WOOD RODGERS

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PROJECT:	Butte Creek			JOB #:	8230.001
FEATURE:	HEC-RAS Modeling	BY:	JPP	DATE:	3/30/04
ITEM:	Evaluation of Lower Butte Creek Capacity (with 3-feet of freeboard).				

PURPOSE:

The purpose of this analysis is to determine the capacity in Butte Creek downstream of Highway 99.

DATA USED:

FEMA FIS for Butte Creek performed in 1994 by Borcalli & Associates, HEC-2 model filename: "BCC.DAT."

ANALYSIS:

HEC-RAS modeling prepared by Wood Rodgers' San Francisco office was used as the basis for determining the capacity of Lower Butte Creek. The HEC-RAS model was adapted from HEC-2 modeling performed by Borcalli & Associates as part of the Butte Creek FIS performed in 1994. The capacity of the creek is defined as the maximum flow that can be conveyed while maintaining a minimum freeboard of 3-feet. This freeboard requirement ensures compliance with FEMA's guidelines for levees along channel banks.

RESULTS:

The HEC-RAS model (Run name: "Butte+Driver (Combined) 9") analyzed three locations for diverting flow out of Lower Butte Creek. The first is located at station 708+27, and diverts 6427 cfs at peak from the Lower Butte Creek. This gives the Lower Butte Creek reach between stations 708+27 and 462+50 a capacity of 23500 cfs while maintaining 3-feet of freeboard in the channel. The second diversion is located at station 462+50, and diverts 18853 cfs at peak from the Lower Butte Creek. This gives the Lower Butte Creek reach between stations 462+50 and 173+08 a capacity of approximately 4600-9774 cfs (peak flow increases proceeding downstream due to inflow from adjacent sheds) while maintaining 3-feet of freeboard in the channel. The third diversion is located at station 173+08, and diverts 3582 cfs at peak from the Lower Butte Creek. This gives the Lower Butte Creek reach between stations 173+08 and 0+00 a capacity of approximately 6185 cfs while maintaining 3-feet of freeboard in the channel.

The outflow volume at each spill location varies, and was calculated using HEC-RAS output and an Excel spreadsheet. At station 708+27, the volume of the outflow hydrograph is approximately 3385 acre-feet. At station 462+50, the volume of the outflow hydrograph is approximately 28,109 acre-feet. At station, 173+08, the volume of the outflow hydrograph is approximately 5067 acre-feet.

In order to implement diversion mitigation measures to protect the entire Lower Butte Creek reach, approximately 36,651 acre-feet of storage would be required. To protect the areas upstream of the Sacramento Northern Railroad crossing, only 3385 acre-feet of storage would be required.

Without these diversions, only the following portions of Lower Butte Creek conform to the 3-foot freeboard requirement:

- Stations 377+92 to 395+00
- Stations 505+42 to 537+99
- Stations 567+08 to 657+47
- Stations 664+62 to 686+85
- Station 712+50 to End

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PROJECT: Butte Creek JOB #: 8230.001

FEATURE: Design Memo BY: JPP DATE: 4/9/04

ITEM: Manning's n-value Determination

PURPOSE: To assess the appropriate channel n-values within the study area using USGS Water Supply Paper # 2339, "Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Flood Plains."

STREAM: Little Chico Creek

REACH OR ROAD CROSSING: In town, between Highway 99 and Oak St.

MANNING "N" ESTIMATE APPLICABLE TO:

LEFT OVERBANK _____ **CHANNEL** X **RIGHT OVERBANK** _____

BRIDGE _____ **CULVERT** _____ **OTHER** _____

FACTORS	**STREAM CONDITION**	**BASE 'n' VALUE & ADJUSTMENT**
Streambed Material (n_b)	Gravel	0.028
Degree of Irregularity (n_1)	Moderate	0.010
Variation in Channel Cross-Section (n_2)	Alternating occasionally	0.002
Effect of Obstruction (n_3)	Minor	0.005
Amount of Vegetation (n_4)	Large	0.035
Degree of Meandering (m)	N/A	1.0

Final Manning 'n' Value = $(n_b + n_1 + n_2 + n_3 + n_4) \cdot m =$ 0.080 Rounded to = 0.080

BUTTE CREEK
BUTTE COUNTY, CALIFORNIA
REQUIRED LEVEE IMPROVEMENTS TO ACHIEVE MINIMUM FREEBOARD

Levee Improvements Required - Existing Butte Creek Flows
HEC-RAS Plan: Existing River: BUTTE Reach: LOWER Profile: Max WS

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Top of Bank LOB Elev	Top of Bank ROB Elev	Levee Height Increase to Provide 3-ft. freeboard Existing Conditions	
														LOB	ROB
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	(ft)	(ft)		
LOWER	74600	Max WS	29951.73	209.4	224.66		226.01	0.003873	9.96	3868.73	773.7	219.8	221.6	7.86	6.06
LOWER	74182.*	Max WS	29944.34	207.4	223.08		224.27	0.003779	9.18	4570.8	2032.09	220.82	222.25	5.26	3.83
LOWER	73764.*	Max WS	29940.28	205.4	221.34		222.68	0.004291	9.29	3223.8	3271.47	221.85	222.9	2.49	1.44
LOWER	73346.*	Max WS	29940.01	203.4	219.81		220.9	0.003649	8.4	3564.47	4451.91	222.88	223.55	0	0
LOWER	72928	Max WS	29939.22	201.4	218.67		219.5	0.002541	7.31	4097.85	6684.66	223.9	224.2	0	0
LOWER	72695	Max WS	29938.77	199.8	217.9	212.06	219.08	0.002418	8.69	3443.59	282.46	228.7	228.7	0	0
LOWER	72672		Bridge	**Highway 99**											
LOWER	72649	Max WS	29937.42	199.8	217.54		218.79	0.002644	8.96	3341.42	280.2	228.7	228.7	0	0
LOWER	72632	Max WS	29937.43	199.8	217.49		218.75	0.002683	9	3324.84	279.88	228.7	228.7	0	0
LOWER	72630	Max WS	29937.43	199.8	217.48		218.74	0.002688	9.01	3322.97	279.84	228.7	228.7	0	0
LOWER	72624	Max WS	29937.44	199.8	217.46	212.03	218.73	0.002698	9.02	3318.32	279.73	228.7	228.7	0	0
LOWER	72602.5		Bridge	**Highway 99**											
LOWER	72581	Max WS	29937.44	199.8	217.07		218.43	0.002979	9.33	3209.76	277.3	228.7	228.7	0	0
LOWER	72428	Max WS	29937.39	196.1	216.71		217.91	0.002802	8.8	3402.31	306.44	221.5	221.3	0	0
LOWER	72035.5*	Max WS	29937.13	194.88	215.53		216.7	0.003387	8.7	3441.11	365.43	219.43	219.57	0	0
LOWER	71643.*	Max WS	29936.65	193.65	214.25		215.38	0.003506	8.52	3514.83	382.62	217.92	217.85	0	0
LOWER	71250.5*	Max WS	29934.54	192.43	213		214.05	0.003216	8.22	3643.11	391.55	216.43	216.12	0	0
LOWER	70858	Max WS	29934.5	191.2	211.91		212.83	0.002707	7.71	3881.4	401.48	215	214.4	0	0.51
LOWER	70436.7*	Max WS	29934.19	189.55	210.74		211.68	0.002787	7.76	3856.15	404.61	213.62	213.05	0.12	0.69
LOWER	70015.5*	Max WS	29931.71	187.9	209.53		210.49	0.002943	7.87	3803.87	407.38	212.25	211.7	0.28	0.83
LOWER	69594.2*	Max WS	29931.86	186.25	208.19		209.21	0.003264	8.1	3697.37	409.15	210.88	210.4	0.31	0.79
LOWER	69173	Max WS	29931.63	184.6	206.6		207.75	0.004012	8.6	3479.16	408.41	209.5	209.1	0.1	0.5
LOWER	68685.*	Max WS	29928.61	183.32	204.74		205.86	0.003784	8.49	3523.21	593.53	208.1	204.98	0	2.76
LOWER	68197.*	Max WS	29928.39	182.04	202.92		204.06	0.003575	8.56	3498.32	381.05	206.7	206.6	0	0
LOWER	67709.*	Max WS	29925.69	180.76	201.29		202.39	0.00322	8.4	3562.87	368.96	205.3	205.4	0	0
LOWER	67221.*	Max WS	29925.84	179.48	199.87		200.89	0.002765	8.12	3686.56	358.07	203.9	204.2	0	0
LOWER	66733	Max WS	29925.7	178.2	198.7		199.63	0.00227	7.73	3872.15	348.24	202.5	203	0	0
LOWER	66504	Max WS	29925.58	177.1	197.59	192.28	199.4	0.004009	10.78	2775.28	230.64	205.8	205.8	0	0
LOWER	66483		Bridge	**Dayton-Durham Highway**											
LOWER	66462	Max WS	29925.58	177.1	197.59		199.4	0.004009	10.78	2775.35	230.64	205.8	205.8	0	0
LOWER	66233	Max WS	29925.42	177.4	196.98		198.33	0.00314	9.3	3216.36	277.97	199.8	199.8	0.18	0.18
LOWER	65746.7*	Max WS	29923.52	175.55	195.38		196.69	0.003543	9.2	3251.45	316.03	198.4	198.41	0	0
LOWER	65260.5*	Max WS	29923.52	173.7	193.66		194.89	0.003708	8.92	3353.12	353.46	197	197.04	0	0
LOWER	64774.2*	Max WS	29922.99	171.85	191.99		193.08	0.003438	8.37	3575.4	390.94	195.65	195.67	0	0
LOWER	64288	Max WS	29920.31	170	190.64		191.49	0.002626	7.42	4033.93	429.85	194.3	194.3	0	0
LOWER	63811.7*	Max WS	29919.89	169.25	189.39		190.27	0.002561	7.54	3968.79	414.68	193.21	193.14	0	0
LOWER	63335.5*	Max WS	29916.53	168.5	188.16		189.08	0.002529	7.66	3903.46	399.67	192.12	191.97	0	0
LOWER	62859.2*	Max WS	29916.43	167.75	186.97		187.91	0.002421	7.79	3841.8	384.82	191.04	190.81	0	0
LOWER	62383.*	Max WS	29915.94	167	185.81		186.78	0.002407	7.91	3779.8	370.12	189.95	189.64	0	0
LOWER	61906.7*	Max WS	29912.86	166.25	184.65		185.66	0.002369	8.06	3710.29	355.44	188.86	188.48	0	0
LOWER	61430.5*	Max WS	29912.87	165.5	183.49		184.55	0.002406	8.25	3627.11	340.72	187.78	187.35	0	0
LOWER	60954.2*	Max WS	29912.54	164.75	182.32		183.43	0.002381	8.47	3530.2	325.82	186.69	186.23	0	0
LOWER	60478	Max WS	29909.56	164	181.11		182.31	0.002508	8.77	3410.71	310.74	185.6	185.1	0	0
LOWER	59983.6*	Max WS	29909.65	163.22	179.88		181.04	0.00257	8.64	3461.85	329.97	184.64	184.06	0	0
LOWER	59489.2*	Max WS	29909.33	162.44	178.63		179.75	0.002571	8.48	3527.77	349.25	183.68	183.02	0	0
LOWER	58994.8*	Max WS	29905.95	161.66	177.42		178.47	0.00249	8.26	3621.77	368.83	182.72	181.98	0	0
LOWER	58500.4*	Max WS	29905.85	160.88	176.28		177.26	0.0023	7.94	3765.46	389.03	181.76	180.94	0	0
LOWER	58006	Max WS	29905.23	160.1	175.17		176.07	0.002375	7.58	3945.53	409.59	180.8	179.9	0	0
LOWER	57573.5*	Max WS	29901.96	158.6	174.13		175.05	0.002367	7.7	3884.18	393.29	178.95	178.42	0	0
LOWER	57141.*	Max WS	29901.81	157.1	173.13		174.06	0.002261	7.72	3873.18	377.33	177.1	176.95	0	0
LOWER	56708.5*	Max WS	29901.33	155.6	172.22		173.11	0.002044	7.61	3930.06	362.08	175.25	175.47	0	0
LOWER	56276	Max WS	29898.03	154.1	171.43		172.27	0.00174	7.35	4065.72	347.82	173.4	174	1.03	0.43
LOWER	55890.*	Max WS	29898.13	151.7	170.74		171.59	0.00183	7.42	4030.47	353.67	172.95	173.15	0.79	0.59
LOWER	55504	Max WS	29898.05	149.3	170.04		170.88	0.001835	7.36	4063.98	359.7	172.5	172.4	0.54	0.64
LOWER	55117.7*	Max WS	29897.8	149	169.11		170.12	0.002486	8.05	3713.84	363.19	171.48	171.65	0.63	0.46
LOWER	54731.5*	Max WS	29897.29	148.7	168.05		169.13	0.002833	8.36	3577.07	365.44	170.45	171	0.6	0.05
LOWER	54345.2*	Max WS	29894.98	148.4	167.07		168.07	0.002465	7.99	3741.09	367.92	169.52	170.35	0.55	0
LOWER	53959	Max WS	29894.94	148.1	166.42		167.18	0.001596	6.97	4290.33	372.4	168.6	169.7	0.82	0
LOWER	53799	Max WS	29894.88	147.91	166.16	158.66	166.94	0.001501	7.08	4221.84	334	169.9	169.9	0	0
LOWER	53779		Bridge	**Dayton-Durham Highway**											
LOWER	53759	Max WS	29894.86	147.99	166		166.8	0.001564	7.17	4167.55	334	169.9	169.9	0	0
LOWER	53690	Max WS	29894.83	147.6	165.83		166.71	0.00201	7.52	3973.03	366.36	167.6	168.3	1.23	0.53
LOWER	53649	Max WS	29894.8	147.5	165.74		166.62	0.002027	7.54	3965.52	367.05	167.5	168.3	1.24	0.44
LOWER	53190.*	Max WS	29894.36	146.5	164.62		165.62	0.002606	8.03	3723.21	379.34	166.42	167.15	1.2	0.47
LOWER	52731.*	Max WS	29892.15	145.5	163.25		164.35	0.003142	8.4	3559.77	390.04	165.34	166	0.91	0.25
LOWER	52272.*	Max WS	29891.95	144.5	161.72		162.86	0.003445	8.54	3499.02	399.33	164.26	164.9	0.46	0
LOWER	51813.*	Max WS	29888.3	143.5	160.24		161.3	0.003202	8.26	3617.78	409.16	163.18	163.8	0.06	0
LOWER	51354	Max WS	29887.91	142.5	159.08		159.93	0.002334	7.4	4037.96	421.76	162.1	162.7	0	0
LOWER	50948.*	Max WS	29882.9	140.88	158.14		158.99	0.002287	7.37	4052.94	421.18	161.25	161.45	0	0
LOWER	50542.*	Max WS	29882.48	139.25	157.25		158.07	0.002185	7.28	4103.72	420.7	160.4	160.2	0	0.05
LOWER	50136.*	Max WS	29875.94	137.62	156.42		157.2	0.00202	7.11	4201.72	420.49	159.55	158.95	0	0.47
LOWER	49730	Max WS	29867.54	136	155.68		156.41	0.001798	6.85	4358	420.73	158.7	157.7	0	0.98
LOWER	49233.1*	Max WS	29856.68	135.57	154.86		155.51	0.001714	6.46	4623.04	474.54	157.71	156.93	0.15	0.93
LOWER	48736.2*	Max WS	29856.31	135.14	154.09		154.66	0.001582	6.05	4937.61	528.68	156.73	156.16	0.36	0.93
LOWER	48239.4*	Max WS	29843.72	134.71	153.41		153.89	0.001395	5.6	5328.82	583.45	155.74	155.39	0.67	1.02
LOWER	47742.5*	Max WS	29829.48	134.29	152.82		153.23	0.001171	5.13	5820.18	639.02	154.76	154.61	1.06	1.21
LOWER	47245.7*	Max WS	29814.04	133.86	152.36		152.69	0.000935	4.63	6438.97	695.49	153.77	153.84	1.59	1.52

BUTTE CREEK
BUTTE COUNTY, CALIFORNIA
REQUIRED LEVEE IMPROVEMENTS TO ACHIEVE MINIMUM FREEBOARD

HEC-RAS Plan: Existing River: BUTTE Reach: LOWER Profile: Max WS

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Top of Bank LOB Elev	Top of Bank ROB Elev	Levee Height Increase to Provide 3-ft. freeboard Existing Conditions LOB	Levee Height Increase to Provide 3-ft. freeboard Existing Conditions ROB
LOWER	46748.8*	Max WS	29798.1	133.43	152		152.26	0.000715	4.14	7200.97	752.74	152.79	153.07	2.21	1.93
LOWER	46252	Max WS	29798.3	133	151.73		151.94	0.000532	3.67	8112.07	810.65	151.8	152.3	2.93	2.43
LOWER	45753.4*	Max WS	29797.7	132.06	151.46		151.66	0.000569	3.62	8241	802.93	151.26	151.76	3.2	2.7
LOWER	45254.8*	Max WS	29796.29	131.12	151.17		151.36	0.000634	3.57	8345.98	794.81	150.72	151.22	3.45	2.95
LOWER	44756.2*	Max WS	29785.81	130.18	150.84		151.04	0.00068	3.54	8425.76	786	150.18	150.68	3.66	3.16
LOWER	44257.6*	Max WS	29785.46	129.24	150.49		150.68	0.000761	3.51	8478.78	777.96	149.65	150.14	3.84	3.35
LOWER	43759	Max WS	29784.47	128.3	150.09		150.28	0.000835	3.5	8508.75	778	149.2	149.6	3.89	3.49
LOWER	43363.7*	Max WS	29778.16	126.03	149.71		149.93	0.000989	3.78	7885.88	711	148.53	149.33	4.18	3.38
LOWER	42968.5*	Max WS	29778.43	123.75	149.24		149.51	0.001191	4.12	7234.47	654	147.95	149.05	4.29	3.19
LOWER	42573.2*	Max WS	29778.31	121.47	148.66		148.98	0.001557	4.56	6529.55	596.33	147.38	148.78	4.28	2.88
LOWER	42178	Max WS	29777.89	119.2	147.85		148.27	0.002193	5.19	5742.82	535.35	146.8	148.5	4.05	2.35
LOWER	42118	Max WS	29777.81	117.9	147.58		148.13	0.003797	5.99	4969.83	490.3	146.6	148.3	3.98	2.28
LOWER	42088	Max WS	29777.76	117.8	147.46		148.02	0.00381	5.98	4975.92	491.41	146.5	148.2	3.96	2.26
LOWER	41988	Max WS	29774.15	117.8	147.09		147.65	0.003662	5.99	4970.52	514.13	146.5	148.1	3.59	1.99
LOWER	41490.4*	Max WS	29773.96	118.88	145.55		145.99	0.002838	5.34	5575.27	580.71	146.23	145.88	2.32	2.67
LOWER	40992.8*	Max WS	29768.82	119.96	144.36		144.71	0.002212	4.74	6281.38	676.33	145.96	145.56	1.4	1.8
LOWER	40495.2*	Max WS	29762.38	121.04	143.44		143.72	0.001725	4.19	7109.08	773.1	145.69	145.24	0.75	1.2
LOWER	39997.6*	Max WS	29762.23	122.12	142.75		142.96	0.001254	3.67	8103.43	868.9	145.42	144.92	0.33	0.83
LOWER	39500	Max WS	29761.17	123.2	142.26		142.42	0.000887	3.19	9319.69	952.08	145.2	144.6	0.06	0.66
LOWER	39073.*	Max WS	29756.78	122.17	141.85		142.01	0.001031	3.28	9073.46	979.5	144.8	144.8	0.05	0.05
LOWER	38646.*	Max WS	29756.77	121.15	141.36		141.53	0.001233	3.39	8769.82	1004.69	144.4	145	0	0
LOWER	38219.*	Max WS	29756.37	120.12	140.75		140.95	0.001536	3.56	8369.88	1027.55	144	145.2	0	0
LOWER	37792	Max WS	29755.76	119.1	139.96		140.19	0.002082	3.82	7785.02	1049.4	143.6	145.4	0	0
LOWER	37681	Max WS	29755.66	114.3	139.39	132.91	140.25	0.001689	7.47	3982.47	307.77	141.6	140	0.79	2.39
LOWER	37672		Bridge	**Railroad at Midway**											
LOWER	37663	Max WS	29755.66	114.3	139.39		140.25	0.001693	7.48	3980.11	307.77	141.6	140	0.79	2.39
LOWER	37615	Max WS	29755.61	113.7	139.64		139.98	0.001016	4.71	6323.22	915.52	141.9	138.6	0.74	4.04
LOWER	37605	Max WS	29755.6	113.6	139.63		139.97	0.00098	4.64	6411.65	917.49	141.8	138.5	0.83	4.13
LOWER	37585	Max WS	29755.57	113.3	139.63	130.97	139.94	0.001205	4.46	6673.65	923.55	141.5	138.2	1.13	4.43
LOWER	37572.5		Bridge	**Midway Road**											
LOWER	37560	Max WS	29754.95	113.3	137.37		138	0.003424	6.39	4656.33	824.75	141.5	138.2	0	2.17
LOWER	37328	Max WS	29754.73	117.7	137.04		137.28	0.001077	3.92	7598.56	1212.88	137.5	139.4	2.54	0.64
LOWER	36875.*	Max WS	29751.86	120.15	136.47		136.73	0.001393	4.07	7314.81	1344.79	137.15	139	2.32	0.47
LOWER	36422	Max WS	29751.84	122.6	135.53		135.88	0.002555	4.72	6308.87	1463.03	136.8	138.6	1.73	0
LOWER	35943.7*	Max WS	29748.9	120.28	134.36		134.68	0.002472	4.53	6569.92	1583.91	135.93	137.25	1.43	0.11
LOWER	35465.5*	Max WS	29744.7	117.95	133.26		133.55	0.002233	4.27	6972.86	1705.28	135.05	135.9	1.21	0.36
LOWER	34987.2*	Max WS	29739.04	115.62	132.36		132.59	0.00174	3.85	7728.06	1828.3	134.18	134.55	1.18	0.81
LOWER	34509	Max WS	29732.43	113.3	131.73		131.89	0.00111	3.27	9085.4	1953.11	133.3	133.2	1.43	1.53
LOWER	34067.6*	Max WS	29731.94	112.2	131.22		131.39	0.00121	3.29	9049.51	1995.14	133.17	132.5	1.05	1.72
LOWER	33626.3*	Max WS	29725.18	111.1	130.67		130.84	0.001288	3.32	8949.05	2033.26	133.03	131.8	0.64	1.87
LOWER	33185	Max WS	29717.45	110	130.05		130.23	0.0015	3.4	8729.23	2068.22	132.9	131.1	0.15	1.95
LOWER	32752.7*	Max WS	29708.6	109.7	129.43		129.61	0.001398	3.37	8812.29	2012.24	132.02	130.68	0.41	1.75
LOWER	32320.5*	Max WS	29698.67	109.4	128.87		129.04	0.001258	3.3	8992.96	1957.91	131.15	130.25	0.72	1.62
LOWER	31888.2*	Max WS	29687.81	109.1	128.38		128.54	0.001085	3.19	9292.96	1902.46	130.27	129.82	1.11	1.56
LOWER	31456	Max WS	29676.56	108.8	127.96		128.11	0.000899	3.06	9709.04	1843.66	129.4	129.4	1.56	1.56
LOWER	30995.8*	Max WS	29665.24	107.23	127.56		127.71	0.000847	3.16	9377.22	1746.98	129	128.93	1.56	1.63
LOWER	30535.6*	Max WS	29653.97	105.67	127.15		127.32	0.00088	3.28	9038.59	1650.31	128.6	128.47	1.55	1.68
LOWER	30075.5*	Max WS	29653.38	104.1	126.73		126.91	0.000945	3.43	8648.42	1553.48	128.2	128	1.53	1.73
LOWER	29615.3*	Max WS	29642.83	102.53	126.26		126.46	0.001044	3.62	8190.59	1456.29	127.8	127.53	1.46	1.73
LOWER	29155.1*	Max WS	29631.73	100.97	125.73		125.96	0.001186	3.88	7646.12	1358.61	127.4	127.07	1.33	1.66
LOWER	28695	Max WS	29619.39	99.4	125.09		125.37	0.001453	4.24	6983.77	1260.05	127	126.6	1.09	1.49
LOWER	28661	Max WS	29606	99	125.05	121.66	125.32	0.001333	4.2	7056.24	1175.54	126.9	126.7	1.15	1.35
LOWER	28651		Bridge	**Durnel Road**											
LOWER	28641	Max WS	29606	99	125.05		125.32	0.001172	4.2	7056.24	1175.54	126.9	126.7	1.15	1.35
LOWER	28502	Max WS	29606.08	102.8	124.93		125.15	0.001062	3.79	7812.78	1296.48	126.4	126.5	1.53	1.43
LOWER	28063.2*	Max WS	29591.26	103.32	124.5		124.7	0.000977	3.62	8178.89	1369.75	125.96	126.22	1.54	1.28
LOWER	27624.4*	Max WS	29575.76	103.84	124.09		124.28	0.000934	3.45	8579.67	1442.85	125.52	125.94	1.57	1.15
LOWER	27185.6*	Max WS	29575.03	104.36	123.72		123.89	0.000846	3.28	9014.09	1516.24	125.08	125.66	1.64	1.06
LOWER	26746.8*	Max WS	29560.4	104.88	123.37		123.52	0.000792	3.11	9501.64	1589.84	124.64	125.38	1.73	0.99
LOWER	26308	Max WS	29546.78	105.4	123.06		123.19	0.000701	2.94	10039.28	1663.7	124.2	125.1	1.86	0.96
LOWER	25882.4*	Max WS	29546.91	104.92	122.8		122.93	0.00054	2.83	10439.34	1508.13	123.96	125.02	1.84	0.78
LOWER	25456.8*	Max WS	29546.25	104.44	122.59		122.71	0.000479	2.85	10365.08	1352.82	123.72	124.94	1.87	0.65
LOWER	25031.2*	Max WS	29545.16	103.96	122.37		122.51	0.000476	3.03	9760.8	1197.43	123.48	124.86	1.89	0.51
LOWER	24605.6*	Max WS	29543.79	103.48	122.11		122.29	0.000606	3.45	8574.78	1036.45	123.24	124.78	1.87	0.33
LOWER	24180	Max WS	29540.51	103	121.66		121.96	0.001137	4.41	6692.89	884.09	123	124.7	1.66	0
LOWER	23694.6*	Max WS	34149.24	102.62	120.99		121.35	0.001169	4.81	7100.37	843.91	122.75	124.12	1.24	0
LOWER	23209.2*	Max WS	34131.27	102.25	120.52		120.84	0.000899	4.53	7532.54	805.56	122.5	123.55	1.02	0
LOWER	22723.8*	Max WS	34130.79	101.88	120.15		120.44	0.000719	4.32	7897.11	768.15	122.25	122.97	0.9	0.18
LOWER	22238.5*	Max WS	34113.38	101.5	119.84		120.11	0.000605	4.18	8152.72	731.37	122	122.4	0.84	0.44
LOWER	21753.1*	Max WS	34112.92	101.12	119.57		119.84	0.000537	4.12	8275.82	694.94	121.75	121.82	0.82	0.75
LOWER	21267.7*	Max WS	34096.54	100.75	119.32		119.58	0.000506	4.13	8247.02	658.84	121.5	121.25	0.82	1.07
LOWER	20782.3*	Max WS	34096.51	100.38	119.06		119.34	0.00051	4.23	8052.92	622.81	121.25	120.67	0.81	1.39
LOWER	20297	Max WS	34095.85	100	118.78		119.09	0.000553	4.44	7684.47	586.78	121	120.1	0.78	1.68
LOWER	19799.*	Max WS	34081.1	99.12	118.49		118.81	0.00057	4.58	7438.87	623.44	119.9	119	1.59	2.49
LOWER	19301.*	Max WS	34080.64	98.23	118.17		118.51	0.000669	4.65	7321.32	656.74	118.8	117.9	2.37	3.27
LOWER	18803.*	Max WS	34066.24	97.35	117.82		118.15	0.000732	4.67	7293.93	682.5	117.7	116.8	3.12	4.02
LOWER	18305.*	Max WS	34065.76	96.47	117.45		117.78	0.000745	4.62	7370.98	705.33	116.6	115.7	3.85	4.75
LOWER	17807.*	Max WS	34051.8	95.58	117.09		117.4	0.000703	4.5	7568.1	728.17	115.5	114.6	4.59	5.49
LOWER	17309	Max WS	34051.3	94.7	116.75		117.04	0.000654	4.31	7891.62	751	114.4	113.5	5.35	6.25
LOWER	16886.8*	Max WS	34038.11	94.57	116.45		116.74	0.000679	4.34	7835.2	761.5	114.48	113.75	4.97	5.7
LOWER	16464.6*	Max WS	34037.9	94.43	116.14		116.43	0.00071	4.38	7774.56	772	114.57	114	4.57	5.14

BUTTE CREEK
BUTTE COUNTY, CALIFORNIA
REQUIRED LEVEE IMPROVEMENTS TO ACHIEVE MINIMUM FREEBOARD

HEC-RAS Plan: Existing River: BUTTE Reach: LOWER Profile: Max WS

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Top of Bank LOB Elev	Top of Bank ROB Elev	Levee Height Increase to Provide 3-ft. freeboard Existing Conditions	
														LOB	ROB
LOWER	16042.5*	Max WS	34025.15	94.3	115.8		116.11	0.000747	4.42	7699.09	782.5	114.65	114.25	4.15	4.55
LOWER	15620.3*	Max WS	34025.11	94.17	115.45		115.76	0.000791	4.47	7610.03	793	114.73	114.5	3.72	3.95
LOWER	15198.1*	Max WS	34012.65	94.03	115.09		115.41	0.000837	4.53	7514.95	803.5	114.82	114.75	3.27	3.34
LOWER	14776	Max WS	34012.66	93.9	114.71		115.04	0.000898	4.59	7412.76	812.83	114.9	115	2.81	2.71
LOWER	14343.8*	Max WS	34000.42	93.22	114.33		114.65	0.000891	4.56	7448.95	806.93	114.64	114.62	2.69	2.71
LOWER	13911.6*	Max WS	34000.44	92.54	113.95		114.27	0.000894	4.54	7490.48	800.99	114.38	114.24	2.57	2.71
LOWER	13479.4*	Max WS	33988.51	91.86	113.57		113.89	0.000864	4.51	7541.63	795	114.12	113.86	2.45	2.71
LOWER	13047.2*	Max WS	33988.59	91.18	113.2		113.51	0.000866	4.47	7601	788.87	113.86	113.48	2.34	2.72
LOWER	12615	Max WS	33987.96	90.5	112.83		113.14	0.000881	4.44	7660.89	782.33	113.6	113.1	2.23	2.73
LOWER	12554	Max WS	33977.13	89.6	112.39	104.49	113.3	0.001753	7.67	4431.76	316	114.1	114.1	1.29	1.29
LOWER	12540		Bridge	**Nelson Road**											
LOWER	12526	Max WS	33977.13	89.6	112.39		113.3	0.001754	7.67	4430.92	316	114.1	114.1	1.29	1.29
LOWER	12285	Max WS	33977.03	91	112.41		112.74	0.000964	4.6	7392.61	790.03	112.5	112.6	2.91	2.81
LOWER	11835.*	Max WS	33964.85	91.17	111.97		112.31	0.000967	4.72	7199.56	776.29	112.37	112.07	2.6	2.9
LOWER	11385.*	Max WS	33964.68	91.33	111.52		111.88	0.000964	4.84	7017.74	762.67	112.23	111.53	2.29	2.99
LOWER	10935	Max WS	33952.43	91.5	111.05		111.44	0.001057	4.97	6827.75	748.73	112.1	111	1.95	3.05
LOWER	10522.5*	Max WS	33951.97	91.38	110.68		111.02	0.000888	4.67	7276.35	773.6	110.97	110.45	2.71	3.23
LOWER	10110.*	Max WS	33939.71	91.25	110.38		110.67	0.000722	4.33	7829.64	797	109.85	109.9	3.53	3.48
LOWER	9697.5*	Max WS	33939.45	91.12	110.14		110.39	0.000575	4	8480.72	819.5	108.72	109.35	4.42	3.79
LOWER	9285	Max WS	33938.76	91	109.95		110.16	0.000452	3.68	9230.34	842	107.6	108.8	5.35	4.15
LOWER	8817.*	Max WS	33928.43	91	109.7		109.93	0.000512	3.85	8808.68	835.2	107.88	108.96	4.82	3.74
LOWER	8349.*	Max WS	33928.4	91	109.42		109.67	0.000583	4.02	8437.91	828.4	108.16	109.12	4.26	3.3
LOWER	7881.*	Max WS	33927.88	91	109.11		109.39	0.000653	4.18	8114.99	820.33	108.44	109.28	3.67	2.83
LOWER	7413.*	Max WS	33919.94	91	108.78		109.07	0.000711	4.32	7850.47	809.75	108.72	109.44	3.06	2.34
LOWER	6945	Max WS	33920.07	91	108.42		108.73	0.000752	4.43	7650.25	798.44	109	109.6	2.42	1.82
LOWER	6478.*	Max WS	33919.75	90.18	108.04		108.37	0.00081	4.59	7391.66	775.14	108.74	109.12	2.3	1.92
LOWER	6011.*	Max WS	33919.05	89.36	107.63		107.98	0.000888	4.77	7103.59	751.05	108.48	108.64	2.15	1.99
LOWER	5544.*	Max WS	33914.14	88.54	107.17		107.55	0.000993	5	6781.15	725.51	108.22	108.16	1.95	2.01
LOWER	5077.*	Max WS	33914.06	87.72	106.64		107.07	0.001141	5.29	6416.48	697.65	107.96	107.68	1.68	1.96
LOWER	4610	Max WS	33913.57	86.9	106		106.5	0.001415	5.67	5984.92	670.7	107.7	107.2	1.3	1.8
LOWER	4563	Max WS	33913.49	83.5	105.75	102.09	106.52	0.002991	7.02	4831.81	654.36	107.8	105.8	0.95	2.95
LOWER	4550		Bridge	**(Aquas Frias Road)**											
LOWER	4537	Max WS	33913.49	83.5	105.75		106.52	0.002991	7.02	4831.79	654.36	107.8	105.8	0.95	2.95
LOWER	4418	Max WS	33909.54	88	105.7		106.11	0.001014	5.16	6574.38	666.98	107.4	106.6	1.3	2.1
LOWER	3934.4*	Max WS	33909.68	87.42	105.19		105.58	0.00117	5.05	6713.77	709.05	106.62	106.04	1.57	2.15
LOWER	3450.8*	Max WS	33909.5	86.84	104.62		105.01	0.001197	5.01	6775.05	741.89	105.84	105.48	1.78	2.14
LOWER	2967.2*	Max WS	33908.99	86.26	104.02		104.41	0.001285	5.01	6762.11	773.59	105.06	104.92	1.96	2.1
LOWER	2483.6*	Max WS	33908.18	85.68	103.33		103.74	0.001516	5.12	6625.05	804.47	104.28	104.36	2.05	1.97
LOWER	2000	Max WS	33907.32	85.1	102.5	98.56	102.95	0.001806	5.37	6313.61	834.34	103.5	103.8	2	1.7

BUTTE CREEK
BUTTE COUNTY, CALIFORNIA
REQUIRED LEVEE IMPROVEMENTS TO ACHIEVE MINIMUM FREEBOARD

Levee Improvement Requirements - Increased Diversion from Little Chico
HEC-RAS Plan: Existing River: BUTTE Reach: LOWER Profile: Max WS

