.

Front-end loaders load haul trucks, and the haul trucks subsequently transport the borrow material to the fill site. The depression or ditch may be further excavated to provide a surface that the fill soil may be keyed into. The haul trucks dump the material and motor graders or bulldozers smooth the material level with the surrounding land surface. An excavator may also be used for placement. Sheepsfoot rollers compact the material, and water trucks distribute water over the material to ensure proper moisture for compaction.

Removal and Relocation of Pacific Gas & Electric Facilities

Prior to and/or concurrent with levee rehabilitation construction, Pacific Gas and Electric Company (PG&E) will need to remove and relocate facilities located within the footprint of the FRWLP. PG&E's utility relocations will need to occur in advance of SBFCA's construction activities at any given location. Construction sequencing for SBFCA's work will be dynamic throughout SBFCA's project planning and design. PG&E's construction schedule will be determined by further engineering to clarify and determine efficacy of site-specific measures; the availability of funding for FRWLP; easement and right-of-way acquisition; availability of borrow material for the levee improvement activities; and/or environmental clearances based on wildlife presence, lifecycle activity, and location of habitats. PG&E's construction schedule will be further influenced by utility operation and maintenance constraints, particularly for relocation activities that require taking existing facilities temporarily out of service. As necessary, geotechnical mitigation measures will be incorporated into construction design to ensure that utility facilities effectively co-exist with the FRWLP, relocation will be done where this is not feasible.

For PG&E's electrical transmission and distribution activities, PG&E will install and remove new electrical transmission and distribution poles. Electrical transmission and distribution pole removal is conducted by a line crew, who typically access each pole site with a line truck and trailer or a boom truck, except in those instances when the pole is located on the levee crown (a crane may be used in those instances). On average, removal of vegetation up to 50 feet from the toe of the levee will need to occur to accommodate pole installation activities; this distance may be greater in instances where the installation activity is located further than 30 feet from the levee toe. After vegetation is cleared, PG&E will remove and replace the existing wood distribution and power poles and related equipment.

For PG&E's natural gas transmission and distribution activities, PG&E will install gas transmission and distribution steel pipe. This also typically includes the removal and disposal of existing pipe. Other typical types of gas transmission and distribution equipment that may be installed include Electric Test System/ Gas Cathodic Test System meter stations for future pipe monitoring purposes, and pipeline markers at angle points and at levee crossing locations. Clearing and grading operations in support of installation of natural gas facilities typically involve preparation of the right-of-way, including vegetation removal, debris disposal, and land leveling. Installation sites are backfilled using sand to create a 6-inch insulation zone around the pipe and then covered by native soil from the project area. In some instances, a crane may be required to place pipe at crossing sites located at the crowns of the levees. Dump trucks will be used to transport sand and soil materials. Spoil piles may be temporarily placed onsite while the installation activities are occurring.

Hydrostatic testing associated with installation of natural gas facilities will be performed to test the strength of the new pipeline. Test water intake and discharge will be performed in accordance with all regulations and permit requirements.

Typical electrical and natural gas transmission and distribution project work schedules are comprised of an average 9-hour day, at an average of 6 days per week per crew. Typical crews consist of 3 to 5 members.

PG&E work areas will be about 125 feet by 125 feet in diameter and located in close proximity to installation activity locations. On average, PG&E will require up to 10 work areas per contract phase. PG&E will utilize the work areas identified by SBFCA whenever possible. Typically, PG&E project access is achieved through existing public and private roads. Removal of vegetation to utilize access roads by PG&E equipment and transport of facilities may be required. PG&E currently owns easements along the entire project corridor. However, temporary and/or permanent easements as required for construction and maintenance of these facilities are being acquired by SBFCA.

Encroachment and Vegetation Removal

Encroachments - Existing facilities found within the footprint of an alternative may require removal and replacement nearby, abandonment, or relocation. Encroachments are numerous (over 400 identified) along the Feather River West Levee and may need to be addressed if they present a threat to the stability of the levee, do not currently comply with the levee encroachment criteria, or will be disrupted or otherwise impacted by construction activities. Typical encroachments include pressure pipelines (water supply pipelines from waterside pump stations and drainage pipelines from landside drainage pump stations), gravity drainage pipes, gas lines, telephone utilities, overhead utilities, structural encroachments, and other types and variations. Debris from structure and embankment fill material of poor quality will be hauled offsite to a permitted disposal site within 20 miles of the removal location.

Vegetation Removal - Vegetation removal will involve stripping of herbaceous (non-woody) vegetation by bulldozer. Vegetation will be removed only from within the direct construction footprint and the minimum areas necessary for staging and access. Consistent with the Central Valley Flood Protection Plan guidance for levee repair or improvement, vegetation will be removed to meet specific project objectives. Any vegetation removed as part of direct construction activities will not be replaced at that location, but will involve offsite, in-kind mitigation, to be determined in consultation with the appropriate resource agencies.

In accordance with the State of California's Urban Levee Design Criteria, at a minimum, all roots larger than 1.5 inches in diameter that are within 3 feet of the perimeter of the tree trunk will be removed. Immature trees less than 4 inches in diameter at breast height that will be removed may be cut off at or below ground level, generally without root removal. Any excavation will be

backfilled with engineered fill using appropriate placement, moisture conditioning, and compaction methods. Additional measures for removing non-compliant vegetation are listed below.

- Ensure that the resulting void is free of organic debris.
- Cut poles to salvage propagation materials for replanting, such as willows and cottonwoods.
- Conduct hand clearing using chainsaws and trimmers.
- Conduct mass clearing using bulldozers.

Debris from vegetation removal will be hauled offsite to a permitted disposal site within 20 miles of the removal location.

Construction Staging, Access, and Temporary Facilities

Staging areas will only be provided within the Action Area. Staging areas will be used for staging construction activities and to provide space to house construction equipment and materials, offices, employee parking, and other uses needed for construction of the proposed project.

To facilitate construction, temporary earthen ramps will be constructed for equipment access between the levee crown and the staging area(s). The earthen ramps will be removed when construction is complete.

Cutoff wall construction requires temporary establishment of an onsite slurry batch plant that will occupy about 1–2 acres. Batch plants will be located at about 1-mile intervals along the levee. The batch plant site will likely contain tanks for water storage, bulk bag supplies of bentonite, bentonite storage silos, a cyclone mixer, pumps, and two generators that meet air quality requirements. Slurry ingredients will be mixed with water and the mixture will be pumped from tanks through pipes to the construction work sites. The batch plant will produce two different slurry mixes, one for trench stabilization and one for the soil backfill mix. Therefore, two slurry pipes or hoses, typically 4- or 6-inch high-density polyethelene pipes, will be laid on the ground and will extend to all work sites. An additional pipe may be used to supply water to the work sites.

Staging, access, and other temporary construction areas will be located away from wetlands, woody vegetated areas, wildlife species habitat, known cultural resources, or other sensitive areas and will be limited to disturbed or ruderal grasslands subject to review by Corps and resource agencies.

Material Importation, Reuse, and Borrow

Materials imported to the FRWLP construction area will include water, bentonite, cement, incidental construction support materials, aggregate base rock, asphalt, concrete, hydroseed, and embankment fill soil. Large quantities of fill soil, or borrow will be required. To meet borrow demands, embankment fill material excavated as part of construction will be evaluated for reuse. Embankment fill material deemed suitable will be used as part of levee reconstruction and berms. The total volume of material required is 1,500,000 cubic yards.

SBFCA has explored the option of purchasing fill or borrow material from a local commercial quarry or other permitted source; however, there are not currently any sites near the Action Area that could supply the volume and type of material required. Consequently, SFBCA plans to purchase fill from local landowners willing to sell borrow material.

Six borrow sites have been identified in the Action Area. Each site was investigated to determine the quantity of available material, hauling distance, material composition, groundwater elevation, and prospects for acquisition. Sufficient fill volume is estimated to be present within an approximate 10-mile, one-way haul distance from the area of construction.

SBFCA will maximize the potential borrow sites' use through gradation, placement, and treatment so that they could continue to be used for their current use or otherwise returned to their pre-project condition. As part of borrow operations, the upper 4–6 inches of topsoil will be set aside and replaced after construction in each construction season. After the FRWLP is completed, the borrow site will be re-contoured and reclaimed.

Through outreach efforts, SBFCA identified a number of sites owned by individuals or government agencies willing to sell their property or provide material on a cubic yard basis. Each borrow site is described below.

North Valley Property - The North Valley property is owned by North Valley Properties, LLC and is located south of Ella Road between Feather River Boulevard and Arboga Road. The Wheeler Ranch housing development is proposed at the site. Borrow for the FRWLP will be taken from the northeast corner of the property to create a 24.5 acre detention pond (referred to as the Drainage Basin C Regional Detention Pond, but commonly referred to as the South Ella Detention Pond). The Ella Basin is being constructed as part of Reclamation District No. 784's Master Drainage Plan. Historically, the site was cultivated for agricultural purposes. Currently, the site is disked ruderal grassland with some roads cut in the southern portion of the property for the Wheeler Ranch development. The depth of excavation is anticipated to be 15–20 feet and the yield of material from this site could be 400,000–500,000 cubic yards. Borrow material from this site will be used for work in Contracts B and C. If borrow material is remaining, it may also be used for Contract D. The haul route to Contract C will use existing roads. The post-project land use of the site will be a regional detention pond for Reclamation District No. 784.

Marler Property - The Marler property is a 10-acre property at Johnson Road near Messick Road, north of Star Bend and south of Shanghai Bend. The site is currently an orchard. The depth of

excavation could be upwards of 6 feet. The yield of material from this site could be 75,000 cubic yards. The haul route will use existing roads. The post-project land use for the property will be agricultural production, likely row crops or orchard.

Lanza Property - The Lanza property is 40 acres in size and is currently farmed in field/row crops. It is located at North Township Road and Pease Road south of Live Oak and north of Yuba City. The site has not yet been investigated to determine the types of materials present. Excavation of the site to a depth of 6 feet may occur. The yield of material from this site could be 200,000 cubic yards. The likely haul route will be along Pease Road directly east to the levee. The post-project land use for the property will be rice production.

City of Live Oak Detention Basin - Live Oak owns the property formerly known as the Caltrans Detention Basin Site located west of SR 99 and south of Paseo Avenue. The site is currently fallow. Live Oak intends to construct soccer fields and a stormwater detention basin at the site in 2013 or later. Although the site will require hauling for a short distance through a residential neighborhood, it is anticipated the residents will be amenable to the hauling as it will be a part of the public amenity constructed by Live Oak. This site is about 25 acres, and the depth of excavation is anticipated to be 3–6 feet. The yield of material from this site could be 125,000 cubic yards, and will likely be used for Contract C. Haul routes will use existing roads.

Live Oak (2012) reports that land at this location has historically been cultivated for agricultural purposes and reported that there was no evidence of any wetland or other sensitive plant or wildlife areas remaining onsite. No wetland features were identified during a preliminary wetland delineation of the area in December 2012. The previous agricultural use has displaced native species of plants and animals except those varieties capable of co-existing with humans in urban settings. The post-project use of the site will be a community park and stormwater detention basin facility.

Oroville Wildlife Area Dredge Tailings Area - This site is within the Oroville Wildlife Area and consists of several mounds of dredge tailings waterside of the existing levee. The material is suitable for use in seepage berms in Contract D. The availability of tailings in the area should be sufficient to meet the total deficit for berm material in these reaches. The excavation of the material will be coordinated to maximize hydraulic benefits from the reshaping of the overbank area. The site also represents an opportunity to provide waterside habitat enhancements. The useful area of this site could be about 75 acres and the depth of excavation could be upwards of 10 feet. The yield of material from this site could be 375,000 cubic yards. Hauling from this site will not take place on public roads. It is anticipated the contractor will use an existing waterside levee ramp (or create one), directly accessing the levee patrol road. The future land use for this site will be similar to its present day use (managed habitat area).

Construction Timing

Specific sequencing of construction will be dynamic throughout planning and design of the FRWLP, subject to change based on factors including the following.

- Further engineering in determining the clarity and efficacy of site-specific measures.

- Easement and right-of-way acquisition (where necessary).
- Availability of proximate, suitable, and cost-effective borrow material.
- Environmental clearances based on wildlife presence, lifecycle activity, and location of habitats.

Based on current planning analysis for the FRWLP, construction will occur in more than one annual construction season (typically April 15 to November 30, subject to conditions). Although subject to change, the four contracts and their respective areas for construction of the FRWLP are identified below.

- Contract A, 2016 – 2017
- Contract B, 2014 – 2015
- Contract C, 2013 – 2014
- Contract D, 2014 – 2015

Construction is anticipated to occur in single 10-hour shifts, 6 days per week. An exception to this schedule is slurry cutoff wall construction, which is anticipated to occur in two 10-hour shifts (essentially 24-hour construction), 6 days per week. While actual construction will not occur between the two 10-hour shifts, equipment maintenance and preparations for the upcoming work shift will occur.

Conservation Measures

SBFCA will implement the following conservation measures to avoid and minimize effects on federally listed species. To ensure their implementation, the measures listed below will be included in the project specifications.

General

Conservation Measure 1: Conduct Mandatory Biological Resources Awareness Training for All Project Personnel and Implement General Requirements

Before any ground-disturbing work (including vegetation clearing and grading) occurs in the Action Area, a Service-approved biologist will conduct a mandatory biological resources awareness training for all construction personnel about federally-listed species that could potentially occur onsite (beetle and snake). The training will include the natural history, representative photographs, and legal status of each federally-listed species and avoidance and minimization measures to be implemented. Proof of personnel attendance will be provided to the Service within 1 week of the training. If new construction personnel are added to the project, the contractor will ensure that the new personnel receive the mandatory training before starting work. The subsequent training of personnel can include videotape of the initial training and/or the use of written materials rather than in-person training by a biologist. Requirements that will be followed by construction personnel are listed below.

- Where suitable habitat is present for listed species, SBFCA will clearly delineate the construction limits through the use of survey tape, pin flags, orange barrier fencing, or other means, and prohibit any construction-related traffic outside these boundaries.
- Project-related vehicles will observe the posted speed limit on hard-surfaced roads and a 10-mile-per-hour speed limit on unpaved roads during travel in the project construction area. Project-related vehicles and construction equipment will restrict off-road travel to the designated construction areas.
- All food-related trash will be disposed of in closed containers and removed from the project construction area at least once per week during the construction period. Construction personnel will not feed or otherwise attract fish or wildlife to the project site.
- No pets or firearms will be allowed in the project construction area.
- To prevent possible resource damage from hazardous materials such as motor oil or gasoline, construction personnel will not service vehicles or construction equipment outside designated staging areas.
- Any worker who inadvertently injures or kills a federally-listed species or finds one dead, injured, or entrapped will immediately report the incident to the biological monitor and construction foreman. The construction foreman will immediately notify SBFCA, who will provide verbal notification to the Sacramento Fish and Wildlife Office and the local CDFW warden or biologist within 1 working day. SBFCA will follow up with written notification to Service and CDFW within 5 working days. The biological monitor will follow up with SBFCA to ensure that the wildlife agencies were notified.
- The biological monitor will record all observations of federally-listed species on California Natural Diversity Database (CNDDB) field sheets and submit to CDFW.

Valley Elderberry Longhorn Beetle

Conservation measures for the beetle are based on Service's 1999 *Conservation Guidelines for the Valley Elderberry Longhorn Beetle* (Conservation Guidelines) (U.S. Fish and Wildlife Service 1999a).

Conservation Measure 2: Fence Elderberry Shrubs to be Protected and Monitor Fencing during Construction

Elderberry shrubs/clusters within 100 feet of the construction area that will not be removed will be protected during construction. A qualified biologist (i.e., with elderberry/beetle experience), under contract to SBFCA, will mark the elderberry shrubs and clusters that will be protected during construction. Orange construction barrier fencing will be placed at the edge of the respective buffer areas. The buffer area distances will be proposed by the biologist and approved by the Service. No construction activities will be permitted within the buffer zone other than those activities necessary to erect the fencing. Signs will be posted every 50 feet (15.2 meters) along the perimeter of the buffer area fencing. The signs will contain the following information:

This area is habitat of the valley elderberry longhorn beetle, a threatened species, and must not be disturbed. This species is protected by the Endangered Species Act of 1973, as amended. Violators are subject to prosecution, fines, and imprisonment.

In some cases, where the elderberry shrub dripline is within 10 feet of the work area, k-rails will be placed at the shrub's dripline to provide additional protection to the shrub from construction equipment and activities. Temporary fences around the elderberry shrubs and k-rails at shrub driplines will be installed as the first order of work. Temporary fences will be furnished, constructed, maintained, and later removed, as shown on the plans, as specified in the special provisions, and as directed by the project engineer. Temporary fencing will be 4 feet (1.2 meters) high, commercial-quality woven polypropylene, orange in color.

Buffer area fences around elderberry shrubs will be inspected weekly by a qualified biological monitor during ground-disturbing activities and monthly after ground-disturbing activities until project construction is complete or until the fences are removed, as approved by the biological monitor and the resident engineer. The biological monitor will be responsible for ensuring that the contractor maintains the buffer area fences around elderberry shrubs throughout construction. Biological inspection reports will be provided to the project lead and the Service.

Conservation Measure 3: Conduct Beetle Surveys Prior to Elderberry Shrub Transplantation

Surveys of elderberry shrubs to be transplanted will be conducted by a qualified biologist prior to transplantation. Surveys will be conducted in accordance with the Conservation Guidelines (U.S. Fish and Wildlife Service 1999a). The biologist will survey the area surrounding the shrub to be transplanted to ensure that there are not additional elderberry shrubs that need to be removed. Surveys will consist of counting and measuring the diameter of each stem, and examining elderberry shrubs for the presence of beetle exit holes. Survey results and an analysis of the number of elderberry seedlings/cuttings and associated native plants based on the survey results will be submitted to the Service. SBFCA plans to plant elderberry seedlings/cuttings and associated native plants prior to transplantation of elderberry shrubs. The data collected during the surveys prior to transplantation will be used to determine if SFBCA is exceeding their compensation needs or if additional plantings are necessary. Because the Proposed Action will be constructed in four separate contracts, elderberry survey data for each contract will be used to rectify any discrepancies in compensation for the previous contract and to ensure that SBFCA has minimized effects to the beetle.

Conservation Measure 4: Water Down Construction Area to Control Dust

SFBCA or the contractor will ensure that the project construction area will be watered down as necessary to prevent dirt from becoming airborne and accumulating on elderberry shrubs within the 100–foot buffer.

Conservation Measure 5: Compensate for Direct and Indirect Effects on Valley Elderberry Longhorn Beetle Habitat

Before construction begins, SBFCA will compensate for direct effects on elderberry shrubs by transplanting shrubs that cannot be avoided to a Service-approved conservation area (described below). Elderberry seedlings or cuttings and associated native species will also be planted in the conservation area. Each elderberry stem measuring 1 inch or greater in diameter at ground level that is adversely affected (i.e., transplanted or destroyed) will be replaced, in the conservation

area, with elderberry seedlings or cuttings at a ratio ranging from 1:1 to 8:1 (new plantings to affected stems). The numbers of elderberry seedlings/cuttings and associated riparian native trees/shrubs to be planted as replacement habitat are determined by stem size class of affected elderberry shrubs, presence or absence of exit holes, and whether the shrub lies in a riparian or non-riparian area. Stock of either seedlings or cuttings will be obtained from local sources (including the Action Area if acceptable to the Service).

At the discretion of the Service, shrubs that are unlikely to survive transplantation because of poor condition or location, or a plant that will be extremely difficult to move because of access problems, may be exempted from transplantation. In cases where transplantation is not possible, compensation ratios will be increased to offset the additional habitat loss.

The relocation of the elderberry shrubs will be conducted according to Service-approved procedures outlined in the Conservation Guidelines (U. S. Fish and Wildlife Service 1999a). Elderberry shrubs within the project construction area that cannot be avoided will be transplanted during the plant's dormant phase (November through the first 2 weeks of February). A qualified biological monitor will remain onsite while the shrubs are being transplanted.

Property inaccessibility and the high density of vegetation along portions of the Feather River riparian corridor limited the number of elderberry shrubs that could be surveyed (73 shrubs were surveyed). For this reason, compensation for the removal of 91 shrubs was estimated based on the average number of stems in each stem diameter range for the 73 shrubs that could be surveyed. Those average shrub stem counts are as follows.

- Number of stems $\geq$1 inch and $\leq$3 inches = 4.
- Number of stems >3 inches and <5 inches = 1.
- Number of stems $\geq$5 inches = 1.

Table 1 shows the estimated compensation. Because the shrubs are located in riparian habitat and did not have exit holes, the compensation ratios for these conditions were used. As noted in Table 1, one elderberry shrub will need to be transplanted prior to the start of work in 2013 (in Reach 13) and outside of the elderberry dormancy period.

Based on the information in Table 1, the conservation area will be at least 12.15 acres in size to accommodate about 91 elderberry shrubs, 1,470 elderberry cuttings or seedlings, and 1,470 native plants. The conservation area in which the transplanted elderberry shrubs and seedlings are planted will be protected in perpetuity as habitat for the beetle.

Evidence of beetle occurrence in the conservation area, the condition of the elderberry shrubs in the conservation area, and the general condition of the conservation area itself will be monitored over a period of 10 consecutive years or for 7 years over a 15-year period from the date of transplanting. SBFCA will be responsible for funding and providing monitoring reports to the Service in each of the years in which a monitoring report is required. As specified in the Conservation Guidelines, the report will include information on timing and rate of irrigation, growth rates, and survival rates and mortality.

Table 1. Elderberry Stem Sizes and Compensation

Location	Stems (maximum diameter at ground level)	Exit Hole on Shrub (Yes or No)	Elderberry Seedling Ratio	Associated Native Plant Ratio	Multiplier for transplanting between June 15 – August 15	Number of Stems	Required Elderberry Plantings	Required Associated Native Plant Plantings
Riparian	stems ≥1" & ≤3"	No	2:1	1:1	No	360	720	720
Riparian	stems > 3" & <5"	No	3:1	1:1	No	90	270	270
Riparian	stems > 5"	No	4:1	1:1	No	90	360	360
2013 Construction - Reach 13								
Riparian	stems ≥1" & ≤3"	No	2:1	1:1	2.5	1	5	5
Riparian	stems > 3" & <5"	No	3:1	1:1	2.5	2	15	15
Riparian	stems > 5"	No	4:1	1:1	2.5	10	100	100
Total replacement plantings							1,470	1,470
Total elderberry shrubs to be transplanted								91
2940 /10 = 294 valley elderberry longhorn beetle credits or 12.15 acres								

To meet the success criteria specified in the Conservation Guidelines, a minimum survival rate of 60% of the original number of elderberry replacement plantings and associated native plants must be maintained throughout the monitoring period.

Proposed Conservation Area

SBFCA proposes to transplant elderberry shrubs to the existing 48.5-acre Star Bend Conservation Area, located on the west levee of the Feather River, about 6 miles south of Yuba City. In 2009, Levee District 1 of Sutter County proposed to construct the Feather River Setback Levee and Habitat Enhancement Project at Star Bend to replace a portion of existing levee that poses a high risk of failure in order to decrease the flood stage, velocity, and scour potential; increase and improve floodplain habitat; and improve habitat connectivity between the Abbot Lake and O'Connor Lakes Units of CDFW's Feather River Wildlife Area. The Star Bend project created 48.5 acres of floodplain habitat, which included habitat enhancement and onsite compensation for impacted elderberry shrubs.

In 2009, River Partners and Stillwater Sciences prepared a *Habitat Enhancement Plan for the Feather River Setback Levee and Habitat Enhancement Project at Star Bend* to be implemented by Levee District 1. It provides further information on the conditions at the time the site was proposed. About 20 acres have been used for elderberry transplants and associated native plants. In early 2012, a fire at the Star Bend site damaged portions of the site; however, elderberry shrub

planting losses were minimal. The remaining 28.5 acres are available at the conservation area for compensating for impacts on elderberry shrubs from construction of the FRWLP. The long-term goal of the conservation area is to merge this area with CDFW's adjoining O'Conner Lakes and Abbott Lakes Wildlife Units. SBFCA will prepare a mitigation and monitoring plan for the 28.5 acres that are available and will be used as a conservation area for effects to the beetle, as well as riparian impacts. This plan is currently being coordinated with the Service, Corps, and CDFW. Additionally, SBFCA will obtain a conservation easement for the 28.5 acre conservation area.

Giant Garter Snake

Conservation Measure 6: Conduct Construction Activities during the Active Period for Giant Garter Snake

Construction activity within giant garter snake aquatic and upland habitat (200 feet of aquatic habitat) will be conducted during the snake's active period (May 1–October 1). During this timeframe, potential for injury and mortality are lessened because snakes are actively moving and avoiding danger. The only work that will be conducted outside of the active season is levee slope flattening within the Sutter-Butte Canal in Reaches 26–28 (scheduled for 2016) and pipe reconstruction at two sites in the same reaches because these activities must be conducted when the canal is dry (February–March). Additional protective measures will be implemented at these locations (see Conservation Measure 14 below).

Conservation Measure 7: Install and Maintain Exclusion and Construction Barrier Fencing around Suitable Giant Garter Snake Habitat

To reduce the likelihood of giant garter snakes entering the construction area, SBFCA will install exclusion fencing and orange construction barrier fencing along the portions of the construction area that are within 200 feet of suitable aquatic and upland habitat. The exclusion and construction barrier fencing will be installed during the active period for giant garter snakes (May 1–October 1) to reduce the potential for injury and mortality during this activity.

The construction specifications will require that SBFCA or its contractor retain a qualified biologist to identify the areas that are to be avoided during construction. Areas adjacent to the directly affected area required for construction, including staging and access, will be fenced off to avoid disturbance in these areas. Before construction, the contractor will work with the qualified biologist to identify the locations for the barrier fencing and will place flags or flagging around the areas to be protected to indicate the locations of the barrier fences. The protected area will be clearly identified on the construction specifications. The fencing will be installed the maximum distance practicable from the aquatic habitat areas and will be in place before construction activities are initiated.

The exclusion fencing will consist of 3-foot-tall silt fencing buried 6 inches below ground level. The exclusion fencing will ensure that giant garter snakes are excluded from the construction area and that suitable upland and aquatic habitat is protected throughout construction. The construction barrier fencing will be commercial-quality, woven polypropylene, orange in color,

and 4 feet high (Tensor Polygrid or equivalent). The fencing will be tightly strung on posts with a maximum of 10-foot spacing.

Barrier and exclusion fences will be inspected daily by a qualified biological monitor during ground-disturbing activities and weekly after ground-disturbing activities until project construction is complete or until the fences are removed, as approved by the biological monitor and the resident engineer. The biological monitor will be responsible for ensuring that the contractor maintains the buffer area fences around giant garter snake habitat throughout construction. Biological inspection reports will be provided to the project lead and the Service.

Conservation Measure 8: Minimize Potential Impacts on Giant Garter Snake Habitat

SBFCA will implement the following measures to minimize potential impacts on giant garter snake habitat.

- Staging areas will be located at least 200 feet from suitable giant garter snake habitat.
- Any dewatered habitat will remain dry for at least 15 consecutive days after April 15 and prior to excavating or filling of the dewatered habitat.
- Vegetation clearing within 200 feet of the banks of suitable giant garter snake aquatic habitat will be limited to the minimum area necessary. Avoided giant garter snake habitat within or adjacent to the Action Area will be flagged and designated as an environmentally sensitive area, to be avoided by all construction personnel.
- The movement of heavy equipment within 200 feet of the banks of suitable giant garter snake aquatic habitat will be confined to designated haul routes to minimize habitat disturbance.

Conservation Measure 9: Prepare and Implement a Stormwater Pollution Prevention Plan

SBFCA will prepare a stormwater pollution prevention plan (SWPPP) that describes the BMPs that will be implemented to control accelerated erosion, sedimentation, and other pollutants during and after project construction. The SWPPP will be prepared prior to commencing earth-moving construction activities. This will also comply with the U.S. Environmental Protection Agency's National Pollutant Discharge Elimination System (NPDES) general construction activity stormwater permit.

The specific BMPs that will be incorporated into the erosion and sediment control plan and SWPPP will be site-specific and will be prepared by the construction contractor in accordance with the California Regional Water Quality Control Board Field Manual. However, the plan likely will include, but not be limited to, one or more of the following standard erosion and sediment control BMPs.

- **Timing of construction.** The construction contractor will conduct all construction activities during the typical construction season to avoid ground disturbance during the rainy season.
- **Staging of construction equipment and materials.** To the extent possible, equipment and materials will be staged in areas that have already been disturbed.

- **Minimize soil and vegetation disturbance.** The construction contractor will minimize ground disturbance and the disturbance/destruction of existing vegetation. This will be accomplished in part through the establishment of designated equipment staging areas, ingress and egress corridors, and equipment exclusion zones prior to the commencement of any grading operations.
- **Stabilize grading spoils.** Grading spoils generated during the construction will be temporarily stockpiled in staging areas. Silt fences, fiber rolls, or similar devices will be installed around the base of the temporary stockpiles to intercept runoff and sediment during storm events. If necessary, temporary stockpiles may be covered with an appropriate geotextile to increase protection from wind and water erosion.
- **Install sediment barriers.** The construction contractor may install silt fences, fiber rolls, or similar devices to prevent sediment-laden runoff from leaving the construction area. Natural/biodegradable erosion control measures (i.e., coir rolls, straw wattles or hay bales) will be used. Plastic monofilament netting (erosion control matting) will not be allowed because animals can become caught in this type of erosion control material.
- **Stormwater drain inlet protection.** The construction contractor may install silt fences, drop inlet sediment traps, sandbag barriers, and/or other similar devices.
- **Permanent site stabilization.** The construction contractor will install structural and vegetative methods to permanently stabilize all graded or otherwise disturbed areas once construction is complete. Structural methods may include the installation of biodegradable fiber rolls and erosion control blankets. Vegetative methods may involve the application of organic mulch and tackifier and/or the application of an erosion control seed mix. Implementation of a SWPPP will substantially minimize the potential for project-related erosion and associated adverse effects on water quality.

Conservation Measure 10: Prepare and Implement a Bentonite Slurry Spill Contingency Plan (Frac-Out Plan)

Before excavation begins, SBFCA will ensure the contractor will prepare and implement a bentonite slurry spill contingency plan (BSSCP) for any excavation activities that use pressurized fluids (other than water). The plan will be subject to approval by the Corps, Service, and SBFCA before excavation can begin. The BSSCP will include measures intended to minimize the potential for a frac-out (short for "fracture-out event") associated with excavation and tunneling activities; provide for the timely detection of frac-outs; and ensure an organized, timely, and "minimum-effect" response in the event of a frac-out and release of excavation fluid (i.e., bentonite). The BSSCP will require, at a minimum, the following measures.

- If a frac-out is identified, all work will stop, including the recycling of the bentonite fluid. In the event of a frac-out into water, the location and extent of the frac-out will be determined, and the frac-out will be monitored for 4 hours to determine whether the fluid congeals (bentonite will usually harden, effectively sealing the frac-out location).
- NMFS, the Service, CDFW, and the RWQCB will be notified immediately of any spills and will be consulted regarding clean-up procedures. A Brady barrel will be onsite and used if a frac-out occurs. Containment materials, such as straw bales, also will be onsite prior to and during all operations, and a vacuum truck will be on

retainer and available to be operational onsite within notice of 2 hours. The site supervisor will take any necessary follow-up response actions in coordination with agency representatives. The site supervisor will coordinate the mobilization of equipment stored at staging areas (e.g., vacuum trucks) as needed.

- If the frac-out has reached the surface, any material contaminated with bentonite will be removed by hand to a depth of 1-foot, contained, and properly disposed of, as required by law. The drilling contractor will be responsible for ensuring that the bentonite is either properly disposed of at an approved Class II disposal facility or properly recycled in an approved manner.
- If the bentonite fluid congeals, no other actions, such as disturbance of the streambed, will be taken that will potentially suspend sediments in the water column.
- The site supervisor has overall responsibility for implementing this BSSCP. The site supervisor will be notified immediately when a frac-out is detected. The site supervisor will be responsible for ensuring that the biological monitor is aware of the frac-out, coordinating personnel, response, cleanup, regulatory agency notification and coordination to ensure proper clean-up, disposal of recovered material, and timely reporting of the incident. The site supervisor will ensure all waste materials are properly containerized, labeled, and removed from the site to an approved Class II disposal facility by personnel experienced in the removal, transport, and disposal of drilling mud.
- The site supervisor will be familiar with the contents of this BSSCP and the conditions of approval under which the activity is permitted to take place. The site supervisor will have the authority to stop work and commit the resources (personnel and equipment) necessary to implement this plan. The site supervisor will ensure that a copy of this plan is available (onsite) and accessible to all construction personnel. The site supervisor will ensure that all workers are properly trained and familiar with the necessary procedures for response to a frac-out, prior to commencement of excavation operations.

Conservation Measure 11: Prepare and Implement a Spill Prevention, Control, and Counter-Measure Plan

A spill prevention, control, and counter-measure plan (SPCCP) is intended to prevent any discharge of oil into navigable water or adjoining shorelines. SBFCA or its contractor will develop and implement an SPCCP to minimize the potential for and effects from spills of hazardous, toxic, or petroleum substances during construction and operation activities. The SPCCP will be completed before any construction activities begin. Implementation of this measure will comply with State and Federal water quality regulations. The SPCCP will describe spill sources and spill pathways in addition to the actions that will be taken in the event of a spill (e.g., an oil spill from engine refueling will be immediately cleaned up with oil absorbents). The SPCCP will outline descriptions of containments facilities and practices such as doubled-walled tanks, containment berms, emergency shut-offs, drip pans, fueling procedures and spill response kits. It will also describe how and when employees are trained in proper handling procedure and spill prevention and response procedures.

SBFCA will review and approve the SPCCP before onset of construction activities and routinely inspect the construction area to verify that the measures specified in the SPCCP are properly implemented and maintained. SBFCA will notify its contractors immediately if there is a non-compliance issue and will require compliance.

The Federal reportable spill quantity for petroleum products, as defined in 40 CFR 110, is any oil spill that results in one or more of the following.

- Violates applicable water quality standards.
- Causes a film or sheen on or discoloration of the water surface or adjoining shoreline.
- Causes a sludge or emulsion to be deposited beneath the surface of the water or adjoining shorelines.

If a spill is reportable, the contractor's superintendent will notify SBFCA, and SBFCA will take action to contact the appropriate safety and cleanup crews to ensure that the SPCCP is followed. A written description of reportable releases must be submitted to the Central Valley RWQCB. This submittal must contain a description of the release, including the type of material and an estimate of the amount spilled, the date of the release, an explanation of why the spill occurred, and a description of the steps taken to prevent and control future releases. The releases will be documented on a spill report form.

Conservation Measure 12: Conduct Preconstruction Surveys and Monitoring for Giant Garter Snake

Prior to ground-disturbing activities within 200 feet of suitable habitat, a Service-approved biological monitor will conduct a preconstruction survey of suitable aquatic and upland habitat and inspect exclusion and orange barrier fencing to ensure they are both in good working order each morning. If any snakes are observed within the construction area at any other time during construction the Service-approved biological monitor will be contacted to survey the site for giant garter snakes. The biological monitor will have the authority to stop construction activities until appropriate corrective measures have been completed or it is determined that the snake will not be harmed. Giant garter snakes encountered during construction activities will be allowed to move away from construction activities on their own. If unable to move away on their own, trapped or injured giant garter snakes will be only be removed by a biologist with a federal 10(a)1(a) permit which allows them to handle the snake and will be placed in a location determined through discussions with the Service. The biological monitor will immediately report the finding of a snake to Service by phone and will provide a written account of the details of the incident within 24 hours.

Once all initial ground-disturbing activities are completed, the biological monitor will perform weekly checks of the site for the duration of construction in order to ensure that construction barrier fences and exclusion fences are in good order, trenches are being covered, project personnel are conducting checks beneath parked vehicles prior to their movement, and that all other required biological protection measures are being complied with. The biological monitor will document the results of monitoring on construction monitoring log sheets, which will be provided to the Service within 1 week of each monitoring visit.

Conservation Measure 13: Provide Escape Ramps or Cover Open Trenches at the End of Each Day

To avoid entrapment of giant garter snake, thereby preventing injury or mortality resulting from falling into trenches, all excavated areas more than 1 foot deep will be provided with one or more escape ramps constructed of earth fill or wooden planks at the end of each workday. If escape ramps cannot be provided, then holes or trenches will be covered with plywood or other hard material. The biological monitor or construction personnel designated by the contractor will be responsible for thoroughly inspecting trenches for the presence of giant garter snakes at the beginning of each workday. Capture and relocation of trapped or injured individuals can only be attempted by personnel or individuals with current Service recovery permits pursuant to section 10(a)1(A) of the Act.

Conservation Measure 14: Implement Additional Protective Measures during Work in Suitable Habitat during the Giant Garter Snake Dormant Period

SBFCA will implement additional protective measures during time periods when work must occur during the giant garter snake dormant period (October 2–April 30), when snakes are more vulnerable to injury and mortality. It is expected that these additional measures will be implemented during levee slope flattening within the Sutter-Butte Canal in Reaches 26–28 (scheduled for 2016) and pipe reconstruction adjoining the canal at two sites in the same reaches during February–March, and if construction activities extend to the period between October 2 and November 1. SBFCA will implement additional protective measures when conducting work in suitable giant garter snake habitat between October 2 and April 30.

- A full-time Service-approved biological monitor will be onsite for the duration of construction activities.
- All emergent vegetation within the Sutter-Butte Canal on the levee side, and vegetation within 200 feet of the canal will be cleared prior to the giant garter snake hibernation period (i.e., vegetation clearing must be completed by October 1 for following winter work).
- Exclusion fencing will be installed around the perimeter of the work area and across the Sutter-Butte Canal where construction activities associated with levee slope flattening and pipe reconstruction activities will occur. The fencing should enclose the work area to the maximum extent possible to prevent giant garter snakes from entering the work area. Fencing will be installed during the active period for giant garter snakes (May 1–October 1) to reduce the potential for injury and mortality during fence installation. The Service-approved biological monitor will work with the contractor to determine where fencing should be placed and will monitor fence installation. The exclusion fencing will consist of 3-foot-tall erosion fencing buried 4– 6 inches below ground level. The exclusion fencing will minimize opportunities for giant garter snake hibernation in the adjacent upland area (between canal and existing levee).
- Portions of the Sutter-Butte Canal that are temporarily disturbed during construction will be revegetated with emergent vegetation and adjacent disturbed upland habitat will be revegetated with native grasses and forbs after construction is complete.

Conservation Measure 15: Restore Temporarily Disturbed Aquatic and Upland Habitat to Pre-Action Conditions

Upon completion of the proposed project, SBFCA will restore 42.52 acres of suitable aquatic habitat and 118.80 acres of suitable upland habitat for the giant garter snake to pre-project conditions. Restoration of aquatic vegetation and annual grassland will be detailed in a mitigation and monitoring plan that will be reviewed and approved by the Corps and Service prior to the start of construction. Habitat will be restored within one season (defined as May 1–October 1) and providing vegetative cover within 1 year of construction beginning in that area.

Conservation Measure 16: Compensate for Permanent Loss of Aquatic Habitat for Giant Garter Snake

SBFCA will compensate for the permanent loss of 0.004 acre of suitable aquatic habitat for giant garter snake by purchasing preservation credits equal to 0.012 acre of giant garter snake habitat at Westervelt Ecological Services' Sutter Basin Conservation Bank in Sutter County. This bank has available giant garter snake credits and is approved by both the Service and CDFW.

The 0.012 acre of habitat at the conservation bank will be protected in perpetuity for giant garter snake. Prior to the start of construction (excluding Reach 13, as there is no giant garter snake habitat in this reach), SBFCA will provide funding to Westervelt Ecological Services for preservation credits equivalent to 0.012 acre of giant garter snake habitat at the Sutter Basin Conservation Bank. The transaction will take place through a purchase and sale agreement, and funds must be transferred within 30 days, and before any construction activities are initiated. SBFCA will provide the Service and CDFW with copies of the credit sale agreement and fund transfer.

Analytical Framework for the Jeopardy Analysis

In accordance with policy and regulation, the jeopardy analysis in this biological opinion relies on four components: (1) the *Status of the Species*, which evaluates the beetle's and snake's range-wide condition, the factors responsible for that condition, and their survival and recovery needs; (2) the *Environmental Baseline*, which evaluates the condition of the beetle and the snake in the action area, the factors responsible for that condition, and the relationship of the action area to the survival and recovery of the beetle and snake; (3) the *Effects of the Action*, which determines the direct and indirect impacts of the proposed federal action and the effects of any interrelated or interdependent activities on the beetle and snake; and (4) the *Cumulative Effects*, which evaluates the effects of future, non-Federal activities in the action area on the beetle and snake.

In accordance with policy and regulation, the jeopardy determination is made by evaluating the effects of the proposed Federal action in the context of the beetle's and snake's current status, taking into account any cumulative effects, to determine if implementation of the proposed

action is likely to cause an appreciable reduction in the likelihood of both the survival and recovery of the beetle and snake.

The jeopardy analysis in this biological opinion places an emphasis on consideration of the range-wide survival and recovery needs of the beetle and snake and the role of the action area in the survival and recovery of the beetle and snake as the context for evaluating the significance of the effects of the proposed Federal action, taken together with cumulative effects, for purposes of making the jeopardy determination.

Status of the Species

Valley Elderberry Longhorn Beetle

Please refer to the *Valley Elderberry Longhorn Beetle (Desmocerus californicus dimorphus) 5-year Review: Summary and Evaluation* (Service 2006) for the current status of the species.

Giant Garter Snake

Please refer to the *Giant Garter Snake (Thamnophis gigas) 5-year Review: Summary and Evaluation* (Service 2012) for the current status of the species.

Environmental Baseline

Valley Elderberry Longhorn Beetle

The closest beetle occurrence in the CNDDB (2013) is about 0.5 mile from the proposed project. Suitable habitat for the beetle (in the form of elderberry shrubs) exists in numerous places along the 41 miles of proposed levee repair. A total of 267 elderberry shrubs were mapped within the action area. Many others exist at various locations between the levee and the river. Of these SBFCA is proposing to avoid 175 elderberry shrubs and transplant 91 elderberry shrubs. Because the action area is within the range of the species, there are known occurrences from the vicinity of the action area, and suitable habitat is present, the Service concludes that it is reasonably likely for the beetle to occupy the action area.

Giant Garter Snake

The *Draft Recovery Plan for the Giant Garter Snake* subdivides the range of the species into four recovery units (Service 1999b). The action area for the proposed project is located within the Sacramento Valley Recovery Unit. There are 20 records of the snake within 5 miles of the action area. The closest occurrence documented in the CNDDB is 2 miles from the action area. Snakes have the potential to occur within the action area because suitable aquatic and upland habitat is present as it is hydrologically connected to areas that support rice agriculture and areas where the snake has previously been detected. The action area is a long corridor that occasionally has irrigation ditches, which run parallel to the levee for limited stretches. The main threat to the snake in the action area is loss of habitat or connectivity due to channel and levee maintenance.

Effects of the Proposed Action

Valley Elderberry Longhorn Beetle

Ninety-one elderberry shrubs will be removed and transplanted. The 91 affected shrubs have 361 stems between 1 and 3 inches, 92 stems between 3 and 5 inches and 100 stems greater than 5 inches at ground level.

Loss of an elderberry shrub or even a stem can affect the beetle breeding and feeding because adult beetles rely solely on elderberry foliage and flowers for food and must lay their eggs on elderberry stems to successfully reproduce.

Transplantation of elderberry shrubs that are or could be used by beetle larvae is expected to adversely affect the beetle. Beetle larvae will be killed or the beetle's life cycle will be interrupted during or after the transplanting process. For example:

1. Transplanted elderberry shrubs may experience stress or become unhealthy due to changes in soil, hydrology, microclimate, or associated vegetation. This may reduce their quality as habitat for the valley elderberry longhorn beetle, or impair their production of habitat-quality stems in the future.

2. Elderberry shrubs may die as a result of transplantation.

3. Branches containing larvae may be cut, broken, or crushed as a result of the transplantation process.

SBFCA has proposed to transplant one shrub outside of the elderberry shrub's dormant season (November 1 to February 15). To offset the increased risk of the transplantation not being successful SBFCA has proposed to plant 2.5 times the number of elderberry seedlings at the Star Bend Conservation Area.

Temporal loss of habitat will occur. Although conservation measures for effects on the beetle will involve creation or restoration of habitat, it generally takes 5 or more years for elderberry plants to become large enough to support beetles, and it may take 25 years or longer for riparian habitats to reach their full value. Temporal loss of habitat may cause fragmentation of habitat and isolation of subpopulations.

Permanent and temporary habitat loss adversely affects the beetles breeding and foraging requirements. Habitat creation and transplantation of the shrubs will minimize these effects. Success of a restoration site has been linked to presence of transplanted elderberry shrubs that have served to colonize a newly created riparian habitat. Transplants that survive also provide diversity within the conservation area as they are older, larger shrubs within the plantings of young small elderberry seedlings. The Star Bend Conservation Area will be protected with a conservation easement and managed in perpetuity for riparian habitat including valley elderberry longhorn beetle habitat, through development of the *Feather River West Levee Project Mitigation and Monitoring Plan.*

Giant garter snake

Aquatic habitat for the snake near the levee construction varies along the 41 miles of the proposed project. Small areas of aquatic habitat are present in Contract A and C and they are hydrologically connected to areas that support habitat for the snake (rice). Contract D has the largest amount of snake aquatic habitat as the Sutter Butte Canal parallels the levee for longer lengths. Canal filling due to cutoff wall construction will permanently fill 0.004 acre of snake aquatic habitat. Upland habitat around this aquatic habitat will be temporarily disturbed but returned to pre-project condition within one year. Temporary effects will result from temporary fill of aquatic habitat for construction access, reshaping the slope of the Sutter Butte Canal and adjacent levee, and degradation and reconstruction of the levee. These activities will temporarily affect 6.81 acres of aquatic habitat. Levee degradation and reconstruction will temporarily affect 112.47 acres of upland habitat. All temporarily affected areas will be restored to pre-project conditions within the same year the disturbance will occur. This will minimize effects to giant garter snakes because the amount of time the habitat will be unavailable to the snake will be minimized. Permanently affected habitat, such as the canals that will be made smaller will be offset by purchasing 0.012 acre of giant garter snake habitat at Westervelt Ecological Services' Sutter Basin Conservation Bank in Sutter County. None of the borrow sites in the project description have upland or aquatic giant garter snake habitat.

The majority of the construction work will occur during the giant garter snake active season (May 1 to October 1). Increased construction activity in areas where snakes are known to occur could expose snakes to increased risks of injury and mortality from predation, exposure, vehicular traffic, and construction equipment. Because snakes are more mobile during the active season, these effects should be lessened. There are a few activities which SBFCA could not construct during the active season. Because of cooler temperatures in the inactive season (October 1 to May 1), the snake is not as mobile and is most frequently found within burrows. Ground disturbing activities during this timeframe will increase the likelihood of snake mortality when the burrows are disturbed with heavy equipment. SBFCA has proposed to disturb (clear and grub) the out of season work area and place exclusion fencing around the work area during the active season which will create an area that will not support overwintering snakes (lack of burrows). This will minimize the chance of injuring or killing an overwintering snake during out of season construction. This will only occur on one side of the canal, leaving the other side of the canal available as overwintering habitat for the snake.

Temporary effects within the action area will affect both aquatic and upland snake habitat. In some locations degradation of the levee could cause soil to fall into the aquatic habitat or fuel or oil leaks could also adversely affect the habitat and the snake. Placement of sediment fencing and implementing sediment and contaminant BMPs will lessen this effect. Levee degradation will temporarily make upland habitat unavailable to the snake during the active season. Snakes use upland habitat for thermoregulation both as a place to bask and as a place to escape extreme heat (burrows) and cover for shedding and giving birth to young. While snakes are more active during the summer months and more likely to move away from construction, some snakes may choose to remain where they are and therefore will be subject to mortality when construction activities are occurring. In addition to direct mortality, the upland habitat will be temporarily unavailable to the snake during construction. Even once construction is completed it will take a

year or two for the upland habitat to become completely functional for the snake, with burrows or crevices available for them to use. This is likely to result in disturbance, displacement, injury, and/or mortality of snakes. To lessen these effects SBFCA is implementing the conservation measures described above as well as affecting only one side of the canal. This will leave the other side of the canal intact and available to the snake for use, minimizing displacement of snakes. Additionally, because of the staging of construction not all of the upland habitat will be unavailable for use at one time. It will be staged as construction progresses through the various contracts.

Cumulative Effects

Cumulative effects include the effects of future State, Tribal, local, or private actions that are reasonably certain to occur in the action area considered in this biological opinion. Future Federal actions that are unrelated to the proposed project are not considered in this section, because they require separate consultation pursuant to section 7 of the Act. Any future land use conversions and routine agricultural practices are not subject to Federal authorization or funding and may alter the habitat or result in take of listed valley elderberry longhorn beetle or giant garter snake and are, therefore, cumulative to the proposed project.

Conclusion

After reviewing the current status of the valley elderberry longhorn beetle and giant garter snake, the environmental baselines for these species, the effects of the proposed project, and the cumulative effects on this species, it is the Service's biological opinion that the proposed FRWLP, as described herein, is not likely to jeopardize the continued existence of these species. Although critical habitat has been designated for the beetle, the proposed action will not affect critical habitat.

INCIDENTAL TAKE STATEMENT

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the Act prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harass is defined by the Service as an intentional or negligent act or omission which creates the likelihood of injury to a listed species by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding or sheltering. Harm is defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by impairing behavioral patterns including breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act, provided that such taking is in compliance with this Incidental Take Statement.

The measures described below are nondiscretionary for listed species of this biological opinion and must be implemented by the Corps and SBFCA in order for the exemption in section 7(o)(2)

to apply. The Corps has a continuing duty to regulate the activity that is covered by this incidental take statement. If the Federal agency (1) fails to adhere to the terms and conditions of the incidental take statement, and/or (2) fails to retain oversight to ensure compliance with these terms and conditions, the protective coverage of section 7(o)(2) may lapse.

Amount or Extent of Take

Valley Elderberry Longhorn Beetle

The Service expects that incidental take of the valley elderberry longhorn beetle will be difficult to detect or quantify. The cryptic nature of this species and their relatively small body size make the finding of an injured or dead specimen unlikely. The species occurs in habitats that make them difficult to detect. Due to the difficulty in quantifying the number of beetles that will be taken as a result of the proposed action, the Service is quantifying take incidental to the project as the number of elderberry stems one inch or greater in diameter at ground level (beetle habitat) that will become unsuitable for beetles due to direct or indirect effects as a result of levee construction. Therefore, the Service estimates that all beetles inhabiting 91 elderberry plants containing stems 1 inch or greater at ground level (361 stems between 1-3 inches, 92 stems between 3 and 5 inches and 100 stems $\geq$5 inches; see Table 1 in the text) will be taken as a result of the proposed action.

Giant Garter Snake

The Service anticipates that incidental take of the snake will be difficult to detect or quantify for the following reasons: the snake is cryptically colored, secretive, and known to be sensitive to human activities. Snakes may avoid detection by retreating to burrows, soil crevices, vegetation, or other cover. Individual snakes are difficult to detect unless they are observed, undisturbed, at a distance. Most close-range observations represent chance encounters that are difficult to predict. It is not possible to make an accurate estimate of the number of snakes that will be harassed, harmed or killed during construction activities (staging areas, work on canal banks, levee degradation and reconstruction, soil borrow areas, and vehicle traffic to and from borrow areas). In instances when take is difficult to detect, the Service may use the quantification of acreage as a surrogate for the individuals that will be taken. Therefore, the Service anticipates take incidental to this project as the 0.004 acre of suitable habitat that will be permanently lost and the 119.28 acres (6.81 acres aquatic and 112.47 acres upland) of suitable snake habitat that will be temporarily lost. Upon implementation of the Reasonable and Prudent Measure, Terms and Conditions, and the Proposed Conservation Measures considered herein, incidental take within this acreage for the proposed project, will be exempt from the prohibitions described under Section 9 of the Act.

Effect of the Take

The Service has determined that this level of anticipated take is not likely to result in jeopardy to the beetle or snake.

Reasonable and Prudent Measures

The Service has determined that the following reasonable and prudent measure is necessary and appropriate to minimize the adverse effects of the Feather River West Levee Project to the beetle and snake and their habitat in the action area.

Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the Act, the Corps and SBFCA must ensure compliance with the following terms and conditions, which implement the reasonable and prudent measures described above. These terms and conditions are nondiscretionary.

The following Terms and Conditions implement the Reasonable and Prudent Measure:

1. All the conservation measures as described in the project description, and as restated here in this biological opinion, must be fully implemented and adhered to.

2. The Corps, SBFCA, and PG&E shall include full implementation and adherence to the conservation measures as outlined in the biological opinion as a condition of any permit or contract issued for the project.

3. In order to monitor whether the amount or extent of take anticipated from implementation of the proposed project is approached or exceeded, the Corps and SBFCA shall adhere to the following reporting requirement. Should this anticipated amount or extent of incidental take be exceeded, the Corps must immediately reinitiate formal consultation as per 50 CFR 402.16.

    a. For those components of the proposed project that will result in habitat degradation or modification whereby incidental take in the form of harm or mortality is anticipated, the Corps and SBFCA will provide weekly updates to the Service with a precise accounting of the total acreage of habitat effected or number of elderberry shrubs and size of stems at ground level transplanted. Updates shall also include any information about changes in the Project Description and not analyzed in this biological opinion.

4. SBFCA shall provide a photo documentation report showing pre- and post-project area conditions for giant garter snake.

Salvage and Disposition of Individuals

The Sacramento Fish and Wildlife Office will be notified within 1 day of the finding of any dead or injured snake or beetle to determine the appropriate measures for salvage and disposition. The Service contact person is the Habitat Conservation Division Chief. In addition, the Recovery Division Chief shall also be notified within 1 day of the procedures implemented for salvage and disposition of the snake or beetle. The applicant must report to the Service immediately any information about take or suspected take of listed species not authorized in this biological

opinion. Notification must include the date, time, and location of the incident or of the finding of a dead or injured listed species. The Habitat Conservation and Recovery Divisions Chiefs can be contacted at (916) 414-6600. The California Department of Fish and Wildlife should also be contacted at (916)358-2900.

CONSERVATION RECOMMENDATIONS

Conservation recommendations are suggestions of the Service regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of new information. These measures may serve to further minimize or avoid the adverse effects of a proposed action on listed, proposed, or candidate species, or on designated critical habitat. They may also serve as suggestions on how action agencies can assist species conservation in furtherance of their responsibilities under section 7(a)(1) of the Act, or recommend studies improving an understanding of a species' biology or ecology. Wherever possible, conservation recommendations should be tied to tasks identified in recovery plans. The Service is providing you with the following conservation recommendations:

1. The Corps and SBFCA should assist in the implementation of the draft, and when published, the final Recovery Plan for the snake.

2. The Corps and SBFCA should provide funding to researchers studying topics identified by the Service in the draft, and when published, the final Recovery Plan for the snake.

3. The Corps should use environmental restoration authorities to acquire and restore beetle and snake habitat.

To be kept informed of actions minimizing or avoiding adverse effects or benefiting listed and proposed species or their habitats, the Service requests notification of the implementation of any conservation recommendations.

REINITIATION - CLOSING STATEMENT

This concludes formal consultation with the Corps on the Feather River West Levee Project. As provided in 50 CFR 402.16, re-initiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been maintained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the proposed action may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect to listed species or critical habitat that was not considered in this opinion; or (4) a new species or critical habitat is designated that may be affected by the proposed action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending re-initiation.

If you have any questions regarding this Feather River West Levee Project biological opinion, please contact Jennifer Hobbs, at (916) 414-6541 or Doug Weinrich, Deputy Assistant Field Supervisor, at (916) 414-6563.

Sincerely,

Roberta Gerson

for Jan C. Knight
Acting Field Supervisor

cc:
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Sutter Basin Pilot Feasibility Study Mitigation and Monitoring Plan

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2 Star Bend Conservation Area

3 Star Bend Conservation Area Conceptual Planting Plan

4 Star Bend Conservation Area Conceptual Planting Plan

List of Abbreviated Terms

AEP	annual exceedance probability
BSSCP	bentonite slurry spill contingency plan
CAPP	Conceptual Area Protection Plans
CDFW	California Department of Fish and Wildlife
CH	fat clay
CL	lean clay
CLSM	controlled low strength material
CVFPB	Central Valley Flood Protection Board
CVFPP	Central Valley Flood Protection Plan
CWA	Clean Water Act
DBH	diameter at breast height
DSM	deep soil mixing
DWR	Department of Water Resources
EIR	environmental impact report
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
ESAs	Environmentally Sensitive Areas
feasibility study	Sutter Basin Pilot Feasibility Study
FR	Federal Register
FRWLP	Feather River West Levee Project
GGS	giant garter snake
GPS	global positioning system
ICF	ICF International
LAE	Land Acquisition Evaluations
LD1	Levee District 1
LL	Liquid Limit
ML	silt
MMP	mitigation and monitoring proposal
MOU	Memorandum of Understanding
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
OHWM	ordinary high water mark
PI	Plasticity Index

RWQCB	Regional Water Quality Control Board
SB	Senate Bill
SBFCA	Sutter Butte Flood Control Agency
SC	clayey sand
SM	silty sand
SPCCP	spill prevention, control, and counter-measure plan
SR	State Route
SWPPP	stormwater pollution prevention plan
UPRR	Union Pacific Railroad
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
VELB	valley elderberry longhorn beetle

Chapter 1
Responsible Parties

This document describes the mitigation and monitoring plan (MMP) for effects associated with implementation of the Sutter Basin Pilot Feasibility Study (feasibility study). Implementation of flood risk reduction projects outlined in the feasibility study will create permanent and unavoidable impacts to habitats and species that require mitigation. This document identifies responsible parties for the mitigation project, describes the location and nature of the project, and discusses the types, functions, and values of United States. Army Corps of Engineers (USACE) jurisdictional wetlands and other waters of the United States.

In addition to the mitigation plan for impacted Section 404 jurisdictional features, this MMP also includes impacts and mitigation for riparian and non-riparian native trees, and special status species habitat for valley elderberry longhorn beetle (VELB) and permanent impacts to giant garter snake (GGS), for which compensatory mitigation is required.

Compensatory mitigation for riparian forest, non-riparian native trees and VELB will occur at the Star Bend Conservation Area and the TRLIA Feather River Floodway Corridor Restoration Site, both located on the Feather River. Mitigation for GGS and Section 404 jurisdictional features will occur at off-site private banking lands.

1.1 Mitigation Planning Guidance

As part of the feasibility study, a MMP was developed based on the following USACE and State guidance and the recommendations of the USFWS and other resource agencies.

1.1.1 USACE Mitigation Planning Guidance

In accordance with Council on Environmental Quality (CEQ) Regulations for Implementing NEPA (40 CFR 1500-1508), and with Appendix C, paragraph C-3 of ER 1105-2-100, "Policy and Planning Guidance for Conducting Civil Works Planning Studies (Planning Guidance Notebook)", the planning of USACE projects must ensure that project-related adverse environmental impacts (i.e., impacts to fish and wildlife resources) have been avoided or minimized to the extent practicable, and that remaining unavoidable significant adverse impacts are compensated to the extent justified. Corps regulations stipulate that the Recommended Plan must contain sufficient mitigation measures to ensure that the plan selected will have no more than negligible net adverse impacts on fish and wildlife resources. Furthermore, a Cost Effectiveness Incremental Cost Analysis must be performed to identify the most cost-effective mitigation plan.

Under WRDA 2007, Section 2036(a) , the Corps must fully develop a mitigation plan that includes the following: 1) monitoring until successful, 2) criteria for determining ecological success, 3) a description of available lands for mitigation and the basis for the determination of availability, 4) the development of contingency plans (i.e., adaptive management), 5) identification of the entity responsible for monitoring; and 6) establishing a consultation process with appropriate Federal and State agencies in determining the success of mitigation.

The pilot study initiative of risk-informed decision making was applied in developing a justified and cost effective mitigation plan. Consistency in approaches between the feasibility study and the 408 Feather River West Levee Project in the development of mitigation plans was a goal to ensure consistency of decisions and communication with the resources agencies. Early on a decision was made to use acreage and habitat significance instead of habitat based modeling such as USFWS habitat evaluation procedures (HEP) due to a number of considerations. The USFWS concurred with a non-HEP approach to impact and mitigation assessment. The cost of mitigation and the impacts to fish and wildlife habitats are relatively small relative the project footprint and overall cost of the project. Proposed fix-in-place levee improvements have generally minimize impacts to the existing levee structure.

A more rigorous more detailed CE/ICA analysis would be unlikely to result in a more cost effective plan. A comparison between mitigation banks and project proposed mitigation showed significant differences in cost depending on habitat type. Compensation requirements prescribed by NMFS and USFWS for effects to listed species amount to about half of the cost of mitigation plan. Mitigation plans achieving less than full compensation for effects to listed species would likely be unacceptable to the USFWS and NMFS and increase the potential for jeopardy determinations from these agencies and risk project delays. The risk to project cost is low because mitigation costs are relatively minor compared to overall project costs and mitigation costs are more likely to go down with consideration of an ETL variance by the project to further minimize loss of riparian habitat.

1.1.2 California Department of Fish and Wildlife Compliance

This document follows the format and contains the elements described in USACE report *Mitigation and Monitoring Proposal Guidelines, December 30, 2004* (USACE 2004). Because this report also includes mitigation for non-Section 404 jurisdictional features and will utilize land at the Star Bend Conservation Area, the document also complies with the California Department of Fish and Wildlife's (CDFW) own guidelines outlined in *Policy for Mitigation on Publicly Owned, Department Owned, and Conserved Lands* (CDFW 2012). The policy statement contained within the CDFW's report states:

> *Mitigation for impacts to fish and wildlife resources may occur on publicly owned, Department owned, and conserved lands if it has been determined by the Department that: 1) the mitigation is consistent with requirements of the law under which the mitigation is being sought; 2) its relative value as mitigation is equal to or greater than it would be if the same mitigation were situated on non-public or non-conserved lands; 3) it results in a clear and quantifiable improvement or positive change above that currently present or reasonably expected to exist under current conditions on the site; 4) the future uses of the land, including encumbrances or easements, will not preclude or diminish the mitigation; 5) the mitigation will not preclude, diminish or interfere with the funding or purpose of acquisition, encumbrances, or management plan for the property; and 6) it will not result in a net loss of existing conservation values.*

CDFW Guidelines for Implementing Mitigation on Department Owned or Conserved Lands

The following guidelines are addressed throughout the MMP below. Items 1 through 4 have been fully addressed in this MMP. Item 5 is addressed in the project's incremental cost analysis. The Memorandum of Understanding described in item 6 below is still a work in progress and will be finalized before the MMP is complete.

1. Mitigation is consistent with the current and future uses of the land including any encumbrances, easements or public use values.
    a. To find information on encumbrances, easements or public use values the following documents should be checked:
        i. Management plan for the property
        ii. Any Conceptual Area Protection Plans (CAPP) or Land Acquisition Evaluations (LAE) written for the property
        iii. Easements can be found on the California Natural Resources Agency website and at the County Recorders office. The Lands Program should also be checked.
        iv. Title search – this should be performed by the entity proposing the mitigation
        v. Site visits should be performed
2. Mitigation is consistent with the purpose for which the land was acquired and the funding source used for acquisition.
3. Mitigation will not preclude, diminish or interfere with encumbrances, or the management plan for the property.
4. Mitigation maintains and or enhances the current ecological and public use values of the land.
    a. Entity proposing the mitigation needs to provide documentation of how placing the mitigation on the land is going to maintain or enhance the ecological and public use values of the land.
5. The full cost of the mitigation is accounted for (this includes but is not limited to all capital improvements, restoration, enhancement, monitoring, long term management and maintenance and reimbursement for any Department staff time including enforcement, on all lands).
6. A Memorandum of Understanding (MOU) is in place prior to the project sponsors undertaking the project. The MOU will be developed in cooperation with the land manager, reviewed for statewide consistency by the Department's Lands Program in the Wildlife Branch and signed by the District Assistant Chief and the Department Regional Manager, the land management agency or non-profit (if other than the Department), and the project sponsor. The MOU will define the mitigation purpose, permit requirements, agreement term, scope of work, schedule, management and/or maintenance requirements, monitoring, and responsibilities of the parties to the agreement.

1.2 Lead Agency

USACE is the lead agency and implementing agency for the feasibility study. USACE is preparing the Environmental Impact Statement (EIS) for the purposes of compliance with the National Environmental Policy Act (NEPA). USACE is also completing Section 7 Endangered Species Act consultation with the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) for the project. USACE is the lead Federal agency with financial responsibility for implementing the MMP and satisfying the success criteria.

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Chapter 2
Project Requiring Mitigation

2.1 Project Location

North to south, the feasibility study area is located in the 41-mile corridor along the west levee of the Feather River that begins at the Thermalito Afterbay and ends approximately 4 miles north of the Sutter Bypass (Figure 1). The project area consists of the project construction footprint plus a 100-foot-wide buffer zone. The feasibility project construction area was defined as the area in which levee improvements—such as seepage berms, stability berms, relief wells, and slurry cutoff walls—are likely to be constructed. All direct and indirect effects would occur within the project area.

The feasibility study area corridor is divided into 41 relatively reaches for ease of describing existing conditions, project components, land cover types, and potential effects (note that this number is coincidental and one reach does not correspond to a length of 1 mile). The levee stations, lengths, landmarks, and dominant land uses for the reaches are listed in Table 2-1. Table 2-1

Table 2-1. Summary of Reaches in the Feasibility Study Area

Reach	Beginning Station	Ending Station	Length (feet)	Landmark(s)	Dominant Land Uses
1	189+00	202+50	2,250	Laurel Avenue	
2	202+50	218+66	1,616		Ruderal grassland; open space
3	218+66	300+66	8,200	Cypress Avenue	Ruderal grassland; open space
4	300+66	410+67	11,001	Central Street; Wilkie Avenue	Orchard; ruderal grassland; riparian forest
5	410+67	478+68	6,801	Wilkie Avenue	Orchard
6	478+68	510+37	3,169	Star Bend	Orchard
7	510+37	596+00	8,563	Abbott Lake	Ruderal grassland; open space
8	596+00	654+75	5,875		Ruderal grassland; open space
9	654+75	706+50	5,175	Boyd's Boat Launch; Nursery	Ruderal grassland; open space
10	706+50	774+00	6,750	Barry Road	Ruderal grassland; open space
11	774+00	830+00	5,600		Ruderal grassland; open space
12	830+00	845+00	1,500	Shanghai Bend	Ruderal grassland; open space
13	845+00	927+00	8,200		Ruderal grassland; open space
14	927+00	954+40	2,740	Airport	Ruderal grassland; open space
15	954+40	968+50	1,410	Airport	Developed; ruderal grassland
16	968+50	1080+00	11,150	Garden Highway, 2nd Street; Twin Cities Memorial Bridge; Colusa Avenue	Developed; ruderal grassland
17	1080+00	1130+86	5,086	Live Oak Boulevard; Union Pacific Railroad	Developed; ruderal grassland
18	1130+86	1213+85	8,299	Live Oak Boulevard; Union Pacific Railroad; Rednall Road	Orchard
19	1213+85	1297+83	8,398		Orchard
20	1297+83	1374+33	7,650		Orchard; ruderal grassland
21	1374+33	1433+83	5,950		Ruderal grassland
22	1433+83	1503+83	7,000		Riparian forest; ruderal grassland
23	1503+83	1609+37	10,554		Orchard
24	1609+37	1623+86	1,449		Riparian forest; ruderal grassland
25	1623+86	1674+37	5,051		Orchard; ruderal grassland
26	1674+37	1707+11	3,274		Orchard
27	1707+11	1721+60	1,449		Ruderal grassland
28	1721+60	1769+31	4,771		Orchard
29	1769+31	1813+33	4,402		Orchard; riparian forest
30	1813+33	1902+00	8,867		Orchard
31	1902+00	1958+00	5,600		Orchard; ruderal grassland
32	1958+00	1989+00	3,100		Orchard
33	1989+00	2122+00	13,300		Orchard
34	2122+00	2182+00	6,000		Orchard
35	2182+00	2224+00	4,200		Orchard; ruderal grassland
36	2224+00	2259+00	3,500		Orchard; ruderal grassland
37	2259+00	2290+00	3,100		Orchard; ruderal grassland
38	2290+00	2303+00	1,300		Ruderal grassland
39	2303+00	2319+00	1,600		Ruderal grassland
40	2319+00	2359+00	4,000		Ruderal grassland
41	2359+00	2368+00	900	Thermalito Afterbay	Ruderal grassland

Note: Certain planning and engineering studies for the feasibility study area make reference to segments within the planning area under which the reaches above are grouped. These segment designations do not have substantial bearing on the alternatives descriptions, environmental setting, or determination of effects and thus for simplicity are not used in this document.

The new study paradigm recognizes that no single factor, including net national economic development benefit, should provide the basis for the USACE decision for a recommendation for Federal investment. Alternative comparison and selection recognizes that there is no single "best" plan, and there are a variety of approaches (quantitative and qualitative) to multi-criteria decision making.

2.1.1 Project Purpose and Need

The purpose of the Sutter Basin Pilot Feasibility Study is to investigate and determine the extent of Federal interest in plans that reduce flood risk to the Sutter Basin in Sutter and Butte Counties. This report: (1) assesses the risk of flooding; (2) describes a range of alternatives formulated to reduce flood risk; and (3) identifies a recommended plan for implementation. This report constitutes both a draft Feasibility Report that describes a USACE "pilot" planning process followed to identify the recommended plan, and an Environmental Impact Statement/Environmental Impact Report (EIS/EIR) required to comply with the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA). Following public and governmental agency review, this draft report will be finalized and submitted to Headquarters, USACE, for review and approval, then transmitted to Congress for recommended project authorization. Project construction would also be dependent upon Congressional appropriation of funding for the Federal share of the project.

A high risk of flooding from levee failure threatens the public safety of approximately 95,000 people, as well as property and critical infrastructure throughout the Sutter Basin study area. Past flooding events have caused loss of life and extensive economic damages. Recent geotechnical analysis and evaluation of past levee performance indicate the existing project levees, which are part of the authorized Sacramento River Flood Control Project, do not meet current U.S. Army Corps of Engineers (USACE) levee design criteria, and are at risk of breach failure at stages less than overtopping of the levees, as has been shown to be true of many of the existing levees within California's Central Valley.

2.1.2 Federal Objectives

In the Flood Control Act of 1970, Congress identified four equal national objectives for use in water resources development planning. These objectives are national economic development (NED), regional economic development (RED), environmental equality (EQ), and social well being (other social effects or OSE). These four categories are known as the System of Accounts, whereby each proposed plan can be easily compared with the no-action plan and other alternatives. The Federal objective identified in the P&G is:

> "The Federal objective of water and related land resources planning is to contribute to national economic development consistent with protecting the Nation's environment, pursuant to national environmental statues, applicable executive orders, and other Federal planning requirements."

In Section 2031 of Water Resources Development Act of 2007, Congress instructed the Secretary of the Army to develop a new P&G for USACE (Public Law 110-114). As a result, the P&G is being revised to include a number of important changes. These changes are expressed in the following proposed new Federal objectives statement:

> "The national objective of water and related land resources planning is to foster environmentally sound, efficient use of the Nation's resources consistent with public safety. This can be accomplished through watershed analyses that recognize the interdependency of water uses. This is strengthened by capitalizing on a collaborative planning and implementation process which incorporates fully

informed participation from Federal agencies, non-Federal interests, non-governmental organizations, State and local and Tribal governments, and a full range of water users and stakeholders."

"Water and related land resources planning that is consistent with the national planning objective seeks to incorporate some or all of these elements: facilitate sustainable national economic development, encourage wise use of water and related land resources – including flood plains, and flood-prone coastal areas, support the protection and restoration of significant aquatic ecosystems, promote the integration and improvement of how the Nation's water resources are managed; and reduce vulnerabilities and losses due to natural disasters."

The Federal objective is not specific enough for the development of a water resource project. The formulation of alternative plans requires the identification of study-specific planning objectives.

2.1.3 Non-Federal Objectives

The State of California, recognizing the continuing risk of flooding within the Central Valley, has enacted the Central Valley Flood Protection Act (CVFPA) and related legislation that establishes in California law the objective of providing 200-year (1/200 or 0.5% annual exceedance probability) protection to urban and urbanizing areas. Additionally, the CVFPA requires an immediate analysis of the condition of the system levees, an action plan for achieving the desired level of protection, and associated actions to reduce residual risks to development within the protected area.

In addition to complying with the state requirement, the non-Federal sponsors seek to reduce residual risk to the rural south portion of the Sutter Basin for sustainable high-value agricultural operations.

2.1.4 Planning Objectives

Planning objectives for the SBPFS are more specific than the Federal and non-Federal objectives and reflect the problems and opportunities in the study area; an objective is developed to address each of the identified problems and opportunities. Planning objectives represent desired positive changes to the future without-project conditions. All of the objectives focus on activity within the study area and within the 50-year period of analysis.

The planning objectives are:

- Reduce the risk to life, health, public safety and critical infrastructure due to flooding.
- Reduce the risk of property damage due to flooding.
- In conjunction with FRM, improve ecosystem functions and values.
- In conjunction with FRM, improve the public's access to and use of outdoor recreational opportunities in the study area.

As discussed above, it is anticipated the construction of the project would be divided into six separate construction contracts (i.e., A, B, C-1, C-2, D-1 and D-2). Although subject to change, the most current information for the six contracts and their respective areas is provided in Table 2-2.

Table 2-2. Feasibility Study Proposed Construction by Contract, Reach, and Year of Construction

Contract	A	*Star Bend	B	C1	C2	D1	D2
Corresponding Reach	2–5	6	7–12	13–18	19–25	26–33	34–41
Proposed Year of Construction	2018–2019	2018–2019	2017–2018	2013–2014	2014–2015	2015–2016	2016–2017

* Included as part of Contract A analysis.

2.1.5 Project Description

The two construction alternatives analyzed in detail through the NEPA process would each accomplish the identified project purpose. However, they would accomplish the project purpose to varying extents, with varying levels of benefits and varying adverse impacts to the aquatic ecosystem.

The following is a summary of project elements for each alternative. In general, Alternative SB-8 entails the greatest amount of levee improvement work and SB-7 the least amount. These alternatives are described in greater detail in Chapter 3 of the integrated report and EIS/EIR.

Alternative SB-8 includes:

41 reaches (2A-North to 41) along the FRWL alignment, beginning at station 180+00 (approximately 2,500 feet south of Laurel Avenue) and ending at station 2368+00 (Thermalito Afterbay). The proposed project features and measures for this alternative include:

- Soil-Bentonite Cutoff Walls
- Deep Soil Mix Cutoff Walls
- Jet Grouting Cutoff Walls
- Seepage Berms
- Levee Relocations
- Canal Relocations
- Embankment Reconstruction/Landside Toe Fill
- Erosion Protections
- Closure Structure
- Utility Improvements
- Utility Relocations
- Structural Relocations

These proposed features and measures will rehabilitate, replace, or tie in and function in junction with the existing system. The existing system includes the following features:

- Existing Embankment
- Existing Cutoff Walls

- Existing Stability Berms
- Existing Relief Wells
- Existing Closure Structures
- Existing Toe Drains

Table 2-3 identifies the construction activities that would occur with each reach.

Table 2-3. SBFS Flood Management Measures by Reach

Reach	Length (feet)	Proposed Action Flood Management Measure
2A	2,250	180+00 to 202+50, 100 ft. wide undrained seepage berm. Seepage berm 5 ft. thick at berm toe. 180+00 to 202+50, Cutoff wall extending to an elevation of 25 ft.
2B	1,616	202+50 to 218+66, cutoff wall extending to an elevation of 25' with 100'-wide undrained seepage berm. Seepage berm 5' thick at berm toe.
3	8,200	218+66 to 230+00, cutoff wall extending to an elevation of 25' with 100'-wide undrained seepage berm. Seepage berm 5' thick at berm toe. 230+00 to 250+00, cutoff wall tip elevation (-)35'. 250+00 to 289+00, cutoff wall tip elevation (-)20'. 289+00 to 300+66, cutoff wall tip elevation (-)12'.
4	11,001	300+66 to 312+00 cutoff wall tip elevation 15'. 312+00 to 349+00 cutoff wall tip elevation 15'. 349+00 to 368+00 cutoff wall tip elevation 10'. 368+00 to 410+67 cutoff wall tip elevation 20'.
5	6,801	410+67 to 417+00, cutoff wall tip elevation 20'. 417+00 to 425+00, cutoff wall tip elevation 10'. 425+00 to 456+00, cutoff wall tip elevation 15'. 456+00 to 475+35, cutoff wall tip elevation 15' with 300' wide undrained seepage berm. Seepage berm 5' thick at berm toe. 475+35 to 478+68 cutoff wall tip elevation 15'.
6	3,169	478+68 to 510+00, No Proposed Flood Management Measures 510+00 to 510+50, potential pipe crossing work to install positive closure device and correct pipe size.
7	8,563	510+37 to 512+00, no flood management required. 512+00 to 514+00, cutoff wall 514+00 to 526+00, cutoff wall tip elevation 15'. 526+00 to 570+00, cutoff wall tip elevation (-)5'. 545+00 to 570+00, relief wells with 60' spacing and 50' depth over one half of the length, distributed at various locations over this stretch of levee. 570+00 to 575+00, cutoff wall tip elevation 5'. 575+00 to 595+00, cutoff wall tip elevation (-)10'. 595+00 to 596+00, cutoff wall tip elevation 15'.

