Fish Passage Assessment
at the State Park Bridge on San Julian Road
Gaviota Creek, California

Prepared for:

California Department of Fish and Game

And

Pacific States Marine Fisheries Commission

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NATURAL RESOURCE ASSESSMENT AND RESTORATION SERVICES

October 8, 2007

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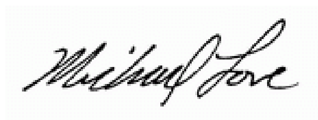
The final report, including analysis and recommendations contained within, was prepared by:



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Fish Passage Assessment at the State Park Bridge on San Julian Road, Gaviota Creek, California

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1. Summary of Findings

This report quantifies the fish passage conditions at the State Park Bridge on San Julian Road over the mainstem of Gaviota Creek. Passage conditions were assessed for adult steelhead, adult rainbow trout, and juvenile trout following the California Department of Fish and Game (CDFG) fish passage assessment protocol (Taylor and Love, 2003). The primary hydraulic feature evaluated was the water surface drop downstream of the crossing.

CDFG and NOAA requirements for a water surface drop over grade control structures is 1 foot maximum for adult steelhead and 0.5 feet for resident trout and juvenile salmonids. Under all flow conditions, the State Park Bridge at San Julian Road experiences drop heights of three feet and greater. Therefore, this crossing is categorized as RED (impeding passage for all target species and life stages) under the CDFG assessment protocol and presents a substantial impediment to all salmonids, including the strongest swimming adult steelhead trout.

The historic nature of the bridge and structural role of the concrete revetment wall on the left channel bank upstream of the bridge makes lowering the channel reach through the bridge section infeasible without costly improvements to the retaining wall and bridge abutments. A more feasible alternative for restoring fish passage at the bridge crossing may be to construct either a roughened channel or step pool channel that would start at the bridge apron and extend approximately 125 feet downstream. This type of alternative could provide upstream passage for both adult and juvenile salmonids as well as other native fish and non-fish species within the stream.

2. Overview

This report describes the project approach and findings from the assessment of existing fish passage conditions at the State Park Bridge on San Julian Road, on the mainstem of Gaviota Creek in Southern Santa Barbara County. This report is a supplement to the Gaviota Creek Fish Passage and Geomorphic Assessment prepared by Michael Love and Associates and Stoecker Ecological, dated March 15, 2007. This work was funded through California Department of Fish and Game's California Coastal Salmon Recovery Program and the Pacific States Marine Fisheries Commission (Grant Agreement No. AWI-SCR-11).

The San Julian Road Bridge is located approximately 180 feet downstream of the confluence with the West Fork of Gaviota Creek and about 1,100 feet downstream of the Highway 1 bridge crossing (Figure 1). The San Julian Road Bridge lies within the Gaviota State Park and is maintained by the California Department of Parks and Recreation (DPR).

The San Julian Road Bridge on Gaviota Creek was identified as barrier GA16 in a recent steelhead habitat and passage assessment report (Stoecker, 2002). The earlier assessment was for the entire southern portion of Santa Barbara County and passage was assessed based primarily on professional judgment. The study identified the crossing as a low to moderate severity barrier (Severity = 0.5) due to a 1 to 2 foot drop over a grouted riprap grade control structure under the bridge. However, following the high flow events of 2005, CDFG staff noticed that the drop over the grade control structure had dramatically increased.

The intent of the current assessment is to quantify the fish passage conditions at the bridge crossing following the California Department of Fish and Game (CDFG) fish passage assessment protocol (Taylor and Love, 2003). Tasks included taking standard measurements of the bridge crossing and stream channel and using the CDFG protocol to analyze fish passage conditions at fish migration flows. Passage conditions were assessed for adult steelhead, adult rainbow trout, and juvenile trout. The primary hydraulic feature evaluated was the water surface drop downstream of the crossing.