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Top of Bank LOB Elev	Top of Bank ROB Elev	Levee Height Increase to Provide 3-ft. freeboard	
														LOB	ROB
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	(ft)	(ft)		
LOWER	74600	Max WS	31718.34	209.4	224.94		226.35	0.003931	10.22	4089.93	806.46	219.8	221.6	8.14	6.34
LOWER	74182.*	Max WS	31711.52	207.4	223.47		224.52	0.003304	8.83	5372.48	2077.84	220.82	222.25	5.65	4.22
LOWER	73764.*	Max WS	31710.53	205.4	221.8		223.15	0.004115	9.34	3395.78	3384.72	221.85	222.9	2.95	1.9
LOWER	73346.*	Max WS	31707.71	203.4	220.32		221.41	0.003389	8.38	3783.66	4878.32	222.88	223.55	0.44	0
LOWER	72928	Max WS	31707.89	201.4	219.24		220.06	0.002476	7.26	4369.34	7029.36	223.9	224.2	0	0
LOWER	72695	Max WS	31707.93	199.8	218.47	212.35	219.67	0.002369	8.8	3604.62	285.99	228.7	228.7	0	0
LOWER	72672		Bridge	**Highway 99**											
LOWER	72649	Max WS	31707.93	199.8	218.09		219.36	0.002596	9.07	3495.05	283.59	228.7	228.7	0	0
LOWER	72632	Max WS	31707.93	199.8	218.03		219.32	0.002632	9.12	3478.56	283.27	228.7	228.7	0	0
LOWER	72630	Max WS	31707.93	199.8	218.03		219.32	0.002637	9.12	3476.69	283.23	228.7	228.7	0	0
LOWER	72624	Max WS	31707.92	199.8	218.01	212.37	219.31	0.002646	9.13	3472.06	283.12	228.7	228.7	0	0
LOWER	72602.5		Bridge	**Highway 99**											
LOWER	72581	Max WS	31707.92	199.8	217.58		218.97	0.002937	9.46	3351.99	280.48	228.7	228.7	0	0
LOWER	72428	Max WS	31707.73	196.1	217.21		218.44	0.003104	8.89	3565.63	341.76	221.5	221.3	0	0
LOWER	72035.5*	Max WS	31705.25	194.88	215.95		217.16	0.003403	8.8	3600.9	376.89	219.43	219.57	0	0
LOWER	71643.*	Max WS	31705.32	193.65	214.63		215.79	0.003475	8.67	3657.88	385.24	217.92	217.85	0	0
LOWER	71250.5*	Max WS	31705.1	192.43	213.35		214.44	0.003211	8.38	3782.14	393.95	216.43	216.12	0	0.23
LOWER	70858	Max WS	31704.61	191.2	212.26		213.22	0.002719	7.88	4022.6	403.99	215	214.4	0.26	0.86
LOWER	70436.7*	Max WS	31702.24	189.55	211.09		212.07	0.002801	7.93	3996.12	407.23	213.62	213.05	0.47	1.04
LOWER	70015.5*	Max WS	31702.28	187.9	209.86		210.87	0.002959	8.04	3941.53	410.11	212.25	211.7	0.61	1.16
LOWER	69594.2*	Max WS	31702	186.25	208.52		209.58	0.003278	8.27	3832.78	412.03	210.88	210.4	0.64	1.12
LOWER	69173	Max WS	31699.03	184.6	206.93		208.12	0.003997	8.77	3616.14	411.56	209.5	209.1	0.43	0.83
LOWER	68685.*	Max WS	31698.72	183.32	205.11		206.16	0.003712	8.2	3863.93	1120.05	208.1	204.98	0.01	3.13
LOWER	68197.*	Max WS	31695.54	182.04	203.31		204.48	0.003533	8.7	3644.85	383.91	206.7	206.6	0	0
LOWER	67709.*	Max WS	31695.7	180.76	201.69		202.82	0.003184	8.54	3711.67	371.67	205.3	205.4	0	0
LOWER	67221.*	Max WS	31695.45	179.48	200.28		201.34	0.002746	8.26	3834.93	360.61	203.9	204.2	0	0
LOWER	66733	Max WS	31694.93	178.2	199.11		200.08	0.002274	7.89	4016.8	350.57	202.5	203	0	0
LOWER	66504	Max WS	31694.67	177.1	197.98	192.69	199.88	0.004088	11.06	2864.53	232.02	205.8	205.8	0	0
LOWER	66483		Bridge	**Dayton-Durham Highway**											
LOWER	66462	Max WS	31694.67	177.1	197.98		199.88	0.004088	11.06	2864.57	232.02	205.8	205.8	0	0
LOWER	66233	Max WS	31693.05	177.4	197.36		198.78	0.003197	9.54	3321.63	280.09	199.8	199.8	0.56	0.56
LOWER	65746.7*	Max WS	31693.14	175.55	195.73		197.11	0.00358	9.42	3364.04	318.07	198.4	198.41	0.33	0.32
LOWER	65260.5*	Max WS	31692.85	173.7	194		195.29	0.003717	9.12	3476.59	355.53	197	197.04	0	0
LOWER	64774.2*	Max WS	31689.96	171.85	192.35		193.48	0.003415	8.53	3716.49	393.08	195.65	195.67	0	0
LOWER	64288	Max WS	31689.71	170	191.02		191.9	0.002603	7.55	4195.58	432.11	194.3	194.3	0	0
LOWER	63811.7*	Max WS	31685.75	169.25	189.78		190.69	0.002537	7.67	4129.13	417.01	193.21	193.14	0	0
LOWER	63335.5*	Max WS	31685.87	168.5	188.56		189.51	0.002506	7.8	4062.2	402.06	192.12	191.97	0	0
LOWER	62859.2*	Max WS	31685.52	167.75	187.38		188.35	0.002402	7.93	3998.07	387.27	191.04	190.81	0	0
LOWER	62383.*	Max WS	31681.74	167	186.22		187.23	0.002391	8.06	3933.07	372.63	189.95	189.64	0	0
LOWER	61906.7*	Max WS	31681.9	166.25	185.07		186.11	0.002362	8.21	3858.86	357.98	188.86	188.48	0	0
LOWER	61430.5*	Max WS	31681.71	165.5	183.91		185	0.002405	8.4	3769.96	343.27	187.78	187.35	0	0
LOWER	60954.2*	Max WS	31681.21	164.75	182.73		183.89	0.002392	8.64	3664.88	328.39	186.69	186.23	0	0
LOWER	60478	Max WS	31678.39	164	181.51		182.76	0.002533	8.96	3535.31	313.21	185.6	185.1	0	0
LOWER	59983.6*	Max WS	31678.33	163.22	180.27		181.48	0.002587	8.82	3590.98	332.43	184.64	184.06	0	0
LOWER	59489.2*	Max WS	31677.81	162.44	179.02		180.18	0.00258	8.65	3662.78	351.72	183.68	183.02	0	0
LOWER	58994.8*	Max WS	31674.52	161.66	177.8		178.9	0.002492	8.41	3764.07	371.32	182.72	181.98	0	0
LOWER	58500.4*	Max WS	31674.28	160.88	176.66		177.68	0.0023	8.09	3915.45	391.53	181.76	180.94	0	0
LOWER	58006	Max WS	31670.07	160.1	175.56		176.49	0.002352	7.71	4106.18	412.14	180.8	179.9	0	0
LOWER	57573.5*	Max WS	31670.19	158.6	174.53		175.49	0.002346	7.83	4042.38	395.92	178.95	178.42	0	0
LOWER	57141.*	Max WS	31669.92	157.1	173.54		174.5	0.002249	7.86	4027.79	380.02	177.1	176.95	0	0
LOWER	56708.5*	Max WS	31669.33	155.6	172.62		173.56	0.002046	7.76	4078.96	364.79	175.25	175.47	0.37	0.15
LOWER	56276	Max WS	31666.02	154.1	171.84		172.72	0.001761	7.53	4206.47	350.5	173.4	174	1.44	0.84
LOWER	55890.*	Max WS	31666.04	151.7	171.13		172.03	0.001851	7.59	4170.96	356.38	172.95	173.15	1.18	0.98
LOWER	55504	Max WS	31665.88	149.3	170.42		171.31	0.001858	7.53	4203.81	362.37	172.5	172.4	0.92	1.02
LOWER	55117.7*	Max WS	31665.53	149	169.49		170.54	0.002491	8.22	3853.04	365.8	171.48	171.65	1.01	0.84
LOWER	54731.5*	Max WS	31662.56	148.7	168.43		169.55	0.002822	8.52	3717.8	368.11	170.45	171	0.98	0.43
LOWER	54345.2*	Max WS	31662.66	148.4	167.46		168.49	0.002468	8.15	3882.91	370.71	169.52	170.35	0.94	0.11
LOWER	53959	Max WS	31662.55	148.1	166.8		167.59	0.001622	7.14	4431.59	374.97	168.6	169.7	1.2	0.1
LOWER	53799	Max WS	31662.46	147.91	166.53	159.07	167.35	0.001534	7.29	4344.99	334	169.9	169.9	0	0
LOWER	53779		Bridge	**Dayton-Durham Highway**											
LOWER	53759	Max WS	31662.44	147.99	166.36		167.21	0.001599	7.38	4288.52	334	169.9	169.9	0	0
LOWER	53690	Max WS	31662.39	147.6	166.19		167.11	0.00204	7.71	4106.34	369.13	167.6	168.3	1.59	0.89
LOWER	53649	Max WS	31662.36	147.5	166.1		167.03	0.002059	7.73	4098.51	369.92	167.5	168.3	1.6	0.8
LOWER	53190.*	Max WS	31661.87	146.5	164.96		166.01	0.002631	8.21	3855.21	382.38	166.42	167.15	1.54	0.81
LOWER	52731.*	Max WS	31659.61	145.5	163.59		164.73	0.003149	8.57	3693.25	392.87	165.34	166	1.25	0.59
LOWER	52272.*	Max WS	31659.35	144.5	162.07		163.24	0.003429	8.7	3636.98	402.07	164.26	164.9	0.81	0.17
LOWER	51813.*	Max WS	31655.55	143.5	160.59		161.69	0.003177	8.41	3763.68	411.88	163.18	163.8	0.41	0
LOWER	51354	Max WS	31655.15	142.5	159.44		160.33	0.00233	7.55	4192.27	424.43	162.1	162.7	0.34	0
LOWER	50948.*	Max WS	31649.83	140.88	158.51		159.39	0.002286	7.52	4207.01	424.07	161.25	161.45	0.26	0.06
LOWER	50542.*	Max WS	31649.44	139.25	157.61		158.47	0.002188	7.43	4257.63	423.55	160.4	160.2	0.21	0.41
LOWER	50136.*	Max WS	31642.36	137.62	156.78		157.6	0.00203	7.27	4354.64	423.41	159.55	158.95	0.23	0.83
LOWER	49730	Max WS	31633.01	136	156.03		156.8	0.001819	7.02	4507.67	423.69	158.7	157.7	0.33	1.33
LOWER	49233.1*	Max WS	31621.69	135.57	155.21		155.89	0.001723	6.6	4789.64	477.43	157.71	156.93	0.5	1.28
LOWER	48736.2*	Max WS	31621.36	135.14	154.44		155.04	0.00158	6.17	5124.64	531.56	156.73	156.16	0.71	1.28
LOWER	48239.4*	Max WS	31607.34	134.71	153.77		154.27	0.001385	5.71	5538.62	586.37	155.74	155.39	1.03	1.38
LOWER	47742.5*	Max WS	31591.64	134.29	153.19		153.61	0.001159	5.22	6054.02	641.99	154.76	154.61	1.43	1.58
LOWER	47245.7*	Max WS	31574.38	133.86	152.73		153.07	0.000925	4.71	6697.75	698.49	153.77	153.84	1.96	1.89
LOWER	46748.8*	Max WS	31573.93	133.43	152.37		152.65	0.00071	4.22	7484.47	756.23	152.79	153.07	2.58	2.3
LOWER	46252	Max WS	31557.53	133	152.11		152.33	0.000529	3.75	8419.17	812.31	151.8	152.3	3.31	2.81
LOWER	45753.4*	Max WS	31557.73	132.06	151.84		152.05	0.000566	3.69	8545.8	804	151.26	151.76	3.58	3.08
LOWER	45254.8*	Max WS	31557.12	131.12	151.55		151.75	0.000633	3.65	8648.31	795	150.72	151.22	3.83	3.33

BUTTE CREEK
BUTTE COUNTY, CALIFORNIA
REQUIRED LEVEE IMPROVEMENTS TO ACHIEVE MINIMUM FREEBOARD

HEC-RAS Plan: Existing River: BUTTE Reach: LOWER Profile: Max WS

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Top of Bank LOB Elev	Top of Bank ROB Elev	Levee Height Increase to Provide 3-ft. freeboard	
														LOB	ROB
LOWER	44756.2*	Max WS	31555.76	130.18	151.22		151.43	0.00068	3.62	8724.59	786	150.18	150.68	4.04	3.54
LOWER	44257.6*	Max WS	31545.73	129.24	150.87		151.07	0.000762	3.6	8773.86	777.96	149.65	150.14	4.22	3.73
LOWER	43759	Max WS	31545.65	128.3	150.47		150.67	0.000837	3.58	8803.07	778	149.2	149.6	4.27	3.87
LOWER	43363.7*	Max WS	31545.2	126.03	150.08		150.31	0.000995	3.87	8152.3	711	148.53	149.33	4.55	3.75
LOWER	42968.5*	Max WS	31544.42	123.75	149.61		149.89	0.001199	4.22	7475.98	654	147.95	149.05	4.66	3.56
LOWER	42573.2*	Max WS	31539.55	121.47	149.02		149.36	0.001571	4.68	6745.74	597	147.38	148.78	4.64	3.24
LOWER	42178	Max WS	31539.74	119.2	148.2		148.64	0.002225	5.32	5930.58	537.85	146.8	148.5	4.4	2.7
LOWER	42118	Max WS	31539.73	117.9	147.92		148.51	0.003862	6.14	5139.11	495.4	146.6	148.3	4.32	2.62
LOWER	42088	Max WS	31539.72	117.8	147.81		148.39	0.003873	6.13	5144.43	496.1	146.5	148.2	4.31	2.61
LOWER	41988	Max WS	31539.66	117.8	147.43		148.01	0.003714	6.13	5144.26	519.41	146.5	148.1	3.93	2.33
LOWER	41490.4*	Max WS	31534.57	118.88	145.87		146.33	0.002868	5.48	5759.03	581.96	146.23	145.88	2.64	2.99
LOWER	40992.8*	Max WS	31534.09	119.96	144.67		145.04	0.002236	4.86	6487.15	677.4	145.96	145.56	1.71	2.11
LOWER	40495.2*	Max WS	31527.87	121.04	143.74		144.02	0.001746	4.3	7337.3	774.08	145.69	145.24	1.05	1.5
LOWER	39997.6*	Max WS	31526.95	122.12	143.04		143.26	0.001276	3.78	8350.3	870.31	145.42	144.92	0.62	1.12
LOWER	39500	Max WS	31521.22	123.2	142.54		142.7	0.00091	3.29	9579.59	954.01	145.2	144.6	0.34	0.94
LOWER	39073.*	Max WS	31521.03	122.17	142.11		142.29	0.001057	3.38	9330.15	981.43	144.8	144.8	0.31	0.31
LOWER	38646.*	Max WS	31520.41	121.15	141.61		141.79	0.001263	3.49	9020.44	1006.74	144.4	145	0.21	0
LOWER	38219.*	Max WS	31519.52	120.12	140.99		141.2	0.001571	3.66	8610.73	1029.15	144	145.2	0	0
LOWER	37792	Max WS	31518.41	119.1	140.17		140.41	0.002128	3.93	8010.16	1050.9	143.6	145.4	0	0
LOWER	37681	Max WS	31518.21	114.3	139.57	133.18	140.51	0.001817	7.81	4037.25	307.81	141.6	140	0.97	2.57
LOWER	37672		Bridge	**Railroad at Midway**											
LOWER	37663	Max WS	31518.21	114.3	139.56		140.51	0.00182	7.81	4034.87	307.81	141.6	140	0.96	2.56
LOWER	37615	Max WS	31518.14	113.7	139.84		140.2	0.001059	4.84	6507.19	919.62	141.9	138.6	0.94	4.24
LOWER	37605	Max WS	31518.11	113.6	139.83		140.19	0.001022	4.78	6595.83	921.59	141.8	138.5	1.03	4.33
LOWER	37585	Max WS	31518.06	113.3	139.83	131.36	140.16	0.001248	4.6	6858.78	930.75	141.5	138.2	1.33	4.63
LOWER	37572.5		Bridge	**Midway Road**											
LOWER	37560	Max WS	31518.46	113.3	137.55		138.21	0.003545	6.56	4807.83	840.98	141.5	138.2	0	2.35
LOWER	37328	Max WS	31517.98	117.7	137.22		137.47	0.001105	4.04	7809.46	1214.06	137.5	139.4	2.72	0.82
LOWER	36875.*	Max WS	31515.46	120.15	136.64		136.91	0.001421	4.18	7532.59	1347.14	137.15	139	2.49	0.64
LOWER	36422	Max WS	31515.04	122.6	135.69		136.05	0.002558	4.83	6530.75	1464.32	136.8	138.6	1.89	0.09
LOWER	35943.7*	Max WS	31512.11	120.28	134.51		134.84	0.002469	4.63	6805.06	1585.27	135.93	137.25	1.58	0.26
LOWER	35465.5*	Max WS	31507.56	117.95	133.42		133.71	0.002218	4.35	7235.42	1706.81	135.05	135.9	1.37	0.52
LOWER	34987.2*	Max WS	31501.23	115.62	132.52		132.76	0.001727	3.93	8020.14	1829.76	134.18	134.55	1.34	0.97
LOWER	34509	Max WS	31493.6	113.3	131.89		132.06	0.001114	3.35	9397.82	1954.39	133.3	133.2	1.59	1.69
LOWER	34067.6*	Max WS	31485.21	112.2	131.38		131.56	0.00121	3.36	9370.84	1996.69	133.17	132.5	1.21	1.88
LOWER	33626.3*	Max WS	31484.43	111.1	130.83		131.01	0.001282	3.39	9281.3	2035.98	133.03	131.8	0.8	2.03
LOWER	33185	Max WS	31466.25	110	130.22		130.41	0.001474	3.46	9084.72	2070.29	132.9	131.1	0.32	2.12
LOWER	32752.7*	Max WS	31455.06	109.7	129.62		129.8	0.00137	3.43	9181.63	2015.44	132.02	130.68	0.6	1.94
LOWER	32320.5*	Max WS	31442.72	109.4	129.06		129.24	0.001233	3.36	9369.78	1960.97	131.15	130.25	0.91	1.81
LOWER	31888.2*	Max WS	31429.73	109.1	128.58		128.74	0.001063	3.25	9677.61	1903.97	130.27	129.82	1.31	1.76
LOWER	31456	Max WS	31428.85	108.8	128.17		128.32	0.000886	3.11	10097.07	1844.96	129.4	129.4	1.77	1.77
LOWER	30995.8*	Max WS	31416.12	107.23	127.77		127.93	0.000835	3.22	9755.93	1748.36	129	128.93	1.77	1.84
LOWER	30535.6*	Max WS	31403.65	105.67	127.37		127.55	0.000868	3.34	9404.3	1651.77	128.6	128.47	1.77	1.9
LOWER	30075.5*	Max WS	31391.33	104.1	126.95		127.14	0.000931	3.49	8998.9	1555	128.2	128	1.75	1.95
LOWER	29615.3*	Max WS	31390.65	102.53	126.49		126.7	0.001029	3.68	8524.41	1457.9	127.8	127.53	1.69	1.96
LOWER	29155.1*	Max WS	31378.56	100.97	125.96		126.2	0.001168	3.94	7963.15	1360.31	127.4	127.07	1.56	1.89
LOWER	28695	Max WS	31351.2	99.4	125.33		125.62	0.001422	4.3	7286.79	1261.87	127	126.6	1.33	1.73
LOWER	28661	Max WS	31351.22	99	125.29	121.77	125.57	0.001316	4.27	7338.61	1178.13	126.9	126.7	1.39	1.59
LOWER	28651		Bridge	**Durnel Road**											
LOWER	28641	Max WS	31351.22	99	125.29		125.57	0.00117	4.27	7338.61	1178.13	126.9	126.7	1.39	1.59
LOWER	28502	Max WS	31351.16	102.8	125.17		125.4	0.001045	3.86	8128.13	1297.86	126.4	126.5	1.77	1.67
LOWER	28063.2*	Max WS	31335.41	103.32	124.75		124.96	0.000955	3.67	8527.15	1371.39	125.96	126.22	1.79	1.53
LOWER	27624.4*	Max WS	31318.99	103.84	124.36		124.55	0.000906	3.49	8964.85	1444.67	125.52	125.94	1.84	1.42
LOWER	27185.6*	Max WS	31318.02	104.36	124		124.17	0.000815	3.32	9440.26	1518.06	125.08	125.66	1.92	1.34
LOWER	26746.8*	Max WS	31302.41	104.88	123.67		123.82	0.000757	3.14	9972.38	1591.83	124.64	125.38	2.03	1.29
LOWER	26308	Max WS	31287.99	105.4	123.37		123.51	0.000666	2.96	10559.2	1665.89	124.2	125.1	2.17	1.27
LOWER	25882.4*	Max WS	31288.13	104.92	123.13		123.26	0.000521	2.86	10927.13	1510.43	123.96	125.02	2.17	1.11
LOWER	25456.8*	Max WS	31287.52	104.44	122.92		123.05	0.000468	2.89	10809.6	1355.2	123.72	124.94	2.2	0.98
LOWER	25031.2*	Max WS	31286.48	103.96	122.7		122.85	0.000468	3.08	10157.55	1199.89	123.48	124.86	2.22	0.84
LOWER	24605.6*	Max WS	31285.22	103.48	122.44		122.63	0.000599	3.51	8919.46	1039.48	123.24	124.78	2.2	0.66
LOWER	24180	Max WS	31281.49	103	121.99		122.31	0.001108	4.47	6991.13	886.88	123	124.7	1.99	0.29
LOWER	23694.6*	Max WS	35916.9	102.62	121.35		121.71	0.001132	4.85	7399.77	846.68	122.75	124.12	1.6	0.23
LOWER	23209.2*	Max WS	35898.08	102.25	120.89		121.21	0.000879	4.59	7828.86	808.37	122.5	123.55	1.39	0.34
LOWER	22723.8*	Max WS	35898.04	101.88	120.52		120.82	0.00071	4.39	8184.86	771	122.25	122.97	1.27	0.55
LOWER	22238.5*	Max WS	35879.98	101.5	120.22		120.5	0.000602	4.26	8428.26	734.25	122	122.4	1.22	0.82
LOWER	21753.1*	Max WS	35879.96	101.12	119.95		120.22	0.000539	4.2	8537.17	697.83	121.75	121.82	1.2	1.13
LOWER	21267.7*	Max WS	35879.24	100.75	119.69		119.97	0.000511	4.22	8493.05	661.74	121.5	121.25	1.19	1.44
LOWER	20782.3*	Max WS	35863.31	100.38	119.43		119.72	0.000517	4.33	8283.21	625.72	121.25	120.67	1.18	1.76
LOWER	20297	Max WS	35863.06	100	119.15		119.47	0.000562	4.54	7898.53	589.54	121	120.1	1.15	2.05
LOWER	19799.*	Max WS	35847.66	99.12	118.85		119.19	0.000577	4.68	7663.9	629.95	119.9	119	1.95	2.85
LOWER	19301.*	Max WS	35847.62	98.23	118.53		118.88	0.000671	4.74	7556.01	658.4	118.8	117.9	2.73	3.63
LOWER	18803.*	Max WS	35832.67	97.35	118.17		118.52	0.000731	4.76	7535.26	682.5	117.7	116.8	3.47	4.37
LOWER	18305.*	Max WS	35832.61	96.47	117.8		118.14	0.000743	4.7	7618.62	705.33	116.6	115.7	4.2	5.1
LOWER	17807.*	Max WS	35818.1	95.58	117.44		117.76	0.000702	4.58	7821.65	728.17	115.5	114.6	4.94	5.84
LOWER	17309	Max WS	35818.09	94.7	117.1		117.4	0.000653	4.39	8149.97	751	114.4	113.5	5.7	6.6
LOWER	16886.8*	Max WS	35817.44	94.57	116.79		117.09	0.000679	4.43	8093.81	761.5	114.48	113.75	5.31	6.04
LOWER	16464.6*	Max WS	35804.5	94.43	116.47		116.78	0.000708	4.46	8033.79	772	114.57	114	4.9	5.47
LOWER	16042.5*	Max WS	35804.07	94.3	116.13		116.45	0.000745	4.5	7958.33	782.5	114.65	114.25	4.48	4.88
LOWER	15620.3*	Max WS	35791.47	94.17	115.77		116.1	0.000787	4.55	7868.86	793	114.73	114.5	4.04	4.27
LOWER	15198.1*	Max WS	35791.16	94.03	115.41		115.74	0.000833	4.6	7775.28	803.5	114.82	114.75	3.59	3.66
LOWER	14776	Max WS	35778.77	93.9	115.04		115.38	0.000891	4.66	7676.5	814	114.9	115	3.14	3.04
LOWER	14343.8*	Max WS	35778.5	93.22	114.65		114.99	0.000887	4.64	7711.22	808.4	114.64	114.62	3.01	3.03
LOWER	13911.6*	Max WS	35766.42	92.54	114.27		114.6	0.000889	4.61	7751.41	802.64	114.38	114.24	2.89	3.03
LOWER	13479.4*	Max WS	35766.21	91.86	113.9		114.22	0.000862	4.58	7801.12	796.81	114.12	113.86	2.78	3.04
LOWER	13047.2*	Max WS	35754.46	91.18	113.53		113.85	0.000864	4.55	7859.4	790.87	113.86	113.48	2.67	3.05

BUTTE CREEK
BUTTE COUNTY, CALIFORNIA
REQUIRED LEVEE IMPROVEMENTS TO ACHIEVE MINIMUM FREEBOARD

HEC-RAS Plan: Existing River: BUTTE Reach: LOWER Profile: Max WS

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Top of Bank LOB Elev	Top of Bank ROB Elev	Levee Height Increase to Provide 3-ft. freeboard	
														LOB	ROB
LOWER	12615	Max WS	35754.41	90.5	113.16		113.48	0.000877	4.52	7918.69	784.65	113.6	113.1	2.56	3.06
LOWER	12554	Max WS	35754.35	89.6	112.7	104.88	113.66	0.001815	7.9	4528.58	316	114.1	114.1	1.6	1.6
LOWER	12540		Bridge	**Nelson Road**											
LOWER	12526	Max WS	35742.33	89.6	112.7		113.66	0.001815	7.89	4527.78	316	114.1	114.1	1.6	1.6
LOWER	12285	Max WS	35742.45	91	112.73		113.07	0.000959	4.67	7645.5	791	112.5	112.6	3.23	3.13
LOWER	11835.*	Max WS	35742.3	91.17	112.29		112.65	0.000962	4.8	7448.63	777.72	112.37	112.07	2.92	3.22
LOWER	11385.*	Max WS	35730.09	91.33	111.84		112.22	0.000958	4.92	7263.42	763.74	112.23	111.53	2.61	3.31
LOWER	10935	Max WS	35729.65	91.5	111.38		111.77	0.001044	5.05	7071.02	749.74	112.1	111	2.28	3.38
LOWER	10522.5*	Max WS	35717.43	91.38	111.01		111.36	0.000879	4.74	7529.24	774.5	110.97	110.45	3.04	3.56
LOWER	10110.*	Max WS	35716.97	91.25	110.71		111.01	0.000718	4.41	8090.02	797	109.85	109.9	3.86	3.81
LOWER	9697.5*	Max WS	35705.06	91.12	110.46		110.72	0.000575	4.08	8746.98	819.5	108.72	109.35	4.74	4.11
LOWER	9285	Max WS	35705.11	91	110.27		110.49	0.000455	3.76	9501.72	842	107.6	108.8	5.67	4.47
LOWER	8817.*	Max WS	35704.77	91	110.02		110.26	0.000514	3.93	9074.77	835.2	107.88	108.96	5.14	4.06
LOWER	8349.*	Max WS	35703.97	91	109.74		110	0.000584	4.1	8698.53	828.4	108.16	109.12	4.58	3.62
LOWER	7881.*	Max WS	35695.5	91	109.42		109.71	0.000655	4.26	8369.83	821.6	108.44	109.28	3.98	3.14
LOWER	7413.*	Max WS	35695.37	91	109.08		109.39	0.000714	4.41	8099.08	811.26	108.72	109.44	3.36	2.64
LOWER	6945	Max WS	35694.8	91	108.73		109.05	0.000755	4.52	7893.22	800.5	109	109.6	2.73	2.13
LOWER	6478.*	Max WS	35688.43	90.18	108.35		108.69	0.000814	4.68	7625.01	777.47	108.74	109.12	2.61	2.23
LOWER	6011.*	Max WS	35688.53	89.36	107.93		108.29	0.000893	4.87	7326.53	753.78	108.48	108.64	2.45	2.29
LOWER	5544.*	Max WS	35688.27	88.54	107.46		107.86	0.001001	5.1	6992.28	728.62	108.22	108.16	2.24	2.3
LOWER	5077.*	Max WS	35687.66	87.72	106.92		107.37	0.001152	5.4	6614.9	701.13	107.96	107.68	1.96	2.24
LOWER	4610	Max WS	35683.34	86.9	106.28		106.79	0.001419	5.78	6172.15	672.62	107.7	107.2	1.58	2.08
LOWER	4563	Max WS	35683.35	83.5	106.03	102.31	106.82	0.002956	7.12	5015.15	659.78	107.8	105.8	1.23	3.23
LOWER	4550		Bridge	**(Aquas Frias Road)**											
LOWER	4537	Max WS	35683.35	83.5	106.03		106.82	0.002956	7.12	5015.14	659.78	107.8	105.8	1.23	3.23
LOWER	4418	Max WS	35683.36	88	105.98		106.41	0.001029	5.28	6762.26	669.71	107.4	106.6	1.58	2.38
LOWER	3934.4*	Max WS	35683.17	87.42	105.46		105.87	0.001183	5.17	6908.42	711.72	106.62	106.04	1.84	2.42
LOWER	3450.8*	Max WS	35682.64	86.84	104.89		105.29	0.00121	5.12	6973.8	744.06	105.84	105.48	2.05	2.41
LOWER	2967.2*	Max WS	35679.45	86.26	104.28		104.69	0.001298	5.12	6964.19	775.54	105.06	104.92	2.22	2.36
LOWER	2483.6*	Max WS	35679.7	85.68	103.59		104.01	0.001522	5.22	6831.88	806.3	104.28	104.36	2.31	2.23
LOWER	2000	Max WS	35679.84	85.1	102.76	98.7	103.22	0.001805	5.47	6527.51	836.11	103.5	103.8	2.26	1.96

BUTTE CREEK
BUTTE COUNTY, CALIFORNIA
REQUIRED LEVEE IMPROVEMENTS TO ACHIEVE MINIMUM FREEBOARD

Improvement Increment Between Existing and Increased Diversion Flows
HEC-RAS Plan: Existing River: BUTTE Reach: LOWER Profile: Max WS

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Top of Bank LOB Elev	Top of Bank ROB Elev	Levee Height Increase to Provide 3-ft. freeboard Increased Diversion Flow		Increase Beyond Existing Conditions Requirements	
														LOB	ROB	LOB	ROB
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	(ft)	(ft)				
LOWER	74600	Max WS	31718.34	209.4	224.94		226.35	0.003931	10.22	4089.93	806.46	219.8	221.6	8.14	6.34	0.28	0.28
LOWER	74182.*	Max WS	31711.52	207.4	223.47		224.52	0.003304	8.83	5372.48	2077.84	220.82	222.25	5.65	4.22	0.39	0.39
LOWER	73764.*	Max WS	31710.53	205.4	221.8		223.15	0.004115	9.34	3395.78	3384.72	221.85	222.9	2.95	1.9	0.46	0.46
LOWER	73346.*	Max WS	31707.71	203.4	220.32		221.41	0.003389	8.38	3783.66	4878.32	222.88	223.55	0.44	0	0.44	0
LOWER	72928	Max WS	31707.89	201.4	219.24		220.06	0.002476	7.26	4369.34	7029.36	223.9	224.2	0	0	0	0
LOWER	72695	Max WS	31707.93	199.8	218.47	212.35	219.67	0.002369	8.8	3604.62	285.99	228.7	228.7	0	0	0	0
LOWER	72672		Bridge	**Highway 99**												0	0
LOWER	72649	Max WS	31707.93	199.8	218.09		219.36	0.002596	9.07	3495.05	283.59	228.7	228.7	0	0	0	0
LOWER	72632	Max WS	31707.93	199.8	218.03		219.32	0.002632	9.12	3478.56	283.27	228.7	228.7	0	0	0	0
LOWER	72630	Max WS	31707.93	199.8	218.03		219.32	0.002637	9.12	3476.69	283.23	228.7	228.7	0	0	0	0
LOWER	72624	Max WS	31707.92	199.8	218.01	212.37	219.31	0.002646	9.13	3472.06	283.12	228.7	228.7	0	0	0	0
LOWER	72602.5		Bridge	**Highway 99**												0	0
LOWER	72581	Max WS	31707.92	199.8	217.58		218.97	0.002937	9.46	3351.99	280.48	228.7	228.7	0	0	0	0
LOWER	72428	Max WS	31707.73	196.1	217.21		218.44	0.003104	8.89	3565.63	341.76	221.5	221.3	0	0	0	0
LOWER	72035.5*	Max WS	31705.25	194.88	215.95		217.16	0.003403	8.8	3600.9	376.89	219.43	219.57	0	0	0	0
LOWER	71643.*	Max WS	31705.32	193.65	214.63		215.79	0.003475	8.67	3657.88	385.24	217.92	217.85	0	0	0	0
LOWER	71250.5*	Max WS	31705.1	192.43	213.35		214.44	0.003211	8.38	3782.14	393.95	216.43	216.12	0	0.23	0	0.23
LOWER	70858	Max WS	31704.61	191.2	212.26		213.22	0.002719	7.88	4022.6	403.99	215	214.4	0.26	0.86	0.26	0.35
LOWER	70436.7*	Max WS	31702.24	189.55	211.09		212.07	0.002801	7.93	3996.12	407.23	213.62	213.05	0.47	1.04	0.35	0.35
LOWER	70015.5*	Max WS	31702.28	187.9	209.86		210.87	0.002959	8.04	3941.53	410.11	212.25	211.7	0.61	1.16	0.33	0.33
LOWER	69594.2*	Max WS	31702	186.25	208.52		209.58	0.003278	8.27	3832.78	412.03	210.88	210.4	0.64	1.12	0.33	0.33
LOWER	69173	Max WS	31699.03	184.6	206.93		208.12	0.003997	8.77	3616.14	411.56	209.5	209.1	0.43	0.83	0.33	0.33
LOWER	68685.*	Max WS	31698.72	183.32	205.11		206.16	0.003712	8.2	3863.93	1120.05	208.1	204.98	0.01	3.13	0.01	0.37
LOWER	68197.*	Max WS	31695.54	182.04	203.31		204.48	0.003533	8.7	3644.85	383.91	206.7	206.6	0	0	0	0
LOWER	67709.*	Max WS	31695.7	180.76	201.69		202.82	0.003184	8.54	3711.67	371.67	205.3	205.4	0	0	0	0
LOWER	67221.*	Max WS	31695.45	179.48	200.28		201.34	0.002746	8.26	3834.93	360.61	203.9	204.2	0	0	0	0
LOWER	66733	Max WS	31694.93	178.2	199.11		200.08	0.002274	7.89	4016.8	350.57	202.5	203	0	0	0	0
LOWER	66504	Max WS	31694.67	177.1	197.98	192.69	199.88	0.004088	11.06	2864.53	232.02	205.8	205.8	0	0	0	0
LOWER	66483		Bridge	**Dayton-Durham Highway**												0	0
LOWER	66462	Max WS	31694.67	177.1	197.98		199.88	0.004088	11.06	2864.57	232.02	205.8	205.8	0	0	0	0
LOWER	66233	Max WS	31693.05	177.4	197.36		198.78	0.003197	9.54	3321.63	280.09	199.8	199.8	0.56	0.56	0.38	0.38
LOWER	65746.7*	Max WS	31693.14	175.55	195.73		197.11	0.00358	9.42	3364.04	318.07	198.4	198.41	0.33	0.32	0.33	0.32
LOWER	65260.5*	Max WS	31692.85	173.7	194		195.29	0.003717	9.12	3476.59	355.53	197	197.04	0	0	0	0
LOWER	64774.2*	Max WS	31689.96	171.85	192.35		193.48	0.003415	8.53	3716.49	393.08	195.65	195.67	0	0	0	0
LOWER	64288	Max WS	31689.71	170	191.02		191.9	0.002603	7.55	4195.58	432.11	194.3	194.3	0	0	0	0
LOWER	63811.7*	Max WS	31685.75	169.25	189.78		190.69	0.002537	7.67	4129.13	417.01	193.21	193.14	0	0	0	0
LOWER	63335.5*	Max WS	31685.87	168.5	188.56		189.51	0.002506	7.8	4062.2	402.06	192.12	191.97	0	0	0	0
LOWER	62859.2*	Max WS	31685.52	167.75	187.38		188.35	0.002402	7.93	3998.07	387.27	191.04	190.81	0	0	0	0
LOWER	62383.*	Max WS	31681.74	167	186.22		187.23	0.002391	8.06	3933.07	372.63	189.95	189.64	0	0	0	0
LOWER	61906.7*	Max WS	31681.9	166.25	185.07		186.11	0.002362	8.21	3858.86	357.98	188.86	188.48	0	0	0	0
LOWER	61430.5*	Max WS	31681.71	165.5	183.91		185	0.002405	8.4	3769.96	343.27	187.78	187.35	0	0	0	0
LOWER	60954.2*	Max WS	31681.21	164.75	182.73		183.89	0.002392	8.64	3664.88	328.39	186.69	186.23	0	0	0	0
LOWER	60478	Max WS	31678.39	164	181.51		182.76	0.002533	8.96	3535.31	313.21	185.6	185.1	0	0	0	0
LOWER	59983.6*	Max WS	31678.33	163.22	180.27		181.48	0.002587	8.82	3590.98	332.43	184.64	184.06	0	0	0	0
LOWER	59489.2*	Max WS	31677.81	162.44	179.02		180.18	0.00258	8.65	3662.78	351.72	183.68	183.02	0	0	0	0
LOWER	58994.8*	Max WS	31674.52	161.66	177.8		178.9	0.002492	8.41	3764.07	371.32	182.72	181.98	0	0	0	0
LOWER	58500.4*	Max WS	31674.28	160.88	176.66		177.68	0.0023	8.09	3915.45	391.53	181.76	180.94	0	0	0	0
LOWER	58006	Max WS	31670.07	160.1	175.56		176.49	0.002352	7.71	4106.18	412.14	180.8	179.9	0	0	0	0
LOWER	57573.5*	Max WS	31670.19	158.6	174.53		175.49	0.002346	7.83	4042.38	395.92	178.95	178.42	0	0	0	0
LOWER	57141.*	Max WS	31669.92	157.1	173.54		174.5	0.002249	7.86	4027.79	380.02	177.1	176.95	0	0	0	0
LOWER	56708.5*	Max WS	31669.33	155.6	172.62		173.56	0.002046	7.76	4078.96	364.79	175.25	175.47	0.37	0.15	0.37	0.15
LOWER	56276	Max WS	31666.02	154.1	171.84		172.72	0.001761	7.53	4206.47	350.5	173.4	174	1.44	0.84	0.41	0.41
LOWER	55890.*	Max WS	31666.04	151.7	171.13		172.03	0.001851	7.59	4170.96	356.38	172.95	173.15	1.18	0.98	0.39	0.39
LOWER	55504	Max WS	31665.88	149.3	170.42		171.31	0.001858	7.53	4203.81	362.37	172.5	172.4	0.92	1.02	0.38	0.38
LOWER	55117.7*	Max WS	31665.53	149	169.49		170.54	0.002491	8.22	3853.04	365.8	171.48	171.65	1.01	0.84	0.38	0.38
LOWER	54731.5*	Max WS	31662.56	148.7	168.43		169.55	0.002822	8.52	3717.8	368.11	170.45	171	0.98	0.43	0.38	0.38
LOWER	54345.2*	Max WS	31662.66	148.4	167.46		168.49	0.002468	8.15	3882.91	370.71	169.52	170.35	0.94	0.11	0.39	0.11
LOWER	53959	Max WS	31662.55	148.1	166.8		167.59	0.001622	7.14	4431.59	374.97	168.6	169.7	1.2	0.1	0.38	0.1
LOWER	53799	Max WS	31662.46	147.91	166.53	159.07	167.35	0.001534	7.29	4344.99	334	169.9	169.9	0	0	0	0
LOWER	53779		Bridge	**Dayton-Durham Highway**												0	0
LOWER	53759	Max WS	31662.44	147.99	166.36		167.21	0.001599	7.38	4288.52	334	169.9	169.9	0	0	0	0
LOWER	53690	Max WS	31662.39	147.6	166.19		167.11	0.00204	7.71	4106.34	369.13	167.6	168.3	1.59	0.89	0.36	0.36
LOWER	53649	Max WS	31662.36	147.5	166.1		167.03	0.002059	7.73	4098.51	369.92	167.5	168.3	1.6	0.8	0.36	0.36
LOWER	53190.*	Max WS	31661.87	146.5	164.96		166.01	0.002631	8.21	3855.21	382.38	166.42	167.15	1.54	0.81	0.34	0.34
LOWER	52731.*	Max WS	31659.61	145.5	163.59		164.73	0.003149	8.57	3693.25	392.87	165.34	166	1.25	0.59	0.34	0.34
LOWER	52272.*	Max WS	31659.35	144.5	162.07		163.24	0.003429	8.7	3636.98	402.07	164.26	164.9	0.81	0.17	0.35	0.17
LOWER	51813.*	Max WS	31655.55	143.5	160.59		161.69	0.003177	8.41	3763.68	411.88	163.18	163.8	0.41	0	0.35	0
LOWER	51354	Max WS	31655.15	142.5	159.44		160.33	0.00233	7.55	4192.27	424.43	162.1	162.7	0.34	0	0.34	0
LOWER	50948.*	Max WS	31649.83	140.88	158.51		159.39	0.002286	7.52	4207.01	424.07	161.25	161.45	0.26	0.06	0.26	0.06
LOWER	50542.*	Max WS	31649.44	139.25	157.61		158.47	0.002188	7.43	4257.63	423.55	160.4	160.2	0.21	0.41	0.21	0.36
LOWER	50136.*	Max WS	31642.36	137.62	156.78		157.6	0.00203	7.27	4354.64	423.41	159.55	158.95	0.23	0.83	0.23	0.36
LOWER	49730	Max WS	31633.01	136	156.03		156.8	0.001819	7.02	4507.67	423.69	158.7	157.7	0.33	1.33	0.33	0.35
LOWER	49233.1*	Max WS	31621.69	135.57	155.21		155.89	0.001723	6.6	4789.64	477.43	157.71	156.93	0.5	1.28	0.35	0.35
LOWER	48736.2*	Max WS	31621.36	135.14	154.44		155.04	0.00158	6.17	5124.64	531.56	156.73	156.16	0.71	1.28	0.35	0.35
LOWER	48239.4*	Max WS	31607.34	134.71	153.77		154.27	0.001385	5.71	5538.62	586.37	155.74	155.39	1.03	1.38	0.36	0.36
LOWER	47742.5*	Max WS	31591.64	134.29	153.19		153.61	0.001159	5.22	6054.02	641.99	154.76	154.61	1.43	1.58	0.37	0.37
LOWER	47245.7*	Max WS	31574.38	133.86	152.73		153.07	0.000925	4.71	6697.75	698.49	153.77	153.84	1.96	1.89	0.37	0.37
LOWER	46748.8*	Max WS	31573.93	133.43	152.37		152.65	0.00071	4.22	7484.47	756.23	152.79	153.07	2.58	2.3	0.37	0.37
LOWER	46252	Max WS	31557.53	133	152.11		152.33	0.000529	3.75	8419.17	812.31	151.8	152.3	3.31	2.81	0.38	0.38
LOWER	45753.4*	Max WS	31557.73	132.06	151.84		152.05	0.000566	3.69	8545.8	804	151.26	151.76	3.58	3.08	0.38	0.38
LOWER	45254.8*	Max WS	31557.12	131.12	151.55		151.75	0.000633	3.65	8648.31	795	150.72	151.22	3.83	3.33	0.38	0.38
LOWER	44756.2*	Max WS	31555.76	130.18	151.22		151.43	0.00068	3.62	8724.59	786	150.18	150.68	4.04	3.54	0.38	0.38
LOWER	44257.6*	Max WS	31545.73	129.24	150.87		151.07	0.000762	3.6	8773.86	777.96	149.65	150.14	4.22	3.73	0.38	0.38
LOWER	43759	Max WS	31545.65	128.3	150.47		150.67	0.000837	3.58	8803.07	778	149.2	149.6	4.27	3.87	0.38	0.38
LOWER	43363.7*	Max WS	31545.2	126.03	150.08		150.31	0.000995	3.87	8152.3	711	148.53	149.33	4.55	3.75	0.37	0.37
LOWER	42968.5*	Max WS	31544.42	123.75	149.61		149.89	0.001199	4.22	7475.98	654	147.95	149.05	4.66	3.56	0.37	0.37
LOWER	42573.2*	Max WS	31539.55	121.47	149.02		149.36	0.001571	4.68	6745.74	597	147.38	148.78	4.64	3.24	0.36	0.36