Reach	Length (feet)	Proposed Action Flood Management Measure
8	5,875	596+00 to 654+75, cutoff wall tip elevation 15'.
9	5,175	654+75 to 670+00, cutoff wall tip elevation 15'. 670+00 to 697+00, cutoff wall tip elevation 20'. 697+00 to 706+50: cutoff wall tip elevation 10'.
10	6,750	706+50 to 726+00, cutoff wall tip elevation (-)10'. 726+00 to 746+00, cutoff wall tip elevation (-)5'. 746+00 to 754+50, cutoff wall tip elevation 5'. 754+50 to 774+00, cutoff wall tip elevation 25'
11	5,600	774+00 to 784+50, cutoff wall tip elevation 25'. 784+50 to 827+50, cutoff wall tip elevation 5'. 827+50 to 830+00, cutoff wall tip elevation 25'
12	1,500	832+30, relocate two 24-inch sewer pipes.
13	8,200	844+50 to 923+75: cutoff wall tip elevation (-)38'. Full levee degrade from 844+50 to 897+50.
14	2,740	952+00 investigation of 12 kV cable to determine if it meets Title 23 requirements.
15	1,410	No flood management measures required.
16	11,150	Closure of gap in cutoff wall at 5th Street bridge crossing around Station 1007+00, cutoff wall tip elevation 40'. Closure of gap in cutoff wall at 10th Street bridge crossing around Station 1026+00, by using a seepage berm within the abandoned railroad tunnel. 1077+85 to 1080+00, cutoff wall tip elevation 30' and backfill landside toe depression. Miscellaneous landside encroachment relocations/removals.
17	5,086	1080+00 to 1089+00, cutoff wall tip elevation 30' and backfill landside toe depression. 1089+00 to 1125+00, cutoff wall tip elevation 35' and backfill landside toe depression. 1125+00 to 1130+86, cutoff wall tip elevation 0'.
18	8,299	1130+86 to 1151+50, cutoff wall tip elevation 0'. 1151+50 to 1159+50: cutoff wall tip elevation 30'. 1159+50 to 1169+50: cutoff wall tip elevation 25'. 1169+50 to 1189+50: cutoff wall tip elevation 30'. 1189+50 to 1209+50: cutoff wall tip elevation 40'. 1209+50 to 1213+85: cutoff wall tip elevation 35'.
19	8,398	1213+85 to 1219+75, cutoff wall tip elevation 35'. 1219+75 to 1224+00, cutoff wall tip elevation 5'. 1224+00 to 1238+00, cutoff wall tip elevation (-)28'. 1238+00 to 1248+00, cutoff wall tip elevation (-)42'. 1248+00 to 1268+75, cutoff wall tip elevation 3'. 1268+75 to 1297+83, cutoff wall tip elevation 35'.

Reach	Length (feet)	Proposed Action Flood Management Measure
20	7,650	1297+83 to 1298+75, cutoff wall tip elevation 35'. 1298+75 to 1359+00, cutoff wall tip elevation 50'. 1359+00 to 1369+00: cutoff wall tip elevation 40'. 1369+00 to 1374+33: cutoff wall tip elevation 32'.
21	5,950	1374+33 to 1386+00 cutoff wall tip elevation 32'. 1386+00 to 1408+00: cutoff wall tip elevation 55'. 1408+00 to 1432+50: cutoff wall tip elevation 40'. 1432+50 to 1433+83: Levee relocation (20 ft riverward, transition only) 1429+00 to 1433+83 Sutter Butte Main Canal relocation.
22	7,000	1433+83 to 1450+00: Levee relocation (20ft riverward) 1451+50 to 1451+50: Levee relocation (20ft riverward, transition only) 1451+50 to 1468+83, cutoff wall tip elevation 50'. 1455+00 to 1461+00, full levee degrade and reconstruction. 1468+83 to 1503+83, cutoff wall tip elevation 55'.
23	10,554	1503+83 to 1508+50, cutoff wall tip elevation 55'. 1508+50 to 1528+75, cutoff wall tip elevation 60'. 1528+75 to 1566+50, cutoff wall tip elevation 55'. 1566+50 to 1608+75, cutoff wall tip elevation 60'. 1608+50 to 1609+37: Levee relocation (20ft riverward, transition only)
24	1,449	1609+37 to 1612+00: Levee relocation (20ft riverward, transition only) 1612+00 to 1623+00: Levee relocation (20ft riverward) 1623+00 to 1623+86: Levee relocation (20ft riverward, transition only)
25	5,051	1623+86 to 1624+50: Levee relocation (20ft riverward, transition only) 1673+00 to 1674+37: Levee relocation (20ft riverward, transition only) 1639+00, replace two 24-inch steel storm drain pipes.
26	3,274	1674+37 to 1675+00: Levee relocation (20ft riverward, transition only) 1675+00 to 1707+11: Levee relocation (20ft riverward) Reconstruction of landside slope extends down to elevation of bottom of canal.
27	1,449	1707+11 to 1721+60: Levee relocation (20ft riverward)
28	4,771	1721+60 to 1753+00: Levee relocation (20ft riverward) 1753+00 to 1754+50: Levee relocation (20ft riverward, transition only) 1752+00 to 1766+00: Sutter Butte Main Canal Relocation 1766+00 to 1769+31, cutoff wall tip elevation 45'.
29	4,402	1770+00, 1785+24, 1785+55, 1792+96, 1799+44, 1809+65, storm drain and irrigation pipe replacements.
30	8,867	1813+33 to 1816+50, cutoff wall tip elevation 80', with full levee degrade and reconstruction. 1816+50 to 1848+25, cutoff wall tip elevation 30'. 1848+25 to 1866+00, cutoff wall tip elevation 70'. 1866+00 to 1877+75, cutoff wall tip elevation 47'. 1877+75 to 1883+00, cutoff wall tip elevation 40'. 1883+00 to 1902+00, cutoff wall tip elevation 27'.

Reach	Length (feet)	Proposed Action Flood Management Measure
31	5,600	1902+00 to 1907+50, cutoff wall tip elevation 27'. 1907+50 to 1917+50, cutoff wall tip elevation 44'. 1907+92 to 1909+42, waterside slope flattening or other remedial measure. 1917+50 to 1927+50, cutoff wall tip elevation 75'. 1927+50 to 1937+00, cutoff wall tip elevation 50'. 1937+00 to 1958+00, cutoff wall tip elevation 40'.
32	3,100	1958+00 to 1971+80, cutoff wall tip elevation 40'. 1971+80 to 1987+25, cutoff wall tip elevation 48'. 1987+25 to 1989+00, cutoff wall tip elevation 10'.
33	13,300	1989+00 to 2002+00, cutoff wall tip elevation 10'. 2002+00 to 2016+75, cutoff wall tip elevation 90'. 2016+75 to 2036+75, cutoff wall tip elevation 20'. 2036+75 to 2041+00, cutoff wall tip elevation 53'. 2041+00 to 2067+00, cutoff wall tip elevation 38'. 2067+00 to 2088+00, cutoff wall tip elevation 33'. 2088+00 to 2122+00, cutoff wall tip elevation 90'.
34	6,000	2122+00 to 2137+00, cutoff wall tip elevation 90'. 2137+00 to 2148+00, cutoff wall tip elevation 20'. 2148+00 to 2164+00, cutoff wall tip elevation 90'. 2164+00 to 2182+00, cutoff wall tip elevation 50'.
35	4,200	2182+00 to 2196+50, cutoff wall tip elevation 40'. 2196+50 to 2212+00, cutoff wall tip elevation 45'. 2212+00 to 2218+25, cutoff wall tip elevation 50'. 2218+25 to 2224+00, cutoff wall tip elevation 55'.
36	3,500	2224+00 to 2233+50, cutoff wall tip elevation 55'. 2233+50 to 2245+75, cutoff wall tip elevation 70'. 2245+75 to 2259+00, cutoff wall tip elevation 42'.
37	3,100	2259+00 to 2277+00, cutoff wall tip elevation 42'. 2277+00 to 2290+00, cutoff wall tip elevation 45'.
38	1,300	2290+00 to 2292+00 cutoff wall to elevation +45'. 2290+00 to 2303+00 construct 11' high seepage berm, 50' wide at the top and 170' wide from levee centerline.
39	1,600	2312+10, remove 24" storm drain pipe.
40	4,000	2331+00 to 2335+00, construct 120'-wide seepage berm. 2335+00 to 2359+00, 100'-wide seepage berm. Berms are 9' thick at the levee toe and 3' thick at the berm toe.
41	900	2359+00 to 2368+00, construct 100'-wide seepage berm with 1'-thick drain layer. 2360+00; fill waterside pit (up to elevation 130').

Encroachments

Existing facilities found within the footprint of an alternative may require removal and replacement nearby, abandonment, or relocation. Encroachments are numerous (over 400 identified) along the Feather River West Levee and may need to be addressed if they present a threat to the stability of the levee, do not currently comply with the levee encroachment criteria, or would be disrupted or otherwise impacted by construction activities. Typical encroachments include pressure pipelines (water supply pipelines from waterside pump stations and drainage pipelines from landside drainage pump stations), gravity drainage pipes, gas lines, telephone utilities, overhead utilities, structural encroachments, and other types and variations. Debris from structure and embankment fill material of poor quality would be hauled offsite to a permitted disposal site within 20 miles of the removal location.

Vegetation Removal

Bulldozers would be used to remove woody and herbaceous vegetation from the direct construction footprint and the minimum areas needed for project staging and access routes. Any vegetation removed as part of direct construction activities would not be replaced at that location and would require offsite, in-kind mitigation, to be determined in consultation with the appropriate resource agencies.

More extensive root removal may be required, depending upon the location, size, and type of tree; the quantity, orientation, and size of the roots; the dimensions of the levee (or floodwall); the composition of the levee and foundation; and the levee features that address seepage and underseepage. Less extensive root removal may be justified where roots from adjacent trees would be unduly damaged. Any excavation resulting from the above actions would be backfilled with engineered fill using appropriate placement, moisture conditioning, and compaction methods. Additional measures for removing non-compliant vegetation are listed below.

- Ensure that the resulting void is free of organic debris.
- Cut poles to salvage propagation materials for replanting, such as willows and cottonwoods.
- Conduct hand clearing using chainsaws and trimmers.
- Conduct mass clearing using bulldozers.

Debris from vegetation removal would be hauled offsite to a permitted disposal site within 20 miles of the removal location.

Construction Staging, Access, and Temporary Facilities

The contractor would be responsible for obtaining all required local, state, and Federal permits for any staging areas outside of these limits. Staging areas would be used for equipment staging, storage of equipment and materials, mobile project offices, construction staff parking, etc.

To facilitate project construction, temporary earthen ramps would be constructed for equipment access between the levee crown and the staging area(s). The earthen ramps would be removed when construction is complete.

Cutoff wall construction requires temporary establishment of an onsite slurry batch plant that would occupy approximately 1–2 acres. Batch plants would be located at approximately 1-mile

intervals within the project footprint. The batch plant site would likely contain tanks for water storage, bulk bag supplies of bentonite, bentonite storage silos, a cyclone mixer, pumps, and two generators that meet air quality requirements. The site would also accommodate slurry tanks to store the blended slurries temporarily until they are pumped to the work sites. Slurry ingredients would be mixed with water at the batch plant and the mixture would be pumped from the tanks through pipes to the cutoff wall construction work sites. The batch plant would produce two different slurry mixes, one for trench stabilization and one for the soil backfill mix. Therefore, two slurry pipes or hoses, typically 4- or 6-inch high-density polyethelene pipes, would be laid on the ground and would extend to all work sites. An additional pipe may be used to supply water to the work sites.

Staging areas, access routes, and other temporary construction areas would be located away from wetlands, riparian habitat, oak woodlands, special-status wildlife habitat, known cultural resources, or other sensitive areas and would be limited to disturbed or ruderal grasslands subject to review by USACE and Federal and state resource agencies.

Material Importation, Reuse, and Borrow

Materials imported to the project site would include water, bentonite, cement, incidental construction support materials, aggregate base rock, asphalt, concrete, hydroseed, and embankment fill soil. Each alternative would require the use of large quantities of fill soil, or borrow. To meet borrow demands, embankment fill material excavated as part of construction would be evaluated for reuse. Embankment fill material deemed suitable would be used as part of levee reconstruction and berms.

Borrow Volume

The total volume of material required is 1,619,250 cubic yards. The quantities were calculated assuming a 20% shrinkage factor between excavation at the borrow site and placement at the levee. Only material suitable for placement in levee construction may be borrowed (HDR et al. 2012). These materials are identified as low to medium plasticity soils classified in accordance with American Society for Testing and Materials D 2487 as silty sand (SM) and clayey sand (SC), silt (ML), or clay (lean clay [CL] or fat clay [CH]). The materials should have a Liquid Limit (LL) less than or equal to 45 (may be extended up to 55 with justification and approval from USACE and the CVFPB), a Plasticity Index (PI) greater than or equal to 12 and less than 40, and a fines content greater than or equal to 30%. The material should be free from visible organics and be no greater than 2 inches in any dimension.

Borrow Site Selection Factors

The first choice for fill or borrow material would be from a local commercial quarry or other permitted source. In the event that material is desired from a source that is not presently permitted, for reasons such as quality, proximity, or volume available, soil supply protection measures would be implemented. One such measure would be maximizing on-site use through gradation, placement, and treatment. Another measure would be the preservation and replacements of topsoil at borrow sites, so that they could be continued to be used for their current use or otherwise returned to their pre-project condition. As part of borrow operations, the upper 12 inches of topsoil would be set aside and replaced after project construction in each construction season. After the project is

completed, the borrow site would be re-contoured and reclaimed. An additional measure would be independent environmental documentation and regulatory compliance, as required.

Factors determining borrow sources and sites are (followed by a description of each factor and discussion of potential borrow sources).

- Hauling distance and haul route
- Depth to groundwater
- Royalty fees
- Post-construction land use
- Environmental factors

Hauling Distance and Routes. The cost for borrow site excavation and hauling is directly related to the distance required to haul the material and the route by which the materials must be transported. To the extent possible, sites should be selected that minimize haul route length and the use of public roadways (Wood Rodgers 2011).

Depth to Groundwater. Because the top layer of a borrow site must be removed and stockpiled to exclude organics from the borrow material, it is economical to maximize the depth of the excavation. This maximum depth is typically governed by the normal seasonal depth of groundwater. Once excavation extends to within a few feet of the groundwater table, additional expense is incurred to implement dewatering at the site. Groundwater elevations generally fluctuate throughout the year and can be influenced by standing water or irrigation activities on adjacent lands. Typically, groundwater depths are higher at the beginning of spring, and become deeper toward the end of summer (Wood Rodgers 2011).

Royalty Fees. Royalty fees for material excavated directly affect the cost of the borrow and also typically trigger more substantial permitting requirements. It is desirable to find a property owner who wishes to have excavation carried out for his own purposes, such as creating a detention basin to support future development, so that royalty fees and a SMARA permit are avoided (Wood Rodgers 2011).

Post-Construction Land Use. The post-construction use of the property can also effect the depth of excavation. Borrow sites must be free draining after the material is excavated, and therefore cannot be extended deeper than the offsite drainage facilities can accommodate (Wood Rodgers 2011).

Environmental Factors. Environmental factors, including the need for mitigation for special-status species and wetlands encroachments, are also a factor in selecting borrow sites. Consideration should also be given to haul routes when evaluating environmental effects. Routes which could be unavailable during the early months of the construction season due to the presence of nesting raptors should be avoided (Wood Rodgers 2011). If waterside borrow sites outside the construction footprint are needed, only sites that do not impact woody vegetation associated with fish-inhabited waters should be considered. All sites will be surveyed for potential wildlife habitat, jurisdictional waters, cultural resources, and other environmental regulatory triggers prior to use, and environmental documentation and permits will be secured independently or supplemental to the project documentation and permits.

Borrow Sources and Proposed Borrow Sites

Fill or borrow material may be purchased from a local commercial quarry or other permitted source; however, there are not currently any sites near the project area that would supply the volume and type of material required. Consequently, the most likely possibility is for fill to be purchased from local landowners willing to sell borrow material.

Five borrow sites have been identified in the project area. Each site was investigated to determine the quantity of available material, hauling distance, material composition, groundwater elevation, and prospects for acquisition. The purpose of the investigation was to identify the sites with the greatest potential to economically provide material for the project. Economical hauling has been determined to be within a 2-miles radius and marginally economic hauling within a 10-mile radius. As a result of the borrow analysis, sufficient fill volume is present within an approximate 10-mile, one-way haul distance from the area of construction.

A potential borrow sites' utilization would be maximized through gradation, placement, and treatment so that they could continue to be used for their current use or otherwise returned to their pre-project condition. As part of borrow operations, the upper 4–6 inches of topsoil would be set aside and replaced after construction in each construction season. After the project is completed, the borrow site would be re-contoured and reclaimed.

Through outreach efforts, a number of sites owned by individuals or government agencies willing to sell their property or provide material on a cubic yard basis. Figure 1 shows the locations of the five potential borrow sites identified and the proposed haul routes to the construction area.

North Valley Property

The North Valley property is owned by North Valley Properties, LLC and is located south of Ella Road between Feather River Boulevard and Arboga Road. The Wheeler Ranch housing development is proposed at the site. Borrow for the project would be taken from the northeast corner of the property to create a 24.5 acre detention pond (referred to as referred to as the Drainage Basin C Regional Detention Pond but commonly referred to as the South Ella Detention Pond). The Ella Basin is being constructed as part of Reclamation District No. 784's Master Drainage Plan. Historically, the site was cultivated for agricultural purposes. Currently, the site is disked ruderal grassland with some roads cut in the southern portion of the property for the Wheeler Ranch development. The material at this site is anticipated to be CL from a depth of 18–22 feet, followed by silt-sand material below a depth of 22–25 feet. The depth of excavation is anticipated to be 15–20 feet and the yield of material from this site could be 400,000–500,000 cubic yards. Borrow material from this site would be used for work in Contract C-1 and C-2, and Contract B. If borrow material is remaining, it may also be used for Contract D-1 and D-2.

The haul route to the northern portion of Contract C from the North Valley Property would be west on Ella Avenue to north on Feather River Boulevard to north on SR70 to west on SR20/Colusa Avenue to north on Live Oak Boulevard to north on SR99 to east on Paseo Avenue. Additional access route to the levee along northbound SR99 would be north on Kent Avenue to east on Koch Lane. Additional access routes to the levee along northbound Live Oak Boulevard would be east on Morse Road, east on Rednall Road and east on Market Street to east on Lynn Way. Additional access routes to the levee along westerly SR20/Colusa Avenue would be North on Sutter Street/Market Street to east on Lynn Way.

The haul route to the southern portion of Contract C from the North Valley Property would be west on Ella Avenue to north on Feather River Boulevard to north on SR70 to west on SR20/Colusa Avenue to south on Sutter Street to south on 2nd Street to levee access. Additional access route to the levee along westerly SR20/Colusa Avenue would be south on SR99 to east on Bogue Road to south on Garden Highway to east on Shanghai Bend Road.

The post-project land use of the site would be a regional detention pond for Reclamation District No. 784.

Marler Property

The Marler property is a 10-acre property at Johnson Road near Messick Road north of Star Bend and south of Shanghai Bend. The site is currently an orchard. The depth of excavation could be upwards of 6 feet. The yield of material from this site could be up to 75,000 cubic yards. The likely haul route would be Johnson Road to Messick Road to the Garden Highway, accessing the levee near Oswald Road. The post-project land use for the property would be agricultural production, likely row crops or orchard.

Lanza Property

The Lanza property is 40 acres in size and is currently farmed in field/row crops. It is located at North Township Road and Pease Road south of Live Oak and north of Yuba City. The site has not yet been investigated to determine the types of materials present. Excavation of the site to a depth of 6 feet may occur. The yield of material from this site could be up to 200,000 cubic yards. The likely haul route would be along Pease Road directly east to the levee. The post-project land use for the property would be rice production.

City of Live Oak Detention Basin

The City of Live Oak owns the property formerly known as the Caltrans Detention Basin Site located west of SR 99 and south of Paseo Avenue. The site is currently fallow. The City of Live Oak intends to construct soccer fields and a stormwater detention basin at the site in 2013 or later. Although the site would require hauling for a short distance through a residential neighborhood, it is anticipated the residents would be amenable to the hauling as it would be a part of the public amenity constructed by the City of Live Oak. The material at this site is anticipated to be CL from a depth of 1–2.5 feet, followed by more sandy material to a depth of 6 feet. This site is approximately 25 acres, and the depth of excavation is anticipated to be 3–6 feet. The yield of material from this site could be up to 125,000 cubic yards, and would likely be used for Contract C. The haul route to the northern portion of Contract C from the City of Live Oak Detention Basin would be west crossing the canal to north to Treatment Plant Access road and west on Treatment Plant Access Road to north on Farm Access Road to north on Richards Avenue to east on Pennington Road. Additional access routes to the levee from eastbound on Pennington Road are south on SR99 to east on Paseo Avenue and north on Metteer Road to east on Riviera Road. Additional routes to the levee along northerly Metteer Road would be east on Campbell Road and east on Cooley Road.

The City of Live Oak (Schmidt, pers. comm.) reports that land at this location has historically been cultivated for agricultural purposes and that there was no evidence of any wetland or other sensitive plant or wildlife areas remaining onsite. A preliminary wetland delineation of the area conducted by HDR Engineering in December 2012 did not identify any wetland features. The previous agricultural use has displaced native species of plants and animals except those varieties capable of co-existing

with humans in urban settings. The post-project use of the site would be a community park and stormwater detention basin facility.

Oroville Wildlife Area Dredge Tailings Area

This site is within the Oroville Wildlife Area and consists of several mounds of dredge tailings on the waterside of the existing levee. The material is suitable for use in seepage berms at Reaches 40 and 41 and an adjacent levee at Reach 38. The availability of tailings in the area should be sufficient to meet the total deficit for berm material in these reaches. The excavation of the material would be coordinated to maximize hydraulic benefits from the reshaping of the overbank area. The site also represents an opportunity to provide waterside habitat enhancements. The useful area of this site could be approximately 75 acres and the depth of excavation could be upwards of 10 feet. The yield of material from this site could be up to 375,000 cubic yards. Hauling from this site would not take place on public roads. It is anticipated the contractor would use an existing waterside levee ramp (or create one), directly accessing the levee patrol road. The future land use for this site would be similar to its present day use (managed habitat area).

Post-Construction Operations and Maintenance

After construction completion, the levee and staging areas and levee slopes would be hydroseeded for erosion protection, dust abatement, and to prevent colonization of exotic vegetation.

In accordance with Federal Flood Control Regulations (33 CFR 208.10) and State requirements (California Water Code Section 8370), each year the Federal flood control facilities are inspected four times, at intervals not exceeding 90 days. DWR would inspect the system twice per year, and the local maintaining authorities would inspect it twice per year and immediately following major high water events. The findings of these inspections would be reported to the CVFPB's Chief Engineer through DWR's Flood Project Integrity and Inspection Branch.

Permanent facilities associated with relief wells include the wells themselves and surface drainage trenches to control the discharge. Inspection of the relief wells is required at least annually, and observation of flow from the wells is required during high river stages. The wells are test-pumped periodically. The collection ditch is maintained to allow free flow of water.

Because operations and maintenance activities are conducted by DWR and local flood protection districts, the effects of these activities are not part of the project and are not discussed further in this MMP.

2.1.6 Conservation Measures

The following conservation measures will be implemented during project construction to avoid and minimize effects on federally listed species.

General

Conservation Measure 1: Conduct Mandatory Biological Resources Awareness Training for All Project Personnel and Implement General Requirements

Before any ground-disturbing work (including vegetation clearing and grading) occurs in the project area, a biologist approved by USFWS, NMFS, and CDFW will conduct a mandatory biological

resources awareness training for all construction personnel about federally listed species that could potentially occur onsite (VELB, giant garter snake, and fish species). The training will include the natural history, representative photographs, and legal status of each federally listed species and avoidance and minimization measures to be implemented. Proof of personnel attendance will be provided to USFWS, NMFS, and CDFW within 1 week of the training. If new construction personnel are added to the project, the contractor will ensure that the new personnel receive the mandatory training before starting work. The subsequent training of personnel can include videotape of the initial training and/or the use of written materials rather than in-person training by a biologist. Requirements that will be followed by construction personnel are listed below.

- Where suitable habitat is present for listed species, the construction limits will be thoroughly delineated with survey tape, pin flags, orange barrier fencing, or other means, and prohibit any construction-related traffic outside these boundaries.
- Project-related vehicles will observe the posted speed limit on hard-surfaced roads and a 10-mile-per-hour speed limit on unpaved roads during travel in the project construction area.
- Project-related vehicles and construction equipment will restrict off-road travel to the designated construction areas.
- All food-related trash will be disposed of in closed containers and removed from the project construction area at least once per week during the construction period. Construction personnel will not feed or otherwise attract fish or wildlife to the project site.
- No pets or firearms will be allowed in the project construction area.
- To prevent possible resource damage from hazardous materials such as motor oil or gasoline, construction personnel will not service vehicles or construction equipment outside designated staging areas.
- Any worker who inadvertently injures or kills a federally listed species or finds one dead, injured, or entrapped will immediately report the incident to the biological monitor and construction foreman. The construction foreman will immediately notify the implementing agency, who will provide verbal notification to the USFWS Sacramento Endangered Species Office and/or the local CDFW warden or biologist within 1 working day. The implementing agency will follow up with written notification to USFWS or CDFW within 5 working days. The biological monitor will follow up with implementing agency to ensure that the wildlife agencies were notified.
- The biological monitor will record all observations of federally listed species on CNDDB field sheets and submit to CDFW.

Valley Elderberry Longhorn Beetle

Conservation measures for VELB are based on USFWS's 1999 *Conservation Guidelines for the Valley Elderberry Longhorn Beetle* (Conservation Guidelines) (U.S. Fish and Wildlife Service 1999a).

Conservation Measure 2: Fence Elderberry Shrubs to be Protected and Monitor Fencing during Construction

Elderberry shrubs/clusters within 100 feet of the construction area that will not be removed will be protected during construction. A qualified biologist (i.e., with elderberry/VELB experience), under contract to the implementing agency, will mark the elderberry shrubs and clusters that will be

protected during construction. Orange construction barrier fencing will be placed at the edge of the respective buffer areas. The buffer area distances will be proposed by the biologist and approved by USFWS. No construction activities will be permitted within the buffer zone other than those activities necessary to erect the fencing. Signs will be posted every 50 feet (15.2 meters) along the perimeter of the buffer area fencing. The signs will contain the following information:

This area is habitat of the valley elderberry longhorn beetle, a threatened species, and must not be disturbed. This species is protected by the Endangered Species Act of 1973, as amended. Violators are subject to prosecution, fines, and imprisonment.

In some cases, where the elderberry shrub dripline is within 10 feet of the work area, k-rails will be placed at the shrub's dripline to provide additional protection to the shrub from construction equipment and activities. Temporary fences around the elderberry shrubs and k-rails at shrub driplines will be installed as the first order of work. Temporary fences will be furnished, constructed, maintained, and later removed, as shown on the plans, as specified in the special provisions, and as directed by the project engineer. Temporary fencing will be 4 feet (1.2 meters) high, commercial-quality woven polypropylene, orange in color.

Buffer area fences around elderberry shrubs will be inspected weekly by a qualified biological monitor during ground-disturbing activities and monthly after ground-disturbing activities until project construction is complete or until the fences are removed, as approved by the biological monitor and the resident engineer. The biological monitor will be responsible for ensuring that the contractor maintains the buffer area fences around elderberry shrubs throughout construction. Biological inspection reports will be provided to the project lead and USFWS.

Conservation Measure 3: Conduct VELB Surveys Prior to Elderberry Shrub Transplantation

Surveys of elderberry shrubs to be transplanted will be conducted by a qualified biologist prior to transplantation. Surveys will be conducted in accordance with the Conservation Guidelines for the VELB (U.S. Fish and Wildlife Service 1999a). The biologist will survey the area surrounding the shrub to be transplanted to ensure that there aren't additional elderberry shrubs that need to be removed. Surveys will consist of counting and measuring the diameter of each stem, and examining elderberry shrubs for the presence of VELB exit holes. Survey results and an analysis of the number of elderberry seedlings/cuttings and associated native plants based on the survey results will be submitted to USFWS. The data collected during the surveys prior to transplantation will be used to determine if the implementing agency is exceeding their compensation requirements or if additional plantings are necessary. Because the project would be constructed in separate contracts, elderberry survey data for each contract will be used to rectify any discrepancies in compensation for the previous contract and to ensure that impacts to VELB are fully mitigated.

Conservation Measure 4: Water Down Construction Area to Control Dust

The implementing agency or the contractor will ensure that the project construction area will be watered down as necessary to prevent dirt from becoming airborne and accumulating on elderberry shrubs within the 100-foot buffer.

Conservation Measure 5: Compensate for Direct and Indirect Effects on Valley Elderberry Longhorn Beetle Habitat

Project impacts to VELB habitat are discussed in Section 2.3 and compensation ratios are discussed below in Section 3.4.

Giant Garter Snake

Conservation measures for giant garter snake were developed using portions of the *Programmatic Formal Consultation for U.S. Army Corps of Engineers 404 Permitted Projects with Relatively Small Effects on the Giant Garter Snake within Butte, Colusa, Glenn, Fresno, Merced, Sacramento, San Joaquin, Solano, Stanislaus, Sutter, and Yolo Counties, California* (U.S. Fish and Wildlife Service 1997).

Conservation Measure 6: Conduct Construction Activities during the Active Period for Giant Garter Snake

To the maximum extent possible, all construction activity within giant garter snake aquatic and upland habitat within 200 feet of aquatic habitat will be conducted during the snake's active period (May 1–October 1). During this timeframe, potential for injury and mortality are lessened because snakes are actively moving and avoiding danger. Canal relocation at Reaches 22 and 28 to 29 and pipe reconstruction at Reaches 26–28 must be conducted when the canal is dry (February–March). Additional protective measures will be implemented at these locations (see Conservation Measure 14 below).

Conservation Measure 7: Install and Maintain Exclusion and Construction Barrier Fencing around Suitable Giant Garter Snake Habitat

To reduce the likelihood of giant garter snakes entering the construction area, the implementing agency will install exclusion fencing and orange construction barrier fencing along the portions of the construction area that are within 200 feet of suitable aquatic and upland habitat. The exclusion and construction barrier fencing will be installed during the active period for giant garter snakes (May 1–October 1) to reduce the potential for injury and mortality during this activity.

The construction specifications will require that the implementing agency or its contractor retain a qualified biologist to identify the areas that are to be avoided during construction. Areas adjacent to the directly affected area required for construction, including staging and access, will be fenced off to avoid disturbance in these areas. Before construction, the contractor will work with the qualified biologist to identify the locations for the barrier fencing and will place flags or flagging around the areas to be protected to indicate the locations of the barrier fences. The protected area will be clearly identified on the construction specifications. The fencing will be installed the maximum distance practicable from the aquatic habitat areas and will be in place before construction activities are initiated.

The exclusion fencing will consist of 3 foot-tall silt fencing buried at least 4–6 inches below ground level. The exclusion fencing will ensure that giant garter snakes are excluded from the construction area and that suitable upland and aquatic habitat is protected throughout construction. The construction barrier fencing will be commercial-quality, woven polypropylene, orange in color, and 4 feet high (Tensor Polygrid or equivalent). The fencing will be tightly strung on posts with a maximum of 10-foot spacing.

Barrier and exclusion fences will be inspected daily by a qualified biological monitor during ground-disturbing activities and weekly after ground-disturbing activities until project construction is complete or until the fences are removed, as approved by the biological monitor and the resident engineer. The biological monitor will be responsible for ensuring that the contractor maintains the buffer area fences around giant garter snake habitat throughout construction. Biological inspection reports will be provided to the project lead and USFWS.

Conservation Measure 8: Minimize Potential Impacts on Giant Garter Snake Habitat

The implementing agency will implement the following measures to minimize potential impacts on giant garter snake habitat.

- Staging areas will be located at least 200 feet from suitable giant garter snake habitat.
- Any dewatered habitat will remain dry for at least 15 consecutive days after April 15 and prior to excavating or filling of the dewatered habitat.
- Vegetation clearing within 200 feet of the banks of suitable giant garter snake aquatic habitat will be limited to the minimum area necessary. Avoided giant garter snake habitat within or adjacent to the project area will be flagged and designated as an environmentally sensitive area, to be avoided by all construction personnel.
- The movement of heavy equipment within 200 feet of the banks of suitable giant garter snake aquatic habitat will be confined to designated haul routes to minimize habitat disturbance.

Conservation Measure 9: Prepare and Implement a Stormwater Pollution Prevention Plan

Because ground disturbance for the project would be greater than 1 acre, the implementing agency would obtain coverage under the U.S. Environmental Protection Agency's (EPA's) National Pollutant Discharge Elimination System (NPDES) general construction activity stormwater permit. The Central Valley Regional Water Quality Control Board (RWQCB) administers the NPDES stormwater permit program in Sutter and Butte Counties. Obtaining coverage under the NPDES general construction activity permit generally requires that the project applicant prepare a stormwater pollution prevention plan (SWPPP) that describes the BMPs that would be implemented to control accelerated erosion, sedimentation, and other pollutants during and after project construction. The SWPPP would be prepared prior to commencing earth-moving construction activities.

The specific BMPs that would be incorporated into the erosion and sediment control plan and SWPPP would be site-specific and would be prepared by the construction contractor in accordance with the California RWQCB Field Manual. However, the plan likely would include, but not be limited to, one or more of the following standard erosion and sediment control BMPs.

- **Timing of construction.** The construction contractor will conduct all construction activities during the typical construction season to avoid ground disturbance during the rainy season.
- **Staging of construction equipment and materials.** To the extent possible, equipment and materials will be staged in areas that have already been disturbed.
- **Minimize soil and vegetation disturbance.** The construction contractor will minimize ground disturbance and the disturbance/destruction of existing vegetation. This will be accomplished in part through the establishment of designated equipment staging areas, ingress and egress

corridors, and equipment exclusion zones prior to the commencement of any grading operations.

- **Stabilize grading spoils.** Grading spoils generated during the construction will be temporarily stockpiled in staging areas. Silt fences, fiber rolls, or similar devices will be installed around the base of the temporary stockpiles to intercept runoff and sediment during storm events. If necessary, temporary stockpiles may be covered with an appropriate geotextile to increase protection from wind and water erosion.
- **Install sediment barriers.** The construction contractor may install silt fences, fiber rolls, or similar devices to prevent sediment-laden runoff from leaving the construction area. Natural/biodegradable erosion control measures (i.e., coir rolls, straw wattles or hay bales) will be used. Plastic monofilament netting (erosion control matting) will not be allowed because animals can become caught in this type of erosion control material.
- **Stormwater drain inlet protection.** The construction contractor may install silt fences, drop inlet sediment traps, sandbag barriers, and/or other similar devices.
- **Permanent site stabilization.** The construction contractor will install structural and vegetative methods to permanently stabilize all graded or otherwise disturbed areas once construction is complete. Structural methods may include the installation of biodegradable fiber rolls and erosion control blankets. Vegetative methods may involve the application of organic mulch and tackifier and/or the application of an erosion control seed mix. Implementation of a SWPPP will substantially minimize the potential for project-related erosion and associated adverse effects on water quality.

Conservation Measure 10: Prepare and Implement a Bentonite Slurry Spill Contingency Plan (Frac-Out Plan)

Before excavation begins, the implementing agency would ensure the contractor would prepare and implement a bentonite slurry spill contingency plan (BSSCP) for any excavation activities that use pressurized fluids (other than water). If the contactor prepares the plan, it would be subject to approval by USACE, NMFS, and SBFCA before excavation can begin. The BSSCP would include measures intended to minimize the potential for a frac-out (short for "fracture-out event") associated with excavation and tunneling activities; provide for the timely detection of frac-outs; and ensure an organized, timely, and "minimum-effect" response in the event of a frac-out and release of excavation fluid (i.e., bentonite). The BSSCP would require, at a minimum, the following measures.

- If a frac-out is identified, all work will stop, including the recycling of the bentonite fluid. In the event of a frac-out into water, the location and extent of the frac-out will be determined, and the frac-out will be monitored for 4 hours to determine whether the fluid congeals (bentonite will usually harden, effectively sealing the frac-out location).
- NMFS, CDFW, and the RWQCB will be notified immediately of any spills and will be consulted regarding clean-up procedures. A Brady barrel will be onsite and used if a frac-out occurs. Containment materials, such as straw bales, also will be onsite prior to and during all operations, and a vacuum truck will be on retainer and available to be operational onsite within notice of 2 hours. The site supervisor will take any necessary follow-up response actions in coordination with agency representatives. The site supervisor will coordinate the mobilization of equipment stored at staging areas (e.g., vacuum trucks) as needed.

- If the frac-out has reached the surface, any material contaminated with bentonite will be removed by hand to a depth of 1-foot, contained, and properly disposed of, as required by law. The drilling contractor will be responsible for ensuring that the bentonite is either properly disposed of at an approved Class II disposal facility or properly recycled in an approved manner.
- If the bentonite fluid congeals, no other actions, such as disturbance of the streambed, will be taken that will potentially suspend sediments in the water column.
- The site supervisor has overall responsibility for implementing this BSSCP. The site supervisor will be notified immediately when a frac-out is detected. The site supervisor will be responsible for ensuring that the biological monitor is aware of the frac-out, coordinating personnel, response, cleanup, regulatory agency notification and coordination to ensure proper clean-up, disposal of recovered material, and timely reporting of the incident. The site supervisor will ensure all waste materials are properly containerized, labeled, and removed from the site to an approved Class II disposal facility by personnel experienced in the removal, transport, and disposal of drilling mud.
- The site supervisor will be familiar with the contents of this BSSCP and the conditions of approval under which the activity is permitted to take place. The site supervisor will have the authority to stop work and commit the resources (personnel and equipment) necessary to implement this plan. The site supervisor will ensure that a copy of this plan is available (onsite) and accessible to all construction personnel. The site supervisor will ensure that all workers are properly trained and familiar with the necessary procedures for response to a frac-out, prior to commencement of excavation operations.

Conservation Measure 11: Prepare and Implement a Spill Prevention, Control, and Counter-Measure Plan

A spill prevention, control, and counter-measure plan (SPCCP) is intended to prevent any discharge of oil into navigable water or adjoining shorelines. the implementing agency or its contractor would develop and implement an SPCCP to minimize the potential for and effects from spills of hazardous, toxic, or petroleum substances during construction and operation activities. The SPCCP would be completed before any construction activities begin. Implementation of this measure would comply with State and Federal water quality regulations. The SPCCP would describe spill sources and spill pathways in addition to the actions that would be taken in the event of a spill (e.g., an oil spill from engine refueling would be immediately cleaned up with oil absorbents). The SPCCP would outline descriptions of containments facilities and practices such as doubled-walled tanks, containment berms, emergency shut-offs, drip pans, fueling procedures and spill response kits. It would also describe how and when employees are trained in proper handling procedure and spill prevention and response procedures.

The implementing agency would review and approve the SPCCP before onset of construction activities and routinely inspect the construction area to verify that the measures specified in the SPCCP are properly implemented and maintained. The implementing agency would notify its contractors immediately if there is a non-compliance issue and would require compliance.

The Federal reportable spill quantity for petroleum products, as defined in 40 CFR 110, is any oil spill that results in one or more of the following.

- Violates applicable water quality standards.

- Causes a film or sheen on or discoloration of the water surface or adjoining shoreline.
- Causes a sludge or emulsion to be deposited beneath the surface of the water or adjoining shorelines.

If a spill is reportable, the contractor's superintendent would notify the implementing agency, and the implementing agency would take action to contact the appropriate safety and cleanup crews to ensure that the SPCCP is followed. A written description of reportable releases must be submitted to the Central Valley RWQCB. This submittal must contain a description of the release, including the type of material and an estimate of the amount spilled, the date of the release, an explanation of why the spill occurred, and a description of the steps taken to prevent and control future releases. The releases would be documented on a spill report form.

Conservation Measure 12: Conduct Preconstruction Surveys and Monitoring for Giant Garter Snake

Prior to ground-disturbing activities within 200 feet of suitable habitat, a USFWS-approved biological monitor will conduct a preconstruction survey of suitable aquatic and upland habitat and inspect exclusion and orange barrier fencing to ensure they are both in good working order each morning. If any snakes are observed within the construction area at any other time during construction the USFWS-approved biological monitor will be contacted to survey the site for giant garter snakes. The biological monitor will have the authority to stop construction activities until appropriate corrective measures have been completed or it is determined that the snake will not be harmed. Giant garter snakes encountered during construction activities will be allowed to move away from construction activities on their own. If unable to move away on their own, trapped or injured giant garter snakes will be only be removed by the USFWS-approved biological monitor and will be placed in the nearest suitable habitat that is outside of the construction area. The biological monitor will immediately report these activities to USFWS by phone and will provide a written account of the details of the incident within 24 hours.

Once all initial ground-disturbing activities are completed, the biological monitor will perform weekly checks of the site for the duration of construction in order to ensure that construction barrier fences and exclusion fences are in good order, trenches are being covered, project personnel are conducting checks beneath parked vehicles prior to their movement, and that all other required biological protection measures are being complied with. The biological monitor will document the results of monitoring on construction monitoring log sheets, which will be provided to USFWS within 1 week of each monitoring visit.

Conservation Measure 13: Provide Escape Ramps or Cover Open Trenches at the End of Each Day

To avoid entrapment of giant garter snake, thereby preventing injury or mortality resulting from falling into trenches, all excavated areas more than 1 foot deep will be provided with one or more escape ramps constructed of earth fill or wooden planks at the end of each workday. If escape ramps cannot be provided, then holes or trenches will be covered with plywood or other hard material. The biological monitor or construction personnel designated by the contractor will be responsible for thoroughly inspecting trenches for the presence of giant garter snakes at the beginning of each workday. If any individuals have become trapped, the USFWS-approved biological monitor will be contacted to relocate the snake and no work will occur in that area until approved by the biologist.

Conservation Measure 14: Implement Additional Protective Measures during Work in Suitable Habitat during the Giant Garter Snake Dormant Period

USACE will implement additional protective measures during time periods when work must occur during the giant garter snake dormant period (October 2–April 30), when snakes are more vulnerable to injury and mortality. It is expected that these additional measures will be implemented during canal relocation at Reaches 22 and 28 to 29 and pipe reconstruction at Reaches 26–28 and during February–March, and if construction activities extend to the period between October 2 and November 1. A full-time USFWS-approved biological monitor will be onsite for the duration of construction activities.

- All emergent vegetation within the Sutter-Butte Canal on the levee side, and vegetation within 200 feet of the canal will be cleared prior to the giant garter snake hibernation period (i.e., vegetation clearing must be completed by October 1 for following winter work).
- Exclusion fencing will be installed around the perimeter of the work area and across the Sutter-Butte Canal where construction activities associated with levee slope flattening and pipe reconstruction activities would occur. The fencing should enclose the work area to the maximum extent possible to prevent giant garter snakes from entering the work area. Fencing will be installed during the active period for giant garter snakes (May 1–October 1) to reduce the potential for injury and mortality during fence installation. The USFWS-approved biological monitor will work with the contractor to determine where fencing should be placed and will monitor fence installation. The exclusion fencing will consist of 3 foot-tall erosion fencing buried 4-6 inches below ground level. The exclusion fencing will minimize opportunities for giant garter snake hibernation in the adjacent upland area (between canal and existing levee).

  Portions of the Sutter-Butte Canal that are temporarily disturbed during construction will be revegetated with emergent vegetation and adjacent disturbed upland habitat will be revegetated with native grasses and forbs after construction is complete.

Conservation Measure 16: Restore Temporarily Disturbed Aquatic and Upland Habitat to Pre-Project Conditions

To avoid permanent impacts, Upon completion of the construction, USACE will restore temporarily affected suitable and upland habitat for giant garter snake to pre-project conditions within a maximum of one season (a season is defined as the calendar year between May 1 and October 1 [U.S. Fish and Wildlife Service 1997]).

Conservation Measure 17: Compensate for Permanent Loss of Suitable Habitat for Giant Garter Snake

Compensation for permanent effects on giant garter snake aquatic and upland habitat will follow the guidance in the Programmatic Consultation. USACE will compensate for the permanent loss of suitable aquatic habitat and upland habitat for giant garter snake by purchasing preservation credits at a USFWS and CDFW approved conservation bank. Project impacts to GGS are discussed in Section 2.3 and compensation ratios are discussed below in Section 3.4.

2.2 Site Characteristics

2.2.1 Biological Resources in the Project Area

This section identifies the field surveys conducted to identify biological resources known to occur or having the potential to occur in the project area, special-status wildlife and fish species with potential to occur in the project area, and the effects of the project on sensitive biological resources.

Field Surveys

The field surveys conducted to identify biological resources in the project area consisted of habitat mapping, a delineation of wetlands and other waters of the U.S., special-status wildlife surveys, and a tree survey.

Land Cover Mapping

The information pertaining to land cover types in the project area was derived primarily from the collaborative mapping done in November 2010 by ICF International GIS staff and Galloway Consulting and updated as needed based on the results of the 2011 reconnaissance-level biological assessment conducted by ICF International biologists. These 2010 and 2011 field surveys were conducted by combination of aerial photograph interpretation and walking and driving through the project area.

Land cover types in the project area fall into four broad categories: wildlands, potential wetlands and other waters of the U.S., agricultural lands, and developed/disturbed areas.

Delineation of Wetlands and Other Waters of the U.S.

In June, July, and August 2012, HDR conducted a formal delineation of wetlands and other waters for all areas that may potentially be directly affected by construction of the project. Potential borrow site locations were surveyed for wetlands in winter 2012. An approved Preliminary Jurisdictional Delineation for the project area was received on May 1, 2013.

Special-Status Wildlife Surveys

Field surveys to identify habitats for special-status wildlife and elderberry shrub (*Sambucus* spp.) habitat for VELB in the project area were conducted by ICF biologists on July 20–22, July 27, and August 31, 2011. Additional mapping of the elderberry shrubs was conducted by ICF concurrently with arborist surveys in summer 2012. During the 2011 surveys, biologists located elderberry shrubs by driving and walking along the levee in the project area and mapped elderberry shrubs (and shrub clusters) with a sub-meter accuracy global positioning system (GPS). When the bases of shrubs were accessible, stem counts, heights, and widths of shrubs were recorded, and shrubs were surveyed for VELB exit holes. Where dense poison oak (*Toxicodendron diversilobum*), Himalayan blackberry (*Rubus armeniacus*), and/or other vegetation surrounds elderberry shrubs, stem counts and exit hole surveys could not be conducted. Final stem counts will be conducted on all elderberry shrubs prior to removal for transplanting.

An assessment of habitat for giant garter snake was conducted by ICF and HDR biologists on July 12, 2012, and October 25, 2012. During the assessment, biologists evaluated aquatic and upland habitat

for giant garter snake, took representative photographs of habitat present, and recorded all wildlife species observed.

Borrow sites recently have been identified and have not been surveyed yet. Surveys of these sites are planned to occur prior to construction. Any borrow site that contains habitat for listed species will not be utilized.

Tree Survey

ICF arborists assessed trees within the project footprint from July 17 to October 11, 2012. The arborist survey methods followed standard professional practices. Tree location data were collected with a GPS unit. Trees within the defined project footprint, overhanging the project footprint, and greater than 4 inches in DBH were surveyed. Trees were labeled with an aluminum tree tag with unique numbers inscribed on the tags.

The assessment criteria and recorded data from the arborist survey included:

- Identification of the species
- Status of the species
- Number of trunks
- Diameter of trunk 4.5 feet above the ground surface (DBH)
- Tree height
- Canopy dripline radius
- Health, vigor, and structure
- Remarks

For trees with relatively symmetrical canopies, the measurement from the trunk to the end of the longest lateral limb was measured and doubled to determine the diameter of the canopy. For trees with asymmetrical canopies, the diameter of the canopy was determined by adding the distance as measured from the longest lateral limb to the trunk to the distance measured from the trunk to the longest lateral limb on the opposite side of the tree (greater than 90 degrees either side from the first measurement).

Tree health and structure were rated as *good*, *fair*, or *poor*. Table 2-3 provides a general definition of these ratings. Where conditions were between ratings of good and fair or fair and poor, intermediate ratings of fair-good and fair-poor were given.

Table 2-3. Criteria Used to Rate the Health, Vigor, Structure and Form of Surveyed Trees

Rating	Tree Health and Vigor
Good	Overall appearance of the tree is exemplary of the species. No visible wounds or defects, or completely healed. Crown root area displays no signs of wood deterioration. Bark missing from less than 10% of trunk circumference. Trunk does not show any signs of wood decay, cracking, or deterioration. Foliage is exemplary of the species, no sprout growth observed, evenly distributed, and free of pests. No signs of disease symptoms or pests observed. Current annual twig growth is greater than expected for the species. Buds are normal size, viable, abundant, and uniform throughout canopy. Little to no evidence of stress or nutrient deficiency.
Fair	Overall appearance of the tree is representative of the species. Wounds actively healing, but not completely healed. Crown root area displays minor signs of wood deterioration. Bark missing from more than 10% but less than 30% of trunk circumference. Trunk does not show any signs of wood decay, cracking, or deterioration. Foliage is representative of the species, some sprout growth observed, foliage is unevenly distributed yet balanced across whole tree, or only a minor pest problem observed. Disease symptoms or pests observed create an intermittent or temporary nuisance. Current annual twig growth is as expected for the species. Buds are of normal size and viable, but are somewhat sparse or irregular throughout the canopy. Some evidence of minor stress or nutrient deficiency observed.
Poor	Overall appearance of the tree deviates from species representative. Wounds not healing vigorously or are showing signs of decay. Crown root area decayed over more than 30% of tree's cross section. Bark missing from more than 30% of trunk circumference. Trunk shows signs of wood decay, cracking, or deterioration. Foliage deviates from species representative, sprout growth observed, foliage is unevenly distributed, or pest infestation observed. Disease symptoms or pests observed threaten the health and well-being of host and/or adjacent trees. Current annual twig growth is less than expected for the species. Buds are few, or not viable, or sparse, or irregular throughout the canopy. Evidence of stress or nutrient deficiency observed.

Rating	Tree Structure and Form
Good	Tree structure has a low potential for failure. Ample space for tree to grow to mature size characteristic of the species. No visible root defects or damage from roots to infrastructure observed. No anchor roots exposed. Trunk appears solid and free of cavities, decay, or hollowness. No bark inclusion observed. Canopy is full and balanced. Single leader, branch attachment solid, and angle of branch attachment exemplary. No dead limbs observed, all limbs free of defects, and limbs are not overburdened.
Fair	Tree structure has a moderate potential for failure. Adequate space available for tree to grow to a size representative of the species. Roots abutting infrastructure, displacing built objects from normal alignment. Some anchor root exposure. Trunk displays some signs of minor deterioration, but structurally still solid and in process of healing. Bark inclusion observed only on minor branches and away from posing threats to health, safety, and welfare of the public. Canopy is slightly lacking or unbalanced. Leader not clearly defined, but not missing; branch attachment characteristic of species. One minor dead limb observed, but solidly attached, other limbs free of defects, limbs only slightly overburdened.
Poor	Tree structure has a high potential for failure. Inadequate space available for tree to grow to a size representative of the species. Roots lifting sidewalks or built objects from normal grade, extensive portions of root system cut, decay of root crown in excess of 30%, or root zone subject to overwatering. Anchor roots exposed. Trunk decay is affecting 30% or more of the trunk cross section, healing process slow or not evident, or crack observed. Unequal weight distribution within tree structure due to trunk lean. Bark inclusion at branches, involving main trunk, or posing a threat to health, safety, or welfare of the public. Canopy is lacking or unbalanced, or concentrated in the upper 1/3 of tree. Double leader or no leader observed, a branch observed nearly as large as trunk, narrow angles of branch attachment, multiple limb attachments or attachments of limbs not characteristic of species, or decay observed at branch attachment. More than one dead limb observed, a wound in limb observed greater than 30% of cross section, limbs overburdened, or multiple branches sprouting from cuts.

2.2.2 Special-Status Plants

Special-status plant species are plants that are legally protected under CESA, ESA, or other regulations, and species considered sufficiently rare by the scientific community to qualify for such listing.

Nine special-status plant species have been reported in the seven USGS quadrangles that overlap the project area (California Department of Fish and Game 2010; California Native Plant Society 2012; California Department of Fish and Game 2012; U.S. Fish and Wildlife Service 2012). Two species, slender Orcutt grass (*Orcuttia tenuis*) and Greene's tuctoria (*Tuctoria greenei*) are vernal pool species that lack potential habitat in the project area. No vernal pools were observed in the area during the 2010 and 2011 field surveys. Six species were determined to have low potential for occurrence because the potential habitat (i.e., oak woodland, ruderal areas outside the toe of the levee) constitutes a relatively small portion of the biological study area and has been lowered in quality by past and ongoing disturbance (agricultural activities, dredging). Additionally, suitable microhabitat requirements (subalkaline flats, heavy clay soils, acidic clay soils) for these species may not be met.

Sanford's arrowhead is the only special status species that could occur in jurisdictional habitat, including freshwater marshes, sloughs, canals, and other slow moving habitats. It is neither federally or state listed, but is classified as fairly endangered in California according to the California Rare Plant Rank. For the project area, it was determined to have low potential to occur along the edges of irrigation canals, inundated areas of the river's floodplain within riparian forest, and ponds on the land side of the levee that support a fringe of riparian forest.

2.2.3 Special-Status Wildlife Species

Special-status wildlife species are defined as animals that are legally protected under the ESA, CESA, or other regulations and species that are considered sufficiently rare by the scientific community to qualify for such listing. Special-status wildlife species are defined as follows.

- Species that are listed or proposed for listing as threatened or endangered under the ESA (50 CFR 17.11 for listed animals and various notices in the Federal Register (FR) for proposed species).
- Species that are candidates for possible future listing as threatened or endangered under the ESA (77 FR 69993, November 21, 2012).
- Species listed or proposed for listing by the State of California as threatened or endangered under the CESA (14 CCR 670.5).
- Species that meet the definitions of rare or endangered under CEQA (State CEQA Guidelines Section 15380).
- Animals listed as California species of special concern on CDFW's Special Animals List (California Department of Fish and Game 2011).
- Animals that are fully protected in California under the California Fish and Game Code (Sections 3511 [birds], 4700 [mammals], and 5050 [reptiles and amphibians]).

Based on the USFWS (2012) species list and CNDDB (California Department of Fish and Game 2012) records search for the quadrangles overlapping the affected area, 23 special-status wildlife species

were identified as having potential to occur in the affected area. Of these 23 species, four are known to occur in the affected area (western pond turtle, Swainson's hawk, western yellow-billed cuckoo, and bank swallow). Swainson's hawk was observed in the affected area during 2011 field surveys. Though not reported to occur in the affected area, 10 other special-status wildlife species have a moderate or high potential to occur in the affected area given their known range, reports of occurrence, and/or the presence of suitable habitat. These species include Antioch Dunes anthicid beetle (*Anthicus antiochensis*), Sacramento anthicid beetle (*A. sacramento*), Sacramento Valley tiger beetle (*Cicindela hirticollis abrupta*), VELB, giant garter snake, northern harrier, bald eagle, western burrowing owl, tricolored blackbird, and silver-haired bat. The remaining nine species have low or no potential to occur. Seven additional species were added as having at least a moderate potential to occur in the affected area based on species habitat requirements and professional judgment (white-tailed kite, loggerhead shrike, purple martin, yellow warbler, pallid bat, hoary bat, and western red bat).

ESA Consultation to Date

Of the 10 federally listed species considered for inclusion, only VELB and the giant garter snake have the potential to be affected by the project.

USACE, pursuant to ESA, must consult with USFWS with regard to any proposed actions that may affect the continued existence of a federally listed species. Following is a summary of communications with USFWS for the project.

The Corps has determined that the proposed project may affect, and is likely to adversely affect the federally-listed as threatened valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*)(beetle) and the giant garter snake (*Thamnophis gigas*)snake. A Biological Opinion (08ESMF00-2013-F-0342-1) was received from USFWS on May 2, 2013 concurring with the Corps determination and that critical habitat will not be affected concluding ESA section 7 consultation for the proposed project.

Project impacts to VELB and GGS habitat are discussed below.

Valley Elderberry Longhorn Beetle

Status and Distribution

VELB was listed by USFWS as a threatened species on August 8, 1980 (45 FR 52803–52807), due to loss of habitat and inadequate regulatory protection. The current known range of VELB extends from southern Shasta County, south to Fresno County, and from the east side of the Coast Range to the Sierra Nevada foothills (Barr 1991; U.S. Fish and Wildlife Service 2006). The USFWS promulgated the final ruling designating critical habitat for VELB on August 8, 1980 (45 Federal Register [FR] 52804). Two critical habitat areas were designated along portions of the American River in Sacramento County (the Sacramento Zone and the American River Parkway Zone). The Proposed Action addressed in this BA is not located within designated critical habitat for VELB. Critical habitat has not been designated for giant garter snake. Accordingly, critical habitat is not discussed further in this BA.

In 2006, USFWS released a 5-year review for VELB that recommended delisting the species due to reduction of its primary threats (loss of riparian and inadequacy of regulatory mechanisms) and the increased number of occurrences in the Central Valley (U.S. Fish and Wildlife Service 2006). The

report recommended a post-delisting monitoring plan that includes monitoring of the 195 known VELB locations. The purpose of the plan would be to ensure that VELB remains stable after ESA protections are removed.

On August 19, 2011, USFWS announced a 90-day finding on a petition to delist VELB (76 FR 51929–51931). USFWS found that the petition presented substantial scientific or commercial information indicating that delisting may be warranted and requested further scientific and commercial data and other information regarding VELB. Following the review of additional information, USFWS will issue a 12-month finding on the petition, which will address whether the petitioned action is warranted.

Habitat and Biology

VELB is dependent on its host plant, elderberry, which is a common component of riparian corridors and adjacent upland areas in the Central Valley. VELB has four stages of life: egg, larva, pupa, and adult. Females deposit eggs on or adjacent to the host elderberry. Egg production varies and females have been observed to lay between 16 and 180 eggs (U.S. Fish and Wildlife Service 2007). Eggs hatch within a few days of being deposited and larvae emerge. The larvae bore into the wood of the host plant and create a long feeding gallery in the pith of the elderberry stem. The larvae feed on the pith of the plant for 1–2 years. When a larva is ready to pupate, it chews an exit hole to the outside of the stem and then plugs it with frass. The larva then retreats into the feeding gallery and constructs a pupal chamber from wood and frass. The larvae metamorphose between December and April; the pupal stage lasts about a month. The adult remains in the chamber for several weeks after metamorphosis and then emerges from the chamber through the exit hole. Most records for adults show occurrence from late-April to mid-May (U.S. Fish and Wildlife Service 2007). Adults feed on elderberry leaves and mate within the elderberry canopy.

Studies conducted in the American River basin demonstrate that VELB occurs most frequently and is most abundant in significant riparian zones that are well developed. Within significant riparian zones, VELB primarily occurs within the riparian corridor but can occur infrequently in non-riparian scrub habitats adjacent to the riparian corridor. Along the American River, the beetle tends to occupy woodlands dominated by exotic trees (black locust [*Robinia psuedoacacia*]) and black walnut [*Juglans californica*]), and in mixed riparian forests. The beetle less commonly occupies annual grasslands and live oak woodlands. One study showed that the beetle preferentially occupies elderberry shrubs in wooded areas with a relatively dense canopy cover over elderberry shrubs located in open and sparsely wooded areas. Of the occupied shrubs found in wooded areas, about 50% were under a canopy cover of 25–50%, while 25% were under canopies with 50–75% cover and 25% were under canopies with 75–100% cover. The study also demonstrated that VELB appears to be capable of limited dispersal and prefers to remain within contiguous patches of high quality riparian habitat. Clusters of local aggregations of VELB along the American River Parkway were approximately 600–800 meters in diameter (Talley 2005 in Talley et al. 2006).

A variety of branch sizes are utilized for larval development and pupation, although most of those measured in Barr's study (1991) were 2–4 inches (5–10 centimeters) in diameter at the exit hole. Infrequently, smaller branches (less than 1.5 inches [3.8 centimeters] in diameter) that contained exit holes were encountered. Lang et al. (1989) found no current-year exit holes on stems smaller than 1 inch (2.5 centimeters) in diameter. Talley et al. (2007) found that exit holes most frequently occurred in stems that were 0.8–2.8 inches (2–7 centimeters) in diameter and below 3.2 feet (1 meter) (79%). Holes were also found in larger diameter stems (2.8–4.7 inches [7–12 centimeters]) (36% of occurrences) and at heights of 3.2–6.4 feet (1–2 meters) above the ground (19%).

Reasons for Decline

The primary threat to VELB has been attributed to habitat loss and degradation of the riparian forest ecosystem as a result of agricultural and urban development (Barr 1991; Barbour et al. 1993; Eng 1984; Kucera and Barrett 1995; Katibah 1984). Colonization by the Argentine ant (*Linepithema humile*) may also pose a biological threat to VELB through egg predation (Huxel 2000).

Occurrence in the Project Area

The closest VELB occurrence in the CNDDB (California Department of Fish and Game 2012) is approximately 0.5 mile from the project area. Numerous other occurrences are located within 10 miles of the project area.

Suitable habitat for VELB is located at numerous places in the project area along the levee construction footprint. There were no elderberry shrubs observed at the five borrow site locations during the wetlands delineation effort at these sites. A total of 267 shrubs/shrub clusters were mapped in the project area. Because of property inaccessibility and the high density of California grape and Himalayan blackberry along portions of the Feather River riparian corridor, stem counts and examination of shrubs for VELB exit holes could only be conducted for 73 shrubs/shrub clusters in the project area.

Effects of the Project on Valley Elderberry Longhorn Beetle

Direct effects are defined as the direct or immediate effects of a proposed action on a species or its habitat. Direct effects may result from the action and may include the effects of interrelated and interdependent actions. An *interrelated action* is an activity that is part of the proposed action and depends on the proposed action for its justification. An *interdependent action* is an activity that has no independent utility apart from the action under consultation (U.S. Fish and Wildlife Service and National Marine Fisheries Service 1998).

Indirect effects are caused by or result from the proposed action, are later in time, and are reasonably certain to occur. Indirect effects may occur outside the area directly affected by the action (U.S. Fish and Wildlife Service and National Marine Fisheries Service 1998).

Direct Effects

Permanent Loss of Elderberry Shrubs and Potential Loss of Individual VELB from Shrub Removal

Removal of habitat (elderberry) and potential injury or mortality of VELB associated with construction of the project would be considered direct effects on VELB. Trimming of elderberry branches that are 1 inch or greater in diameter could also result in injury or mortality of VELB. Because VELB larvae may feed on the roots of elderberries, disturbance of elderberry roots within the shrub dripline could also result in injury or mortality of individuals. Where root damage is expected to be extensive, elderberry shrubs would be removed. Where damage is limited (few roots affected) and roots are expected to grow back, impacts would be considered temporary. Because incidental take of VELB would be difficult to detect or quantify, effects on elderberry shrubs will be used as a proxy for measuring take.

Elderberry shrubs within the construction area that cannot be protected will be removed in accordance with to USFWS-approved procedures outlined in the Conservation Guidelines (U.S. Fish and Wildlife Service 1999a). Shrubs will be transplanted to the Star Bend Conservation Area.

Transplanted shrubs will be moved prior to construction when the plants are dormant, approximately November through the first 2 weeks in February, after they lose their leaves. Transplanting during the dormant period will reduce shock to the plant and increase transplantation success. However, transplanted elderberry shrubs may experience stress, a decline in health, or death due to changes in soil, hydrology, microclimate, or associated vegetation.

Elderberry shrubs that can be avoided at the dripline of the shrub or greater distance will be protected with fencing and/or k-rail as described in Conservation Measure 2. Based on the location of shrubs in the project footprint, there is anticipated to be 162 elderberry shrubs that will require transplantation during construction of the project.

As described in Conservation Measure 3, surveys of elderberry shrubs to be transplanted will be conducted by a qualified biologist prior to transplantation. The data collected during the surveys prior to transplantation will be used to determine if compensation requirements are being met, or if additional plantings are necessary. Because the project would be constructed in six separate contracts, elderberry survey data for each contract will be used to rectify any discrepancies in compensation for the previous contract, and ensure that impacts are being fully mitigated. Compensation ratios for VELB habitat is discussed below in Section 3.4.

Indirect Effects

As discussed above, *indirect effects* are caused by or result from the project, are later in time, and are reasonably certain to occur. Indirect effects may occur outside the area directly affected by the action.

Loss of Connectivity to Adjacent Habitat

Loss of connectivity between elderberry shrubs may result when elderberries or associated vegetation is removed. Removal of such vegetation could result in gaps in vegetation that are too wide for VELB to travel across due to their fairly limited movement distances (Talley et al. 2006a), resulting in separation of individuals or reducing the possibility of colonization of adjacent areas. Removal of associated vegetation may result in an altered habitat structure or microclimate that could affect behaviors of VELB in response to these changes in unforeseen ways (U.S. Fish and Wildlife Service 2003).

Although more research is needed, VELB has been observed to fly a mile or more in contiguous or fairly contiguous habitat, and exit holes have been observed on isolated shrubs that are a minimum of 0.25 mile (0.4 kilometer) from the next nearest elderberry (Arnold pers. comm. 2011). Within the American River Basin, evidence suggests that local beetle movements are farther within the riparian corridor (141±144 feet [43±44 meters]) than in the adjacent non-riparian scrub (82±52 feet [25±16 meters]) (average±1 standard deviation nearest neighbor distances between recent exit holes) illustrating that VELB population extents may also be habitat-specific (Talley et al. 2006a).

Soil Disturbance Adjacent to Roots

Ground disturbance within 20 feet (6.1 meters) of an elderberry shrub's dripline could result in disturbance of roots. Root damage could result in stress or reduced vigor of elderberry shrubs. Because construction of the project may result in disturbance within 20 feet (6.1 meters) of the dripline of elderberry shrubs, indirect effects on these shrubs may result. Elderberry shrubs will be fenced and/or protected with k-rail, as described in Conservation Measure 2, to minimize soil disturbance adjacent to roots. With this measure in place, and because elderberry shrubs are hearty

and frequently re-sprout after damage, this indirect effect is not expected to substantially affect VELB.

Dust

Vehicle travel on the levee road adjacent to elderberry shrubs during construction of the project could result in dust becoming airborne and settling on elderberries. The levee road is graveled, and existing shrubs are and have been exposed to dust from vehicles associated with farming and levee maintenance. Construction of the project would increase the amount of dust in the project area as a result of ground-disturbing activities and an increase in the frequency of vehicles driving on the levee road. The amount of dust in the project area would be minimized through dust control measures, as described in Conservation Measure 4. Additionally, according to Talley et al. (2006b), in an experiment along the American River Parkway (Sacramento County) conditions of elderberry shrubs related to dust from nearby trails and roads (paved and dirt) did not affect the presence of VELB. Additional work by Talley and Holyoak (2009) found no effect on elderberries from dust accumulations. Because dust has not been found to greatly affect elderberry shrubs and because dust control measures would be implemented during construction, this indirect effect is not expected to substantially affect VELB.

Altered Hydrology

Reduction of water to elderberry shrubs as a result of altered hydrology from changes in topography or compaction of soil could result in reduced shrub vigor/vitality and an associated decrease in shoot, leaf, and flower production and ultimately reduce the suitability of the shrubs to provide habitat for VELB. In most portions of the project area, the levee will be degraded and re-built within the same footprint, and would not modify the hydrology of the surrounding area where elderberries may be present. There may be a few instances where the slope is modified or there are other changes that may affect the hydrology in the project area. These situations are expected to be rare. Additionally, a substantial portion of the elderberries are located within riparian woodland along the Feather River and obtain water from within the river channel, which will not be hydrologically changed as a result of the project. Therefore, altered hydrology as a result of the project is not expected to substantially affect VELB.

Existing Elderberry Shrubs in the Conservation Area

As described in Conservation Measure 5, elderberry shrubs to be removed will be transplanted to the Star Bend Conservation Area, which contains existing elderberry shrubs. Although transplantation activities may occur within 100 feet of existing elderberry shrubs, it is unlikely that they would be indirectly affected by transplantation activities, as the transplantations would be conducted by qualified individuals who would be knowledgeable about elderberry shrubs and the existing conditions within the conservation area.

Temporal Loss of Habitat

It generally takes 5 or more years for newly planted elderberry cuttings/seedlings to become large enough to support beetles, and it generally takes 25 years or longer for riparian habitats to reach their full value (U.S. Fish and Wildlife Service 1994). Because elderberry shrubs within the project area will be transplanted to the Star Bend Conservation Area, which is immediately adjacent to the project area, no temporal loss of habitat for VELB is expected. Additional elderberry plantings in the conservation area will provide additional and/or replacement habitat for VELB in future years.

Giant Garter Snake

Status and Distribution

Giant garter snake was listed as a threatened species by USFWS on October 20, 1993 (58 FR 54033). The species is also State-listed as threatened. Giant garter snake is endemic to the Sacramento and San Joaquin Valleys where it is found in lowland areas (U.S. Fish and Wildlife Service 1999b). Historically, this species was found throughout the Central Valley from Butte County in the north to Kern County in the south. Currently, giant garter snake is only known to occur in 13 discrete populations in the Sacramento and San Joaquin Valleys in Butte, Colusa, Fresno, Glenn, Merced, Sacramento, San Joaquin, Solano, Stanislaus, Sutter, and Yolo Counties (U.S. Fish and Wildlife Service 1999b:9, 11–12).

Habitat and Ecology

Giant garter snakes inhabit agricultural wetlands and other waterways including irrigation and drainage canals, ricelands, marshes, sloughs, ponds, small lakes, and low gradient streams, as well as adjacent upland areas in the Central Valley. Because of the direct loss of natural habitat, giant garter snake relies heavily on rice fields in the Sacramento Valley, but it also uses managed marsh areas in national wildlife refuges and State wildlife areas.

Habitat requirements for giant garter snake consist of the following.

- Adequate water during the snake's active season (early spring through mid-fall) to provide food and cover.
- Emergent, herbaceous wetland vegetation, such as cattails and bulrushes, for escape cover and foraging habitat during the active season.
- Grassy banks and openings in waterside vegetation for basking.
- Higher elevation uplands for cover and refuge from flood waters during the snake's dormant season in the winter.

Giant garter snake can persist in waterbodies that contain predatory fish if sufficient cover is present. It is typically absent from larger rivers because of lack of suitable habitat and emergent vegetative cover; it is also typically absent from wetlands with sand, gravel, or rock substrates. Riparian woodlands typically do not provide suitable habitat because of excessive shade, lack of basking sites, and absence of prey populations.

Giant garter snake inhabits small mammal burrows and other soil crevices above prevailing flood elevations throughout its winter dormancy period (November through mid-March), where it typically selects burrows with sunny exposure along south and west facing slopes. The breeding season extends from March through May and resumes briefly in September. Females give birth to live young from late July through early September. Giant garter snake feeds primarily on small fishes, tadpoles, and frogs (U.S. Fish and Wildlife Service 1999b:12, 13, 22, 24).

Reasons for Decline

Giant garter snake has been extirpated from the southern third of its range as a result of agricultural and flood control activities, which have eliminated the snake's freshwater marsh habitat in the historical Buena Vista, Tulare, and Kern lakebeds. Much of the habitat on the floor of the Central

Valley has been lost or degraded by upstream watershed modifications, water storage and diversion projects, and urban and agricultural development. Other negative factors that may be contributing to the decline of giant garter snakes include interrupted water supply, poor water quality, and contaminants (U.S. Fish and Wildlife Service 1999b:25.)

Occurrence in the Project Area

There are no CNDDB records of occurrences of giant garter snake in the project area; however, there are 20 records of occurrences within 5 miles of the project area (California Department of Fish and Game 2012). The information for some of these records is suppressed, but the closest available occurrence is approximately 2 miles from the project area (California Department of Fish and Game 2012).

Within the project area, suitable aquatic habitat for giant garter snake is present within rice fields, irrigation canals, drainage canals, and ponds. Some of the drainage canals and ponds in the project area provide suitable aquatic habitat but do not have connectivity to other water features except the Feather River (which is not considered suitable habitat).

Canals

Canals in the project area consist of the Sutter-Butte Canal and other linear, concrete-lined features that convey water across multiple parcels. Many of these features have no vegetation present, while some have herbaceous emergent (rooted) vegetation and shrubs present in the margins. These canals generally convey water only during the active agricultural periods, which take place between April 15 and February 15.

Suitable upland habitat in the project area is limited to the levee banks and adjacent ruderal areas. Giant garter snakes (if present) are expected primarily to be associated with aquatic habitat in the project area. Table 2-5 provides a summary of the suitability of potential aquatic habitat in the levee construction portion of the project area. Table 2-6 provides a summary of the suitability of potential borrow sites to provide habitat for giant garter snake.

Table 2-5. Suitability of Aquatic Habitat for Giant Garter Snake in the Levee Construction Portion of the Project Area

Approximate Stationing	Aquatic Habitat	Suitability for Giant Garter Snake
208	Perennial ponded area, ditch along levee toe	Suitable aquatic—limited upland, no connectivity to other aquatic.
233	Ditch on land side of levee	Suitable aquatic.
254–258	Pond	Suitable aquatic—limited upland, no connectivity to other aquatic.
280	Canal	Suitable aquatic (low quality) —limited upland, has connectivity to other canals/ditches.
292	Concrete lined canal	Suitable—isolated segment but near other canals.
310	Perennial pond	Suitable aquatic—burrows in grassy hillside and levee side, channel from pond continues north along base of levee and also provides habitat.
336	Perennial pond	Dense willow ring, limited basking areas and upland, limited suitability/low potential for species.

Approximate Stationing	Aquatic Habitat	Suitability for Giant Garter Snake
373	Open channel on water side of levee	Suitable aquatic.
396	Canal	Suitable aquatic.
409–410	Cement-lined storage pond	Not suitable—concrete-lined and fenced.
409–410	River backwater, freshwater emergent, and seasonal wetland	Marginal aquatic—area connected to river with marsh.
426	Channel with marsh (seasonal wetlands)	Suitable aquatic—open areas for basking, side of levee may provide upland.
434	Perennial pond	Suitable aquatic—open areas for basking, side of levee provides upland habitat.
512	Canal	Not suitable—canal is concrete-lined, used for drainage, and not connected to other canals/ditches and water not maintained.
544–577	Abbott Lake	Suitable aquatic—open areas for basking, limited upland habitat, connected "channel" along base of levee to the north also provides suitable aquatic.
647–649	Cement-lined storage pond	Not suitable.
689	Canal	Assumed suitable—appears to connect to other canals/ditches, limited suitable upland.
872–880	Seasonal wetland	Wetland feature observed dry during October 25, 2012 site visit. Not suitable—likely does not stay inundated through summer, may not have open water.
1043–1052	Detention pond	Not suitable—unvegetated and unlikely to sustain water through summer.
1043	Stream	Not suitable—stream isolated by river and development.
1060	Stream	Not suitable—stream isolated by river and development.
1375	Unlined canal	Suitable habitat—water present throughout the summer.
1428	Start of Sutter-Butte Canal	Suitable throughout the project area—water year-round, some patches of suitable emergent vegetation, connectivity to other canals/ditches.
1707	Canal	Similar to the Sutter-Butte Canal, suitable aquatic—connectivity to other canals/ditches.
1761–1766	Ditch	Not suitable—ditch is not very defined and is isolated.
1902	Ditch	Suitable aquatic—ditch had water on October 25, 2012 site visit, ditch is small and isolated but is in close proximity to the Sutter-Butte Canal.
1958	Canal/ditch	Assumed suitable—connected to Sutter-Butte Canal.
2076, 2122, 2217, 2262	Ponds in tailings area	Marginal suitability—aquatic areas appear suitable at base, but are often surrounded by steep mounds of tailings; availability of food is questionable; upland areas are rocky and are unlikely to provide burrows.
2359	Canal	Assumed suitable—it connects to other canals and ditches, although canal has stagnant water and really steep sides.