3. Site Description

The crossing is a historic truss bridge with a 73 foot free-span and a deck width of 20 feet. The bridge appears to have been constructed in 1909, as indicated by the historic plaque mounted on the western approach. The stream channel under the bridge is constructed of grouted riprap and sections of broken concrete apron, which is undercut within the active channel (Figure 2). The grouted riprap functions as a grade control, protecting the bridge abutments from scour and preventing channel incision. Presently, there is a residual drop in the channel profile of approximately 4.6 feet, measured from the grouted riprap to the tailwater control of the plunge pool. This drop creates an obvious barrier to upstream fish migration. The tailwater plunge pool formed by the drop is approximately 33 feet long and the residual depth of the pool is 3.6 feet.

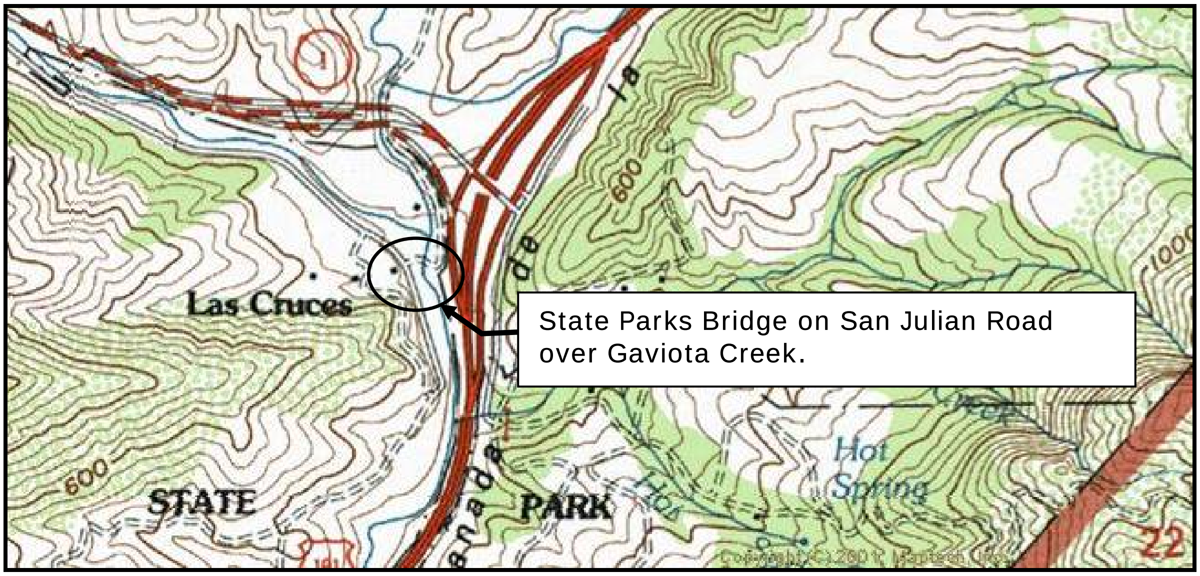

Figure 1 – Location of the Sate Park Bridge on San Julian Road shown on the USGS 7.5 minute Solvang quadrangle.

Upstream of the bridge crossing (Figure 3), the left channel bank (looking downstream) is constructed of a sloping concrete revetment wall, which extends over 1,000 feet upstream to the Highway 1 bridge crossing. The concrete wall is part of the channel realignment and Highway 1 to 101 interchange project. Running along the top of the wall is a ranch road and an on-ramp to Highway 101. The sloping concrete wall is 10 to 15 feet tall and is at roughly a 1H:1V slope. The right bank is unarmored. The concrete that spans the channel bottom at the bridge crossing is higher in elevation than the upstream channel bed, creating a backwater condition during low flows. During the time of the survey the resulting still water within the active channel was dense in herbaceous vegetation and algae.

Downstream of the bridge crossing and scour pool (Figure 4) is a 60 foot long natural reach consisting of unarmored channel banks and an extensive cobble bar along the left side of the channel. A sacrete wall begins on the right channel bank approximately 60 feet downstream of the crossing. During the time of the survey dense herbaceous vegetation and algae choked the active channel downstream of the scour pool in the vicinity of the tailwater cross section.