BUTTE CREEK
BUTTE COUNTY, CALIFORNIA
REQUIRED LEVEE IMPROVEMENTS TO ACHIEVE MINIMUM FREEBOARD

HEC-RAS Plan: Existing River: BUTTE Reach: LOWER Profile: Max WS

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Top of Bank LOB Elev	Top of Bank ROB Elev	Levee Height Increase to Provide 3-ft. freeboard Increased Diversion Flow		Increase Beyond Existing Conditions Requirements	
														LOB	ROB	LOB	ROB
LOWER	42178	Max WS	31539.74	119.2	148.2		148.64	0.002225	5.32	5930.58	537.85	146.8	148.5	4.4	2.7	0.35	0.35
LOWER	42118	Max WS	31539.73	117.9	147.92		148.51	0.003862	6.14	5139.11	495.4	146.6	148.3	4.32	2.62	0.34	0.34
LOWER	42088	Max WS	31539.72	117.8	147.81		148.39	0.003873	6.13	5144.43	496.1	146.5	148.2	4.31	2.61	0.35	0.35
LOWER	41988	Max WS	31539.66	117.8	147.43		148.01	0.003714	6.13	5144.26	519.41	146.5	148.1	3.93	2.33	0.34	0.34
LOWER	41490.4*	Max WS	31534.57	118.88	145.87		146.33	0.002868	5.48	5759.03	581.96	146.23	145.88	2.64	2.99	0.32	0.32
LOWER	40992.8*	Max WS	31534.09	119.96	144.67		145.04	0.002236	4.86	6487.15	677.4	145.96	145.56	1.71	2.11	0.31	0.31
LOWER	40495.2*	Max WS	31527.87	121.04	143.74		144.02	0.001746	4.3	7337.3	774.08	145.69	145.24	1.05	1.5	0.3	0.3
LOWER	39997.6*	Max WS	31526.95	122.12	143.04		143.26	0.001276	3.78	8350.3	870.31	145.42	144.92	0.62	1.12	0.29	0.29
LOWER	39500	Max WS	31521.22	123.2	142.54		142.7	0.00091	3.29	9579.59	954.01	145.2	144.6	0.34	0.94	0.28	0.28
LOWER	39073.*	Max WS	31521.03	122.17	142.11		142.29	0.001057	3.38	9330.15	981.43	144.8	144.8	0.31	0.31	0.26	0.26
LOWER	38646.*	Max WS	31520.41	121.15	141.61		141.79	0.001263	3.49	9020.44	1006.74	144.4	145	0.21	0	0.21	0
LOWER	38219.*	Max WS	31519.52	120.12	140.99		141.2	0.001571	3.66	8610.73	1029.15	144	145.2	0	0	0	0
LOWER	37792	Max WS	31518.41	119.1	140.17		140.41	0.002128	3.93	8010.16	1050.9	143.6	145.4	0	0	0	0
LOWER	37681	Max WS	31518.21	114.3	139.57	133.18	140.51	0.001817	7.81	4037.25	307.81	141.6	140	0.97	2.57	0.18	0.18
LOWER	37672		Bridge	**Railroad at Midway**												0	0
LOWER	37663	Max WS	31518.21	114.3	139.56		140.51	0.00182	7.81	4034.87	307.81	141.6	140	0.96	2.56	0.17	0.17
LOWER	37615	Max WS	31518.14	113.7	139.84		140.2	0.001059	4.84	6507.19	919.62	141.9	138.6	0.94	4.24	0.2	0.2
LOWER	37605	Max WS	31518.11	113.6	139.83		140.19	0.001022	4.78	6595.83	921.59	141.8	138.5	1.03	4.33	0.2	0.2
LOWER	37585	Max WS	31518.06	113.3	139.83	131.36	140.16	0.001248	4.6	6858.78	930.75	141.5	138.2	1.33	4.63	0.2	0.2
LOWER	37572.5		Bridge	**Midway Road**												0	0
LOWER	37560	Max WS	31518.46	113.3	137.55		138.21	0.003545	6.56	4807.83	840.98	141.5	138.2	0	2.35	0	0.18
LOWER	37328	Max WS	31517.98	117.7	137.22		137.47	0.001105	4.04	7809.46	1214.06	137.5	139.4	2.72	0.82	0.18	0.18
LOWER	36875.*	Max WS	31515.46	120.15	136.64		136.91	0.001421	4.18	7532.59	1347.14	137.15	139	2.49	0.64	0.17	0.17
LOWER	36422	Max WS	31515.04	122.6	135.69		136.05	0.002558	4.83	6530.75	1464.32	136.8	138.6	1.89	0.09	0.16	0.09
LOWER	35943.7*	Max WS	31512.11	120.28	134.51		134.84	0.002469	4.63	6805.06	1585.27	135.93	137.25	1.58	0.26	0.15	0.15
LOWER	35465.5*	Max WS	31507.56	117.95	133.42		133.71	0.002218	4.35	7235.42	1706.81	135.05	135.9	1.37	0.52	0.16	0.16
LOWER	34987.2*	Max WS	31501.23	115.62	132.52		132.76	0.001727	3.93	8020.14	1829.76	134.18	134.55	1.34	0.97	0.16	0.16
LOWER	34509	Max WS	31493.6	113.3	131.89		132.06	0.001114	3.35	9397.82	1954.39	133.3	133.2	1.59	1.69	0.16	0.16
LOWER	34067.6*	Max WS	31485.21	112.2	131.38		131.56	0.00121	3.36	9370.84	1996.69	133.17	132.5	1.21	1.88	0.16	0.16
LOWER	33626.3*	Max WS	31484.43	111.1	130.83		131.01	0.001282	3.39	9281.3	2035.98	133.03	131.8	0.8	2.03	0.16	0.16
LOWER	33185	Max WS	31466.25	110	130.22		130.41	0.001474	3.46	9084.72	2070.29	132.9	131.1	0.32	2.12	0.17	0.17
LOWER	32752.7*	Max WS	31455.06	109.7	129.62		129.8	0.00137	3.43	9181.63	2015.44	132.02	130.68	0.6	1.94	0.19	0.19
LOWER	32320.5*	Max WS	31442.72	109.4	129.06		129.24	0.001233	3.36	9369.78	1960.97	131.15	130.25	0.91	1.81	0.19	0.19
LOWER	31888.2*	Max WS	31429.73	109.1	128.58		128.74	0.001063	3.25	9677.61	1903.97	130.27	129.82	1.31	1.76	0.2	0.2
LOWER	31456	Max WS	31428.85	108.8	128.17		128.32	0.000886	3.11	10097.07	1844.96	129.4	129.4	1.77	1.77	0.21	0.21
LOWER	30995.8*	Max WS	31416.12	107.23	127.77		127.93	0.000835	3.22	9755.93	1748.36	129	128.93	1.77	1.84	0.21	0.21
LOWER	30535.6*	Max WS	31403.65	105.67	127.37		127.55	0.000868	3.34	9404.3	1651.77	128.6	128.47	1.77	1.9	0.22	0.22
LOWER	30075.5*	Max WS	31391.33	104.1	126.95		127.14	0.000931	3.49	8998.9	1555	128.2	128	1.75	1.95	0.22	0.22
LOWER	29615.3*	Max WS	31390.65	102.53	126.49		126.7	0.001029	3.68	8524.41	1457.9	127.8	127.53	1.69	1.96	0.23	0.23
LOWER	29155.1*	Max WS	31378.56	100.97	125.96		126.2	0.001168	3.94	7963.15	1360.31	127.4	127.07	1.56	1.89	0.23	0.23
LOWER	28695	Max WS	31351.2	99.4	125.33		125.62	0.001422	4.3	7286.79	1261.87	127	126.6	1.33	1.73	0.24	0.24
LOWER	28661	Max WS	31351.22	99	125.29	121.77	125.57	0.001316	4.27	7338.61	1178.13	126.9	126.7	1.39	1.59	0.24	0.24
LOWER	28651		Bridge	**Durnel Road**												0	0
LOWER	28641	Max WS	31351.22	99	125.29		125.57	0.00117	4.27	7338.61	1178.13	126.9	126.7	1.39	1.59	0.24	0.24
LOWER	28502	Max WS	31351.16	102.8	125.17		125.4	0.001045	3.86	8128.13	1297.86	126.4	126.5	1.77	1.67	0.24	0.24
LOWER	28063.2*	Max WS	31335.41	103.32	124.75		124.96	0.000955	3.67	8527.15	1371.39	125.96	126.22	1.79	1.53	0.25	0.25
LOWER	27624.4*	Max WS	31318.99	103.84	124.36		124.55	0.000906	3.49	8964.85	1444.67	125.52	125.94	1.84	1.42	0.27	0.27
LOWER	27185.6*	Max WS	31318.02	104.36	124		124.17	0.000815	3.32	9440.26	1518.06	125.08	125.66	1.92	1.34	0.28	0.28
LOWER	26746.8*	Max WS	31302.41	104.88	123.67		123.82	0.000757	3.14	9972.38	1591.83	124.64	125.38	2.03	1.29	0.3	0.3
LOWER	26308	Max WS	31287.99	105.4	123.37		123.51	0.000666	2.96	10559.2	1665.89	124.2	125.1	2.17	1.27	0.31	0.31
LOWER	25882.4*	Max WS	31288.13	104.92	123.13		123.26	0.000521	2.86	10927.13	1510.43	123.96	125.02	2.17	1.11	0.33	0.33
LOWER	25456.8*	Max WS	31287.52	104.44	122.92		123.05	0.000468	2.89	10809.6	1355.2	123.72	124.94	2.2	0.98	0.33	0.33
LOWER	25031.2*	Max WS	31286.48	103.96	122.7		122.85	0.000468	3.08	10157.55	1199.89	123.48	124.86	2.22	0.84	0.33	0.33
LOWER	24605.6*	Max WS	31285.22	103.48	122.44		122.63	0.000599	3.51	8919.46	1039.48	123.24	124.78	2.2	0.66	0.33	0.33
LOWER	24180	Max WS	31281.49	103	121.99		122.31	0.001108	4.47	6991.13	886.88	123	124.7	1.99	0.29	0.33	0.29
LOWER	23694.6*	Max WS	35916.9	102.62	121.35		121.71	0.001132	4.85	7399.77	846.68	122.75	124.12	1.6	0.23	0.36	0.23
LOWER	23209.2*	Max WS	35898.08	102.25	120.89		121.21	0.000879	4.59	7828.86	808.37	122.5	123.55	1.39	0.34	0.37	0.34
LOWER	22723.8*	Max WS	35898.04	101.88	120.52		120.82	0.00071	4.39	8184.86	771	122.25	122.97	1.27	0.55	0.37	0.37
LOWER	22238.5*	Max WS	35879.98	101.5	120.22		120.5	0.000602	4.26	8428.26	734.25	122	122.4	1.22	0.82	0.38	0.38
LOWER	21753.1*	Max WS	35879.96	101.12	119.95		120.22	0.000539	4.2	8537.17	697.83	121.75	121.82	1.2	1.13	0.38	0.38
LOWER	21267.7*	Max WS	35879.24	100.75	119.69		119.97	0.000511	4.22	8493.05	661.74	121.5	121.25	1.19	1.44	0.37	0.37
LOWER	20782.3*	Max WS	35863.31	100.38	119.43		119.72	0.000517	4.33	8283.21	625.72	121.25	120.67	1.18	1.76	0.37	0.37
LOWER	20297	Max WS	35863.06	100	119.15		119.47	0.000562	4.54	7898.53	589.54	121	120.1	1.15	2.05	0.37	0.37
LOWER	19799.*	Max WS	35847.66	99.12	118.85		119.19	0.000577	4.68	7663.9	629.95	119.9	119	1.95	2.85	0.36	0.36
LOWER	19301.*	Max WS	35847.62	98.23	118.53		118.88	0.000671	4.74	7556.01	658.4	118.8	117.9	2.73	3.63	0.36	0.36
LOWER	18803.*	Max WS	35832.67	97.35	118.17		118.52	0.000731	4.76	7535.26	682.5	117.7	116.8	3.47	4.37	0.35	0.35
LOWER	18305.*	Max WS	35832.61	96.47	117.8		118.14	0.000743	4.7	7618.62	705.33	116.6	115.7	4.2	5.1	0.35	0.35
LOWER	17807.*	Max WS	35818.1	95.58	117.44		117.76	0.000702	4.58	7821.65	728.17	115.5	114.6	4.94	5.84	0.35	0.35
LOWER	17309	Max WS	35818.09	94.7	117.1		117.4	0.000653	4.39	8149.97	751	114.4	113.5	5.7	6.6	0.35	0.35
LOWER	16886.8*	Max WS	35817.44	94.57	116.79		117.09	0.000679	4.43	8093.81	761.5	114.48	113.75	5.31	6.04	0.34	0.34
LOWER	16464.6*	Max WS	35804.5	94.43	116.47		116.78	0.000708	4.46	8033.79	772	114.57	114	4.9	5.47	0.33	0.33
LOWER	16042.5*	Max WS	35804.07	94.3	116.13		116.45	0.000745	4.5	7958.33	782.5	114.65	114.25	4.48	4.88	0.33	0.33
LOWER	15620.3*	Max WS	35791.47	94.17	115.77		116.1	0.000787	4.55	7868.86	793	114.73	114.5	4.04	4.27	0.32	0.32
LOWER	15198.1*	Max WS	35791.16	94.03	115.41		115.74	0.000833	4.6	7775.28	803.5	114.82	114.75	3.59	3.66	0.32	0.32
LOWER	14776	Max WS	35778.77	93.9	115.04		115.38	0.000891	4.66	7676.5	814	114.9	115	3.14	3.04	0.33	0.33
LOWER	14343.8*	Max WS	35778.5	93.22	114.65		114.99	0.000887	4.64	7711.22	808.4	114.64	114.62	3.01	3.03	0.32	0.32
LOWER	13911.6*	Max WS	35766.42	92.54	114.27		114.6	0.000889	4.61	7751.41	802.64	114.38	114.24	2.89	3.03	0.32	0.32
LOWER	13479.4*	Max WS	35766.21	91.86	113.9		114.22	0.000862	4.58	7801.12	796.81	114.12	113.86	2.78	3.04	0.33	0.33
LOWER	13047.2*	Max WS	35754.46	91.18	113.53		113.85	0.000864	4.55	7859.4	790.87	113.86	113.48	2.67	3.05	0.33	0.33
LOWER	12615	Max WS	35754.41	90.5	113.16		113.48	0.000877	4.52	7918.69	784.65	113.6	113.1	2.56	3.06	0.33	0.33
LOWER	12554	Max WS	35754.35	89.6	112.7	104.88	113.66	0.001815	7.9	4528.58	316	114.1	114.1	1.6	1.6	0.31	0.31
LOWER	12540		Bridge	**Nelson Road**												0	0
LOWER	12526	Max WS	35742.33	89.6	112.7		113.66	0.001815	7.89	4527.78	316	114.1	114.1	1.6	1.6	0.31	0.31
LOWER	12285	Max WS	35742.45	91	112.73		113.07	0.000959	4.67	7645.5	791	112.5	112.6	3.23	3.13	0.32	0.32
LOWER	11835.*	Max WS	35742.3	91.17	112.29		112.65	0.000962	4.8	7448.63	777.72	112.37	112.07	2.92	3.22	0.32	0.32
LOWER	11385.*	Max WS	35730.09	91.33	111.84		112.22	0.000958	4.92	7263.42	763.74	112.23	111.53	2.61	3.31	0.32	0.32
LOWER	10935	Max WS	35729.65	91.5	111.38		111.77	0.001044	5.05	7071.02	749.74	112.1	111	2.28	3.38	0.33	0.33
LOWER	10522.5*	Max WS	35717.43	91.38	111.01		111.36	0.000879	4.74	7529.24	774.5	110.97	110.45	3.04	3.56	0.33	0.33
LOWER	10110.*	Max WS	35716.97	91.25	110.71		111.01	0.000718	4.41	8090.02	797	109.85	109.9	3.86	3.81	0.33	0.33
LOWER	9697.5*	Max WS	35705.06	91.12	110.46		110.72	0.000575	4.08	8746.98	819.5	108.72	109.35	4.74	4.11	0.32	0.32

BUTTE CREEK
BUTTE COUNTY, CALIFORNIA
REQUIRED LEVEE IMPROVEMENTS TO ACHIEVE MINIMUM FREEBOARD

HEC-RAS Plan: Existing River: BUTTE Reach: LOWER Profile: Max WS

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Top of Bank LOB Elev	Top of Bank ROB Elev	Levee Height Increase to Provide 3-ft. freeboard Increased Diversion Flow		Increase Beyond Existing Conditions Requirements	
														LOB	ROB	LOB	ROB
LOWER	9285	Max WS	35705.11	91	110.27		110.49	0.000455	3.76	9501.72	842	107.6	108.8	5.67	4.47	0.32	0.32
LOWER	8817.*	Max WS	35704.77	91	110.02		110.26	0.000514	3.93	9074.77	835.2	107.88	108.96	5.14	4.06	0.32	0.32
LOWER	8349.*	Max WS	35703.97	91	109.74		110	0.000584	4.1	8698.53	828.4	108.16	109.12	4.58	3.62	0.32	0.32
LOWER	7881.*	Max WS	35695.5	91	109.42		109.71	0.000655	4.26	8369.83	821.6	108.44	109.28	3.98	3.14	0.31	0.31
LOWER	7413.*	Max WS	35695.37	91	109.08		109.39	0.000714	4.41	8099.08	811.26	108.72	109.44	3.36	2.64	0.3	0.3
LOWER	6945	Max WS	35694.8	91	108.73		109.05	0.000755	4.52	7893.22	800.5	109	109.6	2.73	2.13	0.31	0.31
LOWER	6478.*	Max WS	35688.43	90.18	108.35		108.69	0.000814	4.68	7625.01	777.47	108.74	109.12	2.61	2.23	0.31	0.31
LOWER	6011.*	Max WS	35688.53	89.36	107.93		108.29	0.000893	4.87	7326.53	753.78	108.48	108.64	2.45	2.29	0.3	0.3
LOWER	5544.*	Max WS	35688.27	88.54	107.46		107.86	0.001001	5.1	6992.28	728.62	108.22	108.16	2.24	2.3	0.29	0.29
LOWER	5077.*	Max WS	35687.66	87.72	106.92		107.37	0.001152	5.4	6614.9	701.13	107.96	107.68	1.96	2.24	0.28	0.28
LOWER	4610	Max WS	35683.34	86.9	106.28		106.79	0.001419	5.78	6172.15	672.62	107.7	107.2	1.58	2.08	0.28	0.28
LOWER	4563	Max WS	35683.35	83.5	106.03	102.31	106.82	0.002956	7.12	5015.15	659.78	107.8	105.8	1.23	3.23	0.28	0.28
LOWER	4550		Bridge	**(Aquas Frias Road)**												0	0
LOWER	4537	Max WS	35683.35	83.5	106.03		106.82	0.002956	7.12	5015.14	659.78	107.8	105.8	1.23	3.23	0.28	0.28
LOWER	4418	Max WS	35683.36	88	105.98		106.41	0.001029	5.28	6762.26	669.71	107.4	106.6	1.58	2.38	0.28	0.28
LOWER	3934.4*	Max WS	35683.17	87.42	105.46		105.87	0.001183	5.17	6908.42	711.72	106.62	106.04	1.84	2.42	0.27	0.27
LOWER	3450.8*	Max WS	35682.64	86.84	104.89		105.29	0.00121	5.12	6973.8	744.06	105.84	105.48	2.05	2.41	0.27	0.27
LOWER	2967.2*	Max WS	35679.45	86.26	104.28		104.69	0.001298	5.12	6964.19	775.54	105.06	104.92	2.22	2.36	0.26	0.26
LOWER	2483.6*	Max WS	35679.7	85.68	103.59		104.01	0.001522	5.22	6831.88	806.3	104.28	104.36	2.31	2.23	0.26	0.26
LOWER	2000	Max WS	35679.84	85.1	102.76	98.7	103.22	0.001805	5.47	6527.51	836.11	103.5	103.8	2.26	1.96	0.26	0.26

BUTTE CREEK
BUTTE COUNTY, CALIFORNIA
REQUIRED LEVEE IMPROVEMENTS TO ACHIEVE MINIMUM FREEBOARD

HEC-RAS Plan: Existing River: BUTTE Reach: LOWER Profile: Max WS

HEC-RAS Plan: Fire-no LC River: BUTTE Reach: LOWER Profile: Max WS														Levee Height Increase to Provide 3-ft. freeboard		EXISTING	DIFFERENCE
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	LOB Elev	ROB Elev	LOB	ROB	WSEL	
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	(ft)	(ft)			FT	FT
LOWER	74600	Max WS	46385.96	209.4	226.72		228.37	0.004066	11.52	5612.06	902.9	219.8	221.6	9.92	8.12	224.94	1.78
LOWER	74182.*	Max WS	46268.41	207.4	225.76		226.35	0.00182	7.54	10754.61	2609.03	220.82	222.25	7.94	6.51	223.47	2.29
LOWER	73764.*	Max WS	46155.02	205.4	225.16		225.59	0.001278	6.39	14303.54	4885.63	221.85	222.9	6.31	5.26	221.8	3.36
LOWER	73346.*	Max WS	46077.11	203.4	224.54		225.13	0.001384	6.75	12761.72	7011.98	222.88	223.55	4.66	3.99	220.32	4.22
LOWER	72928	Max WS	46070.32	201.4	223.96		224.69	0.001363	6.86	6788.96	8928.86	223.9	224.2	3.06	2.76	219.24	4.72
LOWER	72695	Max WS	46065.77	199.8	223.61	214.7	224.85	0.001703	8.95	5149.4	307.24	228.7	228.7	0	0	218.47	5.14
LOWER	72672		Bridge														
LOWER	72649	Max WS	46065.77	199.8	221.64		223.24	0.002516	10.13	4549.06	303.98	228.7	228.7	0	0	218.09	3.55
LOWER	72632	Max WS	46065.76	199.8	221.59		223.2	0.002547	10.16	4532.11	304.03	228.7	228.7	0	0	218.03	3.56
LOWER	72630	Max WS	46065.75	199.8	221.59		223.19	0.002551	10.17	4530.14	304.02	228.7	228.7	0	0	218.03	3.56
LOWER	72624	Max WS	46065.75	199.8	221.57	214.74	223.18	0.002559	10.18	4525.33	303.99	228.7	228.7	0	0	218.01	3.56
LOWER	72602.5		Bridge														
LOWER	72581	Max WS	46065.75	199.8	220.18		222.13	0.00348	11.23	4102.69	300.93	228.7	228.7	0	0	217.58	2.6
LOWER	72428	Max WS	46065.18	196.1	219.82		221.42	0.003415	10.15	4540.07	383.28	221.5	221.3	1.32	1.52	217.21	2.61
LOWER	72035.5*	Max WS	46065.21	194.88	218.49		220.06	0.003419	10.07	4576.27	392.6	219.43	219.57	2.06	1.92	215.95	2.54
LOWER	71643.*	Max WS	46065.16	193.65	217.17		218.68	0.003478	9.89	4657.23	401.98	217.92	217.85	2.25	2.32	214.63	2.54
LOWER	71250.5*	Max WS	46065.02	192.43	215.89		217.32	0.003245	9.59	4804.37	411.86	216.43	216.12	2.46	2.77	213.35	2.54
LOWER	70858	Max WS	46064.13	191.2	214.77		216.06	0.002833	9.1	5062.05	421.94	215	214.4	2.77	3.37	212.26	2.51
LOWER	70436.7*	Max WS	46064.16	189.55	213.55		214.86	0.002935	9.17	5020.93	425.42	213.62	213.05	2.93	3.5	211.09	2.46
LOWER	70015.5*	Max WS	46064.11	187.9	212.25		213.6	0.003124	9.32	4942.19	428.53	212.25	211.7	3	3.55	209.86	2.39
LOWER	69594.2*	Max WS	46063.93	186.25	210.82		212.25	0.003463	9.58	4807.11	438.07	210.88	210.4	2.94	3.42	208.52	2.3
LOWER	69173	Max WS	46062.78	184.6	209.15		210.74	0.004181	10.12	4552.56	439.04	209.5	209.1	2.65	3.05	206.93	2.22
LOWER	68685.*	Max WS	46060.67	183.32	208		208.47	0.002443	5.47	8417.04	1758.46	208.1	204.98	2.9	6.02	205.11	2.89
LOWER	68197.*	Max WS	46060.66	182.04	206.16		207.61	0.003275	9.66	4769.46	405.16	206.7	206.6	2.46	2.56	203.31	2.85
LOWER	67709.*	Max WS	46060.48	180.76	204.66		206.06	0.002975	9.51	4843.33	391.66	205.3	205.4	2.36	2.26	201.69	2.97
LOWER	67221.*	Max WS	46059.58	179.48	203.32		204.66	0.002639	9.29	4958.8	379.26	203.9	204.2	2.42	2.12	200.28	3.04
LOWER	66733	Max WS	46059.64	178.2	202.16		203.42	0.002297	9.01	5111.92	367.75	202.5	203	2.66	2.16	199.11	3.05
LOWER	66504	Max WS	46059.65	177.1	200.86	196.08	203.4	0.004826	12.8	3598.06	261.5	205.8	205.8	0	0	197.98	2.88
LOWER	66483		Bridge														
LOWER	66462	Max WS	46059.65	177.1	200.86		203.4	0.004826	12.8	3598.13	261.5	205.8	205.8	0	0	197.98	2.88
LOWER	66233	Max WS	46059.63	177.4	200.13		202.07	0.003649	11.17	4121.98	302	199.8	199.8	3.33	3.33	197.36	2.77
LOWER	65746.7*	Max WS	46059.49	175.55	198.38		200.22	0.003786	10.89	4228.01	338.66	198.4	198.41	2.98	2.97	195.73	2.65
LOWER	65260.5*	Max WS	46058.53	173.7	196.63		198.31	0.003721	10.39	4432.83	372.24	197	197.04	2.63	2.59	194	2.63
LOWER	64774.2*	Max WS	46058.46	171.85	195.05		196.48	0.00326	9.59	4800.95	410.47	195.65	195.67	2.4	2.38	192.35	2.7
LOWER	64288	Max WS	46056.88	170	193.82		194.94	0.002463	8.48	5433.13	451.09	194.3	194.3	2.52	2.52	191.02	2.8
LOWER	63811.7*	Max WS	46056.92	169.25	192.65		193.8	0.002393	8.6	5352.69	436.02	193.21	193.14	2.44	2.51	189.78	2.87
LOWER	63335.5*	Max WS	46056.8	168.5	191.49		192.68	0.002376	8.74	5268.37	421.14	192.12	191.97	2.37	2.52	188.56	2.93
LOWER	62859.2*	Max WS	46056.57	167.75	190.36		191.59	0.002296	8.89	5181.05	406.41	191.04	190.81	2.32	2.55	187.38	2.98
LOWER	62383.*	Max WS	46055.36	167	189.24		190.51	0.002313	9.05	5086.7	391.81	189.95	189.64	2.29	2.6	186.22	3.02
LOWER	61906.7*	Max WS	46055.34	166.25	188.1		189.43	0.002331	9.26	4973.94	377.04	188.86	188.48	2.24	2.62	185.07	3.03
LOWER	61430.5*	Max WS	46055.19	165.5	186.93		188.34	0.002421	9.52	4836.19	362.09	187.78	187.35	2.15	2.58	183.91	3.02
LOWER	60954.2*	Max WS	46054.96	164.75	185.71		187.22	0.002468	9.86	4672.06	346.89	186.69	186.23	2.02	2.48	182.73	2.98
LOWER	60478	Max WS	46053.95	164	184.42		186.06	0.002693	10.3	4470.36	331.16	185.6	185.1	1.82	2.32	181.51	2.91
LOWER	59983.6*	Max WS	46053.89	163.22	183.12		184.7	0.002692	10.09	4564.1	350.43	184.64	184.06	1.48	2.06	180.27	2.85
LOWER	59489.2*	Max WS	46053.68	162.44	181.85		183.35	0.002631	9.84	4682.46	369.83	183.68	183.02	1.17	1.83	179.02	2.83
LOWER	58994.8*	Max WS	46052.36	161.66	180.63		182.03	0.002498	9.51	4839.98	389.6	182.72	181.98	0.91	1.65	177.8	2.83
LOWER	58500.4*	Max WS	46052.28	160.88	179.51		180.8	0.002283	9.11	5056.73	410.05	181.76	180.94	0.75	1.57	176.66	2.85
LOWER	58006	Max WS	46052.02	160.1	178.47		179.63	0.002217	8.64	5330.66	431.05	180.8	179.9	0.67	1.57	175.56	2.91
LOWER	57573.5*	Max WS	46050.53	158.6	177.49		178.68	0.002232	8.79	5239.44	415.29	178.95	178.42	1.54	2.07	174.53	2.96
LOWER	57141.*	Max WS	46050.48	157.1	176.52		177.74	0.002191	8.87	5189.13	399.69	177.1	176.95	2.42	2.57	173.54	2.98
LOWER	56708.5*	Max WS	46050.35	155.6	175.6		176.82	0.002072	8.87	5192.73	383	175.25	175.47	3.35	3.13	172.62	2.98
LOWER	56276	Max WS	46050.13	154.1	174.76		175.96	0.001872	8.76	5257.22	363	173.4	174	4.36	3.76	171.84	2.92
LOWER	55890.*	Max WS	46048.84	151.7	174.01		175.22	0.001955	8.81	5223.95	369.5	172.95	173.15	4.06	3.86	171.13	2.88
LOWER	55504	Max WS	46048.84	149.3	173.25		174.44	0.002027	8.75	5261.72	385	172.5	172.4	3.75	3.85	170.42	2.83
LOWER	55117.7*	Max WS	46048.77	149	172.28		173.65	0.002508	9.4	4896.74	380	171.48	171.65	3.8	3.63	169.49	2.79
LOWER	54731.5*	Max WS	46048.61	148.7	171.21		172.66	0.002768	9.66	4768.61	384	170.45	171	3.76	3.21	168.43	2.78
LOWER	54345.2*	Max WS	46047.16	148.4	170.24		171.58	0.002543	9.31	4945.39	394.67	169.52	170.35	3.72	2.89	167.46	2.78
LOWER	53959	Max WS	46047.19	148.1	169.53		170.62	0.00183	8.39	5489.23	398.46	168.6	169.7	3.93	2.83	166.8	2.73
LOWER	53799	Max WS	46047.18	147.91	169.18	161.83	170.38	0.001786	8.81	5229.02	334	169.9	169.9	2.28	2.28	166.53	2.65
LOWER	53779		Bridge														
LOWER	53759	Max WS	46047.18	147.99	169.01		170.24	0.001845	8.9	5175.36	334	169.9	169.9	2.11	2.11	166.36	2.65
LOWER	53690	Max WS	46047.17	147.6	168.86		170.12	0.002203	8.99	5120.16	385	167.6	168.3	4.26	3.56	166.19	2.67
LOWER	53649	Max WS	46047.17	147.5	168.76		170.02	0.002292	9	5115.06	396	167.5	168.3	4.26	3.46	166.1	2.66
LOWER	53190.*	Max WS	46047.05	146.5	167.53		168.92	0.0028	9.46	4867.01	407.51	166.42	167.15	4.11	3.38	164.96	2.57
LOWER	52731.*	Max WS	46045.37	145.5	166.14		167.62	0.003124	9.75	4720.31	410	165.34	166	3.8	3.14	163.59	2.55
LOWER	52272.*	Max WS	46045.26	144.5	164.65		166.14	0.003282	9.79	4702.91	421.04	164.26	164.9	3.39	2.75	162.07	2.58
LOWER	51813.*	Max WS	46042.74	143.5	163.25		164.63	0.003005	9.42	4885.41	431.96	163.18	163.8	3.07	2.45	160.59	2.66
LOWER	51354	Max WS	46042.52	142.5	162.15		163.29	0.002298	8.58	5368.17	444.08	162.1	162.7	3.05	2.45	159.44	2.71
LOWER	50948.*	Max WS	46039.09	140.88	161.23		162.36	0.00227	8.54	5390.01	446.59	161.25	161.45	2.98	2.78	158.51	2.72
LOWER	50542.*	Max WS	46038.88	139.25	160.33		161.44	0.002208	8.46	5441.37	448.56	160.4	160.2	2.93	3.13	157.61	2.72
LOWER	50136.*	Max WS	46034.3	137.62	159.47		160.55	0.002105	8.33	5528.4	449.81	159.55	158.95	2.92	3.52	156.78	2.69
LOWER	49730	Max WS	46034.04	136	158.68		159.71	0.001967	8.13	5661.26	451.69	158.7	157.7	2.98	3.98	156.03	2.65
LOWER	49233.1*	Max WS	46028.01	135.57	157.84		158.73	0.001779	7.58	6074.87	503.57	157.71	156.93	3.13	3.91	155.21	2.63
LOWER	48736.2*	Max WS	46020.21	135.14	157.08		157.85	0.001563	7.02	6558.34	555.14	156.73	156.16	3.35	3.92	154.44	2.64
LOWER	48239.4*	Max WS	46019.85	134.71	156.43		157.08	0.001327	6.45	7134.32	606.71	155.74	155.39	3.69	4.04	153.77	2.66
LOWER	47742.5*	Max WS	46010.64	134.29	155.9		156.44	0.001087	5.88	7822.96	658.29	154.76	154.61	4.14	4.29	153.19	2.71
LOWER	47245.7*	Max WS	46010.13	133.86	155.48		155.92	0.000862	5.32	8647.76	709.86	153.77	153.84	4.71	4.64	152.73	2.75
LOWER	46748.8*	Max WS	46000.05	133.43	155.17		155.52	0.000667	4.79	9610.39	761.43	152.79	153.07	5.38	5.1	152.37	2.8
LOWER	46252	Max WS	46000.03	133	154.93		155.21	0.000509	4.29	10710.38	813	151.8	152.3	6.13	5.63	152.11	2.82
LOWER	45753.4*	Max WS	45999.66	132.06	154.67		154.95	0.000554	4.25	10817.5	804	151.26	151.76	6.41	5.91	151.84	2.83
LOWER	45254.8*	Max WS	45998.91	131.12	154.38		154.65	0.000628	4.22	10897.05	795	150.72	151.22	6.66	6.16	151.55	2.83
LOWER	44756.2*	Max WS	45991.81	130.18	154.05		154.32	0.000685	4.2	10947	786	150.18	150.68	6.87	6.37	151.22	2.83
LOWER	44257.6*	Max WS	45992.02	129.24	153.69		153.96	0.000777	4.19	10968.95	777.96	149.65	150.14	7.04	6.55	150.87	2.82
LOWER	43759	Max WS	45991.85	128.3	153.28		153.55	0.000857	4.18	10990.97	778	149.2	149.6	7.08	6.68	150.47	2.81
LOWER	43363.7*	Max WS	45991.53	126.03	152.87		153.19	0.001034	4.54	10135.42	711	148.53	149.33	7.34	6.54	150.08	2.79
LOWER	42968.5*	Max WS	45991.05	123.75	152.37		152.75	0.001254	4.96	9279.39	654	147.95	149.05	7.42	6.32	149.61	2.76
LOWER	42573.2*	Max WS	45990.47	121.47	151.73		152.2	0.00165	5.5	8364.81	597	147.38	148.78	7.35	5.95	149.02	2.71
LOWER	42178	Max WS	45987.7	119.2	150.84		151.45	0.002344	6.25	7358.07	540	146.8	148.5	7.04	5.34	148.2	2.64
LOWER	42118	Max WS	45987.71	117.9	150.54		151.32	0.003963	7.13	6453.41	503	146.6	148.3	6.94	5.24	147.92	2.62
LOWER	42088	Max WS	45987.7	117.8	150.42		151.21	0.003977	7.12	6459.83	504	146.5	148.2	6.92	5.22	147.81	2.61
LOWER	41988	Max WS	45987.67	117.8	150.05		150.82	0.003698	7.04	6528.76	530	146.5	148.1	6.55	4.95	147.43	2.62
LOWER	41490.4*	Max WS	45983.29	118.88	148.53		149.14	0.002805	6.28	7325.26	588.7	146.23	145.88	5.3	5.65	145.87	2.66
LOWER	40992.8*	Max WS	45983.06	119.96	147.41		147.88	0.002094	5.5	8363.51	687.39	145.96	145.56	4.45	4.85	144.67	2.74
LOWER	40495.2*	Max WS	45977.45	121.04	146.58		146.94	0.001583	4.81	9552.58	786.09	145.69	145.24	3.89	4.34	143.74	2.84
LOWER	39997.6*	Max WS	45977.23	122.12	145.97		146.24	0.001131	4.21	10916.82	879.2	145.42	144.92	3.55	4.05	143.04	2.93