Table 2-6. Habitat Suitability of Potential Borrow Sites for Giant Garter Snake

Potential Borrow Site	Habitat Present	Habitat Suitability
Oroville Wildlife Area Dredge Tailings Area	Tailings with emergent vegetation	Not considered suitable—aquatic areas appear suitable at base, but are often surrounded by steep mounds of tailings; availability of food is questionable; upland areas are rocky and are unlikely to provide burrows.
City of Live Oak Detention Basin	Irrigation ditch and grassland	Suitable—irrigation ditch along the edge of the property extends beyond the potential borrow site and provides suitable aquatic habitat; adjacent grassland provides suitable upland habitat.
South Ella Detention Pond	Ruderal grassland	Not suitable—no reported aquatic habitat within 200 feet of potential detention pond borrow site.
Lanza 40-acre property	Agricultural/ row crops	Suitable—irrigation ditch along the edge of the property provides suitable aquatic habitat but adjacent area where borrow would be removed is not suitable (i.e., no impacts to irrigation ditch).
Marler property	Agricultural/ row crops	Not suitable—no aquatic or upland habitat present.

Effects of the Project on Giant Garter Snake

Suitable aquatic habitat for giant garter snake in the project area consists of rice fields, irrigation canals, drainage canals, and ponds. Suitable upland habitat consists of ruderal grassland on the levee banks and adjacent to the levee banks. For the effects discussion below, impacts on ruderal grassland areas were calculated if they occur within 200 feet of suitable aquatic habitat.

Permanent and Temporary Disturbance of Suitable Aquatic and Upland Habitat for Giant Garter Snake

Permanent and temporary losses of suitable aquatic and upland habitat for giant garter snake within the project area are summarized in Table 2-7. Construction of SB-8 would result in the permanent loss of 3.54 acres of suitable upland habitat for giant garter snake. The permanent loss results from the installation of 3,700 linear feet of landside levee slope erosion protection (anchored high performance turf reinforced mat). Construction of SB-8 would also result in the temporary loss or disturbance of 118.80 acres of suitable upland habitat for giant garter snake. Temporary impacts to suitable upland habitat would mostly occur along the levee and at the City of Live Oak Detention Basin borrow site.

Permanently impacted suitable upland and aquatic habitat for giant garter snake would be compensated for through purchasing preservation credits equal to 22.5 acres of giant garter snake habitat at Westervelt Ecological Services' Sutter Basin Conservation Bank in Sutter County, as described in Conservation Measure 17.

Temporarily affected aquatic and upland habitat would be restored to pre-project conditions within a maximum of one season (a season is defined as the calendar year between May 1 and October 1 [U.S. Fish and Wildlife Service 1997]), as described in Conservation Measure 16.

If additional impacts to giant garter snake habitat are expected to occur within or outside of the project area, USACE will consult with USFWS to determine whether reinitiation of Section 7 consultation is necessary to address these additional effects.

Disturbance or degradation of suitable aquatic habitat for giant garter snake in the project area could occur if soil or other materials are sidecast or fall into the habitat. Fuel or oil leaks or spills adjacent to aquatic habitat could also cause degradation of habitat. These potential effects would be avoided by installing sediment and construction barrier fencing (Conservation Measure 7), locating staging areas away from aquatic habitat (Conservation Measure 8), implementing sediment and contaminant BMPs as required by the NPDES permit (SWPPP) (Conservation Measure 9), and preparing a frac-out plan and SPCCP (Conservation Measures 10 and 11).

Table 2-7. Effects on Giant Garter Snake Habitat in the project area

Habitat	SB8 Levee Construction Area	Borrow Sites in Acres	SB8 Total Acreage
Temporary Effects			
Aquatic habitat	11.9	127.72	139.62
Upland habitat (ruderal within 200 feet of aquatic habitat)	96.79	175.47	272.26
Permanent Effects			
Aquatic habitat	0	0	0
Upland habitat (ruderal within 200 feet of aquatic habitat)	3.54	0	3.54

Potential Injury or Mortality of Giant Garter Snake

Construction activities in suitable habitat could result in the injury, mortality, or disturbance of giant garter snakes. Giant garter snakes could be injured or crushed by construction equipment working in suitable aquatic and upland habitat, or if soil or other materials are side-cast or fall into suitable aquatic habitat. Snakes could also be killed by construction vehicles traveling though the project area. Fuel or oil spills from construction equipment into aquatic habitat could also cause illness or mortality of giant garter snakes. Trenches left open overnight could trap snakes moving through the construction area during the early morning hours. Noise and vibrations from construction equipment, and presence of human activity during construction activities may also disturb giant garter snakes within the project area.

Most construction activities will be limited to the snake's active period (May 1–October 1) when the potential for direct mortality is reduced because snakes can actively move and avoid danger. However, realignment work for the Sutter-Butte Canal (Reaches 22, 28-29) requires construction during February and March when the irrigation canal is dry. Giant garter snakes, if present, in the upland ruderal grassland adjacent to the canal could be injured or killed during work within the snake's dormant period. Conservation Measure 14 would be implemented to reduce the potential for mortality.

Potential effects on giant garter snake would be minimized or avoided by conducting biological resources awareness training (Conservation Measure 1), conducting work during the active period (May 1–October 1) (Conservation Measure 6), installing exclusion fencing around suitable habitat (Conservation Measure 7), conducting preconstruction surveys and monitoring (Conservation

Measure 12), and providing escape routes or covering open trenches (Conservation Measure 13). If work continues past October 1, additional preconstruction surveys and monitoring will be required (Conservation Measure 14).

Indirect Effects

Construction of the project is not expected to have any indirect effects on giant garter snake. Two potential indirect effects on giant garter snake and its habitat were considered but were determined to have no potential to occur as a result of the project. Specifically, the following determinations were made.

- There would be no increase of trash, hazardous waste, or off-road vehicle use due to increased human presence. The project would not result in development or increased access to giant garter snake habitat.
- The project would not result in indirect effects on habitat suitability through changes in the length of inundation or other habitat modifications that would make the habitat less suitable for giant garter snake.

Cumulative Effects

As described above, cumulative effects are future State, local, and private actions not involving a Federal action that are reasonably certain to occur within the action area under consideration. No other actions within the action area are proposed at this time. Therefore, no cumulative effects would result from the proposed action.

Future Federal actions that are unrelated to the project are not considered in this section because they would be subject to separate consultation pursuant to Section 7 of the ESA.

2.2.4 Special-Status Fish Species

Several special-status fish species occur or have the potential to occur in or near the study area. Critical habitat for spring-run Chinook salmon and Central Valley steelhead falls within the study area in the Feather River. In addition, the Feather River is designated critical habitat for green sturgeon (74 FR 52345 October 9, 2009). While the Feather River is not designated critical habitat for winter-run Chinook salmon, effects on this species were considered as they have the potential to occur in the study area for at least part of their life-cycle.

No construction activities are proposed in-river or below ordinary high water mark (OHWM); all activities that would result in physical disturbance and removal of vegetation on the waterside slope of the levee would be limited to areas above OHWM. Therefore, no physical modification of critical habitat for ESA-listed fish species would be expected because all proposed construction activities would occur above the OHWM of the Feather River. No mitigation measures are required for special-status fish due to project impacts. Loss of waterside riparian habitat that may indirectly affect fish habitat is being compensated for as described below.

2.2.5 Riparian Forest

Riparian forest occurs along the Feather River, on the waterside and landside of the levees, and forms a fringe around ponds. Riparian forests support an overstory dominated by mature native and nonnative trees. The dominant overstory species are valley oak (*Quercus lobata*), Fremont

cottonwood (*Populus fremontii* ssp. *fremontii*), or Goodding's black willow (*Salix gooddingii*). Other trees commonly observed in the riparian forest are box elder (*Acer negundo* var. *californicum*), arroyo willow (*S. lasiolepis*), Oregon ash (*Fraxinus latifolia*), and western sycamore (*Platanus racemosa*). The shrub layer of most of the riparian forest in the biological study area is extremely dense, and species commonly observed are Himalayan blackberry, poison oak, button bush (*Cephalanthus occidentalis*), wild rose (*Rosa* spp.) and blue elderberry (*Sambucus nigra* ssp. *caerulea*). Blue elderberry is the host plant for the valley elderberry longhorn beetle, federally listed as threatened. Many of the trees and shrubs in the riparian forest are covered in California grape (*Vitis californica*). The herbaceous understory of riparian forest contains a mixture of native and introduced species. Representative species observed were horsetails (*Equisetum* spp.), mugwort (*Artemisia douglasiania*), and curly dock (*Rumex crispus*). Several patches of the invasive giant reed (*Arundo donax*) occur along the edges of riparian areas.

Effects of the Project on Riparian Forest

An arborist survey of the project area was conducted during the summer of 2012 to identify riparian trees that would be affected by the project. Cutoff wall and seepage berm construction would require removal of vegetation within the construction footprint. An additional amount of riparian habitat located in the ETL vegetation-free zone could require removal to comply with USACE levee vegetation policy. A variance under the policy would reduce this loss.

Construction of the project is estimated to impact 42.50 acres of riparian forest and scrub shrub riparian habitat (USFWS Draft Coordination Act Report). Tree survey dripline canopy data indicates that this impact acreage provides in total 2.88 acres of riparian tree canopy. Impacts to riparian trees were generated from data collected during the arborist survey described above in Section 2.3.1.

Vegetation removed would not be restored onsite because riparian restoration would not be permitted on the levees or seepage berms as it would conflict with USACE levee vegetation policy. The policy requires that the crown, slopes, and areas within 15 feet of the waterside and landside levee toes be maintained free of all woody vegetation.

Riparian communities, including cottonwood riparian woodland and valley oak riparian woodland, are considered sensitive natural communities by the CNDDB (California Department of Fish and Game 2012). These woodlands would be regulated by CDFW and USFWS (46 FR 7644) under no-net-loss policies for existing riparian habitat values.

2.2.6 Oak Woodland

The biological study area contains several small patches of oak woodland. The overstory of oak woodlands is predominantly valley oak but some ornamental tree species are also present. The understory of oak woodland contains annual grasses mixed with native and nonnative forbs. Representative understory species are wild oat (*Avena* spp.), soft chess (*Bromus hordeaceus*), ripgut brome (*B. diandrus*), field hedge parsley (*Torilis arvensis*), and the invasive yellow starthistle (*Centaurea solstitialis*).

Construction of the project is estimated to impact 1.30 acres of oak woodland (USFWS Draft Coordination Act Report). Tree survey dripline canopy data indicates a loss of oak trees totaling 10.12 acres of non-riparian native tree canopy. Impacts to non-riparian native trees were generated from data collected during the arborist survey described above in Section 2.3.1.

2.2.7 USACE Section 404 Jurisdictional Areas

The project area contains numerous features that are potential wetlands and other (i.e., non-wetland) waters of the United States that may be subject to USACE jurisdiction under Section 404 of the Clean Water Act (CWA). An approved Preliminary Jurisdictional Delineation for project site was received on May 1, 2013 from the USACE Sacramento District.

Affected Wetland and Other Water Types

The types and acreages of wetlands and other waters that would be affected by the proposed project are listed below in Table 2-8. A description of each type of affected wetland and other water is provided below.

Table 2-8. Acreages of Affected Wetlands and Other Waters

Land Cover Types	SB8 Alternative - Permanent	SB8 Alternative - Temporary
Irrigation/canal ditch	4.19	3.08
Riparian forest wetland	0.005	0.324
Forested Wetland	0.002	0
Drainage Fixture	0.006	0.008
Tailings wetland	0.911	0.11
Seasonal wetlands	0.026	0
Open water	0.038	0
Subtotal	***5.178***	***3.099***

Irrigation Ditches/Canals

The drainage ditches and canals scattered within the biological study area are anthropogenic features that drain water from active agricultural lands during the growing season or following a rain event. They consist of the Sutter-Butte Canal, and other linear, concrete-lined features that convey water across multiple parcels. Many of these features are unvegetated; however, some support emergent vegetation or shrubs along their margins.

Open Water

In addition to providing habitat for fish, open water provides foraging, cover, and reproductive sites for a variety of wildlife species. Open water areas provide essential foraging habitat for a variety of birds, including wading birds such as great blue heron, great egret, and snowy egret (*Egretta thula*); waterfowl such as northern shoveler (*Anas clypeata*), northern pintail (*Anas acuta*), common goldeneye (*Bucephala clangula*), mallard (*Anas platyrhynchos*), common merganser (*Mergus merganser*), ruddy duck (*Oxyura jamaicensis*), gadwall (*Anas strepera*), and cinnamon teal (*Anas cyanoptera*); other water birds such as eared grebe (*Podiceps nigricollis*), double-crested cormorant (*Phalacrocorax auritus*), and American white pelicans (*Pelecanus erythrorhynchos*); and land birds such as bald eagle (*Haliaeetus leucocephalus*), bank swallow (*Riparia riparia*), and belted kingfisher (*Megaceryle alcyon*).

Reptiles and amphibians, including western pond turtle, common garter snake, western aquatic garter snakes (*Thamnophis couchii*), Pacific tree frog, western toad, and bullfrog, use open water

areas for breeding, foraging, and cover. Canals and ditches that contain water through mid-fall, have suitable prey, and adequate cover and foraging habitat have the potential to support giant garter snake (*Thamnophis gigas*).

Mammals that use open water habitats for foraging include bats such as California myotis, Yuma myotis, hoary bat, and western red bat, which forage for insects over open water. Additionally, terrestrial mammals such as black-tailed deer, raccoon, striped skunk, and Virginia opossum use open water habitats as water sources. Aquatic and semi-aquatic mammals that occur in open water habitats include beaver, river otter (*Lutra canadensis*), mink (*Mustela vison*), and muskrat.

Riparian Forest Wetlands

Forested/shrub wetlands occur on the waterside of the levee along the margins of the Feather River (but are outside the OHWM of the river) and are concentrated in the southern half of the biological study area. The vegetation in riparian forest wetlands is comparable to that of non-wetland riparian forest and non-wetland riparian scrub-shrub (described above); however, the forested/shrub wetlands exhibit positive indicators of all three Federal wetland criteria.

Tailing Ponds

Tailing ponds are concentrated in the northern portion of the project area. As indicated, these waterbodies formed in the tailings from dredge mining and are ringed by trees and shrubs. Similar to freshwater emergent wetlands, tailing ponds with standing water typically contain a mixture of floating and emergent wetland vegetation such as common rush, tall flatsedge, lady's thumb, spikerush (*Eleocharis* spp.) floating primrose willow, and common duckweed. The adjacent trees and shrubs are Pacific willow (*Salix lasiandra*), Goodding's black willow, and valley oak.

Seasonal Wetlands

Seasonal wetlands are scattered throughout the southern half of the project area. The vegetation in seasonal wetlands is dominated by herbaceous species such as tall flatsedge, ripgut brome, Hooker's evening primrose (*Oenothera elata*), horseweed (*Conyza canadensis*), common rush (*Juncus effusus*), seashore vervain (*Verbena litoralis*), and Bermuda grass (*Cynodon dactylon*). Based on the lack of a restrictive layer and absence of a plant community with species that are typically found only in vernal pools (e.g., coyote thistle [*Eryngium* sp.]), the seasonal wetlands in the project area were determined to not be vernal pools.

Temporary Impacts

All areas within any project land cover type which incurs temporary impacts to waters of the United States would be restored to their original state following construction. Best management practices and storm water pollution prevention plans would ensure no additional impacts to existing wetlands and waters.

Soils and Substrate

The Natural Resources Conservation Service (NRCS) Soil Survey shows the permanent impacts to jurisdictional waters are mapped within 10 different soil types. Descriptions of the soil types are listed in Table 2-9. Most of the soils have loamy alluvium parent materials, except for the 118 Xerorthents, which are dredge spoils. The soils are found on low slope floodplain and terrace landorms and range from somewhat poorly drained to somewhat excessively drained.

Hydric soils are formed under saturated conditions (due to flooding or ponding) for sufficiently long enough duration during the growing season to form anaerobic conditions in the upper soil layer. The soils support growth of hydrophytic vegetation. The 7 soils with a hydric rating and criteria are also indicated in Table 2-. Five of 7 hydric soils listed are described by the NRCS as only containing minor hydric soil components located in only 3–5% of the soil mapping unit, which means that the soils in the impacted areas themselves may not contain any hydric soil layers.

The predominant soil types of the permanently impacted jurisdictional areas (excluding canals) are 118 Xerorthents, tailings, 0 to 50 percent slopes (45% of area) and 124 Conejo loam, 0 to 2 percent slopes (29% of area). Soil type 118 Xerorthents, tailings is derived from dredged spoil piles from gravelly alluvium derived from igneous, metamorphic and sedimentary rock. The texture of the surface layer is very gravelly sandy loam. It is rated as a hydric soil across 80% of its mapping unit with a hydric rating of 4, which refers to soils that are frequently flooded for long or very long duration during the growing season. Soil type 124 Conejo loam, 0 to 2 percent slopes is derived from loamy alluvium derived from mixed sources. Typically, the surface layer is an approximate 7 inch brown loam and the subsoil is brown loam about 23 inches thick. It is not rated as a hydric soil. The third soil type comprising a substantial portion (17%) of the total impacted area is 121 Boga-Loemstone complex, 0 to 1 percent slopes. It's derived from loamy alluvium over dense silty alluvium derived from igneous and metamorphic rock. The surface layer texture is loam and it is not rated as a hydric soil.

Vegetation

The dominant plant communities in the impacted areas are described above in Section 2.3.3.

Threatened and Endangered Species

Discussion of federally-listed and other special status species is described in detail above in Section 2.3.2 and 2.3.3.

VELB was listed by USFWS as a threatened species on August 8, 1980 (45 FR 52803–52807), due to loss of habitat and inadequate regulatory protection (U.S. Fish and Wildlife Service 2011). The current known range of VELB extends from southern Shasta County, south to Fresno County, and from the east side of the Coast Range to the Sierra Nevada foothills (Barr 1991; U.S. Fish and Wildlife Service 2006). Two critical habitat areas have been designated along portions of the American River in Sacramento County (U.S. Fish and Wildlife Service 1984).

The giant garter snake is the only federally listed species occurring in jurisdictional waters requiring ESA consultation. Critical habitat has not been designated for the giant garter snake.

Table 2-9. Characteristics of Soils in the Impacted Areas

Soil Unit	Parent Material	Slope	Drainage Class	Capacity of Limiting Layer to Transmit Water	Landform	Hydric Rating	Hydric Criteria
Sutter County							
124 Conejo loam, 0 to 2 percent slopes	Loamy alluvium derived from mixed sources	0–2%	Well drained	Moderately high or high (0.57–1.98 in/hr)	Terraces		
126 Conejo-Tisdale complex, 0 to 2 percent slopes	Loamy alluvium derived from mixed sources	0–2%	Well Drained	Moderately High (0.2–0.57 in/hr)	Terraces	Yes [a]	2B3, 4
138 Liveoak sandy clay loam, 0 to 2 percent slopes	Loamy alluvium derived from igneous and metamorphic rock	0–2%	Moderately well drained	Moderately high or high (0.57–1.98 in/hr)	Terraces		
143 Marcum-Gridley clay loams, 0 to 1 percent slopes	Loamy alluvium derived from mixed sources	0–1%	Moderately well drained	Very low (0.00–0.00 in/hr)	Terraces	Yes [b]	2B3, 4
165 Shanghai silt loam, frequently flooded, 0 to 2 percent slopes	Alluvium derived from mixed sources	0–2%	Somewhat poorly drained	Moderately high or high (0.57–1.98 in/hr)	Floodplains	Yes	4
Butte County							
118 Xerorthents, tailings, 0 to 50 percent slopes	Dredged spoil piles from gravelly alluvium derived from igneous, metamorphic and sedimentary rock	0–50%	Somewhat Excessively Drained	High (1.98–4.25 in/hr)	Floodplains	Yes	4
121 Boga-Loemstone complex, 0 to 1 percent slopes	Loamy alluvium over dense silty alluvium derived from igneous and metamorphic rock	0–1%	Moderately well drained	Low to moderately low (0.00–0.06 in/hr)	Terraces		
152 Gianella fine sandy loam, 0 to 1 percent slopes, frequently flooded	Stratified coarse-loamy alluvium derived from igneous, metamorphic and sedimentary rock	0–1%	Moderately well drained	Moderately high or high (1.13–5.38 in/hr)	Floodplains	Yes [c]	4
161 Gianella fine sandy loam, 0 to 1 percent slopes, rarely flooded	Stratified coarse-loamy alluvium derived from igneous, metamorphic and sedimentary rock	0–1%	Moderately well drained	Moderately high or high (1.13–5.95 in/hr)	Floodplains	Yes [d]	2B2
162 Gianella loam, 0 to 1 percent slopes, rarely flooded	Stratified coarse-loamy alluvium derived from igneous, metamorphic and sedimentary rock	0–1%	Moderately well drained	Moderately high or high (0.85–1.98 in/hr)	Floodplains	Yes [e]	2B2

[a] Only for the Oswald component, which comprises 3% of the soil mapping unit.
[b] Only for the Oswald and Capay components, which comprise a combined 4% of the soil mapping unit.
[c] Only for the Columbia, frequently flooded component, which comprises 3% of the soil mapping unit.
[d] Only for the Columbia taxadjunct, very fine sandy loam component, which comprises 3% of the soil mapping unit.
[e] Only for the Columbia taxadjunct, very fine sandy loam component, which comprises 5% of the soil mapping unit.
2B2 - A water table at a depth of 0.5 foot or less during the growing season if permeability is equal to or greater than 6.0 in/hr in all layers within a depth of 20 inches
2B3 - A water table at a depth of 1.0 foot or less during the growing season if permeability is less than 6.0 in/hr in any layer within a depth of 20 inches.
4 - Soils that are frequently flooded for long or very long duration during the growing season.

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Chapter 3
Mitigation Design

3.1 Basis for Design

On-site replacement habitat involves replacement of affected habitat with new habitat of the same type and at the same location as the loss. Because much of the affected habitat (specifically, woody vegetation) is not compliant in its location with USACE levee vegetation policy, this option is not considered feasible. Further, the highly dispersed nature of the impact locations makes efficient replacement infeasible. Therefore, on-site replacement was not considered further as a viable option for this project and off-site, in-kind habitat replacement was selected as the best option for mitigation. It involves replacement of affected habitat with the same type of habitat at a different location off-site. This often allows for consolidation of mitigation at a single or small number of sites, allowing for economy of scale and higher quality habitat due to large patch size.

The project will utilize two sub-types of off-site, in-kind replacement:

- **Permittee-responsible mitigation.** This option involves replacement of in-kind habitat on habitat lands operated by the permittee. Two separate sites are proposed for this mitigation option. The first site is the Star Bend Conservation Area (SBCA) on the west levee of the Feather River near river mile 18 is an existing floodplain habitat restoration site that was created as part of the Star Bend setback levee project. The second site is the proposed 500-acre Three Rivers Levee Improvement Authority (TRLIA) Feather River Floodway Corridor Restoration Project (FRFCRP) located on the east bank of the Feather River just upstream of the Star Bend site. Together, both sites contain sufficient area to accommodate all of the project's upland compensatory mitigation and will be used for mitigating impacts to: 1) riparian forest; 2) oak woodland; and 3) VELB.
- **Purchase of credits at commercial mitigation banks.** This option involves replacement of in-kind habitat through purchase of credits issued for habitat lands operated by a commercial mitigation bank. For the aquatic habitat impacts to GGS, the project proposes to purchase credits at the Sutter Basin Conservation Bank, operated by Westervelt Ecological Services in Sutter County, which is the only bank that presently offers giant garter snake credits approved by both the USFWS and CDFW. The project proposes to purchase jurisdictional water credits at the River Ranch Wetland Mitigation Bank, owned and operated by Wildlands, Inc., and located at the confluence of the Sacramento and Feather Rivers in Yolo County. There are currently no mitigation banks that offer oak woodland (non-riparian native tree) credits.

3.2 Characteristics of Design Reference Site

Previous mitigation work was performed at the 48.5-acre SBCA starting in 2009 for the Feather River Setback Levee and Habitat Enhancement Project (Restoration Resources 2010). The work was done as part of a project to replace a portion of the Feather River west levee with a new setback levee approximately 3,400 feet long that begins near the intersection of Star Bend Road and continues southeasterly to the intersection of Tudor Road. For Phase 1A of the project, 37 existing elderberry

shrubs were transplanted. For Phase 1B, 20 acres of elderberry and native associate plants were installed to enhance VELB habitat. For Phase 1C, approximately 2.46 acres of California blackberry (*Rubus ursinus*) and California rose (*Rosa californica*) were planted to protect an area of cultural significance (Restoration Resources 2010). Phase 2 of the Star Bend mitigation project will consist of planting the remaining approximately 24.5 acres. This acreage will be utilized for the mitigation described in this MMP.

The design characteristics used in the initial mitigation work at SBCA will serve as a reference site for the additional VELB mitigation to be performed at Star Bend for this MMP. These characteristics are described in the report *Habitat Enhancement Plan for the Feather River Setback Levee and Habitat Enhancement Project at Star Bend*, prepared by River Partners and Stillwater Sciences in 2009 for Levee District 1 (LD1)and Wood Rodgers.

Design characteristics for riparian forest and oak woodland will incorporate the species composition and plant spacing found in other natural areas in the project site that will not be disturbed. These areas were field mapped, including field inventories of species composition and size. Additional guidance will be provided by the guidelines for Phase 2 riparian habitat planting outlined in River Partners and Stillwater Sciences (2009).

Design of the FRFCRP has not begun, but the site's ecological setting is similar to that found at the SBCA, and it is likely that design principles used at that site could be applied to the FRFCRP.

As described above, mitigation for USACE jurisdictional habitat and GGS will occur off-site at commercial mitigation and conservation banks.

3.2.1 Previous Work Credit

Much of the design information presented below that is specific to the Star Bend site is taken from the report *Habitat Enhancement Plan for the Feather River Setback Levee and Habitat Enhancement Project at Star Bend*, prepared by River Partners and Stillwater Sciences in 2009 for Levee District 1 and Wood Rodgers.

3.3 Proposed Mitigation Site

3.3.1 Location

The SBCA mitigation site is located on the water side (east) of the new setback levee that was constructed in 2009 on the Feather River, approximately six miles south of Yuba City, Sutter County, California (Figures 1 and 2). The 48.5-acre site is just upstream of the Star Bend boat ramp (near River Mile 18) and is bounded on the north and east by a sharp bend in the river. Access by road is from the west via Star Bend Road off of Garden Highway (River Partners and Stillwater Sciences 2009). The property to the east is part of the O'Connor Lakes unit of CDFW's Feather River Wildlife Area. The unit is managed by CDFW and DWR to provide wildlife habitat, restore native plant communities, and convey Feather River flood events. The land to the west of the levee is primarily orchards.

In 2009, LD 1 of Sutter County constructed the Feather River Setback Levee and Habitat Enhancement Project at Star Bend to replace a portion of existing levee that poses a high risk of

failure in order to decrease the flood stage, velocity, and scour potential; increase and improve floodplain habitat; and improve habitat connectivity between the Abbot Lake and O'Connor Lakes Units of CDFW's Feather River Wildlife Area. The SBCA project created approximately 48.5 acres of floodplain habitat, which included habitat enhancement and onsite mitigation for impacted elderberry.

Approximately 20 acres have been used for elderberry transplants and associated native plants. In early 2012, a fire at the SBCA damaged portions of the site; however, VELB planting losses were minimal. The remaining approximately 24.5 acres are available at the conservation area for compensating for impacts on elderberry shrubs, riparian forest, and non-riparian, native trees from construction of the FRWLP.

The FRFCRP site is located on the east side of the Feather River in the levee setback area created by the TRLIA EIP Feather River Setback Levee project (Figure 1). The FRFCRP is located along a section of the Feather River which currently provides over 3,000 acres of wildlife habitat. Restoration on this site is important because it would add another large block of contiguous habitat (approximately 500 acres) along the lower Feather River; thereby reducing habitat fragmentation.

3.3.2 Ownership Status

The SBCA is under joint control by one of SBFCA's member agencies (Levee District 1) and CDFW. The FRFCRP site is entirely owned by TRLIA.

3.3.3 Jurisdictional Areas

There are no known jurisdictional areas in or near the mitigation activities.

3.3.4 Aquatic Functions

The Feather River Setback Levee and Habitat Enhancement Project at Star Bend constructed in 2009, along with the TRLIA EIP Feather River Setback Levee project, increased the amount of floodplain potentially exposed to inundating flows by approximately 1649 acres. The floodplain restoration allows for higher quality floodplain habitat (better water quality, food inputs, and shelter) for juvenile salmonids and other native species such as Sacramento splittail and steelhead. Organic material produced by native deciduous species restored within the floodplain provides an increased nutrient load for the aquatic environment. This influx of nutrients provides for a greater invertebrate population, thereby creating an abundant food source for fish.

3.3.5 Hydrology and Topography

Both the SBCA and the FRFCRP site were once part of a dynamic system of meandering channels and oxbow lakes that covered an area much wider than the levees of the Feather River Flood Control Project. Levee construction, beginning in the 1860's, confined the channel to its present location, and dams on the Feather and Yuba rivers regulate flows (River Partners and Stillwater Sciences 2009).

To the north of the SBCA, overbank flow from the Feather River periodically (i.e., modeled stage of the 2.5- to 3-year recurrence interval flow [approximately 60,000 cfs]) fills the drainage feature and depressions left by dredger mining (Wood Rodgers, Inc. 2007). In the O'Connor Lakes unit, scour channels, debris accumulations in trees and shrubs, and deposits of sand are evidence of periodic

overbank flow. Periodic maintenance on the O'Connor Lakes Unit is conducted by DWR to increase the conveyance of flood flows and transport sediment (River Partners and Stillwater Sciences 2009).

On the land-side of the existing levee system, rain, flood irrigation and seepage under the levee are the primary sources of surface water. Flooding is used to irrigate the orchard crops, occasionally leaving standing water behind for short periods of time following irrigation. The levee ditch was constructed to contain any water seeping under the toe of the levee, but was only inundated in 1986 and 1997, years in which extremely large flood events occurred (B. Hampton, Manager, LD1, pers. comm., 2007). During those events, water remained for a couple of weeks, generally percolating into soil after flood flows had receded (B. Hampton, Manager, LD1, pers. comm., 2007). In 2006, which had a relatively large flood event, there was no water in the levee ditch (B. Hampton, Manager, LD1, pers. comm., 2007) (River Partners and Stillwater Sciences 2009).

The 2010 initial monitoring report for the Star Bend site (Restoration Resources 2010) stated that surface water was present within the 20 acre habitat area in March 2010 due to low depressions that do not provide sufficient drainage, but began to dry out into April. These areas may have stayed inundated due to the more than average rain received in the regional area during the winter and early spring season.

Elevations of the project area average 45 feet above sea level. Topography is generally flat, with steeper gradients at the river's edge. Several small hills and depressions occur in the O'Connor Lakes Unit as a result of overbank flood scour and deposition, and previous soil excavation and habitat enhancement projects (River Partners and Stillwater Sciences 2009).

Hydrologic function and existing topography of the FRFCRP is likely similar to that found at the SBCA.

3.3.6 Soils and Substrate

The Sutter County Soil Survey (Lytle 1988, NRCS 2008) identifies two soil series within the SBCA. The majority of the site consists of mapping unit 124 Conejo loam, 0 to 2 percent slopes. Conejo soils are very deep, well drained soils formed in alluvium and are observed on alluvial fans and stream terraces. Conejo soils contain about 39.2% sand, 37.3% silt and 23.5% clay. They are classified in hydrologic group B, which have moderately low runoff potential when thoroughly wet and water transmission through the soils is unimpeded.

Mapping unit 134 Holillipah loamy sand, 0 to 2 percent slopes occupies the northern boundary of the site along the Feather River. The Holillipah soils, which contain deep sand to loamy sand derived from mixed alluvium, are frequently flooded, and somewhat excessively well drained (River Partners and Stillwater Sciences 2009).

Detailed soil information for the FRFCRP has not been collected.

3.3.7 Vegetation

Vegetation types at the SBCA were assessed during a September 13, 2006 field survey by EIP Associates (EIP Associates 2007) and were mapped and described during wetland delineation surveys conducted in September 2007 and January 2008 by Stillwater Sciences (Stillwater Sciences 2008b) (River Partners and Stillwater Sciences 2009).

Plant species observed during a September 13, 2006 field survey by EIP Associates included wild oats (*Avena fatua*), ripgut brome (*Bromus diandrus*), soft brome (*Bromus hordeaceus*), turkey mullein

(*Eremocarpus setigerus*), wild mustard (*Brassica* sp.), and prickly lettuce (*Lactuca serriola*) (EIP Associates 2007) (River Partners and Stillwater Sciences 2009).

Riparian forest habitat occurs north of the SBCA, throughout much of the levee ditch, and across much of the O'Connor Lakes unit to the southeast. The area north of the existing levee has a dense canopy of native riparian tree species (approximately one acre), including Fremont cottonwood (*Populus fremontii*), Goodding's black willow (*Salix gooddingii*), northern California black walnut (*Juglans californica* var. *hindsii*), Oregon ash (*Fraxinus latifolia*), and valley oak (*Quercus lobata*). There is a sparse to moderately dense shrub layer with arroyo willow (*Salix lasiolepis*), box elder (*Acer negundo*), California button willow (*Cephalanthus occidentalis*), California rose, and narrowleaf willow (*Salix exigua*). The vine layer is thin, containing predominantly California wild grape (*Vitis californica*) and poison oak (*Toxicodendron diversilobum*). The herbaceous layer is generally absent, with small clearings containing black mustard (*Brassica nigra*), oat (*Avena* sp.), perennial pepperweed (*Lepidium latifolium*), seashore vervain (*Verbena littoralis*), and soft brome (River Partners and Stillwater Sciences 2009).

Portions of the Star Bend setback levee ditch (approximately three acres) are predominantly comprised of a mature canopy of valley oak, occasionally shared with blue elderberry (*Sambucus mexicana*). The understory is fairly sparse, with blue wildrye (*Elymus glaucus*), California blackberry, California rose, California wild grape, Goodding's black willow, narrowleaf willow, and poison oak (River Partners and Stillwater Sciences 2009).

The northwest corner of the SBCA includes the recent mitigation work previously described. For Phase 1A of the project, 37 existing elderberry shrubs were transplanted. For Phase 1B, 20 acres of elderberry and native associate plants were installed to enhance VELB habitat. For Phase 1C, approximately 2.46 acres of California blackberry (*Rubus ursinus*) and California rose (*Rosa californica*) were planted to protect an area of cultural significance (Restoration Resources 2010).

The majority of the land west of the SBCA is a plum orchard that is flood irrigated. Annual grass and weedy forb species occur between the rows of trees, but the sparse distribution and short stature of the forbs indicate they are sprayed with herbicides or otherwise controlled on a regular basis (River Partners and Stillwater Sciences 2009).

The FRFCRP is vegetated with non-native annual grasses and forbs and is devoid of any woody vegetation. The site is mostly surrounded by orchards or other agriculture, but there an area of existing riparian vegetation adjacent to the southwest corner.

3.3.8 Present and Historical Uses of the Mitigation Area

Prior to the arrival of Europeans, Native Americans of the Valley Nisenan populations established villages along the Feather River and its tributaries in the vicinity of the site. The northwest corner of the site is a historic low rise along the river and contains an historic record of an indigenous village site (Bayham 2004) (River Partners and Stillwater Sciences 2009).

John Sutter laid claim to the region when he secured the New Helvetia Land Grant in the 1840s. He promptly built Hock Farm, a rancho in the vicinity of the site, which provided cattle stock that ranged freely along Feather River. W. H. Ashford owned and farmed a section of the west bank as early as 1880, which includes most of the site. In 1880, the O'Connor family owned the parcel to the south of the site where the lakes are located (Sutter County 1880). The 1912 (U.S. Army Corps of Engineers 1912) geologic survey shows dredging activities to the north and south of the site, but not within the

site. The 1912 survey also shows that the site had not been cleared for agriculture (River Partners and Stillwater Sciences 2009).

The SBCA is presently being used for the Phase I and Phase II mitigation work previously described. The SBCA converted 55 acres of former orchard and levee into floodplain habitat. Twenty acres of elderberry shrubs and native associate plants for VELB habitat were planted as part of the initial mitigation. The remaining 35 acres were not planted.

The FRFCRP is currently being managed as open floodplain habitat. Prior to inclusion in the setback area created by the TRLIA EIP Feather River Setback Levee project, the site was largely planted in orchard trees.

3.3.9 Present and Proposed Uses of All Adjacent Areas

The Feather River and three other properties surround the SBCA (i.e., Churkin, Singh, and CDFW properties). The majority of the area west of the site on the land side of the levee is a plum (*Prunus* sp.) orchard that is flood irrigated. The existing levee, operated by LD1, and the Star Bend pumping plant also are located along the site's western boundary. The pumping plant includes pump station discharge lines and irrigation pipelines that bisect the northern portion of the site and continue to adjacent properties. All the property to the east of the SBCA is part of the O'Connor Lakes unit of CDFW's Feather River Wildlife Area. The unit is managed by CDFW and DWR to provide wildlife habitat, restore native plant communities, and convey Feather River flood events.

The FRFCRP is surrounded by orchards or other agricultural land uses to the north, south, and east. To the west is an area of riparian vegetation.

3.4 Created/Restored Habitats

3.4.1 Compensation Ratios

The amount of proposed compensation is based on the significance of the habitats affected to fish and wildlife resources, USFWS general fish and wildlife mitigation recommendations (Fish and Wildlife Coordination Act Report), USFWS GGS programmatic biological opinion and VELB Conservation Guidelines. Compensation ratios may be adjusted at the project preconstruction engineering and design stage as a result of further assessments of habitat values and functions in consultation with the USFWS and other resource agencies.

VELB Habitat

Before construction begins, USACE will compensate for direct effects on elderberry shrubs by transplanting shrubs that cannot be avoided to the SBCA. Elderberry seedlings or cuttings and associated native species will also be planted in the conservation area. Each elderberry stem measuring 1 inch or greater in diameter at ground level that is adversely affected (i.e., transplanted) would be replaced, in the Star Bend area, with elderberry seedlings or cuttings at a ratio ranging from 1:1 to 8:1 (new plantings to affected stems). The numbers of elderberry seedlings/cuttings and associated riparian native trees/shrubs to be planted as replacement habitat are determined by stem size class of affected elderberry shrubs, presence or absence of exit holes, and whether the shrub lies

in a riparian or non-riparian area. Stock of either seedlings or cuttings would be obtained from local sources (including the project area if acceptable to USFWS).

At the discretion of USFWS, shrubs that are unlikely to survive transplantation because of poor condition or location, or a plant that would be extremely difficult to move because of access problems, may be exempted from transplantation. In cases where transplantation is not possible, minimization ratios would be increased to offset the additional habitat loss.

The relocation of the elderberry shrubs will be conducted according to USFWS-approved procedures outlined in the Conservation Guidelines (U.S. Fish and Wildlife Service 1999a). Elderberry shrubs within the project construction area that cannot be avoided will be transplanted during the plant's dormant phase (November through the first 2 weeks of February). A qualified biological monitor will remain onsite while the shrubs are being transplanted.

Property inaccessibility and the high density of vegetation along portions of the Feather River riparian corridor limited the number of elderberry shrubs that could be surveyed (73 shrubs were surveyed). For this reason, compensation for the removal of approximately 162 shrubs was estimated based on the average number of stems in each stem diameter range for the 73 shrubs that could be surveyed (see Table 3-1). Those averages are as follows.

- Number of stems ≥1 inch and ≤3 inches = 4.
- Number of stems >3 inches and <5 inches = 1.
- Number of stems ≥5 inches = 1.

Because most of the shrubs are located in riparian habitat and did not have exit holes, the compensation ratios for these conditions were used.

Table 3-1. Estimated Compensation for Elderberry Shrubs Removed

Stem Diameter	Number of Stems[1]	Seedling Ratio[2]	Native Plant Ratio[2]	Total Seedlings	Total Native Plants
Stems ≥1" to ≤3"	648	2:1	1:1	1,296	1,296
Stems >3" to <5"	162	3:1	1:1	486	486
Stems ≥5"	162	4:1	1:1	648	648
Total	972			2,466	2,466

N/A = not applicable.

1 The number of stems per shrub was based on the average number of stems in each stem diameter range for the 72 shrubs that could be surveyed. Those averages are as follows: number of stems ≥1" and ≤3" = 4; number of stems >3" and <5" = 1; and number of stems ≥5" = 1.

2 Ratios are based on shrubs within riparian habitat with no VELB exit holes.

Based on the information in Table 3-1, 493 elderberry units, or 20.38 acres, will be required to fully mitigate for project impacts per USFWS VELB Conservation Guidelines. All of this mitigation will occur at the SBCA.

Riparian Habitat and Oak Woodland

Project impacts would be mitigate at a 2:1 compensation ratio as listed in Table 3-2. The USFWS Draft Fish and Wildlife Coordination Act Report (FWCA report) recommended at least a 2:1 replacement ratio to compensate for loss in functions and values.

USACE Section 404 Jurisdictional Areas

Project impacts would be mitigated at a 2:1 compensation ratio per the USFWS FWCA report. Of the 5.178 acres of impact (Table 2-8), approximately 4.10 acres would be compensated onsite in conjunction with relocation of the Sutter Butte canal.

Table 3-2. Anticipated Project Impacts to Sensitive Resources and Proposed Compensatory Mitigation

Impact Type	Impact Unit	Impact Quantity	Mitigation Need	Mitigation Area
Riparian Forest and Riparian Scrub Shrub	acres of cover type	42.50 acres	85.00 acres (2:1 replacement ratio[1])	85.00 acres at 10' o.c. plant spacing
Oak Woodland	acres of cover type	1.30 acres	2.60 (2:1 replacement ratio1[1])	2.60 acres at 10' o.c. plant spacing
Elderberry	individual shrubs and total stem count within each shrub	162 shrubs with 972 total stems	162 transplants, 2,466 elderberry seedlings, and 2,466 native associates	20.38 acres [2] (493 elderberry units)
Giant Garter Snake	acres of permanent impact	0.00 aquatic 3.54 acres upland	3.54 acres (3:1 replacement ratio[3])	10.62 acres
Jurisdictional Waters	acres of permanent impact	1.71 acres	3.42 acres (2:1 replacement ratio1[1])	3.42 acres

Notes:

1 Compensation ratio from USFWS Draft Fish and Wildlife Coordination Act Report .

2 Compensation acreage determined based on USFWS VELB Compensation Guidelines.

3 Compensation ratio from USFWS Programmatic Biological Opinion (U.S. Fish and Wildlife Service 1997)

To fully mitigate for project impacts, approximately 87.60 acres of land will be required (elderberry transplantation/compensation (20.38 acres) met through riparian forest compensation). If all of the 24.5 acre SBCA Phase 2 land is used for mitigation purposes, approximately 63.10 acres of land would be required at the FRFCRP site to accommodate the remaining mitigation.

Compensation for GGS and Section 404 wetland impacts would be met by purchase of 14.04 acres of equivalent credit through mitigation or conservation banks (i.e., Sutter Basin Conservation Bank and River Ranch Wetland Mitigation Bank).

3.4.2 Long-Term Goal(s)

The long-term ownership goal is to merge the SBCA with CDFW's adjoining O'Conner Lakes and Abbott Lakes Wildlife Units. A similar goal with an appropriate public agency is also envisioned for the FRFCRP.

Given the presence of good soils and potential exposure to frequent flooding, both project areas should sustain rapid growth of restored riparian species throughout the life of the project implementation (approximately 3 years). An "over-planting" approach is used to rapidly establish native riparian species. Over-planting the project site will eliminate the need for any additional replanting efforts. The ultimate ecological objective for over-planting is that in time the area will thin out and create a complex of open canopy, dense forest, and dead snags, all of which provide benefits to wildlife (River Partners and Stillwater Sciences 2009).

It is anticipated that at the end of the 3-year establishment period, 70% survivorship of woody species will be attained. Over time, mortality based on differences of soil textures and water table depths will create areas of complex, open canopy, dense forest, and dead snags, all of which create habitat for wildlife (River Partners and Stillwater Sciences 2009).

3.4.3 Aquatic Functions

No jurisdictional open water habitat will be created at the either site. The Feather River Setback Levee and Habitat Enhancement Project at Star Bend, together with the TRLIA EIP Feather River Setback Levee project, increased the amount of floodplain potentially exposed to inundating flows by approximately 1649 acres. The floodplain restoration allows for higher quality floodplain habitat (better water quality, food inputs, and shelter) for juvenile salmonids and other native species such as Sacramento splittail and steelhead. Organic material produced by native deciduous species restored within the floodplain provides an increased nutrient load for the aquatic environment. This influx of nutrients also provides for a greater invertebrate population, thereby creating an abundant food source for fish. The additional mitigation plantings for VELB habitat and plantings for riparian forest and non-riparian, native trees proposed for this MMP will further increase the food inputs and shelter for aquatic species by expanding the acreage of floodplain forest and upland habitat at the site (River Partners and Stillwater Sciences 2009).

3.4.4 Hydrology and Topography

The long-term source of water for the new SBCA and FRFCRP mitigation plantings will be groundwater and Feather River flood flows. After the plants have become established enough to discontinue irrigation, groundwater will be the primary source of water. Additional surface water flooding will be provided during when the Feather River flows, most often high during spring and early summer snowmelt. Hydraulic modeling shows that the Feather River overbanks at locations north of the Star Bend site approximately once every 2.5 to 3 years (Wood Rodgers, Inc. 2007, as cited in River Partners and Stillwater Sciences 2009). It is anticipated that flooding will occur at the proposed mitigation site on a similar recurrence interval frequency. The duration of flooding will depend upon water year type. In some years, the river will not overtop its banks and inundate the site. In other years, flooding may occur over a period of several days, while in the wetter years the site could be flooded for several weeks. Flood water that overbanks into the site will generally flow downgradient from the north to south and eventually infiltrate into the ground or recede back into the river when the river's flood stage decreases.

3.4.5 Soils and Substrate

The majority of the SBCA consists of 124 Conejo loam soils, which are very deep, well drained soils formed in alluvium and are observed on alluvial fans and stream terraces. They are classified in

hydrologic group B, which have moderately low runoff potential when thoroughly wet and water transmission through the soils is unimpeded. These soils are highly suitable for supporting elderberry shrubs and associated plans for VELB habitat, and for supporting riparian and non-riparian tree species. The same species that will be planted in the soils at the SBCA are currently growing in the same soils in lands in the site's vicinity.

Detailed soil information has not been collected at the FRFCRP site.

3.4.6 Vegetation

The target plant communities and species at the SBCA and FRFCRP site will include riparian forest, non-riparian native trees, and elderberry shrubs and associated plants for VELB habitat (Table 3-3).

Table 3-3. Woody Planting Species for Star Bend Conservation Area

Common Name	Scientific Name
Coyote brush	*Baccharis pilularis*
Mule fat	*Baccharis salicifolia*
Buttonbush	*Cephalnathus occidentalis*
California Rose	*Rosa californica*
California Blackberry	*Rubus ursinus*
Sandbar willow	*Salix exigua*
Arroyo willow	*Salix lasiolepis*
Blue elderberry	*Sambucus mexicana*
Valley oak	*Quercus lobata*
Interior live oak	*Quercus wislizeni*
Oregon ash	*Fraxinus latifolia*
Fremont cottonwood	*Populus fremontii*
Box elder	*Acer negundo*

The detailed planting plan is described below in Section 5.2.

Chapter 4
Success Criteria and Monitoring

4.1 Success Criteria

For this MMP, a "success criterion" is a measure that indicates whether the mitigation goals have been achieved at the end of the monitoring period. The mitigation will be evaluated annually using the annual performance standards. Table 4-1 summarizes the monitoring success criteria for restored and enhanced wetlands, drainages, and upland and riparian areas.

Table 4-1. Monitoring Success Criteria for Planted Areas at the SBCA and FRFCRP site

Riparian Vegetation, Oak Woodland, Elderberry, and Non-Riparian Native Vegetation		
Monitored Characteristic	*Monitoring Year*	*Success Criteria Standards*
Plant survival	1–2	Demonstrate at least 80% survival of all riparian vegetation and Oak Woodland plantings after 2 years.
Plant survival	3	Demonstrate at least 70% survival of all riparian vegetation and Oak Woodland plantings after 3 years.
Plant survival	4-20	Demonstrate at least 60% survival of all riparian vegetation and Oak Woodland plantings after 20 years.

Riparian Vegetation, Oak Woodland, Elderberry, and Non-Riparian Native Vegination

A minimum survival rate of at least 80% must be maintained throughout the first 2 years of the monitoring period. A minimum survival rate of at least 70% must be maintained at the end of the third year. A minimum survival rate of at least 60% at the end of 20 years. Within one year of discovery that survival has dropped below the respective percent for each monitoring year, failed plantings will be replaced to bring survival above this level. USACE in consultation with the resource agencies will make any determination as to replacement responsibilities arising from circumstances beyond its control, such as plants damaged or killed as a result of severe flooding or vandalism.

4.2 Monitoring

4.2.1 Methods

Monitoring will be quantitative and qualitative. The monitoring methods that will be used during the annual performance monitoring are described below by habitat and restoration/mitigation category.

Annual Surveys

At the end of the first growing season, the restoration contractor will conduct a complete census of all woody species planted. The data are best analyzed using a database to calculate survivorship, and to determine any changes to or omissions from the original planting design. During years two and

three, woody species plantings will be sampled to determine survivorship, growth, and coverage. Sampling of native grass and herbaceous understory plantings will also be conducted (River Partners and Stillwater Sciences 2009).

Census

At the end of the first growing season, a census noting survivorship for each location (alive, dead, or missing/not planted) will be conducted. The census allows for pattern analysis to examine the effects of soil, hydrology, or other factors affecting survivorship. During implementation, changes in the planting design are possible (or even desirable) and should be noted. Deviations in planting can also be recorded during the census. Results of the census will be used to determine progress towards performance criteria and replanting, if necessary (River Partners and Stillwater Sciences 2009).

Permanent Plot Sampling

After the initial census, subsequent monitoring (years 2 and 3) utilizes permanent plots to collect data on overall survivorship, height, and cover. The sampling procedure is modified for a restoration setting from protocol developed by Dr. Dave Wood (CSU, Chico) to establish permanent plots in riparian forests (personal communication). Some of the methods have been adapted from Elzinga et al. 1998. Comparison of survivorship between the sampling procedure and census indicates that sampling estimates are within 2% and provide additional information on cover and recruitment (results based on data from field 4 of the Ord Bend Unit, Sacramento River National Wildlife Refuge (River Partners 2003)). The sampling procedure may also be used to compare pre- and post-restoration vegetation, if the permanent plots are installed beforehand (River Partners and Stillwater Sciences 2009).

Plot location and Size

All samples are based on 20 m x 50 m (1,000 m^2) plots (quadrats) placed with the long axis oriented in a north-south direction. Permanent plot locations will be selected by stratifying the field and using the grid cell method (overlaying each field with a 20 m x 50 m grid) to select sampled plots. Plots that extend past the plantable area are generally rejected. In addition, we exclude locations that are not characteristic of that particular area. In general, a plot should be established every 5-20 acres. The plots serve as areas to collect information on woody, shrub, and herbaceous species (if desired) (River Partners and Stillwater Sciences 2009).

Once each specific plot location is randomly selected, its field location will be permanently recorded at the upstream, inland corner of the plot. The position will be recorded with a GPS unit, and, in subsequent monitoring years, will be reestablished in the same position (River Partners and Stillwater Sciences 2009).

Measurements

At each plot, cover and height measurements of all shrubs and trees inside the 20 m x 50 m plot will be recorded. To assess the survivorship of planted species, we will note their status: alive, dead, or missing (not planted). Because restoration activities often create conditions that favor the survivorship and natural recruitment of native plants, newly recruited native riparian woody species will also be recorded. The estimate of aerial cover of both trees and shrubs will be based on the longest diameter through the horizontal plane of the plant's drip line, a thin line at which a drop

of water would fall from the outward most oriented leaf (River Partners and Stillwater Sciences 2009).

4.2.2 Monitoring Schedule

The riparian forest and oak woodland non-riparian native tree restoration areas will be monitored annually during Years 1 through 5 following completion of mitigation project implementation. First year monitoring will not be completed until after one full growing season for vegetation has passed since completion of construction. The implementing agency will submit an annual report at the end of each monitoring year and a final report to USFWS and other resource agencies for review and approval. These areas will be monitored annually during May or June.

The population of valley elderberry longhorn beetles, the general condition of the conservation area, and the condition of the elderberry and associated native plantings in the conservation area must be monitored over a period of either ten (10) consecutive years or for seven (7) years over a 15-year period. The applicant may elect either 10 years of monitoring, with surveys and reports every year; or 15 years of monitoring, with surveys and reports on years 1, 2, 3, 5, 7, 10, and 15. The conservation plan provided by the applicant must state which monitoring schedule will be followed. No change in monitoring schedule will be accepted after the project is initiated. If conservation planting is done in stages (i.e., not all planting is implemented in the same time period), each stage of conservation planting will have a different start date for the required monitoring time. In any survey year, a minimum of two site visits between February 14 and June 30 of each year must be made by a qualified biologist (River Partners and Stillwater Sciences 2009).

4.2.3 Photo-Documentation

The progress of the restoration areas will be documented photographically. Permanent photo-documentation stations will be established at several points throughout both sites. The locations of photo-documentation stations will be determined during the first year of the monitoring period, and the locations will be identified in the field and mapped, either on a map or by using a GPS receiver.

The number of photographs taken at a given photo-documentation station will vary, depending on the area and habitat. Photos will include panoramic views taken from a high point at the site that will not be obscured in future years by growing vegetation. A sufficient number of stations will be established to ensure that the photographs provide a visual record of the sites. Photographs will be taken during June of each monitoring year. Additional representative photographs may be taken at other times of the year at the implementing agency's discretion.

Chapter 5
Implementation Plan

5.1 Site Preparation

5.1.1 Avoidance Measures

Site preparation during the first phase of work will involve implementing the following avoidance measure actions related to preconstruction surveys and construction staking.

- Stake the limits of the work area, including construction, staging, and access areas.
- Perform pre-construction surveys for giant garter snake, western pond turtle, nesting birds/raptors, native bats and valley elderberry longhorn beetle.
- Stake the limits of Environmentally Sensitive Areas (ESAs).
- Place protection fencing around the perimeter of ESAs.
- Place silt fencing, when appropriate, around the perimeter of ESAs.
- Perform preconstruction surveys of affected drainages.

Prior to construction, the construction contractor, under the supervision of SBFCA, will survey and stake the location of the work area and ESAs. These locations will be based on the project construction documents prepared by SBFCA and will be in accordance with this MMP.

The construction contractor will install protective fencing and/or silt fencing according to the specifications in the project construction documents around ESAs to be preserved. Protective fencing will consist of orange plastic-mesh fencing that is secured to metal T-posts. To prevent soil or sediment from entering sensitive areas, silt fencing may be installed around areas to be preserved. Silt fencing may be used in combination with protective fencing and will be installed in accordance with the Stormwater Pollution Prevention Plan that will be prepared by the contractor and the best management practices identified in the project construction documents. This silt fence will also serve as exclusion fencing to aid in preventing wildlife from entering active construction areas.

Prior to initial ground disturbance, preconstruction surveys for giant garter snake, western pond turtle, nesting migratory birds/raptors, and roosting bats will be conducted to ensure that these sensitive species are not directly or indirectly affected by restoration activities. Nesting bird and raptor surveys will be conducted no more than 14 days prior to the start of construction to ensure that no active bird nests are present within 50 feet and no raptor nests are present within 300 feet of restoration activities. A bat emergence survey will also be conducted within 14 days prior to construction to ensure that no trees supporting maternal roosts are present within or adjacent to restoration activities.

If a special-status species is identified within or adjacent to restoration activities, appropriate no-disturbance buffers will be established for breeding sites or the individual(s) will be allowed to passively move out of the construction area. Buffers will be determined by a qualified biologist, coordinating with the appropriate regulatory agency, and will depend on the species identified and

one or more of the following factors: season of activity, level of noise or construction activity, level of ambient noise in the vicinity, and line-of-sight.

5.1.2 Pest Plant Removal

Weed control is necessary for the successful establishment of native plants and improvement of habitat. The weeds of greatest concern at the site are black mustard, yellow starthistle and pepperweed (River Partners and Stillwater Sciences 2009).

In areas to be planted with herbaceous species, spraying and mowing for an entire season before planting is recommended. Once the herbaceous species are planted, weed control methods will be mowing, possibly applying 2,4-D to control broad leaf pressure. The restoration contractor will abide by county and state herbicide permitting and reporting requirements. Roundup® (glyphosate) and 2,4-D (for broad-leaf control in native grass planting) are likely to be the most commonly used herbicides on the project. Rodeo® (for areas adjacent to water bodies), Telar® (for pepperweed control), Poast® (for post-emergence control of annual grasses in herbaceous understory planting) and Garlon™ (for woody species control) may also be used (River Partners and Stillwater Sciences 2009). No herbicide will be applied on days when wind speed is high enough to cause drift onto adjacent natural or planting areas.

Phase 2 planting areas that are within 200' of any elderberry plantings or transplants in the Phase 1 planting area will not be sprayed with any herbicide during site preparation activities. Only hand or mechanical weed removal methods will be employed in these areas.

Herbicide and pesticide application actions require compliance with a Statewide General National Pollutant Discharge Elimination System (NPDES) permit process for residual pesticide discharges to waters of the United States. The SBFCA site management representative will ensure compliance with the NPDES permit.

5.1.3 Construction Monitor

An individual familiar with this mitigation and monitoring plan will supervise all phases of construction of the project. These phases may include:

- Layout of proposed other waters of the United States boundaries prior to construction.
- Placement and installation of ESA fencing.
- Site preparation/vegetation clearing operations.
- Planting and seeding operations.

The construction monitor will have authority to direct equipment operators and will submit a summary report to USACE documenting construction observations and any problems that arise.

5.2 Planting/Seeding

5.2.1 Planting Plan

A conceptual planting plan and plant palette for the SBCA is shown in Figures 3 and 4. Planting of the SBCA and FRFCRP site will consist of the following species for Elderberry mitigation, riparian mitigation, oak woodland (non-riparian native tree mitigation) and upland seed mix (Tables 5-1 through 5-4):

Table 5-1. Plant Palette for Elderberry Mitigation Areas

Scientific Name	Common Name	Percent of Planting Mix	Plant Spacing (feet on-center)	Container Size
Sambucus mexicana	Blue elderberry	50		1-gallon
Baccharis pilularis	Coyote brush	10		1-gallon
Populus fremontii	Fremont cottonwood	10		1-gallon
Rosa californica	California rose	10	10' O.C.	1-gallon
Quercus lobata	Valley oak	10		1-gallon
Salix lasiolepis	Arroyo willow	5		1-gallon
Salix exigua	Sandbar willow	5		1-gallon

Table 5-2. Plant Palette for Riparian Mitigation Areas

Scientific Name	Common Name	Percent of Planting Mix	Plant Spacing (feet on-center)	Container Size
Populus fremontii	Fremont cottonwood	25		1-gallon
Box elder	Acer negundo	12.5		1-gallon
Oregon ash	Fraxinus latifolia	12.5		1-gallon
Rosa californica	California rose	10		1-gallon
Quercus lobata	Valley oak	10	10' O.C.	1-gallon
Salix lasiolepis	Arroyo willow	10		1-gallon
Salix exigua	Sandbar willow	10		1-gallon
Rubus ursinus	California blackberry	5		1-gallon
Cephalanthus occidental	Buttonbush	5		1-gallon

Table 5-3. Plant Palette for Oak Woodland (Non-Riparian Native Tree Mitigation Areas)

Scientific Name	Common Name	Percent of Planting Mix	Plant Spacing (feet on-center)	Container Size
Quercus lobata	Valley oak	75		1-gallon
Baccharis pilularis	Coyote brush	15	10' O.C.	1-gallon
Quercus wislizeni	Interior live oak	10		1-gallon

Table 5-4. Upland Seed Mix

Botanical Name	Common Name	Pounds Pure Live Seed Per Acre

		(Slope Measurement)
In-Stream Bench Seeding (Type 1)		
Leymus triticoides	Creeping wild rye	10
Hordeum brachyantherum ssp californicum	Meadow barley	12
Elymus glaucus	Blue wild rye	12
Eschscholizia californica	California poppy	2
Lupinus succulentus	Arroyo lupine	4
Triticum x Elymus	Regreen	25

5.2.2 Nature and Source of Propagules

Container plants will be purchased from a commercial nursery located within two hours of the project site. If possible, container plants will be grown from seeds or cuttings collected at or near the project site in order to populate the site with species ecotypes that are adapted to local ecological conditions.

5.3 Irrigation

Because of the dry summers typical of the climate in the area, irrigation will be required for plant establishment and survival. Irrigation should be applied with the goal that plants will become self-sufficient by the end of the third growing season (River Partners and Stillwater Sciences 2009).

In the first growing season, the rapidly growing seedlings have roots only in the surface (the top 1–2 feet) of the soil profile. The rooting zone must be kept moist through the season to ensure optimum growth and survival. Because of the sandy soils at the site and water table depths of over 20 feet, the soil moisture of the fields planted with woody species will need to be closely monitored. The intervals between irrigations are dependent upon soil texture, depth to water table, the weather conditions, and plant water stress. Because a mixture of species with different water demands is proposed, the plants must be carefully observed to maintain a balance of soil moisture that is acceptable for xeric species like valley oak and elderberry as well as more mesic species like cottonwood and willow (River Partners and Stillwater Sciences 2009).

Prior to project implementation, a more detailed irrigation design will be developed. All irrigation water at the SBCA will be provided by an existing well located in the O'Connor Lakes Unit, near the midpoint of the eastern edge of the project area. The mainline will run west from the well (River Partners and Stillwater Sciences 2009). Irrigation water at the FRFCRP site will be supplied from existing wells on-site.

Based on knowledge of the site and plant design, the following are expected to be the requirements for the system:

- The plant spacing throughout most of the restoration and mitigation areas will be 10-foot-wide rows with a 10-foot distance down the planting rows, and rows planted in an approximate east-west direction.
- Planting rows will curve and run parallel to flood flows. The irrigation system will utilize existing wells as water sources.

- The drip-line emitters will be spaced, with three emitters per plant 12 inches apart. The design flow will be 0.6 gallons per hour per emitter (1.8 gallons per plant per hour).

Within selected areas, soil-moisture sensors will be placed throughout both planting areas. Sensors will be installed at depths of 12 and 36 inches (River Partners and Stillwater Sciences 2009).

In conjunction with these measurements, plant stress observations before and after irrigation periods will be necessary to critically judge the timeliness and effectiveness of irrigation. Measurements provide the most direct assessment of soil moisture. Table 5-5 provides the irrigation goals of the project (River Partners and Stillwater Sciences 2009).

Table 5-5. Irrigation Goals for the Star Bend Conservation Area

Year	Goal	Frequency
1	Keep the shallow roots (1–2 feet) of young plants moist to ensure optimum growth and survival.	Utilize soil moisture probes to monitor and maintain moisture throughout the soil column.
2	Encourage deep rooting and enhance field access to facilitate weed control.	Deliver less frequent but longer irrigations.
3	Encourage deep rooting and enhance field.	Continue with long irrigations and extend the access to facilitate weed control period between irrigations.

Source: River Partners and Stillwater Sciences 2009

The strategy for the second and third year is to train the roots to grow deep. Roots at depth (5–15 feet) will need less water and may be able to tap into the water table on the site and outcompete more shallow-rooted weeds. Less frequent, deep watering will encourage roots to grow deeper, well below the roots of the weeds, allowing the tree exclusive use of this deep moisture. As the tree's roots grow deeper, the times between irrigations become longer; this allows the soil surface layers to dry, thereby reducing weed vigor (River Partners and Stillwater Sciences 2009).

We anticipate that the well-drained, sandy soils, and relatively deep groundwater present on the site, will require frequent irrigations and careful observation of water stress. These areas may dictate the frequency of watering on the site. Field managers should use a combination of methods including evapotranspiration estimates, soil probes, gypsum blocks, and plant water stress signs to assess soil moisture and alter the irrigation regime (River Partners and Stillwater Sciences 2009).

5.4 Implementation Schedule

The mitigation project would be implemented concurrent with project construction. Elderberry shrub transplant activities would take place during the dormant period. Mitigation maintenance will begin immediately following completion of the mitigation activities.

Chapter 6
Maintenance during Monitoring Period

6.1 Maintenance Activities

6.1.1 Overall

Mitigation and riparian vegetation enhancement activities at the SBCA and FRFCRP site will be monitored by SBFCA and/or CDFW (or their designee) to determine if mitigation requirements and habitat enhancement goals and performance standards are being met. Annual monitoring of riparian vegetation establishment, including natural native plant recruitment, nonnative plant recruitment, and plant development, will determine if remedial actions are needed. Annual monitoring reports will be submitted by December 31 of each year. If monitoring reveals that performance standards are not being met, remedial activities may be implemented (River Partners and Stillwater Sciences 2009).

6.1.2 Irrigation

All planted areas within the mitigation site will be irrigated during the establishment period. Soil moisture should be checked at least twice weekly and plantings should be qualitatively assessed for signs of drought stress. All planting areas will be irrigated at least twice weekly from May through October. Irrigation event duration should be adjusted depending on soil moisture and prevailing weather conditions but should be of sufficient length to maintain vigorous plant growth and encourage deep root growth.

Between November and April soil moisture at the mitigation site will be checked twice a month, and, if necessary, the irrigation system will be run for approximately ½ hour or long enough to replenish soil moisture around the plantings in the mitigation area.

6.1.3 Invasive Plant Control

Weeding efforts will occur on a monthly basis from April to October of each year for 5 years. Weed control will consist of controlling populations of invasive weeds when they occur in the planting areas. Weed control will consist of mechanical or manual removal only. At no time will herbicides be used in the planted areas. Plant Replacement

Dead of diseased plants will be replaced immediately upon their discovery with new plants of the same size and species. Plant species substitutions will only be permitted with the prior approval of the resource manager.

6.1.4 Plant Replacement

Dead of diseased plants will be replaced immediately upon their discovery with new plants of the same size and species. Plant species substitutions will only be permitted with the prior approval of the resource manager.

6.1.5 Irrigation System Maintenance

The resource manager will maintain the irrigation system during the plant establishment maintenance period. Maintenance will include the repair and replacement of parts, ensuring the system is delivering the required amount of water, and ensuring the system is fully operational at all times. The resource manager will regularly inspect the irrigation system, adjust and replace parts as necessary.

6.1.6 Reporting and Record Keeping

The resource manager will prepare and keep current a record of monthly maintenance performed on the project. The record will identify, at a minimum, project name, mitigation planting zones, current date and establishment period. The record will also identify and discuss weed control performed, irrigation activity and maintenance, plant health, vandalism, site feature conditions, general observations, total precipitation for the month, personnel onsite and any other pertinent information describing site conditions and activities performed during the month.

Chapter 7
Proposed Monitoring Reports

7.1 Due Dates

USACE will notify resource agencies of the due date (month and day) for the annual monitoring report.

7.2 As-Builts

As-built planting and irrigation drawings of the mitigation areas will be prepared by the implementing agency following completion of the project. The as-built drawings will be prepared on 40-scale or larger-scale maps and will indicate the following features.

- Extent of planting areas (in plan view).
- Location of any permanent markers (e.g., identification stakes, photo documentation stations).
- Seeded areas.
- Other pertinent features.

Any changes from the original mitigation construction plans will be indicated in indelible red ink. The as-built drawings will be submitted to USACE and other resource agencies within 6 weeks of construction completion.

7.3 Annual Reports

7.3.1 File Number

Any appropriate USACE permit/file numbers will be included on correspondence, including the cover and title page of all reports.

7.3.2 Contents

The following text describes the content that will be included in the mitigation monitoring reports.

Years of Full Monitoring

Annual monitoring report will be prepared by SBFCA in accordance with USACE guidance (U.S. Army Corps of Engineers 2004 and 2006) by December 31 of each monitoring year. Each full-year monitoring report will include the following information.

- Project Information
    - Project name and a summary of the project location and description including date of project commencement and completion.

- Contact information for the applicant.
- A list of the names, titles, and companies of the people who prepared the content of the annual report or participated in monitoring activities that year.
- USACE permit file number.
- Type and acres of impacted habitat.
- The monitoring year.
- Information on any required performance bonds or surety, if applicable.

- Compensatory Mitigation Site Information
  - Location of the mitigation site.
  - Purpose and goals of the mitigation.
  - Dates of mitigation site construction and completion.
  - Dates and summary of maintenance and performance monitoring visits.
  - Contact information for the responsible party for the mitigation site.
  - Summary of remedial actions, if applicable.
- Figures and Graphics
  - Location map.
  - Mitigation site map indicating restored habitats, monitoring locations, photo documentation stations, and any other pertinent site features.
- List of USACE-approved success criteria
- Monitoring Results
  - A summary and analysis of the monitoring results, including an evaluation of site conditions in the context of the performance standards and success criteria, including a comparison with previous monitoring years.
  - Summary of field data taken to determine compliance.
- Problems noted and proposed remedial measures
  - Problems noted during the course of the monitoring surveys or other site visits.
  - Management recommendations, including discussion of areas with inadequate performance and recommendations for remedial action.
- Appendices
  - Original data sheets and technical appendices, as required by USACE and other resource agencies.
  - Photo-documentation of the planting areas using photographs taken during the monitoring surveys.

Final Monitoring Report

A final monitoring report will be submitted by SBFCA after all performance monitoring at the mitigation site is complete. The final report will be prepared by a qualified biologist and will evaluate whether the mitigation has achieved the goals and success criteria set forth in the approved MMP. The final report will be submitted within 90 days of the end of the monitoring period to USFWS and other resource agencies for review and approval.

Chapter 8
Potential Contingency Measures

8.1 Initiating Procedures

If the final report indicates that the mitigation project has been unsuccessful, in part or in whole, based on the approved success criteria for physical and ecological functions, the implementing agency will evaluate the causes for not meeting the criteria and submit a revised or supplemental mitigation plan within 90 days of the end of the monitoring period for the review and approval of USFWS to compensate for those portions of the original program that did not meet the approved success criteria. The approved remedial measures will be developed based on the qualitative and quantitative monitoring results to determine the most effective remedy. The revised mitigation plan containing the remedial measures will be processed as an amendment to the original permit unless USFWS determines that no permit amendment is required.

If, after all remedial measures have been implemented, it becomes evident that the permit requirements cannot be satisfied according to the proposed mitigation plan, the implementing agency will coordinate with the permitting agencies to develop a contingency plan to be approved by all parties.

8.2 Contingency Funding Mechanism

USACE and SBFCA will fund any necessary contingency mitigation efforts, including additional planning, implementation, and monitoring.

Chapter 9
Completion of Mitigation Responsibilities

9.1 Notification

USACE will notify USFWS of completion of mitigation responsibilities in conjunction with the final annual report. A minimum of 2 years will be required after the completion of all maintenance activities (e.g., irrigation, replanting, rodent control, fertilization) before final success criteria will be considered met.

9.2 USFWS Confirmation

After receiving the final monitoring report, USFWS will conduct a site visit and confirm in writing to the implementing agency that the mitigation obligations and responsibilities have been met, or if not met, describe additional actions required.

Chapter 10
Long-Term Management

10.1 Property Ownership

The SBCA is owned in part by LD 1 and in part by CDFW. The FRFCRP site is entirely owned by TRLIA.

10.2 Management Plan

10.2.1 Purpose

This section only addresses permittee-responsible mitigation, as compensatory mitigation not addressed below will be deemed satisfied and complete through purchase of credits from a commercial mitigation bank approved by the appropriate resource agencies.

The purpose of this long-term management plan is to ensure the mitigation site is monitored and maintained in perpetuity. This management plan provides management objectives and tasks to monitor, manage, maintain and report on the mitigated natural resources. Routine monitoring and minor maintenance tasks are intended to assure the viability of the mitigation site's functions and values. This long-term management plan will take effect after the completion of the monitoring period, once it has been determined by the appropriate resource agencies that the mitigation project has achieved its project objectives and outlined performance standards for each habitat type have been reached. During the long-term management period the gradual withdrawal of the required support systems (e.g., irrigation and frequency of maintenance) for mitigation resources will begin. The goal for each mitigation site is to become fully self-sustaining. The designated resource manager(s) will oversee all long-term management activities.

10.2.2 Resource Manager

The resources managers are LD1 and DFW. The resource managers, and subsequent resource managers, upon transfer, shall implement this long-term management plan. Long-term management tasks shall be funded through the mitigation site's endowment fund. The resource manager(s) shall be responsible for providing an annual report, consisting of a description of the management tasks and total funds expended, to the appropriate resource agencies. Any subsequent modification to the mitigation sites by the resource manager(s) or their representatives must be approved by the appropriate resources agencies and the necessary permits obtained.

10.2.3 Management Approach

The general management approach to the long-term maintenance of the mitigation site will be to maintain quality habitat functions and values for each mitigated resource and on-going monitoring and maintenance of the mitigation site. When necessary, adaptive management will be used to adjust management practices, including corrective actions as determined to be appropriate by the

appropriate resources agencies in discussion with the resource manager(s). Adaptive management includes those activities necessary to address the effects of climate change, fire, flood, or other natural events, force majeure, etc. Before considering any adaptive management changes to the long-term management plan, the appropriate resource agencies will consider whether such actions will help ensure the continued viability of the mitigation site's biological resources.

10.2.4 Long-Term Management Needs

The expected long-term management needs and activities necessary to maintain the mitigation site will be resource specific long-term maintenance activities as described below and other general maintenance activities such as exotic species elimination, clean-up and trash removal, infrastructure management such as gate, fence, road, culvert, signage and drainage-feature repair, and other maintenance activities necessary to maintain the functions and values of the mitigation site.

Biological Monitoring

Annual field surveys will be conducted to qualitatively assess and record the general conditions of the riparian, non-riparian native trees, and elderberry planting areas. General hydrology, general vegetative cover, structure and native plant diversity, invasive species, and erosion sites will be recorded, evaluated and mapped during site examinations in the spring. Notes to be made will include observations of species encountered, general condition of the planting areas, occurrences of erosion, and presence of significant populations of non-native invasive plants.

Diversity of native plant species will be maintained by replanting native species as specified in the original planting plan, or when appropriate, introduction of additional native species. Native species from various plant communities should be selected to complement natural seral processes that may take place as the mitigation site ages and matures.

Other Site Management Activities

Other site management and maintenance activities are those that may be required on an as-needed basis. Items listed below may be observed, implemented, and/or recorded during annual site observation and included in annual report to the appropriate resource agencies. Funding for these management and maintenance activities will be covered by the mitigation site's endowment fund.

General Inspections: The resource manager(s) will conduct two general site inspections each year. These inspections may take place while conducting other routine site maintenance visits. Photo documentation will be collected. Permanent photo points for taking photographs will be established, and a site map showing the photo point will be prepared for the mitigation project file. Representative photographs will be taken once per year during the same season.

Mosquito Abatement: Potential mosquito abatement issues will be addressed through the development of a plan by the resource manager(s) and the mosquito and vector control district in coordination with and approved by the appropriate resource agencies.

Trash and Trespass: At least once yearly trash will be collected and disposed within the mitigation site. Vandalism and trespass impacts will be repaired and rectified. Sources of trash and trespass will be monitored.

Non-native Invasive Species: The resource manager(s) will monitor and maintain control over non-native invasive species, including but not limited to noxious weeds, that diminish site quality for which the mitigation project was established. The mitigation site currently functions with a number of nonnative species, some of which have become naturalized. They are predominantly annual species that occur in grasslands. It is unreasonable to require or expect eradication of established nonnative species at the site. The required management of nonnative plants therefore will be limited to the management of newly introduced invasive species and controlling the spread of existing invasive species. Methods of removing or controlling these species are outlined below.

Hand/mechanical: Hand removal or use of small hand-powered or handheld equipment (such as a Weed Wrench or a chainsaw) always should be the preferred method of removing invasive species from the mitigation properties. If hand-removal methods are found ineffective, or the problem is too widespread for hand removal to be practical, mechanical methods (use of larger equipment with motors such as mowers) or biological controls as described below can be used.

Biological controls: The county agricultural commissioner would be the point of contact for use of biological controls in the mitigation properties.

At no time will herbicides be utilized at the mitigation site.

Weeding will be done on an as-needed basis starting in March and ending in October.

Each year's annual walk-through survey (or a supplemental survey) will include a qualitative assessment (e.g., visual estimate of cover) of potential or observed noxious weeds or other non-native species invasions, primarily in or around the wetlands. Additional actions to control invasive species will be evaluated and prioritized.

Fire Hazard Reduction: Potential wildfire fuels will be reduced as needed by mowing in areas where approved by the resource agencies. The site will be maintained as required for fire control while limiting impacts to biological values. Vegetation will be mowed in areas required by authority agency(ies), and as approved by the appropriate resource agencies, for fire control.

Reporting and Administration

The resource manager(s) will provide an annual report on all management tasks conducted and general site conditions to appropriate resource agencies and any other appropriate parties. The annual report will be completed and circulated to the appropriate resource agencies and other parties by August 15 of each year. The report will make recommendations with regard to any habitat enhancement measures deemed to be necessary, any problems that need near short and long-term attention (e.g., weed removal, erosion control), and any changes in the monitoring or management program that appear to be warranted based on monitoring results to date.