4. Fish Observations

As with downstream reaches previously surveyed on Gaviota Creek, juvenile steelhead trout (*Oncorhynchus mykiss*) were observed adjacent to this fish passage barrier. Prior to surveying the structure Matt Stoecker snorkeled the downstream pool and found two juvenile steelhead parr ranging from 4-5 inches in length (Figure 5). In addition, over forty Arroyo chub (*Gila orcutti*), one Southwestern pond turtle (*Actinemys marmorata pallida*), and 15 non-native crawfish were observed in the downstream pool. No fish or other aquatic species were observed upstream of the barrier to the confluence of the West Fork Gaviota Creek. While the downstream scour pool provides good rearing habitat for steelhead and other aquatic species, the bridge apron that creates it is an obvious barrier, hindering or blocking upstream migration of these native fish and other aquatic organisms.

Figure 2 – Looking upstream at the State Park Bridge at San Julian Road. Note undercut broken concrete and grouted riprap within the active channel. The concrete spans the channel and ponds water upstream of the crossing.

Figure 3 – Looking upstream from the crossing. Note concrete revetment wall on right bank. The left bank is natural and vegetated with dense riparian plants.

Figure 4 – Looking upstream towards the tailwater cross section and the crossing.

Figure 5 – One of two juvenile steelhead trout observed in the plunge pool downstream of the bridge apron.

5. Methodology

4.1 Field Survey

The field survey was conducted on July 12th, 2007 following the CDFG fish passage assessment protocol (Taylor and Love, 2003). A field survey of the crossing and stream channel included taking standard measurements of the bridge crossing, surveying a longitudinal profile through the crossing, surveying a channel cross section across the top of the grouted riprap grade control apron and at the tailwater control below the crossing, visually characterizing streambed material, and measuring active channel widths upstream of the crossing within accessible areas.

Data from the field survey was entered into spreadsheets for analysis. Channel slope was computed, and plots were made of the cross sections and longitudinal profile (Attachment 1).

4.2 Hydrology and Fish Passage Flows

Peak Flow Estimates

As part of the CDFG fish passage inventory protocol, the capacity of the channel under the bridge was assessed to determine its ability to accommodate peak flood flows. Magnitudes of peak flows associated with varying recurrence intervals were estimated using a probabilistic analysis of the annual peak flows (20 years of record) from Gaviota Creek at Gaviota (USGS Gage No. 11120550). The peak flows were then scaled to the contributing drainage area of the crossing. Table 1 shows the estimated flows associated with the 2 through 100 year recurrence intervals for Gaviota Creek at the San Julian Road Bridge.

Table 1 - Peak flow estimates for the State Park Bridge over Gaviota Creek at San Julian Road (drainage area = 16.76 mi^2) and associated recurrence intervals.

2-year Flow	=	934 cfs
5-year Flow	=	2,535 cfs
10-year Flow	=	4,130 cfs
25-year Flow	=	6,500 cfs
50-year Flow	=	8,634 cfs
100-year Flow	=	11,009 cfs

Calculated using probabilistic analysis of peak flow record from USGS Gaviota Creek at Gaviota, adjusted by drainage area. Analysis followed USGS Bulletin 17B procedures (USGS 1982), which is based on a Log Pearson Type 3 distribution.

Fish Passage Flows

Analyzing fish passage conditions requires defining a range of flows for which passage should be provided. Generally, passage is not required at extremely low or high flows, when fish are not expected to be moving.

Methods for determining the lower and upper passage flows are defined by NOAA Fisheries (2001) and CDFG (2002) for adult steelhead, adult resident rainbow trout, and juvenile trout. Between the lower and upper passage flows hydraulic conditions at the stream crossing should be adequate for the target species and lifestage. A stream crossing that provides adequate passage conditions at all flows between the lower and upper fish passage flow is considered to be "100% passable" for that species and lifestage. A high number of stream crossings are not 100% passable, but fall into the partial or complete barrier categories. Many block adult steelhead at some flows and juvenile salmonids at all flows.