BUTTE CREEK
BUTTE COUNTY, CALIFORNIA
REQUIRED LEVEE IMPROVEMENTS TO ACHIEVE MINIMUM FREEBOARD

HEC-RAS Plan: Existing River: BUTTE Reach: LOWER Profile: Max WS

HEC-RAS Plan: Fire-no LC River: BUTTE Reach: LOWER Profile: Max WS															Levee Height Increase to Provide 3-ft. freeboard		EXISTING	
Reach	**River Sta**	**Profile**	**Q Total**	**Min Ch El**	**W.S. Elev**	**Crit W.S.**	**E.G. Elev**	**E.G. Slope**	**Vel Chnl**	**Flow Area**	**Top Width**	**LOB Elev**	**ROB Elev**		**LOB**	**ROB**	**WSEL**	**DIFFERENCE**
LOWER	39500	Max WS	45976.46	123.2	145.53		145.74	0.00083	3.68	12483.88	978	145.2	144.6		3.33	3.93	142.54	2.99
LOWER	39073.*	Max WS	45972.11	122.17	145.16		145.37	0.000909	3.72	12366.92	1006.75	144.8	144.8		3.36	3.36	142.11	3.05
LOWER	38646.*	Max WS	45972.31	121.15	144.74		144.96	0.001011	3.76	12227.66	1034.93	144.4	145		3.34	2.74	141.61	3.13
LOWER	38219.*	Max WS	45972.31	120.12	144.28		144.51	0.001135	3.81	12051.94	1061.76	144	145.2		3.28	2.08	140.99	3.29
LOWER	37792	Max WS	45972.2	119.1	143.76		143.99	0.001294	3.89	11825.33	1087.58	143.6	145.4		3.16	1.36	140.17	3.59
LOWER	37681	Max WS	45972.16	114.3	143.32	135.27	144.1	0.001882	7.1	6474.1	922	141.6	140		4.72	6.32	139.57	3.75
LOWER	37672		Bridge															
LOWER	37663	Max WS	48045.38	114.3	141.1		142.8	0.003625	10.44	4602.05	542.71	141.6	140		2.5	4.1	139.56	1.54
LOWER	37615	Max WS	47423.55	113.7	141.3		141.86	0.001466	6.01	7896.57	978.75	141.9	138.6		2.4	5.7	139.84	1.46
LOWER	37605	Max WS	47252	113.6	141.29		141.84	0.001416	5.92	7983.37	982.7	141.8	138.5		2.49	5.79	139.83	1.46
LOWER	37585	Max WS	46908.82	113.3	141.28	136.05	141.78	0.001609	5.69	8251.07	983	141.5	138.2		2.78	6.08	139.83	1.45
LOWER	37572.5		Bridge															
LOWER	37560	Max WS	46908.82	113.3	138.55		139.6	0.004931	8.25	5685.67	901.38	141.5	138.2		0.05	3.35	137.55	1
LOWER	37328	Max WS	45970.97	117.7	138.02		138.45	0.00159	5.23	8792.31	1217.38	137.5	139.4		3.52	1.62	137.22	0.8
LOWER	36875.*	Max WS	45970.94	116.96	137.21		137.65	0.001975	5.35	8589.34	1354.77	137.15	139		3.06	1.21	136.64	0.57
LOWER	36422	Max WS	45968.53	116.23	135.83	133.94	136.44	0.003766	6.28	7314.65	1465.52	136.8	138.6		2.03	0.23	135.69	0.14
LOWER	36420		Inl Struct															
LOWER	35943.7*	Max WS	45968.53	115.5	135.52		135.94	0.002253	5.21	8828.35	1604.03	135.93	137.25		2.59	1.27	134.51	1.01
LOWER	35465.5*	Max WS	45963.58	114.76	134.53		134.9	0.001994	4.88	9415.09	1723.57	135.05	135.9		2.48	1.63	133.42	1.11
LOWER	34987.2*	Max WS	45957.09	114.03	133.73		134.03	0.001581	4.43	10365.83	1843.59	134.18	134.55		2.55	2.18	132.52	1.21
LOWER	34509	Max WS	45948.72	113.3	133.14		133.37	0.001104	3.88	11843.74	1964.94	133.3	133.2		2.84	2.94	131.89	1.25
LOWER	34067.6*	Max WS	45939.16	112.2	132.64		132.87	0.001174	3.86	11891.93	2008.82	133.17	132.5		2.47	3.14	131.38	1.26
LOWER	33626.3*	Max WS	45928.23	111.1	132.12		132.35	0.001201	3.86	11909.16	2052	133.03	131.8		2.09	3.32	130.83	1.29
LOWER	33185	Max WS	45915.74	110	131.57		131.8	0.001303	3.86	11882.28	2094.45	132.9	131.1		1.67	3.47	130.22	1.35
LOWER	32752.7*	Max WS	45901.44	109.7	131.04		131.26	0.001191	3.81	12061.93	2035.75	132.02	130.68		2.02	3.36	129.62	1.42
LOWER	32320.5*	Max WS	45885.86	109.4	130.56		130.77	0.001066	3.73	12315.2	1975.81	131.15	130.25		2.41	3.31	129.06	1.5
LOWER	31888.2*	Max WS	45868.84	109.1	130.14		130.34	0.000936	3.63	12648.11	1915.69	130.27	129.82		2.87	3.32	128.58	1.56
LOWER	31456	Max WS	45851.41	108.8	129.77		129.96	0.000808	3.51	13049.02	1854	129.4	129.4		3.37	3.37	128.17	1.6
LOWER	30995.8*	Max WS	45832.71	107.23	129.4		129.6	0.000773	3.64	12601.65	1757.5	129	128.93		3.4	3.47	127.77	1.63
LOWER	30535.6*	Max WS	45813.72	105.67	129.02		129.24	0.000807	3.78	12132.88	1661	128.6	128.47		3.42	3.55	127.37	1.65
LOWER	30075.5*	Max WS	45813.09	104.1	128.62		128.86	0.000868	3.95	11607.6	1564.5	128.2	128		3.42	3.62	126.95	1.67
LOWER	29615.3*	Max WS	45793.79	102.53	128.18		128.45	0.000958	4.16	11002.35	1468	127.8	127.53		3.38	3.65	126.49	1.69
LOWER	29155.1*	Max WS	45752.83	100.97	127.67		127.98	0.001083	4.44	10300.97	1371.5	127.4	127.07		3.27	3.6	125.96	1.71
LOWER	28695	Max WS	45729.38	99.4	127.08		127.44	0.001292	4.81	9506.45	1275	127	126.6		3.08	3.48	125.33	1.75
LOWER	28661	Max WS	45729.34	99	127.03	122.62	127.4	0.001277	4.85	9426.06	1219.65	126.9	126.7		3.13	3.33	125.29	1.74
LOWER	28651		Bridge															
LOWER	28641	Max WS	45729.34	99	127.03		127.4	0.001195	4.85	9426.06	1219.65	126.9	126.7		3.13	3.33	125.29	1.74
LOWER	28502	Max WS	45729.06	102.8	126.93		127.23	0.000982	4.39	10416.17	1306	126.4	126.5		3.53	3.43	125.17	1.76
LOWER	28063.2*	Max WS	45703.8	103.32	126.54		126.81	0.000881	4.16	10990.22	1380.8	125.96	126.22		3.58	3.32	124.75	1.79
LOWER	27624.4*	Max WS	45677.57	103.84	126.18		126.42	0.000823	3.93	11611.48	1455.6	125.52	125.94		3.66	3.24	124.36	1.82
LOWER	27185.6*	Max WS	45650.91	104.36	125.86		126.07	0.00073	3.72	12275.8	1530.4	125.08	125.66		3.78	3.2	124	1.86
LOWER	26746.8*	Max WS	45624.51	104.88	125.56		125.75	0.000674	3.51	12995.03	1605.2	124.64	125.38		3.92	3.18	123.67	1.89
LOWER	26308	Max WS	45623.97	105.4	125.29		125.46	0.000593	3.31	13763.28	1680	124.2	125.1		4.09	3.19	123.37	1.92
LOWER	25882.4*	Max WS	45599.61	104.92	125.05		125.22	0.00051	3.29	13840.94	1524	123.96	125.02		4.09	3.03	123.13	1.92
LOWER	25456.8*	Max WS	45599.37	104.44	124.83		125	0.000491	3.4	13408.76	1366.93	123.72	124.94		4.11	2.89	122.92	1.91
LOWER	25031.2*	Max WS	45598.2	103.96	124.59		124.8	0.000514	3.67	12428.52	1209.62	123.48	124.86		4.11	2.73	122.7	1.89
LOWER	24605.6*	Max WS	45579.04	103.48	124.29		124.56	0.000673	4.2	10852.82	1053.41	123.24	124.78		4.05	2.51	122.44	1.85
LOWER	24180	Max WS	45559.21	103	123.77		124.21	0.001207	5.31	8580.02	897.4	123	124.7		3.77	2.07	121.99	1.78
LOWER	23694.6*	Max WS	45744.29	102.62	123.27		123.67	0.000962	5.06	9048.73	861.96	122.75	124.12		3.52	2.15	121.35	1.92
LOWER	23209.2*	Max WS	45744.13	102.25	122.88		123.24	0.000784	4.84	9455.71	826.93	122.5	123.55		3.38	2.33	120.89	1.99
LOWER	22723.8*	Max WS	45723.88	101.88	122.54		122.88	0.000664	4.68	9762.86	792.12	122.25	122.97		3.29	2.57	120.52	2.02
LOWER	22238.5*	Max WS	45723.71	101.5	122.25		122.58	0.000587	4.6	9941.91	756.81	122	122.4		3.25	2.85	120.22	2.03
LOWER	21753.1*	Max WS	45722.8	101.12	121.98		122.3	0.000545	4.58	9976.25	721.25	121.75	121.82		3.23	3.16	119.95	2.03
LOWER	21267.7*	Max WS	45704.84	100.75	121.71		122.04	0.000531	4.64	9850.82	685.5	121.5	121.25		3.21	3.46	119.69	2.02
LOWER	20782.3*	Max WS	45704.5	100.38	121.43		121.78	0.000549	4.78	9554.08	649.75	121.25	120.67		3.18	3.76	119.43	
LOWER	20297	Max WS	45686.87	100	121.12		121.51	0.000606	5.03	9078.04	614	121	120.1		3.12	4.02	119.15	1.97
LOWER	19799.*	Max WS	45686.89	99.12	120.8		121.21	0.000595	5.13	8905.79	636.83	119.9	119		3.9	4.8	118.85	1.95
LOWER	19301.*	Max WS	45686.3	98.23	120.47		120.89	0.000669	5.17	8836.98	659.67	118.8	117.9		4.67	5.57	118.53	1.94
LOWER	18803.*	Max WS	45670.48	97.35	120.1		120.51	0.000714	5.16	8849.55	682.5	117.7	116.8		5.4	6.3	118.17	1.93
LOWER	18305.*	Max WS	45669.95	96.47	119.71		120.11	0.000719	5.09	8967.42	705.33	116.6	115.7		6.11	7.01	117.8	1.91
LOWER	17807.*	Max WS	45654.45	95.58	119.33		119.72	0.000683	4.96	9203.35	728.17	115.5	114.6		6.83	7.73	117.44	1.89
LOWER	17309	Max WS	45653.97	94.7	118.97		119.33	0.00064	4.78	9558.77	751	114.4	113.5		7.57	8.47	117.1	1.87
LOWER	16886.8*	Max WS	45639.15	94.57	118.64		119	0.000661	4.8	9506.31	761.5	114.48	113.75		7.16	7.89	116.79	1.85
LOWER	16464.6*	Max WS	45638.98	94.43	118.31		118.67	0.000686	4.83	9451.26	772	114.57	114		6.74	7.31	116.47	1.84
LOWER	16042.5*	Max WS	45624.48	94.3	117.95		118.32	0.000717	4.86	9378.33	782.5	114.65	114.25		6.3	6.7	116.13	1.82
LOWER	15620.3*	Max WS	45624.52	94.17	117.57		117.94	0.000753	4.91	9289.92	793	114.73	114.5		5.84	6.07	115.77	1.8
LOWER	15198.1*	Max WS	45623.92	94.03	117.19		117.57	0.00079	4.96	9205.35	803.5	114.82	114.75		5.37	5.44	115.41	1.78
LOWER	14776	Max WS	45610.54	93.9	116.82		117.21	0.000834	5	9125.34	814	114.9	115		4.92	4.82	115.04	1.78
LOWER	14343.8*	Max WS	45610.09	93.22	116.43		116.82	0.000835	4.99	9149.37	808.4	114.64	114.62		4.79	4.81	114.65	1.78
LOWER	13911.6*	Max WS	45597.06	92.54	116.05		116.44	0.000842	4.97	9179.66	802.8	114.38	114.24		4.67	4.81	114.27	1.78
LOWER	13479.4*	Max WS	45596.84	91.86	115.68		116.06	0.000822	4.95	9218.98	797.2	114.12	113.86		4.56	4.82	113.9	1.78
LOWER	13047.2*	Max WS	45584.27	91.18	115.31		115.68	0.000828	4.92	9267.77	791.6	113.86	113.48		4.45	4.83	113.53	1.78
LOWER	12615	Max WS	45584.33	90.5	114.94		115.31	0.000835	4.89	9319.99	786	113.6	113.1		4.34	4.84	113.16	1.78
LOWER	12554	Max WS	45584.28	89.6	114.5	106.59	115.7	0.002124	8.79	5186.52	654	114.1	114.1		3.4	3.4	112.7	1.8
LOWER	12540		Bridge															
LOWER	12526	Max WS	45584.28	89.6	114.5		115.7	0.002109	8.79	5185.56	654	114.1	114.1		3.4	3.4	112.7	1.8
LOWER	12285	Max WS	45583.93	91	114.48		114.87	0.000913	5.05	9025	791	112.5	112.6		4.98	4.88	112.73	1.75
LOWER	11835.*	Max WS	45571.81	91.17	114.03		114.45	0.000915	5.18	8804.12	778	112.37	112.07		4.66	4.96	112.29	1.74
LOWER	11385.*	Max WS	45571.23	91.33	113.59		114.02	0.000913	5.3	8596.65	765	112.23	111.53		4.36	5.06	111.84	1.75
LOWER	10935	Max WS	45558.95	91.5	113.13		113.58	0.00097	5.43	8384.85	752	112.1	111		4.03	5.13	111.38	1.75
LOWER	10522.5*	Max WS	45558.51	91.38	112.76		113.17	0.000829	5.13	8884.93	774.5	110.97	110.45		4.79	5.31	111.01	1.75
LOWER	10110.*	Max WS	45546.79	91.25	112.45		112.81	0.000692	4.8	9481.18	797	109.85	109.9		5.6	5.55	110.71	1.74
LOWER	9697.5*	Max WS	45546.71	91.12	112.19		112.51	0.000569	4.48	10167.42	819.5	108.72	109.35		6.47	5.84	110.46	1.73
LOWER	9285	Max WS	45546.3	91	111.99		112.26	0.000464	4.16	10948.53	842	107.6	108.8		7.39	6.19	110.27	1.72
LOWER	8817.*	Max WS	45545.49	91	111.72		112.01	0.00052	4.34	10492.85	835.2	107.88	108.96		6.84	5.76	110.02	1.7
LOWER	8349.*	Max WS	45536.39	91	111.41		111.73	0.000586	4.51	10086.6	828.4	108.16	109.12		6.25	5.29	109.74	1.67
LOWER	7881.*	Max WS	45536.38	91	111.08		111.42	0.000652	4.68	9727.02	821.6	108.44	109.28		5.64	4.8	109.42	1.66
LOWER	7413.*	Max WS	45535.99	91	110.71		111.08	0.000713	4.83	9426.41	814.8	108.72	109.44		4.99	4.27	109.08	1.63
LOWER	6945	Max WS	45535.26	91	110.34		110.72	0.00076	4.95	9193.63	808	109	109.6		4.34	3.74	108.73	1.61
LOWER	6478.*	Max WS	45529.3	90.18	109.94		110.35	0.000823	5.13	8873.99	785.2	108.74	109.12		4.2	3.82	108.35	1.59
LOWER	6011.*	Max WS	45529.32	89.36	109.49		109.94	0.000907	5.35	8517.67	762.4	108.48	108.64		4.01	3.85	107.93	1.56
LOWER	5544.*	Max WS	45529.03	88.54	108.99		109.48	0.001024	5.61	8120.21	739.6	108.22	108.16		3.77	3.83	107.46	1.53
LOWER	5077.*	Max WS	45528.46	87.72	108.42		108.96	0.001187	5.93	7679.46	716.8	107.96	107.68		3.46	3.74	106.92	1.5
LOWER	4610	Max WS	45524.75	86.9	107.74		108.37	0.001462	6.35	7171.37	694	107.7	107.2		3.04	3.54	106.28	1.46
LOWER	4563	Max WS	45524.75	83.5	107.49	103.33	108.39	0.002783	7.59	6000.58	685.55	107.8	105.8		2.69	4.69	106.03	1.46
LOWER	4550		Bridge															
LOWER	4537	Max WS	45524.75	83.5	107.49		108.39	0.002783	7.59	6000.57	685.55	107.8	105.8		2.69	4.69	106.03	1.46
LOWER	4418	Max WS	45524.74	88	107.46		107.99	0.001104	5.86	7769.95	690	107.4	106.6		3.06	3.86	105.98	1.48
LOWER	3934.4*	Max WS	45524.57	87.42	106.9		107.41	0.001231	5.73	7941.62	720.6	106.62	106.04		3.28	3.86	105.46	1.44

BUTTE CREEK
BUTTE COUNTY, CALIFORNIA
REQUIRED LEVEE IMPROVEMENTS TO ACHIEVE MINIMUM FREEBOARD

HEC-RAS Plan: Existing River: BUTTE Reach: LOWER Profile: Max WS

HEC-RAS Plan: Fire-no LC River: BUTTE Reach: LOWER Profile: Max WS

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	LOB Elev	ROB Elev	Levee Height Increase to Provide 3-ft. freeboard LOB	Levee Height Increase to Provide 3-ft. freeboard ROB	EXISTING WSEL	DIFFERENCE
LOWER	3450.8*	Max WS	45524.13	86.84	106.28		106.78	0.001261	5.68	8020.65	751.2	105.84	105.48	3.44	3.8	104.89	1.39
LOWER	2967.2*	Max WS	45523.48	86.26	105.64		106.14	0.001351	5.67	8024.43	781.8	105.06	104.92	3.58	3.72	104.28	1.36
LOWER	2483.6*	Max WS	45521.92	85.68	104.92		105.43	0.001549	5.76	7909.8	812.4	104.28	104.36	3.64	3.56	103.59	1.33
LOWER	2000	Max WS	45522.12	85.1	104.08	99.39	104.63	0.001803	5.96	7636.04	843	103.5	103.8	3.58	3.28	102.76	1.32

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PROJECT:	Butte Creek			JOB #:	8230.001
FEATURE:	Hydraulic Analysis	BY:	JPP	DATE:	4/10/04
ITEM:	Analysis of levee improvement alternative for Butte Creek (Highway 99 to Midway Road)				

PURPOSE:

The purpose of this analysis is to determine the extent of levee improvements required along Butte Creek between Highway 99 and Midway Road to establish 3-feet of freeboard.

DATA USED:

FEMA FIS for Butte Creek performed in 1994 by Borcalli & Associates, HEC-2 model filename: "BCC.DAT."

ANALYSIS:

Using the HEC-2 model prepared as part of the Butte Creek FIS as a base, Wood Rodgers prepared a HEC-RAS model with the following modifications:

- The model input was configured to perform an unsteady state analysis using the input hydrographs calculated in the FIS.
- Channel bank stations were modified to reflect the actual top of bank at each cross-section. Levee and ineffective flow definitions were modified accordingly.
- No split flows or levee failure scenarios were analyzed through the study reach.
- The model was run without channel improvements.

ATTACHMENTS:

Table 1, attached (Butte_Creek_levee_improvements.xls)

RESULTS:

The HEC-RAS output table was inserted into a spreadsheet (attached), which was used to calculate the required increase in bank elevation at each station to ensure compliance with the 3-feet of freeboard

design requirement. The section of reach between station 49730 and Midway Road requires the most significant amount of levee improvement (over 4-feet in some sections).

Table 1
Levee Improvements Required - Existing Butte Creek Flows
HEC-RAS Plan: Existing River: BUTTE Reach: LOWER Profile: Max WS

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Top of Bank LOB Elev	Top of Bank ROB Elev	Levee Height Increase to Provide 3-ft. freeboard Existing Conditions LOB	Levee Height Increase to Provide 3-ft. freeboard Existing Conditions ROB
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	(ft)	(ft)		
LOWER	74600	Max WS	29952	209.4	224.66		226	0.0039	9.96	3868.7	773.7	219.8	221.6	7.86	6.06
LOWER	74182.*	Max WS	29944	207.4	223.08		224.3	0.0038	9.18	4570.8	2032.1	220.82	222.25	5.26	3.83
LOWER	73764.*	Max WS	29940	205.4	221.34		222.7	0.0043	9.29	3223.8	3271.5	221.85	222.9	2.49	1.44
LOWER	73346.*	Max WS	29940	203.4	219.81		220.9	0.0036	8.4	3564.5	4451.9	222.88	223.55	0	0
LOWER	72928	Max WS	29939	201.4	218.67		219.5	0.0025	7.31	4097.9	6684.7	223.9	224.2	0	0
LOWER	72695	Max WS	29939	199.8	217.9	212.06	219.1	0.0024	8.69	3443.6	282.46	228.7	228.7	0	0
LOWER	72672		Bridge	**Highway 99**											
LOWER	72649	Max WS	29937	199.8	217.54		218.8	0.0026	8.96	3341.4	280.2	228.7	228.7	0	0
LOWER	72632	Max WS	29937	199.8	217.49		218.8	0.0027	9	3324.8	279.88	228.7	228.7	0	0
LOWER	72630	Max WS	29937	199.8	217.48		218.7	0.0027	9.01	3323	279.84	228.7	228.7	0	0
LOWER	72624	Max WS	29937	199.8	217.46	212.03	218.7	0.0027	9.02	3318.3	279.73	228.7	228.7	0	0
LOWER	72603		Bridge	**Highway 99**											
LOWER	72581	Max WS	29937	199.8	217.07		218.4	0.003	9.33	3209.8	277.3	228.7	228.7	0	0
LOWER	72428	Max WS	29937	196.1	216.71		217.9	0.0028	8.8	3402.3	306.44	221.5	221.3	0	0
LOWER	72035.5*	Max WS	29937	194.88	215.53		216.7	0.0034	8.7	3441.1	365.43	219.43	219.57	0	0
LOWER	71643.*	Max WS	29937	193.65	214.25		215.4	0.0035	8.52	3514.8	382.62	217.92	217.85	0	0
LOWER	71250.5*	Max WS	29935	192.43	213		214.1	0.0032	8.22	3643.1	391.55	216.43	216.12	0	0
LOWER	70858	Max WS	29935	191.2	211.91		212.8	0.0027	7.71	3881.4	401.48	215	214.4	0	0.51
LOWER	70436.7*	Max WS	29934	189.55	210.74		211.7	0.0028	7.76	3856.2	404.61	213.62	213.05	0.12	0.69
LOWER	70015.5*	Max WS	29932	187.9	209.53		210.5	0.0029	7.87	3803.9	407.38	212.25	211.7	0.28	0.83
LOWER	69594.2*	Max WS	29932	186.25	208.19		209.2	0.0033	8.1	3697.4	409.15	210.88	210.4	0.31	0.79
LOWER	69173	Max WS	29932	184.6	206.6		207.8	0.004	8.6	3479.2	408.41	209.5	209.1	0.1	0.5
LOWER	68685.*	Max WS	29929	183.32	204.74		205.9	0.0038	8.49	3523.2	593.53	208.1	204.98	0	2.76
LOWER	68197.*	Max WS	29928	182.04	202.92		204.1	0.0036	8.56	3498.3	381.05	206.7	206.6	0	0
LOWER	67709.*	Max WS	29926	180.76	201.29		202.4	0.0032	8.4	3562.9	368.96	205.3	205.4	0	0
LOWER	67221.*	Max WS	29926	179.48	199.87		200.9	0.0028	8.12	3686.6	358.07	203.9	204.2	0	0
LOWER	66733	Max WS	29926	178.2	198.7		199.6	0.0023	7.73	3872.2	348.24	202.5	203	0	0
LOWER	66504	Max WS	29926	177.1	197.59	192.28	199.4	0.004	10.78	2775.3	230.64	205.8	205.8	0	0
LOWER	66483		Bridge	**Dayton-Durham Highway**											
LOWER	66462	Max WS	29926	177.1	197.59		199.4	0.004	10.78	2775.4	230.64	205.8	205.8	0	0
LOWER	66233	Max WS	29925	177.4	196.98		198.3	0.0031	9.3	3216.4	277.97	199.8	199.8	0.18	0.18
LOWER	65746.7*	Max WS	29924	175.55	195.38		196.7	0.0035	9.2	3251.5	316.03	198.4	198.41	0	0
LOWER	65260.5*	Max WS	29924	173.7	193.66		194.9	0.0037	8.92	3353.1	353.46	197	197.04	0	0

Table 1
Levee Improvements Required - Existing Butte Creek Flows
HEC-RAS Plan: Existing River: BUTTE Reach: LOWER Profile: Max WS

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Top of Bank LOB Elev	Top of Bank ROB Elev	Levee Height Increase to Provide 3-ft. freeboard Existing Conditions LOB	Levee Height Increase to Provide 3-ft. freeboard Existing Conditions ROB
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	(ft)	(ft)		
LOWER	64774.2*	Max WS	29923	171.85	191.99		193.1	0.0034	8.37	3575.4	390.94	195.65	195.67	0	0
LOWER	64288	Max WS	29920	170	190.64		191.5	0.0026	7.42	4033.9	429.85	194.3	194.3	0	0
LOWER	63811.7*	Max WS	29920	169.25	189.39		190.3	0.0026	7.54	3968.8	414.68	193.21	193.14	0	0
LOWER	63335.5*	Max WS	29917	168.5	188.16		189.1	0.0025	7.66	3903.5	399.67	192.12	191.97	0	0
LOWER	62859.2*	Max WS	29916	167.75	186.97		187.9	0.0024	7.79	3841.8	384.82	191.04	190.81	0	0
LOWER	62383.*	Max WS	29916	167	185.81		186.8	0.0024	7.91	3779.8	370.12	189.95	189.64	0	0
LOWER	61906.7*	Max WS	29913	166.25	184.65		185.7	0.0024	8.06	3710.3	355.44	188.86	188.48	0	0
LOWER	61430.5*	Max WS	29913	165.5	183.49		184.6	0.0024	8.25	3627.1	340.72	187.78	187.35	0	0
LOWER	60954.2*	Max WS	29913	164.75	182.32		183.4	0.0024	8.47	3530.2	325.82	186.69	186.23	0	0
LOWER	60478	Max WS	29910	164	181.11		182.3	0.0025	8.77	3410.7	310.74	185.6	185.1	0	0
LOWER	59983.6*	Max WS	29910	163.22	179.88		181	0.0026	8.64	3461.9	329.97	184.64	184.06	0	0
LOWER	59489.2*	Max WS	29909	162.44	178.63		179.8	0.0026	8.48	3527.8	349.25	183.68	183.02	0	0
LOWER	58994.8*	Max WS	29906	161.66	177.42		178.5	0.0025	8.26	3621.8	368.83	182.72	181.98	0	0
LOWER	58500.4*	Max WS	29906	160.88	176.28		177.3	0.0023	7.94	3765.5	389.03	181.76	180.94	0	0
LOWER	58006	Max WS	29905	160.1	175.17		176.1	0.0024	7.58	3945.5	409.59	180.8	179.9	0	0
LOWER	57573.5*	Max WS	29902	158.6	174.13		175.1	0.0024	7.7	3884.2	393.29	178.95	178.42	0	0
LOWER	57141.*	Max WS	29902	157.1	173.13		174.1	0.0023	7.72	3873.2	377.33	177.1	176.95	0	0
LOWER	56708.5*	Max WS	29901	155.6	172.22		173.1	0.002	7.61	3930.1	362.08	175.25	175.47	0	0
LOWER	56276	Max WS	29898	154.1	171.43		172.3	0.0017	7.35	4065.7	347.82	173.4	174	1.03	0.43
LOWER	55890.*	Max WS	29898	151.7	170.74		171.6	0.0018	7.42	4030.5	353.67	172.95	173.15	0.79	0.59
LOWER	55504	Max WS	29898	149.3	170.04		170.9	0.0018	7.36	4064	359.7	172.5	172.4	0.54	0.64
LOWER	55117.7*	Max WS	29898	149	169.11		170.1	0.0025	8.05	3713.8	363.19	171.48	171.65	0.63	0.46
LOWER	54731.5*	Max WS	29897	148.7	168.05		169.1	0.0028	8.36	3577.1	365.44	170.45	171	0.6	0.05
LOWER	54345.2*	Max WS	29895	148.4	167.07		168.1	0.0025	7.99	3741.1	367.92	169.52	170.35	0.55	0
LOWER	53959	Max WS	29895	148.1	166.42		167.2	0.0016	6.97	4290.3	372.4	168.6	169.7	0.82	0
LOWER	53799	Max WS	29895	147.91	166.16	158.66	166.9	0.0015	7.08	4221.8	334	169.9	169.9	0	0
LOWER	53779		Bridge	**Dayton-Durham Highway**											
LOWER	53759	Max WS	29895	147.99	166		166.8	0.0016	7.17	4167.6	334	169.9	169.9	0	0
LOWER	53690	Max WS	29895	147.6	165.83		166.7	0.002	7.52	3973	366.36	167.6	168.3	1.23	0.53
LOWER	53649	Max WS	29895	147.5	165.74		166.6	0.002	7.54	3965.5	367.05	167.5	168.3	1.24	0.44
LOWER	53190.*	Max WS	29894	146.5	164.62		165.6	0.0026	8.03	3723.2	379.34	166.42	167.15	1.2	0.47
LOWER	52731.*	Max WS	29892	145.5	163.25		164.4	0.0031	8.4	3559.8	390.04	165.34	166	0.91	0.25
LOWER	52272.*	Max WS	29892	144.5	161.72		162.9	0.0034	8.54	3499	399.33	164.26	164.9	0.46	0
LOWER	51813.*	Max WS	29888	143.5	160.24		161.3	0.0032	8.26	3617.8	409.16	163.18	163.8	0.06	0
LOWER	51354	Max WS	29888	142.5	159.08		159.9	0.0023	7.4	4038	421.76	162.1	162.7	0	0

Table 1
Levee Improvements Required - Existing Butte Creek Flows
HEC-RAS Plan: Existing River: BUTTE Reach: LOWER Profile: Max WS