10.2.5 Management Responsibilities and Plan Modification

Transfer of Management Responsibilities

Any subsequent transfer of management responsibilities under this long-term management plan to a different resource manager shall be requested in writing by the existing resource manager(s). The request shall be made to the appropriate resource agencies, which will issue written approval that shall be incorporated as an amendment into this long-term management plan. Any subsequent

property owner assumes resource manager responsibilities described in this long-term management plan and as required in the conservation easement, unless otherwise amended in writing by the appropriate resource agencies.

Amendment to Management Plan

The resource manager(s), property owner, and the resource agencies may meet and confer from time to time, upon the request of any one of them, to revise the long-term management plan to better meet management objectives and preserve the habitat functions and values of the mitigation site. Any proposed changes to the long-term management plan shall be discussed with the appropriate resource agencies and the resource manager(s). Any proposed changes will be designed with input from all parties. Amendments to the long-term management plan shall be approved by the appropriate resource agencies in writing and implemented by the resource manager(s).

10.2.6 Funding

Long-Term Funding Mechanism

An endowment will be provided by the implementing agency to CDFW who will hold the principal and interest monies as required by law in a deposit fund, or subsequent state authorized trustee fund which consists of monies that are paid into it in trust pursuant to law, and will be appropriated to fulfill purposes for which payments into it are made. These interest monies will fund the long-term management, enhancement and monitoring activities set forth by the conservation easement and consistent with this long term management plan.

The resource manager(s) shall consult with CDFW as required to determine the amount of funding available for management and monitoring activities.

10.2.7 Long-Term Conservation Mechanism

Conservation Easement

Conservation easements will be created for the portion of the SBCA owned by LD, and the entire FRFCRP site. They will act as a legal binding agreement to restrict the use of the parcel for the purpose of conserving in perpetuity the mitigated natural resources. The conservation easement will be attached to the property's fee title and apply to present and all future owners and resources managers of the mitigation site should LD1 relinquish or transfer land management responsibilities.

Chapter 11
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Figures

SUTTER BASIN PILOT FEASIBILITY STUDY COST EFFECTIVENESS INCREMENTAL COST ANALYSIS REPORT

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List of Acronyms and Abbreviations

CE/ICA	cost-effectiveness/incremental cost analysis
DFW	California Department of Fish and Wildlife
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
MMP	Mitigation and Monitoring Plan
Project	Feather River West Levee Project applicant-preferred alternative
SBFCA	Sutter Butte Flood Control Agency

Draft Sutter Basin Pilot Feasibility Study
Cost Effectiveness and Incremental Cost Analysis

Analysis Scope and Objective

This document is a cost effectiveness incremental analysis of the options for mitigating habitat and jurisdictional waters impacts associated with the SB 8 alternative and Sutter Butte Flood Control Agency's (SBFCA's) Feather River West Levee Project applicant-preferred alternative (Project).

For the purpose of this analysis, the two alternatives are treated the same because they are nearly perfectly congruent in construction footprint and activity, with the exceptions that SB 8 extends slightly farther to the south and has minor variations in staging and borrow areas. The difference in the southern limit is considered scalable between the two alternatives and would not represent different effect types, relative effect magnitude, or mitigation options. The differences in the staging and borrow areas is considered insignificant to this analysis because resultant habitat effects would be predominantly temporary and would not require habitat mitigation. Therefore, these differences are not discussed further in this analysis.

This analysis in presented in compliance with ER 1105-2-100 (April 22, 2000) and its included guidance on cost-effectiveness/incremental cost analysis (CE/ICA). It is intended to determine the least-cost solution for habitat mitigation for the project.

Project Description, Impacts, and Mitigation Needs

The project consists of levee improvements in a 41-mile corridor along the west levee of the Feather River from the Thermalito Afterbay downstream to approximately 3 miles north of the confluence with the Sutter Bypass. The levee improvements include mostly slurry cutoff walls with short segments of seepage berms and other location-specific measures like removal or treatment of encroachments.

Potential borrow sites that could supply the soil borrow material necessary for levee construction and upgrades, and routes from the project construction area to the borrow sites, are also included as part of the work. It is not anticipated that all sites would be used over the multi-year phased construction period but would be available for use if the need arises.

Existing Ecological Resources

Table 1 provides a summary of all existing land cover types within the Project area.

Table 1. Acreages of Existing Land Cover Types in the Project Area

Land Cover Type	Permanent Impacts for Which Mitigation Is Required?	Unit	Levee Construction Footprint [a]	Borrow Sites[a]	Total
Terrestrial					
Riparian Forest	Y	acre	252.71	9.97	262.68
Oak woodland	Y	acre	0.35	0	0.35
Orchard	N	acre	1212.89	0	1212.89
Field and row crops	N	acre	147.65	50.59	198.24
Wet agriculture (rice)	N	acre	0	348.08	348.08
Developed	N	acre	404.68	20.94	425.62
Ruderal	N	acre	903.24	82.96	986.20
Aquatic					
Freshwater emergent wetland	N	acre	0.57	0	0.57
Seasonal wetland	Y	acre	12.23	0	12.23
Open water	Y	acre	59.32	4.7	64.02
Tailing ponds	Y	acre	6.44	3.59	10.03
Stream	N	acre	0.17	0	0.17
Canal/ditch	Y	acre	22.51	0.64	23.15
Wet agriculture (rice)	N	acre	0	35.74	35.74

[a] Accuracy to 0.01 acre is subject to ±5% accuracy depending upon the accuracy of aerial imagery and topographic maps.

Significant Losses to Ecological Resources, Impact Units and Proposed Mitigation

Detailed discussion of the project impacts may be found in the Project's Environmental Impact Report/Supplemental Environmental Impact Statement (EIR/SEIS). Table 2 summarizes the project's impacts to sensitive ecological resources, impact unit of measure, and the proposed compensatory mitigation ratios and quantities.

Table 2. Anticipated Project Impacts to Sensitive Resources and Proposed Compensatory Mitigation

Impact Type	Impact Unit	Impact Quantity	Mitigation Need	Mitigation Area
Riparian Forest and Riparian Scrub Shrub	acres of cover type	42.50 acres	85.00 acres (2:1 replacement ratio[1])	85.00 acres at 10' o.c. plant spacing
Oak Woodland	acres of cover type	1.30 acres	2.60 (2:1 replacement ratio1[1])	2.60 acres at 10' o.c. plant spacing
Elderberry	individual shrubs and total stem count within each shrub	162 shrubs with 972 total stems	162 transplants, 2,466 elderberry seedlings, and 2,466 native associates	20.38 acres [2] (493 elderberry units)
Giant Garter Snake	acres of permanent impact	0.00 aquatic 3.54 acres upland	3.54 acres (3:1 replacement ratio[3])	10.62 acres
Jurisdictional Waters	acres of permanent impact	1.71 acres	3.42 acres (2:1 replacement ratio1[1])	3.42 acres

Notes:

[1] Compensation ratio from USFWS Draft Fish and Wildlife Coordination Act Report.

[2] Compensation acreage determined based on USFWS VELB Compensation Guidelines.

[3] Compensation ratio from USFWS Programmatic Biological Opinion (U.S. Fish and Wildlife Service 1997)

Mitigation Planning Objectives and Potential Mitigation Strategies

The mitigation planning objective for this project is to provide compensatory mitigation at resource agency approved ratios for all permanent impacts to sensitive ecological resources.

There were four primary habitat mitigation solutions considered, listed below with a statement of applicability.

- **In-lieu fee program.** This option, wherein a permittee/applicant pays the permitting agency to implement mitigation at its discretion, generally has low favorability with the agencies requiring mitigation because it shifts the burden of responsibility for providing replacement habitat from the applicant/permittee to the permitting agency. It is often regarded as a "last resort" and typically applies only to very small projects and impacts where other mitigation options may not be feasible, upon negotiation with the permitting agency. Approved in-lieu fee programs may not exist for all mitigation needs in the project area. For this combination of reasons, in-lieu fee programs were not considered further as a viable solution for this project.
- **Out-of-kind replacement habitat.** This option involves replacement of habitat with a different type than that which was impacted, either on-site or off-site. Because in-kind replacement habitat is not feasible, this option was not considered further as a viable solution for this project.

- **On-site replacement habitat.** This option involves replacement of affected habitat with new habitat of the same type and at the same location as the loss. Because much of the affected habitat (specifically, woody vegetation) is not compliant in its location with USACE levee vegetation policy, this option is not considered feasible. Further, the highly dispersed nature of the impact locations makes efficient replacement infeasible. On-site replacement was not considered further as a viable option for this project.
- **Off-site, in-kind replacement habitat.** This option involves replacement of affected habitat with new habitat of the same type but at a different location than the loss. This often allows for consolidation of mitigation at a single or small number of sites, allowing for economy of scale and higher quality habitat due to large patch size. There are two sub-types:
    - **Permittee-responsible mitigation.** This option involves replacement of in-kind habitat on habitat lands operated by the permittee. Permittee-responsible mitigation is considered viable and is addressed in the Mitigation and Monitoring Plan (MMP) developed for the project.
    - **Purchase of credits at commercial mitigation banks.** This option involves replacement of in-kind habitat through purchase of credits issued for habitat lands operated by a commercial mitigation bank. Purchase of credits is considered viable and is addressed in the MMP developed for the project.

Permittee-Responsible Mitigation. Permittee-responsible offsite mitigation involves securing an appropriate mitigation site, implementing the mitigation plan, monitoring its performance, maintaining the site during the establishment period, developing a conservation mechanism, and arranging a source of funding for long-term protection of the site.

The Star Bend and TRLIA Feather River mitigation sites are existing floodplain habitat restoration sites that were created as part of the Star Bend setback levee and Feather River setback levee projects, respectively. Together, both sites contain sufficient area to accommodate all of the project's upland compensatory mitigation, consisting of mostly woody vegetation. Aquatic habitat mitigation, including giant garter snake habitat and jurisdictional waters, could be created through restoration of a rice field used for soil borrow for the project.

Table 3 provides a summary of the permittee-responsible mitigation and the anticipated costs. Appendix 1 contains detailed construction and establishment cost breakdowns for each category to establish a unit cost for equitable comparison between mitigation solutions (i.e., "apples-to-apples" comparison).

Table 3. Permittee-Responsible Mitigation Costs

Mitigation Type	Location	Quantity	Unit	Cost per Unit	Cost
Oak Woodland	Star Bend	1.30	Acres	$36,684	$47,689
Oak Woodland	TRLIA Feather River	1.30	Acres	$36,684	$47,689
Elderberry (New Plantings)/Riparian Forest Mitigation[1]	Star Bend	493	Units	$1,488	$733,584
Riparian Forest	Star Bend	4.12	Acres	$35,855	$147,722
Riparian Forest	TRLIA Feather River	60.50	Acres	$35,855	$2,169,228
Elderberry (Transplants)	Star Bend	162	Each	$1,200	$194,400
Giant Garter Snake	Restored rice field	10.62	Acres	$40,291	$427,890
Jurisdictional Waters	Restored rice field	3.42	Acres	$164,167	$561,452
				Total	**$4,329,654**

[1] Riparian forest mitigation can be met through elderberry mitigation.

Mitigation Bank. Purchase of mitigation bank credits involves utilizing a commercial mitigation bank or banks to fulfill the project's compensatory mitigation obligation. The mitigation bank or banks would need to have been approved by the permitting agencies for the habitat types and service area that covers the impact.

Currently there is not one mitigation bank that can solely fulfill all of the credit types needed for the project's mitigation requirements. For the upland habitat impacts, the River Ranch Elderberry Conservation Bank, owned and operated by Wildlands, Inc., is located at the confluence of the Sacramento and Feather Rivers in Yolo County. This bank can fulfill the riparian and elderberry mitigation requirements of the project. There are currently no mitigation banks that offer oak woodland (non-riparian native tree) credits.

For the aquatic habitat impacts, the Sutter Basin Conservation Bank, owned and operated by Westervelt Ecological Services in Sutter County, is the only bank that presently offers giant garter snake credits approved by both the U.S. Fish and Wildlife Service and California Department of Fish and Wildlife (DFW). Jurisdictional water credits are available at the River Ranch Wetland Mitigation Bank (discussed above).

Table 4 provides a summary of the agency-approved mitigation credits available at the banks in the service area of the impacts.

Table 4. Mitigation Bank Costs

Mitigation Type	Location	Quantity	Unit	Cost per Unit	Total
Oak Woodland	None	2.60	Acres	$50,000[1]	$130,000
Elderberry (New Plantings) and Riparian Forest Mitigation[2]	River Ranch Elderberry Conservation Bank	493	Units	$4,000	$1,972,000
Riparian Forest		64.62	Acres	$100,000	6,462,000
Elderberry (Transplants)		162	Each	$1,200	$194,400
Giant Garter Snake	Sutter Basin Conservation Bank	10.62	Acres	$40,000	$424,800
Jurisdictional Waters	River Ranch Wetlands Mitigation Bank	3.42	Acres	$100,000	$342,000
				Total	**$9,525,200**

[1]Estimate; no market credits are available at this time.

[2]Riparian forest mitigation can be fulfilled through purchase of elderberry credits

Summary of Results

The total cost for the permitted responsible mitigation option is $4,329,654. The total cost for the mitigation bank option is $9,525,200. On a cost per unit basis, the most cost-effective solution would be a blend between the two options, as shown below in Table 5.

Table 5. Unit Cost Comparison

Mitigation Type	Unit	Permittee-Responsible Mitigation Cost per Unit	Mitigation Bank Cost per Unit	Most Cost-Effective Solution
Oak Woodland	acre	$36,684	$50,000*	Permittee-responsible
Elderberry (New Plantings)/Riparian Tree Mitigation	unit	$1,488	$4,000	Permittee-responsible
Elderberry (Transplants)	each	$1,200	$1,200	Permittee-responsible/Mitigation bank
Giant Garter Snake	acre	$40,291	$40,000	Mitigation bank
Jurisdictional Waters	acre	$164,167	$100,000	Mitigation bank

*Estimate; no market credits are available at this time.

Therefore, in accordance with ER 1105-2-100 (Appendix E, page 153), the most cost-effective plan is a combination of permittee-responsible mitigation and purchase of credits at a commercial mitigation bank, as no other plan costs less, and no other plan yields more output for less money.

This blended solution is detailed in Table 6. The total compensation cost using this solution is about $4.6 million.

Table 6. Most Cost-Effective Mitigation Solution

Mitigation Type	Location	Quantity/ Unit	Cost per Unit	Total
Oak Woodland	Star Bend or TRLIA Feather River	2.6 acres	$36,684	$95,378
Elderberry (New Plantings)/Riparian Tree Mitigation	Star Bend	493 units	$1,488	$733,584
Elderberry (Transplants)		162 each	$1,200	$194,400
Riparian Forest	Star Bend or TRLIA Feather River	4.12 acres	$35,855	$147,722
Riparian Forest	TRLIA Feather River	60.50 acres	$35,855	$2,169,228
Giant Garter Snake	Sutter Basin Conservation Bank	22.5 acres	$40,000	$900,000
Jurisdictional Waters	River Ranch Wetlands Mitigation Bank	3.42 acres	$100,000	$342,000
Total				**$4,582,312**

There are other factors influencing favorability of this blended solution. One such factor is that oak woodland mitigation is not presently available at a bank, meaning a bank-only solution is not feasible. Moreover, enhancement of the Star Bend restoration area is favored by the permitting agencies to more fully realize the floodplain habitat potential for this area for fish and wildlife. Additionally, the Star Bend site is under joint control by one of SBFCA's member agencies (Levee District 1) and CDFW, easing issues with maintenance, ownership, and protective status in conservation. Conversely, these issues are not resolved for a permittee-responsible aquatic mitigation site, increasing the favorability of mitigation bank solution for these impacts.

Nearly half ($2.4 million) of the total mitigation cost of 4.6 million is endangered species compensation. The remainder is primarily compensation for loss of riparian forest. Riparian forest is a significant resource based on scarcity, institutional and public significance criteria. It is estimated that 95 percent of pre-European acres of riparian habitat in California's Central Valley have been lost to recent human activities.

An incremental cost analysis was not performed because there were no breakpoints where the incremental cost per unit changed dramatically with increasing cost and where less than full compensation for riparian forest may be justified based on incremental costs. In part, this was a result of using acres of habitat rather than habitat units as the output metric to compare measures.

More detailed analyses using habitat based modeling methods such as Habitat Evaluation Procedures may be performed during future design phases to ensure that significant habitat function and values are compensated for and the most cost effective and incrementally justified solution is identified.

Table A1. Elderberry Mitigation Costs at Star Bend

Habitat Feature	Task Description	Unit	Unit Cost	Quantity	Total Cost	Assumptions
Elderberry plantings at Star Bend (20.38 acres)	Mobilization	LS	$15,000	1	$15,000	
	Container plant	EA	$20	4,932	$98,640	Assumes 5 elderberry and 5 associates per unit (242 plants/acre)
	Irrigation system	AC	$8,500	20.38	$173,230	Assumes flood proof drip system
	Irrigation POC	EA	$15,000	1	$5,000	Assumes pumping ou of Feather River
	Maintenance Years 1-4	LS	$42,298	1	$107,462	Assumes 20% morality for Years 1-3 and 10% for Year 4
	Monitoring Years 1-10	LS	$92,400	1	$160,000	
	15% Contingency				$83,548	
	Total				**$642,880**	

2306

Table A2. Non-Riparian Native Tree Mitigation Costs at Star Bend and TRLIA Feather River

Habitat Feature	Task Description	Unit	Unit Cost	Quantity	Total Cost	Assumptions
Oak plantings at Star Bend and TRLIA Feather River (20.14 acres)	Mobilization	LS	$15,000	2	$30,000	
	Container plant	EA	$20	10,180	$203,600	Assumes 10' O.C. spacing
	Acorn plantings	EA	$3	10,120	$30,360	Assumes 500 acorns/acre
	Irrigation system	AC	$8,500	20.14	$171,190	Assumes flood proof drip system
	Irrigation POC	EA	$15,000	1	$15,000	Assumes utilizing existing well
	Maintenance Years 1-4	LS	$107,462	1	$107,462	Assumes 20% morality for Years 1-3 and 10% for Year 4
	Monitoring Years 1-10	LS	$84,000	1	$84,000	
	15% Contingency				$97,203	
	Total				**$738,815**	

Table A3. Riparian Mitigation Costs at Star Bend

Habitat Feature	Task Description	Unit	Unit Cost	Quantity	Total Cost	Assumptions
Riparian plantings at Star Bend (9.51 acres)	Mobilization	LS	$15,000	1	$15,000	
	Container plant	EA	$20	4783	$95,660	Assumes 10' O.C. spacing
	Irrigation system	AC	$8,500	9.51	$80,835	Assumes flood proof drip system
	Maintenance Years 1-4	LS	$16,657	1	$67,887	Assumes 20% morality for Years 1-3 and 10% for Year 4
	Monitoring Years 1-10	LS	$13,950	1	$37,200	
	15% Contingency				$44,475	
	Total				$340,977	

2307

Table A4. GGS Mitigation at Generic Permittee-Responsible Site

Habitat Feature	Task Description	Unit	Unit Cost	Quantity	Total Cost	Assumptions
GGS (7.5 acres aquatic and 15 acres upland)	Land cost	AC	$7,500	22.5	$168,750	
	Mobilization	LS	$15,000	1	$15,000	
	Grading	CY	$4	36,300	$145,200	Assumes 3' of cut over 7.5 acres and on-site spoils disposal
	Seeding	AC	$1,000	22.5	$22,500	Assumes seeding over all 22.5 acres
	Planting	EA	$3	15,090	$45,270	Assumes plug planting at 5' O.C. over 7.5 acres
	Erosion control	LS	$5,000	1	$5,000	
	Design and permitting	LS	$46,594	1	$46,594	Assumes 20% of construction costs
	GGS monitoring	YR	$8,000	5	$40,000	
	Endowment	LS	$300,000	1	$300,000	Assumes $6,000/year for long term maintenance and monitoring at 2% annual return on principal
	15% Contingency				$118,247	
	Total				**$906,561**	

2308

Table A5. Jurisdictional Habitat Mitigation at Generic Permittee-Responsible Site

Habitat Feature	Task Description	Unit	Unit Cost	Quantity	Total Cost	Assumptions
Wetlands and waters (3.42 acres)	Land cost	AC	$7,500	6	$45,000	Assumes approximately 2.5 acres of upland for spoils disposal and buffer
	Mobilization	LS	$15,000	1	$15,000	
	Grading	CY	$4	16,552	$66,208	Assumes 3' of cut over 3.41 acres and on-site spoils disposal
	Seeding	AC	$1,000	6	$6,000	Assumes seeding over all 6 acres
	Planting	LS	$3	9,309	$27,927	Assumes plug planting at 5' O.C. over 3.42 acres
	Erosion control	LS	$5,000	1	$5,000	
	Design and permitting	LS	$24,027	1	$24,027	Assumes 20% of construction costs
	Wetland monitoring	YR	$12,000	5	$60,000	
	Endowment	LS	$200,000	1	$200,000	Assumes $4,000/year for long term maintenance and monitoring at 2% annual return on principal
	25% Contingency				$112,290	
	Total				**$561,452**	

2309

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PROGRAMMATIC AGREEMENT
AMONG
THE U.S. ARMY CORPS OF ENGINEERS AND
THE CALIFORNIA STATE HISTORIC PRESERVATION OFFICER,
REGARDING
THE SUTTER BASIN FEASIBILITY STUDY

WHEREAS, the U. S. Army Corps of Engineers, Sacramento District (Corps), is proceeding with the Sutter Basin Feasibility Study, and the Corps has determined that the study and subsequent approved project alternatives (Project) constitute an Undertaking as defined in the Advisory Council on Historic Preservation Procedures 36 CFR § 800.16(y); and

WHEREAS, the purpose of the Sutter Basin Feasibility Study is to address Flood Risk Management in conjunction with Ecosystem Restoration and Recreation. The study area is located in Sutter and Butte Counties California and is roughly bounded by the Feather River, Sutter Bypass, Wadsworth Canal, Sutter Buttes, and Cherokee Canal. The study area covers approximately 300 square miles and is approximately 43 miles long and 9 miles wide. The study area includes the communities of Yuba City, Live Oak, Gridley, Biggs, and Sutter. A map of the study area is included as Appendix 1 to this Programmatic Agreement (PA).

WHEREAS, the Undertaking is authorized under the Flood Control Act of 1962 (Public Law 87-874), that provides the Corps the authority to study flood risk management and related water resources problems in the Sacramento River Basin, including the study area in Sutter and Butte Counties; and

WHEREAS, The Corps has determined that effects on properties that are either included in, or are eligible for inclusion in the National Register of Historic Places (NRHP) cannot be fully determined prior to completion of the Sutter Basin Feasibility Study and selection of approved alternatives; this agreement addresses all phases and segments of the Project; and

WHEREAS, the Corps has consulted with the California State Historic Preservation Officer (SHPO) and offered the Advisory Council on Historic Preservation (ACHP) the opportunity to consult pursuant to Section 106 of the National Historic Preservation Act of 1966 (Section 106), and the implementing regulations described under 36 CRF Part 800; and

WHEREAS, by letter dated March 13, 2012, the ACHP declined to participate in the consultation.

WHEREAS, the Corps has consulted with the non-Federal cost-sharing agencies, the Sutter Butte Flood Control Agency and the Central Valley Flood Protection Board, and has invited them to participate as concurring parties; and

WHEREAS, the Corps has contacted the Mechoopda Indian Tribe of Chico Rancheria, the Greenville Rancheria of Maidu Indians, the Maidu Nation, the Butte Tribal Council, the Mooretown Rancheria of Maidu Indians, the United Auburn Indian Community of the Auburn Rancheria, the Maidu Cultural and Development Group, the KonKow Valley Band of Maidu, the T'Si-akim Maidu, the Strawberry Valley Rancheria, the Berry Creek Rancheria of Maidu Indians, the Enterprise Rancheria of Maidu Indians, and other Native individuals; and invited them to consult on this agreement; and

WHEREAS, the Corps has consulted with the United Auburn Indian Community of the Auburn Rancheria, the Estom Yumeka Maidu Tribe of the Enterprise Rancheria, and the Mechoopda Indian Tribe

of Chico Rancheria who have indicated their interest in participating in this agreement and are invited to participate as concurring parties; and

WHEREAS, the definitions set forth in 36 CFR § 800.16, with amendments effective August 5, 2004, are incorporated herein by reference and apply throughout this PA;

NOW, THEREFORE, the Corps and the SHPO agree that the proposed undertaking shall be implemented in accordance with the following stipulations in order to take into account the effects of the undertaking on historic properties and to satisfy the Corps' Section 106 responsibilities for all individual aspects of the undertaking.

STIPULATIONS

The Corps shall ensure that the following measures are carried out:

Stipulation I
Professional Qualification

The Corps shall ensure that historic, architectural, and archaeological work conducted pursuant to this agreement is carried out by, or under the direct supervision of, a person or persons who meet the qualifications set by the Secretary of the Interior for Archaeology and Historic Preservation under 36 CFR Part 61.

Stipulation II
Area of Potential Effects

A. Should the Corps determine that an undertaking is warranted and alternatives are defined, the Corps shall define and document the area of potential effects for all defined alternatives (APE) in consultation with SHPO. If future project design requires redefining the APE, the Corps shall consult with SHPO in a timely manner to amend the APE.

B. The APE shall include the footprint of all construction activities, staging areas, haul roads, and mitigation sites. The APE may also include sensitive structures within range of vibratory or sonic disturbances, and historic properties and districts close enough to project construction that the integrity of their setting or feeling could be affected.

C. The APE may include portions of the study area indicated on the map included as Appendix 1.

Stipulation III
Identification and Evaluation

A. The study is intended to determine the feasibility of a federal action. In the course of making that determination the Corps shall consider the probability of an action effecting historic properties by consulting with Native American groups and reviewing pertinent archaeological records and literature.

B. The Corps shall acquire a current and complete records and literature search from the Northeast Information Center at California State University, Chico prior to conducting archaeological surveys of the

APE. Records and literature searches shall be considered complete and current for a period of three years after they are conducted unless, in the professional opinion of Corps archaeologists, more frequent updates are required.

C. The Corps shall consult with Native American groups and individuals, identified as described in Stipulation V (A), to identify properties that are of religious and cultural significance to them and that may be eligible for the National Register. Traditional Cultural Properties will be evaluated following the guidance presented in National Register Bulletin 38: *Guidelines for Evaluating and Documenting Traditional Cultural Properties*.

D. The Corps shall complete and report the results of all required cultural resources inventories of the undertaking's APE in a manner consistent with the "Secretary of the Interior's Standards and Guidelines for Identification" (48 FR 44720-23) and take into account the National Park Service's publication, "The Archeological Survey: Methods and Uses" (1978: GPO stock #024-016-00091). Inventories shall include both archaeological surveys and inventories of historic buildings, structures, and districts as appropriate. The Corps shall include a geoarchaeological evaluation of the APE in its survey and shall undertake subsurface reconnaissance as appropriate. Surveys shall include areas not previously surveyed and areas where the Corps, in consultation with SHPO, deems previous surveys to be inadequate. The Corps will also include additional areas that may be affected by changes in the project design, borrow areas, haul roads, staging areas, extra work space, mitigation sites, and other ancillary areas related to the undertaking. If identified cultural resources do not need to be evaluated but can be determined eligible based on the results of the survey, context statements, and historic documentation, then the Corps may request SHPO concurrence with those determinations at that time. The Corps shall submit reports produced as a result of intensive surveys to SHPO for review. The Corps shall deliver its submissions to the SHPO in the most expeditious manner possible: by electronic means such as email or fax; or hand delivery. SHPO shall have 15 calendar days after receipt to provide comments to the Corps.

E. The Corps shall include in its site recordation documents all unrecorded archaeological sites, linear features, and isolates encountered in the course of the survey. The Corps shall prepare updated records of previously recorded sites as necessary. The Corps' survey shall record all prehistoric sites and all historical sites, structures, buildings, and engineering features greater than forty-five (45) years of age. Historic sites to be recorded shall include, but not be limited to: commercial, residential, and ecclesiastical buildings, roads, trails, bridges, levees, culverts, and agricultural features, including ditches.

F. The Corps shall use the California Department of Parks and Recreation (DPR) form 523 to record all newly discovered historic or prehistoric archaeological sites and isolates, previously recorded archaeological sites, and where necessary, shall create updated site records using the DPR 523 form. Isolates shall be numbered sequentially, plotted on a map, and recorded on a single table within the report. The Corps shall examine non-linear sites that extend outside of the APE in their entirety unless access to land is prohibited or the scale of the resource makes doing so prohibitive. In the event access cannot be gained, the Corps shall consult with SHPO regarding appropriate means of evaluating a given site. The Corps shall record linear resources (i.e., railroad, road, trail, ditch, levee, etc.) that appear on GLO plat maps or are known from other archival data to be potentially significant, or which have associated features or dateable artifacts on DPR 523 site forms. The Corps will treat linear resources not mentioned on GLO plat maps or that appear on GLO plat maps but which are not associated with features or dateable artifacts, or do not otherwise appear to be significant on the basis of known archival data as "isolated feature segments" and shall record them in tabular form and shall include at a minimum a basic GPS map of the linear feature within the APE. Historic structures and buildings shall be recorded using the State Historic Preservation Office, Historic Resources Inventory form.

G. If the selected project alternative would involve impacts to Federal levees, the levees will be treated as though they were eligible for inclusion in the National Register of Historic Places or an Evaluation Plan (EP) will be developed to provide for consistent and thorough evaluation. If the Corps elects to prepare an EP, the analysis in the EP shall consider the levees in the context of the entire Feather River levee system. Additionally, the EP shall include clear and specific criteria for determining both (1) contributing and non-contributing elements of the levee system and (2) thresholds of adverse effect. Should the Corps, in consultation with the SHPO, determine that a given levee is eligible for the NRHP; a Historic Property Treatment Plan, as described unber Stipulation VI, shall be produced for that property.

H. The Corps shall ensure that EPs prepared for previously unevaluated cultural resources identified within the APE are consistent with the "Secretary of the Interior's Standards and Guidelines for Evaluation" (48 FR 44723-26). The Corps shall develop individual EPs to address different categories of potentially eligible historic properties. The Corps shall develop a Discovery Evaluation Plan (DEP) and a Construction Monitoring Plan (CMP) as components of an EP. An EP shall be used whenever the Corps, in consultation with the SHPO, determines that a cultural resource should be evaluated and use of the EP is essential to determine the boundaries and data potential of the site. If the Corps undertakes any archaeological testing, such testing shall be sufficient to define and delineate the site clearly, and to determine the site's eligibility for inclusion in the NRHP.

I. The Corps shall submit the EP for concurrent review to the SHPO and appropriate Native American groups. The Corps shall deliver its submissions in the most expeditious manner possible: by electronic means such as email or fax; or hand delivery. The Corps shall allow reviewers 30 calendar days after receipt to comment on the draft EP. The Corps shall ensure that any comments received within that time period are taken into account and incorporated into the final EP. If the Corps cannot concur with comments made by SHPO and/or Native American groups, the Corps will resolve the dispute in accordance with Stipulation XIII. Failure of the SHPO to comment within the specified time period shall not preclude the Corps from finalizing and implementing the draft EP. The Corps shall ensure that the SHPO is expeditiously provided with copies of the final EP.

J. The Corps and the SHPO may develop standard protection plans (SPP) for classes of resources that occur commonly in the APE and that may be encountered unexpectedly during construction. SPPs shall include a clear description of the class or classes of resources covered and the specific actions that the Corps will take to mitigate or avoid adverse effects to those resources.

K. The Corps shall submit all SPPs for concurrent review to the SHPO and appropriate Native American groups. Submissions shall be delivered in the most expeditious manner possible: by electronic means such as email or fax; or hand delivery. The Corps shall allow reviewers 30 calendar days after receipt to comment on the draft SPP. The Corps shall ensure that any comments received within that time period are taken into account and incorporated into the final SPP. If the Corps cannot concur with comments made by SHPO and/or Native American groups, the Corps will resolve the dispute in accordance with Stipulation XIII. Failure of the SHPO to comment within the specified time period shall not preclude the Corps from finalizing and implementing the draft SPP. The Corps shall ensure that the SHPO is expeditiously provided with copies of the final SPP.

L. The Corps, in consultation with SHPO, shall ensure that determinations of eligibility are made in accordance with the criteria set forth in 36 CFR §60.4 for all properties not covered by an SPP, within the APE, that would be affected by the Project; including additional areas that may be affected by changes in the project design, borrow areas, haul roads, staging areas, extra work space, mitigation sites, and other ancillary areas related to the undertaking. If the Corps and the SHPO cannot agree on the eligibility of a property for the NRHP, the Corps shall obtain a determination from the Keeper of the National Register

in accordance with 36 CFR Part 63. The determination of the Keeper shall be final for purposes of this PA. Any other disputes shall be settled following the procedure set forth under Stipulation XIII

Stipulation IV
Determinations of Effect

The Corps shall apply the Criteria of Adverse Effect pursuant to 36 CFR §800.5(a) (1) to all historic properties within the APE that will be affected by the Project. The Corps shall make determinations of effect in consultation with the SHPO and other interested parties. If the Corps determines that the project will result in no adverse effects to historic properties then the Corps may issue a notice to proceed with construction. If adverse effects are unavoidable, the Corps shall develop a Historic Properties Treatment Plan following the procedure set forth under Stipulations VI and VII.

Stipulation V
Non-Federal Stakeholder Involvement

A. The Corps will identify potentially interested Native American groups in consultation with the Native American Heritage Commission (NAHC). In consultation with appropriate Indian groups and the NAHC, the Corps will identify historic properties of traditional religious and cultural importance.

B. Following the guidance provided in National Register Bulletin 38, the Corps shall seek comments from all potentially interested Native American groups when making determinations of eligibility for any Traditional Cultural Properties.

C. The Corps has consulted with the Sutter Butte Flood Control Agency and the Central Valley Flood Protection Board in the development of this agreement. Both agencies are concurring parties and will be given the opportunity to comment on the identification and treatment of historic properties.

D. The Corps shall give members of the public an opportunity to comment on the identification and treatment of historic properties.

E. The Corps shall allow all reviewers 15 calendar days after receipt to provide comments to the Corps. The Corps shall ensure that any comments received during this time period are taken into account and incorporated into the final survey and evaluation reports. Disputes shall be resolved by the Corps in accordance with Stipulation XIII.

F. Pursuant to Section 36 CFR § 800.6(c)(2-3) of the ACHP's regulations, the Corps shall consider requests by consulting parties and others to become concurring parties to this Programmatic Agreement.

Stipulation VI
Preparation of Historic Property Treatment Plans

The Corps, in consultation with SHPO shall ensure that a Historical Property Treatment Plan (HPTP) is developed for the mitigation of anticipated effects on historic properties that will result from the Project. Further, the Corps, in consultation with SHPO, will ensure the development of location and property specific Data Recovery Plans.

A. Avoidance of adverse effects on historic properties is the preferred treatment approach. The

HPTP shall discuss and justify the chosen approaches to the treatment of project historic properties and those treatment options considered, but rejected. If preservation of part or all of any historic properties is proposed, the treatment plan shall include discussion of the following:

1. Description of the area or portions of the historic properties to be preserved in-place, and an explanation of why those areas or portions of sites were chosen;
2. Explanation of how the historic properties will be preserved in-place, including both legal and physical mechanism for such preservation;
3. A plan for monitoring and assessing the effectiveness of mechanisms to preserve the historic properties; and
4. A plan for minimizing or mitigating future adverse effects on the historic properties if preservation in-place mechanisms prove to be ineffective.

B. When avoidance is not feasible, the Corps, in consultation with the SHPO, shall ensure the development of an appropriate treatment plan designed to lessen or mitigate project-related effects to historic properties. For properties eligible under criteria described in 36 CFR §60.4(a) through (c), the Corps may consider mitigation other than data recovery in the treatment plan (e.g., HABS/HAER recordation, oral history, historic markers, exhibits, interpretive brochures or publications, etc.). Where appropriate, the Corps shall include provision in the treatment plans (content and number of copies) for a publication for the general public.

C. When data recovery is proposed, the Corps in consultation with the SHPO, shall ensure the development of a data recovery plan that is consistent with the Secretary of the Interior's Standards and Guidelines for Archeology and Historic Preservation and the ACHP's "Recommended Approach for Consultation on Recovery of Significant Information from Archaeological Sites" (ACHP June 17, 1999). Components to be included in research designs and data recovery plans are found in Appendicies 2 and 3 to this PA.

D. Each phase or segment specific treatment plan shall relate directly to the HPTP prepared for the project, providing specific direction for the conduct of data recovery within any project segment. Appendix 3 lists components to be included in data recovery plans.

E. The Corps shall invite the interested public, including Native American groups to provide input on the identification, evaluation, and proposed treatment of historic properties. The Corps shall involve the interested public through letters of notification, public meetings, and/or site visits as the Corps deems appropriate.

Stipulation VII
Review of Treatment Plan

The Corps shall ensure that draft HPTPs are submitted concurrently to the SHPO, the ACHP, and appropriate Native American groups and individuals for review and comment. The Corps shall allows reviewers 30 calendar days after receipt of the draft HPTP to provide comments to the Corps. The Corps shall ensure that any comments received during this time period are taken into account and incorporated into the final HPTP. In the event that disputes are not easily remedied, the Corps shall resolve them in accordance with Stipulation XIII. Failure to comment within this time period shall not preclude the Corps from finalizing and implementing the HPTP. The Corps shall ensure that all reviewers are expeditiously provided copies of the final HPTP.

A. If the Corps revises the HPTP, it shall allow any party, including the SHPO, 15 calendar days to review the revised HPTP. Failure of the SHPO to comment within the specified time period shall not preclude the Corps from finalizing and implementing the revised HPTP in accordance with the terms of this stipulation.

B. Once the reviewing parties determine that the HPTP is adequate, the Corps shall issue authorization to proceed with the implementation of the plans.

C. The Corps shall provide final drafts of the HPTP to SHPO and the ACHP.

Stipulation VIII
Modifications of Project Scope

A. Identification and Evaluation

1. If modification of the project scope becomes necessary or if activities are proposed in ancillary areas (AAs) such as borrow or disposal areas that have not been previously surveyed for historic properties, the Corps shall ensure that the APE, defined as described under Stipulation II (B), of the modified project or un-surveyed AA is inventoried. Any properties located within those modified APEs that may be affected by the undertaking shall be evaluated.

2. The Corps shall identify and evaluate such properties in the manner specified in Stipulations II through IV.

3. If the Corps discovers any historic properties eligible for listing on the NRHP in the modified APE, the Corps shall develop and implement a supplemental HPTP in the manner specified in Stipulations VI and VII.

B. The Corps may authorize construction in any area subject to the provisions of this stipulation after the Corps and the SHPO have consulted and agreed in writing that such construction either will not affect historic properties, or that the area does not contain historic properties.

Stipulation IX
Notices To Proceed With Construction

A Notices to Proceed (NTP) may be issued by the Corps for individual construction segments, defined by the Corps in its construction specifications, under any of the following conditions:

1. the Corps and SHPO have determined that there are no historic properties within the APE for a particular construction segment; or

2. the Corps and SHPO have determined that there will be no adverse effects caused to historic properties within the APE for a particular construction segment; or

3. the Corps after consultation with the SHPO and interested persons has implemented an adequate treatment plan for the construction segment, and

(a) the fieldwork phase of the treatment option has been completed; and

(b) The Corps has accepted and approved a summary of the fieldwork performed and a reporting schedule for that work.

Stipulation X
Unanticipated Discovery of Historic Properties

If historic properties potentially eligible for the NRHP are discovered during construction, the Corps shall cease ground disturbing activities until it has satisfied the provisions of 36 CFR §800.13(b), "discoveries without prior planning". The Corps shall provide the SHPO and the ACHP an opportunity to review and comment on proposed treatment in accordance with Stipulation VII. The Corps shall contact the SHPO within 48 hours of the discovery. The SHPO has 48 hours to respond following initial contact by the Corps.

Stipulation XI
Curation

The Corps shall ensure that all cultural materials and associated records resulting from identification, evaluation, and treatment efforts conducted under this PA are curated in accordance with 36 CFR Part 79, except as specified in Stipulation XII. Archaeological items and materials from privately owned lands to be returned to their owners should be maintained in accordance with 36 CFR Part 79 until any specified analyses are complete.

Stipulation XII
Native American Consultation and Treatment of Human Remains

A. The Corps shall ensure that the Indian groups identified above are invited to participate in the development and implementation of the terms of this PA. The specific manner in which this Native American involvement will occur shall be set forth in the HPTPs.

B. The Corps shall ensure that Native American human remains, grave goods, items of cultural patrimony, and sacred objects encountered during the undertaking that are located on state or private land are treated in accordance with the requirements California State Health and Safety Code, Section 7050.5, NRS 383.

C. The Corps shall ensure that Native American human remains, grave goods, items of cultural patrimony, and sacred objects encountered during the undertaking that are located on federal or tribal land are treated in accordance with the requirements of the requirements California State Health and Safety Code, Section 7050.5, NRS 383, and the Native American Graves Protection and Repatriation Act of 1990, as amended.

Stipulation XIII
Dispute Resolution

A. Should any signatory to this PA object within 15 calendar days to plans provided for review pursuant to this PA or to actions proposed or carried out pursuant to this PA, not including determinations of NRHP eligibility (see Stipulation III [J]), the Corps shall notify the SHPO and consult to resolve the objection. If the Corps determines that the objection cannot be resolved, the Corps shall forward all documentation relevant to the dispute to the ACHP. Within 45 days after receipt of all pertinent documentation, the ACHP shall either:

1. Provide the Corps with recommendations that the Corps shall take into account in reaching the final decision regarding the dispute; or

2. Notify the Corps that it will comment pursuant to 36 CFR §800.7, and proceed to comment. Any ACHP comment provided in response to such a request shall be taken into account by the Corps in accordance with 36 CFR §800.7 with reference to the subject of the dispute.

B. Any recommendation or comment provided by the ACHP will be understood to pertain only to the subject of the dispute. The Corps's responsibility to carry out all actions required by this PA that are not subject of the dispute shall remain unchanged.

Stipulation XIV
Amendments, Noncompliance, and Termination

A. If any signatory believes that the terms of this PA cannot be carried out or are not being met, or that an amendment to its terms should be made, that signatory shall immediately consult with the other signatories to consider and develop amendments to this PA pursuant to 36 CFR §800.6(c)(7)

B If this PA is not amended as provided for in this stipulation, the Corps, or the SHPO may terminate it. The party terminating the PA shall in writing provide all other signatories with an explanation of the reasons for termination in accordance with §800.6(c)(8).

C. If this PA is terminated and the Corps determines that the undertaking authorizing the project will proceed, the Corps shall comply with 36 CFR §800.3-800.6.

Stipulation XV
Duration of the PA

A. Five years after the execution of the PA, the signatories shall meet to discuss project progress and efficacy of the PA. Signatories will have the option to implement modifications or revisions to the PA at this point.

B. If the project has not been implemented within ten (10) years of the date of execution of the PA and the PA has not been terminated, the signatories shall consult on a date not less than 90 days prior to the tenth anniversary of the execution of this PA to reconsider its terms. Reconsideration may include continuation of the PA as originally executed, amendment, or termination. If the PA is terminated because the undertaking no longer meets the definition of an "undertaking" set forth in 36 CFR §800.16(y), Stipulation XIV (C) shall apply.

C. This PA shall be in effect through the Corps's implementation of the undertaking, and shall terminate and have no further force or effect when the Corps, in consultation with the SHPO, determines that the terms of this PA have been fulfilled in a satisfactory manner and/or Corps involvement in the project has ended. The Corps shall provide the other signatories with written notice of its determination and of termination of this PA.

Stipulation XVI
Effective Date

This PA shall take effect on the date that it has been fully executed by the Corps and the SHPO.

EXECUTION of this PA by the Corps, the SHPO, and the ACHP, and its transmittal to the ACHP, and subsequent implementation of its terms evidence that the Corps has afforded the ACHP an opportunity to comment on the undertaking and its effects on historic properties, that the Corps shall take into account the effects of the undertaking on historic properties, and that the Corps has satisfied its responsibilities under Section 106 of the National Historic Preservation Act and applicable implementing regulations for all aspects of the undertaking.

SIGNATORIES:

U.S. ARMY CORPS OF ENGINEERS, SACRAMENTO DISTRICT

BY: _____ DATE: 30 APRIL 2012

William J. Leady, P.E., Colonel, U.S. Army Corps of Engineers, District Commander

CALIFORNIA STATE HISTORIC PRESERVATION OFFICE

BY: _____ DATE: 6/8/12

for Milford Wayne Donaldson, FAIA, State Historic Preservation Officer

CONCURRING PARTIES:

SUTTER BUTTE FLOOD CONTROL AGENCY

BY: _____ DATE: _____

TITLE:

STATE OF CALIFORNIA DEPARTMENT OF WATER RESOURCES, ACTING BY AND THROUGH THE CENTRAL VALLEY FLOOD PROTECTION BOARD

BY: _____ DATE: _____

TITLE:

MECHOOPDA INDIAN TRIBE OF CHICO RANCHERIA

BY: _____ DATE: _____

TITLE:

UNITED AUBURN INDIAN COMMUNITY OF THE AUBURN RANCHERIA

BY: _____ DATE: _____

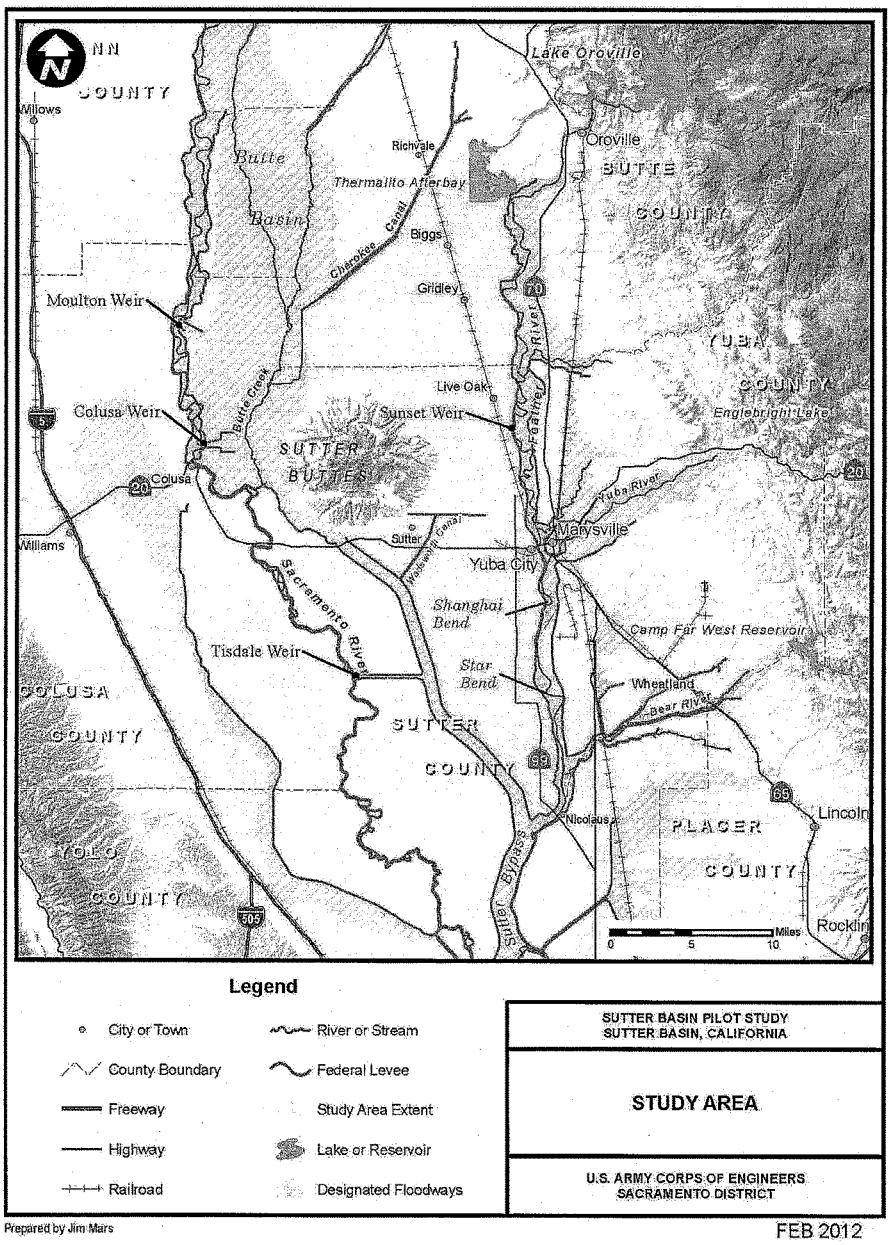
TITLE:

ESTOM YUMEKA MAIDU TRIBE OF ENTERPRISE RANCHERIA

BY: _____ DATE: _____

TITLE:

Appendix 1
Study Area Map



Appendix 2
Standards and Guidelines for Research Designs

Research designs prepared for this undertaking shall specify, at a minimum:

- The property, or properties, or portions of properties where data recovery is to be carried out;
- Any property, or properties or portions of properties that will be destroyed with data recovery;
- The research questions to be addressed through the data recovery, with an explanation of their relevance and importance;
- The methods to be used, with an explanation of their relevance to the research questions;
- The methods to be used in analysis, data management, and dissemination of data, including a schedule;
- The proposed disposition of recovered materials and records;
- Proposed methods by which the parties to the Programmatic Agreement will be kept informed of the work and afforded the opportunity to participate; and
- A proposed schedule for the submission of progress reports to the California State Historic Preservation Officer.

Appendix 3
Historic Property Treatment Plans (HPTP) shall address:

- The historic properties or portions of historic properties where treatment will be implemented;
- Any historic properties or portions of historic properties that will be destroyed or altered without treatment;
- If the property or properties are eligible under criteria (a), (b), or (c), a mitigation plan other than data recovery may be considered. These may include, but are not limited to HABS/HAER recordation, oral history, historic markers, exhibits, interpretive brochures or publications.
- If the property or properties are eligible under criterion (d), a research design including the research questions and goals that the data recovery on a property could inform, an explanation of the theoretical and substantive relevance and importance of the proposed research, and specifically how the proposed actions will inform those questions and goals;
- The field and analysis methods to be used, with an explanation of their relevance to the goals of the mitigation;
- The methods to be used in data management and dissemination of data, including a schedule;
- The proposed disposition of recovered materials and records;
- Proposed methods for disseminating results of work to cultural resources professionals and separately to the interested public;

- Proposed methods by which appropriate Native American groups and individuals, local governments, and other interested persons will be kept informed about implementation of the HPTP and afforded an opportunity to comment;

- A proposed schedule for submission of progress reports to the Corps, SHPO, and the Council;

- Methods and procedures for the recovery, analysis, treatment, and disposition of human remains, associated grave goods, and objects of cultural patrimony that reflect any concerns and/or conditions identified as a result of consultations between the Corps and any affected Native American Group (see Stipulation XII);

- Qualifications of consultants employed to undertake the implementation of the STP, meeting at minimum those standards described in Stipulation I.

Avoidance of adverse effects on historic properties is the preferred treatment approach. The HPTP will discuss and justify the chosen approaches to the treatment of project historic properties and those treatment options considered, but rejected. If preservation of part or all of any historic properties is proposed, the treatment plan will include discussion of the following:

1. Description of the area or portions of the historic properties to be preserved in-place, and an explanation of why those areas or portions of sites were chosen;
2. Explanation of how the historic properties will be preserved in-place, including both legal and physical mechanism for such preservation;
3. A plan for monitoring and assessing the effectiveness of mechanisms to preserve the historic properties; and
4. A plan for minimizing or mitigating future adverse effects on the historic properties if preservation in-place mechanisms prove to be ineffective.

Section 404(b) (1) Clean Water Act Compliance Evaluation
Sutter Basin Feasibility Study

I. Introduction

This appendix evaluates compliance of the recommended plan, Alternative SB-8, with the Guidelines established under the Federal Pollution Control Act (Clean Water Act) Amendments of 1972 (Public Law 92-500), as amended by the Clean Water Act of 1977 (Public Law 95-217), legislation collectively referred to as the Clean Water Act.
The Clean Water Act sets national goals and policies to eliminate the discharge of water pollutants into navigable waters. Any discharge of dredged or fill material into waters of the U.S. by the Corps requires a written evaluation that demonstrates that a proposed action complies with the guidelines published at 40 CFR Part 230. These guidelines, referred to as the Section 404(b) (1) Guidelines or "Guidelines," are the substantive criteria used in evaluating discharges of dredged or fill material under Section 404 of the Clean Water Act.

Fundamental to the Guidelines is the precept that "dredged or fill material should not be discharged into the aquatic ecosystem, unless it can be demonstrated such a discharge will not have an unacceptable adverse impact either individually or in combination with known and/or probable impacts of other activities affecting the ecosystems of concern."

The procedures for documenting compliance with the Guidelines include the following:

- Examining practicable alternatives to the proposed discharge that might have fewer adverse environmental impacts, including not discharging into a water of the U.S. or discharging into an alternative aquatic site
- Evaluating the potential short- and long-term effects, including cumulative effects, of a proposed discharge of dredged or fill material on the physical, chemical, and biological components of the aquatic environment.
- Identifying appropriate and practicable measures to mitigate the unavoidable adverse environmental impacts of the proposed discharge
- Making and documenting the Findings of Compliance required by §230.12 of the Guidelines.

This Clean Water Act, Section 404(b)(1) evaluation of compliance with the Guidelines is not intended to be a "stand alone" document; it relies heavily on information provided in the integrated feasibility and EIS/EIR to which it is attached.

II. Project Description

A. Project Purpose

The purpose of the proposed project is to reduce flood risk to a study area defined as the 300 square mile Sutter Basin located in Northern California in Sutter and Butte Counties within the 14,000 sq. mile Sacramento River Watershed. The Sutter Basin is located in north-central California in Sutter and Butte Counties. The elongated, irregularly shaped basin covers

about 326 square miles and is about 44 miles long north to south and up to 14 miles wide east to west. It is roughly bounded by the Feather River (to the east), Cherokee Canal, the Sutter Buttes, and Sutter Bypass (to the west, listed from north to south). Floodwaters potentially threatening the basin originate from the Feather River watershed or the upper Sacramento River watershed, above Colusa Weir. These waterways have drainage areas of 5,921 and 12,090 square miles, respectively. In addition to Yuba City, communities in the basin include Biggs, Gridley, Live Oak, and Sutter.

The project area is meant to provide spatial boundaries for evaluation of resources that may be more directly impacted by the Sutter Basin Feasibility Study (SBFS), and is therefore a smaller area, more immediate to the proposed project features. Specifically, the project area is defined as the footprint of where potential project actions would occur. This project area takes into consideration areas of potential direct impact as well as areas potentially affected by immediate indirect or secondary impacts. The study area encompasses a much larger area that provides spatial boundaries for resources that could potentially be indirectly impacted by the SBFS.

B. Location

The proposed levee improvement areas are located along the west levee of the Feather River from Thermalito Afterbay on the north to approximately 4 miles north of the Sutter Bypass on the south. The direct effects of the project are located in a corridor roughly 500 feet toward the land side of the existing levees and 100 feet toward the water side. This corridor was determined as the area in which levee improvements, such as seepage berms, stability berms, relief wells, setback levees, erosion protection, and slurry cutoff walls, are likely to occur. The corridor is approximately 41 miles long, divided into 41 relatively homogeneous reaches for ease of describing the affected environment, and potential environmental effects (note that this number is coincidental and one reach does not consistently correspond to a length of 1 mile. The project area would also include borrow/spoil sites or project mitigation sites outside of this corridor. Plate 1-1 from the integrated main report shows the overall Sutter Basin Feasibility Study project area (Refer to page 21). The project reaches are listed in Table 1-1, below.

Table 1-1 Contract and Corresponding Reach*

Contract	**A**	***Star Bend**	**B**	**C1**	**C2**	**D1**	**D2**
Corresponding Reach	2-5	6	7-12	13-18	19-25	26-33	34-41
Proposed Year of Construction	2018-2019	2018-2019	2017-2018	2013-2014	2014-2015	2015-2016	2016-2017

*Construction contract timing determined by risk to population centers.

C. General Description

An initial array of 10 alternatives (including the No-Action Alternative) was developed by USACE and the local sponsors (SBFCA and the State DWR) during the alternatives

formulation process. The alternatives represented varying combinations of measures.

Alternatives were initially developed based on the USACE' federal planning objectives for water resource projects, specific planning objectives developed for the feasibility study, and opportunities and constraints for implementing flood risk management activities. After formulation and refinement of the project alternatives, alternatives were ranked and screened based on FRM benefits and implementation costs. Chapter 3 of the integrated report addresses in greater detail the alternative formulation process.

The SBFS plan formulation process resulted in two action alternatives in the final array:

- Alternative SB-7 (National Economic Development Plan): Fix in Place Feather River, Sunset Weir to Laurel Avenue. This alternative focuses on levee improvements to reduce flood risk to Yuba City. SB-7 includes contracts A, Star Bend, B, C1, and C2.

- Alternative SB-8 (Recommended plan). This alternative includes SB-7 but extends Feather River fix-in-place levee improvements all the way north to Thermalito as shown in the figure below. This alternative addresses flood risk to Yuba City but also reduces risk to the smaller communities north of Yuba City. SB-8 includes contracts A, Star Bend, B, C1, C2, D1, and D2.

D. Background

Although the flood control structures have been extensively improved and upgraded since construction, the underlying foundation of most of the levees and channels pre-dates any state or USACE involvement and still retains the original materials that include dredged riverbed sands, soil, and organic matter. At the time of the Sacramento River Flood Control Project (SRFCP) authorization in 1917, the areas being protected by the levees were primarily agricultural with minimal improved infrastructure such as railroads and highways. Today, the area remains largely agricultural with population centers including Yuba City, Biggs, Gridley, Live Oak, and Sutter.

Over that past two decades, several studies have been conducted by USACE, DWR, or SBFCA to evaluate the condition of the levees protecting the planning area relative to criteria for stability, seepage, erosion, geometry, and levee height. These studies have indicated that the levee system is deficient and that the consequences of levee failure from a major flood event would be significant.

E. Authority and Purpose

The Corps ensure that the project complies with the CWA, including Sections 404, 401, and 402. Placement of fill within jurisdictional wetlands and waters of the United States is required for the project. A Section 401 State Water Quality Certification for activities associated with implementation of the proposed project is required as a condition of Section 404, and the sponsor will submit a 401 certification application to the RWQCB for each

contract. The project would also require an NPDES permit, through the development of a SWPPP because the project would disturb more than 1 acre of ground.

The primary purpose of the study is to reduce flood risk for the entire planning area by addressing known levee deficiencies along the Feather River West Levee from Thermalito Afterbay downstream to approximately 4 miles upstream of the confluence with the Sutter Bypass. The Corps project goal is to achieve a minimum of 200-year flood protection for the more urbanized areas with population centers and 100-year flood protection for the remaining more rural agricultural parts of the planning area. A 200-year flood is a flood that has a 0.5% chance of occurring in any given year, also referred to as a 0.5% annual exceedance probability (AEP). A 100-year flood has a 1% AEP.

III. Final Array of Alternatives

A. Guidelines

Section 230.10 of the Guidelines dictates that, except as provided under §404(b)(2), "no discharge of dredged or fill material shall be permitted if there is a practicable alternative to the proposed discharge which would have less adverse impact on the aquatic ecosystem, so long as the alternative does not have significant adverse environmental considerations." While the NEPA process, through the EIS, extensively examines alternatives and discloses all of their environmental impacts, the 404(b) (1) Evaluation focuses on the impacts of alternatives to the aquatic ecosystem. The Guidelines require choosing for implementation the practicable alternative that has the least damage to the aquatic ecosystem, assuming that this alternative has no significant adverse environmental impacts to other components of the environment, such as endangered species that occupy upland habitat. A "practicable alternative" is defined as "available and capable of being done after taking into consideration cost, existing technology, and logistics in light of overall project purposes."

The Guidelines also require that "where the activity associated with a discharge which is proposed for a special aquatic site does not require access or proximity to or siting within the special aquatic site in question to fulfill its basic purpose (i.e., is not "water dependent"), practicable alternatives that do not involve special aquatic sites are presumed to be available, unless clearly demonstrated otherwise." The basic purpose of this project—to reduce flood risk to the Sutter basin study area—is water dependent, since the project purpose cannot be fulfilled outside the river.

B. Practical Alternative

The Guidelines further specify that where a discharge is proposed for a special aquatic site, all practicable alternatives to the proposed discharge that do not involve a discharge into a special aquatic site are presumed to have less adverse impact on the aquatic ecosystem, unless otherwise clearly demonstrated. The utility and canal relocation improvements occurring at Reaches 22, 23, 24, 28-29, and 43 are the only special aquatic site type in the project area. Section III, parts E and F describe the proposed activities for each reach.

For the purpose of a 404(b) (1) alternatives analysis, practicable alternatives include:

- Offsite alternatives—i.e., discharges of dredged or fill material at other locations in waters of the United States.
- On-site alternatives—these include project designs that do not involve a discharge of dredged or fill material into waters of the United States as well as project designs that have different impacts to waters of the U.S.

C. Off-Site Alternatives

The locations of this project were selected based upon the need for increased flood risk management and levee safety. Off-site alternatives therefore are not practicable at this time.

D. On-Site Alternatives

The two construction alternatives analyzed in detail through the NEPA process would each accomplish the identified project purpose. However, they would accomplish the project purpose to varying extents, with varying levels of benefits and varying adverse impacts to the aquatic ecosystem.

The following is a summary of project elements for each alternative. In general, Alternative SB-8 entails the greatest amount of levee improvement work and SB-7 the least amount. These alternatives are described in greater detail in Chapter 3 of the integrated report and EIS/EIR.

Alternative SB-8 includes 41 reaches (2 north to 41) along the FRWL alignment, beginning at station 180+00 (approximately 2,000 feet south of Laurel Avenue) and ending at station 2368+00 (Thermalito Afterbay). The proposed project features and measures for this alternative include:

- Soil-Bentonite Cutoff Walls
- Deep Soil Mix Cutoff Walls
- Jet Grouting Cutoff Walls
- Seepage Berms
- Levee Relocations
- Canal Relocations
- Embankment Reconstruction/Landside Toe Fill
- Erosion Protections
- Closure Structure
- Utility Improvements
- Utility Relocations
- Structural Relocations

These proposed features and measures will rehabilitate, replace, or tie in and function in junction with the existing system. The existing system includes the following features:

- Existing Embankment

- Existing Cutoff Walls
- Existing Stability Berms
- Existing Relief Wells
- Existing Closure Structures
- Existing Toe Drains

Alternative SB7 includes 21 reaches (2 north to 21) along the FRWL alignment, beginning at station 180+00 (approximately 2,000 feet south of Laurel Avenue) and ending at station 1433+83 (Thermalito Afterbay). The proposed project features and measures for this alternative include:

- Soil-Bentonite Cutoff Walls
- Deep Soil Mix Cutoff Walls
- Jet Grouting Cutoff Walls
- Seepage Berms
- Levee Relocations
- Canal Relocations
- Embankment Reconstruction/Landside Toe Fill
- Erosion Protections
- Closure Structure
- Utility Improvements
- Utility Relocations
- Structural Relocations

These proposed features and measures will rehabilitate, replace, or tie in and function in junction with the existing system. The existing system (see chapter 3) includes the following features:

- Existing Embankment
- Existing Cutoff Walls
- Existing Stability Berms
- Existing Relief Wells
- Existing Closure Structures
- Existing Toe Drains

E. General Description and Quantity of Dredged or Fill Material

Table 1-2. provides a general description of the quantity and fill materials for each site within the project. Permanent and temporary impacts are a result of Sacramento District Corps Regulatory analysis.

Table 1-2

Feature/Station Point	Fill Volume (cubic yards)	Permanent Impacts (acres)	Temporary Impacts (acres)
Contract A			
Reach 2 210+00 Irrigation Ditch Fill	109	0.066	.05
Reach 3 210+60 to 231+50 Irrigation Ditch Fill	1573	.32	
Reach 3 281+00 to 288+25 Irrigation Ditch Fill	1940	.40	
Reach 5 410+00 Irrigation Pond/Open Water Fill	122	.038	
Reach 5 410+00 Seasonal Wetland	62	.026	
Total Contract A	***3806***	***.85***	***0.05***

Feature/Station Point	Fill Volume (cubic yards)	Permanent Impacts (acres)	Temporary Impacts (acres)
Contract B			
Reach 7 513+00 to 543+50+00 Irrigation Ditch Fill	833	.385	
Reach 9 689+00 Irrigation ditch head works	39	.001	
Total Contract B	***872***	***.386***	***0***

Feature/Station Point	Fill Volume (cubic yards)	Permanent Impacts (acres)	Temporary Impacts (acres)
Contract C1			
Reach 16 1043+50 Drainage outfall Armoring	21	.006	.008
Total Contract C1	***21***	***.006***	***.008***
Contract C2			
Reach 20 1315+00 Riparian Forest Wetland – Inlet Reset	39	.002	
Reach 20 1315+00 Canal Ditch Fill	39	.001	
Reach 20 1346+50 Forested Wetlands	100	.002	
Reach 22 1429+00 to 1433+83 Sutter Butte Canal relocation	7500	0.9	0.9
Reach 24 1611+00 placement of a new concrete slab within the existing Sutter Butte Canal	13	.016	.033
Total Contract C2	***7691***	***.921***	***.933***

Feature/Station Point	Fill Volume (cubic yards)	Permanent Impacts (acres)	Temporary Impacts (acres)
Contract D1			
Reach 26 1675+00 Riparian Forest	75	.003	
Reach 28 to 29 1752+00 to 1766+00 Sutter Butte Canal relocation	5,185	2.0	2.0
Feature/Station Point	**Fill Volume (cubic yards)**	**Permanent Impacts (acres)**	**Temporary Impacts (acres)**
Reach 28 1766+00 Sutter Butte Canal Recharge Infill Headworks	66	.113	
Total Contract D1	5326	2.11	2

Contract D2			
Reach 34 2160+00 Tailing Area			0.005
Reach 35 2186+00 Tailing Area			0.011
Reach 35 2200+00 Tailing Area			0.002
Reach 35 2210+50 to 2220+00 Tailing Area			0.003
Reach 36 2229+00 to 2230+50 Tailing Area	450	.18	
Reach 40 2322+50 to 2330+50 Tailing Area	890	.55	
Reach 40 2334+00 Tailing Area	152	.063	
Reach 40 2348+00 Tailing Area	190	.118	
Reach 43 2359+00 to 2360+00 Old Sutter Butte Main Canal Head works	15,000	.6	0.1
Total Contract D	***16682***	***1.51***	***1.07***
Totals	***34,398***	***5.78***	***3.07***
Feature/Station Point	**Fill Volume Cubic Yards**	**Permanent Impacts Acres**	**Temporary Impacts Acres**
SB-7	***8,571***	***1.25***	***.058***
SB-8	***34,398***	***5.78***	***3.07***

F. Description of the Proposed Discharge Site(s)

Contract A Discharge into Waters of the U.S – Feature Description.

Reach 2 (210+00): An existing earthen agricultural irrigation ditch on the landside would be filled to accommodate the new levee prism. Approximately 109 cubic yards of material are required to permanently fill 480 lineal feet of ditch.

Reach 3 (210+60 to 231+50) Irrigation Ditch Fill: An existing concrete lined irrigation ditch on the landside would be filled to accommodate the new levee prism. Approximately 1573 cubic yards of material are required to permanently fill 1430 lineal feet of ditch.

Reach 3 (281+00 to 288+25) Irrigation Ditch Fill: An existing concrete lined irrigation ditch on the landside would be filled to accommodate the new levee prism. Approximately 122 cubic yards of material are required to permanently fill 1750 lineal feet of ditch.

Reach 5 (410+00) Irrigation Pond/Open Water Fill: An existing concrete lined irrigation pond on the landside would be filled to accommodate the new levee prism. Approximately 62 cubic yards of material are required to permanently fill 1130 square feet of seasonal wetland.

Contract B Discharge into Waters of the U.S – Feature Description.

Reach 7 (513+00 to 543+50+00) Irrigation Ditch Fill: An existing earthen irrigation ditch on the landside would be filled to accommodate the new levee prism. Approximately 833 cubic yards of material are required to permanently fill 3050 lineal feet of ditch.

Reach 9 (689+00) Irrigation Ditch Head Works: An existing earthen irrigation ditch head works on the landside would be filled to accommodate the new levee prism. Approximately 39 cubic yards of material are required to permanently fill 550 square feet of existing ditch. A new pipe section would be reconfigured to accommodate the new fill area.

Contract C1 Discharge into Waters of the U.S – Feature Description.

Reach 16 (1043+50) Drainage Outfall Armoring: An existing drainage outfall on the waterside would be filled to accommodate the new levee prism. Approximately 21 cubic yards of material are required to permanently fill 700 square feet of existing outfall area. New pipe sections would be reconfigured to accommodate the new fill area.

Contract C2 Discharge into Waters of the U.S – Feature Description.

Reach 20 (1315+00) Irrigation Ditch Head Works: An existing earthen irrigation ditch head works on the landside would be filled to accommodate the new levee prism. Approximately 39 cubic yards of material are required to permanently fill 550 square feet of existing ditch. A new pipe section would be reconfigured to accommodate the new fill area.

Reach 20 (1315+00) Riparian Forest Wetland – Inlet Reset: An existing earthen irrigation ditch head works on the waterside would be filled to accommodate the new levee prism. Approximately 39 cubic yards of material are required to permanently fill 550 square feet of existing ditch. A new pipe section would be reconfigured to accommodate the new fill area.

Reach 20 (1346+50): Forested wetlands on the waterside would be filled to accommodate the new levee prism. Approximately 100 cubic yards of material are required to permanently fill 2800 square feet of existing forested wetlands.

Reach 22 (1429+00 to 1433+83) Sutter Butte Canal Relocation: The new permanent canal alignment requires an offset 81 feet west of the center line of the existing canal. New canal dimensions are the same as existing - 45' across from top of bank to top of bank and 25'

bottom channel width. The total new channel realignment length is 800 feet. Canal relocation is necessary to obtain a required landside easement currently where the existing canal channel is located adjacent. Permanent fill requirements total 7500 cubic yards of material.

Reach 24 (1611+00): A utility enhancement requiring the placement of a new rectangular cross-section concrete depth indicator within the existing Sutter Butte Canal (landside) at approximately 1611+00. A 12 cubic yard protective concrete pad overlay at the base of the existing permanent irrigation canal will protect a pipe crossing during sediment removal procedures.

Contract D1 Discharge into Waters of the U.S.

Reach 28-29 (1721+60 to1754+50) Sutter Butte Canal Relocation The new permanent canal alignment requires an offset 81 feet west of the center line of the existing canal. New canal dimensions are the same as existing - 45' across from top of bank to top of bank and 25' bottom channel width. The total new channel realignment length is 1600 feet. Canal relocation is necessary to obtain a required landside easement currently where the existing canal channel is located adjacent. Permanent fill requirements total 15000 cubic yards of material.

Reach 28 (1766+00) Sutter Butte Canal Recharge Infill Headworks: Conveyance pipes through the existing levee at the head works on the landside would be filled to accommodate the new levee prism. Approximately 66 cubic yards of material are required to permanently fill 1350 square feet of existing earthen ditch. New pipe sections would be reconfigured to accommodate the new fill area.

Reach 34 (2160+00) Tailing Area: Temporary fill of wetland tailing area resulting from levee degradation.

Reach 35 (2186+00) Tailing Area: Temporary fill of wetland tailing area resulting from levee degradation.

Reach 35 (2200+00) Tailing Area: Temporary fill of wetland tailing area resulting from levee degradation.

Contract D2 Discharge into Waters of the U.S.

Reach 35 (2210+50 to 2220+00) Tailing Area: Temporary fill of wetland tailing area resulting from levee degradation.

Reach 36 (2229+00 to 2230+50) Tailing Area: Permanent fill of existing waterside tailing wetland area to accommodate the new levee prism. Approximately 450 cubic yards of material are required to permanently fill 7800 square feet of area.

Reach 40 (2322+50+00 to 2330+50) Tailing Area: Permanent fill of existing landside tailing wetland area to accommodate the new levee prism and maintenance road. Approximately 890 cubic yards of material are required to permanently fill 16,000 square feet of area.

Reach 40 2334+00) Tailing Area: Permanent fill of existing landside tailing wetland area to accommodate the new levee prism and maintenance road. Approximately 152 cubic yards of material are required to permanently fill 4100 square feet of area.

Reach 40 (2348+00) Tailing Area: Permanent fill of existing landside tailing wetland area to accommodate the new levee prism and maintenance road. Approximately 190 cubic yards of material are required to permanently fill 5100 square feet of area.

Reach 43 (2359+00 to 2360+00): The Old Sutter Butte Main Canal Headworks will be permanently filled to create a contiguous levee structure. The existing vehicular bridge will be removed and replaced with 15,000 cubic yards of levee earthen fill and slurry wall materials.

G. Timing and Duration of Discharge

The construction activities that would affect the waters of the U.S. would be conducted over six years, beginning in late July 2013 and continuing into September of 2019. Canal relocations and improvements would occur in February and March when the canal is dry. Drainage ditch and levee improvements would be conducted during the spring and summer months.

H. Description of Disposal Method

Placement of fill materials includes the use of excavators and loaders. Construction equipment would not operate within the river channel.

IV. Factual Determinations (Section 230.11)

A. Physical Substrate Determinations (consider items in Section 230.11 and 230.20 Substrate)

(1) Substrate Elevation and Slope. SB-8 project elevations vary from 130 feet above sea level to 25 feet above sea level with an average channel slope 2.5 feet per mile SB-7 project elevations vary from 80 feet above sea level to 25 feet above sea level with an average channel slope 2.5 feet per mile.

(2) Sediment Type. Soils and sediment type for both Alternatives SB-8 and SB-7 are composed of river deposits which include silts, sands, gravel, and bedrock.

(3) Dredged/ Fill Material Movement:

a) Fill: Alternatives SB-8 and SB-7 require permanent filling of irrigation ditches/canals, wetlands, and existing and former canal headworks. Placement of new fill materials would be above the ordinary high water mark would not have any effect on hydraulic movement.

b) Irrigation Ditch and Levee Improvements: SB-7 and SB-8 both include irrigation ditch and levee improvements. Irrigation ditch work requires replacement of drainage pipes which would not affect or aid in erosion or transport of backfill material. Levee improvements stated in this analysis require the placement of materials above the ordinary high water mark. Placement of the new levee structure and fill materials will not have any effect on hydraulic movement.

c) Canal Relocation: Alternatives SB-8 and SB-7 both include canal relocations. Migration of fill material would not be possible since pre and post construction activities required to fill the canal channels are completely isolated from the new and existing canal alignments. Work will be scheduled during months when the canal is dry (February and March).

(4) Physical Effects on Benthos (burial, changes in sediment type, etc.).

a) Fill: Alternatives SB-8 and SB-7 require permanent filling of irrigation ditches/canals, wetlands, and existing and former canal headworks. Placement of new fill materials would be above the ordinary high water mark would not have any effect on benthos.

b) Irrigation Ditch and Levee Improvements: Alternatives SB-8 and SB-7 irrigation ditch and levee improvement work will have no effect on benthos. Work areas are located of the river main channel for both alternatives.

c) Canal Relocation: Alternatives SB-8 and SB-7 canal relocations would not affect benthos since is the relocations occurring within each alternative are located out of the river main channel.

(5) Turbidity

a) Fill: Alternatives SB-8 and SB-7 require permanent filling of irrigation ditches/canals, wetlands, and existing and former canal headworks. Placement of new fill materials would be above the ordinary high water mark and would not affect turbidity.

b) Irrigation Ditch and Levee Improvements: Alternatives SB-8 and SB-7 irrigation ditch and levee improvement work will have no effect on turbidity since construction activities are located out of the river main channel

c) Canal Relocation: The canal relocations located within both Alternative SB-8 and SB-7 will have no effect on turbidity since the relocations

occurring within each alternative are located out of the river main channel and the work would be executed during dry months.

(6) Actions Taken to Minimize Impacts. Best Management Practices (BMP's) will be employed to avoid and minimize run-off, sedimentation, and erosion.

B. Water Circulation, Fluctuation, and Salinity Determinations

(1) Consider effects on (for both Alternatives SB-8 and SB-7):

a) Salinity. Not applicable.
b) Water Chemistry (pH, etc.). No significant effect.
c) Clarity. No significant effect.
d) Color. No significant effect.
e) Odor. No significant effect.
f) Taste. No significant effect.
g) Dissolved Gas Level. No significant effect.
h) Nutrients. No significant effect.
i) Eutrophication. No significant effect.
j) Others as Appropriate. No significant effect.

(2) Current Patterns and Circulation (for both Alternatives SB-8 and SB-7). No significant effect.

(3) Normal Water level Fluctuations (for both Alternatives SB-8 and SB-7): No significant effect.