The lower and upper passage flows are defined in terms of exceedance flows (Table 2). Exceedance flows, which are obtained from flow duration curves (FDC's), express the average amount of time within a year that flows are above a certain threshold. For example, flows within the stream are greater than the 25% exceedance flow one quarter of the time during the course of an average water year.

Because no stream flow gage is maintained on Gaviota Creek at the State Park Bridge on San Julian Road, exceedance flows were obtained from the USGS *Gaviota Creek at Gaviota* stream gage (USGS Gage No. 11120550) and then adjusted to the drainage area at the crossing. The fish passage flows were then determined for adult steelhead, adult resident rainbow trout, and juvenile salmonids (Table 3) using the constructed FDC for the site (Figure 6) and the fish passage design flow criteria provided by NOAA Fisheries and CDFG.

Fish Passage Criteria Assessment

The primary hydraulic feature evaluated at each fish passage flow was the water surface drop over the grade control structure below the bridge. The CDFG (2002) and NOAA Fisheries (2001) recommend assessment of water surface drops were applied. Because the channel bed consists of natural substrate upstream and downstream of the crossing, water velocities and depths were not considered in the fish passage analysis.

Although the CDFG and NOAA guidelines were originally developed for culverts, the drop height criteria can be applied to grade control structures. CDFG and NOAA requirements for water surface drop over grade control structures is 1 foot maximum for adult steelhead and 0.5 feet for resident trout and juvenile salmonids. Because the CDFG protocol was developed for culvert crossings, some modifications to the assessment process were necessary to apply them to this bridge crossing. These modifications included evaluating the hydraulic conditions of the bridge crossing assuming uniform flow over the grade control structure.

Modeling was performed using FishXing version 3.0. Model input included surveyed cross sections, channel slope, and an estimate of hydraulic roughness. Water surface elevations and resultant water surface drop heights from the bridge crossing to the channel below were then computed at each fish passage flow.

The hydraulics at the bridge cross section was evaluated using the surveyed water surface slope of 0.0031 ft/ft and a Manning's n value of 0.035 to characterize the smooth surface of the grouted riprap and broken concrete at the crossing.

Table 2 – Fish passage flow criteria as defined by NOAA Fisheries (2001) and CDFG (2002).

Species and Lifestage	Lower Passage Flow	Upper Passage Flow
Adult Steelhead	50% exceedance flow or 3 cfs (whichever is greater)	1% exceedance flow
Adult Rainbow Trout	90% exceedance flow or 2 cfs (whichever is greater)	5% exceedance flow
Juvenile Salmonids	95% exceedance flow or 1 cfs (whichever is greater)	10% exceedance flow