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Top of Bank LOB Elev	Top of Bank ROB Elev	Levee Height Increase to Provide 3-ft. freeboard Existing Conditions LOB	Levee Height Increase to Provide 3-ft. freeboard Existing Conditions ROB
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	(ft)	(ft)		
LOWER	50948.*	Max WS	29883	140.88	158.14		159	0.0023	7.37	4052.9	421.18	161.25	161.45	0	0
LOWER	50542.*	Max WS	29882	139.25	157.25		158.1	0.0022	7.28	4103.7	420.7	160.4	160.2	0	0.05
LOWER	50136.*	Max WS	29876	137.62	156.42		157.2	0.002	7.11	4201.7	420.49	159.55	158.95	0	0.47
LOWER	49730	Max WS	29868	136	155.68		156.4	0.0018	6.85	4358	420.73	158.7	157.7	0	0.98
LOWER	49233.1*	Max WS	29857	135.57	154.86		155.5	0.0017	6.46	4623	474.54	157.71	156.93	0.15	0.93
LOWER	48736.2*	Max WS	29856	135.14	154.09		154.7	0.0016	6.05	4937.6	528.68	156.73	156.16	0.36	0.93
LOWER	48239.4*	Max WS	29844	134.71	153.41		153.9	0.0014	5.6	5328.8	583.45	155.74	155.39	0.67	1.02
LOWER	47742.5*	Max WS	29829	134.29	152.82		153.2	0.0012	5.13	5820.2	639.02	154.76	154.61	1.06	1.21
LOWER	47245.7*	Max WS	29814	133.86	152.36		152.7	0.0009	4.63	6439	695.49	153.77	153.84	1.59	1.52
LOWER	46748.8*	Max WS	29798	133.43	152		152.3	0.0007	4.14	7201	752.74	152.79	153.07	2.21	1.93
LOWER	46252	Max WS	29798	133	151.73		151.9	0.0005	3.67	8112.1	810.65	151.8	152.3	2.93	2.43
LOWER	45753.4*	Max WS	29798	132.06	151.46		151.7	0.0006	3.62	8241	802.93	151.26	151.76	3.2	2.7
LOWER	45254.8*	Max WS	29796	131.12	151.17		151.4	0.0006	3.57	8346	794.81	150.72	151.22	3.45	2.95
LOWER	44756.2*	Max WS	29786	130.18	150.84		151	0.0007	3.54	8425.8	786	150.18	150.68	3.66	3.16
LOWER	44257.6*	Max WS	29785	129.24	150.49		150.7	0.0008	3.51	8478.8	777.96	149.65	150.14	3.84	3.35
LOWER	43759	Max WS	29784	128.3	150.09		150.3	0.0008	3.5	8508.8	778	149.2	149.6	3.89	3.49
LOWER	43363.7*	Max WS	29778	126.03	149.71		149.9	0.001	3.78	7885.9	711	148.53	149.33	4.18	3.38
LOWER	42968.5*	Max WS	29778	123.75	149.24		149.5	0.0012	4.12	7234.5	654	147.95	149.05	4.29	3.19
LOWER	42573.2*	Max WS	29778	121.47	148.66		149	0.0016	4.56	6529.6	596.33	147.38	148.78	4.28	2.88
LOWER	42178	Max WS	29778	119.2	147.85		148.3	0.0022	5.19	5742.8	535.35	146.8	148.5	4.05	2.35
LOWER	42118	Max WS	29778	117.9	147.58		148.1	0.0038	5.99	4969.8	490.3	146.6	148.3	3.98	2.28
LOWER	42088	Max WS	29778	117.8	147.46		148	0.0038	5.98	4975.9	491.41	146.5	148.2	3.96	2.26
LOWER	41988	Max WS	29774	117.8	147.09		147.7	0.0037	5.99	4970.5	514.13	146.5	148.1	3.59	1.99
LOWER	41490.4*	Max WS	29774	118.88	145.55		146	0.0028	5.34	5575.3	580.71	146.23	145.88	2.32	2.67
LOWER	40992.8*	Max WS	29769	119.96	144.36		144.7	0.0022	4.74	6281.4	676.33	145.96	145.56	1.4	1.8
LOWER	40495.2*	Max WS	29762	121.04	143.44		143.7	0.0017	4.19	7109.1	773.1	145.69	145.24	0.75	1.2
LOWER	39997.6*	Max WS	29762	122.12	142.75		143	0.0013	3.67	8103.4	868.9	145.42	144.92	0.33	0.83
LOWER	39500	Max WS	29761	123.2	142.26		142.4	0.0009	3.19	9319.7	952.08	145.2	144.6	0.06	0.66
LOWER	39073.*	Max WS	29757	122.17	141.85		142	0.001	3.28	9073.5	979.5	144.8	144.8	0.05	0.05
LOWER	38646.*	Max WS	29757	121.15	141.36		141.5	0.0012	3.39	8769.8	1004.7	144.4	145	0	0
LOWER	38219.*	Max WS	29756	120.12	140.75		141	0.0015	3.56	8369.9	1027.6	144	145.2	0	0
LOWER	37792	Max WS	29756	119.1	139.96		140.2	0.0021	3.82	7785	1049.4	143.6	145.4	0	0
LOWER	37681	Max WS	29756	114.3	139.39	132.91	140.3	0.0017	7.47	3982.5	307.77	141.6	140	0.79	2.39
LOWER	37672		Bridge	**Railroad at Midway**											
LOWER	37663	Max WS	29756	114.3	139.39		140.3	0.0017	7.48	3980.1	307.77	141.6	140	0.79	2.39

Table 1
Levee Improvements Required - Existing Butte Creek Flows
HEC-RAS Plan: Existing River: BUTTE Reach: LOWER Profile: Max WS

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Top of Bank LOB Elev	Top of Bank ROB Elev	Levee Height Increase to Provide 3-ft. freeboard Existing Conditions LOB	Levee Height Increase to Provide 3-ft. freeboard Existing Conditions ROB
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	(ft)	(ft)		
LOWER	37615	Max WS	29756	113.7	139.64		140	0.001	4.71	6323.2	915.52	141.9	138.6	0.74	4.04
LOWER	37605	Max WS	29756	113.6	139.63		140	0.001	4.64	6411.7	917.49	141.8	138.5	0.83	4.13
LOWER	37585	Max WS	29756	113.3	139.63	130.97	139.9	0.0012	4.46	6673.7	923.55	141.5	138.2	1.13	4.43
LOWER	37573		Bridge	**Midway Road**											
LOWER	37560	Max WS	29755	113.3	137.37		138	0.0034	6.39	4656.3	824.75	141.5	138.2	0	2.17
LOWER	37328	Max WS	29755	117.7	137.04		137.3	0.0011	3.92	7598.6	1212.9	137.5	139.4	2.54	0.64
LOWER	36875.*	Max WS	29752	120.15	136.47		136.7	0.0014	4.07	7314.8	1344.8	137.15	139	2.32	0.47
LOWER	36422	Max WS	29752	122.6	135.53		135.9	0.0026	4.72	6308.9	1463	136.8	138.6	1.73	0
LOWER	35943.7*	Max WS	29749	120.28	134.36		134.7	0.0025	4.53	6569.9	1583.9	135.93	137.25	1.43	0.11
LOWER	35465.5*	Max WS	29745	117.95	133.26		133.6	0.0022	4.27	6972.9	1705.3	135.05	135.9	1.21	0.36
LOWER	34987.2*	Max WS	29739	115.62	132.36		132.6	0.0017	3.85	7728.1	1828.3	134.18	134.55	1.18	0.81
LOWER	34509	Max WS	29732	113.3	131.73		131.9	0.0011	3.27	9085.4	1953.1	133.3	133.2	1.43	1.53
LOWER	34067.6*	Max WS	29732	112.2	131.22		131.4	0.0012	3.29	9049.5	1995.1	133.17	132.5	1.05	1.72
LOWER	33626.3*	Max WS	29725	111.1	130.67		130.8	0.0013	3.32	8949.1	2033.3	133.03	131.8	0.64	1.87
LOWER	33185	Max WS	29717	110	130.05		130.2	0.0015	3.4	8729.2	2068.2	132.9	131.1	0.15	1.95
LOWER	32752.7*	Max WS	29709	109.7	129.43		129.6	0.0014	3.37	8812.3	2012.2	132.02	130.68	0.41	1.75
LOWER	32320.5*	Max WS	29699	109.4	128.87		129	0.0013	3.3	8993	1957.9	131.15	130.25	0.72	1.62
LOWER	31888.2*	Max WS	29688	109.1	128.38		128.5	0.0011	3.19	9293	1902.5	130.27	129.82	1.11	1.56
LOWER	31456	Max WS	29677	108.8	127.96		128.1	0.0009	3.06	9709	1843.7	129.4	129.4	1.56	1.56
LOWER	30995.8*	Max WS	29665	107.23	127.56		127.7	0.0008	3.16	9377.2	1747	129	128.93	1.56	1.63
LOWER	30535.6*	Max WS	29654	105.67	127.15		127.3	0.0009	3.28	9038.6	1650.3	128.6	128.47	1.55	1.68
LOWER	30075.5*	Max WS	29653	104.1	126.73		126.9	0.0009	3.43	8648.4	1553.5	128.2	128	1.53	1.73
LOWER	29615.3*	Max WS	29643	102.53	126.26		126.5	0.001	3.62	8190.6	1456.3	127.8	127.53	1.46	1.73
LOWER	29155.1*	Max WS	29632	100.97	125.73		126	0.0012	3.88	7646.1	1358.6	127.4	127.07	1.33	1.66
LOWER	28695	Max WS	29619	99.4	125.09		125.4	0.0015	4.24	6983.8	1260.1	127	126.6	1.09	1.49
LOWER	28661	Max WS	29606	99	125.05	121.66	125.3	0.0013	4.2	7056.2	1175.5	126.9	126.7	1.15	1.35
LOWER	28651		Bridge	**Durnel Road**											
LOWER	28641	Max WS	29606	99	125.05		125.3	0.0012	4.2	7056.2	1175.5	126.9	126.7	1.15	1.35
LOWER	28502	Max WS	29606	102.8	124.93		125.2	0.0011	3.79	7812.8	1296.5	126.4	126.5	1.53	1.43
LOWER	28063.2*	Max WS	29591	103.32	124.5		124.7	0.001	3.62	8178.9	1369.8	125.96	126.22	1.54	1.28
LOWER	27624.4*	Max WS	29576	103.84	124.09		124.3	0.0009	3.45	8579.7	1442.9	125.52	125.94	1.57	1.15
LOWER	27185.6*	Max WS	29575	104.36	123.72		123.9	0.0008	3.28	9014.1	1516.2	125.08	125.66	1.64	1.06
LOWER	26746.8*	Max WS	29560	104.88	123.37		123.5	0.0008	3.11	9501.6	1589.8	124.64	125.38	1.73	0.99
LOWER	26308	Max WS	29547	105.4	123.06		123.2	0.0007	2.94	10039	1663.7	124.2	125.1	1.86	0.96
LOWER	25882.4*	Max WS	29547	104.92	122.8		122.9	0.0005	2.83	10439	1508.1	123.96	125.02	1.84	0.78
LOWER	25456.8*	Max	29546	104.44	122.59		122.7	0.0005	2.85	10365	1352.8	123.72	124.94	1.87	0.65

Table 1
Levee Improvements Required - Existing Butte Creek Flows
HEC-RAS Plan: Existing River: BUTTE Reach: LOWER Profile: Max WS

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Top of Bank LOB Elev	Top of Bank ROB Elev	Levee Height Increase to Provide 3-ft. freeboard Existing Conditions LOB	Levee Height Increase to Provide 3-ft. freeboard Existing Conditions ROB
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	(ft)	(ft)		
		WS													
LOWER	25031.2*	Max WS	29545	103.96	122.37		122.5	0.0005	3.03	9760.8	1197.4	123.48	124.86	1.89	0.51
LOWER	24605.6*	Max WS	29544	103.48	122.11		122.3	0.0006	3.45	8574.8	1036.5	123.24	124.78	1.87	0.33
LOWER	24180	Max WS	29541	103	121.66		122	0.0011	4.41	6692.9	884.09	123	124.7	1.66	0
LOWER	23694.6*	Max WS	34149	102.62	120.99		121.4	0.0012	4.81	7100.4	843.91	122.75	124.12	1.24	0
LOWER	23209.2*	Max WS	34131	102.25	120.52		120.8	0.0009	4.53	7532.5	805.56	122.5	123.55	1.02	0
LOWER	22723.8*	Max WS	34131	101.88	120.15		120.4	0.0007	4.32	7897.1	768.15	122.25	122.97	0.9	0.18
LOWER	22238.5*	Max WS	34113	101.5	119.84		120.1	0.0006	4.18	8152.7	731.37	122	122.4	0.84	0.44
LOWER	21753.1*	Max WS	34113	101.12	119.57		119.8	0.0005	4.12	8275.8	694.94	121.75	121.82	0.82	0.75
LOWER	21267.7*	Max WS	34097	100.75	119.32		119.6	0.0005	4.13	8247	658.84	121.5	121.25	0.82	1.07
LOWER	20782.3*	Max WS	34097	100.38	119.06		119.3	0.0005	4.23	8052.9	622.81	121.25	120.67	0.81	1.39
LOWER	20297	Max WS	34096	100	118.78		119.1	0.0006	4.44	7684.5	586.78	121	120.1	0.78	1.68
LOWER	19799.*	Max WS	34081	99.12	118.49		118.8	0.0006	4.58	7438.9	623.44	119.9	119	1.59	2.49
LOWER	19301.*	Max WS	34081	98.23	118.17		118.5	0.0007	4.65	7321.3	656.74	118.8	117.9	2.37	3.27
LOWER	18803.*	Max WS	34066	97.35	117.82		118.2	0.0007	4.67	7293.9	682.5	117.7	116.8	3.12	4.02
LOWER	18305.*	Max WS	34066	96.47	117.45		117.8	0.0007	4.62	7371	705.33	116.6	115.7	3.85	4.75
LOWER	17807.*	Max WS	34052	95.58	117.09		117.4	0.0007	4.5	7568.1	728.17	115.5	114.6	4.59	5.49
LOWER	17309	Max WS	34051	94.7	116.75		117	0.0007	4.31	7891.6	751	114.4	113.5	5.35	6.25
LOWER	16886.8*	Max WS	34038	94.57	116.45		116.7	0.0007	4.34	7835.2	761.5	114.48	113.75	4.97	5.7
LOWER	16464.6*	Max WS	34038	94.43	116.14		116.4	0.0007	4.38	7774.6	772	114.57	114	4.57	5.14
LOWER	16042.5*	Max WS	34025	94.3	115.8		116.1	0.0007	4.42	7699.1	782.5	114.65	114.25	4.15	4.55
LOWER	15620.3*	Max WS	34025	94.17	115.45		115.8	0.0008	4.47	7610	793	114.73	114.5	3.72	3.95
LOWER	15198.1*	Max WS	34013	94.03	115.09		115.4	0.0008	4.53	7515	803.5	114.82	114.75	3.27	3.34
LOWER	14776	Max WS	34013	93.9	114.71		115	0.0009	4.59	7412.8	812.83	114.9	115	2.81	2.71
LOWER	14343.8*	Max WS	34000	93.22	114.33		114.7	0.0009	4.56	7449	806.93	114.64	114.62	2.69	2.71
LOWER	13911.6*	Max WS	34000	92.54	113.95		114.3	0.0009	4.54	7490.5	800.99	114.38	114.24	2.57	2.71
LOWER	13479.4*	Max WS	33989	91.86	113.57		113.9	0.0009	4.51	7541.6	795	114.12	113.86	2.45	2.71
LOWER	13047.2*	Max WS	33989	91.18	113.2		113.5	0.0009	4.47	7601	788.87	113.86	113.48	2.34	2.72
LOWER	12615	Max WS	33988	90.5	112.83		113.1	0.0009	4.44	7660.9	782.33	113.6	113.1	2.23	2.73
LOWER	12554	Max WS	33977	89.6	112.39	104.49	113.3	0.0018	7.67	4431.8	316	114.1	114.1	1.29	1.29
LOWER	12540		Bridge	**Nelson Road**											
LOWER	12526	Max WS	33977	89.6	112.39		113.3	0.0018	7.67	4430.9	316	114.1	114.1	1.29	1.29
LOWER	12285	Max WS	33977	91	112.41		112.7	0.001	4.6	7392.6	790.03	112.5	112.6	2.91	2.81
LOWER	11835.*	Max WS	33965	91.17	111.97		112.3	0.001	4.72	7199.6	776.29	112.37	112.07	2.6	2.9
LOWER	11385.*	Max WS	33965	91.33	111.52		111.9	0.001	4.84	7017.7	762.67	112.23	111.53	2.29	2.99

Table 1
Levee Improvements Required - Existing Butte Creek Flows
HEC-RAS Plan: Existing River: BUTTE Reach: LOWER Profile: Max WS

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Top of Bank LOB Elev	Top of Bank ROB Elev	Levee Height Increase to Provide 3-ft. freeboard Existing Conditions LOB	Levee Height Increase to Provide 3-ft. freeboard Existing Conditions ROB
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	(ft)	(ft)		
LOWER	10935	Max WS	33952	91.5	111.05		111.4	0.0011	4.97	6827.8	748.73	112.1	111	1.95	3.05
LOWER	10522.5*	Max WS	33952	91.38	110.68		111	0.0009	4.67	7276.4	773.6	110.97	110.45	2.71	3.23
LOWER	10110.*	Max WS	33940	91.25	110.38		110.7	0.0007	4.33	7829.6	797	109.85	109.9	3.53	3.48
LOWER	9697.5*	Max WS	33939	91.12	110.14		110.4	0.0006	4	8480.7	819.5	108.72	109.35	4.42	3.79
LOWER	9285	Max WS	33939	91	109.95		110.2	0.0005	3.68	9230.3	842	107.6	108.8	5.35	4.15
LOWER	8817.*	Max WS	33928	91	109.7		109.9	0.0005	3.85	8808.7	835.2	107.88	108.96	4.82	3.74
LOWER	8349.*	Max WS	33928	91	109.42		109.7	0.0006	4.02	8437.9	828.4	108.16	109.12	4.26	3.3
LOWER	7881.*	Max WS	33928	91	109.11		109.4	0.0007	4.18	8115	820.33	108.44	109.28	3.67	2.83
LOWER	7413.*	Max WS	33920	91	108.78		109.1	0.0007	4.32	7850.5	809.75	108.72	109.44	3.06	2.34
LOWER	6945	Max WS	33920	91	108.42		108.7	0.0008	4.43	7650.3	798.44	109	109.6	2.42	1.82
LOWER	6478.*	Max WS	33920	90.18	108.04		108.4	0.0008	4.59	7391.7	775.14	108.74	109.12	2.3	1.92
LOWER	6011.*	Max WS	33919	89.36	107.63		108	0.0009	4.77	7103.6	751.05	108.48	108.64	2.15	1.99
LOWER	5544.*	Max WS	33914	88.54	107.17		107.6	0.001	5	6781.2	725.51	108.22	108.16	1.95	2.01
LOWER	5077.*	Max WS	33914	87.72	106.64		107.1	0.0011	5.29	6416.5	697.65	107.96	107.68	1.68	1.96
LOWER	4610	Max WS	33914	86.9	106		106.5	0.0014	5.67	5984.9	670.7	107.7	107.2	1.3	1.8
LOWER	4563	Max WS	33913	83.5	105.75	102.09	106.5	0.003	7.02	4831.8	654.36	107.8	105.8	0.95	2.95
LOWER	4550		Bridge	**(Aquas Frias Road)**											
LOWER	4537	Max WS	33913	83.5	105.75		106.5	0.003	7.02	4831.8	654.36	107.8	105.8	0.95	2.95
LOWER	4418	Max WS	33910	88	105.7		106.1	0.001	5.16	6574.4	666.98	107.4	106.6	1.3	2.1
LOWER	3934.4*	Max WS	33910	87.42	105.19		105.6	0.0012	5.05	6713.8	709.05	106.62	106.04	1.57	2.15
LOWER	3450.8*	Max WS	33910	86.84	104.62		105	0.0012	5.01	6775.1	741.89	105.84	105.48	1.78	2.14
LOWER	2967.2*	Max WS	33909	86.26	104.02		104.4	0.0013	5.01	6762.1	773.59	105.06	104.92	1.96	2.1
LOWER	2483.6*	Max WS	33908	85.68	103.33		103.7	0.0015	5.12	6625.1	804.47	104.28	104.36	2.05	1.97
LOWER	2000	Max WS	33907	85.1	102.5	98.56	103	0.0018	5.37	6313.6	834.34	103.5	103.8	2	1.7

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PROJECT:	Butte Creek			JOB #:	8230.001
FEATURE:	Hydraulic Analysis	BY:	JPP	DATE:	4/10/04
ITEM:	Analysis of levee improvement alternative for Butte Creek (Midway Road to County Line)				

PURPOSE:

The purpose of this analysis is to determine the extent of levee improvements required along Butte Creek between Midway Road and the County line to establish 3-feet of freeboard.

DATA USED:

FEMA FIS for Butte Creek performed in 1994 by Borcalli & Associates, HEC-2 model filename: "BCC.DAT."

ANALYSIS:

Using the HEC-2 model prepared as part of the Butte Creek FIS as a base, Wood Rodgers prepared a HEC-RAS model with the following modifications:

- The model input was configured to perform an unsteady state analysis using the input hydrographs calculated in the FIS.
- Channel bank stations were modified to reflect the actual top of bank at each cross-section. Levee and ineffective flow definitions were modified accordingly.
- No split flows or levee failure scenarios were analyzed through the study reach.

RESULTS:

The model was run without channel improvements. The HEC-RAS output table (below) was used to calculate the required increase in bank elevation at each station to ensure compliance with the 3-feet of freeboard design requirement. Almost the entire reach requires some improvement in order to meet the freeboard requirement. In addition to this, levee certification would be required to meet FEMA's criteria for levees.

Additionally, a series of steady state runs were performed with a series of flow rates. The existing capacity of Butte Creek downstream of Midway Road with 3-feet of freeboard at all locations is approximately 8,500 cfs. The existing capacity of Butte Creek downstream of Midway Road flowing

full with no freeboard is approximately 18,400 cfs. The channel cross-section with the least capacity is Station 17309, which is located between Durnell Road and Nelson Road.

River Sta	Q Total	W.S. Elev	LOB Elev	ROB Elev	Levee Height Increase to Provide 3-ft. freeboard	
					LOB	ROB
37672	Bridge					
37663	29755.66	139.39	141.6	140	0.79	2.39
37615	29755.61	139.64	141.9	138.6	0.74	4.04
37605	29755.6	139.63	141.8	138.5	0.83	4.13
37585	29755.57	139.63	141.5	138.2	1.13	4.43
37572.5	Bridge					
37560	29754.95	137.37	141.5	138.2	0	2.17
37328	29754.73	137.04	137.5	139.4	2.54	0.64
36875.*	29751.86	136.47	137.15	139	2.32	0.47
36422	29751.84	135.53	136.8	138.6	1.73	0
35943.7*	29748.9	134.36	135.93	137.25	1.43	0.11
35465.5*	29744.7	133.26	135.05	135.9	1.21	0.36
34987.2*	29739.04	132.36	134.18	134.55	1.18	0.81
34509	29732.43	131.73	133.3	133.2	1.43	1.53
34067.6*	29731.94	131.22	133.17	132.5	1.05	1.72
33626.3*	29725.18	130.67	133.03	131.8	0.64	1.87
33185	29717.45	130.05	132.9	131.1	0.15	1.95
32752.7*	29708.6	129.43	132.02	130.68	0.41	1.75
32320.5*	29698.67	128.87	131.15	130.25	0.72	1.62
31888.2*	29687.81	128.38	130.27	129.82	1.11	1.56
31456	29676.56	127.96	129.4	129.4	1.56	1.56
30995.8*	29665.24	127.56	129	128.93	1.56	1.63
30535.6*	29653.97	127.15	128.6	128.47	1.55	1.68
30075.5*	29653.38	126.73	128.2	128	1.53	1.73
29615.3*	29642.83	126.26	127.8	127.53	1.46	1.73
29155.1*	29631.73	125.73	127.4	127.07	1.33	1.66
28695	29619.39	125.09	127	126.6	1.09	1.49
28661	29606	125.05	126.9	126.7	1.15	1.35
28651	Bridge					
28641	29606	125.05	126.9	126.7	1.15	1.35
28502	29606.08	124.93	126.4	126.5	1.53	1.43
28063.2*	29591.26	124.5	125.96	126.22	1.54	1.28
27624.4*	29575.76	124.09	125.52	125.94	1.57	1.15
27185.6*	29575.03	123.72	125.08	125.66	1.64	1.06
26746.8*	29560.4	123.37	124.64	125.38	1.73	0.99
26308	29546.78	123.06	124.2	125.1	1.86	0.96
25882.4*	29546.91	122.8	123.96	125.02	1.84	0.78
25456.8*	29546.25	122.59	123.72	124.94	1.87	0.65
25031.2*	29545.16	122.37	123.48	124.86	1.89	0.51
24605.6*	29543.79	122.11	123.24	124.78	1.87	0.33

24180	29540.51	121.66	123	124.7	1.66	0
23694.6*	34149.24	120.99	122.75	124.12	1.24	0
23209.2*	34131.27	120.52	122.5	123.55	1.02	0
22723.8*	34130.79	120.15	122.25	122.97	0.9	0.18
22238.5*	34113.38	119.84	122	122.4	0.84	0.44
21753.1*	34112.92	119.57	121.75	121.82	0.82	0.75
					Levee Height Increase to Provide 3-ft. freeboard	
River Sta	**Q Total**	**W.S. Elev**	**LOB Elev**	**ROB Elev**	**LOB**	**ROB**
21267.7*	34096.54	119.32	121.5	121.25	0.82	1.07
20782.3*	34096.51	119.06	121.25	120.67	0.81	1.39
20297	34095.85	118.78	121	120.1	0.78	1.68
19799.*	34081.1	118.49	119.9	119	1.59	2.49
19301.*	34080.64	118.17	118.8	117.9	2.37	3.27
18803.*	34066.24	117.82	117.7	116.8	3.12	4.02
18305.*	34065.76	117.45	116.6	115.7	3.85	4.75
17807.*	34051.8	117.09	115.5	114.6	4.59	5.49
17309	34051.3	116.75	114.4	113.5	5.35	6.25
16886.8*	34038.11	116.45	114.48	113.75	4.97	5.7
16464.6*	34037.9	116.14	114.57	114	4.57	5.14
16042.5*	34025.15	115.8	114.65	114.25	4.15	4.55
15620.3*	34025.11	115.45	114.73	114.5	3.72	3.95
15198.1*	34012.65	115.09	114.82	114.75	3.27	3.34
14776	34012.66	114.71	114.9	115	2.81	2.71
14343.8*	34000.42	114.33	114.64	114.62	2.69	2.71
13911.6*	34000.44	113.95	114.38	114.24	2.57	2.71
13479.4*	33988.51	113.57	114.12	113.86	2.45	2.71
13047.2*	33988.59	113.2	113.86	113.48	2.34	2.72
12615	33987.96	112.83	113.6	113.1	2.23	2.73
12554	33977.13	112.39	114.1	114.1	1.29	1.29
12540	Bridge					
12526	33977.13	112.39	114.1	114.1	1.29	1.29
12285	33977.03	112.41	112.5	112.6	2.91	2.81
11835.*	33964.85	111.97	112.37	112.07	2.6	2.9
11385.*	33964.68	111.52	112.23	111.53	2.29	2.99
10935	33952.43	111.05	112.1	111	1.95	3.05
10522.5*	33951.97	110.68	110.97	110.45	2.71	3.23
10110.*	33939.71	110.38	109.85	109.9	3.53	3.48
9697.5*	33939.45	110.14	108.72	109.35	4.42	3.79
9285	33938.76	109.95	107.6	108.8	5.35	4.15
8817.*	33928.43	109.7	107.88	108.96	4.82	3.74
8349.*	33928.4	109.42	108.16	109.12	4.26	3.3
7881.*	33927.88	109.11	108.44	109.28	3.67	2.83
7413.*	33919.94	108.78	108.72	109.44	3.06	2.34
6945	33920.07	108.42	109	109.6	2.42	1.82
6478.*	33919.75	108.04	108.74	109.12	2.3	1.92

6011.*	33919.05	107.63	108.48	108.64	2.15	1.99
5544.*	33914.14	107.17	108.22	108.16	1.95	2.01
5077.*	33914.06	106.64	107.96	107.68	1.68	1.96
4610	33913.57	106	107.7	107.2	1.3	1.8
4563	33913.49	105.75	107.8	105.8	0.95	2.95
4550	Bridge					
4537	33913.49	105.75	107.8	105.8	0.95	2.95
4418	33909.54	105.7	107.4	106.6	1.3	2.1
3934.4*	33909.68	105.19	106.62	106.04	1.57	2.15

					Levee Height Increase to Provide 3-ft. freeboard	
River Sta	**Q Total**	**W.S. Elev**	**LOB Elev**	**ROB Elev**	**LOB**	**ROB**
3450.8*	33909.5	104.62	105.84	105.48	1.78	2.14
2967.2*	33908.99	104.02	105.06	104.92	1.96	2.1
2483.6*	33908.18	103.33	104.28	104.36	2.05	1.97
2000	33907.32	102.5	103.5	103.8	2	1.7

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PROJECT:	Butte Creek			JOB #:	8230.001
FEATURE:	HEC-RAS Modeling	BY:	JPP	DATE:	5/04/04
ITEM:	Evaluation of Lower Butte Creek Channel Widening Alternative.				

PURPOSE:

The purpose of this analysis is to evaluate the suitability of channel widening as an improvement alternative in lower Butte Creek.

DATA USED:

FEMA FIS for Butte Creek performed in 1994 by Borcalli & Associates, HEC-2 model filename: "BCC.DAT."

ANALYSIS:

HEC-RAS modeling prepared by Wood Rodgers' San Francisco office was used as the basis for evaluating the capacity of Lower Butte Creek. The HEC-RAS model was adapted from HEC-2 modeling performed by Borcalli & Associates as part of the Butte Creek FIS performed in 1994. The design capacity of the creek is defined as the maximum flow that can be conveyed while maintaining a minimum freeboard of 3-feet. This freeboard requirement ensures compliance with FEMA's guidelines for levees along channel banks.

RESULTS:

Using the existing conditions HEC-RAS model output, two modified geometries were prepared using the Channel Modification option in HEC-RAS to develop widened channels in increments of 20-feet and 30-feet. Both improvement configurations provided water surface improvements in the magnitude of a few hundredths of a foot.

In order to more efficiently arrive at an estimate that would reflect the magnitude of channel widening required to pass the 100-year flow through lower Butte Creek, Wood Rodgers opted to compare the existing cross-sectional flow area at several cross-sections with the cross-sectional flow area remaining in the existing cross-sections when lowering water surfaces to comply with the 3-foot freeboard requirement. The results are summarized in Table 1:

TABLE 1

Station	100-year cross-sectional flow area ($ft.^2$)	Existing cross-sectional area with 3-feet of freeboard ($ft.^2$)	% of Channel Area Requiring Excavation	Excavated Area ($ft.^2$)	Length ($ft.^2$)	Volume (cy)
37585	6673.65	2961.36	55.6%	3712.3		
					4403	443969
41988	4970.52	3237.78	34.9%	1732.7		
					1771	153987
43759	8508.75	5546.2	34.8%	2962.55		
					2493	244849
46252	8112.07	5771.03	28.9%	2341.04		
					7397	382271
53649	3965.52	3515.88	11.3%	449.64		
					Total Volume	**1.23 million cy**

Maximum depths through lower Butter Creek average approximately 20 feet during the 100-year storm. In order to obtain 3-feet of freeboard, many sections of the channel would need to be widened 100-150 feet. The large cross-sectional areas required to obtain 3-feet of freeboard are a reflection of the channel width (which varies between 500 and 1000 feet). Given the excavated volume requirements for this alternative, levee improvements may represent the preferred alternative.

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PROJECT:	Butte Creek			JOB #:	8230.001
FEATURE:	Analysis of Fire Hazard Impact on Flooding	BY:	JPP	DATE:	6/3/04
ITEM:	SCS Curve Number Adjustments				

PURPOSE:

The purpose of this analysis is to evaluate the hydrologic impacts of a large wildfire event occurring in Butte County preceding a 100-year storm.

DATA USED:

- FEMA FIS for Butte Creek performed in 1994 by Borcalli & Associates, HEC-1 model filename: "ALL100.DAT."
- "Urban Hydrology For Small Watersheds, TR-55," USDA NRCS, June 1986.

ASSUMPTIONS:

For purposes of this analysis, only areas within 2400 meters of extreme threats were considered to be damaged. Although there is no documentation in TR-55 regarding CN adjustments for areas affected by wildfire disasters, Wood Rodgers assumed that in general, fire damage from a large event would effectively remove all of the vegetation in the damaged area. Areas within the damage zone were revised to reflect the following CN values based on Table 2-2a from TR-55:

	CN for Hydrologic Soil Groups			
	A	B	C	D
Newly graded areas (pervious areas only, no vegetation)	77	86	91	94

ANALYSIS:

Runoff loss coefficients calculated in the Butte County FIS study were based on the methodology detailed in the Natural Resources Conservation Service (NRCS) document, TR-55 "Urban Hydrology for Small Watersheds." Using the NRCS methodology in conjunction with soil mapping and land use information, a runoff coefficient number (CN) was calculated for each drainage basin. For purposes of this analysis, these base values were modified in order to evaluate the impacts to runoff that would result from a large wildfire event occurring in Butte County prior to a large storm event.

The California State Wildland Fire Threat Category Map was consulted to estimate areas that would be damaged in a large wildfire event. This document was considered the best source for approximating the extent of damage during a worst-case wildfire event. For purposes of this analysis, only areas within 2400 meters of extreme threats were considered to be damaged. Although there is no documentation in TR-55 regarding CN adjustments for areas affected by wildfire disasters, Wood Rodgers assumed that in general, fire damage from a large event would effectively remove all of the vegetation in the damaged area.

The revised CN values for sheds within the study area are summarized in Table 1 (below). These values were used to modify existing conditions HEC-1 models for Little Chico Creek (original filename: CH15100.DAT) as well as the overall system (original filename: ALL100.DAT).

TABLE 1
ADJUSTED SCS CURVE NUMBERS FOR POST-WILDFIRE HAZARD CONDITIONS IN BUTTE COUNTY

Shed	No.	Total Area ($miles^2$)	Total Area (ac.)	Burned Area (ac.)	% Soil Type A	% Soil Type B	% Soil Type C	% Soil Type D	Existing CN	Revised CN
Butte	1	30.12	19276.8	0	0%	100%	0%	0%	41	41
	2	12.13	7763.2	6554.4	0%	100%	0%	0%	47	80
	3	23.85	15264	0	0%	48%	52%	0%	44	44
	4	17.4	11136	0	0%	86%	14%	0%	40	40
	5	11.43	7315.2	0	0%	14%	86%	0%	48	48
	6	23.43	14995.2	14104.9	0%	37%	3%	60%	58	89
	7	29.28	18739.2	11601	0%	48%	22%	31%	54	76
	8	0.56	358.4	358.4	0%	0%	0%	100%	71	94
	9	3.19	2041.6	1887.8	37%	0%	0%	63%	89	89
	10	0.102	65.28	0	33%	0%	0%	67%	89	89
Little Chico	1	2.8	1792	1323.1	0%	0%	0%	100%	40	80
	2	3.8	2432	2432	0%	75%	0%	26%	46	88
	3	3.4	2176	2176	0%	57%	0%	43%	54	89
	4	3.7	2368	2368	0%	19%	0%	81%	65	93
	5	4.1	2624	2624	0%	0%	0%	100%	71	94
	6	3.7	2368	2368	0%	0%	0%	100%	71	94
	7	3.9	2496	2496	0%	0%	0%	100%	71	94
	8r	2.59	1657.6	1657.6	0%	2%	2%	97%	89	94
	9u	0.409	261.76	261.76	0%	14%	14%	73%	89	93
	9d	0.602	385.28	40.4	0%	14%	14%	73%	88	89
	9p	0.071	45.44	45.44	0%	14%	14%	73%	100	100
	9b	0.469	300.16	300.16	0%	14%	14%	73%	86	93
	Dhsb	1.06	678.4	678.4	0%	14%	14%	73%	89	93
	10	0.88	563.2	563.2	0%	8%	8%	84%	78	93
	11r	1.05	672	0	0%	58%	42%	0%	75	75
	12	2.25	1440	0	0%	53%	47%	0%	82	82
	13	0.73	467.2	0	0%	56%	44%	0%	64	64
	14	1.34	857.6	0	0%	49%	49%	2%	66	66

	15	1.19	761.6	0	0%	32%	52%	16%	76	76
Diversion	1	1.703	1.703	1.703	0%	0%	0%	100%	71	94
	2	4.778	1.703	1.703	0%	0%	0%	100%	71	94

TABLE 1
ADJUSTED SCS CURVE NUMBERS FOR POST-WILDFIRE HAZARD CONDITIONS IN BUTTE COUNTY (CONT.)

Shed	No.	Total Area (miles^2)	Total Area (ac.)	Burned Area (ac.)	% Soil Type A	% Soil Type B	% Soil Type C	% Soil Type D	Existing CN	Revised CN
Comanche	1	**Existing Comanche flows will be used. The drainage area contributing to Comanche Creek is outside of the areas designated as hazardous. As such, no adjustment to CN for the Comanche Creek drainage sheds is necessary.**								
	2									
	3									
	4									
Hamlin	1	4.56	2918.4	1069.3	0%	0%	0%	100%	80	85
	2	6.35	4064	0	0%	13%	48%	39%	71	71
	3	9.3	5952	3824.4	0%	4%	1%	95%	60	81
	4	10.16	6502.4	2186.5	0%	22%	0%	78%	61	71
	5	3.48	2227.2	0	0%	0%	0%	100%	79	79
	6	3.9	2496	0	0%	1%	5%	94%	80	80

Using the existing conditions HEC-1 model (filename: "ALL100.DAT") as a base, a HEC-1 model (filename: "ALLFIRE.DAT") was prepared using the modified CN values in Table 1. This model was prepared to evaluate the hydrologic impacts to the 100-year event should a large wildfire strike Butte County in the summer months preceding the storm.

RESULTS:

A comparison between HEC-1 results for the 100-year storm between existing conditions and the post-wildfire condition is presented in Table 2 (below). The results presented in Table 2 indicate that although the range of flow increases for individual sheds range from 12% to 417%, the overall increase to the flows in Butte Creek is approximately 57%.