(4) Salinity Gradients (for both Alternatives SB-8 and SB-7): Not applicable

(5) Actions That Will Be Taken to Minimize Impacts (for both Alternatives SB-8 and SB-7). Since disturbance throughout the project is greater than 1 acre, the contractor would be required to file and adhere to a Storm water Pollution Prevention Plan (SWPPP).

C. Suspended Particulate/ Turbidity Determinations

(1) Expected Changes in Suspended Particulates and Turbidity Levels in Vicinity of Disposal Site (for both Alternatives SB-8 and SB-7). No significant effect.

(2) Effects, Degree, and Duration on Chemical and Physical Properties of the Water Column (for both Alternatives SB-8 and SB-7):

a) Light Penetration. No significant effect.
b) Dissolved Oxygen. No significant effect.
c) Toxic Metals and Organics. No significant effect.
d) Pathogens. Not applicable.
e) Esthetics. Not applicable.

f) Others as Appropriate. No significant adverse effects to the chemical and physical properties of the water column are anticipated.

(3) Effects on Biota (for both Alternatives SB-8 and SB-7):

Primary Production, Photosynthesis. No significant adverse effects to the primary production and photosynthesis processes are anticipated.
(Suspension/ Filter Feeders. No significant adverse effects to suspension and filter feeders are anticipated.
Sight Feeders. No significant adverse effects to sight feeders are anticipated.

(4) Actions Taken to Minimize Impacts (for both Alternatives SB-8 and SB-7). Since disturbance throughout the project is greater than 1 acre, the contractor would be required to file and adhere to a Storm water Pollution Prevention Plan (SWPPP).

D. Contaminant Determinations. The proposed project Alternatives SB-8 and SB-7 would not add contaminants to any nearby body of water. Best management practices to reduce the potential of accidental spills during gravel injection would follow all regulatory requirements in conjunction with the National Pollution Discharge Elimination System permitting process.

E. Aquatic Ecosystem and Organism Determinations

(1) Effects on Plankton. The proposed project Alternatives SB-8 and SB-7 would have no affect on plankton communities.

(2) Effects on Benthos. The proposed project Alternatives SB-8 and SB-7 would have no effect on benthos communities.

(3) Effects on Nekton. The proposed project Alternatives SB-8 and SB-7 would have no effect on nekton communities.

(4) Effects on aquatic Food Web. The proposed project Alternatives SB-8 and SB-7 would have no effect on the aquatic food web, or the plankton, benthic and nekton communities with the proposed project.

(5) Effects on Special Aquatic Sites.

a) Sanctuaries and Refuges. The proposed project Alternatives SB-8 and SB-7 would require work adjacent to the Bobelaine Audubon Sanctuary. Appropriate fencing and BMP's would be utilized to reduce impacts to wildlife resources. Any potential impacts would be temporary and less than significant for both alternatives.
b) Wetlands. Alternatives SB-8 and SB-7 both permanently impact wetlands. SB-8 requires filling 0.033 acres of wetlands. SB-7 requires

filling 0.03 acres of wetlands. Impacts to filled wetlands would be mitigated by purchasing credits at an offsite mitigation bank.

c) Mud Flats. None exist in project area.
d) Vegetated Shallows. None exist in project area.
e) Coral Reefs. None exist in project area.
f) Riffle and Pool Complexes.

(6) Threatened and Endangered Species.

a) Alternatives SB-8 and SB-7 are not likely to result in adverse water quality or noise effects on spring run Chinook salmon, steelhead, and green sturgeon or their critical habitat. Restriction of all work activities to the proposed construction footprints and adherence to all erosion and sediment control BMPs would further minimize the potential for project-related increases in turbidity and suspended sediment in the Feather River. Implementation of a spill prevention, control, and countermeasure plan and bentonite slurry spill contingency plan is anticipated to minimize the potential for toxic or hazardous spills or discharges into the Feather River. Based on the location and duration of pile driving activities and other noise-generating activities, potential noise and vibration impacts on fish are expected to be negligible.

b) Alternatives SB-8 and SB-7 are not likely to result in adverse modification of the PCEs of critical habitat of spring-run Chinook salmon, steelhead, and green sturgeon. There would be no direct physical modification of riparian vegetation or SRA cover within the designated critical habitat of these species below the high water mark. Temporary and permanent losses of riparian vegetation for Alternative SB-8 would be limited to approximately 42.5 acres of riparian forest and scrub-shrub within the permanent and temporary footprints of the project above the OHWM. Approximately 891 trees (mixed native and non-native riparian and orchard trees) would be removed from the waterside levee slope and toe. Temporary and permanent losses of riparian vegetation for Alternative SB-7 would be limited to approximately 24.42 acres of riparian forest and scrub-shrub within the permanent and temporary footprints of the project above the OHWM. Approximately 652 trees (mixed native and non-native riparian and orchard trees) would be removed from the waterside levee slope and toe. The removal of vegetation from these areas may indirectly affect critical habitat through temporal reductions in large wood recruitment, nutrient contributions, and other riparian functions. However, the sponsor proposes to compensate for permanent and temporary losses of woody riparian vegetation through a combination of onsite and offsite compensation. Onsite compensation may include re-vegetation of waterside slopes and floodplain areas within the project footprint or in the project vicinity.

c) The canal relocations within SB-8 and SB-7 may affect but are not likely to adversely affect Giant Garter Snake (GGS) and its' critical habitat. Effects to GGS aquatic habitat are unlikely since canal relocation will occur during dry canal months of February and March. The upland habitat and potential overwintering habitat adjacent to the existing canals will be fenced appropriately to avoid impacts to the GGS during relocation and filling activities. Implementation of FWS conservation measures as cited in the April 2013 Biological Opinion will avoid and minimize impacts to the GGS.

(7) Other Wildlife. The proposed project action would have no significant adverse effect on wildlife because construction is linear and limited to specific areas. The duration of adverse effects is temporary. Any displaced wildlife would be expected to return to the area after the action is completed.

(8) Actions to Minimize Impacts. There would be no significant adverse effects to wildlife due to proposed project action. Therefore, there would be no minimization measures needed.

F. Proposed Disposal Site Determinations

(1) Mixing Zone Determination (for both Alternatives SB-8 and SB-7) Not applicable.

(2) Determination of Compliance with Applicable Water Quality Standards (for both Alternatives SB-8 and SB-7). No water quality or effluent standards would be violated during proposed project action.

(3) Potential Effects on Human Use Characteristics (for both Alternatives SB-8 and SB-7). The proposed project would not have any significant adverse effects to municipal and private water supply, recreational and commercial fisheries, or water-related recreation. Any displacement of recreational activities would be temporary.

G. Determination of Cumulative Effects on the Aquatic Ecosystem

The potential cumulative impacts from implementation of the Preferred Alternative considered with other relevant actions in the general vicinity of the Sutter Feasibility Study, have been assessed and are discussed in Section 4.12 of the EIS. Nearly all potentially significant impacts from Alternatives SB-8 and SB-7 could be reduced to less than significant levels by mitigation measures specified in this EIS. The Alternatives would not have any significant cumulative effects on the aquatic ecosystem. Implementation of the either the recommended plan (SB-8) or the NED (SB-7) Alternatives will provide flood safety protection which benefits adjacent communities.

H. Determination of Secondary Effects on the Aquatic Ecosystem

Secondary effects (or impacts) are "effects on an aquatic ecosystem that are associated with a discharge of dredged or fill materials, but do not result from the actual placement of the dredged or fill material" (40 CFR 230.11(h) (1)). Therefore, secondary effects are limited to other actions in the aquatic environment that are indirectly related to implementation of the action, such as erosion or downstream sedimentation, or compensatory mitigation.

Implementation of the recommended plan(SB-8) or the NED (SB-7) could result in the potential secondary impacts such as the unintentional placement of fill material outside of the proposed project area, and an increase in contaminants from construction vehicles and equipment. These actions could result in additional adverse impacts to water quality, erosion and accretion patterns, aquatic and other wildlife habitat, recreation, aesthetics and air quality. To help minimize impacts associated with the placement of fill material outside the proposed project area, Corps construction contracts require that the contractor mark the project boundaries, and that all work be conducted either when the project area is dewatered or that the contractor install erosion control (i.e. silt fencing, silt curtains) within any standing waters. Additionally, the contractor will be required to adhere to the details of a Storm Water Pollution Prevention Plan (SWPPP) plan which prevents or reduces adverse impacts to water quality from runoff.

V. Findings of Compliance or Non-Compliance with the Restrictions on Discharge

A. Adaptation of the Section 404(b) (1) Guidelines to this Evaluation: No significant adaptations of the guidelines were made relative to this evaluation of the recommended plan (SB-8) or the NED (SB-7).

B. Evaluation of Availability of Practicable Alternatives to the Proposed Discharge Site Which Would Have Less Impact on the Aquatic Ecosystem: Alternatives SB-8 and SB-7 create impacts to the waters of the United States and associated aquatic systems. SB-8 creates 5.78 acres of permanent impacts and 3.07 acres of temporary impacts. SB-7 results in 1.25 acres of permanent impacts and 0.058 acres of temporary impacts. (Refer to 1-2 for exact locations and quantities.) SB-8 creates more impacts to the waters of the United States than SB-7. The total project length for SB-8 is 41 miles compared to SB-7 which is 24 miles long. Therefore, SB-8 creates more impact to the waters of the United States based upon the additional 16 mile of proposed work. No alternative exists which does not involve discharge of fill and rock materials into waters of the U.S.

Alternative SB-7 does not provide the range and extents of flood risk management and study objectives as Alternative SB-8. SB-7 involves discharge of fill and rock materials into the waters of the U.S. and has less adverse effects on the aquatic ecosystem than SB-8. However, SB-7 does not meet the study's planning objectives which include reducing the risk to life, health, public safety, property damage, and critical infrastructure from flooding.

The recommended plan (SB-8) meets the Corps 404 (b) (1) permit criteria of the least environmentally damaging practical alternative (LEDPA). The 404 (b)(1) guidelines, § 230.3 Definitions (q) define practicable as 'a means available and capable of being done after taking into consideration cost, existing technology, and logistics in light of overall project purposes. The Corps also conducts a public interest review. This review considers a number of factors, including safety, flood hazards, floodplain values, economics, and the needs and welfare of the population at risk. These factors guide the selection of the alternative that provides a reduction in flood risk and a greater margin of safety to a larger number of people. The recommended plan (SB-8) provides a locally preferred level of flood risk reduction.

Appropriate steps to minimize potential adverse impacts of the discharge on the waters of the United States and associated aquatic systems would be implemented. The proposed disposal sites for the discharge of fill and rock materials would meet construction plan and specification guidelines and comply with the requirements of practicable conditions and measures to minimize pollution or adverse effects to the aquatic ecosystem. Permanent impacts to the waters of the United States and associated wetlands would be mitigated by purchasing credits from a wetlands mitigation bank.

C. Compliance with Applicable State Water Quality Standards, and; Compliance with Applicable Toxic Effluent Standard or Prohibition Under Section 307 of the Clean Water Act: State water quality standards would not be violated. Alternatives SB-8 and SB-7 would not violate the Toxic Effluent Standards of Section 307 of the Clean Water Act.

D. Compliance with Endangered Species Act (ESA) of 1973: The Corps has initiated consultation with USFWS and NOAA Fisheries under Section 7 of the Endangered Species Act (16 U.S.C. 1536[c]) for potential effects to listed species and their critical habitats for both Alternatives SB-8 and SB-7. All terms and conditions of the Biological Opinion from the USFWS will be fully implemented. Refer to Appendix D, Sub-Appendix C for the terms and conditions.

E. Compliance with Specified Protection Measures for Marine Sanctuaries Designated by the Marine Protection, Research, and Sanctuaries Act of 1972: Not applicable to both Alternatives SB-8 and SB-7.

F. Evaluation of Extent of Degradation of the Waters of the United States: The placement of fill and rock materials would not result in significant adverse effects on human health and welfare, including municipal and private water supplies, recreational and commercial fishing, fish, shellfish, wildlife, and special aquatic sites. The life stages of aquatic species and other wildlife would not be adversely affected. No significant adverse effects on aquatic ecosystem diversity, productivity and stability, and recreational, aesthetic, and economic values would occur .

(1) Significant Adverse Effects on Human Health and Welfare (Alternatives SB-8 and SB-7).

a) *Municipal and Private Water Supplies.* No significant effect.
b) *Recreation and Commercial Fisheries.* No significant effect.

c) *Plankton*. No significant effect.
d) *Fish*. No significant effect.
e) *Shellfish*. No significant effect.
f) *Wildlife*. No significant effect.
g) *Special Aquatic Sites*. No significant effect.

(2) Significant Adverse Effects on Life Stages of Aquatic Life and Other Wildlife Dependent on Aquatic Ecosystems. None for both lternatives SB-8 and SB-7 .

(3) Significant Adverse Effects on Aquatic Ecosystem Diversity, Productivity, and Stability. None for both lternatives SB-8 and SB-7 .

(4) Significant Adverse Effects on Recreational, Esthetic, and Economic Values. Temporary and not significant. None for both lternatives SB-8 and SB-7 .

End of Evaluation

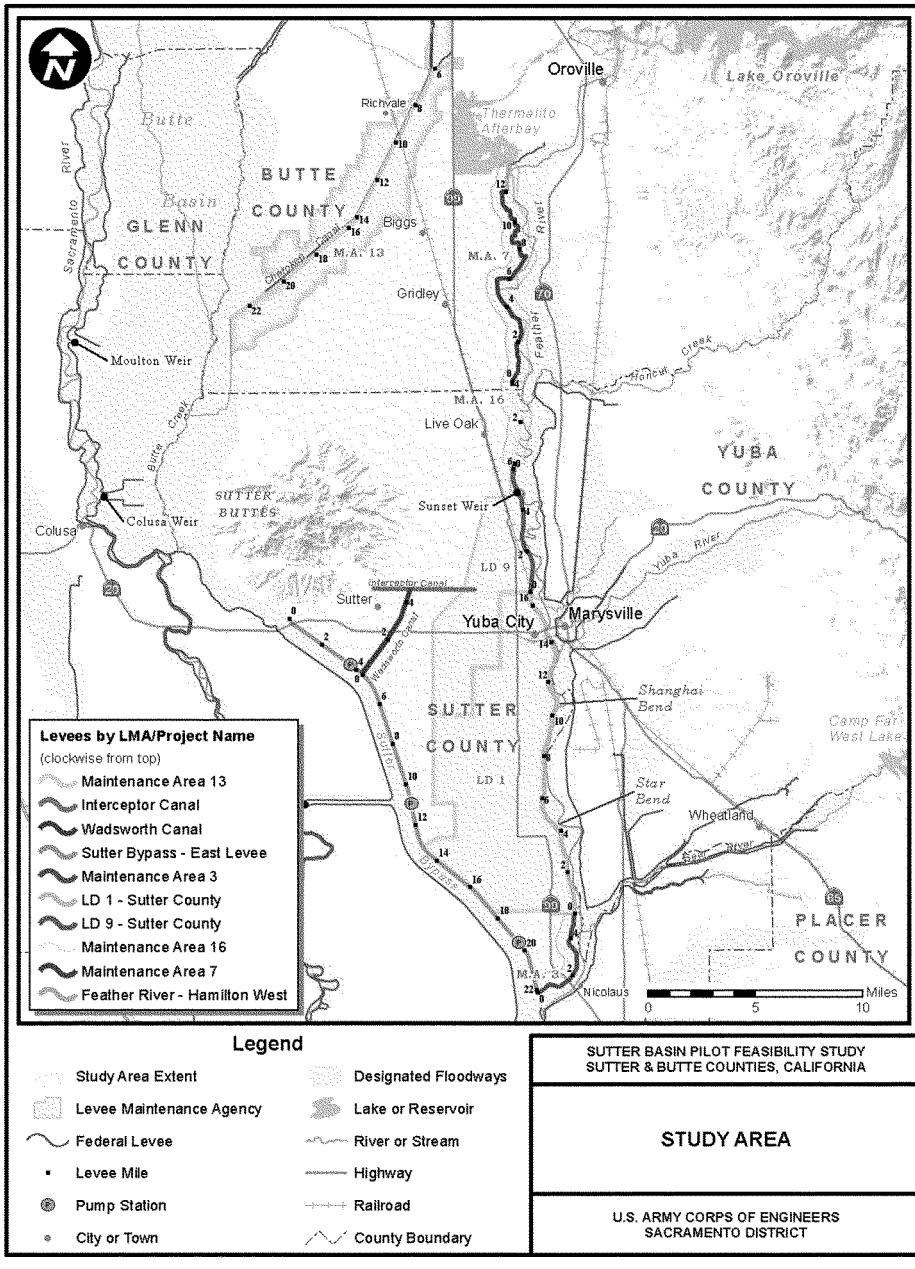


Plate 1-1. Study Area

DEPARTMENT OF THE ARMY
U.S. ARMY ENGINEER DISTRICT, SACRAMENTO
CORPS OF ENGINEERS
1325 J STREET
SACRAMENTO, CALIFORNIA, 95814-2922

REPLY TO
ATTENTION OF

Environmental Resources Branch

JUN 25 2013

Mr. Rodney R. McInnis
Regional Administrator
National Marine Fisheries Service
501 West Ocean Boulevard, Suite 4200
Long Beach, California

Dear Mr. McInnis:

This letter requests your agency's concurrence with our "may affect, but not likely to adversely affect," determination of the effects of the Sutter Basin Pilot Feasibility Study (SBPFS) on the Federally listed Central Valley spring-run Chinook salmon (*Onorhyncus tshawytscha*), Sacramento River winter-run Chinook salmon *O. tshawytscha*; Central Valley steelhead (*O. mykiss*), and the North American green sturgeon (*Acipenser medirostris*) and their designated critical habitats pursuant to Section 7(a) of the Endangered Species Act, as amended.

The work would involve modifying approximately 41 miles of the Feather River west levee to reduce flood damages, and risk to public safety. The levee modifications would involve (1) installing approximately 37 miles of soil and bentonite cutoff walls (2) constructing 2.46 miles of seepage berms, (3) placing 0.39 miles of irrigation canal ditch fill, and (4) relocating levees or removing encroachments along approximately 0.41 miles of the Feather River west levee system. When completed, the work would eliminate or reduce levee deficiencies resulting from through- and under-seepage, slope instability, erosion, and encroachments within the construction footprint. Details of the project design are provided in the Sutter Basin Pilot Feasibility Draft Report – Draft Environmental Impact Report/Supplemental Environmental Impact Statement (CD enclosed). The Biological Assessment (BA) is also enclosed.

Based on the enclosed BA, there would be no direct effect on the designated critical habitat for the Chinook salmon, steelhead, and green sturgeon since all work would be located above the ordinary high water mark. Vegetation loss would be confined to the construction footprint and to a waterside easement necessary for compliance with the Corps' levee vegetation policy. No adverse modification of riparian vegetation or shaded riverine aquatic cover would occur within the designated critical habitat areas of these listed fish species.

Construction of the project would impact about 44 acres of riparian forest and shrub scrub habitat. Approximately 891 trees (mixed native riparian) would be removed from the waterside levee slope and toe above the ordinary high water mark. No in-water construction would occur. Most of these areas are set well back from the west side of the river, ranging from approximately 20 to 5,600 feet from the Feather River during typical summer base flows. A mitigation and monitoring plan accompanies the BA. The plan details compensation for loss of riparian habitat to ensure no net loss of woody riparian habitat functions and values.

We have also determined that this project would have no direct effects on Essential Fish Habitat (EFH) pursuant to the Magnuson-Stevens Fishery Management Act, and no further EFH consultation is needed for this project. In addition, the project would implement numerous measures to avoid and/or minimize any effects of the project on the Federally-listed fish species. These conservation and mitigation measures are listed in the BA and in Chapter 4.9 in the draft EIR/SEIS on the enclosed CD.

Based on the information in the letter and enclosure, we request your agency's concurrence with our determination that the SBPFS "may affect, but not likely to adversely affect," the Federally listed Central Valley spring-run Chinook salmon, Sacramento River winter-run Chinook salmon, Central Valley steelhead, and the North American green sturgeon and their designated critical habitats. If you have any questions or need additional information, please contact Mr. Brad Johnson, Environmental Manager, at (916) 557-7812 or email: Bradley.C.Johnson@usace.army.mil. Thank you for your attention to this matter.

Sincerely,

E. Scott Clark

Alicia E. Kirchner
Chief, Planning Division

Enclosure

Copy furnished (w/encl):
Mr. Howard Brown, NOAA National Marine Fisheries Service, 650 Capitol Mall, Suite 5-100, Sacramento, CA 95814
Mr. Mike Hendrick, NOAA National Marine Fisheries Service, 650 Capitol Mall, Suite 5-100, Sacramento, CA 95814

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Region
501 West Ocean Boulevard, Suite 4200
Long Beach, California 90802-4213

SEP 26 2013

In response refer to:
2013/9685

E. Scott Clark
Acting Chief, Planning Division
Department of Army
U.S. Army Corps of Engineers
1325 J Street
Sacramento, California 95814-2922

Dear Mr. Clark:

This letter is in response to your August 30, 2013, request for initiation of section 7 consultation with NOAA's National Marine Fisheries Service (NMFS) pursuant to the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq.*), concerning the Sutter Basin Pilot Feasibility Study (SBPFS). The SBPFS, located in Sutter and Butte counties, California, evaluates alternatives to reduce flood risk in the Sutter Basin.

The U.S. Army Corps of Engineers (Corps) has determined that the proposed project may affect, but is not likely to adversely affect federally listed as threatened Central Valley (CV) spring-run Chinook salmon (*Oncorhynchus tshawytscha)* evolutionarily significant unit (ESU), endangered Sacramento River winter-run Chinook salmon (*O. tshawytscha)* ESU, threatened California CV (CCV) steelhead (*O. mykiss*) distinct population segment (DPS), threatened Southern DPS of North American green sturgeon (*Acipenser medirostris*), and their designated critical habitats. This letter also serves as consultation under the authority of, and in accordance with, the provisions of the Fish and Wildlife Coordination Act of 1934 (FWCA), as amended.

I. Consultation to Date

The following is a summary of the NMFS consultation activities on the proposed project:

(1) On June 27, 2013, the Corps submitted a letter to NMFS requesting concurrence with a "may affect, but not likely to adversely affect," determination to effects from the SBPFS.

(2) On August 21, 2013, NMFS submitted an insufficiency letter to the Corps. This letter outlined various deficiencies in the biological assessment (BA) that was included with the Corps' June 27 consultation package.

(3) In response to NMFS' August 21, 2013, letter, on August 30, 2013, the Corps delivered a revised BA and initiation letter for the SBPFS. The revised letter requests NMFS concurrence with a "may affect, not likely to adversely affect" determination.

II. Project Description

The SBPFS is being conducted in partnership with the Sutter-Butte Flood Control Agency (SBFCA) and the State of California Central Valley Flood Protection Board (CVFPB). The primary purpose of the SBPFS is flood risk management. A high risk of flooding exists from levee failure that threatens the public safety of approximately 80,000 people, as well as property and infrastructure throughout the Sutter Basin area.

The proposed project includes:

(1) Construction of 2,250 linear feet of seepage berm and cutoff walls;
(2) Relocation of 1,683 linear feet of the Sutter Butte Canal;
(3) Realignment of 11,000 linear feet of levee along the Sutter Butte Canal;
(4) Installation of 7,660 linear feet of landside levee slope erosion protection matting; and
(5) Removal of about 30 acres (includes orchard removal) of waterside trees and shrubs within the construction footprint and to conform with the U.S. Army Corps of Engineers (Corps) Engineering Technical Letter No. 1110-2-571 *Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures* (ETL). This includes the removal of 2,814 riparian trees.
(6) Compensation for permanent and temporary losses of woody riparian vegetation will be achieved through offsite compensation. The Corps proposes to conduct offsite compensation for riparian impacts in the existing 48.5-acre Star Bend Conservation Area, located within the setback area adjacent to the west levee of the Feather River, approximately 6 miles south of Yuba City. This will include the following actions:

    a. To compensate for the loss of riparian vegetation and the loss of riverine function, the Corps will compensate for the loss of 30 acres of riparian habitat at a 3:1 ratio. This will be accomplished by planting at a combination of Star Bend Conservation Area and other NMFS approved areas within the proposed action area. If appropriate land is not available, a NMFS approved riparian conservation bank may be allowed.
    b. The acreage compensation must include appropriate space to compensate for the loss of 2,814 riparian trees at a 3:1 ratio. The planting palatte and location must be NMFS approved prior to the initiation of any proposed SBPFS activities. If the above designated acreage will not suitably allow for the compensation of the loss of 2,814 trees, offsite mitigation may be used with NMFS approval.
    c. To help ensure that there is limited temporal habitat damage to riparian habitat, the vegetation planting will be initiated prior to the start of any vegetation removal associated with the proposed project.

(7) Success criteria for the revegetated sites are described in the Monitoring and Mitigation Plan associated with the SBPFS BA.

III. Action Area

The regulations governing consultations under the ESA define *action area* as "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action" (51 FR 19957). The action area should be determined based on all direct and indirect effects of the proposed action (50 CFR 402.02 and 402.14(b)(2)).

The proposed action area consists of the 41-mile corridor along the west levee of the Feather River from the Thermalito Afterbay to approximately 4 miles north of the Sutter Bypass. The proposed action area includes the project construction area and a 100-foot buffer around this area. The proposed construction area is defined as the area in which levee improvements (seepage berms, stability berms, relief wells, and slurry cutoff walls) are likely to be constructed. All of the potential direct and indirect effects will occur within this area and the 100-foot buffer around this area.

The proposed action area also includes the Three River Levee Improvement Authorities (TRLIA) Feather River Floodway Corridor Restoration Project Site located on the east bank of the Feather River. The TRLIA site is proposed as a compensation site for the loss of riparian habitat resulting from removal of vegetation necessary to comply with the Corps ETL.

IV. Effects of Proposed Action

All federally listed fish species potentially found in the area of the proposed project, the CV spring-run Chinook salmon ESU, CCV steelhead DPS, and Southern DPS of North American green sturgeon, have life histories, biological and habitat requirements that may be impacted by the proposed project. The Sacramento River winter-run Chinook salmon ESU is not found within the proposed project's action area; therefore there will be no impacts to this ESU or its designated critical habitat.

The proposed action area of the SBPFS provides migratory habitat for adult CV spring-run Chinook salmon, and migratory and rearing habitat for juveniles. Based on observations in the Feather River, adults are likely to be present in the proposed action area between February and July as they migrate to summer holding habitat. The proposed action area of the SBPFS borders the designated critical habitat of CV spring-run Chinook salmon in the Feather River. Primary constituent elements (PCEs) of critical habitat in the adjacent reaches of the Feather River include: (1) freshwater rearing sites that have adequate water quality and quantity, floodplain connectivity, and natural cover that supports juvenile growth and mobility, and (2) freshwater migration corridors that support adequate water quantity and quality as well as natural cover to provide food and migration pathways for juveniles as well as adults. Critical habitat includes the river channel and lateral extent as defined by the ordinary high water line. In areas where the ordinary high water line has not been defined, the lateral extent is defined by the bankfull elevation or the elevation at which water begins to leave the channel and move on to the floodplain (this generally corresponds to a discharge that generally has a recurrence interval of one to two years on the annual flood series) (70 FR 52488).

The proposed action area of the SBPFS provides migratory habitat for adult steelhead, and migratory and rearing habitat for juveniles. Adult steelhead immigration in the Feather River occurs from September through March (SWRI 2003). The proposed action area of the FRWLP borders the designated critical habitat of CCV steelhead in the Feather River, which includes the river channel and lateral extent as defined by the ordinary high water line. The PCEs of critical habitat are as described for spring-run Chinook salmon.

The proposed action area provides migratory and foraging habitat and likely spawning habitat for green sturgeon (Beamesderfer et al. 2004; Seesholtz pers. comm.). Historical sightings of adult green sturgeon in the Feather River have been in the spring during the general period of upstream migration in the Sacramento River. The proposed action area of the SBPFS borders designated critical habitat of the Southern DPS of North American green sturgeon, which includes the Feather River upstream to Oroville Dam.

Freshwater PCEs for the Southern DPS of North American green sturgeon include sufficient food resources for juvenile foraging, growth, and development; suitable substrates for egg incubation and development; suitable water quantity and quality for normal behavior, growth, and survival of all life stages; suitable passage conditions for adults, larvae, and juveniles; suitable holding pools and water depths for adults; and sediments free of elevated levels of contaminants capable of adversely affecting green sturgeon (74 FR 52300).

The Corps has determined that there will be no direct effect on the designated critical habitat for federally listed fish species, because all work on the waterside slope will stay above the ordinary high water mark (OHWM) and outside of designated critical habitat. Vegetation losses will be attributed to the construction footprint and as a result of the Corps ETL. As a result, there will be modification of riparian vegetation within the proposed action area, but none of this removal will occur in designated critical habitat of federally listed fish species.

Direct effect to riparian vegetation will include the removal of 2,814 trees. This includes both native (1,178) and non-native (1,636) trees. Of the 1,178 native trees, 957 of these are located on the waterside of the levee prism. There will also be 574 non-native trees removed on the waterside of the levee prism. A majority of these are orchard trees. The only vegetation allowed under the Corps ETL in the vegetation free zone will be non-irrigated perennial grasses. To help compensate for permanent and temporary loss of woody riparian vegetation, the Corps developed a mitigation and monitoring plan (MMP).

Proposed construction and levee repair activities are not likely to result in adverse turbidity- or sedimentation-related effects on winter-run Chinook salmon, spring-run Chinook salmon, steelhead, and green sturgeon or their critical habitat. For the SBPFS, no in-river construction activities are proposed and all activities that will result in physical disturbance or removal of soil or vegetation on the waterside slope of the levee will be limited to areas above the OHWM. With implementation of the stormwater pollution prevention plan (SWPPP) and the associated erosion and sediment control best management practices (BMPs), exposed or imported soil will be largely contained within the immediate project footprint and stabilized using structural or vegetative methods. Any increases in turbidity and sedimentation attributable to the proposed project are expected to be well below levels associated with injury or reduced growth of juvenile

salmonids, and will not likely result in significant disruption of normal feeding, sheltering, and migratory behavior of Chinook salmon, steelhead, or green sturgeon.

Contaminants used at construction sites, including gasoline, diesel fuel, lubricants, and hydraulic fluid, could enter the Feather River as result of spills or leakage from machinery or storage containers and injure or kill listed salmon, steelhead, and sturgeon. These substances can kill aquatic organisms through exposure to lethal concentrations or exposure to non-lethal levels that cause physiological stress and increased susceptibility to other sources of mortality such as predation. There is also a slight risk of the release of bentonite into the Feather River during jet grouting or deep soil mixing used to construct slurry cut off walls. Implementation of a spill prevention, control, and countermeasure plan (SPCCP) and bentonite slurry spill contingency plan as part of the environmental commitments of the project is anticipated to minimize the potential for toxic or hazardous spills or discharges into the Feather River. Adherence to all preventative, contingency, and reporting measures in the approved plans will reduce the risk of injury or mortality of listed fish species to negligible levels.

For the SBPFS, sheet piles will be used only as a site-specific treatment at roadway or railroad crossings, and will be restricted to the levee crown above the OHWM where sound waves will be expected to attenuate quickly before reaching the Feather River. Consequently, pile driving activities will have negligible noise and vibration effects on fish in the Feather River.

The SBPFS is proposing to relocate the Sutter Butte Main Canal levee 20 feet towards the Feather River for a total of 11,850 linear feet. Relocating levees closer to the river will reduce space for river meanders, limit the ability to reconnect floodplains, decrease the transport and deposition of sediment, and decrease the diversity of riverine and floodplain habitats. This will also limit the ability to support agriculture within expanded floodways. The move of the levee towards the river will decrease the ability to enhance juvenile rearing habitat (e.g., food resources and cover) by decreasing the connectivity of riparian areas and floodplain ecosystems that contribute to food web productivity.

V. ESA Section 7 Consultation

Based on our review of the material provided with your request and the best scientific and commercial information currently available, NMFS concurs that the Corps determination that the proposed project as described is not likely to adversely affect federally listed CV spring-run Chinook salmon ESU (*O. tshawytscha*), Sacramento River winter-run Chinook salmon ESU (*O. tshawytscha),* CCV steelhead DPS (*O. mykiss*), Southern DPS of North American green sturgeon (*Acipenser medirostris*), or their designated critical habitats. No construction activities are proposed in-river or below the OHWM; all activities that will result in physical disturbance and removal of vegetation on the waterside slope of the levee will be limited to areas above OHWM. The proposed project is not likely to result in adverse water quality or noise effects on listed fish species or their critical habitat. The proposed project is not likely adversely affect PCEs of critical habitat of winter-run Chinook salmon, spring-run Chinook salmon, steelhead, and green sturgeon. There will be no direct physical impacts to riparian vegetation or SRA cover within the designated critical habitat of these species. Therefore, no physical modification of critical

habitat for ESA-listed fish species will be expected because all proposed construction activities will occur above the OHWM of the Feather River.

In addition to the above, NMFS reached this determination based on the incorporation of the following measures into the project description:

(1) Construction personnel will receive worker environmental awareness training. This training will instruct workers to recognized sensitive species and their habitats.
(2) Erosion control BMPs and a SWPPP will be implemented to address and minimize water quality issues.
(3) Where suitable habitat is present for listed species, the Corps will clearly delineate the construction limits through the use of survey tape, pin flags, orange barrier fencing, or other means, and prohibit any construction-related traffic outside these boundaries.
(4) If a sensitive species is encountered by a biological monitor during construction, activities will cease until appropriate corrective measures have been completed or it has been determined that the species will not be harmed.
(5) Implementation of a spill prevention, control, and countermeasure plan and bentonite slurry spill contingency plan is anticipated to minimize the potential for toxic or hazardous spills or discharges into the Feather River.
(6) To prevent possible resource damage from hazardous materials such as motor oil or gasoline, construction personnel will not service vehicles or construction equipment outside designated staging areas unless it is done offsite.
(7) The biological monitor will record all observations of federally listed species on California Natural Diversity Database field sheets and submit to the Corps, NMFS, U.S. Fish and Wildlife Service, and California Department of Fish and Wildlife.
(8) Because ground disturbance for the proposed project will be greater than one acre, the Corps will obtain coverage under the U.S. Environmental Protection Agency's (EPA's) National Pollutant Discharge Elimination System general construction activity stormwater permit.
(9) The specific BMPs that will be incorporated into the erosion and sediment control plan and SWPPP will be site-specific and will be prepared by the construction contractor in accordance with the California Regional Water Quality Control Board Field Manual.

This concludes ESA section 7 consultation for the proposed project. This concurrence does not provide incidental take authorization pursuant to section 7(b)(4) and section 7(o)(2) of the ESA. Re-initiation of the consultation is required where discretionary Federal agency involvement or control over the proposed project has been retained (or is authorized by law), and if: (1) new information reveals effects of any of the proposed projects that may affect listed species or critical habitat in a manner or to an extent not considered; (2) any of the proposed projects are subsequently modified in a manner that causes adverse effects to listed species or critical habitat; or (3) a new species is listed or critical habitat designated that may be affected by any of the proposed projects.

Section 7(a) (1) of the ESA directs Federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of threatened and endangered species. Conservation measures are discretionary agency activities intended to

minimize or avoid adverse effects of a proposed project on listed species or critical habitat, to help implement recovery plans, or to develop information. In order to fulfill the requirements of section 7(a)(1), NMFS recommends the Corps implement the conservation recommendations that are described below in section VIII.

VI. EFH Consultation

With regards to essential fish habitat (EFH) consultation, the proposed action area has been identified as EFH for Pacific salmon in Amendment 14 of the Pacific Salmon Fishery Management Plan pursuant to the Magnuson – Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act). Federal action agencies are mandated by the Magnuson-Stevens Act (section 305(b)(2)) to consult with NMFS on all actions that may adversely affect EFH, and NMFS must provide EFH conservation recommendations to those agencies (section 305(b)(4)(A)). Based on our review of the material provided, and the best scientific and commercial information currently available, NMFS has determined that the proposed action will adversely affect EFH for Pacific salmon. Therefore, NMFS is providing conservation recommendations to minimize or avoid these adverse effects in section VIII, below.

Section 305(b)4(B) of the Magnuson-Stevens Act requires the Corps to provide NMFS with a detailed written response within 30 days, and 10 days in advance of any action, to the EFH conservation recommendations, including a description of measures adopted by the Corps for avoiding, minimizing, or mitigating the impact of the project on EFH (50 CFR §600.920[j]). In the case of a response that is inconsistent with our recommendations, the Corps must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the proposed action and the measures needed to avoid, minimize, or mitigate such effects.

VII. FWCA Consultation

The purpose of the FWCA is to ensure that wildlife conservation receives equal consideration and is coordinated with other aspects of water resources development (16 U.S.C. 661). The FWCA establishes a consultation requirement for Federal departments and agencies that undertake any action that proposes to modify any stream or other body of water for any purpose, including navigation and drainage (16 U.S.C. 662(a)). Consistent with this consultation requirement, NMFS provides recommendations and comments to Federal action agencies for the purpose of conserving fish and wildlife resources. The FWCA provides the opportunity to offer recommendations for the conservation of species and habitats beyond those currently managed under the ESA and Magnuson-Stevens Act. FWCA recommendations are provided in section VIII, below.

VIII. Conservation Recommendations

Section 7(a) (1) of the ESA directs Federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of threatened and endangered species. Conservation measures are discretionary agency activities intended to minimize or avoid adverse effects of a proposed project on listed species or critical habitat, to

help implement recovery plans, or to develop information. In order to fulfill the requirements of section 7(a)(1), NMFS recommends, under section 7(a)(1) of the ESA, section 305(b)(4)(A) of the Magnuson-Stevens Act, and pursuant the FWCA, that the Corps implement the following recommendations as conservation measures:

(1) As the Corps continues to develop details of the proposed action and moves beyond the 30 percent design stage, strong consideration should be given to revising proposed levee alignments to avoid or further minimize waterside construction. NMFS recognizes that the Corps negotiated the existing levee alignment with the U.S. Fish and Wildlife Service without the participation of NMFS. Our position is that if NMFS had been involved during the development of the Feasibility Study, we would have made a strong recommendation to avoid waterside re-alignment. Regardless of the analytical outcome of the Corps BA and the concurrence by NMFS that the proposed alignment is not likely to adversely affect listed species or designated critical habitat because the existing floodplain is broad and above the OHWM, the cumulative effects (as defined under NEPA) of such actions are likely to result in incremental loss of habitat that will eventually harm listed species.

(2) The Corps should consider options other than strict adherence to the ETL. We recommend that, at a minimum, the Corps should issue itself a variance that allows trees to remain along the levee under certain circumstances. Our preferred recommendation is for the Corps to follow the vegetation approach that is a part of the Central Valley Flood Protection Plan (CVFPP). On June 29, 2012, the CVFPB adopted the CVFPP, a comprehensive new framework for systemwide flood management and flood risk reduction in the CV. The CVFPP proposes a State Systemwide Investment Approach for sustainable, integrated flood management. In 2009, the California Levees Roundtable signed the California's Central Valley Flood System Improvement Framework (Levees Framework Agreement). This Framework included interim criteria for managing vegetation on levees for visibility (inspections) and accessibility (floodfight and maintenance) with the expectation that a comprehensive strategy would be developed and included in the 2012 CVFPP. A full Levee Vegetation Management Strategy is included in the Conservation Framework of the CVFPP. The 2012 CVFPP describes implementation of the State's approach to levee vegetation management, which will be adaptive and responsive to:

   a. The results of ongoing and future research, and
   b. Knowledge gained from levee performance during high water events.

   The CVFPP Levee Vegetation Management Strategy reflects a flexible and adaptive management strategy that meets public safety goals, and protects and enhances sensitive habitats in the CV. This strategy also reflects a prudent use of limited public resources in addressing flood risk. Based on the current understanding of levee failure mechanisms, properly trimmed and spaced levee vegetation poses a low threat to levee integrity as compared to many indisputable risk factors, such as under-seepage, through-seepage, slope instability, erosion, and rodents.

The adaptive Levee Vegetation Management Strategy encourages and supports continued research on the risks and benefits of trees in relation to levee performance. State and local agency-sponsored research, along with Corps sponsored research, are addressing information gaps surrounding levee performance through applied research and an ongoing synthesis of historical information. Findings of these research programs are informing current policy development, and will continue to do so for future CVFPP updates. Waterside vegetation acts to stabilize the bank and provide erosion protection, while also providing habitat for sensitive species. In order to sustain this critical habitat, the CVFPP levee management strategy retains waterside vegetation. Vegetation would be removed (in coordination with resource agencies) only when it presents an unacceptable threat.

(3) In addition to the 3:1 replacement of vegetation that is proposed as a result of project construction, NMFS recommends purchasing riparian enhancement credits at a NMFS-approved conservation bank within the project's service area.

IX. Recommendations to the Corps Regarding Feasibility Studies for Future Consultations

(1) Future consultations (including Feasibility Studies) should have NMFS participation early in the planning process. This will allow NMFS to assist with identification of avoidance and minimization measures, design of self-mitigating sites where appropriate, and assistance in evaluating potential mitigation options. For example, the American River Common Features General Reevaluation Report is a complex project with significant potential for adverse effects to listed species and their designated critical habitat. Early NMFS participation will assist in reducing these impacts and facilitate a quicker and more streamlined consultation process.

(2) NMFS has significant concerns regarding strict application of the ETL to future action proposed by the Corps and the potentially significant impacts that this application may have on federally listed anadromous fish and their designated critical habitat. The ESA requires all Federal agencies to ensure that designated critical habitat will not be destroyed or adversely modified and that Federal agencies are required to support and implement programs for the conservation of listed species. As described above under Conservation Recommendation #2, the Corps should consider vegetation management alternatives other than strict adherence to the ETL, such as a variance that includes vegetation management standards adopted by the CVFPP.

(3) NMFS is concerned that future requests for consultation (including Feasibility Studies) at the 30 percent design, may not meet the information needs to initiate formal consultation as described in CFR 402.14(c). The Corps should work closely with NMFS to ensure that future requests for consultation are specific enough to adequately analyze the effects the full scope of potential effects on Federally listed species and their designated critical habitat.

(4) Final or draft Environmental Impact Statement analysis should not be used in lieu of appropriate analysis needed as part of a BA. To serve as reference for consultation on future Corps Feasibility Studies, the following six pieces of information needed in detail as described in CFR 402.14(c) are required for Section 7 Consultation:

a. A description of the proposed action to be covered;
b. A description of the specific area that may be affected by the proposed action;
c. A description of any listed species or critical habitat that may be affected by the proposed action;
d. A description of the manner in which the action may affect any listed species or critical habitat, and an analysis of any direct, indirect, or cumulative effects;
    i. Direct Effects: Effects to listed species of designated critical habitat that occur during implementation of the project;
    ii. Indirect Effects: Effects to listed species that occur later in time or offsite, but are reasonably certain to occur;
    iii. Cumulative Effects: For purposes of the ESA, cumulative effects are defined as the effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within an action area of the Federal action subject to consultation (50 CFR 402.02). Future Federal actions are not included here because they require separate consultation pursuant to Section 7 of the ESA;
e. Relevant reports, including any environmental impact statements, environmental assessments, biological assessments or other analysis prepared regarding the proposal; and
f. Any other relevant studies or other information available on the action, the affected listed species, or critical habitat.

If you have any questions or comments regarding this letter, please contact Mike Hendrick at (916) 930-3605 or via e-mail at Michael.Hendrick@noaa.gov.

Sincerely,

for William W. Stelle Jr.
Acting Regional Administrator

cc: Copy to file ARN: 151422SWR2013SA00183
NMFS, PRD, Long Beach, CA
Daniel Welsh, Acting Field Supervisor, US Fish and Wildlife Service, 2800 Cottage Way, Room W-2605, Sacramento, CA, 95825-1846
Sandra Morey, Deputy Director, California Department of Fish and Wildlife, 1416 Ninth Street, #1208, Sacramento, CA, 95814

Mike Inamine, Executive Director, Sutter Butte Flood Control Agency, 1227 Bridge Street, Suite C, Yuba City, CA 95991

Literature Cited

Beamesderfer, R., M. Simpson, G. Kopp, J. Inman, A. Fuller, and D. Demko. 2004. Historical and current information on green sturgeon occurrence in the Sacramento and San Joaquin rivers and tributaries. Prepared for State Water Contractors by S.P. Cramer and Associates, Inc., Gresham, Oregon. 46 pages.

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Personal Communication

Seesholtz, Alicia. 2008. Environmental Scientist. California Department of Water Resources. Sacramento, CA. September 19, 2008—telephone conversation.

DEPARTMENT OF THE ARMY
U.S. ARMY ENGINEER DISTRICT, SACRAMENTO
CORPS OF ENGINEERS
1325 J STREET
SACRAMENTO, CALIFORNIA, 95814-2922

REPLY TO
ATTENTION OF

JUN 25 2013

Environmental Resources Branch

Ms. Jan Knight, Acting Field Supervisor
U.S. Fish and Wildlife Service
2800 Cottage Way, Suite W2605
Sacramento, California 95825-1846

Dear Ms. Knight:

This letter is to request reinitiation of formal consultation to address effects of the Sutter Basin Pilot Feasibility Study (SBPFS) on the Federally listed valley elderberry longhorn beetle (Desmocerus californicus) (VELB) and giant garter snake (Thamnophis gigas) (GGS) pursuant to Section 7(a) of the Endangered Species Act, as amended.

On May 2, 2013, the USFWS issued a Biological Opinion (Reference File: 08ESMF00-2013-F-0342-1) for the Feather River West Levee Improvement Project (FRWLP). Based on coordination between our staffs, it was determined that Section 7 consultation for the SBPFS would be accomplished by reinitiating formal consultation under the Biological Opinion issued for the FRWLP. Construction of the SBPFS is dependent on Congressional authorization and funding appropriation; construction of the SBPFS may be limited to those project reaches that are not constructed under the FRWLP.

The SBPFS' Tentatively Selected Plan (TSP) would have additional effects to the VELB and GGS due to USACE's levee safety vegetation policy, levee design modifications, and operation and maintenance activities. Enclosed is our biological assessment addendum to reinitiate formal consultation and details of the TSP are provided in the Sutter Basin Pilot Feasibility Draft Report – Draft Environmental Impact Report/Supplemental Environmental Impact Statement (CD enclosed).

The biological assessment addendum indicates that the SBPFS TSP is likely to adversely affect VELB due to the removal of 162 elderberry shrubs and the potential for injury or mortality of VELB during removal and transplantation. The TSP is also likely to adversely affect GSS due to temporary loss of 6.18 acres of suitable aquatic habitat and 112.47 acres of upland habitat, the permanent loss of 3.54 acres of upland habitat, and the potential for injury or mortality to the snake during construction and operation and maintenance activities.

A draft Mitigation and Monitoring Plan has been developed to address effects to listed species, Waters of the U.S., and natural habitats. Effects to VELB would be compensated at the existing 48.5-acre Star Bend Conservation Area, approximately 6 miles south of Yuba City on the west levee of the Feather River. The appropriate compensation for these effects would require at least 20.1 acres of land to accommodate approximately 162 elderberry shrubs, 2,430 elderberry cuttings or seedlings, and 2,430 native plants. The conservation area in which the transplanted elderberry shrubs and seedlings are planted will be protected in perpetuity as habitat

for VELB. The TRLIA Feather River Floodway Corridor Restoration Project is proposed as a second mitigation site for riparian habitat compensation. The proposed site is located on the east bank of the Feather River just upstream of the Star Bend site.

The Corps proposes to compensate for permanent impacts of the 3.54 acres of upland snake habitat by purchasing credits at a USFWS approved mitigation bank, as described in the BA. Temporarily affected aquatic and upland habitat would be restored to pre-project conditions within a maximum of one season. The proposed action includes other conservation measures to avoid and/or minimize any effects on the VELB and GGS.

Based on the information in this letter and enclosure, please provide an amended BO based on the additional effects of the SBPFS on the Federally listed VELB and GGS. If you have any questions or need additional information, please contact Mr. Brad Johnson, Environmental Manager, at (916) 557-7812 or email: Bradley.C.Johnson@usace.army.mil. Thank you for your attention to this matter.

Sincerely,

Alicia E. Kirchner
Chief, Planning Division

Enclosures

Copy furnished (w/encl):
Mr. Doug Weinrich, U.S. Fish and Wildlife Service, 2800 Cottage Way, Sacramento, CA 95825
Ms. Jennifer Hobbs, U.S. Fish and Wildlife Service, 2800 Cottage Way, Sacramento, CA 95825

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Sacramento Fish and Wildlife Office
2800 Cottage Way, Room W-2605
Sacramento, California 95825-1846

In Reply Refer To:
08ESMF00-2013-F-0342-R001

SEP 19 2013

Ms. Alicia Kirchner
Chief, Planning Division
U.S. Army Corps of Engineers, Sacramento District
1325 J Street
Sacramento, California 95814

Subject: Formal Consultation on the Feather River West Levee Project, Sutter County, California

Dear Ms. Kirchner:

This is in response to your June 25, 2013, request to reinitiate formal consultation with the U.S. Fish and Wildlife Service (Service) on the Feather River West Levee Project in Sutter and Butte Counties, California. Your request was received in our office on June 27, 2013. The original biological opinion (81420-2013-F-0342-1) was completed on May 2, 2013. The original consultation was conducted with the Corps and the Sutter Butte Flood Control Agency (SBFCA). SBFCA's proposed project is currently being constructed in advance of the federally led Sutter Basin Pilot Feasibility Study (SBPFS). The Corps is reinitiating consultation due to changes in the project description that modifies the project such that it meets Corps regulations. The changes enlarge the footprint of the project. This enlarged footprint would affect the federally-threatened giant garter snake (*Thamnophis gigas)* and valley elderberry longhorn beetle (*Desmocerus californicus*). These effects have not been previously analyzed. This response is in accordance with 50 CFR 402.16 of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*) (Act).

The May 2, 2013, biological opinion's project description was for the SBFCA Feather River West Levee Project (FRWLP), which was planned in advance of the Corps' SBPFS planning. The majority of the footprint for the two projects is the same. The Corps' SBPFS has a slightly larger footprint and a few new activities, which changes the effects of the project on listed species. Because SBFCA wanted to construct as soon as possible, they initiated section 7 consultation through the Corps as part of their 408 approvals. SBFCA is currently constructing a portion of the project in 2013. The SBPFS is part of the Corps' Civil Works program and the Corps is reinitiating consultation to include the additional footprint and activities. The project description in this biological opinion is inclusive of the SBFCA project and includes the additional SBPFS activities.

The Service is amending the project description and effects analysis within this biological opinion. Paragraphs that contain changes from the May 2, 2013, document have been bolded. This biological opinion supersedes the May 2, 2013, biological opinion.

CONSULTATION HISTORY

July 13, 2012. The Service, ICF International, HDR Inc., consultants to Sutter Butte Flood Control Agency (SBFCA), California Department of Fish and Wildlife (CDFW), California Department of Water Resources, and the Corps participated in a site visit to the proposed project. Potential effects to giant garter snake were discussed on the trip.

September 27, 2012. The Service, Corps, HDR, and ICF met to discuss the biological opinion and the level of detail that will be available in order to initiate consultation. The applicant determined that they will have sufficient information to initiate consultation at the project level.

December 18, 2012. The Service, Corps, SBFCA, ICF, and HDR met to discuss effects to giant garter snake. Permanent and temporary effects were discussed as well as the Service providing suggestions on conservation measures that could be incorporated.

February 12, 2013. The Service, Corps, ICF, CDFW, and HDR met to discuss long-term operations and maintenance (O&M). The outcome of this meeting was that the SBFCA FRWLP will not include operations and maintenance in their project description because their project will not be changing O&M. However, the Corps will be initiating consultation on the Sutter Feasibility Study in the next 6 months and this project description will include O&M activities.

March 22, 2013. The Corps initiated section 7 consultation with the Sacramento Fish and Wildlife Office.

June 25, 2013. The Corps reinitiated consultation due to an expansion of the project description as part of the Corps' SBPFS. The addendum to the O&M manual has not been written yet and therefore is not fully part of the project description. The Corps will re-initiate consultation with the Service when the addendum has been written.

BIOLOGICAL OPINION

Description of Action Area

North to south, the Action Area consists of the 41-mile corridor along the west levee of the Feather River from the Thermalito Afterbay to a point about 4 miles north of the Sutter Bypass. The Action Area includes the project construction area and a 100-foot buffer around this area which includes staging and spoils areas. The project construction area was defined as the area in which levee improvements—such as seepage berms, stability berms, relief wells, sheet-pile walls, and slurry cutoff walls—are likely to be constructed. All direct and indirect effects will occur within this area and the 100-foot buffer around this area.

The corridor is divided into 41 relatively homogeneous reaches for ease of describing existing conditions, project components, land cover-types, and potential effects (note that this number is coincidental and one reach does not correspond to a length of 1 mile; additionally, Reach 1 is not part of the FRWLP) (Figure 1).

The Action Area also includes six potential borrow sites that could supply the borrow material necessary for levee construction and upgrades, and routes from the project construction area to the borrow sites. It is not anticipated that all six sites will be used over the multi-year phased construction period, but until additional geotechnical and soil samplings are completed, all sites will be available for use and are included in the Action Area.

Finally, the Action Area includes the existing 48.5-acre Star Bend Conservation Area, located on the west levee of the Feather River, about 6 miles south of Yuba City. Compensation for the Proposed Action's effects on the beetle is proposed to occur in a portion of this conservation area, which is discussed below under Conservation Measure 5.

Description of Proposed Action

The primary purpose of the **FRWLP/SBPFS (Proposed Project)** is to reduce flood risk in the Sutter Basin by addressing known levee deficiencies along the Feather River West Levee from Thermalito Afterbay downstream to a point about 4 miles upstream of the Feather River's confluence with the Sutter Bypass. While the **Proposed Project** will not by itself reduce all flood risks affecting the Sutter Basin, it will address the most immediate risks based on the following.

- The proximity of the Feather River to population centers and key infrastructure.
- The nature of the Feather River West Levee being the longest and most contiguous portion of the planning area perimeter.
- The location of known levee deficiencies and the clarity and feasibility of available measures to address them.

The construction of the **Proposed Project** will be divided into four separate reaches. **Reach** A begins near the intersection of the Feather River West Levee and Laurel Road. It continues north to the beginning of the improvements constructed as part of the Star Bend Setback Levee Project. The total length of the levee in this portion of the **Proposed Project** is 27,618 linear feet. **Reach** B begins at the end of the improvements constructed as part of the Star Bend Setback Levee Project, and continues north for 31,963 linear feet. **Reach** C begins near the north end of the Shanghai Bend Setback Levee, and continues north for a total of 77,886 linear feet. **Reach** D then begins and continues north for 69,363 linear feet.

For **Reach** A, a cutoff wall ranging between 10 and 35 feet deep will be constructed along the centerline of the levee for the entire length of levee. The overall height of the levee will be degraded by about 50%. In addition to the cutoff wall, a portion of the levee will have a **12,066**-foot-long; 100-foot-wide seepage berm installed.

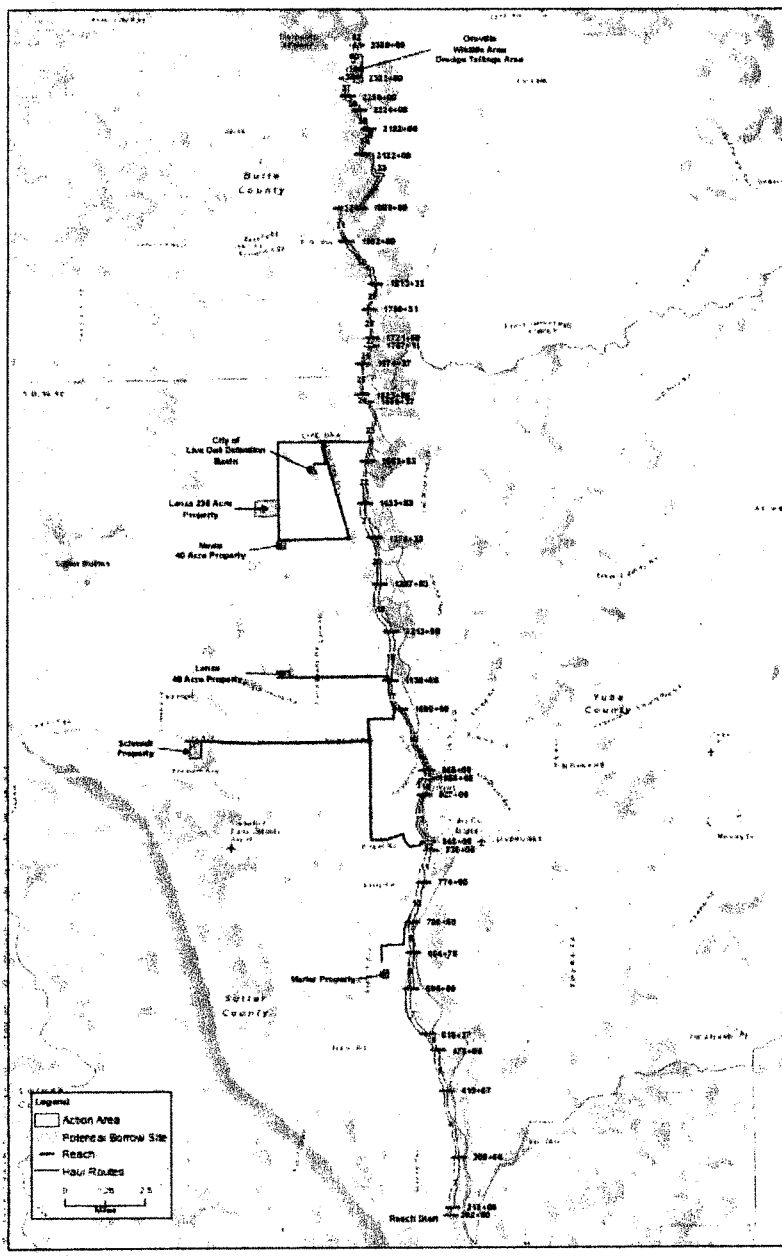

Figure 1. Proposed Project

For **Reach** B, a cutoff wall ranging between 5 and 25 feet deep will be constructed along the centerline of the levee for 31,600 linear feet. The overall height of the levee will be degraded by about 50%. Relief wells 60 feet apart and 50 feet deep will be installed along a 2,500 linear foot section. **To address erosion caused by potential levee overtopping 5,760 linear feet of landside levee will have erosion protection matting installed.** Finally, two small sections will involve pipe crossing work.

For **Reach** C, a cutoff wall ranging between 5 and 65 feet deep will be constructed along the centerline of the levee for 62,117 linear feet. The overall height of the levee will be degraded by about 50%, with about 5,900 linear feet of the levee needing to be fully degraded. A 7-foot tall and 50-foot-wide seepage berm will be placed near the 10th Street bridge and extend through the existing abandoned railroad tunnel. **To address erosion caused by potential levee overtopping 1,900 linear feet of landside levee will have erosion protection matting installed. In two locations along this reach the Sutter Butte Canal is adjacent to the levee. For 483 linear feet the Corps will move the canal away from the levee and for 3,100 linear feet the Corps will move the levee away from the canal.** Finally, there will be a few storm drain pipes replaced within the levee.

For **Reach** D, a cutoff wall ranging between 10 and 90 feet deep will be constructed along the centerline of the levee for 57,361 linear feet. For all but 317 linear feet of levee, the levee will be degraded by about 50%. The remaining 317 linear feet will have a full levee degrade and reconstruction. **The Sutter Butte Canal is adjacent to the landside of the levee. For 7,900 linear feet the levee will be relocated away from the canal and for 1,200 linear feet the canal will be relocated away from the levee.** Six storm drain and irrigation pipes will need to be replaced along a section of the levee. About 4,800 linear feet of seepage berm will be constructed at the northern end of the proposed project. The berm will vary in width between 100 and 170 feet. Additionally, a waterside pit located in this area will be filled.

Materials imported to the construction site will include water, bentonite, cement, incidental construction support materials, aggregate base rock, hydroseed, and up to 1,500,000 cubic yards of embankment fill material for the new levee surfaces from offsite commercial borrow sites or local landowners willing to sell borrow material. For backfill of new pipelines crossing the levee, controlled low strength material (CLSM) (otherwise known as lightweight concrete) will be placed to the pipeline's spring line.

Construction methods for the flood management measures are described in detail below.

Slurry Cutoff Wall

A slurry cutoff wall consists of impermeable material that is placed parallel to the levee, typically through the center of the levee crown. There are three methods for constructing a slurry cutoff wall: (1) conventional slot trench, (2) deep soil mixing (DSM), and (3) jet grouting. The first two are the primary methods for application over longer areas, while jet grouting is a spot application based on limiting conditions. A slurry cutoff wall addresses the deficiency of seepage (through- and under-seepage).

Conventional Slot Trench Method - To begin construction, the construction site and any necessary construction staging or slurry mixing areas are cleared, grubbed, and stripped. In the conventional slot trench method, a trench is excavated at the top center of the levee and into subsurface materials. The size of the trench is based on the severity of the seepage but can be typically 3 feet wide and up to 80–90 feet deep. As the trench is excavated, it is filled temporarily with bentonite water slurry to prevent cave-in. The soil from the excavated trench is hauled to a nearby location where it is mixed with hydrated bentonite to reduce permeability and cement in some applications where increased strength is desired. The soil-bentonite mixture then is returned to the levee and backfilled into the trench. This mixture hardens and creates the impermeable barrier wall in the levee.

In most cases, degradation of the levee crown is necessary to create a large enough working platform to reduce the risk of hydraulic fracturing from the insertion of slurry fluids, and allowing greater depths to be reached. Dependent on the conditions of the particular levee, it may be necessary to degrade the levee by one- to two-thirds its existing height. The material from degrading the levee is hauled to a nearby stockpile area. Following completion of the slurry cutoff wall, the material is hauled back to the levee to restore the levee to its original dimensions. The material may need to be hauled offsite to a local landfill, and borrow material may need to be imported if the in-situ levee material is found to be unsuitable for current levee standards.

One construction crew typically is able to construct 75-100 linear feet of slurry wall (about 70-80 feet deep) in an 8-hour shift. Equipment needed for the crew includes a long-reach track hoe, three or four dump trucks (15 cubic yard capacity each), two loaders at the mixing location, bulldozers, excavators, loaders, a rough terrain forklift, compactors, maintainers, and a water truck. Vertical clearance of about 40 feet is needed for the excavator boom. Horizontal clearance of about 30 feet beyond the levee crest may be required for excavator swing when loading dump trucks.

A mixing area is located at the construction staging area. The mixing area is to prepare the soil-bentonite mixture and supply bentonite-water slurry. The mixing area is contained to avoid inadvertent dispersal of the mixing materials. Dump trucks haul material between the excavator and the mixing area along the levee.

An access road made of aggregate base rock is constructed on the levee crown to enable regular levee inspections. Post-construction, areas used for construction staging, mixing, the levee crown, slopes, and any other disturbed areas are hydroseeded.

Deep Soil Mixing (DSM) Method - The DSM method of constructing a slurry cutoff wall uses a crane-supported set of two to four mixing augers (typically 36 inches in diameter) set side by side. These augers are drilled through the levee crown and foundation to the required depth (capable of a maximum depth of about 200 feet). As the augers are inserted and withdrawn, a soil-bentonite grout is injected through the augers and mixed with the native soil. An overlapping series of mixed columns is drilled to create a continuous seepage cutoff barrier.

To provide a wide enough working platform on the levee crown, the upper portion of some segments of the levee requires excavation with a paddle wheel scraper. Material is scraped and

stockpiled at a nearby stockpile area. Dependent on the depth of the wall required, vertical clearance for the crane also may be needed. An excavator manipulates injector return spoils near the DSM rig, and transport trucks are used to haul spoils offsite. A crane is used for in-place sampling of DSM material and also for loading bentonite into the batch plant hopper. A mobile batch plant (diesel-powered) is required near each DSM rig at the work area to prepare the cement-bentonite grout. The grout is transported to the DSM rig through flexible hoses. Each batch plant requires a pad of 50 by 100 feet. Hauling at the work area involves scraper runs along the levee to the staging area and cement and bentonite deliveries to the batch plant.

During DSM slurry wall construction, one DSM rig typically can construct 50 linear feet of DSM wall per 8-hour shift (for wall depths up to 135 feet). Post-construction, areas used for construction staging, the levee slopes, and any other disturbed areas are hydroseeded.

Jet Grouting Method - Jet grouting involves injecting fluids or binders into the soil at very high pressure. The injected fluid can be grout; grout and air; or grout, air, and water. Jet grouting breaks up soil and, with the aid of a binder, forms a homogenous mass that solidifies over time to create a mass of low permeability. Jet grouting typically is used in constructing a slurry cutoff wall to access areas other methods cannot. In this regard, it is typically a spot application rather than a treatment to be applied on a large scale along an entire reach.

Equipment required for jet grouting consists of a drill rig fitted with a special drill string; a high pressure, high flow pump; and an efficient batching plant with sufficient capacity for the required amount of grout and water. The high-pressure pump conveys the grout, air, and/or water through the drill string to a set of nozzles located just above the drill bit. The diameter of the jet grout column is dependent on site-specific variables such as soil conditions, grout mix, nozzle diameter, rotation speed, withdrawal rate, and grout pressure. Jet grouted columns range from 1 to 16 feet in diameter and are typically interconnected to form cutoff barriers or structural sections. Under ideal conditions, one construction crew—consisting of a site supervisor, pump operator, batch plant operator, chuck tender, and driller—can construct two 6-foot diameter, 50-foot columns per day consisting of about 100 cubic yards of grout injected per 8-hour shift. Ideal conditions will be characterized by no technical issues occurring at either the batch plant or the drilling site, such as loss of fluid pressure, breakdown of equipment, or subsurface obstructions to drilling operations.

To initiate jet grouting, a borehole is drilled through the levee crown and foundation to the required depth (to a maximum depth of about 130 feet) by rotary or rotary-percussive methods using water, compressed air, bentonite, or a binder as the flushing medium. When the required depth is reached, the grout is injected at a very high pressure as the drill string is rotated and slowly withdrawn. Use of the double, triple, and superjet systems create eroded spoil materials that are expelled out of the top of the borehole, this material is frequently used as a construction fill.

To provide a wide enough working platform on the levee crown, the upper portion of some segments of the levee may require degradation with a paddle wheel scrapper. Material is scraped and stockpiled at a nearby stockpile area. Hauling at the work area involves scraper runs along the levee to the staging area and grout, bentonite, and water deliveries to the batch plant.

Batch plants are typically centrally located to the injection site, with pipelines for mixed grout that run the length of the work. Grout mixing and injection equipment consists of grout mixers, high powered grout pumps and supporting generators and air compressors, holding tanks, and water tanks, with bulk silos of grout typically used to feed large mixers. Smaller equipment can be used in combination with the single phase-fluid system and can be permanently trailer-mounted to permit efficient mobilization and easy movement at the job site.

Prior to commencing production jet grouting, a field test program is typically completed to evaluate injection parameters and to assess jet grout column geometries, and mechanical and permeability properties. Where possible, jet grout test elements are exposed by excavation and properties are obtained by direct measurement. Where excavation is not possible, core drilling is employed to obtain samples from the jet grout test columns for strength testing.
Areas used for construction staging, the levee slope, and any other disturbed areas are restored and hydroseeded following construction.

Slope Flattening

Slope flattening is a mechanical method to repair or reshape slopes that do not meet standards for geometry and stability. Levee slopes are typically subject to a standard of 3:1 (horizontal to vertical), but this may vary based on site-specific conditions and supporting engineering analysis. Slope flattening addresses the deficiency of slope stability and geometry. To begin slope flattening activities, the area is cleared, grubbed, and stripped to provide space for construction and reshaping of slopes. Additional embankment fill material may be necessary to achieve slope flattening—if so, bulldozers excavate and stockpile borrow material from a nearby permitted borrow site. Front-end loaders load haul trucks with the borrow material. The haul trucks transport the material to slope flattening site. Motor graders spread material evenly according to levee design plans, and sheepsfoot rollers compact the material. Water trucks distribute water over the material to ensure proper moisture for compaction.

To reshape a waterside slope, the existing crown of the levee is shifted farther landward and the waterside slope is trimmed and reshaped to a 3:1 slope. The shifted levee crown will be a minimum of 20 feet wide, with a 3:1 slope on the landward side. An access road made of aggregate base rock is constructed on the levee crown. Post-construction, the construction staging areas, levee slopes, and any other disturbed areas will be hydroseeded.

Stability Berm

A stability berm will be constructed against the landside slope of the existing levee with the purpose of supplying support as a buttress. The height of the stability berm is generally two-thirds the height of the levee; the structural needs of the levee determine the distance it extends along that reach. A stability berm addresses the deficiency of stability. To begin the construction of a stability berm, the site is cleared, grubbed, and stripped to provide space for construction and shaping of the berm. Embankment fill material necessary to construct the berm is excavated by a bulldozer from a nearby borrow site. Front-end loaders load haul trucks with the borrow material, and the haul trucks transport the material to the stability berm site. Motor graders spread the material evenly according to design specifications, and a sheepsfoot roller

compacts the material. Water trucks distribute water over the material to ensure proper moisture for compaction.

Stability berms may be drained or undrained. An undrained berm consists of embankment fill only. A drained berm includes a layer of drain rock placed along the ground surface underneath the fill material, separated by a casing of filter fabric. Drainage water seeping from the berm will sheetflow on the adjacent landside surface.

Levee Reconstruction

Levee reconstruction will be necessary where a levee has been degraded to facilitate implementation of another measure (such as a slurry cutoff wall), where a substantial encroachment has been removed from within the levee prism, or otherwise where the levee is found to be deficient and needs to be replaced with materials and methods that meet current engineering standards. The existing levee is first cleared, grubbed, and stripped to the desired surface to allow a working platform for other measures (such as a slurry cutoff wall), to remove an encroachment, or to remove substandard material. Embankment fill material necessary to construct the new levee is excavated by a bulldozer from a nearby borrow site. Front-end loaders load haul trucks with the borrow material and the haul trucks transport the material to the stability berm site. Motor graders spread the material evenly according to design specifications, and a sheepsfoot roller compacts the material. Water trucks distribute water over the material to ensure proper moisture for compaction. The new levee will be built in cross section to meet current engineering standards.

Sheet-Pile Wall

A sheet-pile wall is a series of vertical panels of interlocking steel that is placed parallel to the levee, typically through the center of the levee crown to provide an impermeable barrier. A sheet-pile wall addresses the deficiencies of seepage and will be used only as a site-specific treatment (rather than applied on a reach-wide basis) such as at roadway or railroad crossings. The site where sheet piles are to be installed is cleared, grubbed, and stripped to allow for construction activities, including removal of the roadway or railroad. A hydraulic- or pneumatically-operated pile-driving head attached to a crane drives the sheet pile into the levee crown to the desired depth (up to 135 feet). If the levee material is particularly solid, pre-drilling may be necessary. The conditions of the site and the desired life of the project determine the thickness and configuration of the sheet piles.

Post-construction, construction staging areas, the levee crown, slopes, and any other disturbed areas are hydroseeded and the roadway or railroad will be replaced in-kind to the pre-project condition.

Seepage Berm

Seepage berms are wide embankment structures made up of low-permeability materials that resist accumulated water pressure and safely release seeping water. A seepage berm is typically one-third the height of the levee, extending outward from the landside levee toe for 300–400 feet, and laterally along the levee as needed relative to the seepage conditions. A seepage berm

addresses the deficiency of under-seepage. A seepage berm can vary in width, from a minimum of four times the levee height to a maximum of 300 feet. Berm heights can also vary but are typically a minimum of 5 feet tall at the landside toe of the levee and generally taper down to 3 feet at the end of the berm.

Construction consists of clearing, grubbing, and stripping the ground surface. Bulldozers then excavate and stockpile borrow material from a nearby borrow site. Front-end loaders load haul trucks, and the haul trucks subsequently transport the borrow material to the berm site. The haul trucks dump the material and motor graders spread it evenly, placing 3–5 feet of embankment fill material. Sheepsfoot rollers compact the material, and water trucks distribute water over the material to ensure proper moisture for compaction.

Seepage berms may have an optional feature of a drainage relief trench under the toe of the berm. Drained seepage berms include the installation of a drainage layer (gravel or clean sand) beneath the seepage berm backfill and above the native material at the levee landside toe. A drained seepage berm does not increase the overall footprint of the berm. Post-construction, areas used for construction staging, the levee, the berm, and any other disturbed areas are hydroseeded.

Relief Wells

Relief wells are passive systems that are constructed near the levee landside toe to provide a low-resistance pathway for under-seepage to exit to the ground surface in a controlled and observable manner. A low-resistance pathway allows under-seepage to exit without creating sand boils or piping levee foundation materials. Relief wells are an option only in reaches where geotechnical analyses have identified continuous sand and gravel layers. Relief wells are constructed using soil-boring equipment to drill a hole vertically through the fine-grained blanket layer (sand) into the coarse-grained aquifer layer (gravel) beneath. Pipe casings and gravel/sand filters are installed to allow water to flow freely to the ground surface, relieving the pressure beneath the clay blanket without transporting fine materials to the surface, which can undermine the levee foundation. Relief wells will be designed to discharge onto a cobble splash, and the water will then sheet flow into adjacent agricultural fields. In areas where sheet flow is not feasible, a swale will be excavated and connected to a drainage canal.

Relief wells generally are spaced at 50- to 100-foot intervals, dependent upon the amount of under-seepage, and extend to depths of 150 feet. Areas for relief well construction are cleared, grubbed, and stripped. During relief well construction, a typical well-drilling rig is used to drill to the required depth and construct the well (including well casing, gravel pack material, and well seal) beneath the ground surface. The drill rig likely will be an all-terrain, track-mounted rig that could access the well locations from the levee toe.

Piezometers, also called monitoring wells, could be installed between relief wells to allow monitoring of groundwater levels to ensure the wells are relieving the pressure within the aquifer.

Areas along the levee toe may be used to store equipment and supplies during construction of each well. Construction of each well and the lateral drainage system typically takes 10–20 days.

Additional time may be required for site restoration. Post-construction, areas used for construction staging, the levee slopes, and any other disturbed areas are hydroseeded.

Depression/Ditch Infilling

Landside depressions and ditches can contribute to risk of levee failure if a seepage pathway forms under the levee and the water then surfaces through the depression or ditch, exploiting its less resistive nature compared to surrounding soil mass. This measure involves placing fill soil in such depressions and ditches to remove localized susceptibility to seepage. Construction consists of clearing, grubbing, and stripping the ditch or depression surface to remove vegetative material. Bulldozers then excavate and stockpile borrow material from a nearby borrow site. Front-end loaders load haul trucks, and the haul trucks subsequently transport the borrow material to the fill site. The depression or ditch may be further excavated to provide a surface that the fill soil may be keyed into. The haul trucks dump the material and motor graders or bulldozers smooth the material level with the surrounding land surface. An excavator may also be used for placement. Sheepsfoot rollers compact the material, and water trucks distribute water over the material to ensure proper moisture for compaction.

Erosion Protection Matting

Erosion protection matting will be installed at two locations on the landside of the levee to provide protection in case of a levee overtopping event. The matting will be installed on the landside of the levee. The surface will be degraded 4 to 6 inches and the topsoil will be reserved, the matting will then be placed and anchored with steel cables and pins placed 6 feet on center to a depth of 1 foot. The edges of the matting will be buried 18 to 24 inches deep to prevent the edges from coming loose. The surface will then be hydroseeded, covered with the 2 inches of topsoil, and then hydroseeded again.

Sutter Butte Canal Seepage Remediation

The Sutter Butte Canal is adjacent to the levee at three locations in two separate reaches. This can cause seepage and stability issues as the bank of the canal is also the landside levee slope. This will be addressed through the slurry wall, but it does not allow for a maintenance easement at the landside toe of the levee. The Corps needs a 15-foot easement off the levee toe, which includes a maintenance road and access for flood fighting. In order to provide the required easement the Corps will either move the levee waterward or the canal landward to provide the space for the operation and maintenance easement. For the canal relocation, construction of the new canal would occur prior to filling of the existing canal. Once construction of the new canal is complete, it will be connected to the existing system through the removal of soil to place the new canal into service. The old canal will be dewatered and remain dry for 15 days prior to filling it. For levee relocation half of the existing levee would be degraded to create the new access road on the landside of the levee. The remaining levee would be degraded and a slurry wall would be placed at the center of the new levee location. The levee will then be rebuilt in its new location.

Removal and Relocation of Pacific Gas & Electric Facilities

Prior to and/or concurrent with levee rehabilitation construction, Pacific Gas and Electric Company (PG&E) will need to remove and relocate facilities located within the footprint of the **Proposed Project**. PG&E's utility relocations will need to occur in advance of SBFCA's **and the Corps'** construction activities at any given location. Construction sequencing for SBFCA's and **the Corps'** work will be dynamic throughout project planning and design. PG&E's construction schedule will be determined by further engineering to clarify and determine efficacy of site-specific measures; the availability of funding for the **Proposed Project**; easement and right-of-way acquisition; availability of borrow material for the levee improvement activities; and/or environmental clearances based on wildlife presence, lifecycle activity, and location of habitats. PG&E's construction schedule will be further influenced by utility operation and maintenance constraints, particularly for relocation activities that require taking existing facilities temporarily out of service. As necessary, geotechnical mitigation measures will be incorporated into construction design to ensure that utility facilities effectively co-exist with the **Proposed Project**; relocation will be done where this is not feasible.