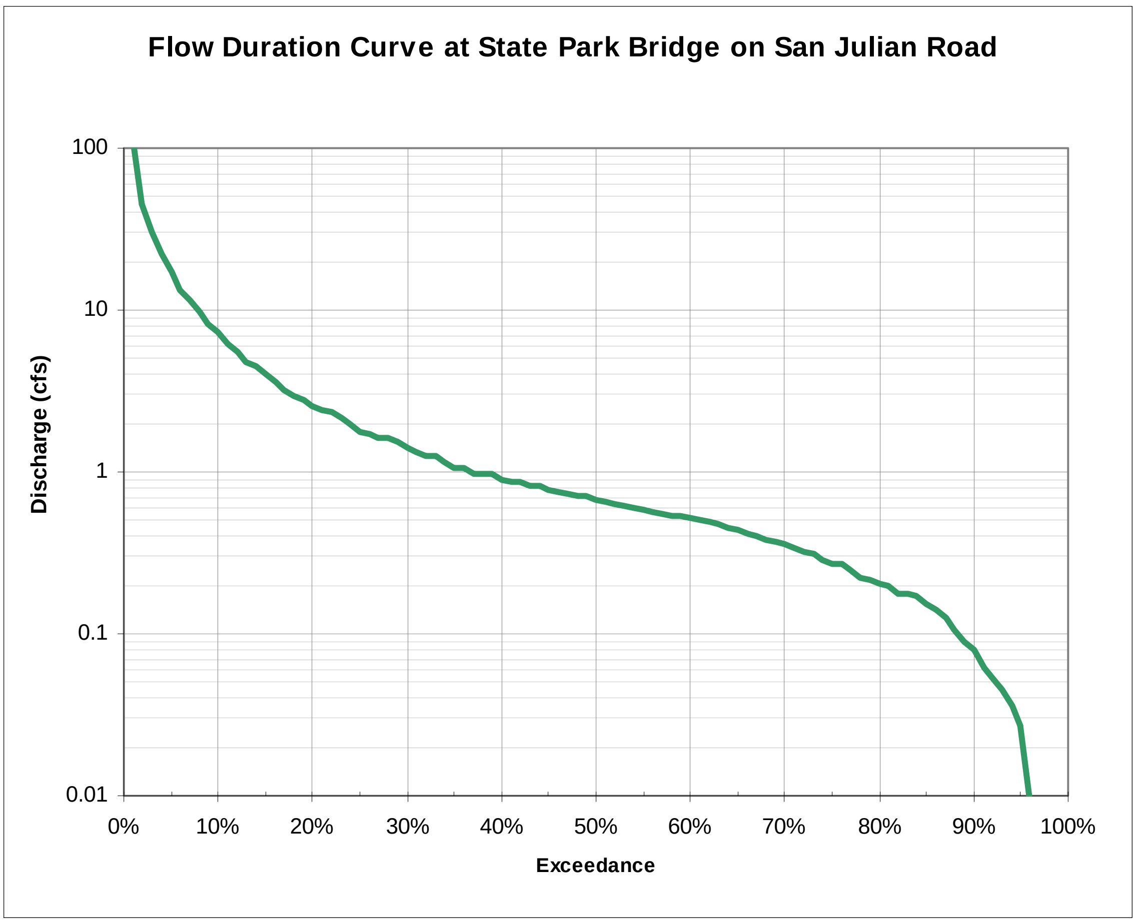

Figure 6 – Flow duration curve for Gaviota Creek at the State Park Bridge on San Julian Road, constructed from Gaviota Creek at Gaviota daily average streamflow records (USGS Gage No. 11120550) scaled by drainage area.

Table 3 – Fish passage flows for Gaviota Creek at the State Park Bridge on San Julian Road determined from the flow duration curve constructed for the site.

	Fish Passage Flows					
	Adult Steelhead		Adult Resident Rainbow Trout		Juvenile Salmonids	
Location	Lower	Upper	Lower	Upper	Lower	Upper
State Park Maintained San Julian Road Bridge on Gaviota Creek	3 cfs	102.5 cfs	2 cfs	16.9 cfs	1 cfs	7.2 cfs

The downstream tailwater control cross section was modeled using the surveyed thalweg slope of 0.0074 ft/ft. To evaluate the possible seasonal impacts of the in-channel vegetation growth on channel roughness, this section was evaluated under two tailwater control scenarios for each fish passage flow.

The first tailwater control scenario (Smoother Tailwater Scenario) used a Manning's n values of 0.035 to simulate "smoother" channel conditions when the vegetation is not present or when flows may have pressed it flat. A lower "n" value results in shallower, higher velocity flows and a larger water surface drop.

The second scenario (Rougher Tailwater Scenario) used a Manning's n values of 0.05 to simulate "rougher" channel conditions when the vegetation is dense. A higher "n" value results in deeper, slower flows, and may result in less of a water surface drop from the bridge cross section.

6. *Findings*

5.1 Fish Passage Conditions

Figure 7 and Table 4 present water surface elevations and total water surface drop between the bridge cross section and two tailwater control cross section for each scenario. Figure 8 illustrates the minimum computed drop height for the San Julian Road Bridge crossing. At all fish passage flows the drop exceeds the maximum recommended by CDFG and NOAA Fisheries. The smallest water surface drop occurs at the upper adult steelhead passage flow, and at least 3.0 feet. The drop heights shown in Figure 8 would likely function as a complete barrier to upstream migrating juvenile and resident trout, and a substantial impediment to most upstream migrating adult steelhead.