TABLE 2
COMPARISON BETWEEN EXISTING CONDITIONS AND POST-WILDFIRE CONDITIONS 100-YEAR STORM RUNOFF

	EXISTING CONDITIONS	**FIRE RESULTS**	
NODE	**PEAK DISCHARGE**	**PEAK DISCHARGE**	**Increase to Peak Flow**

	(cfs)	(cfs)	(cfs)	%
B1	6139	6139	0	0%
BATOBB	6068	6052	-16	0%
B2	2840	8690.2	5850.2	206%
BB	8736	13314	4578	52%
BBTOBC	8657	13199	4542	52%
B3	6073	6073	0	0%
BC	13633	18503	4870	36%
BCTOBD	13602	18413	4811	35%
B4	2681	2681	0	0%
B5	4272	4272	0	0%
BD	18787	23836	5049	27%
BDTOBE	18672	23653	4981	27%
B6	5259	12479	7220	137%
B7	5405	11869	6464	120%
BE	27227	39596	12369	45%
BETOBF	27187	39580	12393	46%
B8	191	346	155	81%
BF	27264	39686	12422	46%
BFTOBG	27176	39611	12435	46%
B9	1191	1191	0	0%
BG	27654	40130	12476	45%
BGTOBH	27649	40117	12468	45%
B10	43	43	0	0%
BH	27661	40106	12445	45%
LC1	414	2141	1727	417%
LCATOLCB	410	2101	1691	412%
LC2	778	3034	2256	290%
LCB	1152	5004	3852	334%
LCBTOLCC	1149	4964	3815	332%
LC3	793	2322	1529	193%
LCC	1882	7190	5308	282%
LCCTOLCD	1874	7131	5257	281%
LC4	1202	2485	1283	107%
LCD	2780	9059	6279	226%
LCDTOLCE	2774	9007	6233	225%
LC5	1624	2830	1206	74%
LCE	3745	10619	6874	184%
LCETOLCF	3741	10607	6866	184%
LC6	1097	2091	994	91%
LCF	4515	11889	7374	163%
LCFTOLCG	4494	11814	7320	163%
LC7	802	1714	912	114%
LCG	5098	12878	7780	153%
DIVERT	1985	3024	1039	52%
LCGTOUCA	3103	9814.1	6711.1	216%
UC1	341	341	0	0%
UCA	3316	10027	6711	202%

UCATOBH	3298	9977	6679	203%
UC2	965	965	0	0%
BHTOBI	30103	47325	17222	57%
HS1	1247	1483	236	19%

TABLE 2
COMPARISON BETWEEN EXISTING CONDITIONS AND POST-WILDFIRE CONDITIONS 100-YEAR STORM RUNOFF (CONT.)

NODE	EXISTING CONDITIONS PEAK DISCHARGE (cfs)	FIRE RESULTS PEAK DISCHARGE (cfs)	Increase to Peak Flow	
			(cfs)	%
HSATOHSC	1139	1355	216	19%
HS2	583	583	0	0%
HSC	1621	1823	202	12%
HS3	1654	3754	2100	127%
HS4	2098	3156	1058	50%
HSB	3737	6831	3094	83%
HSBTOHSC	3684	6725	3041	83%
HS5	803	803	0	0%
HSCTOHSD	5670	8690	3020	53%
HS6	526	526	0	0%
HSD	6183	9170	2987	48%
HSDTOBI	6034	8875	2841	47%
HS7	345	345	0	0%
BI	6292	9150	2858	45%
BITOBJ	34745	54607	19862	57%
Outlet	**34745**	**54607**	**19862**	**57%**

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PROJECT:	Butte Creek			JOB #:	8230.001
FEATURE:	Hydraulic Analysis	BY:	JPP	DATE:	6/8/04
ITEM:	Analysis of improvements required if LCB Diversion flow is increased				

PURPOSE:

The purpose of this analysis is to determine the extent of improvements required along the Little Chico-Butte Creek Diversion Channel should the required diversion capacity be increased.

DATA AVAILABLE:

FEMA FIS for Butte Creek, performed in 1994 by Borcalli & Associates, HEC-2 model filenames: "2DCCC04.DAT", "2DCCR01.DAT", "2DCCR02.DAT."

ASSUMPTIONS:

- Since the FIS was performed, the vegetation at several locations along the Diversion has increased. For this analysis, Wood Rodgers assumed that a vegetation clearing and maintenance program would be in-place to reduce the channel roughness coefficients back to what is reflected in the FIS.

ANALYSIS:

Using the HEC-2 model prepared as part of the Butte Creek FIS as a base, Wood Rodgers prepared a HEC-RAS model with the following modifications:

- The model input was configured to perform an unsteady state analysis using the input hydrographs calculated by modifying the diversion rating curve in HEC-1 to divert all but 100 cfs out of Little Chico Creek.
- Channel bank stations were modified to reflect the actual top of bank at each cross-section. Levee and ineffective flow definitions were modified accordingly.
- No split flows or levee failure scenarios were analyzed through the study reach.

ATTACHMENTS:

RESULTS:

The Diversion is approximately 3 miles long and has intermittent levees along the right bank. In order to evaluate levee improvements as an alternative, Wood Rodgers considered that in addition to levee certification, a minimum of 3-feet of freeboard would be required along the levees in order to ensure compliance with FEMA guidelines. In order to evaluate the required levee improvements, the model was run without channel or crossing improvements. The HEC-RAS output table was used to calculate the required increase in bank elevation at each station to ensure compliance with the 3-feet of freeboard design requirement. Levees would have to be raised between 0.43 and 3.04 feet in some sections to comply with FEMA's freeboard requirements. Cross-sections that require levee improvements are summarized below:

River Station	W.S. Elevation (ft)	ROB Elevation (ft)	Right Levee Freeboard (ft)	Required Levee Elevation Increase (ft)
16142	278.08	279.4	1.32	1.68
15987.*	277.1	277.73	0.63	2.37
15832	276.14	276.1	-0.04	3.04
15741	274.98	276.1	1.12	1.88
15736	275	275.7	0.7	2.3
15208	269.58	271.5	1.92	1.08
14942.5*	269.42	269.69	0.27	2.73
5390	229.53	232.1	2.57	0.43
5050	229.38	230.9	1.52	1.48

*Interpolated Cross-Section

An additional check was performed to ensure that FEMA's requirement of a minimum of 1-foot of freeboard would be met in unleveed open channel sections. In all cases of unleveed sections, this requirement can be met without additional improvements.

As an alternative to the levee improvement scenario described above, several channel improvements were considered in order to reduce water surfaces in the Diversion to meet the 3-foot freeboard requirement. Although the levees would still require certification, the following alternatives could be implemented to ensure freeboard conformance without raising the levees along the diversion:

- Stations 5050 and 5390 are upstream of an unnamed culvert crossing which consists of two 18-inch CMP's. During the 100-year event this structure is overtopped. The purpose of this structure should be determined in order to evaluate whether it can be removed or replaced with some other crossing structure (i.e., steel footbridge). Widening the channel at this location by 60-feet and adding two additional 18-inch CMP's lowers the water surface at Station 5050 by approximately 1-foot. To meet the freeboard requirement at this location, in addition to the 60-foot widening and addition of two culverts, an additional 174 square feet of conveyance area would be still be required. This would be the equivalent of 10 additional culverts of the same size, or a significant increase in channel widening. It may prove more effective to simply replace the structure in kind with a more hydraulically efficient crossing structure.

- Between Stations 14677 and 15208, water surfaces can be lowered to achieve 3-feet of freeboard by widening the channel by 20 feet.

- Between Stations 15708 to 16506.6, water surfaces can be lowered to achieve 3-feet of freeboard by widening the channel by 20 feet. This would include improvements at the Warfield Bridge, which does not have the capacity to convey the increased diversion flows without being overtopped. In order to evaluate the hydraulics of the Warfield Bridge, it was necessary to perform a steady state hydraulic analysis. Due to the steep gradient of the channel invert through this portion of the diversion (S = 0.012), flow is reaching critical depth and providing unstable results under an unsteady flow analysis. Using the mixed flow option on the HEC-RAS unsteady flow editor did not provide stable results either. Under the steady state analysis, a stable run was achieved using the peak flows calculated in HEC-1 and is considered to produce the most reasonable results for purposes of this analysis.

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PROJECT: Butte Creek JOB #: 8230.001

FEATURE: Design Memo BY: JPP DATE: 6/24/04

ITEM: Manning's n-value Determination

PURPOSE: To assess the appropriate channel n-values for existing conditions within the Little Chico – Butte Diversion using USGS Water Supply Paper # 2339, "Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Flood Plains."

STREAM: Little Chico – Butte Diversion

REACH OR ROAD CROSSING: Between Diversion Structure and Station 19203

MANNING "N" ESTIMATE APPLICABLE TO:

LEFT OVERBANK _____ **CHANNEL** X **RIGHT OVERBANK** _____

BRIDGE _____ **CULVERT** _____ **OTHER** _____

FACTORS	**STREAM CONDITION**	**BASE 'n' VALUE & ADJUSTMENT**
Streambed Material (n_b)	Firm Soil	0.027
Degree of Irregularity (n_1)	Minor	0.003
Variation in Channel Cross-Section (n_2)	Negligible	0.000
Effect of Obstruction (n_3)	Minor	0.005
Amount of Vegetation (n_4)	Small to Medium	0.01
Degree of Meandering (m)	N/A	1.0

Final Manning 'n' Value = $(n_b + n_1 + n_2 + n_3 + n_4) \cdot m =$ 0.045 Rounded to = 0.045

Taken at diversion structure, facing downstream.

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PROJECT: Butte Creek JOB #: 8230.001

FEATURE: Design Memo BY: JPP DATE: 6/24/04

ITEM: Manning's n-value Determination

PURPOSE: To assess the appropriate channel n-values for existing conditions within the Little Chico – Butte Diversion using USGS Water Supply Paper # 2339, "Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Flood Plains."

STREAM: Little Chico – Butte Diversion

REACH OR ROAD CROSSING: Between Station 5390 and Confluence with Butte Creek

MANNING "N" ESTIMATE APPLICABLE TO:

LEFT OVERBANK _____ **CHANNEL** X **RIGHT OVERBANK** _____

BRIDGE _____ **CULVERT** _____ **OTHER** _____

FACTORS	**STREAM CONDITION**	**BASE 'n' VALUE & ADJUSTMENT**
Streambed Material (n_b)	Firm Soil	0.027
Degree of Irregularity (n_1)	Minor	0.003
Variation in Channel Cross-Section (n_2)	Negligible	0.000
Effect of Obstruction (n_3)	Minor	0.005
Amount of Vegetation (n_4)	Very Large	0.055
Degree of Meandering (m)	N/A	1.0

Final Manning 'n' Value = $(n_b + n_1 + n_2 + n_3 + n_4) \cdot m =$ 0.09 Rounded to = 0.09

Taken at access road crossing (Station 5390), standing on left bank facing downstream vegetation.

Taken at access road crossing (Station 5390), Standing at right bank, looking upstream.

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PROJECT: Butte Creek JOB #: 8230.001

FEATURE: Design Memo BY: JPP DATE: 6/24/04

ITEM: Manning's n-value Determination

PURPOSE: To assess the appropriate channel n-values for existing conditions within the Little Chico – Butte Diversion using USGS Water Supply Paper # 2339, "Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Flood Plains."

STREAM: Little Chico – Butte Diversion

REACH OR ROAD CROSSING: Between Stations 7500 and 6000

MANNING "N" ESTIMATE APPLICABLE TO:

LEFT OVERBANK _____ **CHANNEL** X **RIGHT OVERBANK** _____

BRIDGE _____ **CULVERT** _____ **OTHER** _____

FACTORS	**STREAM CONDITION**	**BASE 'n' VALUE & ADJUSTMENT**
Streambed Material (n_b)	Firm Soil	0.027
Degree of Irregularity (n_1)	Minor	0.003
Variation in Channel Cross-Section (n_2)	Negligible	0.000
Effect of Obstruction (n_3)	Minor	0.005
Amount of Vegetation (n_4)	Large	0.04
Degree of Meandering (m)	N/A	1.0

Final Manning 'n' Value = $(n_b + n_1 + n_2 + n_3 + n_4) \cdot m =$ 0.075 Rounded to = 0.075

Taken at abandoned railroad crossing, approximately 1000 feet upstream of confluence with Butte Creek.

Taken at abandoned footbridge crossing, approximately 500 feet upstream of confluence with Butte Creek.

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PROJECT:	Butte Creek			JOB #:	8230.001
FEATURE:	Hydrologic Analysis	BY:	MCN	DATE:	6/25/04
ITEM:	Analysis of existing storage capacity in California Park Lake				

PURPOSE:

The purpose of this analysis is to evaluate previous existing conditions analyses defining drainage affecting the California Park Dam and downstream, and evaluate potential alternatives for reconfiguration of California Park Dam to maximize flood control benefits downstream along Little Chico Creek.

DATA USED:

Effective HEC-1 modeling from FEMA FIS for Butte Creek

DSOD Dam Inventory Data – (storage, spillway elevation, etc.)

Recent Aerial Photograph (USGS) for footprint of lake area

Faxed information from James C. Hanson (design engineer for Cal. Park Dam)

ASSUMPTIONS:

Wood Rodgers assumed that the California Park Lake could be reconfigured in reasonable ways to achieve maximum flood control benefit, including partial draining of the pond to preserve flood control storage capacity as well as reconfiguring the outlet structure to make it a flow-through flood control operation. Wood Rodgers understands that any alternative would only be implementable with the consent/agreement of the private owners group overseeing the lake and dam. Currently the lake is kept full year-round for recreational features and is supplemented by groundwater pumping to keep it full. The only impact the lake has is the volume above the spillway crest that slightly dampens downstream peak flows.

ANALYSIS and CONCLUSIONS:

Using the HEC-1 model prepared as part of the Butte Creek FIS as a base, Wood Rodgers prepared a revised existing conditions HEC-1 model with the following modifications:

- The model input was revised to account for development in parts of the upper watershed and break the upper watershed into smaller subbasins that reflected inflow timing changes from

urbanized versus non-urbanized contributing areas. Also added stage-storage-discharge relationships at California Park Lake to reflect attenuation of existing peak flow downstream from the storage above the spillway crest.

The definition of the storage available above the spillway crest was approximated using a scaled aerial photograph and drawing an outline around the shoreline. The surface area of the lake was estimated at approximately 45 acres. The storage below the spillway was taken from the DSOD database listing of 335 acre-feet as the volume below spillway crest. We took the resultant HEC-1 hydrograph for the California Park area and used an Excel spreadsheet to manipulate the hydrograph to reflect different "diversion" scenarios utilizing flood control gates as flow control devices to throttle to a constant outflow and re-utilize the upper storage in the lake. Dictating a maximum specified flow continuing downstream we calculated the associated volume required in California Park Lake to achieve such a downstream control.

ATTACHMENTS:

RESULTS:

The California Park Lake and Dam cannot effectively be reconfigured to utilize existing storage to reduce the peak flow in Little Chico Creek to within channel capacity limitations. The greatest impact to flow in Little Chico Creek during the 100-year event was created when the pond was kept empty and then allowed to fill up during the peak portion of the storm event. This would result in only 700 cfs 100-year flow reduction in Little Chico Creek.

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PROJECT:	Butte Creek			JOB #:	8230.001
FEATURE:	Hydraulic Analysis	BY:	JPP	DATE:	6/25/04
ITEM:	Analysis of existing conditions in LCB Diversion				

PURPOSE:

The purpose of this analysis is to evaluate existing conditions along the Little Chico-Butte Creek Diversion Channel and to identify potential improvement alternatives.

DATA AVAILABLE:

FEMA FIS for Butte Creek, performed in 1994 by Borcalli & Associates, HEC-2 model filenames: "2DCCC04.DAT", "2DCCR01.DAT", "2DCCR02.DAT."

ASSUMPTIONS:

ANALYSIS:

Using the HEC-2 model prepared as part of the Butte Creek FIS as a base, Wood Rodgers prepared a HEC-RAS model with the following modifications:

- The model input was configured to perform an unsteady state analysis using the input hydrographs calculated by the FIS HEC-1 models.
- Channel bank stations were modified to reflect the actual top of bank at each cross-section. Levee and ineffective flow definitions were modified accordingly.
- No levee failure scenarios were analyzed through the study reach.

The Diversion is about 3 miles long and has intermittent levees along the right bank. Since the FIS study was performed, vegetation levels in the Diversion channel prism have increased dramatically in some locations. In the FIS study, the channel was modeled with a Manning's roughness coefficient of 0.035.

To evaluate existing conditions, Wood Rodgers analyzed the impact of the increased vegetation in the Diversion channel relative to the vegetation levels represented in the effective FIS model. Although the roughness coefficient value used in the FIS modeling is appropriate for much of the channel, Wood

Rodgers recalculated the roughness coefficients at three specific locations along the channel that were identified in a field visit dated June 10, 2004. Starting upstream, the first of these areas lies immediately downstream of the diversion structure, and runs between Stations 19693 to 19203. Roughness coefficients were increased to 0.045 for this portion of the channel. The second section starts approximately 2000 feet upstream from the access road crossing (Station 5390) and continues about 1500 feet downstream, and is characterized by trees and brush growing inside the channel banks. This section runs between Stations 7500 and 6000. The roughness coefficients for this portion of the reach were increased to 0.075. The third section runs between the access road crossing (Station 5390) and the confluence with Butte Creek and is heavily vegetated. This section runs between Stations 5050 and 0. Roughness coefficients for this portion of the reach were increased to 0.09.

Increasing the n values through these portions of the LCB Diversion created instability in the unsteady state modeling. As such, Wood Rodgers opted to revert back to steady state modeling to evaluate existing conditions in the LCB Diversion.

ATTACHMENTS:

RESULTS:

The envelope of worst-case flooding in the Diversion channel consists of two non-concurrent floodwaves. The first occurs as a result of the peak spill from Little Chico Creek and represents the worst-case flooding in the upstream end of the Diversion. Worst-case flooding in the downstream end of the Diversion occurs when overland flooding from Butte Creek spills into the Diversion several hours after the peak flow diverted from Little Chico has has passed through the system. Both conditions were modeled using steady state HEC-RAS runs to capture the full envelope of worst case flooding in the Diversion. A comparison between Existing Conditions and the Effective FIS WSEL's is presented below:

Station	Flow (cfs)	Effective FIS WSEL (ft)	Revised Existing Conditions WSEL (ft)	Difference (ft)
19693	3100	296.85	297.77	0.92
19203	3100	293.74	294.22	0.48
18858.6*	3100	291.93	291.93	0
18514.3*	3100	290.18	290.18	0
18170	3100	287.54	287.54	0
17703.*	3100	283.81	283.81	0
17236	3100	280.26	280.26	0
16871.3*	3100	277.56	277.56	0
16506.6*	3100	275.88	275.88	0
16142	3100	275.42	275.42	0
15987.*	3100	274.42	274.42	0
15832	3100	272.76	272.76	0
Station	**Flow**	**Effective FIS WSEL**	**Revised Existing Conditions WSEL**	**Difference**

	(cfs)	(ft)	(ft)	(ft)
15724.5	Bridge	0	0	0
15713	3100	270.33	270.33	0
15708	3100	269.65	269.65	0
15583	3100	267.96	267.96	0
15208	3100	266.81	266.81	0
14942.5*	3100	266.05	266.05	0
14677	3300	263.5	263.49	-0.01
14210	3300	260.05	260.05	0
13808.*	3300	254.48	254.48	0
13406	3300	248.79	248.76	-0.03
13100.*	3300	246.12	246.21	0.09
12794	3300	242.5	242.42	-0.08
12479	3300	237.19	237.01	-0.18
12050.6*	3300	235.08	235.82	0.74
11622.3*	3300	234.94	235.75	0.81
11194	3300	234.92	235.74	0.82
10698	3300	234.9	235.73	0.83
10519	3300	234.9	235.73	0.83
10470	3300	234.59	235.48	0.89
10465	3300	234.58	235.48	0.9
10420.5	Bridge	0	0	0
10376	3300	234.43	235.37	0.94
10371	3300	234.42	235.36	0.94
10352	3300	234.59	235.5	0.91
10023	3300	234.24	235.22	0.98
9573.5*	3300	233.85	235.04	1.19
9124	3300	233.57	234.95	1.38
8708.5*	3300	233.4	234.86	1.46
8293	3300	233.29	234.82	1.53
7832.*	3300	233.06	234.73	1.67
7371	3300	232.91	234.65	1.74
6894.*	4523.71	232.14	234.26	2.12
6417	4523.71	231.13	233.32	2.19
6074.66*	4868.6	230.01	232.13	2.12
5732.33*	4868.6	228.89	229.92	1.03
5390	4868.6	227.71	227.82	0.11
5050	4868.6	226.91	227.15	0.24
5025	Culvert	0	0	0
5000	4868.6	226.2	226.9	0.7
4980	4868.6	225.94	226.07	0.13
4900	Inl Struct	0	0	0
4850	4868.6	225.12	225.45	0.33
4350.*	4868.6	225.1	225.2	0.1
3850	4868.6	225.09	225.1	0.01

Although the largest increases in vegetation occur downstream of the maintenance road crossing at Station 5025, the increase to the WSEL at this location since the FIS study was performed is less than 1-foot. The WSEL at this location could be returned to the levels reflected in the FIS with significant vegetation removal and channel maintenance.

The FIS hydraulic modeling indicated there were two 18-inch CMPs at the maintenance road crossing at Station 5025. However, Wood Rodgers was not able to verify these structures in the field. At the maintenance road, there is no sign of any culverts running under the road. The conveyance provided by these pipes in the FIS modeling is considered negligible relative to the magnitude of a 100-year event, and not considered to significantly influence the water surface profile upstream of the crossing.

Upstream of the maintenance road crossing, water surfaces increase significantly (over 2-feet in some locations) as a result of dense vegetation in the channel prism. Wood Rodgers recommends implementation of a channel maintenance program to reduce the Diversion channel n-values to 0.035, which would involve clearing trees and brush from the channel prism.

Wood Rodgers also investigated the impacts of removing the Warfield Rd. bridge crossing. This bridge consists of a wood frame and concrete abutments. This bridge has been abandoned for some time and recently experienced a fire. Removing the bridge reduces the water surface approximately 1-foot in the vicinity of the crossing.

In the right overbank of the Diversion just upstream of the Warfield bridge crossing, an overbank spill was identified in the FIS study. This appears to have been the result of the channel water surface being significantly higher than the toe of the right bank levee, which warranted a levee failure analysis. Since the time of the study, construction of the Doe Mill Lane Project has began along the right bank. Although no construction has occurred within the hazard zone at this time, the subdivision plans do indicate that construction is planned within the hazard area. Once construction in the hazard area begins, the CLOMR/LOMR application will proceed. At that point the levee failure scenario may no longer be necessary and the overbank flooding mapped in the FIS may no longer be applicable.

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PROJECT:	Butte Creek			JOB #:	8230.001
FEATURE:	Hydrologic Analysis	BY:	MCN	DATE:	6/25/04
ITEM:	Analysis of existing storage capacity in Teichert Pond				

PURPOSE:

The purpose of this analysis is to evaluate existing conditions analyses defining storage within the Teichert pond area and evaluate potential alternatives for reconfiguration of Teichert Pond to maximize flood control benefits downstream along Little Chico Creek.

DATA USED:

Effective HEC-1 and HEC-2 modeling from FEMA FIS for Butte Creek

FIS Aerial Photograph for footprint of pond area

ASSUMPTIONS:

The assumption was made that the Teichert Pond could be reconfigured in reasonable ways to achieve maximum flood control benefit, including partial draining of the pond to preserve flood control storage capacity as well as construction of the inlet/outlet structures to make it an effective flood control operation. Wood Rodgers understands that any alternative would only be implementable with the consent/agreement of the community and will have to undergo rigorous environmental approvals. Currently, The only impact the pond has is slight dampening of peak flow as the flooding spreads out into the pond.

ANALYSIS and CONCLUSIONS:

Using the HEC-1 model prepared as part of the Butte Creek FIS as a base, Wood Rodgers prepared a revised existing conditions HEC-1 model as part of the analysis for California Park Lake. Refer to notes regarding modeling changes under California Park Lake write-up.

The definition of the existing storage available was approximated from the aerial photograph and topography from the FIS study. This information was used to approximate the volume/elevation relationship for this area without additional volume excavation.

The surface area of the pond was estimated at approximately 40 acres. Early in the analysis the County informed Wood Rodgers that Teichert Pond would only provide minimal storage and is considered an ecological zone and is highly regarded in the environmental community. Considering the level of modification it would require to separate Teichert Pond area from Little Chico Creek to be able to control the pond for flood control access it was determined a remotely feasible alternative at best, to gain approval. A control levee structure would have to be constructed on the south side of Little Chico Creek with a spilling weir structure at the upstream (easterly) end of the pond, as well as an outlet structure just near the Highway 99 crossing.

The Little Chico Creek 100-year in-channel flow hydrograph was analyzed using an Excel spreadsheet to assess the impact of utilizing the volume in the pond for flow storage on the residual peak flow downstream.

RESULTS:

The Teichert Pond, when utilized as a stand-alone flood control feature, cannot effectively be reconfigured to utilize existing storage to reduce the peak flow in Little Chico Creek to within channel capacity limitations unless a perimeter levees and flood control inlet/outlet structures are constructed. This Hydrologic and hydraulic analysis showed that the perimeter levee and inlet/outlet structures would result in a reduction of only 300 cfs to 500 cfs in the Little Chico Creek flow during the 100-year event.

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PROJECT: Butte Creek JOB #: 8230.001

FEATURE: Hydraulic Analysis BY: JPP DATE: 7/16/04

ITEM: Little Chico Creek Improvements

PURPOSE:

The purpose of this analysis is to determine what improvements in Little Chico Creek are required in order to contain the 100-year flow in-channel through the City limits.

DATA USED:

FEMA FIS for Butte Creek performed in 1994 by Borcalli & Associates. HEC-RAS geometry file based on HEC-2 model filenames: "2DCMSF04.DAT" (LCB Diversion), "BCCSF1.DAT" (Butte Creek), "CC5SF.DAT" (Comanche Creek), and "LCHSF17B.DAT" (Little Chico Creek).

ASSUMPTIONS:

- Channel n-values are lowered to 0.05 through the City limits along Little Chico Creek via vegetation clearing and maintenance.
- The diversion structure at the Little Chico-Butte Diversion can be modified to increase the flow that is diverted to Butte Creek.
- The capacity of Little Chico Creek for purposes of this analysis shall be defined as the amount of flow that can be conveyed within the channel banks without regard to freeboard.

ANALYSIS:

Using the HEC-2 model prepared as part of the Butte Creek FIS as a base, Wood Rodgers prepared a HEC-RAS model with the following modifications:

- The model input was configured to perform an unsteady state analysis using the input hydrographs calculated by the FIS HEC-1 models that were updated to incorporate the revisions performed as part of the Dead Horse Slough analysis.
- Channel bank stations were modified to reflect the actual top of bank at each cross-section. Ineffective flow definitions were modified accordingly.

- No levee failure scenarios were analyzed through the study reach.

RESULTS:

The results of the unsteady state analysis indicate that once vegetation clearing has been implemented, the diversion structure at the Little Chico-Butte Diversion must be modified such that all but 100 cfs is diverted out of Little Chico Creek. The capacity of Little Chico Creek is limited to approximately 2250 cfs at Stations 41871 and 41811 (in the vicinity of the Chestnut Street crossing). Allowing more than 100 cfs to pass downstream of the Diversion will exceed the channel capacity at these sections, resulting in out of bank flooding.

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PROJECT:	Butte Creek			JOB #:	8230.001
FEATURE:	Butte Creek	BY:	JPP	DATE:	7/28/04
ITEM:	Diversion to Hamlin Slough				

PURPOSE:

The purpose of this analysis is to evaluate the suitability of diverting flow from Butte Creek downstream of Highway 99 to Hamlin Slough.

DATA USED:

- FEMA FIS for Butte Creek, performed in 1994 by Borcalli & Associates
- TOPO! Map printed on 9/8/03 from "California.tpo" and "Untitled.tpg"
- TopoDepot Skytopos aerial photo, 1998.

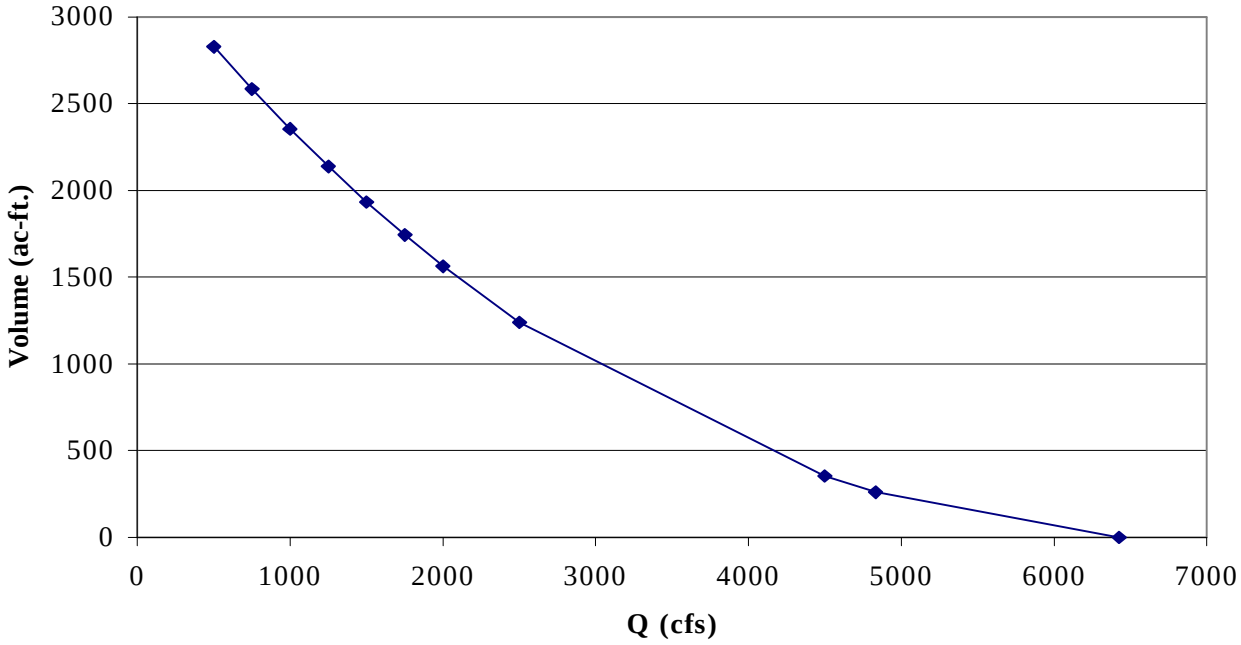
ANALYSIS:

In order to divert water during flood events out of Butte Creek, the following components are required:

- Diversion Channel
- Detention Pond
- Sufficient downstream capacity in Hamlin Slough

As determined in the Evaluation of Lower Butte Creek Capacity, in order to obtain 3-feet of freeboard in Butte Creek downstream of Highway 99, a structure must be designed to divert a peak flow of 6427 cfs out of Butte Creek during the 100-year event. A diversion channel will be designed to convey flow to Hamlin Slough. A lateral overflow weir shall be constructed in the diversion channel to spill to a detention pond to attenuate the peak such that the capacity of Hamlin Slough is not exceeded. A rating curve presenting the relationship between diversion channel capacity and required detention storage volume is presented on Figure 1.

Figure 1
Detention Volume vs. Diversion Capacity



The topography and existing development represent constraints to developing the diversion channel parallel to Highway 99. The 100-year water surface elevation in Butte Creek downstream of Highway 99 is El. 216. In some locations, the ground along the downstream face of Highway 99 is as high as 231.7 feet. As such, significant cut would be required in order to construct the diversion and detention pond parallel to Highway 99. As such, it is recommended that any proposed diversion alignment tie into existing channel alignments to the extent that is feasible.

Wood Rodgers evaluated three potential Butte-Hamlin Diversion and storage configurations:

Alternative 1: In this alternative, storage is configured on the existing golf course southeast of the Highway 99 crossing on Butte Creek. The proposed Diversion ties into a portion of the existing Durham Mutual Ditch, crosses the Oroville-Chico Highway and cuts southeast to tie into the existing alignment of the western upper branch of Hamlin Slough. Under this configuration, the peak flow diverted from Butte Creek is attenuated such that it can be diverted to Hamlin Slough without exceeding the channel capacity of Hamlin Slough. Channel improvements would be required in the Durham Mutual Ditch and portions of Hamlin Slough to convey the peak flow while maintaining one-foot of freeboard (channel capacity varies along Hamlin Slough and the capacity of the Durham Mutual Ditch remains undetermined until more detailed mapping information becomes available), and would result in a smaller floodplain along Hamlin Slough upstream of where the Butte Creek levee failure scenarios govern.

The upper end of Hamlin slough consists of two tributary reaches. The maximum existing capacity of the eastern branch of upper Hamlin Slough through "Bridge #9" is approximately 900 cfs. The capacity of Hamlin Slough between the bridge and the confluence with the northern tributary at station 364+51 is roughly 1000 cfs, except between stations 389+58 and 364+51 where the channel capacity drops to less than 500 cfs and Hamlin Slough is subject to over bank flooding.

Additional diversion capacity is contained in the western branch of upper Hamlin Slough. The capacity of this reach cannot be determined from the existing FIS HEC-2 modeling (cross-sections for this reach were developed from USGS quad topographic mapping, and there is not enough detail to define the channel in the model, see attached). However, it can generally be assumed that the capacity downstream of the confluence of this reach with the eastern branch of upper Hamlin Slough represents the combined capacities of these tributary creeks.

Downstream of the confluence of these two reaches, the capacity of Hamlin Slough is approximately 2300 cfs for the majority of the reach up to the point where the influence of the Butte Creek levee failure scenarios begin to govern the extents of the floodplain (approximately station 225+83). Downstream, between stations 315+83 and 298+83 however, the capacity of Hamlin Slough drops to 500-600 cfs. At this location, channel improvements do not seem particularly feasible given the narrow bottom width (15 feet) and 2:1 sideslopes. Although there are levees on either side of the creek, the most efficient means to increase capacity through this portion of Hamlin Slough is to widen the channel. This requires at least 1700 feet of channel improvements between the two main stations, and would require additional channel widening upstream and downstream of this section (the extents of which would have to be determined with more detailed channel cross-section data).

Alternative 2: This Diversion configuration was developed as an alternative to evaluate diverting flow to match existing 100-year flooding in Hamlin Slough without respect to channel containment. This is considered to represent the maximum flow that can be diverted without expanding the existing floodplain corridor and would not include any improvements to Hamlin Slough.

Under this alternative, flow is diverted from Butte Creek into the proposed Diversion. The Diversion is designed to route a maximum of 1750 cfs to the Durham Mutual Ditch. Flows exceeding the capacity of the Diversion are routed to a detention basin located on the golf course southeast of the Highway 99 crossing on Butte Creek. Although the capacity of the Ditch is undetermined, this flow matches the 100-year peak flow calculated for areas tributary to the Ditch and is considered the maximum flow that can be diverted through the Ditch without expanding the floodplain corridor along the alignment of the Ditch. The diverted peak flow is considered to not coincide with the local peak flows in the Ditch.

Alternative 3: This Diversion configuration was developed as an alternative to evaluate diverting flow to match existing 100-year flooding in Hamlin Slough without respect to channel containment. This is considered to represent the maximum flow that can be diverted without expanding the existing floodplain corridor and would not include any improvements to Hamlin Slough.

Under this alternative, flow is diverted from Butte Creek into the proposed Diversion. The Diversion is designed to route a maximum of 4833 cfs to the western branch of upper Hamlin Slough. Flows exceeding the capacity of the Diversion are routed to a detention basin located on the golf course

southeast of the Highway 99 crossing on Butte Creek. This design flow matches the 100-year peak flow calculated for areas tributary to the confluence of the upper branches of Hamlin Slough and is considered the maximum flow that can be diverted through Hamlin Slough without expanding the floodplain corridor along the alignment of the Slough. The diverted peak flow is considered to not coincide with the local peak flows in Hamlin Slough. Although the capacity of the existing western branch of upper Hamlin Slough is undetermined, it is assumed that the channel will require significant improvements upstream of the confluence with the eastern branch of upper Hamlin Slough in order to convey the design flow without worsening flooding in Hamlin Slough.

ATTACHMENTS:

- Figure 2, Hamlin Slough Improvements - Alternative 1
- Figure 3, Hamlin Slough Improvements - Alternative 2
- Figure 4, Hamlin Slough Improvements - Alternative 3

RESULTS:

Alternative 1: The required footprint for the detention storage is significant. Based on the evaluation of Hamlin Slough's capacity, the feasible maximum total diversion flow rate that can be contained in channel with 1-foot of freeboard is only about 2300 cfs. This would require approximately 2583 ac-ft. of storage. With a 9-foot pond depth, a footprint of 287 acres would be required (about 0.45 square miles). The peaks in Butte Creek and Hamlin Slough are approximately 4 hours apart and the residual flow in Hamlin Slough represents a constraint with respect to the amount of flow that can be diverted from Butte Creek. Although some optimization can be achieved by storing and attenuating the local peak in Hamlin Slough via storage upstream of Highway 99, the cost savings associated with building a second detention facility are considered negligible for purposes of this analysis.

Additionally, two sections of improved channel would be required. The first would run adjacent to the Detention Basin and flow downstream to the upstream face of the Oroville-Chico Highway. This portion of the Diversion could take advantage of the existing Durham Mutual Ditch alignment, but would require channel improvements to widen the channel to a 5-foot bottom width and flow at approximately 9-feet deep at normal depth when full. The footprint for this section of the Diversion would be approximately 100-feet wide (accounting for maintenance roads on both sides of the channel). Downstream of the Oroville-Chico Highway, the Diversion will diverge from the Durham Mutual Ditch alignment and flow east and tie into the existing western branch of Hamlin Slough. Downstream of the Highway, the existing grade is shallower and will require a wider channel footprint for the Diversion. Between the Highway and the confluence between the upper branches of Hamlin Slough, the channel will require a bottom width of 45-feet to flow at 8-feet of normal depth. The channel corridor width required would be approximately 130-feet (including maintenance roads on both sides of the channel).