For PG&E's electrical transmission and distribution activities, PG&E will install and remove new electrical transmission and distribution poles. Electrical transmission and distribution pole removal is conducted by a line crew, who typically access each pole site with a line truck and trailer or a boom truck, except in those instances when the pole is located on the levee crown (a crane may be used in those instances). On average, removal of vegetation up to 50 feet from the toe of the levee will need to occur to accommodate pole installation activities; this distance may be greater in instances where the installation activity is located further than 30 feet from the levee toe. After vegetation is cleared, PG&E will remove and replace the existing wood distribution and power poles and related equipment.

For PG&E's natural gas transmission and distribution activities, PG&E will install gas transmission and distribution steel pipe. This also typically includes the removal and disposal of existing pipe. Other typical types of gas transmission and distribution equipment that may be installed include Electric Test System/ Gas Cathodic Test System meter stations for future pipe monitoring purposes, and pipeline markers at angle points and at levee crossing locations. Clearing and grading operations in support of installation of natural gas facilities typically involve preparation of the right-of-way, including vegetation removal, debris disposal, and land leveling. Installation sites are backfilled using sand to create a 6-inch insulation zone around the pipe and then covered by native soil from the project area. In some instances, a crane may be required to place pipe at crossing sites located at the crowns of the levees. Dump trucks will be used to transport sand and soil materials. Spoil piles may be temporarily placed onsite while the installation activities are occurring.

Hydrostatic testing associated with installation of natural gas facilities will be performed to test the strength of the new pipeline. Test water intake and discharge will be performed in accordance with all regulations and permit requirements.

Typical electrical and natural gas transmission and distribution project work schedules are comprised of an average 9-hour day, at an average of 6 days per week per crew. Typical crews consist of 3 to 5 members.

PG&E work areas will be about 125 feet by 125 feet in diameter and located in close proximity to installation activity locations. On average, PG&E will require up to 10 work areas per **reach** phase. PG&E will utilize the work areas identified by SBFCA **and the Corps** whenever possible. Typically, PG&E project access is achieved through existing public and private roads. Removal of vegetation to utilize access roads by PG&E equipment and transport of facilities may be required. PG&E currently owns easements along the entire project corridor. However, temporary and/or permanent easements as required for construction and maintenance of these facilities are being acquired by SBFCA **and the Corps**.

Encroachment and Vegetation Removal

Encroachments - Existing facilities found within the footprint of an alternative may require removal and replacement nearby, abandonment, or relocation. Encroachments are numerous (over 400 identified) along the Feather River West Levee and may need to be addressed if they present a threat to the stability of the levee, do not currently comply with the levee encroachment criteria, or will be disrupted or otherwise impacted by construction activities. Typical encroachments include pressure pipelines (water supply pipelines from waterside pump stations and drainage pipelines from landside drainage pump stations), gravity drainage pipes, gas lines, telephone utilities, overhead utilities, structural encroachments, and other types and variations. Debris from structure and embankment fill material of poor quality will be hauled offsite to a permitted disposal site within 20 miles of the removal location.

Vegetation Removal - Vegetation removal will involve stripping of herbaceous (non-woody) vegetation by bulldozer. **The Corps will construct this project consistent with their Engineer Technical Letter 1110-2-571, *Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures* (ETL). The ETL requires that a "vegetation free zone" be maintained along all levees in order to provide access for surveillance, inspection, maintenance, monitoring, and flood-fighting.** Any vegetation removed as part of direct construction activities will not be replaced at that location, but will involve offsite, in-kind mitigation.

In accordance with the State of California's Urban Levee Design Criteria, at a minimum, all roots larger than 1.5 inches in diameter that are within 3 feet of the perimeter of the tree trunk will be removed. Immature trees less than 4 inches in diameter at breast height that will be removed may be cut off at or below ground level, generally without root removal. Any excavation will be backfilled with engineered fill using appropriate placement, moisture conditioning, and compaction methods. Additional measures for removing non-compliant vegetation are listed below.

- Ensure that the resulting void is free of organic debris.
- Cut poles to salvage propagation materials for replanting, such as willows and cottonwoods.
- Conduct hand clearing using chainsaws and trimmers.

- Conduct mass clearing using bulldozers.

Debris from vegetation removal will be hauled offsite to a permitted disposal site within 20 miles of the removal location.

Construction Staging, Access, and Temporary Facilities

Staging areas will only be provided within the Action Area. Staging areas will be used for staging construction activities and to provide space to house construction equipment and materials, offices, employee parking, and other uses needed for construction of the proposed project.

To facilitate construction, temporary earthen ramps will be constructed for equipment access between the levee crown and the staging area(s). The earthen ramps will be removed when construction is complete.

Cutoff wall construction requires temporary establishment of an onsite slurry batch plant that will occupy about 1–2 acres. Batch plants will be located at about 1-mile intervals along the levee. The batch plant site will likely contain tanks for water storage, bulk bag supplies of bentonite, bentonite storage silos, a cyclone mixer, pumps, and two generators that meet air quality requirements. Slurry ingredients will be mixed with water and the mixture will be pumped from tanks through pipes to the construction work sites. The batch plant will produce two different slurry mixes, one for trench stabilization and one for the soil backfill mix. Therefore, two slurry pipes or hoses, typically 4- or 6-inch high-density polyethelene pipes, will be laid on the ground and will extend to all work sites. An additional pipe may be used to supply water to the work sites.

Staging, access, and other temporary construction areas will be located away from wetlands, woody vegetated areas, wildlife species habitat, known cultural resources, or other sensitive areas and will be limited to disturbed or ruderal grasslands subject to review by the Corps and resource agencies.

Material Importation, Reuse, and Borrow

Materials imported to the **Proposed Project** construction area will include water, bentonite, cement, incidental construction support materials, aggregate base rock, asphalt, concrete, hydroseed, and embankment fill soil. Large quantities of fill soil, or borrow will be required. To meet borrow demands, embankment fill material excavated as part of construction will be evaluated for reuse. Embankment fill material deemed suitable will be used as part of levee reconstruction and berms. The total volume of material required is 1,500,000 cubic yards.

SBFCA has explored the option of purchasing fill or borrow material from a local commercial quarry or other permitted source; however, there are not currently any sites near the Action Area that could supply the volume and type of material required. Consequently, SFBCA and the Corps plans to purchase fill from local landowners willing to sell borrow material.

Six borrow sites have been identified in the Action Area. Each site was investigated to determine the quantity of available material, hauling distance, material composition, groundwater elevation, and prospects for acquisition. Sufficient fill volume is estimated to be present within an approximate 10-mile, one-way haul distance from the area of construction.

SBFCA **and the Corps** will maximize the potential borrow sites' use through gradation, placement, and treatment so that they could continue to be used for their current use or otherwise returned to their pre-project condition. As part of borrow operations, the upper 4–6 inches of topsoil will be set aside and replaced after construction in each construction season. After the **Proposed Project** is completed, the borrow site will be re-contoured and reclaimed.

Through outreach efforts, SBFCA identified a number of sites owned by individuals or government agencies willing to sell their property or provide material on a cubic yard basis. Each borrow site is described below.

North Valley Property - The North Valley property is owned by North Valley Properties, LLC and is located south of Ella Road between Feather River Boulevard and Arboga Road. The Wheeler Ranch housing development is proposed at the site. Borrow for the **Proposed Project** will be taken from the northeast corner of the property to create a 24.5 acre detention pond (referred to as the Drainage Basin C Regional Detention Pond, but commonly referred to as the South Ella Detention Pond). The Ella Basin is being constructed as part of Reclamation District No. 784's Master Drainage Plan. Historically, the site was cultivated for agricultural purposes. Currently, the site is disked ruderal grassland with some roads cut in the southern portion of the property for the Wheeler Ranch development. The depth of excavation is anticipated to be 15–20 feet and the yield of material from this site could be 400,000–500,000 cubic yards. Borrow material from this site will be used for work in **Reach**s B and C. If borrow material is remaining, it may also be used for **Reach** D. The haul route to **Reach** C will use existing roads. The post-project land use of the site will be a regional detention pond for Reclamation District No. 784.

Marler Property - The Marler property is a 10-acre property at Johnson Road near Messick Road, north of Star Bend and south of Shanghai Bend. The site is currently an orchard. The depth of excavation could be upwards of 6 feet. The yield of material from this site could be 75,000 cubic yards. The haul route will use existing roads. The post-project land use for the property will be agricultural production, likely row crops or orchard.

Lanza Property - The Lanza property is 40 acres in size and is currently farmed in field/row crops. It is located at North Township Road and Pease Road south of Live Oak and north of Yuba City. The site has not yet been investigated to determine the types of materials present. Excavation of the site to a depth of 6 feet may occur. The yield of material from this site could be 200,000 cubic yards. The likely haul route will be along Pease Road directly east to the levee. The post-project land use for the property will be rice production.

City of Live Oak Detention Basin - Live Oak owns the property formerly known as the Caltrans Detention Basin Site located west of SR 99 and south of Paseo Avenue. The site is currently fallow. Live Oak intends to construct soccer fields and a stormwater detention basin at the site in 2013 or later. Although the site will require hauling for a short distance through a residential

neighborhood, it is anticipated the residents will be amenable to the hauling as it will be a part of the public amenity constructed by Live Oak. This site is about 25 acres, and the depth of excavation is anticipated to be 3–6 feet. The yield of material from this site could be 125,000 cubic yards, and will likely be used for **Reach** C. Haul routes will use existing roads.

Live Oak (2012) reports that land at this location has historically been cultivated for agricultural purposes and reported that there was no evidence of any wetland or other sensitive plant or wildlife areas remaining onsite. No wetland features were identified during a preliminary wetland delineation of the area in December 2012. The previous agricultural use has displaced native species of plants and animals except those varieties capable of co-existing with humans in urban settings. The post-project use of the site will be a community park and stormwater detention basin facility.

Oroville Wildlife Area Dredge Tailings Area - This site is within the Oroville Wildlife Area and consists of several mounds of dredge tailings waterside of the existing levee. The material is suitable for use in seepage berms in **Reach** D. The availability of tailings in the area should be sufficient to meet the total deficit for berm material in these reaches. The excavation of the material will be coordinated to maximize hydraulic benefits from the reshaping of the overbank area. The site also represents an opportunity to provide waterside habitat enhancements. The useful area of this site could be about 75 acres and the depth of excavation could be upwards of 10 feet. The yield of material from this site could be 375,000 cubic yards. Hauling from this site will not take place on public roads. It is anticipated the contractor will use an existing waterside levee ramp (or create one), directly accessing the levee patrol road. The future land use for this site will be similar to its present day use (managed habitat area).

Construction Timing

Specific sequencing of construction will be dynamic throughout planning and design of the **Proposed Project**, subject to change based on factors including the following.

- Further engineering in determining the clarity and efficacy of site-specific measures.
- Easement and right-of-way acquisition (where necessary).
- Availability of proximate, suitable, and cost-effective borrow material.
- Environmental clearances based on wildlife presence, lifecycle activity, and location of habitats.

Based on current planning analysis for the **Proposed Project**, construction will occur in more than one annual construction season (typically April 15 to November 30, subject to conditions). Although subject to change, the four **reaches would be constructed over a period of 6 years.**

Construction is anticipated to occur in single 10-hour shifts, 6 days per week. An exception to this schedule is slurry cutoff wall construction, which is anticipated to occur in two 10-hour shifts (essentially 24-hour construction), 6 days per week. While actual construction will not occur between the two 10-hour shifts, equipment maintenance and preparations for the upcoming work shift will occur.

Post-Construction Operation and Maintenance

Upon project completion, the project will be turned over to California Department of Water Resources (DWR), SBFCA and the local reclamation districts for operations, maintenance, repair, replacement, and rehabilitation (OMRR&R). The Corps will provide an addendum to the O&M manual, which summarizes the duties necessary for proper operation of the project. The addendum has not yet been written and therefore, effects to listed species and conservation measures have not been analyzed or developed. The Corps will re-initiate consultation with the Service on the addendum when it is developed and prior to turning the project over to DWR, SBFCA, and the local reclamation districts.

General operation and maintenance activities include:

- **Vegetation removal and control;**
- **Rodent control and repair of rodent damage;**
- **Slope regrading and reseeding;**
- **Repair of waterside erosion;**
- **Maintenance of relief wells and collection ditches;**
- **Maintenance and repair of flap gates and closure structures; and**
- **Road/ramp maintenance.**

Conservation Measures

SBFCA **and/or the Corps** will implement the following conservation measures to avoid and minimize effects on federally listed species. To ensure their implementation, the measures listed below will be included in the project specifications.

General

Conservation Measure 1: Conduct Mandatory Biological Resources Awareness Training for All Project Personnel and Implement General Requirements

Before any ground-disturbing work (including vegetation clearing and grading) occurs in the Action Area, a Service-approved biologist will conduct a mandatory biological resources awareness training for all construction personnel about federally-listed species that could potentially occur onsite (beetle and snake). The training will include the natural history, representative photographs, and legal status of each federally-listed species and avoidance and minimization measures to be implemented. Proof of personnel attendance will be provided to the Service within 1 week of the training. If new construction personnel are added to the project, the contractor will ensure that the new personnel receive the mandatory training before starting work. The subsequent training of personnel can include videotape of the initial training and/or the use of written materials rather than in-person training by a biologist. Requirements that will be followed by construction personnel are listed below.

- Where suitable habitat is present for listed species, SBFCA **and/or the Corps** will clearly delineate the construction limits through the use of survey tape, pin flags, orange barrier fencing, or other means, and prohibit any construction-related traffic outside these boundaries.

- Project-related vehicles will observe the posted speed limit on hard-surfaced roads and a 10-mile-per-hour speed limit on unpaved roads during travel in the project construction area. Project-related vehicles and construction equipment will restrict off-road travel to the designated construction areas.
- All food-related trash will be disposed of in closed containers and removed from the project construction area at least once per week during the construction period.
- Construction personnel will not feed or otherwise attract fish or wildlife to the project site.
- No pets or firearms will be allowed in the project construction area.
- To prevent possible resource damage from hazardous materials such as motor oil or gasoline, construction personnel will not service vehicles or construction equipment outside designated staging areas.
- Any worker who inadvertently injures or kills a federally-listed species or finds one dead, injured, or entrapped will immediately report the incident to the biological monitor and construction foreman. The construction foreman will immediately notify SBFCA **and/or the Corps**, who will provide verbal notification to the Sacramento Fish and Wildlife Office and the local CDFW warden or biologist within 1 working day. SBFCA **and/or the Corps** will follow up with written notification to Service and CDFW within 5 working days. The biological monitor will follow up with SBFCA **and/or the Corps** to ensure that the wildlife agencies were notified.
- The biological monitor will record all observations of federally-listed species on California Natural Diversity Database (CNDDB) field sheets and submit to CDFW.

Valley Elderberry Longhorn Beetle

Conservation measures for the beetle are based on the Service's 1999 *Conservation Guidelines for the Valley Elderberry Longhorn Beetle* (Conservation Guidelines) (U.S. Fish and Wildlife Service 1999a).

Conservation Measure 2: Fence Elderberry Shrubs to be Protected and Monitor Fencing during Construction

Elderberry shrubs/clusters within 100 feet of the construction area that will not be removed will be protected during construction. A qualified biologist (i.e., with elderberry/beetle experience), under contract to SBFCA **or the Corps**, will mark the elderberry shrubs and clusters that will be protected during construction. Orange construction barrier fencing will be placed at the edge of the respective buffer areas. The buffer area distances will be proposed by the biologist and approved by the Service. No construction activities will be permitted within the buffer zone other than those activities necessary to erect the fencing. Signs will be posted every 50 feet (15.2 meters) along the perimeter of the buffer area fencing. The signs will contain the following information:

This area is habitat of the valley elderberry longhorn beetle, a threatened species, and must not be disturbed. This species is protected by the Endangered Species Act of 1973, as amended. Violators are subject to prosecution, fines, and imprisonment.

In some cases, where the elderberry shrub dripline is within 10 feet of the work area, k-rails will be placed at the shrub's dripline to provide additional protection to the shrub from construction equipment and activities. Temporary fences around the elderberry shrubs and k-rails at shrub driplines will be installed as the first order of work. Temporary fences will be furnished, constructed, maintained, and later removed, as shown on the plans, as specified in the special provisions, and as directed by the project engineer. Temporary fencing will be 4 feet (1.2 meters) high, commercial-quality woven polypropylene, orange in color.

Buffer area fences around elderberry shrubs will be inspected weekly by a qualified biological monitor during ground-disturbing activities and monthly after ground-disturbing activities until project construction is complete or until the fences are removed, as approved by the biological monitor and the resident engineer. The biological monitor will be responsible for ensuring that the contractor maintains the buffer area fences around elderberry shrubs throughout construction. Biological inspection reports will be provided to the project lead and the Service.

Conservation Measure 3: Conduct Beetle Surveys Prior to Elderberry Shrub Transplantation

Surveys of elderberry shrubs to be transplanted will be conducted by a qualified biologist prior to transplantation. Surveys will be conducted in accordance with the Conservation Guidelines (U.S. Fish and Wildlife Service 1999a). The biologist will survey the area surrounding the shrub to be transplanted to ensure that there are not additional elderberry shrubs that need to be removed. Surveys will consist of counting and measuring the diameter of each stem, and examining elderberry shrubs for the presence of beetle exit holes. Survey results and an analysis of the number of elderberry seedlings/cuttings and associated native plants based on the survey results will be submitted to the Service. SBFCA **and/or the Corps** plan to plant elderberry seedlings/cuttings and associated native plants prior to transplantation of elderberry shrubs. The data collected during the surveys prior to transplantation will be used to determine if SFBCA is exceeding their compensation needs or if additional plantings are necessary. Because the Proposed Action will be constructed in four separate contracts, elderberry survey data for each contract will be used to rectify any discrepancies in compensation for the previous contract and to ensure that SBFCA **and/or the Corps** has minimized effects to the beetle.

Conservation Measure 4: Water Down Construction Area to Control Dust

SFBCA, **Corps**, or the contractor will ensure that the project construction area will be watered down as necessary to prevent dirt from becoming airborne and accumulating on elderberry shrubs within the 100–foot buffer.

Conservation Measure 5: Compensate for Direct and Indirect Effects on Valley Elderberry Longhorn Beetle Habitat

Before construction begins, SBFCA **and/or the Corps** will compensate for direct effects on elderberry shrubs by transplanting shrubs that cannot be avoided to a Service-approved conservation area (described below). Elderberry seedlings or cuttings and associated native species will also be planted in the conservation area. Each elderberry stem measuring 1 inch or greater in diameter at ground level that is adversely affected (i.e., transplanted or destroyed) will be replaced, in the conservation area, with elderberry seedlings or cuttings at a ratio ranging from

1:1 to 8:1 (new plantings to affected stems). The numbers of elderberry seedlings/cuttings and associated riparian native trees/shrubs to be planted as replacement habitat are determined by stem size class of affected elderberry shrubs, presence or absence of exit holes, and whether the shrub lies in a riparian or non-riparian area. Stock of either seedlings or cuttings will be obtained from local sources (including the Action Area if acceptable to the Service).

At the discretion of the Service, shrubs that are unlikely to survive transplantation because of poor condition or location, or a plant that will be extremely difficult to move because of access problems, may be exempted from transplantation. In cases where transplantation is not possible, compensation ratios will be increased to offset the additional habitat loss.

The relocation of the elderberry shrubs will be conducted according to Service-approved procedures outlined in the Conservation Guidelines (U. S. Fish and Wildlife Service 1999a). Elderberry shrubs within the project construction area that cannot be avoided will be transplanted during the plant's dormant phase (November through the first 2 weeks of February). A qualified biological monitor will remain onsite while the shrubs are being transplanted.

Property inaccessibility and the high density of vegetation along portions of the Feather River riparian corridor limited the number of elderberry shrubs that could be surveyed (73 shrubs were surveyed). For this reason, compensation for the removal of **162** shrubs was estimated based on the average number of stems in each stem diameter range for the 73 shrubs that could be surveyed. Those average shrub stem counts are as follows.

- Number of stems $\geq$1 inch and $\leq$3 inches = 4.
- Number of stems >3 inches and <5 inches = 1.
- Number of stems $\geq$5 inches = 1.

Table 1 shows the estimated compensation. Because the shrubs are located in riparian habitat and did not have exit holes, the compensation ratios for these conditions were used. As noted in Table 1, one elderberry shrub will need to be transplanted prior to the start of work in 2013 (in Reach 13) and outside of the elderberry dormancy period.

Based on the information in Table 1, the conservation area will be at least **21.07** acres in size to accommodate about **162** elderberry shrubs, **2,550** elderberry cuttings or seedlings, and **2,550** native plants. The conservation area in which the transplanted elderberry shrubs and seedlings are planted will be protected in perpetuity as habitat for the beetle.

Evidence of beetle occurrence in the conservation area, the condition of the elderberry shrubs in the conservation area, and the general condition of the conservation area itself will be monitored over a period of 10 consecutive years or for 7 years over a 15-year period from the date of transplanting. SBFCA **and/or the Corps** will be responsible for funding and providing monitoring reports to the Service in each of the years in which a monitoring report is required. As specified in the Conservation Guidelines, the report will include information on timing and rate of irrigation, growth rates, and survival rates and mortality.

Table 1. Elderberry Stem Sizes and Compensation

Location	Stems (maximum diameter at ground level)	Exit Hole on Shrub (Yes or No)	Elderberry Seedling Ratio	Associated Native Plant Ratio	Multiplier for transplanting between June 15 – August 15	Number of Stems	Required Elderberry Plantings	Required Associated Native Plant Plantings
Riparian	stems ≥1" & ≤3"	No	2:1	1:1	No	**648**	**1,296**	**1,296**
Riparian	stems > 3" & <5"	No	3:1	1:1	No	**162**	**486**	**486**
Riparian	stems > 5"	No	4:1	1:1	No	**162**	**648**	**648**
2013 Construction - Reach 13								
Riparian	stems ≥1" & ≤3"	No	2:1	1:1	2.5	1	5	5
Riparian	stems > 3" & <5"	No	3:1	1:1	2.5	2	15	15
Riparian	stems > 5"	No	4:1	1:1	2.5	10	100	100
Total replacement plantings							**2,550**	**2,550**
Total elderberry shrubs to be transplanted								**162**
5,100 /10 = **510** valley elderberry longhorn beetle credits or **21.07** acres								

To meet the success criteria specified in the Conservation Guidelines, a minimum survival rate of 60% of the original number of elderberry replacement plantings and associated native plants must be maintained throughout the monitoring period.

Proposed Conservation Area

SBFCA **and Corps** proposes to transplant elderberry shrubs to the existing 48.5-acre Star Bend Conservation Area, located on the west levee of the Feather River, about 6 miles south of Yuba City. In 2009, Levee District 1 of Sutter County proposed to construct the Feather River Setback Levee and Habitat Enhancement Project at Star Bend to replace a portion of existing levee that poses a high risk of failure in order to decrease the flood stage, velocity, and scour potential; increase and improve floodplain habitat; and improve habitat connectivity between the Abbot Lake and O'Connor Lakes Units of CDFW's Feather River Wildlife Area. The Star Bend project created 48.5 acres of floodplain habitat, which included habitat enhancement and onsite compensation for impacted elderberry shrubs.

In 2009, River Partners and Stillwater Sciences prepared a *Habitat Enhancement Plan for the Feather River Setback Levee and Habitat Enhancement Project at Star Bend* to be implemented by Levee District 1. It provides further information on the conditions at the time the site was proposed. About 20 acres have been used for elderberry transplants and associated native plants. In early 2012, a fire at the Star Bend site damaged portions of the site; however, elderberry shrub planting losses were minimal. The remaining 28.5 acres are available at the conservation area for compensating for impacts on elderberry shrubs from construction of the **Proposed Project**.

The long-term goal of the conservation area is to merge this area with CDFW's adjoining O'Conner Lakes and Abbott Lakes Wildlife Units. SBFCA **and/or the Corp** will prepare a mitigation and monitoring plan for the 28.5 acres that are available and will be used as a conservation area for effects to the beetle, as well as riparian impacts. This plan is currently being coordinated with the Service, Corps, and CDFW. Additionally, SBFCA **and/or the Corps** will obtain a conservation easement for the 28.5 acre conservation area.

Giant Garter Snake

Conservation Measure 6: Conduct Construction Activities during the Active Period for Giant Garter Snake

Construction activity within giant garter snake aquatic and upland habitat (200 feet of aquatic habitat) will be conducted during the snake's active period (May 1–October 1). During this timeframe, potential for injury and mortality are lessened because snakes are actively moving and avoiding danger. The only work that will be conducted outside of the active season is levee slope flattening within the Sutter-Butte Canal in Reaches 26–28 (scheduled for 2016) and pipe reconstruction at two sites in the same reaches because these activities must be conducted when the canal is dry (February–March). Additional protective measures will be implemented at these locations (see Conservation Measure 14 below).

Conservation Measure 7: Install and Maintain Exclusion and Construction Barrier Fencing around Suitable Giant Garter Snake Habitat

To reduce the likelihood of giant garter snakes entering the construction area, SBFCA **and/or the Corps** will install exclusion fencing and orange construction barrier fencing along the portions of the construction area that are within 200 feet of suitable aquatic and upland habitat. The exclusion and construction barrier fencing will be installed during the active period for giant garter snakes (May 1–October 1) to reduce the potential for injury and mortality during this activity.

The construction specifications will require that SBFCA, **the Corps,** or its contractors retain a qualified biologist to identify the areas that are to be avoided during construction. Areas adjacent to the directly affected area required for construction, including staging and access, will be fenced off to avoid disturbance in these areas. Before construction, the contractor will work with the qualified biologist to identify the locations for the barrier fencing and will place flags or flagging around the areas to be protected to indicate the locations of the barrier fences. The protected area will be clearly identified on the construction specifications. The fencing will be installed the maximum distance practicable from the aquatic habitat areas and will be in place before construction activities are initiated.

The exclusion fencing will consist of 3-foot-tall silt fencing buried 6 inches below ground level. The exclusion fencing will ensure that giant garter snakes are excluded from the construction area and that suitable upland and aquatic habitat is protected throughout construction. The construction barrier fencing will be commercial-quality, woven polypropylene, orange in color, and 4 feet high (Tensor Polygrid or equivalent). The fencing will be tightly strung on posts with a maximum of 10-foot spacing.

Barrier and exclusion fences will be inspected daily by a qualified biological monitor during ground-disturbing activities and weekly after ground-disturbing activities until project construction is complete or until the fences are removed, as approved by the biological monitor and the resident engineer. The biological monitor will be responsible for ensuring that the contractor maintains the buffer area fences around giant garter snake habitat throughout construction. Biological inspection reports will be provided to the project lead and the Service.

Conservation Measure 8: Minimize Potential Impacts on Giant Garter Snake Habitat

SBFCA **and/or the Corps** will implement the following measures to minimize potential impacts on giant garter snake habitat.

- Staging areas will be located at least 200 feet from suitable giant garter snake habitat.
- Any dewatered habitat will remain dry for at least 15 consecutive days after April 15 and prior to excavating or filling of the dewatered habitat.
- Vegetation clearing within 200 feet of the banks of suitable giant garter snake aquatic habitat will be limited to the minimum area necessary. Avoided giant garter snake habitat within or adjacent to the Action Area will be flagged and designated as an environmentally sensitive area, to be avoided by all construction personnel.
- The movement of heavy equipment within 200 feet of the banks of suitable giant garter snake aquatic habitat will be confined to designated haul routes to minimize habitat disturbance.

Conservation Measure 9: Prepare and Implement a Stormwater Pollution Prevention Plan

SBFCA **and/or the Corps** will prepare a stormwater pollution prevention plan (SWPPP) that describes the BMPs that will be implemented to control accelerated erosion, sedimentation, and other pollutants during and after project construction. The SWPPP will be prepared prior to commencing earth-moving construction activities. This will also comply with the U.S. Environmental Protection Agency's National Pollutant Discharge Elimination System general construction activity stormwater permit.

The specific BMPs that will be incorporated into the erosion and sediment control plan and SWPPP will be site-specific and will be prepared by the construction contractor in accordance with the California Regional Water Quality Control Board Field Manual. However, the plan likely will include, but not be limited to, one or more of the following standard erosion and sediment control BMPs.

- **Timing of construction.** The construction contractor will conduct all construction activities during the typical construction season to avoid ground disturbance during the rainy season.
- **Staging of construction equipment and materials.** To the extent possible, equipment and materials will be staged in areas that have already been disturbed.
- **Minimize soil and vegetation disturbance.** The construction contractor will minimize ground disturbance and the disturbance/destruction of existing vegetation. This will be accomplished in part through the establishment of designated equipment staging areas,

ingress and egress corridors, and equipment exclusion zones prior to the commencement of any grading operations.

- **Stabilize grading spoils.** Grading spoils generated during the construction will be temporarily stockpiled in staging areas. Silt fences, fiber rolls, or similar devices will be installed around the base of the temporary stockpiles to intercept runoff and sediment during storm events. If necessary, temporary stockpiles may be covered with an appropriate geotextile to increase protection from wind and water erosion.
- **Install sediment barriers.** The construction contractor may install silt fences, fiber rolls, or similar devices to prevent sediment-laden runoff from leaving the construction area. Natural/biodegradable erosion control measures (i.e., coir rolls, straw wattles or hay bales) will be used. Plastic monofilament netting (erosion control matting) will not be allowed because animals can become caught in this type of erosion control material.
- **Stormwater drain inlet protection**. The construction contractor may install silt fences, drop inlet sediment traps, sandbag barriers, and/or other similar devices.
- **Permanent site stabilization**. The construction contractor will install structural and vegetative methods to permanently stabilize all graded or otherwise disturbed areas once construction is complete. Structural methods may include the installation of biodegradable fiber rolls and erosion control blankets. Vegetative methods may involve the application of organic mulch and tackifier and/or the application of an erosion control seed mix. Implementation of a SWPPP will substantially minimize the potential for project-related erosion and associated adverse effects on water quality.

Conservation Measure 10: Prepare and Implement a Bentonite Slurry Spill Contingency Plan (Frac-Out Plan)

Before excavation begins, SBFCA **and/or the Corps** will ensure the contractor will prepare and implement a bentonite slurry spill contingency plan (BSSCP) for any excavation activities that use pressurized fluids (other than water). The plan will be subject to approval by the Corps, Service, and SBFCA before excavation can begin. The BSSCP will include measures intended to minimize the potential for a frac-out (short for "fracture-out event") associated with excavation and tunneling activities; provide for the timely detection of frac-outs; and ensure an organized, timely, and "minimum-effect" response in the event of a frac-out and release of excavation fluid (i.e., bentonite). The BSSCP will require, at a minimum, the following measures.

- If a frac-out is identified, all work will stop, including the recycling of the bentonite fluid. In the event of a frac-out into water, the location and extent of the frac-out will be determined, and the frac-out will be monitored for 4 hours to determine whether the fluid congeals (bentonite will usually harden, effectively sealing the frac-out location).
- NMFS, the Service, CDFW, and the RWQCB will be notified immediately of any spills and will be consulted regarding clean-up procedures. A Brady barrel will be onsite and used if a frac-out occurs. Containment materials, such as straw bales, also will be onsite prior to and during all operations, and a vacuum truck will be on retainer and available to be operational onsite within notice of 2 hours. The site supervisor will take any necessary follow-up response actions in coordination with

agency representatives. The site supervisor will coordinate the mobilization of equipment stored at staging areas (e.g., vacuum trucks) as needed.

- If the frac-out has reached the surface, any material contaminated with bentonite will be removed by hand to a depth of 1-foot, contained, and properly disposed of, as required by law. The drilling contractor will be responsible for ensuring that the bentonite is either properly disposed of at an approved Class II disposal facility or properly recycled in an approved manner.
- If the bentonite fluid congeals, no other actions, such as disturbance of the streambed, will be taken that will potentially suspend sediments in the water column.
- The site supervisor has overall responsibility for implementing this BSSCP. The site supervisor will be notified immediately when a frac-out is detected. The site supervisor will be responsible for ensuring that the biological monitor is aware of the frac-out, coordinating personnel, response, cleanup, regulatory agency notification and coordination to ensure proper clean-up, disposal of recovered material, and timely reporting of the incident. The site supervisor will ensure all waste materials are properly containerized, labeled, and removed from the site to an approved Class II disposal facility by personnel experienced in the removal, transport, and disposal of drilling mud.
- The site supervisor will be familiar with the contents of this BSSCP and the conditions of approval under which the activity is permitted to take place. The site supervisor will have the authority to stop work and commit the resources (personnel and equipment) necessary to implement this plan. The site supervisor will ensure that a copy of this plan is available (onsite) and accessible to all construction personnel. The site supervisor will ensure that all workers are properly trained and familiar with the necessary procedures for response to a frac-out, prior to commencement of excavation operations.

Conservation Measure 11: Prepare and Implement a Spill Prevention, Control, and Counter-Measure Plan

A spill prevention, control, and counter-measure plan (SPCCP) is intended to prevent any discharge of oil into navigable water or adjoining shorelines. SBFCA, **the Corps,** or its contractor will develop and implement an SPCCP to minimize the potential for and effects from spills of hazardous, toxic, or petroleum substances during construction and operation activities. The SPCCP will be completed before any construction activities begin. Implementation of this measure will comply with State and Federal water quality regulations. The SPCCP will describe spill sources and spill pathways in addition to the actions that will be taken in the event of a spill (e.g., an oil spill from engine refueling will be immediately cleaned up with oil absorbents). The SPCCP will outline descriptions of containments facilities and practices such as doubled-walled tanks, containment berms, emergency shut-offs, drip pans, fueling procedures and spill response kits. It will also describe how and when employees are trained in proper handling procedure and spill prevention and response procedures.

SBFCA **and the Corps** will review and approve the SPCCP before onset of construction activities and routinely inspect the construction area to verify that the measures specified in the SPCCP are properly implemented and maintained. SBFCA **and/or the Corps** will notify its contractors immediately if there is a non-compliance issue and will require compliance.

The Federal reportable spill quantity for petroleum products, as defined in 40 CFR 110, is any oil spill that results in one or more of the following.

- Violates applicable water quality standards.
- Causes a film or sheen on or discoloration of the water surface or adjoining shoreline.
- Causes a sludge or emulsion to be deposited beneath the surface of the water or adjoining shorelines.

If a spill is reportable, the contractor's superintendent will notify SBFCA **and/or the Corps**, and they will take action to contact the appropriate safety and cleanup crews to ensure that the SPCCP is followed. A written description of reportable releases must be submitted to the Central Valley RWQCB. This submittal must contain a description of the release, including the type of material and an estimate of the amount spilled, the date of the release, an explanation of why the spill occurred, and a description of the steps taken to prevent and control future releases. The releases will be documented on a spill report form.

Conservation Measure 12: Conduct Preconstruction Surveys and Monitoring for Giant Garter Snake

Prior to ground-disturbing activities within 200 feet of suitable habitat, a Service-approved biological monitor will conduct a preconstruction survey of suitable aquatic and upland habitat and inspect exclusion and orange barrier fencing to ensure they are both in good working order each morning. If any snakes are observed within the construction area at any other time during construction the Service-approved biological monitor will be contacted to survey the site for giant garter snakes. The biological monitor will have the authority to stop construction activities until appropriate corrective measures have been completed or it is determined that the snake will not be harmed. Giant garter snakes encountered during construction activities will be allowed to move away from construction activities on their own. If unable to move away on their own, trapped or injured giant garter snakes will be only be removed by a biologist with a federal 10(a)1(A) permit which allows them to handle the snake and will be placed in a location determined through discussions with the Service. The biological monitor will immediately report the finding of a snake to the Service by phone and will provide a written account of the details of the incident within 24 hours.

Once all initial ground-disturbing activities are completed, the biological monitor will perform weekly checks of the site for the duration of construction in order to ensure that construction barrier fences and exclusion fences are in good order, trenches are being covered, project personnel are conducting checks beneath parked vehicles prior to their movement, and that all other required biological protection measures are being complied with. The biological monitor will document the results of monitoring on construction monitoring log sheets, which will be provided to the Service within 1 week of each monitoring visit.

Conservation Measure 13: Provide Escape Ramps or Cover Open Trenches at the End of Each Day

To avoid entrapment of giant garter snakes, thereby preventing injury or mortality resulting from falling into trenches, all excavated areas more than 1 foot deep will be provided with one or more escape ramps constructed of earth fill or wooden planks at the end of each workday. If escape ramps cannot be provided, then holes or trenches will be covered with plywood or other hard material. The biological monitor or construction personnel designated by the contractor will be responsible for thoroughly inspecting trenches for the presence of giant garter snakes at the beginning of each workday. Capture and relocation of trapped or injured individuals can only be attempted by personnel or individuals with current Service recovery permits pursuant to section 10(a)1(A) of the Act.

Conservation Measure 14: Implement Additional Protective Measures during Work in Suitable Habitat during the Giant Garter Snake Dormant Period

SBFCA **and/or the Corps** will implement additional protective measures during time periods when work must occur during the giant garter snake dormant period (October 2–April 30), when snakes are more vulnerable to injury and mortality. It is expected that these additional measures will be implemented during levee slope flattening within the Sutter-Butte Canal in Reaches 26–28 (scheduled for 2016) and pipe reconstruction adjoining the canal at two sites in the same reaches during February–March, and if construction activities extend to the period between October 2 and November 1. SBFCA **and/or the Corps** will implement additional protective measures when conducting work in suitable giant garter snake habitat between October 2 and April 30.

- A full-time Service-approved biological monitor will be onsite for the duration of construction activities.
- All emergent vegetation within the Sutter-Butte Canal on the levee side, and vegetation within 200 feet of the canal will be cleared prior to the giant garter snake hibernation period (i.e., vegetation clearing must be completed by October 1 for following winter work).
- Exclusion fencing will be installed around the perimeter of the work area and across the Sutter-Butte Canal where construction activities associated with levee slope flattening and pipe reconstruction activities will occur. The fencing should enclose the work area to the maximum extent possible to prevent giant garter snakes from entering the work area. Fencing will be installed during the active period for giant garter snakes (May 1–October 1) to reduce the potential for injury and mortality during fence installation. The Service-approved biological monitor will work with the contractor to determine where fencing should be placed and will monitor fence installation. The exclusion fencing will consist of 3-foot-tall erosion fencing buried 4– 6 inches below ground level. The exclusion fencing will minimize opportunities for giant garter snake hibernation in the adjacent upland area (between canal and existing levee).
- Portions of the Sutter-Butte Canal that are temporarily disturbed during construction will be revegetated with emergent vegetation and adjacent disturbed upland habitat will be revegetated with native grasses and forbs after construction is complete.

Conservation Measure 15: Restore Temporarily Disturbed Aquatic and Upland Habitat to Pre-Action Conditions

Upon completion of the proposed project, SBFCA **and/or Corps** will restore 42.52 acres of suitable aquatic habitat and 118.80 acres of suitable upland habitat for the giant garter snake to pre-project conditions. Restoration of aquatic vegetation and annual grassland will be detailed in a mitigation and monitoring plan that will be reviewed and approved by the Corps and Service prior to the start of construction. Habitat will be restored within one season (defined as May 1–October 1) and providing vegetative cover within 1 year of construction beginning in that area.

Conservation Measure 16: Compensate for Permanent Loss of Aquatic Habitat for Giant Garter Snake

SBFCA/**Corps** will compensate for the permanent loss of 0.004 acre of suitable aquatic habitat **and 3.54 acres of suitable upland habitat** for giant garter snake by purchasing preservation credits equal to **10.632** acres of giant garter snake habitat at Westervelt Ecological Services' Sutter Basin Conservation Bank in Sutter County or **another Service approved conservation bank**. This bank has available giant garter snake credits and is approved by both the Service and CDFW.

The **10.632** acres of habitat at the conservation bank will be protected in perpetuity for giant garter snake. Prior to the start of construction (excluding Reach 13, as there is no giant garter snake habitat in this reach), SBFCA will provide funding to Westervelt Ecological Services for credits equivalent to 0.012 acre of giant garter snake habitat at the Sutter Basin Conservation Bank. **Prior to the Corps beginning construction, they will purchase 10.62 acres of giant garter snake habitat at a Service approved conservation bank.** SBFCA and/**or the Corps** will provide the Service and CDFW with copies of the credit sale agreement and fund transfer.

Conservation Measure 17: Avoid and Minimize Potential Maintenance Impacts on Suitable Habitat for Giant Garter Snake

The Corps will coordinate with the Service and CDFW on the development of the addendum to the O&M manual. Maintenance activities will likely affect potential giant garter snake upland habitat. The Corps will work with the Service and CDFW to develop conservation measures to reduce the effects to giant garter snakes due to maintenance activities.

Analytical Framework for the Jeopardy Analysis

In accordance with policy and regulation, the jeopardy analysis in this biological opinion relies on four components: (1) the *Status of the Species*, which evaluates the beetle's and snake's range-wide condition, the factors responsible for that condition, and their survival and recovery needs; (2) the *Environmental Baseline*, which evaluates the condition of the beetle and the snake in the action area, the factors responsible for that condition, and the relationship of the action area to the survival and recovery of the beetle and snake; (3) the *Effects of the Action*, which determines the direct and indirect impacts of the proposed federal action and the effects of any

interrelated or interdependent activities on the beetle and snake; and (4) the *Cumulative Effects*, which evaluates the effects of future, non-Federal activities in the action area on the beetle and snake.

In accordance with policy and regulation, the jeopardy determination is made by evaluating the effects of the proposed Federal action in the context of the beetle's and snake's current status, taking into account any cumulative effects, to determine if implementation of the proposed action is likely to cause an appreciable reduction in the likelihood of both the survival and recovery of the beetle and snake.

The jeopardy analysis in this biological opinion places an emphasis on consideration of the range-wide survival and recovery needs of the beetle and snake and the role of the action area in the survival and recovery of the beetle and snake as the context for evaluating the significance of the effects of the proposed Federal action, taken together with cumulative effects, for purposes of making the jeopardy determination.

Status of the Species

Valley Elderberry Longhorn Beetle

Please refer to the *Valley Elderberry Longhorn Beetle (Desmocerus californicus dimorphus) 5-year Review: Summary and Evaluation* (Service 2006) for the current status of the species.

Giant Garter Snake

Please refer to the *Giant Garter Snake (Thamnophis gigas) 5-year Review: Summary and Evaluation* (Service 2012) for the current status of the species.

Environmental Baseline

Valley Elderberry Longhorn Beetle

The closest beetle occurrence in the CNDDB (2013) is about 0.5 mile from the proposed project. Suitable habitat for the beetle (in the form of elderberry shrubs) exists in numerous places along the 41 miles of proposed levee repair. A total of 267 elderberry shrubs were mapped within the action area. Many others exist at various locations between the levee and the river. Of these, SBFCA **and the Corps** are proposing to avoid **105** elderberry shrubs and transplant **162** elderberry shrubs. Because the action area is within the range of the species, there are known occurrences from the vicinity of the action area, and suitable habitat is present, the Service concludes that it is reasonably likely for the beetle to occupy the action area.

Giant Garter Snake

The *Draft Recovery Plan for the Giant Garter Snake* subdivides the range of the species into four recovery units (Service 1999b). The action area for the proposed project is located within the Sacramento Valley Recovery Unit. There are 20 records of the snake within 5 miles of the action area. The closest occurrence documented in the CNDDB is 2 miles from the action area.

Snakes have the potential to occur within the action area because suitable aquatic and upland habitat is present as it is hydrologically connected to areas that support rice agriculture and areas where the snake has previously been detected. The action area is a long corridor that occasionally has irrigation ditches, which run parallel to the levee for limited stretches. The main threat to the snake in the action area is loss of habitat or connectivity due to channel and levee maintenance.

Effects of the Proposed Action

Valley Elderberry Longhorn Beetle

One hundred sixty-two elderberry shrubs will be removed and transplanted. The **162** affected shrubs have **649** stems between 1 and 3 inches, **164** stems between 3 and 5 inches and **172** stems greater than 5 inches at ground level.

Loss of an elderberry shrub or even a stem can affect the beetle breeding and feeding because adult beetles rely solely on elderberry foliage and flowers for food and must lay their eggs on elderberry stems to successfully reproduce.

Transplantation of elderberry shrubs that are or could be used by beetle larvae is expected to adversely affect the beetle. Beetle larvae will be killed or the beetle's life cycle will be interrupted during or after the transplanting process. For example:

1. Transplanted elderberry shrubs may experience stress or become unhealthy due to changes in soil, hydrology, microclimate, or associated vegetation. This may reduce their quality as habitat for the valley elderberry longhorn beetle, or impair their production of habitat-quality stems in the future.

2. Elderberry shrubs may die as a result of transplantation.

3. Branches containing larvae may be cut, broken, or crushed as a result of the transplantation process.

SBFCA has proposed to transplant one shrub outside of the elderberry shrub's dormant season (November 1 to February 15). To offset the increased risk of the transplantation not being successful SBFCA has proposed to plant 2.5 times the number of elderberry seedlings at the Star Bend Conservation Area.

Temporal loss of habitat will occur. Although conservation measures for effects on the beetle will involve creation or restoration of habitat, it generally takes five or more years for elderberry plants to become large enough to support beetles, and it may take 25 years or longer for riparian habitats to reach their full value. Temporal loss of habitat may cause fragmentation of habitat and isolation of subpopulations.

Permanent and temporary habitat loss adversely affects the beetles breeding and foraging requirements. Habitat creation and transplantation of the shrubs will minimize these effects. Success of a restoration site has been linked to presence of transplanted elderberry shrubs that

have served to colonize a newly created riparian habitat. Transplants that survive also provide diversity within the conservation area as they are older, larger shrubs within the plantings of young small elderberry seedlings. The Star Bend Conservation Area will be protected with a conservation easement and managed in perpetuity for riparian habitat including valley elderberry longhorn beetle habitat, through development of the *Feather River West Levee Project Mitigation and Monitoring Plan.*

Given the amount of vegetation removal with this project, woody vegetation will be removed from the easement area. Thereafter, yearly maintenance would maintain the levee slopes and easement area as either grassland or maintenance road. Elderberry shrubs do not provide habitat for the valley elderberry longhorn beetle when less than 1-inch at ground level. Provided the levee maintainers remove woody vegetation including elderberry shrubs when young and less than 1-inch in diameter at ground level there should be no long-term effects of levee maintenance on valley elderberry longhorn beetles.

Giant garter snake

Aquatic habitat for the snake near the levee construction varies along the 41 miles of the proposed project. Small areas of aquatic habitat are present in **Reaches** A and C and they are hydrologically connected to areas that support habitat for the snake (rice). **Reach** D has the largest amount of snake aquatic habitat as the Sutter Butte Canal parallels the levee for longer lengths. Canal filling due to cutoff wall construction will permanently fill 0.004 acre of snake aquatic habitat. Upland habitat around this aquatic habitat will be temporarily disturbed but returned to pre-project condition within one year. Temporary effects will result from temporary fill of aquatic habitat for construction access, reshaping the slope of the Sutter Butte Canal and adjacent levee, and degradation and reconstruction of the levee. **The Sutter Butte Canal will be relocated in two locations for a total of 1,683 linear feet to allow space for the placement of an operation and maintenance road. The new canal will be constructed in advance of canal filling. Creating aquatic habitat in advance of filling the existing habitat will allow aquatic habitat to be available for the snake at all times. The work will be done during the active period for the snake so disturbance of upland habitat to create the aquatic would minimize effects to the snake given that the snake can more easily move away from the construction.** These activities will temporarily affect **11.9** acres of aquatic habitat. **In three other locations, the levee would be moved away from the Sutter Butte Canal.** Levee degradation and reconstruction will temporarily affect 112.47 acres of upland habitat. All temporarily affected areas will be restored to pre-project conditions within the same year the disturbance will occur. This will minimize effects to giant garter snakes because the amount of time the habitat will be unavailable to the snake will be minimized. Permanently affected habitat, such as the canals that will be made smaller will be offset by purchasing 0.012 acre of giant garter snake habitat at Westervelt Ecological Services' Sutter Basin Conservation Bank in Sutter County. None of the borrow sites in the project description have upland or aquatic giant garter snake habitat.

The majority of the construction work will occur during the giant garter snake active season (May 1 to October 1). Increased construction activity in areas where snakes are known to occur could expose snakes to increased risks of injury and mortality from predation, exposure, vehicular traffic, and construction equipment. Because snakes are more mobile during the active season, these effects should be lessened. There are a few activities which SBFCA could not

construct during the active season. Because of cooler temperatures in the inactive season (October 1 to May 1), the snake is not as mobile and is most frequently found within burrows. Ground disturbing activities during this timeframe will increase the likelihood of snake mortality when the burrows are disturbed with heavy equipment. SBFCA has proposed to disturb (clear and grub) the out of season work area and place exclusion fencing around the work area during the active season which will create an area that will not support overwintering snakes (lack of burrows). This will minimize the chance of injuring or killing an overwintering snake during out of season construction. This will only occur on one side of the canal, leaving the other side of the canal available as overwintering habitat for the snake.

Placement of erosion matting will permanently cover 3.54 acres of upland giant garter snake habitat, reducing its use to the snake by disallowing the creation of ground squirrel burrows. Snakes use the burrows year round for thermoregulation and hibernacula. The loss of this area would mean that snakes would have to move further to find areas for refuge and may be at a greater risk of predation. The Corps has proposed to offset the loss of this habitat by purchasing 10.62 acres of giant garter snake habitat at a Service approved conservation bank.

Temporary effects within the action area will affect both aquatic and upland snake habitat. In some locations degradation of the levee could cause soil to fall into the aquatic habitat or fuel or oil leaks could also adversely affect the habitat and the snake. Placement of sediment fencing and implementing sediment and contaminant BMPs will lessen this effect. Levee degradation will temporarily make upland habitat unavailable to the snake during the active season. Snakes use upland habitat for thermoregulation both as a place to bask and as a place to escape extreme heat (burrows) and cover for shedding and giving birth to young. While snakes are more active during the summer months and more likely to move away from construction, some snakes may choose to remain where they are and therefore will be subject to mortality when construction activities are occurring. In addition to direct mortality, the upland habitat will be temporarily unavailable to the snake during construction. Even once construction is completed it will take a year or two for the upland habitat to become completely functional for the snake, with burrows or crevices available for them to use. This is likely to result in disturbance, displacement, injury, and/or mortality of snakes. To lessen these effects SBFCA is implementing the conservation measures described above as well as affecting only one side of the canal. This will leave the other side of the canal intact and available to the snake for use, minimizing displacement of snakes. Additionally, because of the staging of construction not all of the upland habitat will be unavailable for use at one time. It will be staged as construction progresses through the various reaches.

Long-term operation and maintenance of the levee will have some effects to giant garter snake. At this time, the Corps has not provided a detailed description of the activities that will be carried out by the local levee maintainers. This will be described in the addendum to the operation and maintenance manual. The Corps intends to coordinate with the Service during the development of the addendum and will provide a description of the actions as well as conservation measures to minimize and avoid effects to giant garter snake. Operation and maintenance is less ground disturbing than that which is described as a result of the construction of the project and therefore there will be fewer effects to the giant garter snake. However, the Service cannot determine the extent of the effects nor the

amount of incidental take until the addendum to the operation and maintenance manual is completed and the Corps reinitiates consultation with the Service.

Cumulative Effects

Cumulative effects include the effects of future State, Tribal, local, or private actions that are reasonably certain to occur in the action area considered in this biological opinion. Future Federal actions that are unrelated to the proposed project are not considered in this section, because they require separate consultation pursuant to section 7 of the Act. Any future land use conversions and routine agricultural practices are not subject to Federal authorization or funding and may alter the habitat or result in take of listed valley elderberry longhorn beetle or giant garter snake and are, therefore, cumulative to the proposed project.

Conclusion

After reviewing the current status of the valley elderberry longhorn beetle and giant garter snake, the environmental baselines for these species, the effects of the proposed project, and the cumulative effects on this species, it is the Service's biological opinion that the **Proposed Project**, as described herein, is not likely to jeopardize the continued existence of these species. Although critical habitat has been designated for the beetle, the proposed action will not affect critical habitat.

INCIDENTAL TAKE STATEMENT

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the Act prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harass is defined by the Service as an intentional or negligent act or omission which creates the likelihood of injury to a listed species by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding or sheltering. Harm is defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by impairing behavioral patterns including breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act, provided that such taking is in compliance with this Incidental Take Statement.

The measures described below are nondiscretionary for listed species of this biological opinion and must be implemented by the Corps and SBFCA in order for the exemption in section 7(o)(2) to apply. The Corps has a continuing duty to regulate the activity that is covered by this incidental take statement. If the Federal agency (1) fails to adhere to the terms and conditions of the incidental take statement, and/or (2) fails to retain oversight to ensure compliance with these terms and conditions, the protective coverage of section 7(o)(2) may lapse.

Amount or Extent of Take

Valley Elderberry Longhorn Beetle

The Service expects that incidental take of the valley elderberry longhorn beetle will be difficult to detect or quantify. The cryptic nature of this species and their relatively small body size make the finding of an injured or dead specimen unlikely. The species occurs in habitats that make them difficult to detect. Due to the difficulty in quantifying the number of beetles that will be taken as a result of the proposed action, the Service is quantifying take incidental to the project as the number of elderberry stems one inch or greater in diameter at ground level (beetle habitat) that will become unsuitable for beetles due to direct or indirect effects as a result of levee construction. Therefore, the Service estimates that all beetles inhabiting **162** elderberry plants containing stems 1 inch or greater at ground level (**649** stems between 1-3 inches, **164** stems between 3 and 5 inches and **172** stems ≥5 inches; see Table 1 in the text) will be taken as a result of the proposed action.

Giant Garter Snake

The Service anticipates that incidental take of the snake will be difficult to detect or quantify for the following reasons: the snake is cryptically colored, secretive, and known to be sensitive to human activities. Snakes may avoid detection by retreating to burrows, soil crevices, vegetation, or other cover. Individual snakes are difficult to detect unless they are observed, undisturbed, at a distance. Most close-range observations represent chance encounters that are difficult to predict. It is not possible to make an accurate estimate of the number of snakes that will be harassed, harmed or killed during construction activities (staging areas, work on canal banks, levee degradation and reconstruction, soil borrow areas, and vehicle traffic to and from borrow areas). **Given the lack of information on the addendum to the operation and maintenance manual, activities associated with this addendum are not included in this biological opinion.** In instances when take is difficult to detect, the Service may use the quantification of acreage as a surrogate for the individuals that will be taken. Therefore, the Service anticipates take incidental to this project as the 3.544 acre of suitable habitat that will be permanently lost and the **124.37** acres (**11.90** acres aquatic and 112.47 acres upland) of suitable snake habitat that will be temporarily lost. Upon implementation of the Reasonable and Prudent Measure, Terms and Conditions, and the Proposed Conservation Measures considered herein, incidental take within this acreage for the proposed project, will be exempt from the prohibitions described under Section 9 of the Act. **Operation and Maintenance activities are not included in the amount of take in this biological opinion.**

Effect of the Take

The Service has determined that this level of anticipated take is not likely to result in jeopardy to the beetle or snake.

Reasonable and Prudent Measures

The Service has determined that the following reasonable and prudent measure is necessary and appropriate to minimize the adverse effects of the Feather River West Levee Project to the beetle and snake and their habitat in the action area.

1. Minimize the adverse effects to the beetle and snake and their habitat in the action area.

Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the Act, the Corps and SBFCA must ensure compliance with the following terms and conditions, which implement the reasonable and prudent measures described above. These terms and conditions are nondiscretionary.

The following Terms and Conditions implement the Reasonable and Prudent Measure:

1. All the conservation measures as described in the project description, and as restated here in this biological opinion, must be fully implemented and adhered to.

2. The Corps, SBFCA, and PG&E shall include full implementation and adherence to the conservation measures as outlined in the biological opinion as a condition of any permit or contract issued for the project.

3. In order to monitor whether the amount or extent of take anticipated from implementation of the proposed project is approached or exceeded, the Corps and SBFCA shall adhere to the following reporting requirement. Should this anticipated amount or extent of incidental take be exceeded, the Corps must immediately reinitiate formal consultation as per 50 CFR 402.16.

    a. For those components of the proposed project that will result in habitat degradation or modification whereby incidental take in the form of harm or mortality is anticipated, the Corps and SBFCA will provide weekly updates to the Service with a precise accounting of the total acreage of habitat effected or number of elderberry shrubs and size of stems at ground level transplanted. Updates shall also include any information about changes in the Project Description not analyzed in this biological opinion.

4. SBFCA **and the Corps** shall provide a photo documentation report showing pre- and post-project area conditions for giant garter snake.

Salvage and Disposition of Individuals

The Sacramento Fish and Wildlife Office will be notified within 1 day of the finding of any dead or injured snake or beetle to determine the appropriate measures for salvage and disposition. The Service contact person is the Habitat Conservation Division Chief. In addition, the Recovery Division Chief shall also be notified within 1 day of the procedures implemented for salvage and disposition of the snake or beetle. The applicant must report to the Service immediately any

information about take or suspected take of listed species not authorized in this biological opinion. Notification must include the date, time, and location of the incident or of the finding of a dead or injured listed species. The Habitat Conservation and Recovery Divisions Chiefs can be contacted at (916) 414-6600. The California Department of Fish and Wildlife should also be contacted at (916) 358-2900.

CONSERVATION RECOMMENDATIONS

Conservation recommendations are suggestions of the Service regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of new information. These measures may serve to further minimize or avoid the adverse effects of a proposed action on listed, proposed, or candidate species, or on designated critical habitat. They may also serve as suggestions on how action agencies can assist species conservation in furtherance of their responsibilities under section 7(a)(1) of the Act, or recommend studies improving an understanding of a species' biology or ecology. Wherever possible, conservation recommendations should be tied to tasks identified in recovery plans. The Service is providing you with the following conservation recommendations:

1. The Corps and SBFCA should assist in the implementation of the draft, and when published, the final Recovery Plan for the snake.

2. The Corps and SBFCA should provide funding to researchers studying topics identified by the Service in the draft, and when published, the final Recovery Plan for the snake.

3. The Corps should use environmental restoration authorities to acquire and restore beetle and snake habitat.

To be kept informed of actions minimizing or avoiding adverse effects or benefiting listed and proposed species or their habitats, the Service requests notification of the implementation of any conservation recommendations.

REINITIATION - CLOSING STATEMENT

This concludes formal consultation with the Corps on the Feather River West Levee Project. As provided in 50 CFR 402.16, re-initiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been maintained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the proposed action may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect to listed species or critical habitat that was not considered in this opinion; or (4) a new species or critical habitat is designated that may be affected by the proposed action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending re-initiation.

If you have any questions regarding this Feather River West Levee Project biological opinion, please contact Jennifer Hobbs, at (916) 414-6541 or Doug Weinrich, Deputy Assistant Field Supervisor, at (916) 414-6563.

Sincerely,

for Jennifer M. Norris
Field Supervisor

cc:
Jeff Koschak, Corps, Sacramento, CA
Matt Davis, Corps, Sacramento, CA
Jenny Marr, CDFW, Chico, CA
Jennifer Haire, ICF, Sacramento, CA

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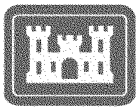

US Army Corps
of Engineers®

Sacramento District
Real Estate Division

Sutter Basin Pilot Feasibility Report - Environmental Impact Report / Supplemental Environmental Impacts Statement

Butte and Sutter Counties, California

REAL ESTATE APPENDIX E

June 2013
Revised: October 2013

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Real Estate Plan
For
Sutter Basin Pilot Feasibility Study
Sutter & Butte Counties, California

1. Statement of Purpose

This Real Estate Plan (REP) is intended to support and present the real estate requirements for the Sutter Basin Pilot Feasibility Study located in Sutter and Butte Counties, California. This REP focuses on the SB-7 and SB-8 alternatives which ultimately identified the Recommended Plan, and is to be used for planning purposes only. Alternative SB-8 has been granted a waiver by the Assistant Secretary of the Army's office as an exception to policy to consider the Locally Preferred Plan (LPP) as the Recommended Plan. There may be modifications to the project and its plans that occur during the Preconstruction, Engineering and Design (PED) phase, thus changing the final acquisition area(s) and/or administrative and land costs reflected in this REP.

This report presents the Real Estate requirements for the Sutter Basin Pilot Feasibility Study, Sutter and Butte Counties, California.

A high risk of flooding from levee failure threatens the public safety of approximately 95,000 people, as well as property and critical infrastructure throughout the Sutter Basin study area. Past flooding events have caused loss of life and extensive economic damages. Recent geotechnical analysis and evaluation of past levee performance indicate the existing project levees, which are part of the authorized Sacramento River Flood Control Project, do not meet current U.S. Army Corps of Engineers (USACE) levee design criteria, and are at risk of breach failure at stages less than overtopping of the levees.

This Real Estate Plan supports the Sutter Basin Pilot Feasibility Study the purpose of which is to investigate and determine the extent of Federal interest in plans that reduce flood risk to the Sutter Basin in Sutter and Butte Counties. That report: (1) assesses the risk of flooding; (2) describes a range of alternatives formulated to reduce flood risk; and (3) identifies a tentatively selected plan (TSP) for implementation. That report constitutes both a draft Feasibility Report that describes a USACE "pilot" planning process followed to identify the Recommended Plan, and an Environmental Impact Statement/Environmental Impact Report (EIS/EIR) required to comply with the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA). Following public and governmental agency review, that draft report will be finalized and submitted to Headquarters, USACE, for review and approval, then transmitted to Congress for recommended project authorization. Project construction would also be dependent upon Congressional appropriation of funding for the Federal share of the project.

2. Project Authority

The authority for the USACE to study Flood Risk Management (FRM) and related water resources problems in the Sacramento River Basin, including the study area in Sutter and Butte Counties, is provided in the Flood Control Act of 1962, Public Law No. 87-874, § 209, 76 Stat. 1180, 1196 (1962).

The existing project levees of the Sutter Basin provide FRM as part of the more comprehensive Sacramento River Flood Control Project (SRFCP) which was authorized by the Flood Control Act of 1917.

The purpose of the Sutter Basin Pilot Feasibility Study analyzed in the Report and this REP, is to address flood risk-related issues in the study area. The study is a General Investigations study undertaken to evaluate structural and non-structural FRM measures including re-operation of existing reservoirs, improvements to existing levees, construction of new levees, and other storage conveyance and non-structural options.

The Report presents planning, engineering, and implementation details of the recommended plan to allow final design and construction to proceed provided USACE approval of the Recommended Plan, and is thereafter expected to be the basis for a recommendation to Congress for authorization of a new project.

3. Project Description

Specifically, this REP identifies the real estate costs for the NED Plan (Alternative SB-7) and the Recommended Plan (SB-8). Alternative SB-7 consists of strengthening approximately 27 miles of the existing Feather River West Levee from Sunset Weir to Laurel Avenue. The Recommended Plan (SB-8) consists of strengthening approximately 41 miles of the existing Feather River West Levee to Thermalito Afterbay and addresses the flooding risks in the communities of Biggs, Gridley, and Live Oak. Alternative SB-8 is supported by the local sponsors as the Recommended Plan, and can be considered in a multi-objective planning context to be a more comprehensive and complete Federal plan. Alternative SB-8 has been granted a waiver by the Assistant Secretary of the Army's office as an exception to policy to consider the LPP as the Recommended Plan and is discussed in more detail in the main Report.

Sutter and Butte counties lie in a portion of north-central California known as the Sacramento Valley. The project area is approximately 40 miles north of the City of Sacramento. The counties are significant components of the Sacramento River Flood Control Project (SRFCP). The SRFCP includes levees along the Sacramento River, the Sutter Bypass, the Feather River, Yankee Slough, Wadsworth Canal Cross Canal and Tisdale Bypass. In 1968, the Oroville Dam was completed, and over the years various improvements have been made to the original levee system to reinforce and enhance flood protection for the basin. Repairs have been made to major weaknesses in local levees since 1997. The most recent construction projects include the Wadsworth Canal slurry wall completed in 2008, and the Feather River setback levee at Star Bend that was completed in 2009.

Components of the Sacramento River Flood Control Project define an area within the counties known as the Sutter-Butte basin. The basin is generally bounded by the Sutter Bypass to the west and south, the Feather River to the east and south, and the Thermalito Afterbay to the north. Urbanized areas located within the basin include Biggs, Gridley, Live Oak and Yuba City. The Feather River flows south through Butte County from the City of Oroville and enters Sutter County near the community of Live Oak. The Feather River forms the Sutter/Yuba County line before flowing into the Sacramento River in southern Sutter County. The Sutter Bypass bisects Sutter County from the Sutter Buttes in the northwest to the Sacramento River in the south. The Sutter Bypass acts as flood relief for the Sacramento River. The Sutter Bypass conveys floodwaters from Butte Basin and additional floodwaters from the Sacramento River through the Tisdale Bypass, which connects to the Sacramento River downstream from the town of Grimes.

The Sutter Butte Flood Control Agency (SBFCA) is proposing to construct the Feather River West Levee Project (FRWLP) to reduce flood risk in the Sutter Basin, which includes portions of Sutter and Butte Counties in the Sacramento Valley of California. The SBFCA was formed as a joint powers authority in 2007 through a joint exercise of powers agreement by the Counties of Sutter and Butte; the Cities of Yuba City, Gridley, Live Oak, and Biggs; and Levee Districts 1 and 9 (LD 1 and LD 9).

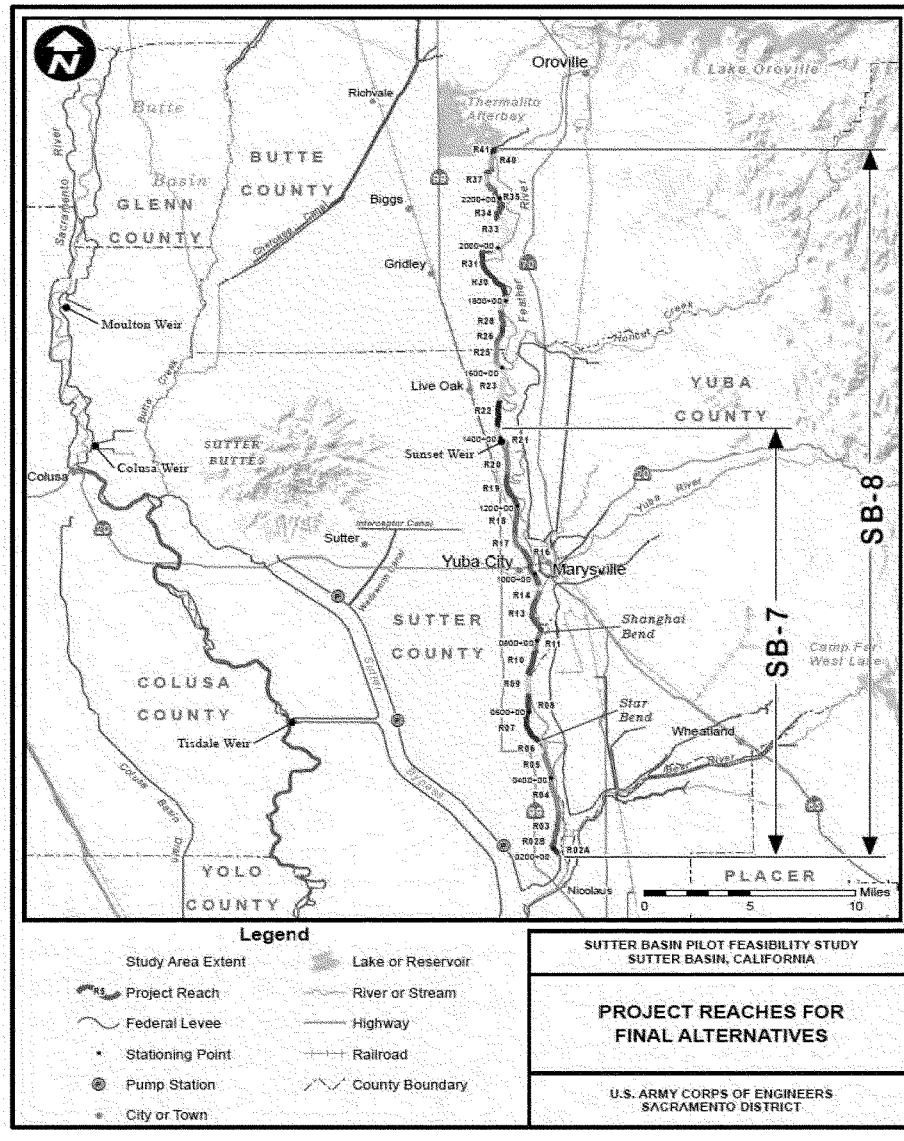
In partnership with the State of California (through the California Department of Water Resources (DWR) and the Central Valley Flood Protection Board (CVFPB), the SBFCA embarked on a comprehensive evaluation of the condition of the levees protecting the area in 2007, the results of which are also being used by the U.S. Army Corps of Engineers (USACE). The evaluation was necessary to identify the magnitude and severity of deficiencies and determine measures to address the deficiencies. The results of the comprehensive evaluation revealed that substantial construction is necessary to meet current flood protection standards.

The FRWLP is being advanced by SBFCA to expeditiously reduce flood risk before the Sutter Basin Pilot Feasibility Study is completed.

To construct the FRWLP, the SBFCA has requested permission from USACE pursuant to Section 14 of the Rivers and Harbors Act of 1899 (33 USC § 408) (hereinafter the "Section 408 permit") for its proposed alteration of an existing federal levee previously constructed as part of the SRFCP. The Report and this REP does not analyze the Section 408 permit, but rather focuses only on the Federal NED Plan (Alternative SB-7) and the Recommended Plan (Alternative SB-8).

4. Description of Lands, Easements, Rights of Way, Relocations and Disposals (LERRDs)

For Alternatives SB-7 and SB-8, a reach identification system was developed as shown in the table below.



The real estate cost estimate of Alternatives SB-7 and SB-8 was developed based on the conventional approach for development of feasibility level design. During development of the REP, the real estate cost estimate was developed for alternatives SB-7 and SB-8 in accordance with ER 405-1-12 and based upon the footprints delineating project requirements developed by the Sacramento's Engineering Division. The Lands, Easements, Rights of Way, Relocations and Disposal (LERRDs) requirements for the REP include: the acquisition of flood protection levee easements, permanent road easements, utility easements, drainage easements, temporary work area easements, borrow easements, and mitigation fee title. The basis for the different types of acquisitions are as follows:

- Flood protection levee easements are required for the construction and operation and maintenance of project levee features. The easements vary in width and are delineated by the toe of existing levee and boundary of the seepage berms (within the project's limit), relocated levee segments and new seepage berms.

- 15 foot permanent road easements along the landside and waterside edge of the flood protection levee easements, at a minimum, are needed for providing maintenance access to and for flood fighting purposes along the toe of the project features.

- Flood protection levee easements and permanent road easements together will be sufficient to cover the acquisition needed for the vegetation free zone and to allow for the movement of construction equipments within the construction site.

- Additional utility easements (approximately 20ft beyond the permanent road easement for O&M roads) may also be needed for obtaining utility corridors for relocation of utilities such as poles and pipelines running parallel to the project's alignment outside of the proposed ROW. The specific locations of these additional utility easements have yet to be identified. The potential costs of such easements were determined by calculating the projected 20 foot easement outside the O&M corridor for the length of the project. These costs are included in the cost estimate tables.

- Drainage Easements are required for the Sutter-Butte Canal relocations. The location of said easements generally falls within [(1) between stations 1429+00 and 1432+70, and (2) between station 1754+30 and 1766+00], and the costs of the easements are covered by existing contingencies in the real estate appraisal.

- Temporary work area easements are required for acquiring staging areas along the length of the project.

- Borrow easements are required for potential borrow sites as shown in the borrow maps.

- Potential on-site mitigation areas will be acquired in fee title as shown in the maps.

Alternative SB-7 contains 21 reaches (2A north to 21) along the Feather River West Levee (FRWL) alignment, beginning at the same point south of Laurel Avenue and extending approximately 24 miles north to immediately north of Sunset Weir (station 1433+83). There are an estimated 292 parcels identified in Alternative SB-7 for project. The real estate costs for Alternative SB-7 are estimated at $42,390,000. There are 242 acres of levee easements, road easements and temporary work easements required for Alternative SB-7. There are also 1,771 acres of potential borrow sites identified and 71 acres of on- site mitigation proposed for Alternative SB-7.

The potential design features of Alternative SB-7 (Reaches 2 – 21) include the following:

Reach	Station	Length (feet)	Primary Design Measures
2A North	180+00 to 202+50	2,250	Cutoff wall with 100-foot-wide undrained seepage berm
2B	202+50 to 218+66	1,616	Cutoff wall with 100-foot-wide undrained seepage berm
3	218+66 to 300+66	8,200	Cutoff wall with 100-foot-wide undrained seepage berm (218+66 to 231+00) Cutoff wall (230+00 to 231+00)
4	300+66 to 410+67	11,001	Cutoff wall
5	410+67 to 478+68	6,801	Cutoff wall (410+67 to 478+65) Cutoff wall with 300-foot-wide undrained seepage berm (453+00 to 478+00)
6 FIP	478+68 to 512+00	3,332	Cutoff wall
6 SB	478+68 to 512+00	3,332	Remove the existing levee and construct a setback levee with 65-foot-deep (from degrade line) cutoff wall
7	512+00 to 596+00	8,563	Cutoff wall (512+00 to 596+00) Cutoff wall with relief wells (545+00 to 570+00) Erosion Protection (High-Performance Turf Reinforced Mat) (547+00 to 596+00)
8	596+00 to 654+75	5,875	Cutoff wall (596+00 to 654+75) Erosion Protection (High-Performance Turf Reinforce Mat) (596+00 to 604+60)
9	654+75 to 706+50	5,175	Cutoff wall
10	706+50 to 774+00	6750	Cutoff wall
11	774+00 to 830+00	5,600	Cutoff wall
12	830+00 to 845+00	1,500	No proposed design measure with exceptions below Cutoff wall (transition only, at both ends of this reach) Cutoff wall, transition only (830+00 to 831+50) Cutoff wall, transition only (844+50 to 845+00)
13	845+00 to 927+00	8,200	Cutoff wall Cutoff wall with full levee degrade and re-construction (844+50 to 897+50)
14	927+00 to 954+40	2,740	No proposed rehabilitation measure
15	954+40 to 968+50	1,410	No proposed rehabilitation measure
16	968+50 to 1080+00	11,150	Jet grouting cutoff wall at 5th Street bridge crossing (1006+04 to 1007+90) Toe berm, 23 feet wide, at 10th Street bridge crossing (1023+90 to 1027+50) Cutoff wall and backfill landside toe depression, transition only (1077+85 to 1080+00)

Reach	Station	Length (feet)	Primary Design Measures
17	1080+00 to 1130+86	5,086	Backfill landside toe depression (1107+00 to 1125+70) Cutoff wall (1080+00 to 1096+00) Jet grouting cutoff wall at Yuba City water treatment plant (1095+80 to 1098+30 Cutoff wall (1098+10 to 1129+50) Jet grouting cutoff wall at railroad north of Yuba City (1129+50 to 1130+67) Cutoff wall (1130+20 to 1130+86) Stop log closure structure or equivalent at 1130+00
18	1130+86 to 1213+85	8,299	Cutoff wall
19	1213+85 to 1297+83	8,398	Cutoff wall
20	1297+83 to 1374+33	7,650	Cutoff wall
21	1374+33 to 1433+83	5,950	Cutoff wall (1374+33 to 1432+50) Cutoff wall with levee relocation (20 feet riverward, transition only), (1432+50 to 1433+83) Sutter Butte Canal relocation (1429+00 to 1433+83)

Recommended Plan SB-8 contains 41 reaches (2A north to 41) along the FRWL alignment, beginning approximately 1.7 miles north of the State Route 99 bridge over the Feather River (at station 180+00, approximately 2,250 feet south of Laurel Avenue) and extends north approximately 41 miles to the Thermalito Afterbay, downstream of Oroville Dam (at station 2368+00). There are an estimated 468 parcels identified in Alternative SB-8 for project implementation. The real estate costs for SB-8 are estimated at $53,546,000. There are 401.6 acres of levee easements, road easements and temporary work easements for Alternative SB-8. There are also 1,771 acres of potential borrow sites identified and there are 71 acres of on-site mitigation proposed for Alternative SB-8.