5.2 Channel Capacity at Bridge

The channel under the bridge can convey roughly a 25-year flood event before the bottom of the bridge deck is wetted. This estimate is based on uniform flow assumptions at the bridge cross section and is considered to be conservative, especially in light of the age of the bridge. A small change in the estimated the water surface slope substantially influences the predicted channel capacity. Therefore, detailed open channel flow modeling, such as with the Army Corps of Engineers HEC-RAS model, is required to develop a more accurate estimate of the channel capacity at the bridge.

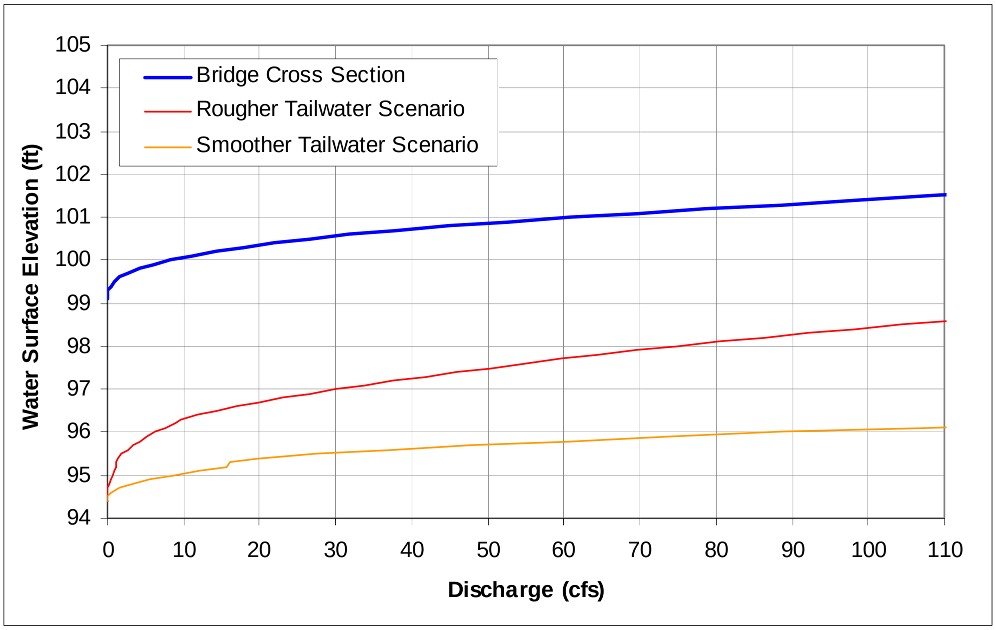

Figure 7 – Results of modeled water surface elevations for the crossing and two tailwater scenarios across the range of fish passage flows.

Table 4 – Predicted water surface drop at the crossing at fish passage flows for two tailwater scenarios. The two scenarios account for the varying hydraulic roughness resulting from seasonal changes in herbaceous vegetation density within the downstream channel.

Fish Passage Condition	**Discharge**	**Total Drop with Rougher Tailwater Scenario (n = 0.05)**	**Total Drop with Smoother Tailwater Scenario (n = 0.035)**
Lower Juvenile Flow	1 cfs	4.3 ft	4.8 ft
Lower Adult Resident Rainbow Trout Flow	2 cfs	4.1 ft	4.9 ft
Lower Adult Steelhead Flow	3 cfs	4.1 ft	4.9 ft
Upper Juvenile Flow	7.2 cfs	3.9 ft	5.0 ft
Upper Adult Resident Rainbow Trout Flow	16.9 cfs	3.7 ft	5.0 ft
Upper Adult Steelhead Flow	102.5 cfs	**3.0 ft**	**5.4 ft**
Residual Drop	0 cfs	4.6 ft	