A schematic of the storage configuration and improvements for this alternative is presented in Figure 2. Based on the aerial photography available, configuring this storage volume and the required diversion reaches may prove difficult.

Alternative 2: This configuration would require approximately 1742 ac-ft. of storage. A 9-foot deep detention basin would translate to a basin footprint of 194 acres (0.30 square miles). A diversion channel with a capacity of 1750 cfs would require a corridor averaging approximately 100-feet wide (which includes maintenance roads on either side of the channel). A portion of the diversion would be a triangular section flowing approximately 9-feet deep at normal depth when full. This section would be adjacent to the Detention Basin and feature hydraulic connections to the detention basin to ensure that the maximum capacity downstream is not exceeded, while providing an outlet to keep the basin drained as efficiently as possible. Downstream of the basin, the channel could be configured with a shallower channel slope and wider bottom width to allow for a shallower depth of flow and reduced channel velocities. Using an average normal depth of 7.5-feet and a channel bottom width of 20-feet would require a channel corridor averaging 100-feet wide (this includes maintenance roads on both sides of the channel). The lower portion of the diversion channel would terminate at the Oroville-Chico Highway and would include any necessary crossing improvements at the Highway to ensure that flooding upstream of the Highway is not worsened. The capacity of the existing crossing at the Oroville-Chico Highway is undetermined, but it is assumed that some improvements would be required in order to convey the peak flow without overtopping the Highway. Downstream of Oroville-Chico Highway the existing channel will be left in place and the Ditch will be allowed to flood no worse than existing conditions. A schematic of the storage configuration and improvements for this alternative is presented in Figure 3.

Alternative 3: This configuration would require approximately 261 ac-ft. of storage. A 9-foot deep detention basin would translate to a basin footprint of 29 acres (0.045 square miles). Two sections of improved channel would be required. The first would run adjacent to the Detention Basin and flow downstream to the upstream face of the Oroville-Chico Highway. This portion of the Diversion could take advantage of the existing Durham Mutual Ditch alignment, but would require channel improvements to widen the channel to a 35-foot bottom width and flow at approximately 9-feet deep at normal depth when full. The footprint for this section of the Diversion would be approximately 125-feet wide (accounting for maintenance roads on both sides of the channel). Downstream of the Oroville-Chico Highway, the Diversion will diverge from the Durham Mutual Ditch alignment and flow east and tie into the existing western branch of Hamlin Slough. Downstream of the Highway, the existing grade is shallower and will require a wider channel footprint for the Diversion. Between the Highway and the confluence between the upper branches of Hamlin Slough, the channel will require a bottom width of 110-feet to flow at 8-feet of normal depth. The channel corridor width required would be approximately 195-feet (including maintenance roads on both sides of the channel). A schematic of the storage configuration and improvements for this alternative is presented in Figure 4.

The proposed channel and detention pond layout alternatives described above are planning level designs intended to present a level of magnitude with respect to the proposed drainage facilities. More detailed survey information should be accumulated in order to design the Diversion Channel and Detention Basin.

FIGURE 2 - HAMLIN SLOUGH IMPROVEMENT ALTERNATIVE 1

BUTTE CREEK

BUTTE COUNTY, CALIFORNIA

APRIL, 2004

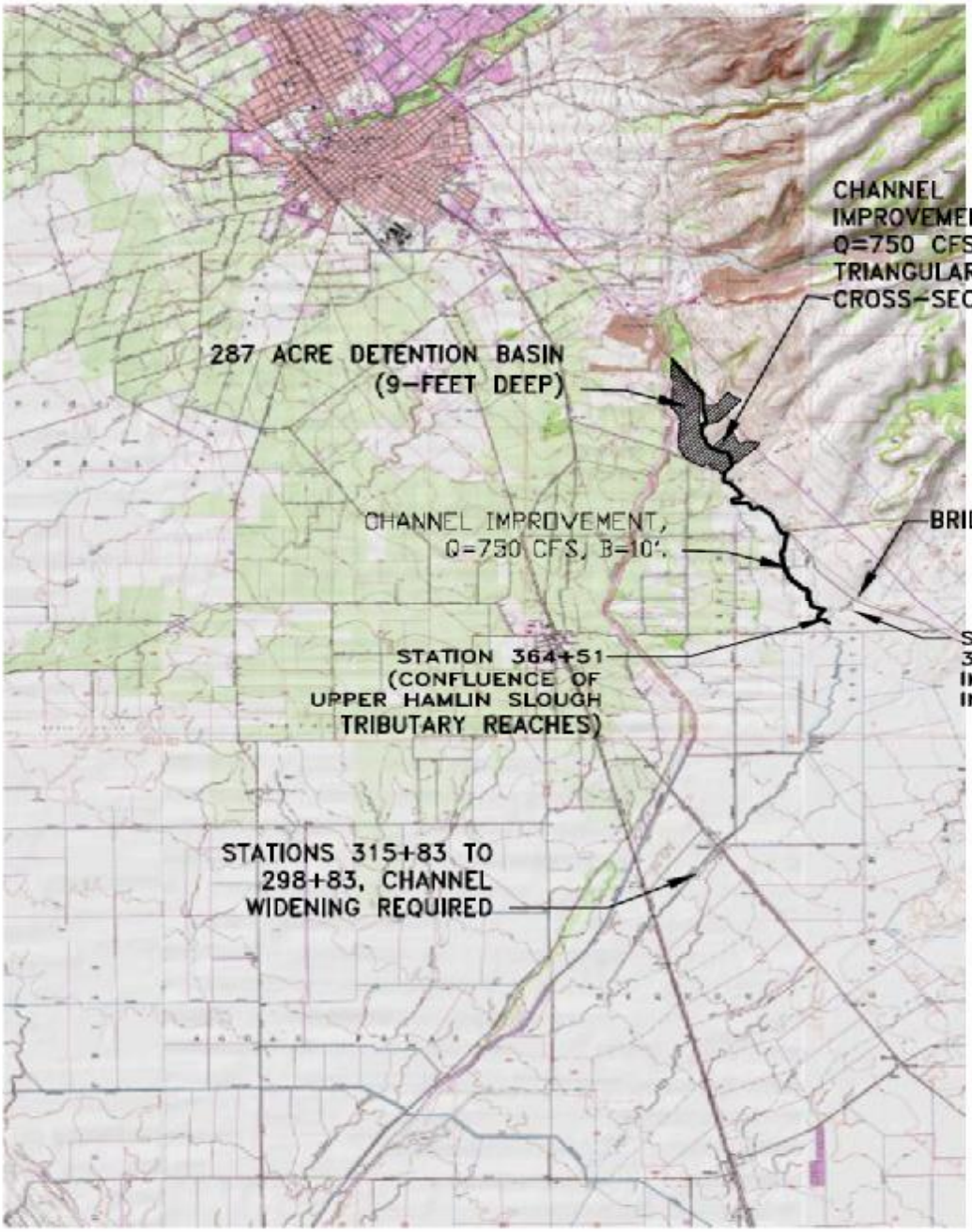


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FIGURE 3 - HAMLIN SLOUGH IMPROVEMENT ALTERNATIVE 2

BUTTE CREEK

BUTTE COUNTY, CALIFORNIA

APRIL, 2004

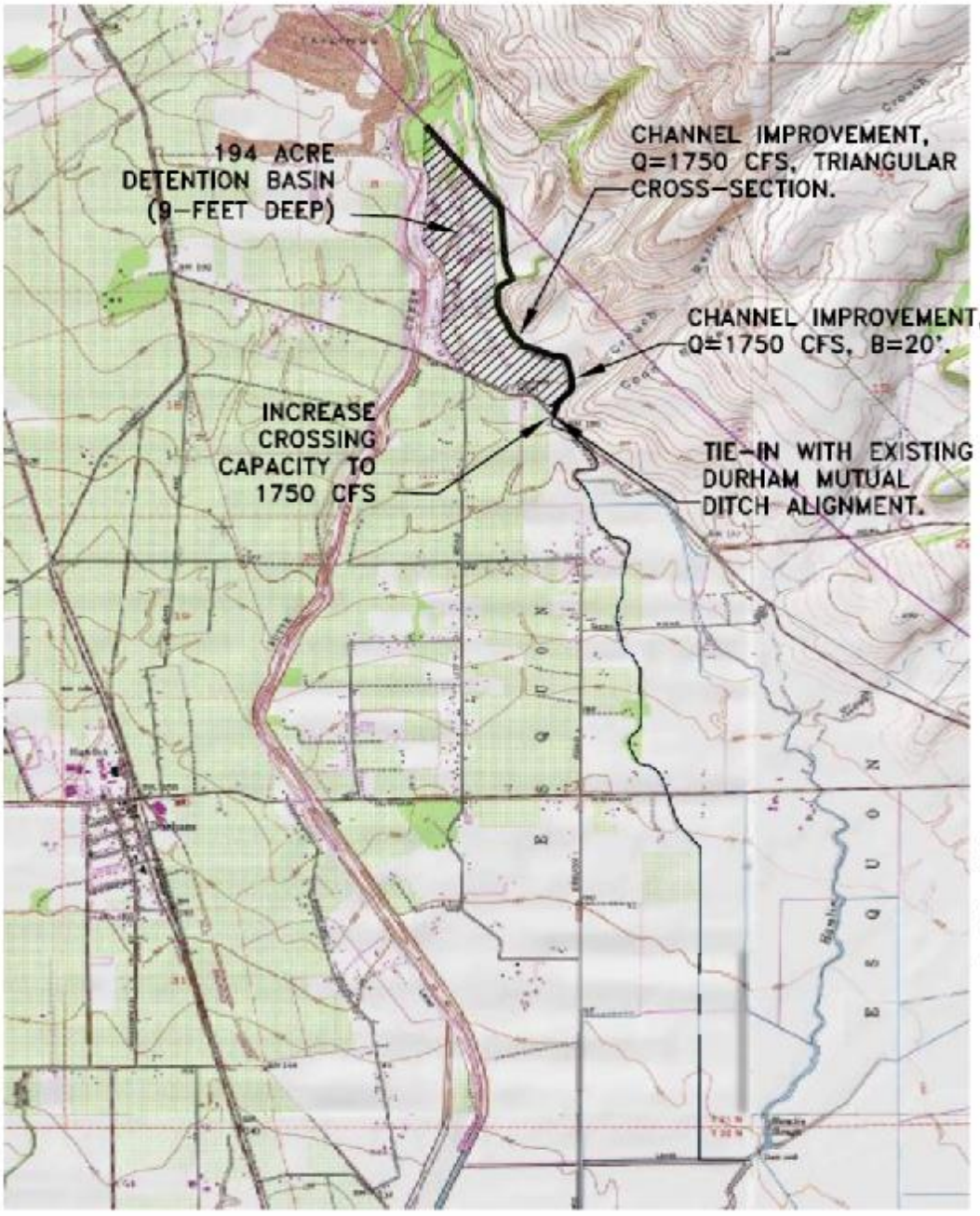

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FIGURE 4 - HAMLIN SLOUGH IMPROVEMENT ALTERNATIVE 3

BUTTE CREEK

BUTTE COUNTY, CALIFORNIA

APRIL, 2004

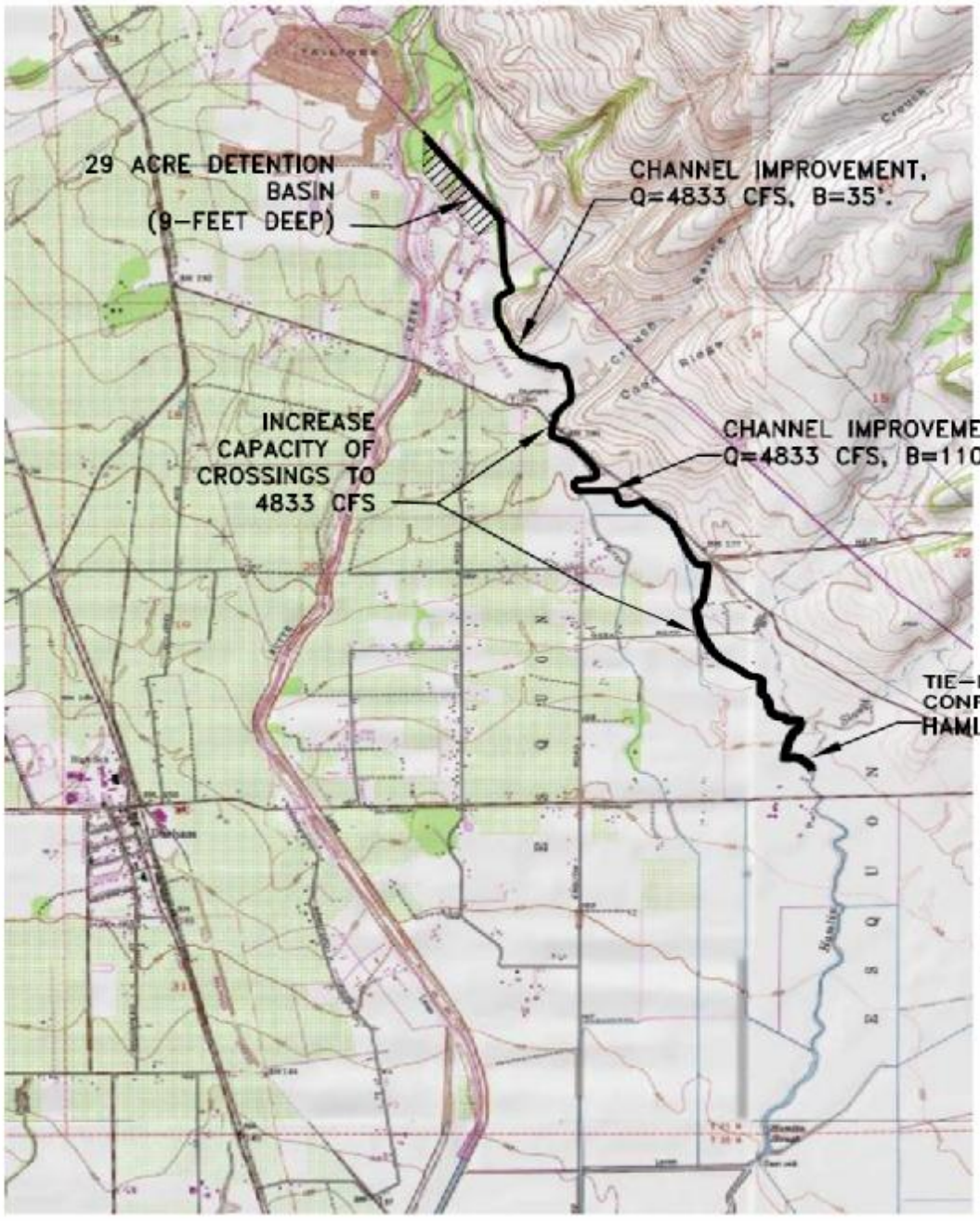

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FIGURE 2 - HAMLIN SLOUGH IMPROVEMENT ALTERNATIVE 1

BUTTE CREEK

BUTTE COUNTY, CALIFORNIA

APRIL, 2004

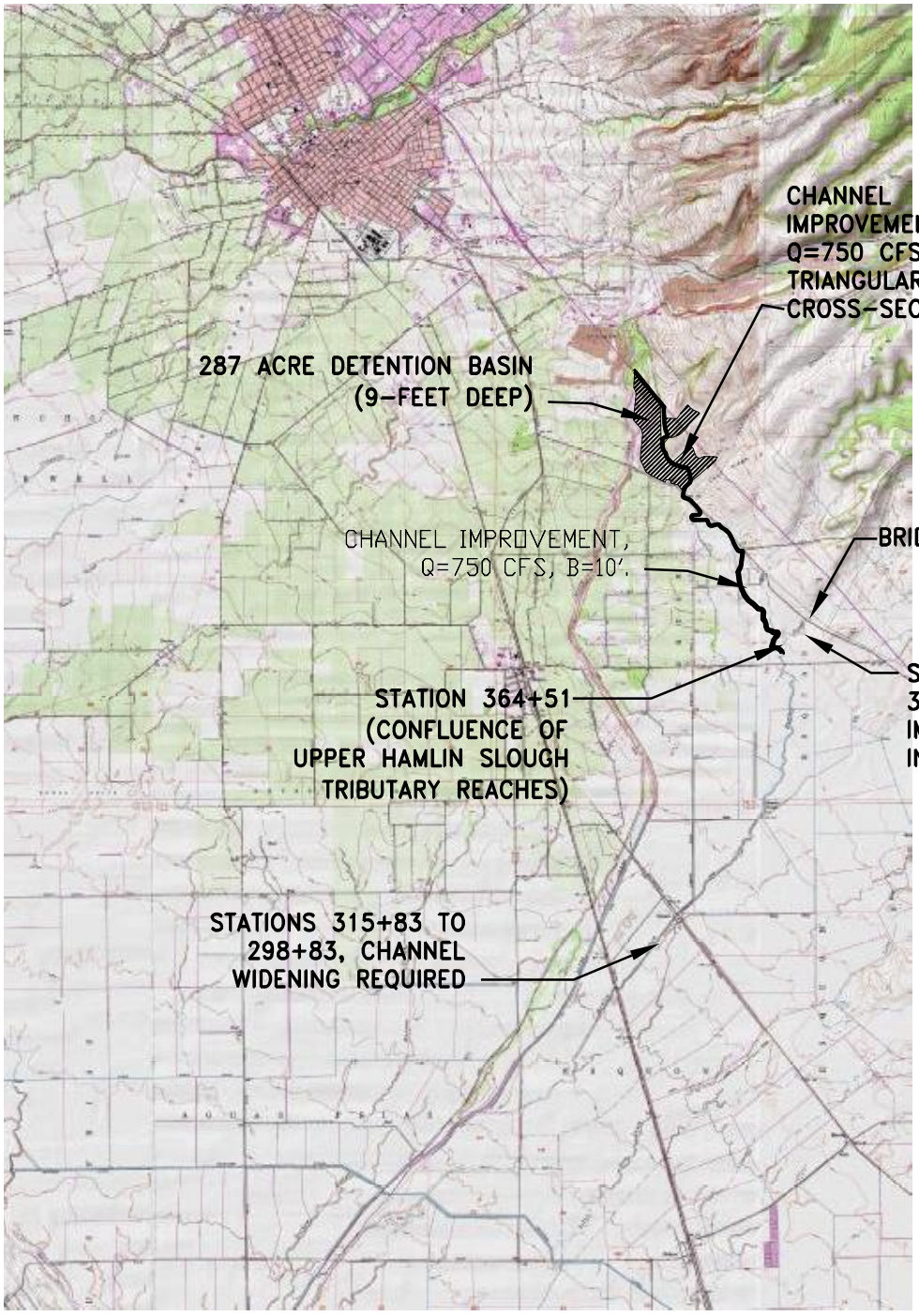

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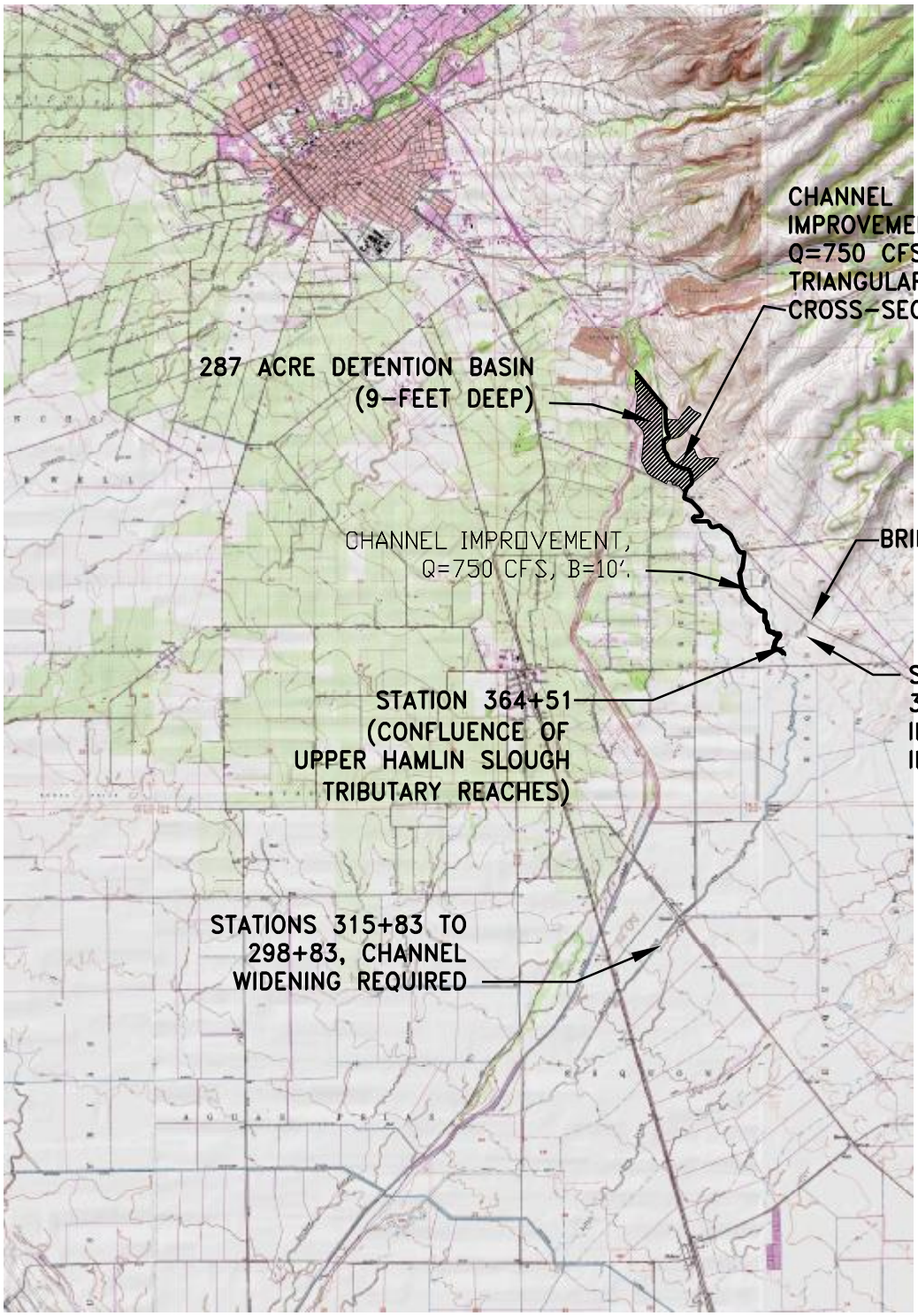
FIGURE 2 - HAMLIN SLOUGH IMPROVEMENT ALTERNATIVE 1

BUTTE CREEK

BUTTE COUNTY, CALIFORNIA

APRIL, 2004



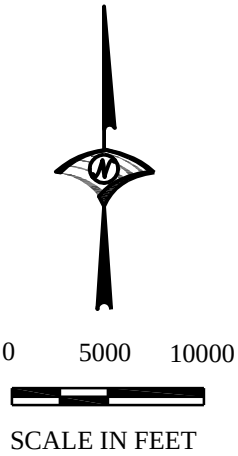


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FIGURE 3 - HAMLIN SLOUGH IMPROVEMENT ALTERNATIVE 2

BUTTE CREEK

BUTTE COUNTY, CALIFORNIA

APRIL, 2004

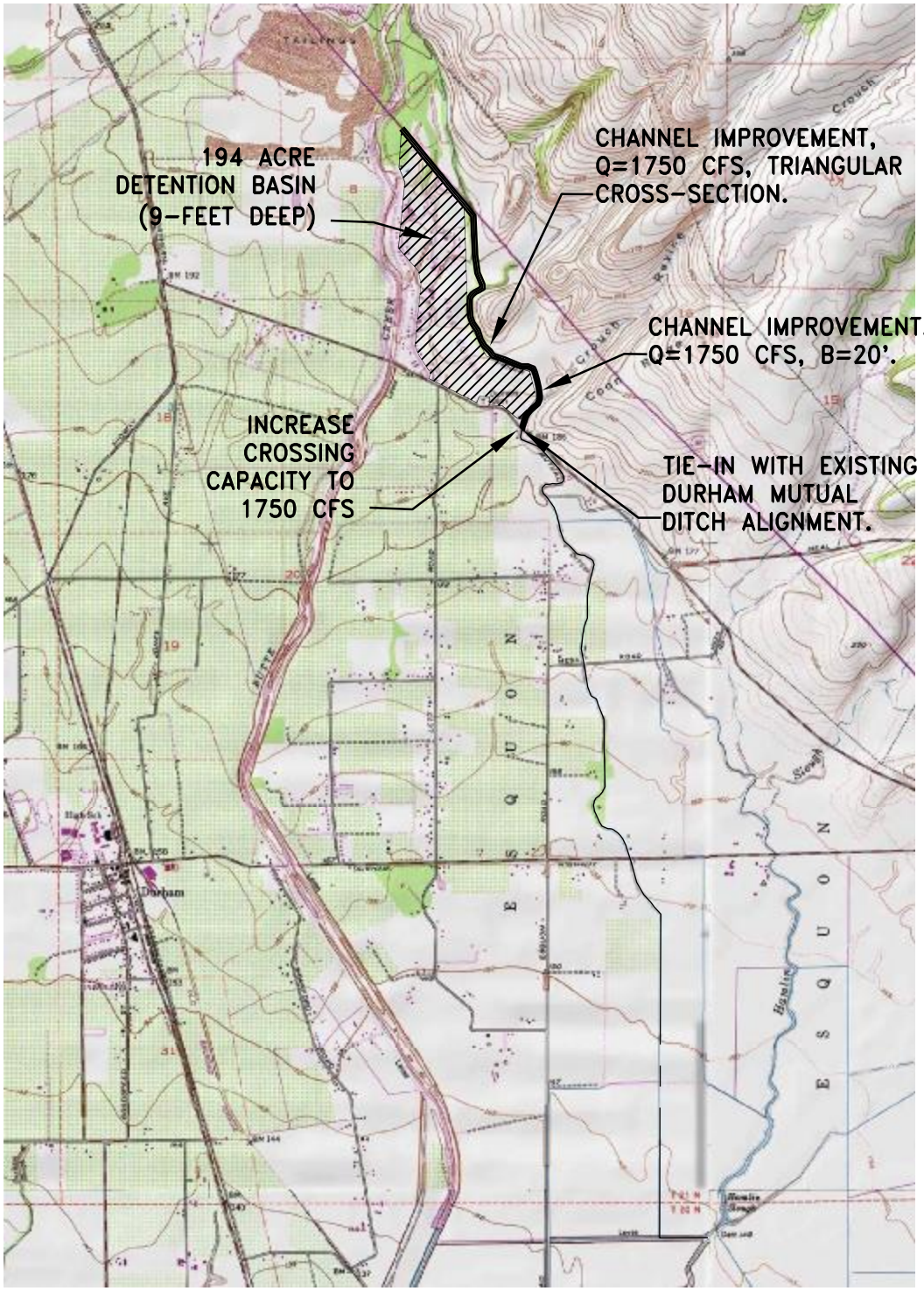

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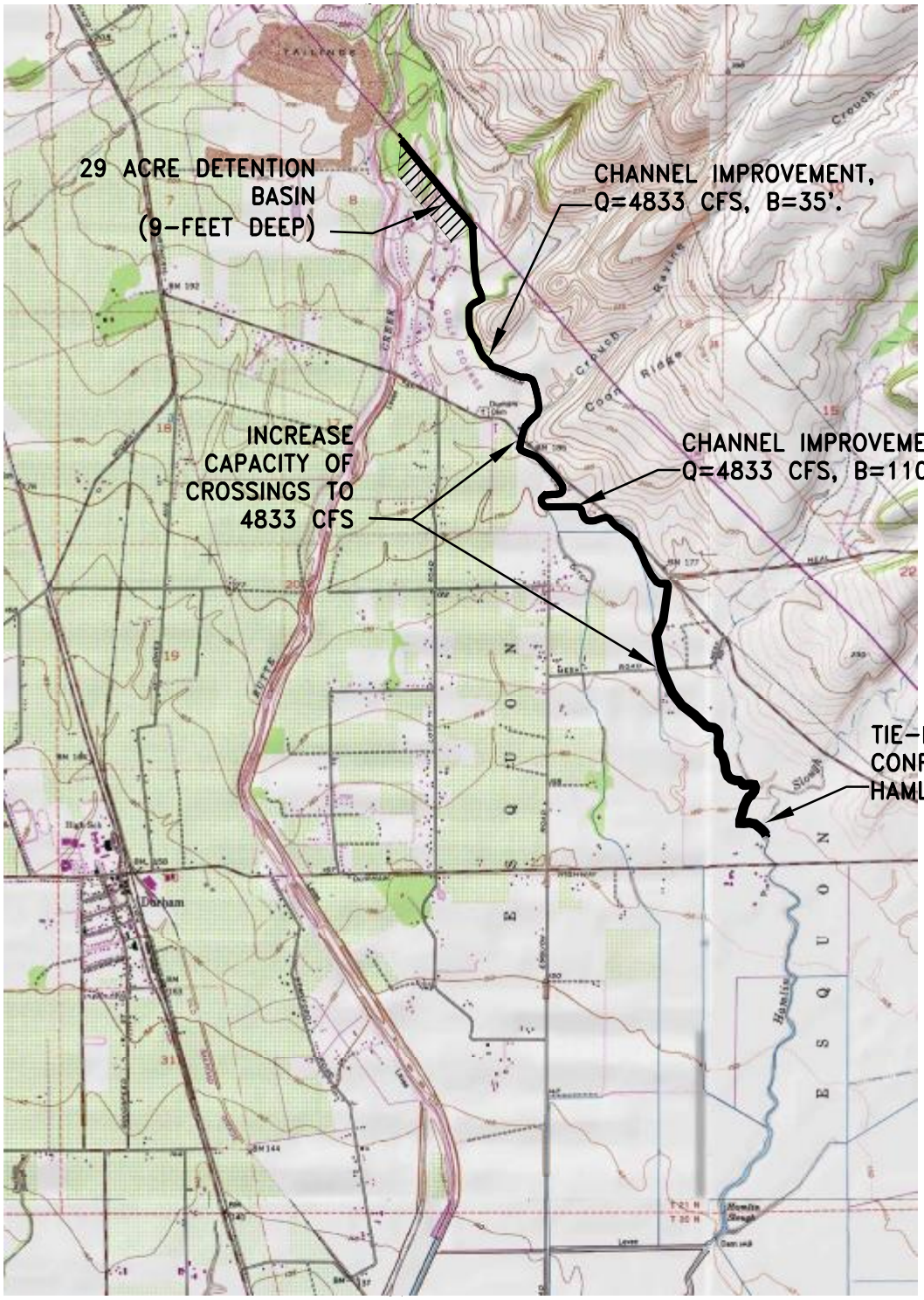
FIGURE 4 - HAMLIN SLOUGH IMPROVEMENT ALTERNATIVE 3

BUTTE CREEK

BUTTE COUNTY, CALIFORNIA

APRIL, 2004



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PROJECT:	Butte Creek			JOB #:	8230.001
FEATURE:	Hydraulic Analysis	BY:	JPP	DATE:	7/28/04
ITEM:	Modification to Little Chico – Butte Creek Diversion Structure				

PURPOSE:

The purpose of this analysis is to determine the modifications required on the Little Chico – Butte Creek diversion structure in order to restrict the downstream flow to Little Chico Creek to a maximum of 100 cfs.

DATA USED:

- FEMA FIS for Butte Creek, performed in 1994 by Borcalli & Associates
- USACOE Operation and Maintenance Manual, "Upper Butte Creek – Part No. 2 from Little Chico Creek Diversion Structure Downstream 9.3 Miles." 1960.
- Diversion rating curves from FIS backup reference USACOE Design Memo #2, 1957.

ASSUMPTIONS:

- Although no as-built construction drawings are available for the diversion structure, the following values were derived from the diversion rating curves in the FIS backup:
    1. Existing weir crest for the diversion weir is at El. 300 (0 cfs discharge point on the "Weir Flow to Diversion" curve).
    2. Invert at Little Chico Creek weir structure is at El. 296 (0 cfs discharge point on the "Orifice Flow to Downstream Little Chico Creek" curve).
- The existing 100-year peak flow upstream of the diversion structure is approximately 5600 cfs. Based on results from the Little Chico Creek Improvement analysis, the maximum flow that can be allowed to spill to Little Chico Creek at this location is 100 cfs. Therefore, 5500 cfs will be required to spill over the Diversion weir. Although this flow point lies outside of the rating curve definition, the curve can be extrapolated to determine the head on the weir required to pass this flow rate.

ANALYSIS:

The Little Chico – Butte Creek Diversion structure is located on Little Chico Creek at the head of the Little Chico Creek to Butte Creek Diversion Channel. The portion of the existing structure that controls flow to Little Chico Creek consists of a reinforced concrete structure with four openings each 4 feet wide by 9 feet high and invert at streambed. This outlet has been modeled in the rating curve using the orifice equation and currently passes low water flows (up to approximately 900 cfs) downstream to Little Chico Creek. The portion of the diversion structure that controls the flow downstream to the Diversion channel consists of an ungated 100-foot long concrete ogee weir. Measurements performed in the field indicate that the crest of the weir is approximately 2.5 feet above the invert of the channel upstream. Although the USACOE documentation indicates that the crest of the weir is 4 feet above the channel invert, it is likely that sediment transport has occurred over the years following the drafting of the USACOE O&M Manual and deposited material against the weir crest, effectively raising the channel invert elevation.

ATTACHMENTS:

- Copy of Little Chico Creek Diversion Rating Curve (from FIS backup)
- Cost estimate

RESULTS:

In order to pass 5500 cfs, the Diversion weir requires approximately 5.6 feet of head. The weir crest of the Diversion weir can only be lowered 2.5 feet before reaching the invert of the existing channel. Although the channel at this location could potentially be excavated to further increase the spill capacity to the diversion, it is not desirable to do so as this could result in shutting off the low flow connection to Little Chico Creek. However, it is desirable to lower the weir in order to minimize the impacts to the water surface profile upstream of the Diversion. Lowering the weir crest 1-foot would allow the weir spill at a lower elevation and reduce the upstream water surface increase to less than 1-foot.

In order to utilize the existing Diversion weir structure, the water surface at the Diversion would have to reach a stage of approximately El. 305.6 in order to pass the 100-year storm flow. The structure controlling the flow to Little Chico would then have to be modified to close off the existing 4-foot by 9-foot openings, and accommodate a low flow orifice or pipe connection of 100 cfs capacity with an overflow weir at El. 304.6. This would involve removing or significantly modifying the existing structure.

The estimated cost of modifying the Diversion structure is $214,000 (see Cost Estimate, attached).