The potential design features of Alternative SB-8 (Reaches 2 – 16) include the following

Reach	Station	Length (feet)	Primary Design Measures
2A North	180+00 to 202+50	2,250	Cutoff wall with 100-foot-wide undrained seepage berm
2B	202+50 to 218+66	1,616	Cutoff wall with 100-foot-wide undrained seepage berm
3	218+66 to 300+66	8,200	Cutoff wall with 100-foot-wide undrained seepage berm (218+66 to 231+00) Cutoff wall (230+00 to 231+00)
4	300+66 to 410+67	11,001	Cutoff wall
5	410+67 to 478+68	6,801	Cutoff wall (410+67 to 478+65) Cutoff wall with 300-foot-wide undrained seepage berm (453+00 to 478+00)
6 FIP	478+68 to 512+00	3,332	Cutoff wall
6 SB	478+68 to 512+00	3,332	Remove the existing levee and construct a setback levee with 65-foot-deep (from degrade line) cutoff wall
7	512+00 to 596+00	8,563	Cutoff wall (512+00 to 596+00) Cutoff wall with relief wells (545+00 to 570+00) Erosion Protection (High-Performance Turf Reinforced Mat) (547+00 to 596+00)
8	596+00 to 654+75	5,875	Cutoff wall (596+00 to 654+75) Erosion Protection (High-Performance Turf Reinforce Mat) (596+00 to 604+60)
9	654+75 to 706+50	5,175	Cutoff wall
10	706+50 to 774+00	6750	Cutoff wall
11	774+00 to 830+00	5,600	Cutoff wall
12	830+00 to 845+00	1,500	No proposed design measure with exceptions below Cutoff wall (transition only, at both ends of this reach) Cutoff wall, transition only (830+00 to 831+50) Cutoff wall, transition only (844+50 to 845+00)
13	845+00 to 927+00	8,200	Cutoff wall Cutoff wall with full levee degrade and re-construction (844+50 to 897+50)
14	927+00 to 954+40	2,740	No proposed rehabilitation measure
15	954+40 to 968+50	1,410	No proposed rehabilitation measure
16	968+50 to 1080+00	11,150	Jet grouting cutoff wall at 5th Street bridge crossing (1006+04 to 1007+90) Toe berm, 23 feet wide, at 10th Street bridge crossing (1023+90 to 1027+50) Cutoff wall and backfill landside toe depression, transition only (1077+85 to 1080+00)

The potential design features of Alternative SB-8 (Reaches 17 – 27) include the following:

Reach	Station	Length (feet)	Primary Design Measures
17	1080+00 to 1130+86	5,086	Backfill landside toe depression (1107+00 to 1125+70) Cutoff wall (1080+00 to 1096+00) Jet grouting cutoff wall at Yuba City water treatment plant (1095+80 to 1098+30 Cutoff wall (1098+10 to 1129+50) Jet grouting cutoff wall at railroad north of Yuba City (1129+50 to 1130+67) Cutoff wall (1130+20 to 1130+86) Stop log closure structure or equivalent at 1130+00
18	1130+86 to 1213+85	8,299	Cutoff wall
19	1213+85 to 1297+83	8,398	Cutoff wall
20	1297+83 to 1374+33	7,650	Cutoff wall
21	1374+33 to 1433+83	5,950	Cutoff wall (1374+33 to 1432+50) Cutoff wall with levee relocation (20 feet riverward, transition only), (1432+50 to 1433+83) Sutter Butte Canal relocation (1429+00 to 1433+83)
22	1433+83 to 1503+83	7,000	Cutoff wall with levee relocation (20 feet riverward) (1433+83 to 1450+00) Cutoff wall with levee relocation (20 feet riverward, transition only) (1450+50 to 1451+50) Cutoff wall with full levee degrade and re-construction (1455+00 to 1461+00) Cutoff wall (1461+00 to 1503+83)
23	1503+83 to 1609+37	10,554	Cutoff wall (1503+83 to 1608+75) Cutoff wall with levee relocation (20 feet riverward, transition only)(1608+50 to 1609+37) Erosion Protection: High-Performance Turf Reinforce Mat (1582+00 to 1601+00)
24	1609+37 to 1623+86	1,449	Cutoff wall with levee relocation (20 feet riverward, transition only) (1609+37 to 1612+00) Cutoff wall with levee relocation (20 feet riverward) (1612+00 to 1623+00) Cutoff wall with levee relocation (20 feet riverward, transition only) (1623+00 to 1623+86)
25	1623+86 to 1674+37	5,051	Cutoff wall with levee relocation (20 feet riverward, transition only) (1623+86 to 1624+50) Cutoff wall (transition only)(1623+86 to 1625+00) Cutoff wall (transition only)(1673+00 to 1674+37) Cutoff wall with levee relocation (20 feet riverward, transition only) (1673+00 to 1674+37)
26	1674+37 to 1707+11	3,274	Cutoff wall with levee relocation (20 feet riverward, transition only) (1674+37 to 1675+00) Cutoff wall with levee relocation (20 feet riverward) (675+00 to 1707+11)
27	1707+11 to 1721+60	1,449	Cutoff wall with levee relocation (20 feet riverward) (1707+11 to 1721+60)

The potential design features of Alternative SB-8 (Reaches 28 – 41) include the following:

Reach	Station	Length (feet)	Primary Design Measures
28	1721+60 to 1769+31	4,771	Cutoff wall with levee relocation (20 feet riverward)(1721+60 to 1753+00) Cutoff wall with levee relocation (20 feet riverward, transition only)(1753+00 to 1754+50) Sutter Butte Canal Relocation (1752+00 to 1766+00) Cutoff wall (1754+50 to 1769+31)
29	1769+31 to 1813+33	4,402	No proposed rehabilitation measure
30	1813+33 to 1902+00	8,867	Cutoff wall (1813+33 to 1900+50) Jet grouting cutoff wall (1900+00 to 1902+00)
31	1902+00 to 1958+00	5,600	Jet grouting cutoff wall (1902+00 to 1904+00) Cutoff wall (1904+50 to 1958+00)
32	1958+00 to 1989+00	3,100	Cutoff wall
33	1989+00 to 2122+00	13,300	Cutoff wall
34	2122+00 to 2182+00	6,000	Cutoff wall
35	2182+00 to 2224+00	4,200	Cutoff wall
36	2224+00 to 2259+00	3,500	Cutoff wall
37	2259+00 to 2290+00	3,100	Cutoff wall
38	2290+00 to 2303+00	1,300	Seepage berm up to 11 feet high tapering to a distance 170 feet from the centerline of the existing levee (2290+00 to 2303+00) Seepage berm with cutoff wall (transition only, extend from reach 37 into reach 38 Cutoff wall (transition only) (2290+00 to 2292+00)
39	2303+00 to 2319+00	1,600	No proposed rehabilitation measure
40	2319+00 to 2359+00	4,000	No design measure: 2319+00 to 2331+00 Seepage berm 120 feet wide (2331+00 to 2335+00) Seepage berm 100 feet wide (2335+00 to 2359+00)
41	2359+00 to 2368+00	900	Seepage berm 100 feet wide with filter drain (2359+00 to 2368+00)

The construction impacts to real property interests due to design features on existing levee sections are discussed below for SB-7 and SB-8.

No Modification Required

There are 7 levee sections along the Feather River West Levee alignment where modification is not required. These sections are between: (1) 831+50 and 844+50, (2) 923+75 and 1006+24, (3) 1007+70 and 1024+00, (4) 1027+50 and 1078+00, (5) 1625+00 and 1673+00, (6) 1769+40 and 1813+30, and (7) 2303+00 and 2331+00, approximately. Existing cutoff walls (30 to 50 feet in depth) are present within the first four levee sections.

Cutoff Wall Only

There are 14 levee sections along the Feather River West Levee alignment where cutoff wall is the only modification feature required. These sections are between: (1) 231+00 and 453+00, (2) 478+68 and 512+00, (3) 570+00 and 831+50, (4) 1078+00 and 1096+00, (5) 1098+10 and 1107+00, (6) 1125+70 and 1129+99, (7) 1130+20 and 1429+00, (8) 1451+50 and 1455+00, (9) 1461+00 and 1608+50, (10) 1624+70 and 1625+00, (11) 1673+00 and 1673+30, (12) 1766+00 and 1769+40, (13) 1813+30 and 1900+50, and (14) 1903+50 and 2290+00.

Jet Grouting Cutoff Wall Only

There are 4 levee sections along the Feather River West Levee alignment where jet grouting cutoff wall is the only modification feature required. These levee sections are between: (1) 1006+04 and 1007+90, (2) 1095+80 and 1098+30, (3) 1129+50 and 1130+67, and (4) 1900+00 and 1904+00.

Seepage Berm Only

There are 3 levee sections along the Feather River West Levee alignment where seepage berm is the only modification feature required. These levee sections are between: (1) 1024+00 and 1027+50, (2) 2290+00 and 2303+00, and (3) 2331+00 and 2368+00.

Cutoff Wall with Full Levee Degrade and Relief Wells

There are 2 levee sections along the Feather River West Levee alignment where the levee will be fully degraded and reconstructed with a cutoff wall along the levee centerline These levee sections area between: (1) 844+50 and 897+50, and (2) 1455+00 and 1461+00.
The proposed cutoff wall will function in combination with the existing seepage interceptor system (including 52 relief wells, a drainage ditch and pump stations) between station 844+50 and station 897+50.

Cutoff Wall with Relief Wells

Cutoff wall is required for the area between station 512+00 and station 570+00. The proposed cutoff wall will function in combination with the existing seepage interceptor system (including 24 relief wells, a drainage ditch and pump stations) between station 512+00 and station 545+00. A new seepage collector system (including 22 relief wells and a 2,500-foot long concrete lined V-ditch) will be installed between station 545+00 and station 570+00 at 120-foot interval. The new seepage interceptor system will be tied in with the existing one at station 545+00.

A cutoff wall is also required for the area between station 897+50 and station 923+75. The proposed cutoff wall will function in combination with the existing seepage interceptor system (including 24 relief wells, drain ditch and pump stations).

Cutoff Wall with Seepage Berm

There are 2 levee sections where both a cutoff wall and a seepage berm are required. These levee sections are between: (1) 180+00 and 231+00, and (2) 453+00 and 478+68.

Cutoff Wall with Levee Relocation

The existing levee will be relocated 20 feet toward the river at three locations, between: (1) 1432+70 and 1451+50, (2) 1608+50 and 1624+70, and (3) 1673+30 and 1754+30. A cutoff wall is required at these locations and will be constructed along the relocated levee alignment.

Cutoff Wall with Landside Toe Fill

A cutoff wall is required for the area between 1107+00 and 1125+70. The landside toe depression in this area will be filled.

Soil- Bentonite versus Deep Soil Mix (DSM) Cutoff Wall

The proposed cutoff walls vary in depth along the project alignment. At locations where a cutoff wall is the required (except for the jet grouting sites), the cutoff wall will be: soil bentonite cutoff wall (if the wall is less than 75 feet in depth) or DSM cutoff wall (if the wall is greater than 75 feet in depth). There are 10 levee sections along the FRWL alignment where DSM cutoff walls are required. These sections are between: (1) 230+00 and 250+00, (2) 1125+00 and 1129+99, (3) 1130+20 and 1151+50, (4) 1224+00 and 1248+00, (5) 1987+25 and 2002+00, (6) 2016+75 and 2036+75, (7) 2067+00 and 2088+00, (8) 2137+00 and 2148+00, (9) 2182+00 and 2196+50, (10) 2245+75 and 2292+00, approximately (see Table 5-2 for more details). The wall's depth at these locations will vary between 75 and 120 feet. Between 844+50 and 897+50, an 85-foot deep soil bentonite cutoff wall is considered adequate for this area.

Erosion Protection

An anchored HPTRM is required on the landside slope for two initial overtopping levee sections located in reaches 7 and 23 between: (1) 547+00 and 604+60, and (2) 1582+00 and 1601+00 to increase the sections' resiliency and enhance flood warning and evacuation time prior to overtopping failure from events that exceed the design event.

Closure Structure

One gate type closure structure or equivalent is required at station 1130+00, where the UPRR crosses the FRWL alignment and would be constructed in Reach 17 near Live Oak Blvd. where the levee crosses the railroad embankment.

The existing project levee is higher than the railway and a gap exists in the top portion of the levee. The gap is required to prevent interference with the approach grade to a Bridge across the Feather River. The current method of closing this levee gap is to fill the reach with sandbags during large flood event. The sandbag approach was last used during the January 1997 flood.

The sandbag approach was not preferred for the TSP because of reliability considerations. Accordingly, the selected approach for the TSP was to construct the referenced gated closure structure. An abutment would be constructed in the levee on each side of the railway. During a large flood event, floodgates hinged on the abutment would be closed across the railway preventing floodwaters from flowing through the gap. When installed, the floodgate structure would be approximately 3-4 feet high. The closure would not interfere with railway traffic because an existing closure structure on the east side of the Feather River Bridge would also be closed during the flood event.

This location is the lowest point along the levee and the performance of project depends on the closure structure operating correctly. If this structure is not operated correctly the levee could breach due to overtopping. This would result in rapid inundation of Yuba City. This is a highly populated area and a failure would have high life safety consequences. To further increase the robustness of the levee, this location would be made more resistant to overtopping.

Because the control structure serves to ensure the integrity of the levee system at its juncture with the railway line, the closure structure is classified as a project feature. The underlying fee owner of the real property is State of California.

Construction of the railroad gate type closure structure will require a Temporary Work Area Easement. Also, the railroad gate type closure structure will require Flood Protection Levee Easement real estate rights to maintain and operate the closure structure system.

Cutoff Wall with Canal Relocation

The Sutter Butte Main Canal (Canal) will be relocated away from the existing levee toe at two locations: (1) between 1429+00 and 1432+70, and (2) between 1754+30 and 1766+00. The existing canal sections will be backfilled for an estimated total of 1500 feet.

A cutoff wall is required at these locations and will be constructed along the levee centerline. Canal relocation was selected for a small section along the alignment where the FRWL is too close to the Feather River's main channel to relocate the levee. This option was also selected for a small section of the Sutter Butte Canal near the Sunset Weir Pump Station, around station 1430+00, because it was deemed to be more cost effective than the levee relocation option which would require relocation of the pump station' electrical system. At one of the four locations where the Sutter Butte Canal encroaches into the proposed ROW, specifically between station 1904+00 and station 1957+00, an existing 10-foot minimum natural berm, on the levee's landside slope, would be utilized for O&M purposes without any further actions.

Levee relocation was deemed to have the least overall impact and was selected as the primary measure for addressing the issue. The relocated levee is required to meet the minimum levee design criteria and height requirement. The cutoff wall would be constructed at the centerline of the relocated levee sections.

The Canal is operated by the Joint Water Districts – which include the following four water districts: the Richvale Irrigation District, the Biggs-West Gridley Water District, the Butte Water District, and the Sutter Extension Water District. The Main Canal delivers Feather River water supply to these four districts that are located generally south and west of Lake Oroville and the Feather River along the eastern side of the Sacramento Valley. The Canal is approximately 17 miles long and is predominately unlined. The existing operating capacity ranges from approximately 1,600 cubic feet per second (cfs) at the upstream end to approximately 500 cfs at the downstream end. Potential impacts to water delivery requirements are discussed herein in Section 14. Both the Canal and the Feather River levee have meandering alignments. The Canal is adjacent to the levee at four locations, for a combined length of about 3.5 miles, and is up to several hundred feet away from the levee in other locations

Seepage and stability issues resulting from the Canal being adjacent to the levee could be addressed by the construction of a cutoff wall through the levee; however, there is no room for a landside easement due to the location of the adjacent canal. The landside easement is required to accommodate an O&M road.

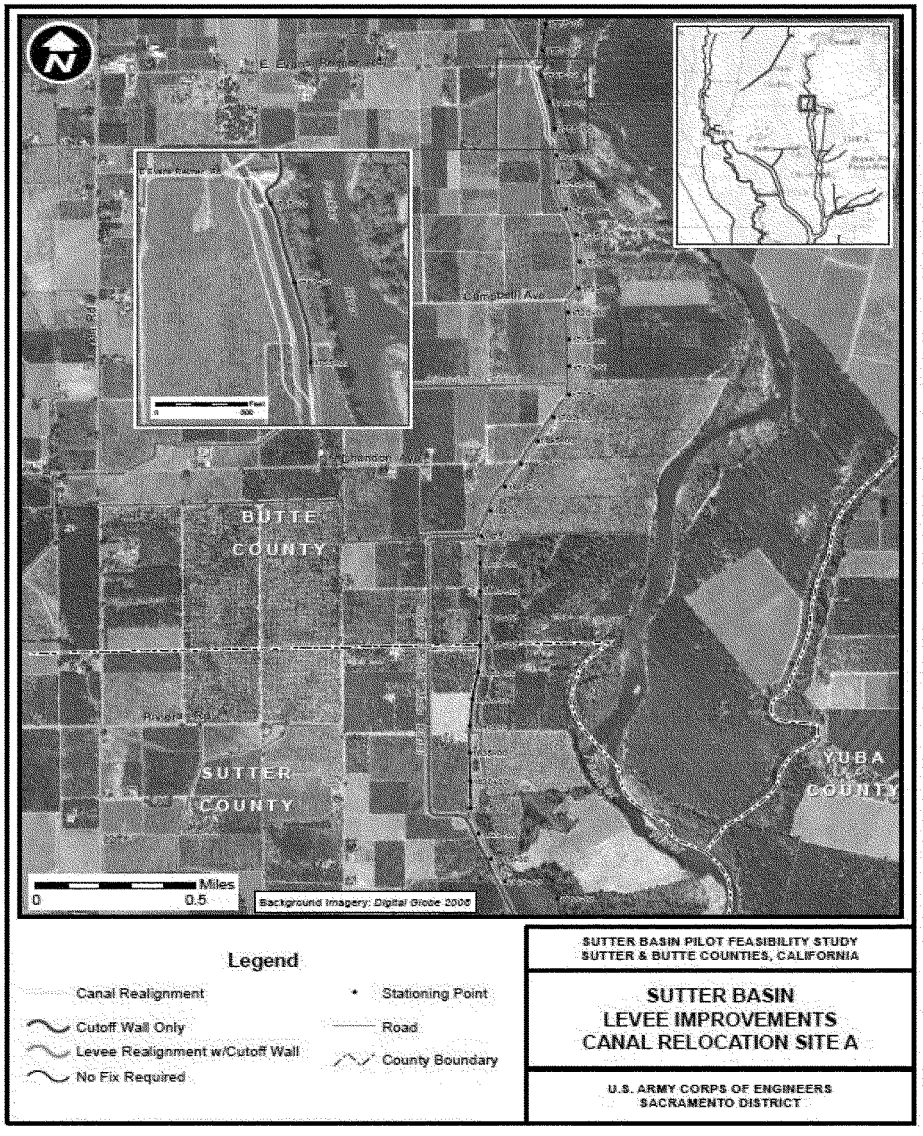
For erosion protection, an Anchored High Performance Turf Reinforced Mat (HPTRM) is required on the landside slope for two levee sections. These levee sections are between (1) 547+00 and 604+60, and (2) 1582+00 and 1601+00, for a total of 7,660 linear feet.

The proposed action for each area is addressed below.

a. Affected Area 1a (1429+00 to 1433+83, FRWLP Reach 21). The proposed option for this area is to move the Canal landward into an adjacent agricultural area to provide space between the Canal and the levee for the landside O&M road. See Plate 4-1.

b. Affected Area 1b (1430+00 to 1449+00, FRWLP Reach 22). The proposed option for this area is to move the levee waterward into the flood overflow area to provide space sufficient for the landside O&M road.

c. Affected Area 2 (1611+00 to 1623+00, FRWLP Reach 24). The proposed option for this area is to move the levee waterward into the flood overflow area to provide space sufficient for the landside O&M road.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COUNTY
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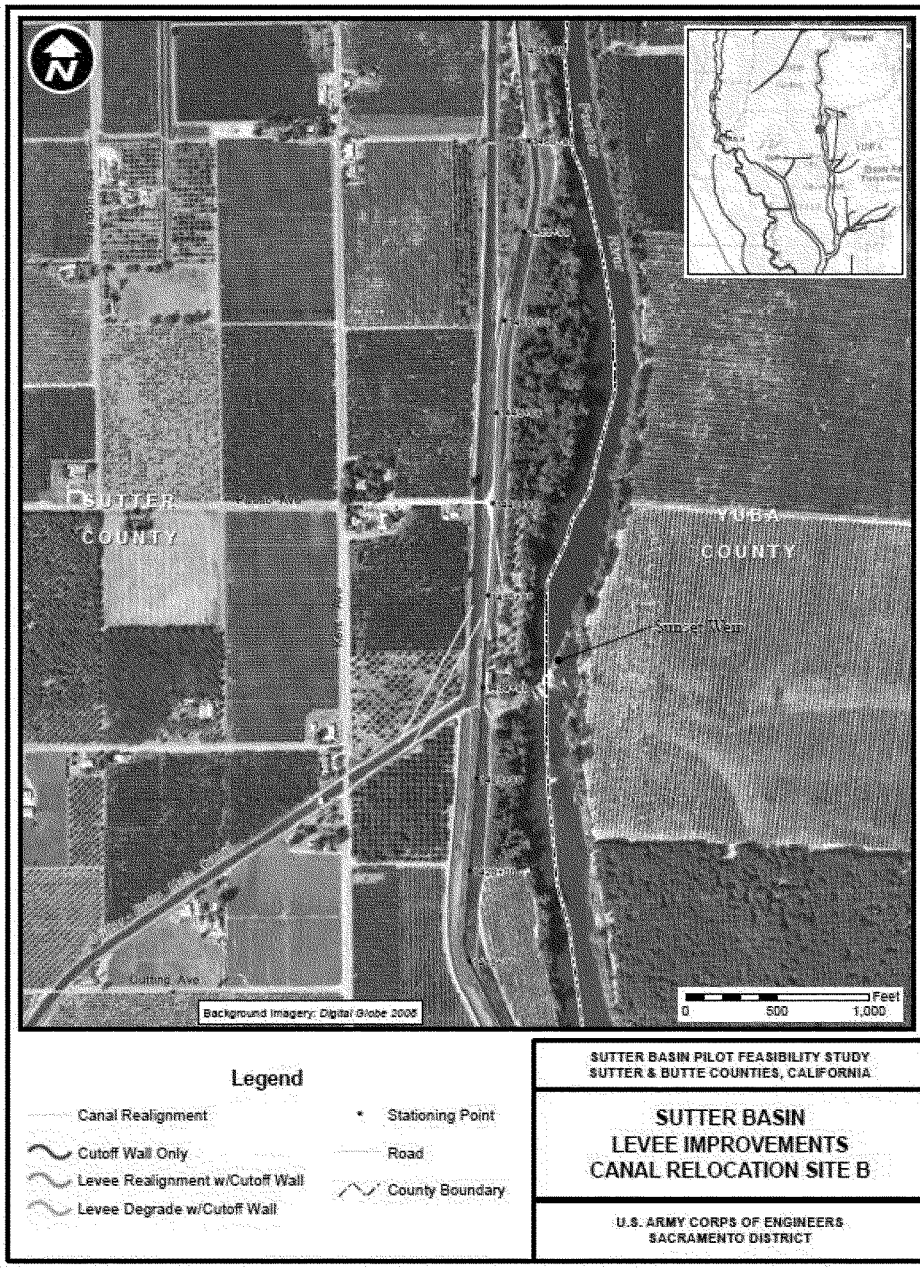
Background Imagery: Digital Globe 2005
Legend
Canal Realignment
Cutoff Wall Only
Levee Realignment w/Cutoff Wall
No Fix Required
Stationing Point
Road
County Boundary
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER & BUTTE COUNTIES, CALIFORNIA
SUTTER BASIN
LEVEE IMPROVEMENTS
CANAL RELOCATION SITE A
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT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Cutoff Wall Only
Levee Realignment w/Cutoff Wall
Levee Degrade w/Cutoff Wall
Stationing Point
Road
County Boundary
SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER & BUTTE COUNTIES, CALIFORNIA
SUTTER BASIN
LEVEE IMPROVEMENTS
CANAL RELOCATION SITE B
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

As previously noted, the 41 reaches along the Feather River are broken into two alternatives: Alternative SB-7 (Reaches 2-21) and Alternative SB-8 (Reaches 2 – 41). Alternative SB-7 is completely included within Alternative SB-8. The reaches are then broken into 7 construction contracts including A, B, C1, C2, D1, and D2. The following tables represent the inventory of potential LERRDs required for the construction, operation and maintenance of alternatives SB-7 and SB-8:

Alternative Name	Acres	Incremental Costs	Total cost
SB7 Lands and Damages	2136	$10,579,000	$42,390,000
SB8 Recommend Lands and Damages	2328	$11,751,000	$53,546,000

Potential Borrow Sites

Potential borrow sites have been identified in various regions in the project area, and each site is summarized in the Table below and shown in the maps below. The borrow sites are the same for SB-7 and SB-8 since SB-7 is completely included within the SB-8 footprint. An investigation of each of the identified sites was based upon the quantity of available material, hauling distance, material composition, groundwater elevation, and prospects for acquisition. The purpose of the investigation was to identify the potential sites with the greatest potential to provide material economically for the project. Economical hauling has been determined to be within a 2-miles radius and marginally economic hauling within a 10-mile radius. Borrowing outside this radius is not recommended and additional sites would be identified to supply material within these limits.

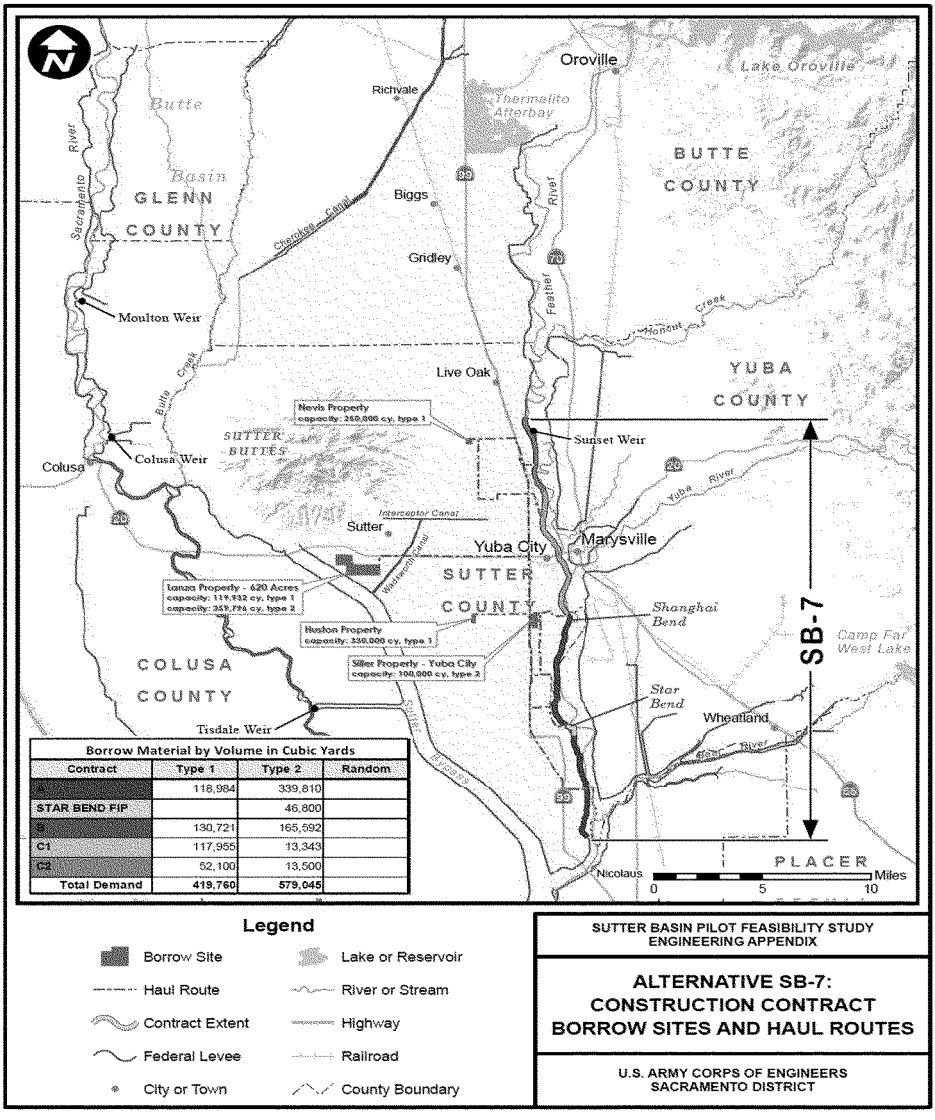
13 sites were identified as potential borrow areas, five of which were eliminated as a result of a preliminary screening process. The screening criteria included contamination level, and relative location to the levee or seepage berm. SBFCA and USACE are currently in the process of sampling and testing the sites to ensure they meet material requirements. It was estimated that the borrow sites may provide up to 1,349,900 cubic yards of Type 1 fill material, 459,800 cubic yards of Type 2 fill material, and 330,800 cubic yards of Random fill material.

Alternative SB-7 may require up to 419,760 cubic yards of Type 1 fill material, 579,045 cubic yards of Type 2 fill material, and no Random fill material required.

Alternative SB-8 may require up to 629,810 cubic yards of Type 1 fill material, 809,845 cubic yards of Type 2 fill material, and 179,520 cubic yards of Random fill material.

22 Potential Parcels for 13 Borrow Sites used in the Screening Process

Parcels	Proposed Borrow Easement Acres
025-230-999-000	11.737
025-280-007-000	2.122
025-280-008-000	12.296
025-280-009-000	24.811
025-280-010-000	7.655
025-280-011-000	2.824
025-280-019-000	4.677
025-280-020-000	9.037
025-280-021-000	20.057
025-280-022-000	9.926
025-290-019-000	21.878
025-290-020-000	5.075
06-470-046	26.27
08-220-013	38.213
08-220-030	0.221
08-220-031	0.490
08-220-032	38.609
08-220-033	38.719
08-260-043	39.245
10-071-001	40
13-270-033	40
10-032-018	12



Borrow Material by Volume in Cubic Yards

Contract	Type 1	Type 2	Random
A	118,984	339,810	
STAR BEND FIP		46,800	
B	130,721	165,592	
C1	117,955	13,343	
C2	52,100	13,500	
Total Demand	419,760	579,045	

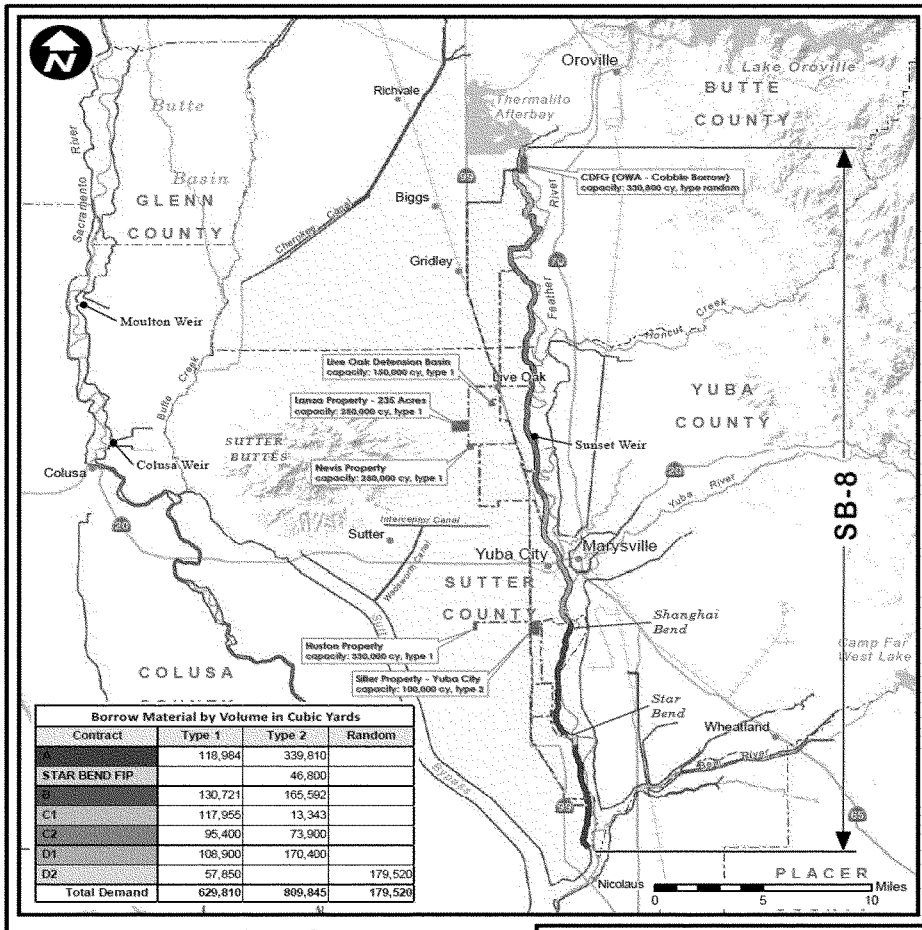
Legend

- Borrow Site
- Haul Route
- Contract Extent
- Federal Levee
- City or Town
- Lake or Reservoir
- River or Stream
- Highway
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

**ALTERNATIVE SB-7:
CONSTRUCTION CONTRACT
BORROW SITES AND HAUL ROUTES**

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



Borrow Material by Volume in Cubic Yards			
Contract	Type 1	Type 2	Random
A	118,984	339,810	
STAR BEND FIP		46,800	
B	130,721	165,592	
C1	117,955	13,343	
C2	95,400	73,900	
D1	108,900	170,400	
D2	57,850		179,520
Total Demand	629,810	809,845	179,520

Legend

- Borrow Site
- Haul Route
- Contract Extent
- Federal Levee
- City or Town
- Lake or Reservoir
- River or Stream
- Highway
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
ENGINEERING APPENDIX

ALTERNATIVE SB-8: CONSTRUCTION CONTRACT BORROW SITES AND HAUL ROUTES

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

APR 2013

PLATE 5-3

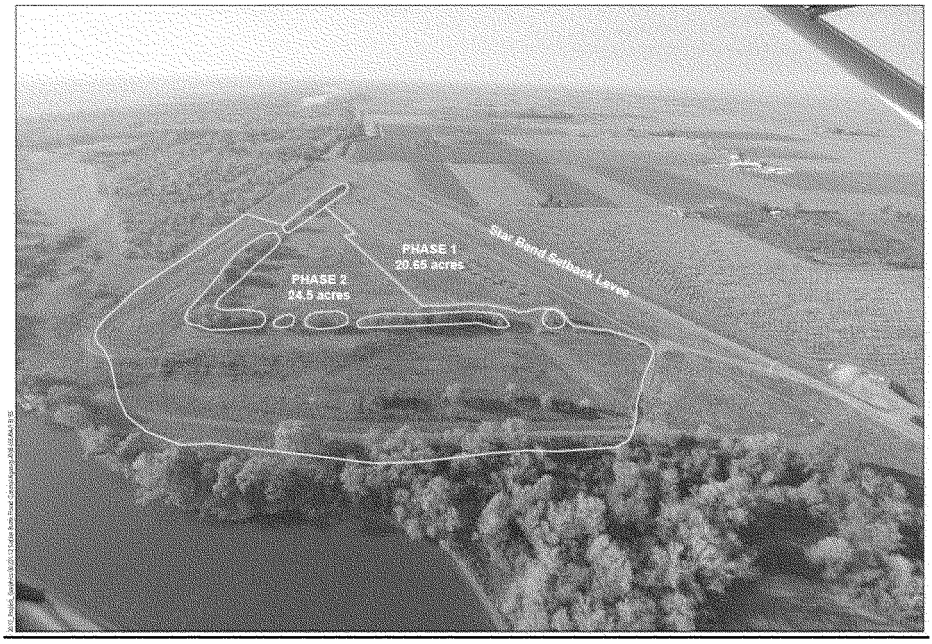
Mitigation Sites

The proposed mitigation plan for SB-7 and SB-8 is to acquire 24.5 acres at Star Bend and 63.1 acres at the Three River Levee Improvement Authority (TRLIA) Feather River Floodway Restoration Project Site. Total mitigation lands needed are 87.6 acres. These sites are to be used to mitigate impacts to Valley Elderberry Longhorn beetle, riparian forest and oak woodland. The entire Star Bend Conservation Area is 48.5 acres site -- about 24.5 acres would restored as shown in the attached figure. Mitigation banks will be used for wetland and giant garter snake mitigation.

Star Bend Mitigation Site (Reach 6)
1 Parcel

Parcels	Mitigation Acres
2010-0001863	24.5

Star Bend Mitigation Site



Proposed 500-acre parcel for habitat restoration in the Feather River Setback Area

This potential mitigation property was purchased in fee by TRLIA for the State of California (DWR) and is currently managed by TRLIA until its fee title transfer to the State. At the time of purchase, the property was used as a pear orchard. The orchards were removed during setback levee construction and used as a borrow site. The property was refilled when the replaced levee was degraded. A small portion of the property is now being used by a local farmer under a short term lease for wheat. The Corp estimates it only needs 63 acres out of the 500. This site is part of the Feather River Floodway Corridor Restoration Project. This is an opportunity for regional cooperation and an ideal location for the mitigation required.

Feather River Setback Area
1 Parcel

Parcels	Mitigation Acres
040-600-082	63.1

Proposed Disposal Sites

Implementation of Alternatives SB-7 and SB-8 may generate up to 220,000 cubic yards of solid waste that would require disposal. Solid waste related to construction activities would include levee material, structural debris from removal of residences and agricultural structures, and roadway pavements. 220,000 cubic yards of unsuitable dirt would be wasted at the proposed borrow sites as LERRD's.

5. LERRDs Owned by the NFS and Crediting

In the event the recommended plan is authorized, crediting will follow standard procedures as set out in the model Project Partnership Agreement (PPA). No credit will be afforded to any lands or interests previously acquired and credited for any applicable Federal project. Credit will only be applied to the acreage within the "project footprint," namely the lands or corridor required for the recommended plan of improvements. Lands outside of the project requirements and lands that may be acquired for the sponsor's own purposes would not be creditable LERRDs. Only land deemed necessary that has not been previously cost shared on a project will be credited.

Corps' policy also prescribes that credit will not be afforded for lands purchased with Federal funds or grants where the granting of such credit is not permissible, whether as prescribed by statute, or as determined by the head of the Federal agency and administer such grants or programs. The Federal Emergency Management Agency (FEMA's) floodplain hazard mitigation and elimination grants are examples of such Federal grant programs where credit would not be allocated.

The Non-Federal sponsors own an estimated 8 parcels (constituting approximately 23 acres of the total acreage required for the project) in fee title, according the County Assessor's office.[1] These 8 fee title parcels (identified in the tract registers in reaches 2, 12, 23, 40 and 41) are assumed sufficient to support project purposes/functions, and no inconsistent encumbrances and/or restrictions on said land is anticipated. At this time, sufficiency of the 93 acres of remaining estates and real property rights held by the non-Federal sponsors, and identified as available to support project purposes/functions in the track registers, is unknown. The potential impact to project costs and/or plan selection as a consequence of this uncertainty is minimal inasmuch as the gross appraisal conservatively estimates the unit costs for the estates required for project purposes and includes seven incremental and improvement contingencies for various unknowns including severance damages, unknowns for level of study definition, unforeseen aspects due to inaccessibility and lack of onsite inspections, cost/value increases from time and development pressure, negotiation latitude above fair market value, potential for excessive cost/awards, potential for unknowns natural resources or minerals, improvement/building contingencies. Accordingly, this contingency assessment should reduce risk and cause no impact to plan selection.

Parcels that are owned by the non-Federal sponsors in fee title are listed in the table below. The Non Federal Sponsors have the legal capability to provide the lands required for the

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[1] The Sac and San Joaquin Drainage District is a subdivision or agency of the State of California, DWR, and thus our non-Federal Sponsor.

project as stated in DWR and SBFCA's Non-Federal Partners Real Estate Acquisition and Capability Assessment, attached as Exhibit A.

Sponsor Fee-Owned Parcels

APN	Reach	Owner	Estate	Perm Road Easement	Levee Easement	Total AC
25-210-015	Reach 02	SAC & SAN JOAQUIN DRAINAGE DIST	Fee	0.636	4.526	5.16
25-210-016	Reach 02	SAC & SAN JOAQUIN DRAINAGE DIST	Fee		4.656	4.66
25-260-031	Reach 02	SAC & SAN JOAQUIN DRAINAGE DIST	Fee	0.379	0.267	0.65
25-260-041	Reach 02	SAC & SAN JOAQUIN DRAINAGE DIST	Fee	0.269	2.446	2.72
55-010-019	Reach 12	STATE OF CALIFORNIA ETAL	Fee	0.374	3.346	3.72
09-230-001	Reach 23	SAC & SAN JOAQUIN DRAINAGE DIST	Fee	0.547	3.259	3.81
025-280-008-000	Reach 40	STATE OF CALIFORNIA - DWR	Fee	0.034	0.007	0.04
030-340-033-00	Reach 41	STATE OF CALIFORNIA -DWR	Fee	0.653	1.664	2.32
			Total	2.256	20.171	23.08

6. Standard Federal Estates and Non Standard Estates

Non-Standard Estates:

Non -standard estates are not anticipated for the proposed project.

Standard Estates:

The following standard estates are anticipated to support project purposes and features.

Fee Simple Title

The fee simple title to [the lands described in Exhibit 1E] subject however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

Flood Protection Levee Easement (FPLE)

A perpetual and assignable right and easement in the land [described in Exhibit1F tract registers] to construct, maintain, repair, operate, patrol and replace a flood protection levee, including all appurtenances thereto; reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

Temporary Work Area Easements (TWAE)

A temporary easement and right-of-way in, on, over and across for a period not to exceed 2 years after the execution of the construction contract, beginning with date possession of the land is granted to the Non Federal Sponsor, for use by the United States, the NFS, its representatives, agents, and contractors as a (borrow area) (work area), including the right to borrow and/or deposit fill, spoil and waste material thereon) (move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the Sutter Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

Permanent Road Easement (PRE)

A perpetual and assignable easement and right-of-way in, on, over and across [parcel number] for the location, construction, operation, maintenance, alternation and replacement of (a) road(s) and appurtenances thereto; together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions and other vegetation, structures, or obstacles within the limits of the right-of-way; (reserving, however, to the owners, their heirs and assigns, the right to cross over or under the right-of-way as access to their adjoining land at the locations indicated in the tract register); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

Borrow Easement

A perpetual and assignable right and easement to clear, borrow, excavate and remove soil, dirt, and other materials from (the land described in Tract register) subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges in said land as may be used without interfering with or abridging the rights and easement hereby acquired.

Utility or Pipeline Easement

A perpetual and assignable easement and right-of-way in, on, over and across [the land described in Exhibit 1F] for the location, construction, operation maintenance, alteration, repair and patrol of [(overhead) or (underground) utility or pipeline]; together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions and other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

Drainage Ditch Easement

A perpetual and assignable easement and right-of-way in, over and across [the land described in Exhibit 1F] to construct, maintain, repair, operate, patrol and replace a drainage ditch, reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

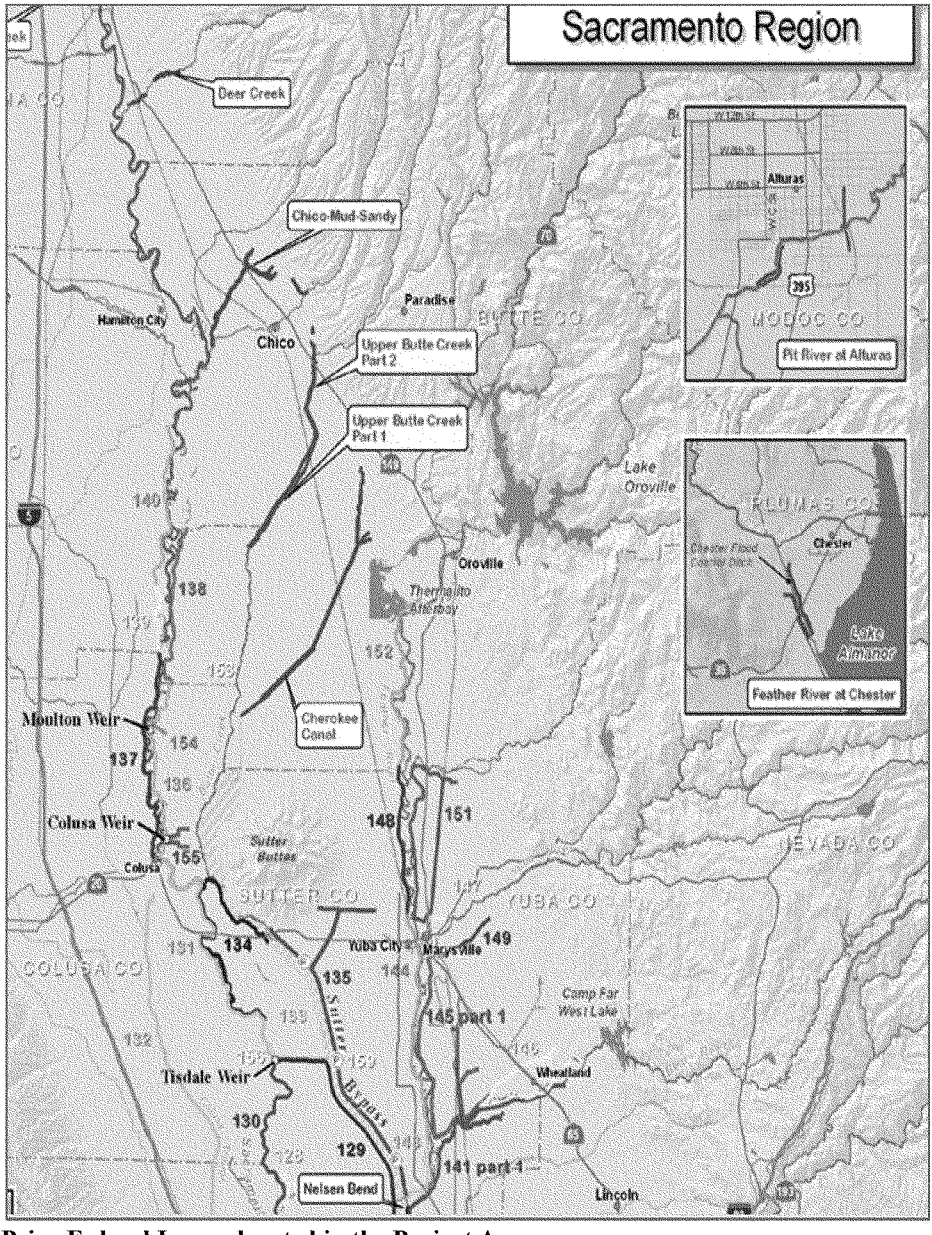
7. Description of Any Existing Federal Project in or Partially in the Proposed Project Area

There are four Federal levee projects constructed prior to 1960 along the Feather River located in the study area or overlapping a portion of the study area. These levees are the same levees that are proposed for rehabilitation in the recommended project plan. Of these prior Federal projects, four Levee Unit Reaches (Reaches 152, 148, 144, and 143) are located along the Feather River as shown in the corresponding map, below, and the levee improvements in these units were part of the Sacramento River Flood Control Project authorized by the Flood Control Act of 1917, as modified by the Acts of 1928, 1937, and 1941. Reaches 152, 148, and 144 overlap with the recommended plan. Less than one-half (½) of the levee length in Unit Reach 143 also overlaps with the recommended plan. The remaining portion of Reach 143 is located outside of the study area completely. The southern levee stretch is longer than the proposed project construction site.

The four Federal levee projects referenced above were constructed prior to 1986 cost share requirements, and lands to support Federal construction were provided and paid for by the non- Federal sponsors. Preliminary review of available Operation & Maintenance (O&M) Manuals and existing agreements from these prior Federal projects indicates no Federal retained right to use the land provided for subsequent Federal projects, contrary to the Corps' post-1986 cost share policy mandates requiring a retained right of access for inspection, repair and rehabilitation of the project .

The non-Federal sponsors for the current recommended plan have existing O&M and levee easements in the prior federally constructed levees, however, it has been assumed for purposes of this study that the non-Federal sponsors will be required to acquire said rights and interests to implement Alternatives SB-7 and SB-8, and the acquisition costs have been included in the total project cost estimate. If during the Planning Engineering and Design (PED) Phase existing levee easements are discovered and available, those existing rights will not be cost-shared, which may lower the total project cost.

The local Levee and Maintenance Districts own, operate and maintain or currently have easements or rights to maintain the various reaches of levee along the Feather River and are not owned by the Sutter Butte Flood Control Agency our current Non-Federal Sponsor. Our other Non-Federal Sponsors, the State of California DWR, currently owns 8 parcels in the project area that overlap the original projects and those parcels are listed in the tract registers located in Exhibit B of this report.



Prior Federal Levees located in the Project Area

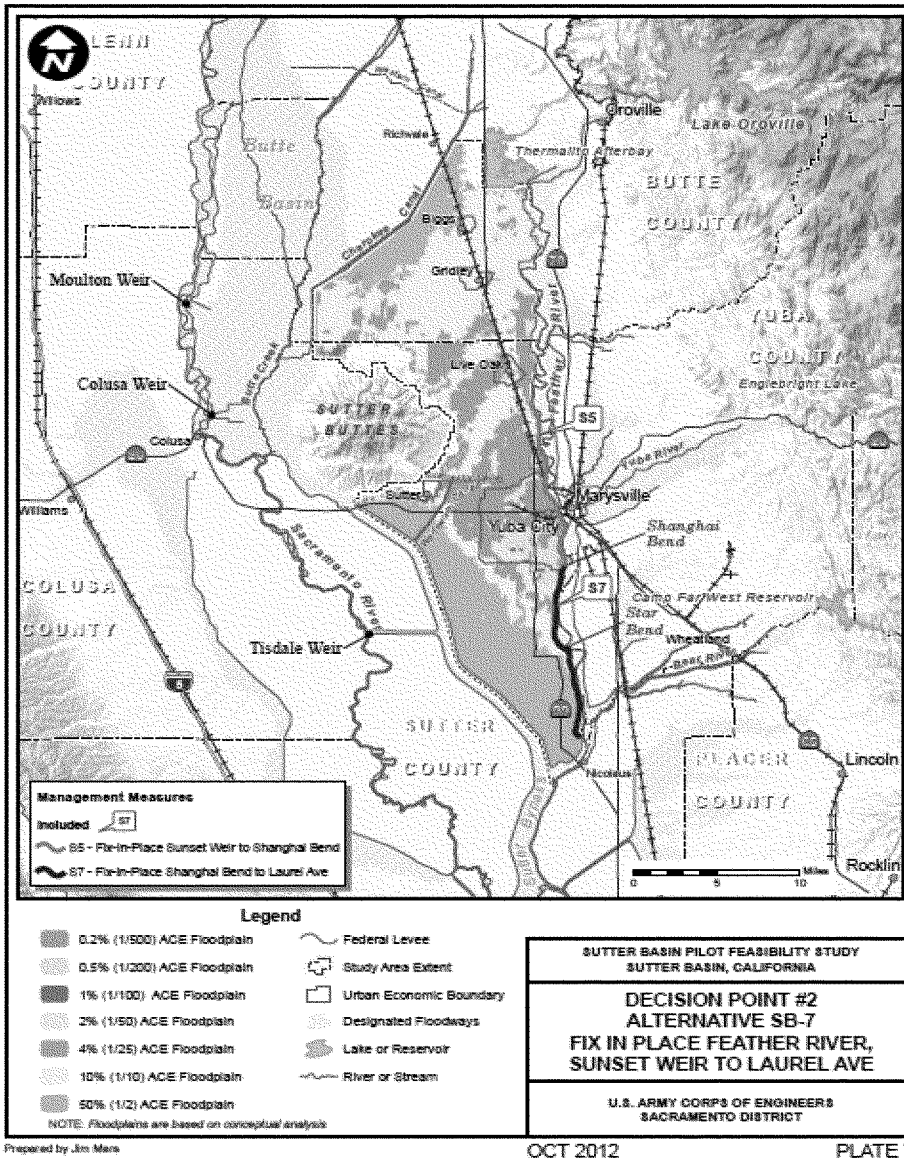
8. Description of any Federally Owned Land Needed for the Project

There does not appear to be any federally owned land available to support the construction, operation and/or maintenance of Alternatives SB-7 or SB-8. The lands needed for the construction, operation and maintenance of each proposed alternative are either state owned, county owned, city owned and/or privately owned.

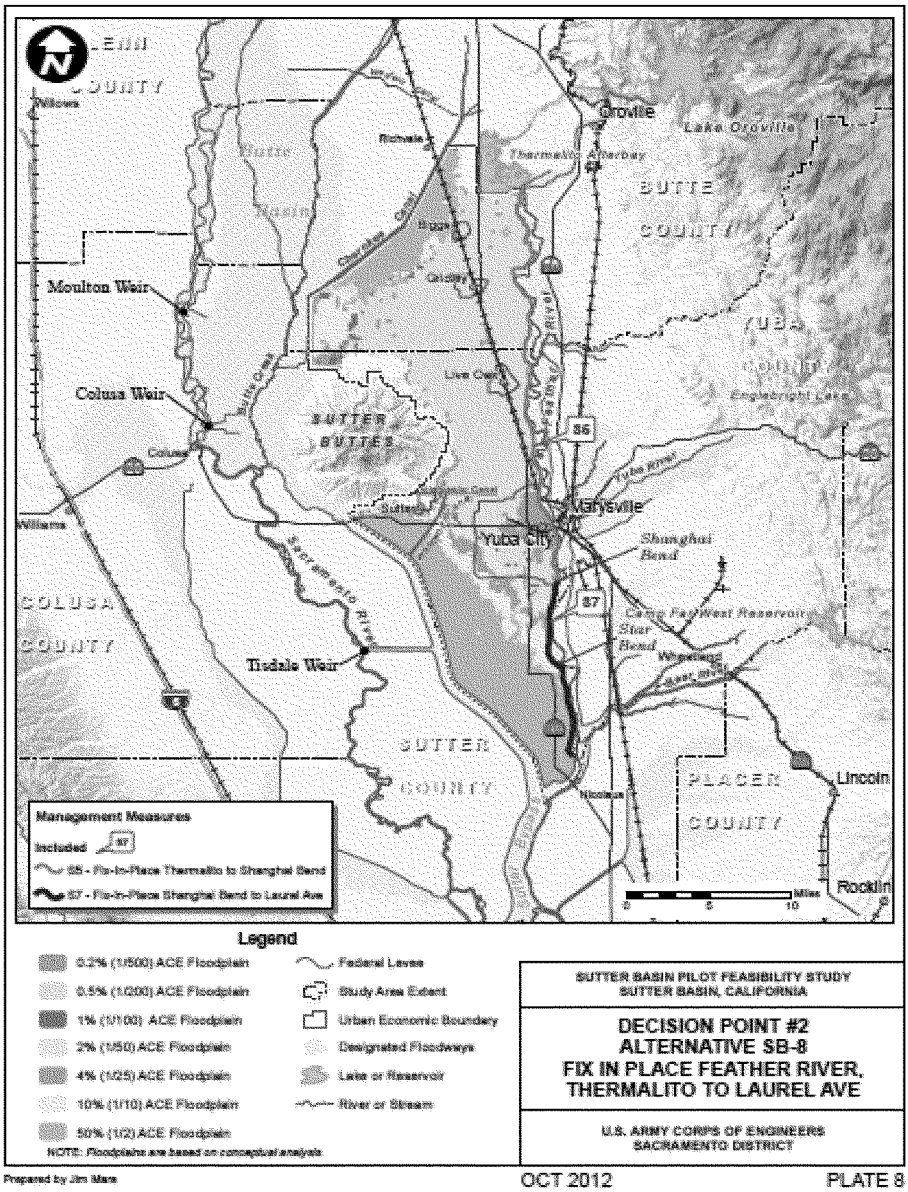
9. Application of Navigational Servitude to the LERRDs Requirement

The levees at issue in the implementation of Alternative SB-7 and Alternative SB-8 are set back from the Feather River. Accordingly, there do not appear to be any lands required for the construction, operation and maintenance of either Alternative SB-7 or SB-8 that fall within the navigational servitude.

10. Project Map Alternative SB7 Fix in Place Feather River Sunset Weir to Laurel



Project Map Alternative SB8 Fix in Place Thermalito to Laurel Ave.



11. Anticipated Increased Flooding and Impacts

Change in Water Surface Elevations and Flood Safety Attributable to Project Design.

Alternative SB-8 represents minor design modifications to the proposed action analyzed in the FRWLP Final EIS. SB-8 includes the proposed realignment of 11,600 linear feet of existing levee where it lies directly adjacent to the Sutter-Butte Canal (Canal). The modification would move the levee about 20 feet waterward to provide a 10-foot maintenance road between the Canal and the project levee. To evaluate whether moving the levee waterward would affect water surface elevations and increase the potential risk of flooding, changes to flow, depth, duration, and velocity were estimated using a hydraulic model. The hydraulic model results were also used to perform a transfer of risk analysis using Risk and Uncertainty based methods.

The hydraulic model results indicated no measureable change in flow, depth, duration, and velocity within the Feather River (stage change less than 0.005 feet). The 20 foot realignment is located where the levee toe is higher than the 0.5% (1/200) ACE water surface elevation. Therefore, any change in water surface elevation would only occur for flood events more rare than 0.5% (1/200) ACE. In addition, this reach of river is over 5000 feet wide and the 20 foot realignment of the levee is a small change in the overall hydraulic cross section.

Transfer of flood risk was evaluated by comparing with-project and without-project levee performance values at index points throughout the system. For purposes of evaluating system impacts, the risk analysis is limited to hydrologic and hydraulic parameters and their uncertainties. This approach is consistent with Section 3.b (2) of the memorandum "Clarification Guidance on the Policy and Procedural Guidance for the Approval of Modifications and Alterations of Corps of Engineers Projects" (USACE, 2008). The analysis is described in detail in the Hydraulic Design and Analysis Appendix.

Analysis of the Alternative SB-8 found no transfer of flood risk. As described above, the hydraulic model created for Alternative SB-8 computed the same water surface elevations as Alternative SB-1 (No Action Alternative). Since the water surface elevations are the input to the Risk and Uncertainty model, and they did not change, there is no change in the project performance and no transfer of flood risk.

Based on this hydraulic analysis there were no anticipated increased flooding or impacts of any significance applicable to Alternatives SB-7 or SB-8.

12. Cost Estimate Summary for Lands and Damages and Relocations

The following is a preliminary analysis estimating the costs of acquiring the required LERRDs to support Alternative SB-7. The table below estimates the costs associated with acquiring real property interests necessary to construct, operate and maintain a local levee project primarily located along the Feather River within the Counties of Butte and Sutter. The date of the approved cost estimate was December 6, 2012. The below is a summary of Real Estate Costs provided to Cost Engineering:

SB7 Real Estate Cost estimate

Alternative SB-7 Features 292 Parcels	Acres	Costs	Incremental Real Estate Costs	Total Costs Rounded
MCACES 01 ACCOUNT - LANDS AND DAMAGES (Non Fed)				
Non Fed Admin		$13,462,170	$673,108 (5%)	$14,135,278
Non Fed Lands	2084	$17,375,434	$9,418,730 (50%)	$26,794,164
Non Fed Relocation Payment Assistance		$588,333	$294,167 (50%)	$882,500
Non Fed New Utility Easements	52	$385,372	$192,686 (50%)	$578,058
TOTAL LANDS AND DAMAGES (Non Fed)		$31,811,000	10,579,000 (33%)	$42,390,000 Rounded
MCACES 01 ACCOUNT - LANDS AND DAMAGES (Fed)				
Federal Admin MCACES 01		$6,952,000	348,000 (5%)	$7,300,000
MCACES 02 ACCOUNT - RELOCATIONS (Non Fed)				
Utility Relocation Costs PED Relocations Construction Management				$22,298,000 $4,014,000 $2,230,000
TOTAL RELOCATIONS				**$28,542,000**

Federal Real Estate Administration costs include all acquisition, cadastral, appraisal, budget, and relocation specialist activities associated with PED, construction, and crediting activities over the 10 year life cycle of the project.

Non Federal Real Estate Administration costs include all effort directly related to acquisition of real property and interests by purchase, donation, exchange, reassignment, permits and options, such as: (a) mapping, writing legal descriptions, surveys and ownership research; (b) obtaining title evidence; (c) negotiations conducted for acquisition of real property of interests therein by purchase, donation, exchange, reassignment or transfer; closing land purchase cases, title curative work; recording of deeds; delivery of checks to landowners; and filing title opinions; and (e) acquisition activities associated with the relocation of facilities, utilities, cemeteries, public roads. Any effort prior to a decision to condemn should be charged to the Acquisition. Once that decision is made, all effort, starting with the mailing of the condemnation includes effort in connection with preparation of condemnation assemblies, including declarations of taking and the processing thereof up to and including the filing of the case. Other activities include obtaining Appraisals, PL 91-646 relocation activities, and obtaining permits.

The following is a preliminary analysis estimating the costs of acquiring the required LERRD's to support the Recommended Plan SB8. The table below estimates the costs associated with acquiring real property interests necessary to construct, operate and maintain a local levee project primarily located along the Feather River within the Counties of Butte and Sutter. The date of the approved cost estimate was December 6, 2012. The below is a summary of Real Estate Costs provided to Cost Engineering:

SB8 Real Estate Cost Estimate

Recommended Plan SB-8 Features (468 Parcels)	Acres	Costs	Incremental Real Estate Costs	Total Costs Rounded
MCACES 01 ACCOUNT - LANDS AND DAMAGES (Non Fed)				
Non Fed Admin		$20,271,010	$1,066,895 (5%)	$21,337,905
Non Fed Lands	2084	$19,917,000	$9,934,000 (50%)	$29,851,000
Non Fed Relocation Payment Assistance		$916,000	$458,000 (50%)	$1,374,000
Non Fed New Utility Easements	52	$690,965	(50%) $345,482	$1,306,905
TOTAL LANDS AND DAMAGES (Non Fed)		$41,795,000	$11,751,000 (28%)	$53,546,000 (Rounded)
MCACES 01 ACCOUNT - LANDS AND DAMAGES (Fed)				
Federal Admin MCACES 01		$11,143,000	$557,000 (5%)	$11,700,000
MCACES 02 ACCOUNT - RELOCATIONS (Non Fed)				
Utility Relocation Costs PED Relocations Construction Management				$68,327,000 $12,299,000 $6,833,000
TOTAL RELOCATIONS				**$87,459,000**

13. Relocation Assistance Benefits (as required by the Uniform Relocation Assistance and Real Property Acquisition Policies Act, P.L. 91-646)

The non-Federal sponsors must comply with the Uniform Relocation Assistance and Real Properties Acquisition Policies Act of 1970, as amended, 42 U.S.C. 4601 *et seq.* (P.L. 91-646, "the Uniform Act") and provide relocation assistance to qualifying residences and businesses within the project area that are displaced, as defined in the Uniform Act, as a consequence of project implementation. The non-Federal sponsors has prepared a draft relocation plan, which the Corps has reviewed. The relocation inventory was created by viewing conceptual designs over Aerial Photographs. The estimated costs of such potential displacements are required for estimating project costs and will be refined by the non-Federal sponsors when construction designs are completed.

Under both alternatives, property will be acquired with permanent easements and/or temporary construction easements. The existing right-of-way (ROW) corridor includes O&M corridors that vary in width along the alignment and that are discontinuous for a significant distance at some locations. The minimum levee design criteria require the project levee to have an O&M corridor along the levee toes of a minimum of 15 feet on each side of the levee. The O&M corridors are necessary for O&M and flood fighting purposes. Therefore, for this Feasibility Study, additional real estate would be acquired to provide sufficient space for the O&M corridors. Acquiring additional real estate would result in relocation of physical structures (e.g., buildings) along the alignment, which may result in potential qualifying displacements.

Implementation of Alternative SB-8 may result in the relocation of 34 residential properties, 5 businesses, and 10 agricultural buildings/structures.

Implementation of Alternative SB-7 may require the relocation of 22 residential properties, 5 businesses, and 2 agricultural buildings/structures. A majority of these structures are within Reach 16 (Yuba City).

Presently, the potential P.L. 91-646 relocation assistance benefit estimates for Alternative SB-7 are $882,500. The improvements and land costs have been estimated in the appraisal in the land and damage 01 account.

Presently, the potential P.L. 91-646 relocation assistance benefit estimates for Alternative SB-8 are $1,374,000. The improvements and land costs have been estimated in the appraisal in the land and damage 01 account.

(Uniform Relocation Act (Moving Assistance Payments)

Reach Station ID	Structure	Cost
Reach 16	Residential	$ 32,500.00
Reach 16	Business	$40,000.00
Reach 16	Business	$40,000.00
Reach 16	Residential	$32,500.00
Reach 16	Residential	$ 32,500.00
Reach 16	Residential	$ 32,500.00
Reach 16	Residential	$ 32,500.00
Reach 16	Residential	$ 32,500.00
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Reach 16	Residential	$ 32,500.00
Reach 16	Residential	$ 32,500.00
Reach 16	Residential	$ 32,500.00
Reach 16	Business	$40,000.00
Reach 16	Residential	$32,500.00
Reach 16	Residential	$32,500.00
Reach 16	Business	$40,000.00
Reach 16	Residential	$32,500.00
Reach 16	Residential	$ 32,500.00
Reach 16	Residential	$ 32,500.00
Reach 16	Residential	$ 32,500.00
Reach 16	Residential	$ 32,500.00
Reach Station ID	Structure	Cost
Reach 16	Assistance Payments for SB7	$842,500.00
Reach 31	Building Contents	$40,000.00
Reach 28	Building Contents	$40,000.00
Reach 28	Residential	$32,500.00
Reach 28	Residential	$32,500.00
Reach 28	Residential	$32,500.00
Reach 26	Residential	$32,500.00
Reach 26	Residential	$32,500.00
Relocations due to Levee Relocations		
Station 1744 Reach 28	Residential	$32,500.00
Station 1734 Reach 28	Ag Building Contents	$32,500.00
Station 1730 Reach 28	Residential	$32,500.00
Station 1726 Reach 28	Residential	$32,500.00
Station 1700 Reach 26	Residential	$32,500.00
Station 1665 Reach 25	2 Ag Building Contents	$22,000.00
Station 1610 Reach 25	Residential	$32,500.00
Station 1470 Reach 22	Residential	$32,500.00
Total est. all Relocations	Assistance Payments for SB8	$1,333,400.00

Availability of Replacement Housing/Business Properties: There are currently over 300 single family homes for sale in Yuba City. At this time there is replacement housing available. There are over 100 businesses for sale or lease available in Yuba City, Marysville, Chico, Live Oak, Gridley and Oroville. There are only five businesses inventoried to be potentially relocated.

The foregoing impacts and estimates relating to potential displacements, and the anticipated need to provide relocation assistance benefits, are provided exclusively for project cost estimating purposes only and are not intended to be relied upon for provision of benefits and/or the payment of the estimates referenced herein. A draft relocation assistance plan has been provided by the Sutter Butte Flood Control Agency and will be refined during PED.

14. Mineral/Timber Activity/Water Rights

Mineral/Timber Activity:

There does not appear to be any effect on the availability of aggregate resources because no structures are anticipated to be constructed that would otherwise interfere with access to permitted mineral resources, and no permitted mineral resource extraction mines exist in the project corridor.

Neither proposed alternative is anticipated to cause the loss of a known mineral resource of regional or local importance as a result of placement according to NEPA and CEQA.

There is no timber harvesting activities going on in the project footprint. There are small portions of agricultural lands (orchards and row crops) that are located in the project footprint, but those have been assessed and are included in the cost estimate.

No natural gas wells are in or near the construction footprint.

Water Rights:

The Sutter-Butte Main Canal (the Canal) delivers Feather River water supply to four water districts (hereinafter the Joint Water Districts) that are located generally south and west of Lake Oroville and the Feather River along the eastern side of the Sacramento Valley. The Joint Water Districts consist of the Sutter Extension Water District, Butte Water District, Richvale Water District and Biggs/West Gridley Water District. In the case of the Canal (which encroaches into the proposed ROW at four locations along the FRWL alignment)\ four potential measures were considered for each area to address ROW needs: construction of a retaining wall in the landside slope, construction of a flood wall, levee relocation and Canal relocation. The proposed measures were also coordinated with the U.S. Fish and Wildlife Service. The flood wall\, retaining wall and Canal relocation options were generally eliminated because these structures were deemed to create substantial barriers to movement of terrestrial wildlife species. Each measure was evaluated based on construction cost and impacts with the conclusion that levee relocation had the least impacts and costs.

Levee relocation was deemed to have the least overall impact and was selected as the primary measure for addressing the issue. The relocated levee is required to meet the minimum levee design criteria and height requirement. The cutoff wall would be constructed at the centerline of the relocated levee sections.

Relocation of the Canal was, however, selected for a small section along the alignment where the FRWL is too close to the Feather River's main channel to relocate the levee. This option was also selected for a small section of the Canal near the Sunset Weir Pump Station, around station 1430+00, because it was deemed to be more cost effective than the levee relocation option which would require relocation of the pump station' electrical system.

It is presently understood that the Joint Water Districts hold senior water rights on the Feather River, predating the State Water Project. Following the construction of the State Water Project's Oroville Dam and related downstream facilities, the Canal began taking supply from a new turnout at the Thermalito Afterbay. The Canal route runs roughly north to south, with major turnouts to each of the four districts' internal distribution systems. The Canal is approximately 17 miles long and is predominantly unlined. The existing operating capacity ranges from approximately 1,600 cubic feet per second (cfs) at the upstream end to approximately 500 cfs at the downstream end. Operation and maintenance (O&M) of the Canal is conducted by the Joint Water Districts Board, which includes representatives of each of the four districts referenced above. The Canal operates as the backbone of a gravity irrigation distribution system, with check dams at regular intervals used to maintain water surface levels at sufficient height to allow gravity diversions to adjacent users.

The Corps and the non-Federal sponsors are mindful that water/irrigation districts and its customers are sensitive to water rights needs and delivery requirements associated with water off of the Canal. Although District Real Estate had no opportunity to review any operative water rights agreements, presently, neither the implementation of Alternative SB-7 or SB-8 anticipates the need for acquisition of potential water rights held by the Joint Water Districts for project implementation purposes. Temporary bypass systems may be provided, if legally required and/or permissible, to avoid or minimize disruption to irrigation and other utility services, when the impacted portion of the Canal is relocated for project purposes, as further discussed in Section 18 of this Real Estate Plan Appendix. Any unanticipated acquisitions associated with the Canal realignment are covered in the real estate cost estimate which includes a 50% contingency for unknown acquisitions issues, and any unanticipated construction impacts and associated costs are included in the Engineering Appendix.

15. Non-Federal Sponsor's Ability to Acquire

The State of California Central Valley Flood Protection Board has partnered with the Corps on many prior projects and has a full Real Estate staff capable of fulfilling its' responsibilities as a non-Federal sponsor.

An assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability has been provided to Corps by both non-Federal sponsors and is included in Exhibit A.

16. Zoning Anticipated in Lieu of Acquisition

The Corps does not propose use of a zoning ordinance that would essentially facilitate property acquisition by prohibiting certain uses of property instead of purchasing the property. No such ordinance is proposed. The plan assumes purchasing property along the levee.

17. **Acquisition Schedule**

The non-Federal sponsors will be directed to begin real property acquisition for the project only after the PPA is fully executed. A risk letter has been sent from the Corps to both the Sutter Butte Flood Control Agency and the State of California alerting them to the risks associated with purchasing project lands in advance of the PPA execution. The construction contracts extend out ten years. Durations of each tasking after the PPA is executed is estimated at 3 to 6 months per construction contract.

REAL ESTATE ACQUISITION SCHEDULE				
Project Name: Sutter Feasibility Contracts A, B, C1, C2, D1, D2	COE Start	COE Finish	NFS Start	NFS Finish
Receipt of preliminary drawings from Engineering/PM	2011	2012	2010	2011
Receipt of final drawings from Engineering/PM	2014	2014	2011	2013
Execution of PPA/Finalize Chief's Report	Feb - June 2014 Depending on HQ and SPD Review times			
Formal transmittal of final drawings & instruction to acquire LERRDS	2015			
Contract A (Reaches 2 -5)			2022	2023
Contract FIP (Reach 6)			2021	2022
Contract B (Reaches 7-12)			2021	2022
Contract C1 (Reaches 13-18)			2017	2018
Contract C2 (Reaches 19-25)			2018	2019
Contract D1 (Reaches 26-33)			2019	2020
Contract D1 (Reaches 34-41)			2020	2021
Conduct Landowner Meetings			2016	2023
Prepare/review mapping & legal descriptions			2016	2023
Obtain/review title evidence			2016	2023
Obtain/review tract appraisals			2016	2023
Conduct negotiations			2016	2023
Prepare/review condemnations			2016	2023
Perform condemnations			2016	2023
Obtain Possession			2016	2023
Complete/review PL 91-646 benefit assistance			2016	2023
Certify all necessary LERRDS are available for construction			2016	2023
Prepare and submit credit requests			2016	2023
Review/approve or deny credit requests	2016	2023		
Establish value for creditable LERRDS	2016	2023		

18. Description of Facility and Utility Relocations

For cost shared projects, the non-Federal sponsors are generally required to perform or assure the performance of all utility/facility relocations necessitated by project implementation, with some specified exceptions.

On January 10, 2013, the Corps issued Real Estate Policy Guidance Letter No. 31--Real Estate Support to Civil Works Planning Paradigm (3x3x3) ("PGL No. 31") establishing additional Corps policy guidance for feasibility-level real estate efforts directed at identifying, defining and estimating the costs of utility/facility relocations resulting from project implementation for planning and budgeting purposes. In qualifying instances, a real estate assessment, in lieu of an attorney's preliminary opinion of compensability, may be prepared and utilized for such purposes (although a final attorney's opinion of compensability will be required for specified relocations prior to execution of the Project Partnership Agreement between the Corps and the non-Federal sponsors.).

The Utility/Facility Inventory table, maps and cost estimates discussed herein and available in Exhibit1B and Exhibit 1D on DVD sets forth the following information: the utilities/facilities falling within the project area that are presently anticipated to be impacted by the construction, operation and maintenance of the project thus requiring "relocation" (as defined in applicable law and regulations); the District's preliminary efforts to identify owners with compensable interests in the impacted utilities/facilities and eligibility for the provision of a substitute or replacement facility under applicable law and regulations; and identification of the non-Federal sponsors' performance and cost responsibilities in connection with the identified relocations for this cost-shared project.

Consistent with requirements of PGL No. 31, the preparation of a real estate assessment is appropriate for this feasibility study because the estimated total cost to modify all project utility/facility relocations identified in the Utility/Facility Inventory (including the value of any additional lands that may be required for perform the relocations) for either Alternative SB-7 or SB-8 do not exceed 30 percent of estimated total project costs. Here, total project costs are estimated at $694,010,000 and the utility relocations are estimated at $68,327,000 which is below the 30% threshold.

The real estate assessment discussed herein, and presented in Exhibit 1B on DVD, is based upon the following assumptions to assist in preliminarily analyzing and determining compensability for Study planning and budgeting purposes:

(1) If an impacted utility/facility is likely supported by a permit that has been issued to the utility/facility owner by the underlying property owner, and the terms of the permit include conditional language stating the utility/facility owner must relocate the impacted utility/facility at its own expense at request of the underlying fee or easement owner, the relocation was categorized as a non-compensable relocation, the costs of which are borne by the utility/facility owner and/or the non-Federal sponsor, and not included in the total project cost estimate.

(2) If the owner of the impacted utility/facility likely has an easement or real property interest in the underlying land, and the utility/facility so impacted preliminarily appears to meet the criteria for the provision of a substitute and/or replacement facility under the substitute facilities doctrine, the relocation was categorized as a compensable relocation, the costs of which are borne by the non-Federal sponsor and included in the total project cost estimate.

(3) If, the impacted utility/facility likely has a pre-1955 permit as provided by the non-Federal sponsors, and it is located within existing Corps O&M manuals, its relocation (which would otherwise be categorized as non-compensable and handled in the same manner as the relocations identified in Assumption No. 1, above) was categorized –for feasibility cost estimating purposes only--as a compensable relocation, the costs of which are borne by the non-Federal sponsor and included in the total project cost estimate. It is expressly understood that this characterization is preliminary and non-binding, and would further require the express permission and approval of the Assistant Secretary of the Army for its ongoing characterization for this specific project.

(4) The proposed relocation of Sutter-Butte Canal (Canal) (approximately 500 feet in one location and 1000 feet in another location) is preliminarily assumed to be compensable since the Canal utility/facility owner likely has a compensable interest in the underlying land (i.e. the Canal is built on private farm properties); however, for feasibility purposes, it is presently assumed that compensation will take the form of the provision of a substitute facility, the cost of which will be borne by the non-Federal sponsor and is included in the total project cost estimate. It is also presently assumed that the relocation of the impacted portion of this Canal shall neither increase or decrease the cfs flowing in the existing Canal. Temporary bypass systems are preliminarily proposed to be provided to minimize disruption to irrigation and other utility services during the farming season Notwithstanding the foregoing, in the event the provision of a substitute and/or replacement facility, and/or the provision of temporary bypass systems, is not legally permissible, associated costs incurred by the non-Federal sponsors in the provision of a substitute and/or replacement facility and/or the provision of temporary bypass systems may be limited to the land damage value at crediting and/or regarded as a "betterment" and thus not included in total project costs.