LITTLE CHICO DIVERSION STRUCTURE MODIFICATION

OPINION OF PROBABLE CONSTRUCTION COST SUMMARY

DESCRIPTION	% of Total Cost	COST, $	TOTAL COST, $
CONSTRUCTION ADMINISTRATION		**20,768**	**20,768**
CONTRACT ADMIN/SUBMITTAL PROCESSING	2.0%	2,308	2,308
MOBILIZATION AND DEMOBILIZATION	3.0%	3,461	3,461
PERFORMANCE/PAYMENT BOND	2.0%	2,308	2,308
LIABILITY INSURANCE	1.0%	1,154	1,154
OVERHEAD AND PROFIT	10.0%	11,538	11,538
SITE AND CIVIL WORK			**75,377**
STRUCTURAL			**40,000**
ENGINEERING AND DESIGN			**36,538**
CONSTRUCTION SUPPORT SERVICES			**6,923**
PROJECT CONTINGENCY	20.0%		**34,787**
TOTAL			**214,000**

BUTTE CREEK
LEVEE RAISING PROJECT
To Reach 3' Freeboard Under Existing Conditions
COSTS

Components of Work	Amount, $
Project Management	320,919
Topographic Surveying and Mapping	240,000
Utilities/Infrastructure Coordination	40,000
Geotechnical Investigation/Construction Testing/Levee Certification	678,334
Environmental Compliance/Permitting	202,000.00
Preliminary Engineering/Plans and Specifications	638,000
Land Acquisition/ Flood Easements	210,000
Construction Documents, Bidding and Contract Award	10,000
Utility/Infrastructure Coordination/Relocation	210,000
Construction Cost (See Table on Next Page)	18,514,626
Construction Contract Administration	925,731
Operations and Maintenance Manual	10,000
TOTAL	**21,999,610**

Butte Creek Levee Construction Cost

(To Achieve 3ft of Freeboard Under Existing Channel Conditions)

ITEM	UNIT	UNIT PRICE	QTY	EXTENDED
MOBILIZATION/DEMOBILIZATION	LS	$667,915.79	1	$667,915.79
CLEARING AND GRUBBING	ACRE	$1,118.00	70.02	$78,283.38
LEVEE STRIPPING	ACRE	$2,300.00	91.24	$209,850.39
LEVEE KEYWAY/INSPECTION TRENCH EXCAVATION	CY	$5.22	137,957	$720,402.01
BORROW SITE EXCAVATION	CY	$7.58	644,960	$4,888,796.78
HAULING	CY	$5.00	709,456	$3,547,279.99
BORROW SITE RECLAMATION	ACRE	$550.00	100	$55,000.00
COMPACTED LEVEE EMBANKMENT	CY	$2.74	507,003	$1,389,187.38
OPERATING ROAD	SY	$7.55	235,497	$1,777,999.83
EROSION CONTROL SEEDING	ACRE	$1,913.00	117	$223,603.65
STOPLOG FLOOD BARRIER - RAILROAD	LS	$51,975.00	2	$103,950.00
STOPLOG FLOOD BARRIER - ROAD	LS	$34,320.00	4	$137,280.00
TRAFFIC CONTROL	LS	$94,150.00	1	$94,150.00
CONSTRUCTION SURVEYS	LS	$110,000.00	1	$110,000.00
BONDING AND INSURANCE	LS	$1,402,623.16	1	$1,402,623.16

SUBTOTAL	$15,428,854.76
20% CONTINGENCY	$3,085,770.95
TOTAL	$18,514,625.71
Per Mile:	$1,383,753.79

BUTTE CREEK
LEVEE RAISING PROJECT
To Reach 3' of Freeboard Under Existing C onditions and
Increased Little Chico Creek-Butte Creek Diversion Flow
COSTS

Components of Work	Amount, $
Project Management	320,919
Topographic Surveying and Mapping	240,000
Utilities/Infrastructure Coordination	40,000
Geotechnical Investigation/Construction Testing/Levee Certification	678,334
Environmental Compliance/Permitting	202,000.00
Preliminary Engineering/Plans and Specifications	638,000
Land Acquisition/ Flood Easements	210,000
Construction Documents, Bidding and Contract Award	10,000
Utility/Infrastructure Coordination/Relocation	210,000
Construction Cost (see Table on Next Page)	18,946,225
Construction Contract Administration	947,311
Operations and Maintenance Manual	10,000
TOTAL	**22,452,789**

Butte Levee Construction Cost

(To Achieve 3' of Freeboard Under Existing Channel Conditions As Well As Increase the Little Chico Creek-Butte Creek Diversion flow)

ITEM	UNIT	UNIT PRICE	QTY	EXTENDED
MOBILIZATION/DEMOBILIZATION	LS	$683,485.75	1	$683,485.75
CLEARING AND GRUBBING	ACRE	$1,118.00	70.02	$78,283.38
LEVEE STRIPPING	ACRE	$2,300.00	91.24	$209,850.39
LEVEE KEYWAY/INSPECTION TRENCH EXCAVATION	CY	$5.22	137,957	$720,402.01
BORROW SITE EXCAVATION	CY	$7.58	664,644	$5,038,000.72
HAULING	CY	$5.00	731,108	$3,655,541.42
BORROW SITE RECLAMATION	ACRE	$550.00	100	$55,000.00
COMPACTED LEVEE EMBANKMENT	CY	$2.74	526,687	$1,443,121.26
OPERATING ROAD	SY	$7.55	235,497	$1,777,999.83
EROSION CONTROL SEEDING	ACRE	$1,913.00	117	$223,603.65
STOPLOG FLOOD BARRIER - RAILROAD	LS	$51,975.00	2	$103,950.00
STOPLOG FLOOD BARRIER - ROAD	LS	$34,320.00	4	$137,280.00
TRAFFIC CONTROL	LS	$94,150.00	1	$94,150.00
CONSTRUCTION SURVEYS	LS	$110,000.00	1	$110,000.00
BONDING AND INSURANCE	LS	$1,435,320.08	1	$1,435,320.08

SUBTOTAL	$15,788,520.89
20% CONTINGENCY	$3,157,704.18
TOTAL	$18,946,225.07
Per Mile:	$1,416,010.84

LCB Diversion Construction Cost

ITEM	UNIT	UNIT PRICE	QTY	EXTENDED
MOBILIZATION/DEMOBILIZATION	LS	$46,429.57	1	$46,429.57
CLEARING AND GRUBBING	ACRE	$1,118.00	16.84	$18,826.51
LEVEE STRIPPING	ACRE	$2,300.00	6.91	$15,887.55
LEVEE KEYWAY/INSPECTION TRENCH EXCAVATION	CY	$5.22	4,593	$23,982.70
BORROW SITE EXCAVATION	CY	$7.58	18,341	$139,021.00
HAULING	CY	$5.00	20,175	$100,872.75
BORROW SITE RECLAMATION	ACRE	$550.00	10	$5,500.00
COMPACTED LEVEE EMBANKMENT	CY	$2.74	13,748	$37,668.98
OPERATING ROAD	SY	$7.55	52,810	$398,715.50
EROSION CONTROL SEEDING	ACRE	$1,913.00	10	$19,869.05
STOPLOG FLOOD BARRIER - ROAD	LS	$34,320.00	2	$68,640.00
TRAFFIC CONTROL	LS	$47,075.00	1	$47,075.00
CONSTRUCTION SURVEYS	LS	$30,000.00	1	$30,000.00
BONDING AND INSURANCE	LS	$97,502.10	1	$97,502.10
			SUBTOTAL	$1,072,523.10
			20% CONTINGENCY	$214,504.62
			TOTAL	$1,287,027.72

HAULING				**per mile:**	$0.10	million
AVE DISTANCE		5				
LOAD TIME		2				
TRAVEL TIME		50				
UNLOAD		5				
		57	TOTAL TIME			
	$	74.10	PER LOAD			
	$	**4.94**	PER YARD			

traffic control

	quantity	cost/day	duration (d	total cost
cms	4	175	30	$21,000.00
flaggers	4	350	47.25	$66,150.00
signage	20		350	$7,000.00
				$47,075.00

Operating Road

Width	Length	Area (syd)	Both Sides
15	15843	26405	52810

		Levee Volume				Keyway Volume				Levee Stripping				Clearing and Grubbing				Erosion Control		
Station	Channel Center Line (ft)	Left Bank (ft^3)	Right Bank (ft^3)	Total (yd^3)		Left Bank (ft^3)	Right Bank (ft^3)	Total (yd^3)		Left Bank (ft^2)	Right Bank (ft^2)	Total (Acre)		Left Bank (ft^2)	Right Bank (ft^2)	Total (Acre)		Left Bank (ft^2)	Right Bank (ft^2)	Total (Acre)
				507003				**137957**				**91**				**70**				**117**
				369231				**90092**				**2683712**				**1776150**				**3389292**
2000	0																			
4418	2418	117805	653706	28574		204502	145709	12971		83119	116463	199582		60450	60450	120900		110394	137560	247954
4537	119	5175	43974	1820		12697	2838	575		4206	6582	10789		2975	2975	5950		5575	7535	13110
Bridge																				
4563	26	1611	7333	331		2628	310	109		637	682	1318		325	325	650		799	836	1634
4610	47	2326	11261	503		6104	1803	293		1962	2485	4447		1175	1175	2350		2513	3011	5523
6945	2335	409431	338003	27683		95315	113026	7716		108554	110259	218813		58375	58375	116750		130725	136119	266844
9285	2340	958757	412062	50771		28162	98128	4677		151281	117129	268410		58500	58500	117000		172540	144472	317012
10935	1650	471768	461175	34553		20600	52817	2719		84546	94677	179223		41250	41250	82500		102242	110657	212900
12285	1350	158659	405155	20882		73521	32461	3925		56565	75836	132401		33750	33750	67500		72468	87710	160178
12526	241	23177	39519	2322		11311	4211	575		8866	9486	18352		6025	6025	12050		11610	11962	23572
Bridge																				
12554	28	653	752	52		139	153	11		300	310	610		350	350	700		447	458	905
12615	61	2892	10167	484		983	1065	76		1633	2470	4103		1525	1525	3050		2301	3105	5406
14776	2161	142875	637938	28919		34446	51864	3197		61167	127391	188558		54025	54025	108050		86213	150481	236694
17309	2533	575244	949064	56456		42668	67378	4076		113884	160111	273995		63325	63325	126650		145268	188784	334052
20297	2988	635294	743265	51058		169943	77046	9148		157094	134535	291629		74700	74700	149400		192412	168553	360965
24180	3883	131109	62283	7163		201198	43431	9060		131575	44091	175667		97075	97075	194150		172794	65953	238746
26308	2128	140086	32952	6409		89514	32484	4518		72863	29643	102506		53200	53200	106400		96058	41198	137256
28502	2194	142413	67806	7786		87431	52459	5181		72106	56956	129062		54850	54850	109700		96152	81211	177363
28641	139	3632	4365	296		1284	2385	136		3176	3369	6546		3475	3475	6950		4643	4902	9544
Bridge																				
28661	20	367	639	37		89	170	10		204	244	448		250	250	500		308	352	660
28695	34	827	1129	72		441	566	37		776	849	1625		850	850	1700		1133	1218	2351
31456	2761	90464	144373	8698		41360	131548	6404		69591	86129	155720		69025	69025	138050		99037	116694	215731
33185	1729	30456	223465	9404		24725	89078	4215		21759	64941	86701		43225	43225	86450		31010	84012	115022
34509	1324	41799	189411	8563		53238	70655	4589		23051	52450	75501		33100	33100	66200		30426	66948	97374
36422	1913	213692	93527	11378		61895	79131	5223		66697	39178	105875		47825	47825	95650		87348	49815	137162
37328	906	100258	8625	4033		4530	5884	386		29862	9033	38895		22650	22650	45300		39547	13762	53309
37560	232	10485	16029	982		2640	4519	265		6204	6734	12937		5800	5800	11600		8706	9319	18025
Bridge				**137772**				**47865**				**1283214**				**1268238**				**1692725**
37585	25	734	2979	137		160	325	18		281	476	757		313	313	625		414	625	1038
37605	20	513	2277	103		256	520	29		433	745	1178		500	500	1000		644	981	1625
37615	10	209	1069	47		128	259	14		206	361	567		250	250	500		310	479	789
37663	48	953	3743	174		549	865	52		966	1518	2484		1200	1200	2400		1466	2062	3528
Bridge																				
37681	18	357	913	47		91	91	7		179	246	425		225	225	450		273	345	618
37792	111	1101	2816	145		560	562	42		1106	1517	2623		2775	2775	5550		1683	2126	3810
39500	1708	0	171927	6368		0	27217	1008		31632	38088	69721		21350	42700	64050		40258	47286	87544
41988	2488	194014	349838	20143		50258	112122	6014		97890	105864	203755		31100	62200	93300		125644	133568	259212
42088	100	21841	7920	1102		3951	4427	310		4732	3586	8318		2500	2500	5000		5997	4729	10726
42118	30	6013	2274	307		1138	627	65		1370	921	2291		750	750	1500		1742	1260	3001
42178	60	10834	3841	544		3227	694	145		2876	1751	4627		1500	1500	3000		3616	2426	6043
43759	1581	447075	264272	26346		71090	28418	3685		91611	63912	155523		39525	39525	79050		111555	82259	193815
46252	2493	565649	559766	41682		101166	128178	8494		133936	128390	262326		62325	62325	124650		164862	157632	322494
49730	3478	224922	366390	21900		107070	168735	10215		85333	130755	216088		86950	86950	173900		124599	169587	294187
51354	1624	0	33284	1233		0	15063	558		0	20146	20146		20300	40600	60900		8120	28948	37068
53649	2295	101014	27976	4777		147993	56388	7570		56342	31901	88243		28688	57375	86063		68965	44087	113052
53690	41	5233	694	220		3136	1220	161		1786	945	2730		1025	1025	2050		2235	1372	3606
53759	69	5770	326	226		828	358	44		1311	631	1942		1725	1725	3450		1687	983	2670
Bridge																				
53799	40	0	0	0		0	0	0		0	0	0		500	500	1000		0	0	0
53959	160	13346	0	494		1949	0	72		3054	0	3054		4000	4000	8000		3902	0	3902
55504	1545	138926	8876	5474		28335	8436	1362		44017	14446	58463		38625	38625	77250		60170	22372	82542
56276	772	36033	12433	1795		38372	23183	2280		21685	17524	39210		19300	19300	38600		29892	25565	55457
58006	1730	69485	17923	3237		75333	42506	4364		32325	23096	55421		43250	43250	86500		41797	32239	74035
60478	2472	0	0	0		0	0	0		0	0	0		30900	30900	61800		0	0	0
64288	3810	0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
66233	1945	0	0	0		0	0	0		0	15249	15249		24313	24313	48625		0	25022	25022
66462	229	0	0	0		0	0	0		0	1795	1795		5725	5725	11450		0	2946	2946
Bridge																				
66504	42	0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
66733	229	0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
69173	2440	0	9967	369		0	10992	407		0	21570	21570		30500	30500	61000		0	34001	34001
70858	1685	0	15906	589		0	16909	626		0	30330	30330		42125	42125	84250		0	47559	47559
72428	1570	0	8407	311		0	8682	322		0	14381	14381		39250	39250	78500		0	22435	22435
72581	153	0	0	0		0	0	0		0	0	0		1913	1913	3825		0	0	0
72624	43	0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
72630	6	0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
72632	2	0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
72649	17	0	0	0		0	0	0		0	0	0		0	0	0		0	0	0

Station	Channel Center Line (ft)	Levee Volume			Keyway Volume			Levee Stripping			Clearing and Grubbing			Erosion Control		
		Left Bank (ft^3)	Right Bank (ft^3)	Total (yd^3)	Left Bank (ft^3)	Right Bank (ft^3)	Total (yd^3)	Left Bank (ft^2)	Right Bank (ft^2)	Total (Acre)	Left Bank (ft^2)	Right Bank (ft^2)	Total (Acre)	Left Bank (ft^2)	Right Bank (ft^2)	Total (Acre)
				526687			**137957**			**91**			**70**			**117**
				379989			**90092**			**2683712**			**1776150**			**3389292**
2000	0															
4418	2418	131225	667126	29569	204502	145709	12971	83119	116463	199582	60450	60450	120900	110394	137560	247954
4537	119	5836	44635	1869	12697	2838	575	4206	6582	10789	2975	2975	5950	5575	7535	13110
Bridge																
4563	26	1755	7477	342	2628	310	109	637	682	1318	325	325	650	799	836	1634
4610	47	2587	11522	523	6104	1803	293	1962	2485	4447	1175	1175	2350	2513	3011	5523
6945	2335	422390	350962	28643	95315	113026	7716	108554	110259	218813	58375	58375	116750	130725	136119	266844
9285	2340	971744	425049	51733	28162	98128	4677	151281	117129	268410	58500	58500	117000	172540	144472	317012
10935	1650	480926	470333	35232	20600	52817	2719	84546	94677	179223	41250	41250	82500	102242	110657	212900
12285	1350	166151	412648	21437	73521	32461	3925	56565	75836	132401	33750	33750	67500	72468	87710	160178
12526	241	24515	40857	2421	11311	4211	575	8866	9486	18352	6025	6025	12050	11610	11962	23572
Bridge																
12554	28	809	908	64	139	153	11	300	310	610	350	350	700	447	458	905
12615	61	3230	10505	509	983	1065	76	1633	2470	4103	1525	1525	3050	2301	3105	5406
14776	2161	154868	649932	29807	34446	51864	3197	61167	127391	188558	54025	54025	108050	86213	150481	236694
17309	2533	589302	963123	57497	42668	67378	4076	113884	160111	273995	63325	63325	126650	145268	188784	334052
20297	2988	651877	759848	52286	169943	77046	9148	157094	134535	291629	74700	74700	149400	192412	168553	360965
24180	3883	152660	83834	8759	201198	43431	9060	131575	44091	175667	97075	97075	194150	172794	65953	238746
26308	2128	151897	44762	7284	89514	32484	4518	72863	29643	102506	53200	53200	106400	96058	41198	137256
28502	2194	148501	73894	8237	87431	52459	5181	72106	56956	129062	54850	54850	109700	96152	81211	177363
28641	139	3632	4365	296	1284	2385	136	3176	3369	6546	3475	3475	6950	4643	4902	9544
Bridge																
28661	20	367	639	37	89	170	10	204	244	448	250	250	500	308	352	660
28695	34	827	1129	72	441	566	37	776	849	1625	850	850	1700	1133	1218	2351
31456	2761	90464	144373	8698	41360	131548	6404	69591	86129	155720	69025	69025	138050	99037	116694	215731
33185	1729	35254	223465	9582	24725	89078	4215	21759	64941	86701	43225	43225	86450	31010	84012	115022
34509	1324	45473	189411	8699	53238	70655	4589	23051	52450	75501	33100	33100	66200	30426	66948	97374
36422	1913	213692	93527	11378	61895	79131	5223	66697	39178	105875	47825	47825	95650	87348	49815	137162
37328	906	100258	8625	4033	4530	5884	386	29862	9033	38895	22650	22650	45300	39547	13762	53309
37560	232	10485	16029	982	2640	4519	265	6204	6734	12937	5800	5800	11600	8706	9319	18025
Bridge				**146698**			**47865**			**1283214**			**1268238**			**1692725**
37585	25	734	2979	137	160	325	18	281	476	757	313	313	625	414	625	1038
37605	20	513	2277	103	256	520	29	433	745	1178	500	500	1000	644	981	1625
37615	10	209	1069	47	128	259	14	206	361	567	250	250	500	310	479	789
37663	48	953	3743	174	549	865	52	966	1518	2484	1200	1200	2400	1466	2062	3528
Bridge																
37681	18	357	913	47	91	91	7	179	246	425	225	225	450	273	345	618
37792	111	1101	2816	145	560	562	42	1106	1517	2623	2775	2775	5550	1683	2126	3810
39500	1708	4740	176667	6719	0	27217	1008	31632	38088	69721	21350	42700	64050	40258	47286	87544
41988	2488	207823	363646	21166	50258	112122	6014	97890	105864	203755	31100	62200	93300	125644	133568	259212
42088	100	22396	8475	1143	3951	4427	310	4732	3586	8318	2500	2500	5000	5997	4729	10726
42118	30	6180	2440	319	1138	627	65	1370	921	2291	750	750	1500	1742	1260	3001
42178	60	11167	4174	568	3227	694	145	2876	1751	4627	1500	1500	3000	3616	2426	6043
43759	1581	455850	273047	26996	71090	28418	3685	91611	63912	155523	39525	39525	79050	111555	82259	193815
46252	2493	579485	573602	42707	101166	128178	8494	133936	128390	262326	62325	62325	124650	164862	157632	322494
49730	3478	244225	385693	23330	107070	168735	10215	85333	130755	216088	86950	86950	173900	124599	169587	294187
51354	1624	9013	37790	1733	0	15063	558	0	20146	20146	20300	40600	60900	8120	28948	37068
53649	2295	113752	34345	5485	147993	56388	7570	56342	31901	88243	28688	57375	86063	68965	44087	113052
53690	41	5461	921	236	3136	1220	161	1786	945	2730	1025	1025	2050	2235	1372	3606
53759	69	5962	518	240	828	358	44	1311	631	1942	1725	1725	3450	1687	983	2670
Bridge																
53799	40	0	0	0	0	0	0	0	0	0	500	500	1000	0	0	0
53959	160	13790	0	511	1949	0	72	3054	0	3054	4000	4000	8000	3902	0	3902
55504	1545	147501	13163	5951	28335	8436	1362	44017	14446	58463	38625	38625	77250	60170	22372	82542
56276	772	40318	16718	2112	38372	23183	2280	21685	17524	39210	19300	19300	38600	29892	25565	55457
58006	1730	74286	22724	3593	75333	42506	4364	32325	23096	55421	43250	43250	86500	41797	32239	74035
60478	2472	0	0	0	0	0	0	0	0	0	30900	30900	61800	0	0	0
64288	3810	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66233	1945	5397	5397	400	0	0	0	0	15249	15249	24313	24313	48625	0	25022	25022
66462	229	635	635	47	0	0	0	0	1795	1795	5725	5725	11450	0	2946	2946
Bridge																
66504	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66733	229	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
69173	2440	6771	16738	871	0	10992	407	0	21570	21570	30500	30500	61000	0	34001	34001
70858	1685	9352	25258	1282	0	16909	626	0	30330	30330	42125	42125	84250	0	47559	47559
72428	1570	4357	12764	634	0	8682	322	0	14381	14381	39250	39250	78500	0	22435	22435
72581	153	0	0	0	0	0	0	0	0	0	1913	1913	3825	0	0	0
72624	43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
72630	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
72632	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
72649	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

			Levee Volume				Keyway Volume				Levee Stripping				Clearing and Grubbing				Erosion Control		
Station		Channel Center Line (ft)	Left Bank (ft^3)	Right Bank (ft^3)	Total (yd^3)		Left Bank (ft^3)	Right Bank (ft^3)	Total (yd^3)		Left Bank (ft^2)	Right Bank (ft^2)	Total (Acre)		Left Bank (ft^2)	Right Bank (ft^2)	Total (Acre)		Left Bank (ft^2)	Right Bank (ft^2)	Total (Acre)
					13748				**4593**				**7**				**17**				**10**
5050				0	0		0	0	0		0	0	0		0	0	0		0	0	0
5390		340		14576	14576		0	7233	7233		0	8075	8075		8500	8500	17000		0	11720	11720
10376		4986		41327	41327		0	28691	28691		0	87440	87440		124650	124650	249300		0	138379	138379
10465		89		298	298		0	384	384		0	1446	1446		2225	2225	4450		0	2344	2344
14210		3745		96537	96537		0	60539	60539		0	80189	80189		93625	93625	187250		0	119510	119510
14677		467		13498	13498		0	7717	7717		0	10493	10493		11675	11675	23350		0	15425	15425
15208		531		3044	3044		0	2480	2480		0	4980	4980		13275	13275	26550		0	10357	10357
15583		375		1678	1678		0	1130	1130		0	3261	3261		9375	9375	18750		0	7057	7057
15708		125		1483	1483		0	912	912		0	2227	2227		3125	3125	6250		0	3521	3521
15736		28		1675	1675		0	542	542		0	748	748		700	700	1400		0	1058	1058
15741		5		488	488		0	155	155		0	174	174		125	125	250		0	233	233
15832		91		10717	10717		0	3835	3835		0	3522	3522		2275	2275	4550		0	4618	4618
16142		310		35717	35717		0	8134	8134		0	11505	11505		7750	7750	15500		0	14972	14972
19203		3061		140129	140129		0	0	0		0	75861	75861		76525	76525	153050		0	106824	106824
19693		490		10022	10022		0	2250	2250		0	10410	10410		12250	12250	24500		0	15563	15563

INSPECTOR	113	CONSTRUCTION DAYS (COUNTING SATURDAYS)
	100	DAILY MILES (42*2+15 SITE MILES)
	0.4	$/MILE
	$4,520.00	COST
CM	21	WEEKS
	1	TRIPS PER WEEK
	21	TOTAL TRIPS
	90	DAILY MILES (42*2+5 SITE MILES)
	0.4	$/MILE
	$756.00	COST
	$5,276.00	TOTAL MILEAGE

WOOD RODGERS

3301 C Street, Building 100-B
Sacramento, California 95816
Tel: (916) 341-7760
Fax: (916) 341-7767

PROJECT: Butte Creek JOB #: 8230.001

FEATURE: Hydraulic Analysis BY: JPP DATE: 5/23/05

ITEM: Butte Creek channel excavation (terracing) between setback levees

PURPOSE:

The purpose of this analysis is to determine the hydraulic impact and cost estimate for channel excavation (terracing) along Butte Creek downstream of the Durham-Dayton Highway.

DATA AVAILABLE:

- FEMA FIS for Butte Creek, performed in 1994 by Borcalli & Associates, HEC-1 model filename: "ALL100.DAT."

ASSUMPTIONS:

- Improvements will focus on the benched areas between the top of channel banks and the setback levees on either side of the Creek.
- The benched areas will be excavated to a depth equivalent to half the distance between the existing bench elevation and the invert of the channel (half the depth of the existing channel).
- Manning's roughness coefficient for the excavated sections is assumed to be equivalent to the existing channel roughness (n = 0.042).

ANALYSIS:

The HEC-2 file from the FIS was modified to reflect channel excavation (terracing) in Butte Creek downstream of the Durham-Dayton Highway, beginning at river station 49730 and terminating at the downstream end of the model. Upstream of this location, the levees are not setback from the top of bank.

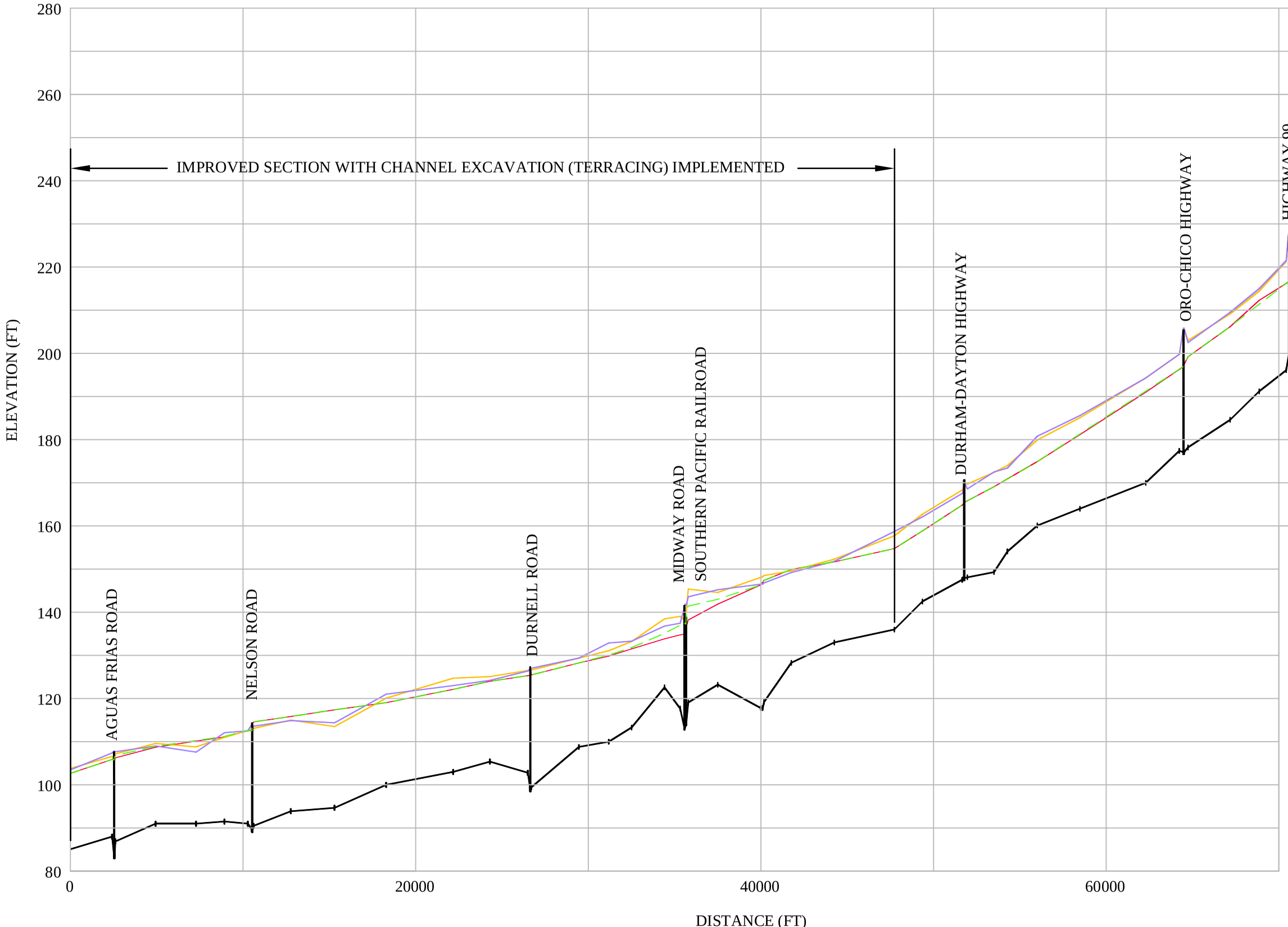
ATTACHMENTS:

- Figure 1, Profiles
- Table 1, Quantities calculation sheet
- Table 2, Cost Estimate

RESULTS:

Excavating the benched areas along Butte Creek to increase the channel conveyance capacity has varying degrees of effectiveness. Depending on the location, these improvements lower the 100-year WSEL between 0 and 2.27 feet (see Figure 1). The most significant benefit was identified in the vicinity of the Midway Road crossing, between river stations 41988 and 31456. Outside of this section, channel excavation has minimal impacts on the 100-year WSEL.

If improvements were implemented between river stations 41988 and 31456 only, noticeable increases to freeboard in the vicinity of Midway Road can be realized. To excavate in this two mile section only would require the removal of approximately 3.5 million cubic yards of material from the benched areas along Butte Creek (see Table 1). The cost of implementing this improvement is estimated to be approximately $66 million (see Table 2).



LEGEND

- CHANNEL INVERT
- EXISTING 100-YEAR WSEL
- PROPOSED 100-YEAR WSEL
- EXISTING TOP OF RIGHT BANK
- EXISTING TOP OF LEFT BANK

BUTTE CREEK WATERSHED FLOODPLAIN MANAGEMENT PLAN

BUTTE CREEK
WATER SURFACE PROFILES
CHANNEL IMPROVEMENT ALTERNATIVE

WOOD RODGERS
ENGINEERING • MAPPING • PLANNING • SURVEYING

FIGURE 1

TABLE 1

CITY OF WOODLAND
STORM DRAINAGE FACILITIES MASTER PLAN
TECHNICAL MEMORANDUM - CLARK PACIFIC - PARCEL A - ALTERNATIVE A

OPINION OF PROBABLE COST

Item			Quantity	Unit	Unit Cost, $[1]	Cost, $
1.	Conveyance Channel					
	a.	Channel Excavation (incl. Haul & Dump within 1 mile)	113,196	cy	4.33	490,140
	b.	Channel Inlet Drain Structures	1	ls	2500.00	2,500
	c.	County Road 102 Box Culverts (2 - 5'x10')	160	lf	375.00	60,000
	d.	Aggregate Surfacing - Access Road	7,067	sy	3.38	23,885
	e.	Dewatering	1	ls	50000.00	50,000
	f.	Temporary Outlet Control Structure	2	ea	5000.00	10,000
	Subtotal					636,525
Construction Contingency @ 25%						159,131
	Subtotal					795,657
Engineering, Surveying, and Contract Administration @ 20%						127,305
	Subtotal					922,962
2.	Storm Drain (Inlet Pipe)					
	a.	Excavation	6,530	cy	1.80	11,755
	b.	Structural Backfill/Compaction	4,367	cy	2.74	11,964
	c.	Pipe Installation (60" Diameter)	2,250	lf	209	470,250
	d.	Manholes	4	ea	1,600	6,400
	Subtotal					500,369
Construction Contingency @ 25%						125,092
	Subtotal					625,462
Engineering, Surveying, and Contract Administration @ 20%						100,074
	Subtotal					725,535
Total (Construction Costs Only)						1,648,497
Land Acquisition						
	a.	Channel Corridor	11.2	ac	15,000	168,320
	b.	Habitat Mitigation (Estimate)	11.2	ac	1,500	16,832
	Subtotal					185,152
TOTAL						1,833,649

[1]Unit costs are based upon 2003 price levels.

12/3/03

TABLE 2

BUTTE CREEK
CHANNEL IMPROVEMENT ALTERNATIVE

OPINION OF PROBABLE COST

Item			Quantity	Unit	Unit Cost, $[1]	Cost, $
1.	Butte Creek Channel Improvement					
	a.	Bulk Excavation (drag line, 3cy in unclasified soil)	3,527,950	cy	3.82	13,476,769
	b.	Haul (5 mile roundtrip, 16.5 cy truck)	3,527,950	cy	7.25	25,577,638
	c.	Place and shape stockpile	3,527,950	cy	1.59	5,609,441
	d.	Mobilization/Demobilization (5%)	1	ls	2233192	2,233,192
	Subtotal					46,897,039
Construction Contingency @ 20%						9,379,408
	Subtotal					56,276,447
Engineering, Surveying, and Contract Administration @ 20%						9,379,408
	Subtotal					65,655,855
Total (Construction Costs Only)						66,000,000

[1]Unit costs are based upon RS Means Heavy Construction 2005 price levels.

TABLE 1

BUTTE CREEK
CHANNEL IMPROVEMENT ALTERNATIVE

QUANTITIES

River Station	Left Bank Sta	Right Bank Sta	Center	Distance Between Bank Stations ft	SS	Approx Levee Height ft	Cut Bottom Width ft	Existing Bench Invert El. ft	Channel Invert El. ft	Improvement Invert El. ft.	Estimated Area Cross-section cut ft^2	End-Area Method Incremental Volume cy	End-Area Method Cum. Volume cy	Notes
49730	11600	12052	11826	452	3	8	404	144	136	140	1712	0	0	
46252	18910	19723	19316.5	813	3	8	765	144.7	133	138.85	4616	407548	407548	
43759	17832	18610	18221	778	3	8	730	141.3	128.3	134.8	4901	439352	846900	
42178	17000	17540	17270	540	3	8	492	140.5	119.2	129.85	5495	304383	1151283	
42118	17027	17530	17278.5	503	3	8	455	139.9	117.9	128.9	5269	11960	1163243	
42088	17003	17507	17255	504	3	8	456	139.8	117.8	128.8	5280	5861	1169104	
41988	17000	17530	17265	530	3	8	482	139.5	117.8	128.65	5490	19945	1189049	Beginning of Midway Improvement Section
39500	15544	16522	16033	978	3	8	930	132.5	123.2	127.85	4436	457340	1646389	
37792	19100	20193	19646.5	1093	3	8	1045	133	119.1	126.05	7430	375306	2021695	
37681	19218	20140	19679	922		8	922	n/a	114.3		0	15272	2036967	Railroad Embankment
37663	19218	20140	19679	922		8	922	n/a	114.3		0	0	2036967	Railroad Embankment
37615	19201	20184	19692.5	983	3	8	935	135.1	113.7	124.4	10261	9121	2046088	
37605	19201	20184	19692.5	983	3	8	935	135	113.6	124.3	10261	3800	2049889	
37585	19201	20184	19692.5	983	3	8	935	134.8	113.3	124.05	10309	7619	2057507	
37560	19201	20184	19692.5	983	3	8	935	134.7	113.3	124	10261	9523	2067031	
37328	18610	19831	19220.5	1221	3	8	1173	132	117.7	124.85	8559	80856	2147887	
36422	19711	21211	20461	1500	3	8	1452	130.8	122.6	126.7	6052	245126	2393012	
34509	20946	22912	21929	1966	3	8	1918	127.1	113.3	120.2	13400	689084	3082096	
33185	20284	22387	21335.5	2103	3	8	2055	125	110	117.5	15593	710848	3792944	
31456	20648	22502	21575	1854	3	8	1806	123.3	108.8	116.05	13268	924054	4716999	End of Midway Improvement Section
28695	23292	24567	23929.5	1275	3	8	1227	120	99.4	109.7	12885	1337183	6054182	
28661	23343	24585	23964	1242	3	8	1194	119.5	99	109.25	12485	15974	6070155	
28641	23343	24585	23964	1242	3	8	1194	119.5	99	109.25	12485	9248	6079403	
28502	23393	24699	24046	1306	3	8	1258	119.7	102.8	111.25	10833	60021	6139424	
26308	23172	24852	24012	1680	3	8	1632	118	105.4	111.7	10433	864018	7003441	
24180	22303	23203	22753	900	3	8	852	116.5	103	109.75	5913	644146	7647587	
20297	22974	23588	23281	614	3	8	566	113	100	106.5	3835	700953	8348540	
17309	23346	24097	23721.5	751	3	8	703	107	94.7	100.85	4471	459601	8808142	
14776	24592	25406	24999	814	3	8	766	107.2	93.9	100.55	5253	456153	9264295	
12615	24203	24989	24596	786	3	8	738	106.5	90.5	98.5	6096	454190	9718486	
12554	24150	24804	24477	654	3	8	606	106	89.6	97.8	5166	12722	9731207	
12526	24150	24804	24477	654	3	8	606	106	89.6	97.8	5166	5357	9736565	
12285	24201	24992	24596.5	791	3	8	743	106	91	98.5	5753	48729	9785294	
10935	24149	24901	24525	752	3	8	704	103.7	91.5	97.6	4441	254833	10040126	
9285	24020	24862	24441	842	3	8	794	99.8	91	95.4	3599	245667	10285793	
6945	24794	25602	25198	808	3	8	760	99.8	91	95.4	3450	305448	10591241	
4610	25480	26174	25827	694	3	8	646	97.8	86.9	92.35	3652	307057	10898298	
4563	25496	26187	25841.5	691	3	8	643	99	83.5	91.25	5169	7677	10905975	
4537	25496	26187	25841.5	691	3	8	643	99	83.5	91.25	5169	4978	10910953	
4418	25538	26228	25883	690	3	8	642	95.8	88	91.9	2597	17115	10928068	
2000	24523	25366	24944.5	843	3	8	795	95.7	85.1	90.4	4341	310673	**11238741**	

RSMeans				
COST DATA 2001				
Excavation and Load into Trucks	2300	2315	400	260
Haul, Dump, and Spread Material Within 1 Mile	2300	2320	200	2160
Road Preparation and Surfacing	2900	2920	340	3200
	2300	2315	300	5040
	2700	2720	200	1520
Compacted Embankment				
Road Surfacing	2700	2720	200	1520
3'x5' Concrete Culvert Installation	2500	2530	730	100
	A12.3-110	12.3-110	3540	
4'x8' Concrete Culvert Installation	2500	2530	730	200
	A12.3-110	12.3-110	3560	
5'x8' Concrete Culvert Installation	2500	2530	730	200
	A12.3-110	12.3-110	3560	
Pavement Replacement	2700	2750	100	500
Excavation/Backfill/Compaction/Spoil Removal	A12.3-110	12.3-110	3560	