(5) Impacted utilities/facilities requiring relocation that likely intercept and/or convey drainage blocked by levees or floodwalls from the protected side of the waterway with measures such as intercepting ditches, ponding areas, pumping plants, gravity outlets, and pressurized conduits, were preliminarily categorized as project features; thus an item of construction to be cost shared and are included in the total project cost estimate. These project features have not been not included in the Utility/Facility Inventory, however, with the exception of costs to increase the size of the facilities to meet special local needs (including betterments), which costs are borne 100% by the non-Federal sponsors and are not included in the total project cost estimate.

The Utility/Facility Inventory was subdivided into two categories: levee prism encroachments and right-of- way (ROW) encroachments.

Levee prism encroachments are utility pipelines and conduits running perpendicular to the levee alignment. Most of these pipeline and conduit crossings are either dated and do not comply with the current standard for levee encroachment, or would be disrupted or otherwise impacted by levee construction. These pipelines and conduits, therefore, would be removed before the cutoff wall construction begins and replaced with proper materials after the cutoff wall construction is completed. Gravity lines (e.g., storm drain) would be replaced in-place. Pressurized lines (e.g., irrigation and drainage discharge lines, gas pipes, water and sewer lines) and conduits (e.g., electrical and communication lines) would be relocated. Pipes that are known to be recent installations would remain because they are assumed to be in compliance with current Corps policy. Abandoned pipelines and conduits would be removed.

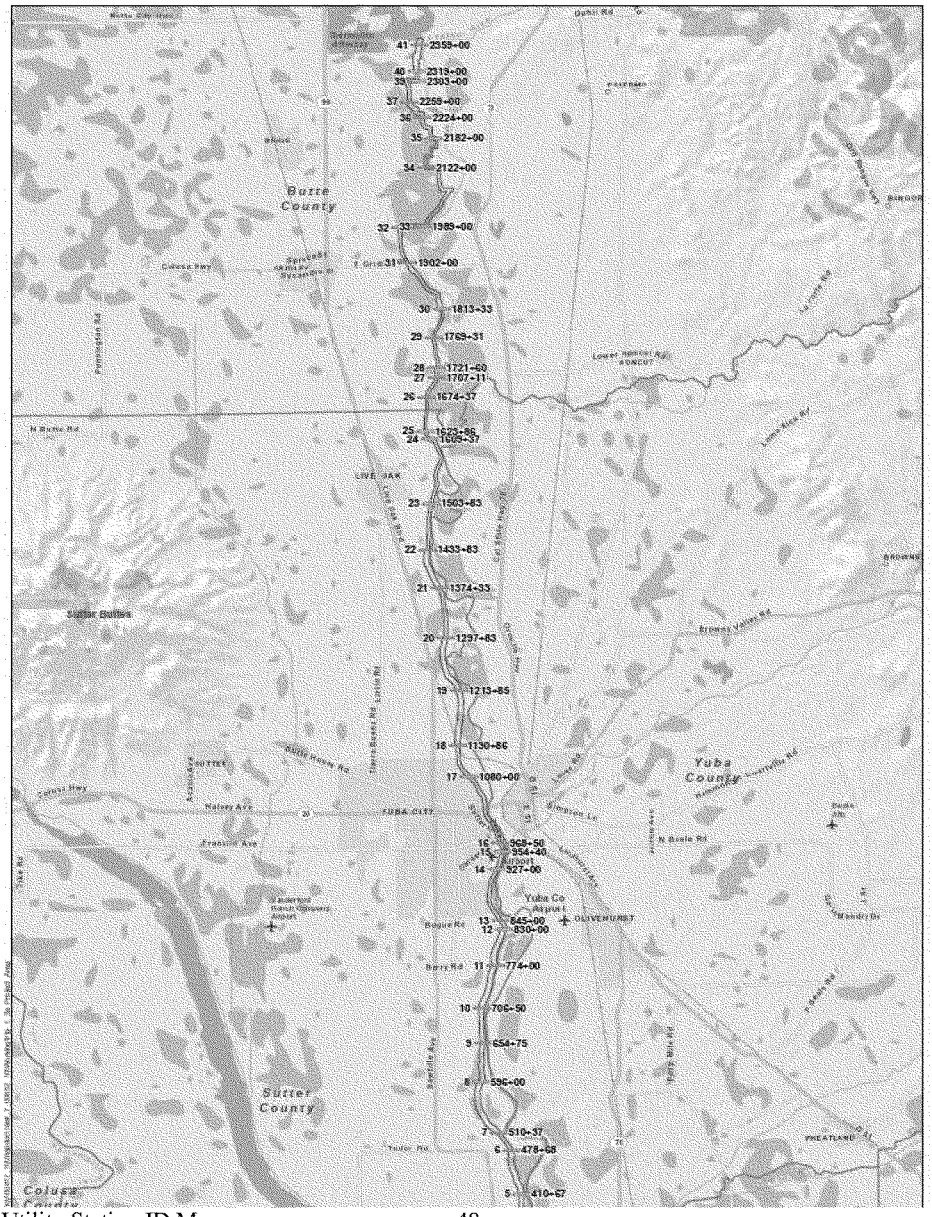
ROW encroachments are utilities and physical structures (e.g., overhead electrical lines) located outside of the levee prism but within the limits of the proposed ROW. These structures would be relocated outside of the proposed ROW prior to levee and seepage berm constructions. Under Alternatives SB-7 and SB-8, utilities that run parallel to the levee alignment and within the proposed ROW would be relocated outside of the proposed ROW. Utility pipelines and conduits crossing the existing levee embankment would be removed, modified or replaced to meet the USACE standard for levee penetration.

Reaches 2 thru 21 represent Alternative SB-7. Alternative SB-7 yields utility/facility relocation costs in the estimated amount of $22,298,000. The additional 52 acres of utility corridor easements required for SB-7 is 578,057.

Reaches 2 thru 41 represent Alternative SB-8 (the TSP). Alternative SB-8 yields utility/facility relocation costs in the estimated amount of $68,327,000. The additional 85 acres of utility corridor easements required for SB- 8 is $1,036,447.

Final Attorney's Opinions of Compensability will be completed during the PED Phase and prior to the execution of the Project Partnership Agreement, as well as prior to any notice to proceed to obtain lands and perform relocations by the non-Federal sponsors.

ANY CONCLUSION OR CATEGORIZATION CONTAINED IN THIS REAL ESTATE PLAN (AND THE REPORT) THAT AN ITEM IS A UTILITY OR FACILITY RELOCATION TO BE PERFORMED BY THE NON-FEDERAL SPONSOR AS PART OF ITS LERRD RESPONSIBILITIES AND/OR IS OTHERWISE COMPENSABLE OR NON-COMPENSABLE IS PRELIMINARY AND FOR DISCUSSION PURPOSES ONLY. THE GOVERNMENT WILL MAKE A FINAL DETERMINATION OF THE RELOCATIONS NECESSARY FOR THE CONSTRUCTION, OPERATION, OR MAINTENANCE OF THE PROJECT AFTER FURTHER ANALYSIS AND COMPLETION AND APPROVAL OF THE FINAL ATTORNEY'S OPINIONS OF COMPENSABILITY FOR EACH OF THE IMPACTED UTILITIES AND FACILITIES DURING FINAL DESIGNS.



Utility Station ID Map 48

19. Statement that the Non-Federal Sponsor has been notified in writing about the Risks Associated with Acquiring Land for this Proposed Project

The Government has sent risk letters to the NFS's in August 2012 enumerating the Sponsor's financial risks associated with acquisition of real property interests prior to execution of the Project Partnership Agreement.

20. Hazardous, Toxic, and Radiological Waste Impacts

A preliminary Phase I Environmental Site Assessment (ESA) has been conducted to identify potential HTRW sites. No known contamination due to HTRW was confirmed within the construction zone, however, a full Phase I ESA has not been conducted.

To further investigate the potential for hazardous toxic radioactive wastes (HTRW) in the project area, a full Phase I Environmental Site Assessment (ESA) would be performed during the project design phase. If the Phase I ESA indicates the presence of HTRW, a Phase II ESA would be performed involving chemical analysis for hazardous substances and/or petroleum hydrocarbons. If hazardous substances are encountered during construction, USACE or its contractor will implement required measures for the proper transport and disposal of such materials in accordance with the appropriate local, state, and Federal laws and regulations.

If any evidence of potential HTRW is found during construction, all work would cease, and the Corps and non-Federal sponsor would be notified for further evaluation of the potential contamination. Any unanticipated hazardous materials encountered during construction would be handled according to applicable federal, state, and local regulations. The Corps would require that a contingency plan that outlines steps to be taken before and during construction activities to document soil conditions, as well as procedures to be followed if unexpected conditions are encountered, be prepared by the contractor.

The non-Federal sponsor is responsible for 100 percent of the cost to develop the clean-up procedures (remedial action plan) and to treat the contaminate in place or relocate the material (ER 1110-2-1150). For further detailed information the Integrated EIS document has a HTRW section and the Engineering appendix contains the HTRW assessment details.

21. Attitude of Landowners

To date, the results of the outreach program from the public scoping meetings have been very favorable, constructive, and supportive. The tone and substance of the input has been consistent with the voter-approved assessment to fund the local share of the project.

EXHIBIT A1

ASSESSMENT OF NON-FEDERAL SPONSOR'S REAL ESTATE ACQUISITION CAPABILITY
SUTTER PILOT FEASIBILITY STUDY

SPONSORS: The State of California, Central Valley Flood Protection Board (CVFPB), Sutter Butte Flood Control Agency (SBFCA)

I. Legal Authority:

a. Do the sponsors have legal authority to acquire and hold title to real property for project purposes? Yes CVFPB; Yes SBFCA

b. Do the sponsors have the power of eminent domain for this project? Yes CVFPB; Yes SBFCA

c. Do the sponsors have "quick-take" authority for this project? Yes CVFPB; Yes SBFCA

d. Are any of the lands/interests in land required for the project located outside the sponsor's political boundary? No CVFPB; No SBFCA

e. Are any of the lands/interests in land required for the project owned by an entity whose property the sponsor cannot condemn? No CVFPB; SBFCA Response: Some of the lands are owned by public entities, including local and state agencies. Under California law, it is more difficult to condemn property owned by public entities. Some of the property within the project area is owned by a railroad company. Condemning railroad property is also more difficult due to federal pre-emption issues.

II. Human Resource Requirements:

a. Will the sponsor's in-house staff require training to become familiar with the real estate requirements of Federal projects including P.L. 91-646, as amended? Yes CVFPB; No SBFCA

b. If the answer to a. is "yes," has a reasonable plan been developed to provide such training? Yes CVFPB; SBFCA N/A

c. Does the sponsor's in-house staff have sufficient real estate acquisition experience to meet its responsibilities for the project? Yes CVFPB; Yes SBFCA

d. Is the sponsor's project in-house staffing level sufficient considering its other workload, if any, and the project schedule? Yes CVFPB; Yes SBFCA

e. Can the sponsor obtain contractor support, if required, in a timely fashion? Yes CVFPB; Yes SBFCA

f. Will the sponsor likely request USACE assistance in acquiring real estate? No CVFPB; No SBFCA

III. Other Project Variables:

a. Will the sponsor's staff be located within reasonable proximity to the project site? Yes CVFPB; Yes SBFCA

b. Has the sponsor approved the project real estate schedule/milestones? Yes CVFPB; SBFCA Response: No, the approval occurs during the preconstruction, engineering and design phase.

IV. Overall Assessment:

a. Has the sponsor performed satisfactorily on other USACE projects? Yes CVFPB; SBFCA Response: SBFCA has not worked on other USACE projects.

b. With regard to this project, the sponsor is anticipated to be: The State of California, Central Valley Flood Protection Board and Sutter Butte Flood Control Agency
V. Coordination:

a. Has this assessment been coordinated with the sponsor? Yes CVFPB; SBFCA Response: SBFCA has coordinated with USACE throughout the Sutter Pilot Feasibility Study.

b. Does the sponsor concur with this assessment? Yes CVFPB; SBFCA Response: SBFCA concurs with USACE at the feasibility stage of the project. SBFCA anticipates refinements during preconstruction, engineering and design.

Prepared by:

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Acquisition Branch

Date Oct 10, 2013

Reviewed and Approved by:

Sharon Caine
Chief, Real Estate Division
U.S. Army Engineer District, Sacramento

Date

EXHIBIT 1A – ASSESSMENT OF NON-FEDERAL PARTNERS REAL ESTATE ACQUISITION CAPABILITY
EXHIBIT1B – SUMMARY OF ENCROACHMENTS FOR ALTERNATIVE SB8
EXHIBIT1C- TENTATIVELY SELECTED PLAN SB-8 CADASTRAL MAP
EXHIBIT 1D- UTILITY INVENTORY MAPS
EXHIBIT1E –TRACT REGISTER BORROW AND MITIGATION SITES
EXHIBIT1F-TRACT REGISTER TENTATIVELY SELECTED PLAN

APPENDIX F

RESPONSES TO COMMENTS

ON THE DRAFT FEASIBILITY REPORT AND EIR/SEIS

This appendix contains the comment letters (including transcribed comments received during the July 22, 2013 public meeting) and USACE's and SBFCA's individual responses to comments.

The draft Integrated Feasibility Report and EIR/SEIS was circulated on June 14, 2013. An "All Interested Parties" notice was also sent out to a mailing list. A Notice of Availability was published in the Federal Register on June 14, 2013, and a public meeting was held by USACE and SBFCA on July 22, 2013 to receive comments on the report from agency representatives and other interested parties. Meeting attendees included five members of the public.

USACE received six comment letters during the 45-day public review period, which ended on July 29, 2013 and two comments were submitted during the July 22, 2013 public meeting. Table 1 lists all parties who submitted comments. Each letter and individual comment has been assigned a number/letter designation for cross-referencing. Table 2 includes the text of all comments and responses to the comments. The comments were reproduced as written and may contain grammatical and spelling errors. The comment letters received follow Table 2.

Table 1
List of Commenters

Letter #	Commenter	Date Of Comment
Federal Agencies (F)		
F1	Federal Emergency Management Agency	June 11, 2013
F2	U.S. Environmental Protection Agency	July 25, 2013
F3	U.S. Department of Interior, Office of Environmental Policy and Compliance	July 29, 2013
State Agencies (S)		
S1	Governor's Office of Planning and Research	July 30, 2013
Local Agencies (L)		
L1	Sacramento Area Flood Control Agency	July 25, 2013
Individuals (I)		
I1	Patrick Porgans	July 29 and 30, 2013
Public Meeting (PM)		
PM1	Lawrence Mentz	July 22, 2013
PM1	Patrick Porgans	July 22, 2013

Table 2 Responses to Comments			
Name	**Comment No.**	**Comment**	**Response**
Federal Agencies			
FEMA	FEMA-1	Please review the current effective countywide Flood Insurance Rate Maps (FIRMS) for the Counties of Butte (Community Number 060017), Maps revised January 6, 2011 and Sutter (Community Number 060394), Maps revised December 2, 2008. Please note that the Counties of Butte and Sutter, State of California are participants in the National Flood Insurance Program (NFIP). The minimum, basic NFIP floodplain management building requirements are described in Vol. 44 Code of Federal Regulations (44 CFR), Sections 59 through 65. A summary of these NFIP floodplain management building requirements are as follows: All buildings constructed in a riverine foodplain (i.e., Flood Zones A, AO, AH, AE, and A1 through A30 as delineated on the FIRM) must be elevated so that the lowest floor is at or above the Base Flood Elevation level in accordance with the effective Flood Insurance Rate Map. If the area of construction is located within a Regulatory Floodway as delineated on the FIRM, any ***development*** must not increase base flood elevation levels. **The term *development* means any man-made change to improved or unimproved real estate, including but not limited to building, other structures, mining, dredging, filling, grading,**	Regulations concerning the NFIP are noted. The proposed action would not result in the construction of buildings in a flood hazard zone or development in a regulatory floodway that would raise base flood levels.

		paving, excavation or drilling operations, and storage of equipment or materials. A hydrologic and hydraulic analysis must be performed *prior* to the start of development, and must demonstrate that the development would not cause any rise in base flood levels. No rise is permitted within regulatory floodways. Upon completion of any development that changes existing Special Flood Hazard Areas, the NFIP directs all participating communities to submit the appropriate hydrologic and hydraulic data to FEMA for a FIRM revision. In accordance with 44 CFR, Section 65.3, as soon as practicable, but not later than six months after such data becomes available, a community shall notify FEMA of the changes by submitting technical data for a flood map revision. To obtain copies of FEMA's Flood Map Revision Application Packages, please refer to the FEMA website at http://www.fema.gov/business/nfip/forms.shtm.	
U.S. Environmental Protection Agency	EPA-1	The SDEIS (p. 6-4) acknowledges that the Tentatively Selected Plan (TSP) must be evaluated pursuant to Section 404(b)(1) of the Clean Water Act in accordance with the Federal Guidelines for Specification of Disposal Sites for Dredged or Fill Materials (40 CFR 230). The SDEIS also acknowledges that the project must be the least damaging practicable alternative (LEDPA) and would include all appropriate and practicable measures necessary to minimize adverse effects on the aquatic environment. The SDEIS does, not however, demonstrate that the TSP is the LEPDA. It states that the 404(b)(1) alternatives analysis will be included in the Final EIS.	A 404(b)(1) Evaluation is included in the Final document in Appendix D. The evaluation identifies the Locally Preferred Plan as the LEDPA. While the NED plan results in less fill than the LPP, the alternative would not reduce flood risk to the communities of Gridley, and Biggs and therefore not adequately meet the project purpose. As described in the evaluation, the fill activity associated with relocation of the Sutter Butte Canal has been minimized by relocation of the levee where feasible to avoid encroaching on the channel and increasing base flood elevations.

		The practice of deferring, until the conclusion of the NEPA process, the disclosure of information needed for findings of compliance with the Guidelines makes it difficult for agencies and the public to provide timely and substantive input on the evaluation of alternatives, which could inform the Corps' decision making process. Integrating the section 404(b)(1) alternatives analysis into the Draft EIS alternatives analysis would afford agencies and the public a more meaningful opportunity to evaluate impacts and provide relevant and timely feedback to inform these analyses and the Corps' decision. We have rated this SDEIS as EC-2 – Environmental Concerns – Insufficient Information (see Enclosure 1: "Summary of Rating Definitions and Follow-Up Action") because it is unclear whether the TSP is LEDPA, and we are unable to assess the likelihood that affected waters would be successfully restored. We recommend that, in the future, the 404(b)(1) alternatives analysis be included in Draft EISs.	
U.S. Environmental Protection Agency	EPA-2	The Sutter Pilot Feasibility Report Mitigation Monitoring Plan (MMP) does not identify restoration measures, success criteria, or monitoring commitments for 3.099 acres of waters of the U.S. that would be temporarily affected by the project. We note that such information is provided in the MMP for restoration and /or creation of riparian, non-riparian, and Valley elderberry habitat. We recommend that the FEIS and MMP include commitments to actively restore temporarily affected waters of the U.S. The FEIS and MMP should identify restoration measures and success criteria, and include monitoring	In response to the comment, the FEIS and MMP has been revised to include restoration measures, success criteria, or monitoring commitments for jurisdictional wetlands temporarily affected by the project.

		commitments to ensure successful restoration of these resources.	
U.S. Environmental Protection Agency	EPA-3	According to the MMP (p. 4-1), success criteria for riparian vegetation, oak woodland, and Valley elderberry include demonstrating at least 60 percent survival of all plantings after 20 years. Elsewhere (p. 3-9), the MMP states, "It is anticipated that at the end of the 3-year establishment period, 70% survivorship of woody species will be attained." According to the Corps Regulatory Program Uniform Performance Standards for Compensatory Mitigation Requirements (Version 8/9/2012, SPD QMS 12505.1) permittees are required to ensure equal or greater than 80 percent survivorship for vegetation and monitor annually until a minimum of 2 years of success post-irrigation. We recommend that the project be required to meet this performance standard.	The recommendation has been adopted. The MMP has been revised to meet the performance standard of at least 80 percent survival for a minimum of 2 years post-irrigation.
U.S. Environmental Protection Agency	EPA-4	The MMP (p. 5-2) recommends herbicide application in areas that will be planted, and identifies the herbicides that are most likely to be used. EPA recommends that the MMP state the conditions under which pesticides would be used, including actions needed to comply with California's general National Pollutant Discharge Elimination System permits for pesticide applications. Note that the California permits may require advance submission of a pesticide application plan,in some cases 90 days in advance. More information is available at http://www.swrcb.ca.gov/water issues/programs /npdes/aquatic.shtml. You may also wish to contact Phil Isorena (Phillip.Isorena@waterboards.ca.gov) at the California State Water Resources Board.	Per EPA's recommendation, text has been added to the MMP to specify under which conditions pesticides would be used and the actions needed to comply with NPDES permits.

U.S. Department of Interior, Office of Environmental Policy and Compliance	DOI-1	The Department of the Interior has received and reviewed the subject document and has no comments to offer.	No response required.
State Agencies			
Governor's Office of Planning and Research	OPR-1	The State Clearinghouse submitted the above Named EIR to selected state agencies for review. The review period closed on July 29, 2013, and no state agencies submitted comments by that date. This letter acknowledges you complied with the State Clearinghouse review requirements for draft environmental documents, pursuant to the California Environmental Quality Act.	No response required.
Local Agencies			
Sacramento Area Flood Control Agency	SAFCA-1	My comments today focus on one issue – the exclusion of a Locally Preferred Plan (LPP) that includes a System Wide Improvement Framework (SWIF) to address the vegetation issue as a means of addressing the worst risk first. In August 2012, a meeting was held on the American River Watershed Common Features GRR with representatives from the Assistant Secretary of the Army for Civil Works and USACE Headquarters. The meeting was held to figure out how to avoid the issues surrounding the vegetation, access, and encroachments on levees from holding up planning reports and the needed structural fixes to the levees for public safety. In that meeting it was generally acknowledged that a plan which proposed removal of	On March 28, 2013, the CVFPB submitted a Letter of Intent (LOI) notifying USACE that the local maintaining agencies within the Sutter Basin led by SBFCA intended to develop and implement a (SWIF) plan. The SWIF would bring the existing levees into compliance with the existing project Operations and Maintenance manual and is considered part of the without project condition (No Action Alternative). Therefore, while a SWIF is not a component of the LPP, a SWIF is being implemented but by the CVFPB and the local maintaining entities separate from the study. The LOI would allow the Basin's levee system to retain eligibility in USACE' PL 84-99 Rehabilitation and Inspection Program (RIP)

		all vegetation would likely not be implementable from a cost, environmental and public acceptance standpoint and would result in the critical risk reduction features being held up due to the vegetation issues. It was decided that the planning document would include an LPP that is consistent with the structural components of the alternative the District developed, but within an overall framework that would allow the worst risks to be addressed first. This would be achieved utilizing a SWIF to address correcting the remaining deficiencies that represent a much lower threat to public safety, such as vegetation.	for a period of two years while SBFCA develops a SWIF. For purposes of the study, a non-variance approach to ETL compliance was assumed for purposes of the study, strict ETL compliance was assumed for TSP and maximum potential impact shown in EIS. During PED phase compliance with ETL 1110-2-571 will be readdressed and every means then available for ETL compliance will be fully evaluated. Based upon the LOI to develop a SWIF plan to achieve compliance with existing Operations and Maintenance requirements, including vegetation removal in accordance with the existing O&M requirements, the Sutter Basin Pilot Feasibility Study has assumed that there will be no deferred maintenance; i.e., the without project condition will be fully compliant with existing O&M requirements. During construction, any unacceptable inspections items and deficiencies that have not been addressed in accordance with the SWIF, will be included in the Government construction contract as a non-Federal expense.
Sacramento Area Flood Control Agency	SAFCA-2	The LPP would have several capital improvement components phased-in over time in a manner to address the worst risk first. The LPP would also have a component that would be a long-term plan of action, including a financing plan, addressing any remaining encroachments, access, real estate, vegetation, and other issues not addressed as part of the capital	As explained above, a SWIF is being implemented to address deficiencies in operation and maintenance. Unwanted vegetation growth, encroachments, and erosion are all system-wide issues and make up 97% of Sutter Basin's deficiencies listed in the USACE Unacceptable Items List.

		improvement components of the LPP for the levees covered by the planning document as part of the SWIF.	
Sacramento Area Flood Control Agency	SAFCA-3	The way the policy is being implemented in the SBPFDR does not allow for the worst risks to be addressed first: it is an all or nothing approach. It significantly increases the risk that the plan will be opposed on several levels because of the vegetation component. Therefore, the way the policy is being implemented in the SBPFDR could result in increased risk to the public by delaying critical structural work.	Critical levee improvements are not being delayed. With USACE 408 permission, SBFCA has initiated construction of the Feather River West Levee Improvement EIP Project.
Sacramento Area Flood Control Agency	SAFCA-4	The Corps should not be promoting the idea of a SWIF as a mechanism to address the concept of "worst first" publically and to Congress, but then deny the use of it in practice.	A use of a SWIF to address levee O&M deficiencies has not been denied. USACE has worked closely with maintaining agencies to promote a SWIF to maintain eligibility in the PL 84-99 RIP.
Sacramento Area Flood Control Agency	SAFCA-5	I respectfully submit these comments and request that the Corps follows the policy it is promoting publically and allow an LPP with a SWIF component to address the controversial vegetation issue, and other difficult but low risk encroachment and access issues over time. An alternative solution may be to include the SWIF components as part of the alternatives presented in the SBPFDR.	As explained above, a SWIF is not a feature of the LPP; the CVFPB has submitted a Letter of Intent to implement a SWIF separate from the study.
Individuals			
Patrick Porgans	Porgans-1	**Position Statement**: As stated in writing and at meetings we acknowledge and support the *Sutter Basin Feasibility Study* and all of the components contained in the Sutter Butte Flood Control Agency's plan to provide the much needed flood control protections for Yuba City, Live Oaks, Gridley and	USACE and SBFCA have conducted an extensive alternatives review during several phases of the project development. Oroville reoperation and other alternatives were considered. The alternatives presented best address the primary levee and flood

		Biggs. However, neither the Feasibility Study nor the proposed flood control plan (Locally Preferred Plan (LLP/Alt.-8) provide assurances that the proposed flood control protections will be effective nor has the local sponsors, Sutter Butte Flood Control Agency and the state Central Valley Flood Control Protection Board, identified or secured the funds required to construct either the Agency's or the State's proposed Flood Plans.	management deficiencies in each stretch of the Feather River. River dredging was evaluated and screened during evaluation of the preliminary array. Oroville reoperation and Feather river dredging would not address geotechnical performance which was determined to be a large component of the current FRM performance and assurance. Comment did not necessitate change to analysis.
Patrick Porgans	Porgans-2	**Feasibility Report - Funding Questions Remain Unanswered:** On behalf of its client, P&A attended federal, state and regional meetings to discuss the issue of securing funding in times or austerity and cutbacks; USACE personnel concede to the fact that there are no assurances that the Congress will authorize the federal contribution to the project. Even if Congress approves funding for the Sutter Butte Flood Control Agency's proposed project, the Agency is dependent on obtaining the state's share of the money required to construct the project; purportedly, the majority of those funds would come from the issuance of voter-approved General Obligation (GO) bonds. GO bonds are backed by the full faith and credit of the people of California and are repaid from the state's deficit-ridden General Fund.	Federal funding is dependent on Congressional authorization and appropriation. As noted, construction is also dependent on the State and SBFCA providing their local cost share of the project cost.
Patrick Porgans (Phone Call on July 30, 2013 between Mr. Porgans and Laura Whitney, USACE Project		Comment: Flood flows and the reoperation of Oroville Dam. Mr. Porgans indicated the reoperation has not been accurate and has not been in compliance with Sec 7 operation regulation. Has this been considered?	The uncertainty in hydrologic frequency is incorporated into the analysis of each alternative's project performance using risk and uncertainty methods. The operation of the reservoir is assumed to follow the existing flood control diagram and release schedule

Manger)			specified in the approved (1970) Water Control Manual. The water control manual allows for operational uncertainty. For example, the manual states "Insofar as possible, the Feather River below the Bear River should be limited to 320,000 c.f.s. The manual also states, "During very large floods releases greater than 150,000 c.f.s. may be required, as indicated by the emergency spillway release diagram, in order to minimize uncontrolled spillway discharges".
Patrick Porgans (Phone Call on July 30, 2013 between Mr. Porgans and Laura Whitney, USACE Project Manger)		Comment: This area, Sutter Basin, has not experienced a 100 year event, therefore historical flooding has perhaps not been addressed adequately.	The 1997 flood event was estimated to be greater than a 100 year event. In highly regulated streams like the Feather River, unregulated flow estimates must be used to determine the frequency of historical flood events. A detailed hydrologic analysis of historical unregulated floods at the Feather River at Oroville gage is provided in Appendix B of the March 2002 Sacramento and San Joaquin Basins Comprehensive Study. Due to reservoir storage attenuation, the frequency of the 3-day average unregulated flow is more representative of the frequency of peak regulated outflow. The January 1997 flood event was the largest flood event experienced since records began in 1902. The unregulated 3-day flow was estimated to be 244,000 cfs. Based on the flood frequency analysis, the 3-day average flow was estimated to have a 0.9% (1/110) Annual Chance of Exceedance. The unregulated 1-day flow was estimated to be 313,000 cfs. Based on the flood frequency

			analysis, the one-day flow was also estimated to have a 0.9% (1/110) Annual Chance of Exceedance.
Patrick Porgans (Phone Call on July 30, 2013 between Mr. Porgans and Laura Whitney, USACE Project Manger)		Mr. Progans stated that this area has not seen a "standard flood" and that he fears with the project we would be allowing more water down the channel specifically from Hwy 62 to Huncut.	Although flood routings for the Standard Project Flood (SPF) are presented in the 1970 Water Control Manual, the SPF is no longer used by USACE to evaluate project performance. The proposed project does not change the hydraulic capacity of the Feather River. The levees will be fixed in place and the height will be restored to the authorized profile or existing profile. The operation of Oroville or New Bullards Bar reservoir will not change. Operational releases from the reservoir are defined by the existing flood control diagram and release schedule. These operational criteria are not related to any of the proposed project features incorporated into alternatives SB-7 or SB-8. The project features address geotechnical performance of the Feather River levee and reservoir operations are not based on geotechnical performance.
Public Meeting			
Lawrence Mentz	Mentz-1	"My concern is that if we don't get this flood thing through, during the last flood -- all the highways are really, really congested. As I recall, the highways follow the levies. They follow the levies on the west side, and they cross over points way up near Biggs. And we need the -- if we have another flood, where are the people going to go?"	Your concern is noted. Flood evacuation routes were evaluated and found to be seriously inadequate.

Lawrence Mentz	Mentz-2	"My other concern is we need money for this project."	Federal participation is contingent on congressional funding.
Patrick Porgans	Porgans-1	"In particular, I was asking on that feasibility assessment what assurances we have that the local property owners who have a tax assessment of approximately 6.8 million a year, why they can be left holding the bag. "The bag," meaning that they can get the 40, which is a good project, but unless certain other changes are made upstream from the proposed project -- for example, the operation of the Oroville Flood Control Facilities, which is operated by the Department of Water Resources under the jurisdiction of the Corps, and unless the operation component states the plan is put into effect, they're only going to increase the risk of danger by increasing the level of protection they're speaking of. And that's reportedly talking about 200 years of protection on 41 miles of levies. And we're saying that it's a good idea, but we can't get enough information to show its economic justification, or that it will be fully-funded."	The dam and reservoir at Oroville were constructed after the Sacramento River Flood Control Project was authorized and after the 1957 profile was established as the design standard for the system. A result of this circumstance is that the levee heights are well above the design flow that the system is intended to convey. Beyond levee height, the levees along the Feather 1 River are considerably set back from the active channel of the river, providing a floodplain that is substantially greater than most of the rivers of the Central Valley, in many places thousands of feet in width. The combined effect is that the Feather River in the study area is not limited by conveyance capacity as a significant flood-management risk.
Patrick Porgans	Porgans-2	"So if the dredge is not going to happen, and the by-pass is not going to happen, and the re-op is not happening, and we don't have the assurances it will, I don't believe I can put a level confidence in this project that would assure people ultimately that they wouldn't be committing they're own demise."	USACE and SBFCA have conducted an extensive alternatives review under both the feasibility study and the FRWLP. Oroville reoperation and other alternatives were considered. The alternatives presented best address the primary levee and flood management deficiencies in each stretch of the Feather River. River dredging does not substantially reduce flood risk because the Feather River in the study area is not limited in conveyance capacity and because dredging would not address the documented deficiencies according

			to Federal and state criteria. Comment did not necessitate change to analysis.

2462

JUN 25 2013

F1

U.S. Department of Homeland Security
FEMA Region IX
1111 Broadway, Suite 1200
Oakland, CA. 94607-4052

FEMA

June 11, 2013

Alicia E. Kirchner, Chief
Planning Division
Department of the Army
U. S. Army Engineering District, Sacramento Corps of Engineers
1325 J. Street
Sacramento, California 95814-2922

Dear Ms. Kirchner:

This is in response to your request for comments on Draft Feasibility Report and Environmental Impact Report/Supplemental Environmental Impact Statement (FR/EIR/SEIS) for Sutter Basin Pilot Feasibility Study (SBPFS).

Please review the current effective countywide Flood Insurance Rate Maps (FIRMs) for the Counties of Butte (Community Number 060017), Maps revised January 6, 2011 and Sutter (Community Number 060394), Maps revised December 2, 2008. Please note that the Counties of Butte and Sutter, State of California are participants in the National Flood Insurance Program (NFIP). The minimum, basic NFIP floodplain management building requirements are described in Vol. 44 Code of Federal Regulations (44 CFR), Sections 59 through 65.

A summary of these NFIP floodplain management building requirements are as follows:

- All buildings constructed within a riverine floodplain, (i.e., Flood Zones A, AO, AH, AE, and A1 through A30 as delineated on the FIRM), must be elevated so that the lowest floor is at or above the Base Flood Elevation level in accordance with the effective Flood Insurance Rate Map.

- If the area of construction is located within a Regulatory Floodway as delineated on the FIRM, any ***development*** must not increase base flood elevation levels. **The term *development* means any man-made change to improved or unimproved real estate, including but not limited to buildings, other structures, mining, dredging, filling, grading, paving, excavation or drilling operations, and storage of equipment or materials.** A hydrologic and hydraulic analysis must be performed *prior* to the start of development, and must demonstrate that the development would not cause any rise in base flood levels. No rise is permitted within regulatory floodways. FEMA-1

- Upon completion of any development that changes existing Special Flood Hazard Areas, the NFIP directs all participating communities to submit the appropriate hydrologic and hydraulic data to FEMA for a FIRM revision. In accordance with 44 CFR, Section 65.3, as soon as practicable, but not later than six months after such data becomes available, a community shall notify FEMA of the changes by submitting technical data for a flood map revision. To obtain copies of FEMA's Flood Map Revision Application Packages, please refer to the FEMA website at http://www.fema.gov/business/nfip/forms.shtm.

FEMA-1 Cont.

Please Note:

Many NFIP participating communities have adopted floodplain management building requirements which are more restrictive than the minimum federal standards described in 44 CFR. Please contact the local community's floodplain manager for more information on local floodplain management building requirements. The Butte County floodplain manager can be reached by calling Tom Fossom, Division Manager, Department of Public Works, at (530) 538-7266. The Sutter County floodplain manager can be reached by calling Douglas Gault, Director, Department of Public Works, at (530) 822-7450.

If you have any questions or concerns, please do not hesitate to call Frank Mansell at (510) 627-7191 and/or Robert Durrin at (510) 627- 7057 of the Mitigation staff.

Sincerely,

Gregor Blackburn, CFM, Branch Chief
Floodplain Management and Insurance Branch

cc:
Brad Johnson, Environmental Manager, Department of the Army, U. S. Army Engineering District, Sacramento Corps of Engineers
Tom Fossom, Division Manager, Department of Public Works, Butte County
Douglas Gault, Director, Department of Public Works, Sutter County
Tim Chao/Raul Barba, State of California, Department of Water Resources, Northern Region Office
Ray Lee, WREA, State of California, Department of Water Resources, North Central Region Office
Robert Durrin, NFIP Planner, DHS/FEMA Region IX
Frank Mansell, NFIP Planner, DHS/FEMA Region IX
Alessandro Amaglio, Environmental Officer, DHS/FEMA Region IX

F2

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105

JUL 2 5 2013

Alicia E. Kirchner
U.S. Army Corps of Engineers, Sacramento District
1325 J Street
Sacramento, California 95814-2922

Subject: Sutter Basin Pilot Feasibility Report Supplemental Draft Environmental Impact Statement (SDEIS), Butte and Sutter Counties, California [CEQ #20130170]

Dear Ms. Kirchner:

The U.S. Environmental Protection Agency (EPA) has reviewed the above referenced document. Our review and comments are provided pursuant to the National Environmental Policy Act (NEPA), the Council on Environmental Quality's (CEQ) NEPA Implementation Regulations at 40 CFR 1500 - 1508, and our review authority under Section 309 of the Clean Air Act.

The reach and environmental impacts of the project analyzed in the Sutter Basin Pilot Feasibility Report SDEIS are similar to those of the Feather River West Levee Project (FRWLP); however, this SDEIS supplements the FRWLP Final EIS to address additional levee improvements.

The SDEIS (p. 6-4) acknowledges that the Tentatively Selected Plan (TSP) must be evaluated pursuant to Section 404(b)(1) of the Clean Water Act in accordance with the Federal Guidelines for Specification of Disposal Sites for Dredged or Fill Materials (40 CFR 230). The SDEIS also acknowledges that the project must be the least environmentally damaging practicable alternative (LEDPA) and would include all appropriate and practicable measures necessary to minimize adverse effects on the aquatic environment. The SDEIS does not, however, demonstrate that the TSP is the LEPDA. It states that the 404(b)(1) alternatives analysis will be included in the Final EIS.

EPA-1

The practice of deferring, until the conclusion of the NEPA process, the disclosure of information needed for findings of compliance with the Guidelines makes it difficult for agencies and the public to provide timely and substantive input on the evaluation of alternatives, which could inform the Corps' decision making process. Integrating the section 404(b)(1) alternatives analysis into the Draft EIS alternatives analysis would afford agencies and the public a more meaningful opportunity to evaluate impacts and provide relevant and timely feedback to inform these analyses and the Corps' decision.

We have rated this SDEIS as EC-2 – Environmental Concerns-Insufficient Information (see Enclosure 1: "Summary of Rating Definitions and Follow-Up Action") because it is unclear whether the TSP is LEDPA, and we are unable to assess the likelihood that affected waters

would be successfully restored. We recommend that, in the future, the 404(b)(1) alternatives analysis be included in Draft EISs. EPA-1 Cont.

The Sutter Basin Pilot Feasibility Report Mitigation and Monitoring Plan (MMP) does not identify restoration measures, success criteria, or monitoring commitments for 3.099 acres of waters of the U.S. that would be temporarily affected by the project. We note that such information is provided in the MMP for restoration and/or creation of riparian, non-riparian, and Valley elderberry longhorn beetle habitat. We recommend that the Final EIS and MMP include commitments to actively restore temporarily affected waters of the U.S. The FEIS and MMP should identify restoration measures and success criteria, and include monitoring commitments to ensure successful restoration of these resources. EPA-2

According to the MMP (p. 4-1), success criteria for riparian vegetation, oak woodland, and Valley elderberry include demonstrating at least 60 percent survival of all plantings after 20 years. Elsewhere (p. 3-9), the MMP states, "It is anticipated that at the end of the 3-year establishment period, 70% survivorship of woody species will be attained." According to the Corps Regulatory Program Uniform Performance Standards for Compensatory Mitigation Requirements (Version 8/9/2012, SPD QMS 12505.1), permittees are required to ensure equal or greater than 80 percent survivorship for vegetation and monitor annually until a minimum of 2 years of success post-irrigation. We recommend that the project be required to meet this performance standard. EPA-3

The MMP (p. 5-2) recommends herbicide application in areas that will be planted, and identifies the herbicides that are most likely to be used. EPA recommends that the MMP state the conditions under which pesticides would be used, including actions needed to comply with California's general National Pollutant Discharge Elimination System permits for pesticide applications. Note that the California permits may require advance submission of a pesticide application plan, in some cases 90 days in advance. More information is available at http://www.swrcb.ca.gov/water_issues/programs/npdes/aquatic.shtml. You may also wish to contact Phil Isorena (Philip.Isorena@waterboards.ca.gov) at the California State Water Resources Control Board. EPA-4

We appreciate the opportunity to review this SDEIS. Please send a copy of the Final EIS to this office (mailcode CED-2) when it is filed with EPA's electronic submittal tool, *e-NEPA*. If you have any questions, please call me at (415) 972-3521 or contact Jeanne Geselbracht, our lead NEPA reviewer for this project, at geselbracht.jeanne@epa.gov or (415) 972-3853.

Sincerely,

Kathleen Martyn Goforth, Manager
Environmental Review Office

Enclosure: Summary of Rating Definitions and Follow-Up Action
cc: Mike Inamine, Sutter Butte Flood Control Agency

F3

United States Department of the Interior

OFFICE OF THE SECRETARY
Office of Environmental Policy and Compliance
Pacific Southwest Region
333 Bush Street, Suite 515
San Francisco, CA 94104

IN REPLY REFER:
(ER 13/0418)

Filed Electronically

29 July 2013

Brad Johnson
U.S. Army Corps of Engineers
1325 J Street
Sacramento, CA 95814

Subject: Review of the Draft Sutter Basin Pilot Feasibility Report/Environmental Impact Report/Supplemental Environmental Impact Statement (FR/EIR/SEIS), Sutter and Butte Counties, CA

Dear Mr. Johnson,

The Department of the Interior has received and reviewed the subject document and has no comments to offer. DOI-1

Thank you for the opportunity to review this project.

Sincerely,

Patricia Sanderson Port

Patricia Sanderson Port
Regional Environmental Officer

cc:
Director, OEPC
OEPC Staff Contact: Loretta B. Sutton

STATE OF CALIFORNIA
GOVERNOR'S OFFICE *of* PLANNING AND RESEARCH
STATE CLEARINGHOUSE AND PLANNING UNIT

EDMUND G. BROWN JR.
GOVERNOR

KEN ALEX
DIRECTOR

July 30, 2013

S1

Brad Johnson
U.S. Army Corps of Engineers
1325 J Street
Sacramento, CA 95814

Subject: Sutter Basin Feasibility Study
SCH#: 2011052085

Dear Brad Johnson:

The State Clearinghouse submitted the above named Draft EIR to selected state agencies for review. The review period closed on July 29, 2013, and no state agencies submitted comments by that date. This letter acknowledges that you have complied with the State Clearinghouse review requirements for draft environmental documents, pursuant to the California Environmental Quality Act. OPR-1

Please call the State Clearinghouse at (916) 445-0613 if you have any questions regarding the environmental review process. If you have a question about the above-named project, please refer to the ten-digit State Clearinghouse number when contacting this office.

Sincerely,

Scott Morgan
Director, State Clearinghouse

Document Details Report
State Clearinghouse Data Base

SCH# 2011052085
Project Title Sutter Basin Feasibility Study
Lead Agency Sutter Butte Flood Control Agency

Type EIR Draft EIR

Description The Feasibility Report includes an integrated EIR / SEIS. The purpose of the Sutter Basin Pilot Feasibility Study (SBPFS) is to investigate and determine the extent of Federal interest in plans that reduce flood risk to the Sutter Basin in Sutter and Butte Counties. This report: (1) assesses the risk of flooding; (2) describes a range of alternatives formulated to reduce flood risk; and (3) identifies a Tentatively Selected Plan (TSP) for implementation. The TSP consists of levee improvements to existing levees of the Sacramento River Flood Control Project extending along approximately 41 miles of the Feather River. The plan would provide higher levels of flood risk management to local communities.

Lead Agency Contact

Name Brad Johnson
Agency U.S. Army Corps of Engineers
Phone 916 557 7812 **Fax**
email inorgaard@icfi.com
Address 1325 J Street
City Sacramento **State** CA **Zip** 95814

Project Location

County Sutter, Butte
City
Region
Lat / Long 39° 8' 25.56" N / 121° 37' .9624" W
Cross Streets Numerous
Parcel No. Numerous
Township **Range** **Section** **Base**

Proximity to:

Highways Hwy 99
Airports Butte County
Railways UPRR
Waterways Feather River
Schools Numerous
Land Use

Project Issues Agricultural Land; Air Quality; Biological Resources; Archaeologic-Historic; Geologic/Seismic; Toxic/Hazardous; Water Quality; Landuse; Other Issues; Minerals; Noise; Population/Housing Balance; Public Services; Recreation/Parks; Economics/Jobs; Traffic/Circulation; Aesthetic/Visual; Drainage/Absorption; Flood Plain/Flooding; Soil Erosion/Compaction/Grading; Solid Waste; Vegetation; Water Supply; Wetland/Riparian; Growth Inducing; Cumulative Effects

Reviewing Agencies Resources Agency; Department of Conservation; Department of Fish and Wildlife, Region 2; Department of Parks and Recreation; Central Valley Flood Protection Board; Department of Water Resources; Office of Emergency Management Agency, California; Caltrans, District 3 N; Regional Water Quality Control Bd., Region 5 (Redding); Regional Water Quality Control Bd., Region 5 (Sacramento); Native American Heritage Commission; State Lands Commission

Date Received 06/13/2013 **Start of Review** 06/14/2013 **End of Review** 07/29/2013

Sacramento
Area Flood
Control
Agency

L1

July 25, 2013

Mr. Brad Johnson
Sacramento District
U.S. Army Corps of Engineers
1325 J. Street
Sacramento, CA 95814

RE: Comments on Sutter Basin Pilot Feasibility Draft Report - Draft Environmental Impact Report/Supplemental Environmental Impact Statement

Dear Mr. Johnson:

SAFCA has reviewed with much interest the Sutter Basin Pilot Feasibility Draft Report (SBPFDR). SAFCA is the local sponsor for the American River Watershed Common Features General Reevaluation Report (GRR). Our GRR and the SBPFDR have been on a parallel path and have some of the same issues.

My comments today focus on one issue - the exclusion of a Locally Preferred Plan (LPP) that includes a System Wide Improvement Framework (SWIF) to address the vegetation issue as a means of addressing the worst risk first.

In August 2012, a meeting was held on the American River Watershed Common Features GRR with representatives from the Assistant Secretary of the Army for Civil Works and USACE Headquarters. The meeting was held to figure out how to avoid the issues surrounding the vegetation, access, and encroachments on levees from holding up planning reports and the needed structural fixes to the levees for public safety. In that meeting it was generally acknowledged that a plan which proposed removal of all vegetation would likely not be implementable from a cost, environmental and public acceptance standpoint and would result in the critical risk reduction features being held up due to the vegetation issues. It was decided that the planning document would include an LPP that is consistent with the structural components of the alternative the District developed, but within an overall framework that would allow the worst risks to be addressed first. This would be achieved utilizing a SWIF to address correcting the remaining deficiencies that represent a much lower threat to public safety, such as vegetation. SAFCA-1

The LPP would have several capital improvement components phased-in over time in a manner to address the worst risk first. The LPP would also have a component that would be a long-term plan of action, including a financing plan, addressing any remaining SAFCA-2

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Sacramento, CA 95814-3407

encroachment, access, real-estate, vegetation, and other issues not addressed as part of the capital improvement components of the LPP for the levees covered by the planning document as part of the SWIF. SAFCA-2 Cont.

With this in mind, SAFCA, Sutter Butte Flood Control Agency (SBFCA), and the State of California were proceeding with the idea that our planning documents would include an LPP that included a SWIF to address vegetation over time, so that public safety could be promoted and the greatest flood risk reduction to the community could be achieved first.

However, a few months ago, Colonel Leady and District staff told SBFCA, SAFCA, and the State that an LPP with a SWIF is "not policy compliant." We were told the alternatives in the documents had to be compliant with the ETL and that an LPP with a SWIF was not considered policy compliant. This is reflected in the draft SBPFDR.

Section ES 8.1 of the SBPFDR states:

> "The TSP assumes all vegetation, except grasses, will be removed from the levee and within 15 feet of the levee toe in compliance with Engineering Technical Letter (ETL) 1110-2-571, *Guidelines for Landscape Plantings and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures* (Vegetation ETL). This assumption discloses the maximum potential impacts of the TSP resulting from vegetation removal. During the design phase of the project, other options with lesser impacts, including a formal Vegetation ETL variance application to allow woody vegetation on the waterside of the levee, might be available and will be considered."

Additionally Section "3.8.2.2.2 Woody Vegetation on Levee" states:

> "However, for the purpose of this feasibility study, the Sacramento District's PDT determined that all alternatives were to be formulated and evaluated under the conservative assumption that each alternative would include necessary work, and costs thereof, for the removal of all vegetation on the levees, with the exception of grasses including 15 feet from the toe of the levee on both the landside and waterside."

The way the policy is being implemented in the SBPFDR does not allow for the worst risks to be addressed first: it is an all or nothing approach. It significantly increases the risk that the plan will be opposed on several levels because of the vegetation component. Therefore, the way the policy is being implemented in the SBPFDR could result in increased risk to the public by delaying critical structural work. SAFCA-3

I testified at the U.S. Senate Committee on Environment and Public Works Hearing on February 7, 2013 entitled, "Oversight Hearing on Implementation of Corps of Engineers Water Resources Policies." At the same hearing, the Assistant Secretary of the Army (Civil Works) Jo-Ellen Darcy stated in her testimony the following:

> "Each levee and its conditions must be considered in its entirety so well informed decisions for prioritizing levee safety actions can be made. The Corps policy enables levee sponsors to address the highest risk issues first."

The Assistant Secretary of the Army testified before the Senate that Corps policy enables levee sponsors to address the highest risk first. However, the Corps is not applying the Corps policy that way in the SBPFDR.

Additionally, on July 8, 2013, the Sacramento District released the video "Levee Safety in California's Central Valley: Levee Vegetation." In THE VIDEO the Corps again states that the Corps program allows the worst risks to be addressed first. The video states:

> "The Corps is working with the State and the local maintaining agencies to offer them a worst first approach. As part of our System Wide Improvement Framework, agencies can submit a plan for how they will deal with their specific levee issues over time, tackling the highest risk first and eventually coming into compliance with their vegetation, if it is not determined to be the highest risk."

An LPP with a SWIF included in the document would allow the District, the State, and SBFCA to move forward with the preparation of the SWIF component of the LPP so that these issues could be addressed in parallel with the SBPFDR with the understanding that the LPP will meet the policy and public safety objectives of the Corps, the State, and SBFCA while providing a pathway for reaching agreement on a levee vegetation management strategy.

The Corp's video itself stresses the need to have more time to address vegetation issue when it states the following:

> "In 2012 research scientists and engineers from all over the world came together in Sacramento for a conference to discuss vegetation on levees. The overwhelming take-away from that conference was simply that we need more information to make educated decisions about how to move forward."

The Corps should not be promoting the idea of a SWIF as a mechanism to address the concept of "worst first" publically and to Congress, but then deny the use of it in practice. SAFCA-4

I respectfully submit these comments and request that the Corps follows the policy it is promoting publically and allow an LPP with a SWIF component to address the controversial vegetation issue, and other difficult but low risk encroachment and access issues over time. An alternative solution may be to include the SWIF components as part of the alternatives presented in the SBPFDR. SAFCA-5

Sincerely,

Richard M. Johnson
Executive Director
Sacramento Area Flood Control Agency

I1

29 July 2013
U.S. Army Corps of Engineers
Sacramento District
1325 J Street
Sacramento, CA 95814

Subject: Comments and Confidence Rating Regarding the *Sutter Basin Pilot Feasibility Draft Report*[1]

Sent to the **Attention of DeDe Cordell**, Public Information Officer, U.S. Army Corps of Engineers DeDe.Cordell@usace.army.mil

Preface: The following comments have been limited due to time constraints, delayed-public notification by lead agencies; inability of project sponsors to provide answers to critical questions pertaining to the uncertainty of sources of funding and or project feasibility. The failure of the project sponsors and/or the USACE to provide such critical information. The ability to ascertain answers to such basis questions raised a series of "red flags"; a problem further impeded and complicated by the unavailability of federal government personnel to respond to questions; purportedly the result of Congressional cutbacks. Therefore, the comments submitted herein should be viewed as preliminary and limited.

Introduction: Thank you for the opportunity to comment on the U.S. Army Corps of Engineers' (USACE) ***Sutter Basin Feasibility Study***. As per DeDe Cordell's directive, this comment letter is being emailed to you, as the assigned project manager was out of the office today (flex day); and none of the USACE personnel assigned to the project were available last Friday, due to cutback.

The following comments are being submitted by *Patrick Porgans & Associates* on behalf of *Planetary Solutionaries*, a public-interest nongovernmental organization. Please be advised that we submitted comments on the USACE's draft Environmental Impact Statement (DEIS) and attended federal, state and regional public meetings expressing support for the study and the proposed flood control plan(s) sponsored by the Sutter Butte Flood Control Agency (Agency).

P&A has a longstanding involvement in flood protection and management issues in California and has taken proactive measures to ensure that the "responsible agencies" with jurisdiction in such matters, perform accordingly. P&A's clients also supported the state's Central Valley Flood Protection Board's adopted Flood Plan; approved by the Board in June 2012, as required by Senate Bill 5. However, as referenced in our comments on the USACE's DEIS, the state Board has since abandoned or opted to shelve three major components of the state's Plan that are critical to the future success of the Agency's proposed Plan:

1. Reoperation of the SWP Oroville Dam and Reservoir to provide more flood control space during the rainy period.
2. Widening the Cherokee Canal to allow a portion of the floodwater releases from the dam to be diverted in the upper reaches of the Feather River as was historically the case.
3. Although the client does not advocate dredging the channel removal of this option also limits the tools in the box.

P&A took the initiative to interact and actively participate in the public-hearing process, wherein it raised questions and expressed concerns regarding the feasibility of the proposed project, in the absence of the modifications made by the Board subsequent to approving the state's Plan. In addition, the uncertainties regarding the ability of the State to get voter approval of billions of dollars in additional General Obligation (GO) bonds for flood control projects. As it stands now, based on the documentation provided by the respective government agencies, we place very limited confidence in the "probability assurances" related to the State and local sponsors to fund the respective plans if turned down by voters. Furthermore, in the event funding shortfalls or operational and management modifications at Oroville, including a viable bypass are unsuccessful, it could result in the local sponsors "holding the bag".

Position Statement: As stated in writing and at meetings we acknowledge and support the *Sutter Basin Feasibility Study* and all of the components contained in the Sutter Butte Flood Control Agency's plan to provide the much needed flood control protections for Yuba City, Live Oaks, Gridley and Biggs. However, neither the Feasibility Study nor the proposed flood control plan (Locally Preferred Plan (LLP/Alt.-8) provide assurances that the proposed flood control protections will be effective nor has

P-1

[1] U.S. Army Corps of Engineers et al, Sutter Basin, California: ***Sutter Basin Pilot Feasibility Draft Report—Draft Environmental Impact Report/Supplemental Environmental Impact Statement***, June 2013.

P-1 Cont.

the local sponsors, Sutter Butte Flood Control Agency and the state Central Valley Flood Control Protection Board, identified or secured the funds required to construct either the Agency's or the State's proposed Flood Plans.

CATO Institute Essay **Critical of USACE Performance**: In March 2012, the **CATO Institute** issued a report stating,

> *The Corps has been greatly mismanaged over the decades, with problems ranging from frequent cost overruns on projects to major engineering failures that contributed to the disaster of Hurricane Katrina. In addition, the dominance of special-interest politics on the agency's activities has resulted in it supporting many wasteful projects.*
>
> *While Corps [USACE] projects are supposed to be based in detailed economic and environmental analyses, political pull often determines the agency's priorities. In an investigation of the Corps in 2003, the Washington Post noted that "powerful members of Congress dictate the selection, pace, and price tag for major projects." While levee upgrades in central New Orleans were stalled prior to Hurricane Katrina, dubious projects elsewhere in Louisiana and other states moved ahead.*
>
> ***Wasteful Projects and Faulty Analyses**: The Army Corps is supposed to do a careful and detailed analysis of proposed projects to ensure that the benefits will outweigh the costs. However, the Corps has often pursued projects based on analyses that were theoretically flawed, had faulty data, or had been deliberately manipulated.* [2]

Planetary Solutionaries Shares CATO's Concerns: Although, it is not P&A's intent to be critical of the USACE (Corps), our clients shares the concerns reference heretofore from the CATO report; however, we are placing emphasis on the following factors that are prefaced on facts ascertained by Porgans & Associates (P&A) for prior clients.

I. P&A conducted an independent fact-finding analysis of the USACE's and the California Department of Water Resources (DWR) judiciary and regulatory relationship subsequent to the 1986 and 1997 flood events; both of notable magnitude. In each event, P&A was actively monitoring the flood-control operation of all USACE "section 7 reservoirs" in the Sacramento, American, and Feather River Basins; a component of Planetary Solutionaries Section 7 Reservoir Monitoring Program.

II. In each of those events, government records confirm the fact that DWR failed to operate the federally funded component of the State Water Project's Oroville Dam and Reservoir in accordance with the USACE's prescribed rules and regulations. As you know, the USACE's regulations for this "section 7 reservoir" requires DWR, as the operator, to be compliant with flood control operations; and during flood events that it evacuate encroachments within the flood storage space and to make flood releases as prescribed in the USACE operating manual and Flood Control Diagram pertinent to Oroville Dam operations. However, in each event prior to the deluge, P&A provided the USACE personnel, responsible for overseeing the operation of section 7 reservoirs, with information it already had in its files. Documents that confirmed DWR was illegally retaining water in the designated flood storage space, in violation of USACE operational requirements; while the impending weather and flooding conditions would have deemed otherwise. At P&A's insistence USACE personnel did formally notify DWR it had to release the unauthorized water it was holding in the space reserved for flood storage; however, it was too much, too late. Lastly, federal flood control laws do not have enforcement provisions; compliance with flood control laws and regulations are left in the hands of the section 7 operators; such as DWR.

III. Subsequent to the warnings, which went unheeded, DWR resorted to increased flood water releases, in excess of USACE requirements. In DWR's own publications, it states that it is tempting to hold back on flood water releases as it enables DWR to generate more electrical energy by moving the water through

[2] CATO Institute, Chris Edwards, Cutting the Army Corps of Engineers, March 2012, p. 1. http://downsizinggovernment.org/usace

the turbines and helps to ensure water for its contractors.[3] Eighty-five percent of DWR's budget is purportedly obtained from revenues received from water and energy contractors. SWP contractors per se are not required to pay for the flood control component of the Oroville facilities; nor do they pay to maintain the Feather River which is used as a canal to move water to SWP contractors in central and southern California.

IV. It is important to keep in mind the purpose and intent of publicly funded flood control projects and plans; reduce or prevent flood damages. The Agency and State Flood Plans as proposed are rife with uncertainties that will only heighten the risk of flood damage, if all of the viable options are not inclusive. Compliance with existing flood control laws and the efficient management of the flood control system currently in place are critical.

Government has a mandate to ensure that flood control projects are designed, built, operated and maintained in accordance with the prescribed laws, rules, regulations, manuals and Memoranda agreements and as a means to ensure that flood control projects are designed, built, operated and maintained accordingly; the record indicates otherwise.

Neither the USACE nor DWR have the expressed right to take any action to impede, obstruct, compromise or jeopardizes the intended designed, maintenance or operational flood control facilities and or conveyances in a manner that is incongruent with the objectives and or integrity of the Flood Control System; unless, of course, an event of magnitude required actions to justify such an action.

Unfortuantely, P&A has to terminate its comments, because they are due today.

P&A apprized the USACE, Sutter Butte Flood Control Agency, and the state's Central Valley Flood Control Protection Board personnel of the aforementioned issues; unfortunately, none of whom could provide specific answers to questions that are critical to the success of the proposed action to provide additional flood control protections in the basin.

Feasibility Report - Funding Questions Remain Unanswered: On behalf of its client, P&A attended federal, state and regional meetings to discuss the issue of securing funding in times or austerity and cutbacks; USACE personnel concede to the fact that there are no assurances that the Congress will authorize the federal contribution to the project.

Even if Congress approves funding for the Sutter Butte Flood Control Agency's proposed project, the Agency is dependent on obtaining the state's share of the money required to construct the project; purportedly, the majority of those funds would come from the issuance of voter-approved General Obligation (GO) bonds. GO bonds are backed by the full faith and credit of the people of California and are repaid from the state's deficit-ridden General Fund.

Currently, the principle on California's GO bond indebtedness is around $80 billion; with interest payments it is estimated to be around $160 billion; however, there is another $50 billion in GO bonds that have been authorized but have yet to be sold. P-2

The State of California, more appropriately, the taxpayers, we asked to approve the State's proposed $17 billion flood plan, a significant portion of which is purportedly from the approval and issuance of General Obligation Bonds, which are repaid by Californians from tax revenues collected in the state's General Fund.

Narrative: Since 1980 Porgans & Associates has been actively engaged in conducting studies and developing plans for clients residing within the Feather River Basin in an effort ensure that the responsible government entities are operating the respective flood control facilities and Sacramento Flood Control System within the region in accordance with prescribed flood control regulations, land use requirements, and protection of listed aquatic and terrestrial species.

[3] California Department of Water Resources, Bulletin 199, ***California Flood Management: An Evaluation of Flood Prevention Programs,*** September 1980, p. 33.

During that time, P&A completed 12 Fact-Finding Reports pertaining to flood regulations, project operations and damages associated with historical and recent flood events within the Feather River Basin. "***Since 1950, 19 flood events in the basin have required extensive flood fighting, and the flood of 1955 resulted in 38 deaths***",[4] according to the USACE.

Government data, obtained via the Freedom of Information Act and the California Public Records Act, attest to the fact that the "responsible" government entities have failed to operate existing authorized flood control facilities in compliance with federal flood control laws, rules and regulations. In addition, the official records will attest to the fact that flood control protections provided heretofore, such as the construction of levees on the west side of the Feather River, which were completed in 1957 as a part of the federally authorized Sacramento Flood Control Project; and construction of the State Water Project's Oroville Dam and Reservoir flood control facilities, which became operable in 1967, have exacerbated flooding and flood damages downstream from the City of Oroville.

> ***USACE Mission****: Deliver vital public military engineering services; partnering in peace and war to strengthen our Nation's security, energize the economy and reduce risks from disaster.*
>
> ***USACE Vision****: Engineering solutions for our Nation's toughest challenges.*[5]

Concerns Regarding the Adequacy, Effectiveness and/or Feasibility of Funding the Proposed Flood Protections:

> ***Chapter 8: Recommendations***
>
> *This chapter describes the Items of Cooperation for a Structural Flood Risk Management (Single Purpose) Project that will be specifically authorized.*
>
> *I [William J. Leady, P.E., Colonel, U.S. Army, District Engineer] recommend that the Tentatively Selected Plan (Alternative SB-8) be authorized for implementation as a Federal project with such modifications thereof as in the discretion of the Commander, U.S. Army Corps of Engineers, may be available. The estimated first cost of the Tentatively Selected Plan is $748,110,000. The estimated Federal cost is $281,786,000 and the estimated non-federal cost is $466,324,000. Federal cost participation is limited to the Federal Cost of the NED Plan (Alternative SB-7).*[6]

The following are excerpts from U.S. Army Corps of Engineers publications pertaining to the Study/Plan:

> *The focus of the Sutter Basin Pilot Feasibility Study is to recommend a plan for flood damage reduction, ecosystem restoration, and recreation for the communities of Yuba City, Live Oak, Gridley and Biggs. The study is located within the boundaries of the Sacramento River Flood Control Project in Sutter County and includes the Sacramento, Feather and Bear Rivers as well as the Sutter and Tisdale Bypasses."*
>
> *The Feasibility Cost Sharing Agreement was signed in March 2000. The non-Federal sponsors are State of California, Central Valley Flood Protection Board and the Sutter-Butte Flood Control Agency. Sutter County is the local sponsor with an agreement with the State of California. The current estimated cost for the complete Feasibility Study is $8.556 million.*

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[4] U.S. Army Corps of Engineers et al, Sutter Basin, California: ***Sutter Basin Pilot Feasibility Draft Report—Draft Environmental Impact Report/Supplemental Environmental Impact Statement***, June 2013.

[5] http://www..spk.usace.army.mil/Missions/CivilWorks/Sutter.aspx, page 1.

[6] *Ibid.*, ***Sutter Basin Pilot Feasibility Draft Report,*** p. 8-3.

This investigation is being conducted under the authority provided by the Energy and Water Development Appropriations Act, 1999. The project was originally authorized by the Flood Control Act of 1962 (Public Law 87-874.[7]

Study Purpose

The purpose of the Sutter Basin Pilot Feasibility Study is to investigate and determine the extent of federal interest in plans that reduce flood risk to the Sutter Basin in Sutter and Butte Counties. The cost f the study is being shared by the U.S. Army Corps of Engineers, the Sutter Butte Flood Control Agency and the California Central Valley Flod Protection Board. The study's draft feasibility report assesses the risk of flooding; describes a range of alternatives formulated to reduce flood risk; and identified a tentatively selected plan for implementation. Currently, approximately 96,600 people and 26,783 structures are at high risk of flooding in the Sutter Basin communities of Yuba City, Live Oak, Gridley and Biggs. Since 1950, 19 flood events in the basin have required extensive flood fighting, and the flood of 1955 resulted in 38 deaths.

The Tentatively Selected Plan

A U.S. Army Corps of Engineers feasibility study identifies a variety of potential solutions to reduce the flood risk and recommends a plan that provides the most benefits. The Corps' tentatively selected plan for the Sutter Basin consist of improvements to existing levees extending along 41 miles of the Feather River from the Thermalito Afterbay below Oroville Dam to Laurel Avenue just south of Yuba City (for a map of the tentatively selected plan, see reverse). This plan would significantly reduce flood risk for 90,000 residents of Yuba City, Live Oak, Gridley and Biggs. The cost of the tentatively selected plan is estimated at $748 million. Completing the project would prevent as much as an estimated $33 million in flood damage a year on average.

Next Steps

The Sutter Basin Feasibility Pilot Study draft report, draft environmental impact report and supplemental environmental impact statement are published for public review and comments through July 29, 2013. Comments will be addressed in a final feasibility report and environmental impact statement, scheduled to be complete and submitted to Corps headquarters for final approval in December 2013.[8]

3.10 The Tentatively Selected Plan

The multi-objective comparison and assessment between the NED Plan and LPP was completed. Both the NED Plan and the LPP would provide significant benefits that exceed their costs. While the NED Plan is more efficient than the LPP, both plans are efficient. Both the NED Plan and the LPP are define as separable hydrologically because they have a separate residual 1% ACE floodplains with resulting distinct economic benefits.

The LPP is supported by the local sponsors SBFCA and CVFPB, and has received ASA (CW) approval with a NED cost share cap.

In a multi-objective context that equally emphasizes the objectives of flood risk management and reducing residual risk to public and life safety across all planning criteria and accounts, the LPP

[7] U.S. Army Corps of Engineers, Sacramento District, Sutter Basin Feasibility Study, http://www..spk.usace.army.mil/Missions/CivilWorks/Sutter.aspx, page 1.

[8] U.S. Army Corps of Engineers, Sacramento District, ***Sutter Basin Feasibility Study***, 22 July 2013, p. 1.

(Alternative SB-8) is recommended as the Tentatively Selected Plan [TSP] *at the NED Plan limit of Federal cost participation. See Figure 3-14.*

7.1 Tentatively Selected Plan Identification

The plan identified as the TSP is the Locally Preferred Plan (LPP), Alternative SB-8. This plan is justified and has a benefit to cost ratio of 1.9 to 1.0. Further, the LPP will comply with California Government Code requirements for a 200-year level of flood protection for urban and urbanizing areas by 2025.

The Assistant Secretary of the Army for Civil Works (ASA(CW)), by Memorandum dated May 7, 2013, has approved an exception to National Economic Development (NED) policy for Federal government to recommend a LPP over the NED Plan, allowing recommendations of the LPP as the TSP at NED level Federal participation cost share.

DRAFT

Mentz and Porgans
Verbal Comments

SUTTER BASIN FEASIBILITY STUDY

U.S. ARMY CORPS OF ENGINEERS

PUBLIC MEETING
1425 Veterans Memorial Circle
Yuba City, California 95993

COMMENTS OF THE PUBLIC

JULY 22, 2013

Reported By: Karen S. Challe, CSR No. 8244, RPR

APPEARANCES: PAGE:

LAWRENCE MENTZ 3
454 Lynn Way
Yuba City, California 95991
(530) 671-6505

PLANETARY SOLUTIONARIES 8
BY: PATRICK PORGANS, Solutionist
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BE IT REMEMBERED, that on Monday, July 22, 2013, commencing at the hour of 5:00 P.M., at the Sutter County Veteran's Hall, 1425 Veterans Memorial Circle, Yuba City, Sacramento, California, before me, KAREN S. CHALLE, a Certified Shorthand Reporter in and for the county of Sacramento, state of California, a public meeting was held and the following comments were made by the public:

LAWRENCE MENTZ
454 Lynn Way
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MR. MENTZ: We've got to get the message out, get the information to the people. We have a lot of low-information people. The low-information voters, they get everything from their cell phone. I'm suggesting that they come up with some short, quick videos showing the effects of the before and after that we've had in the past, and what they're proposing to do, and ask the citizens to -- "Hey, this is what's going on. Contact your Congressman and tell them you support this."

See? The low-information voter, we're trying to get across to the 70-percent of the population that doesn't subscribe to the newspapers, see? They can get

all their news from NBC, and that's all they get. And they don't get any more. Okay? So what I'm looking at is a way to convey this information to low-information voters. I think a small video would do the job.

My example for you would be to look at the Napa Auto Parts store, which just introduced a whole new series of short-segment videos that teach people how to repair cars and troubleshoot things. It works great. We can do the same thing and apply it to flood awareness here.

My concern is that if we don't get this flood thing through, during the last flood -- all the highways are really, really congested. As I recall, the highways follow the levies. They follow the levies on the west side, and they cross over points way up near Biggs. And we need the -- if we have another flood, where are the people going to go? We have no way to get out of this area. And that's my thing. And all I can think about saying then is we have no way to get traffic flow. The flow of traffic being two-lane roads. They get congested with refugees, people that are displaced, the traffic. That is all recorded around the flooded areas. And the trucks -- the big trucks that always have right-of-way. Mentz-1

And let me tell you, it took -- I worked at Beale Air Force Base back in '86 and '87. I lived in Yuba City. It took me an average of two and a half hours to

get home at night, and two hours to get to work in the morning. And I eventually ended up living at the base until the flood water subsided. Roads were open enough for employees to travel, leaving my family behind. And so that's all. I don't know what else.

My other concern is we need money for this project. A project like this costs bucks. Everything goes into overrun. Overrun sucks the crap out of everybody. Everybody gets sticker shock, like buying a new truck, you know. All the rivers in Sacramento are used for both drinking water and recreation and sewage. Isn't that wonderful? To be drinking your water downstream from Sacramento? What I'm suggesting is that the projects that have been done along the Great Lakes -- okay. The Great Lakes is a controlled body of water, doesn't get a lot of rivers into it. And what happens, they were using the rivers for the same thing we're using our rivers for. And the lake was getting algae-infected.

What they did is, all the communities around the area had reverse-sewage systems. They pumped it inland and let it flow to the lake through manmade marshes; cleaned the water up extensively better than any treatment plant could ever do. Let the plants and sunlight do it. If we could come up with a project like that for Feather River, for say, Yuba City, we could sell it on the idea

that it's helping Sacramento's drinking water, by making, by protecting the flood plain, controlling what we do with that land between levies. It just sits there, right? All those weeds, poison oak and vultures. You know, we could make a natural flood plain, like nature had before white man moved in here. You know, let the marshes do the water cleaning. I don't know what else to say about that.

We need money to find some -- to be -- get a way to get money. If we get the environmentalists in the back of that, it would just flow a lot easier, you know? That's all.

The main city that they did this project on, this initial one, was Michigan. I have personally surveyed it. It's a wonderful project. I walked parts of it. Milwaukee's got one on the other side of the lake. The only one not in the game is Chicago, because Chicago does whatever they want to do.

The last little bid to get more funding for our project, to get more funding, once you get the environmentalists on the project, money falls into it. It does. Look how the -- what Bay, Delta Bay, Delta Conservatory -- everybody feeds out of the structure, water transfers down to southern California. If that worked for Yuba City, they could use it for larger metropolitan areas, such as, for example, Yolo By-Pass for

Woodland and Davis. And forget all that water that flows to southern California. They're drinking our sewage.

(End of comments by Mr. Mentz)

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PLANETARY SOLUTIONARIES

BY: PATRICK PORGANS, Solutionist

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MR. PORGANS: I'm Patrick Porgans. I'm here from both Porgans and Associates and Planetary Solutionaries. And I was here to comment on the Feasibly Assessment for the Proposed Feather River Project.

Yes. And I discussed the matter with several of those members of the Corps present. And although they were trying to be helpful, they had -- and in light of the time frame -- it was short -- they couldn't provide me with the interest to the questions that I had proposed for them.

In particular, I was asking on that feasibility assessment what assurances we have that the local property owners who have a tax assessment of approximately 6.8 million a year, why they can be left holding the bag. "The bag," meaning that they can get the 40, which is a good project, but unless certain other changes are made upstream from the proposed project -- for example, the operation of the Oroville Flood Control Facilities, which is operated by the Department of Water Resources under the jurisdiction of the Corps, and unless the operation

Porgans-1

component states the plan is put into effect, they're only going to increase the risk of danger by increasing the level of protection they're speaking of. And that's reportedly talking about 200 years of protection on 41 miles of levies.

And we're saying that it's a good idea, but we can't get enough information to show its economic justification, or that it will be fully-funded. And that's because the state of California gets -- some of this project would have to be paid with general bond funding from California. And that requires a vote of the people. And as I checked -- explained to the gentleman that were discussing the financial feasibility assessment, 80 billion dollars of general operations bonds are already out there, authorized, and that there's another 70-some-odd bills waiting to be issued that's are to be approved. And 20-percent of what's already been issued is water and water-related bonds, including flood protections.

Porgans-1 Cont.

So we're saying we don't have enough information, nor does anyone, after reading thousands of pages of documents provided us, with the assurances of the sources of revenue that they'll need to complete the project. So what it means is that if this project, which I was -- I support the Feather River West Levy Project

which bond controlled agencies put in effect, but if they don't change the operation of Oroville, nor provide more flood protection -- because every major flood that has occurred since '55, there is about -- is the result of government projects. And we're basing this on government-zoning issues.

When they built those levies, they stopped the natural by-flow of -- by-pass of flow of water that would go into the Sutter Butte Basin. So now these big floods we've had in '55, '64 and '86, '97, they're the result of building the levy that's still there, and probably it initially causes flooding on the east side of the river. And those people there, some of which have never been compensated and have no flood protection above Honeycut Creek.

So what I'm saying here is that there was a by-pass proposed in the State plan. And that's the Central Valley Flood Control Protection Plan dated June 2012. That provided for reoperation in Oroville, as we did it on the American River at Folsom back in '86. However, that's been taken off the scene. And there also was a proposed order to put in by-pass or expansion of a canal for more flood waters to go down through the by-pass, avoiding having to go into the mainstem of the Feather River, which would relieve the damage that we

experienced in '86 and '97.

In '86, it cost the taxpayers one billion dollars for damage, loss of -- damage that was filed against the State when the -- that flood occurred there. I was involved in that litigation as a provider of information. Same with the '97 flood.

So what we're looking at here is the third alternative provided was a dredge out the river. The river is what they call an arm, and is requiring, it's compensated, and it doesn't do much for salmon-spawning habitat. The dam stops all new recruitment of aggregate material. So it's contributed to the endangered species as losses, so forth and so on.

Unfortunately, when DWR violates federal flood control, those litigations of Oroville have to be kept in mind that the flood control protection is paid for by the public taxpayers, now by the bond, by the people of California, to two bonds, which cost them as much money as it is to borrow. If we've got 80 billion dollars out in bond, we've got another 80 billion on it. That is a significant amount of money to have to be paid -- repaid.

So if the dredge is not going to happen, and the by-pass is not going to happen, and the re-op is not happening, and we don't have the assurances it will, I don't believe I can put a level confidence in this project

Porgans-2

that would assure people ultimately that they wouldn't be committing they're own demise.

Porgans-2 Cont.

(End of comments by Mr. Porgans.)

REPORTER'S CERTIFICATE

STATE OF CALIFORNIA)
) ss.
COUNTY OF SACRAMENTO)

I, KAREN S. CHALLE, a Certified Shorthand Reporter, licensed by the state of California and empowered to administer oaths and affirmations pursuant to Section 2093 (b) of the Code of Civil Procedure, do hereby certify:

That the said comments were recorded stenographically by me and were thereafter transcribed under my direction via computer-assisted transcription; That the foregoing transcript is a true record of the proceedings which then and there took place;

That I am a disinterested person to said action.

IN WITNESS WHEREOF, I have subscribed my name on July 26, 2013.

_____

Karen S. Challe

Certified Shorthand Reporter No. 8244