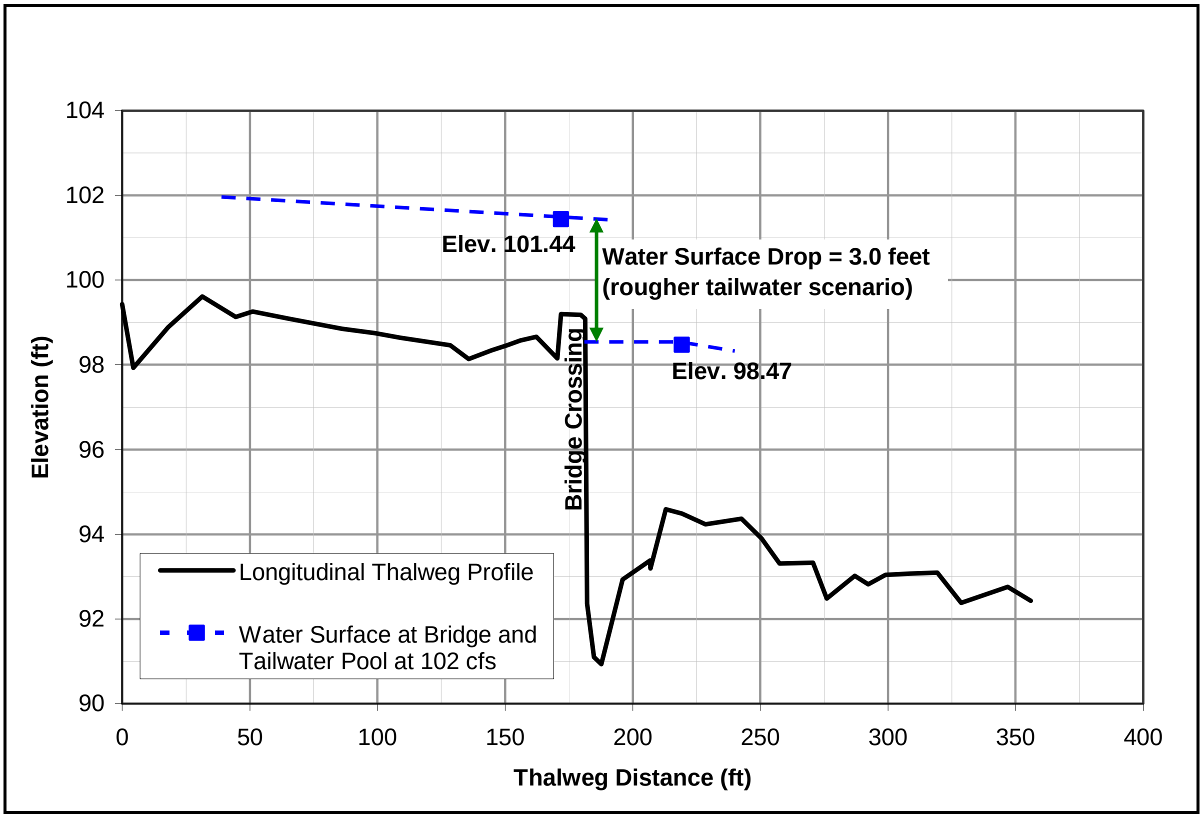

Figure 8 – Predicted water surface elevations at the bridge and tailwater pool at the Upper Adult Steelhead Passage Flow of 102 cfs. Shown water surface elevations are for the rougher tailwater scenario.

7. Recommendations

The historic nature of the bridge and structural role of the concrete revetment wall on the left channel bank upstream of the bridge crossing presents a significant constraint when considering site retrofits for fish passage. Lowering the channel reach through the bridge section is likely infeasible without costly improvements to the retaining wall and bridge footings. Allowing the upstream channel to incise could also threaten the structural stability of upstream crossings and create new fish passage barriers.

A viable alternative may be to construct either a roughened channel or step pool channel starting at the downstream limit of the concrete apron under the bridge. A roughened channel approach consists of a uniformly sloped natural channel reach constructed of a gradation of larger boulders, cobbles and smaller sediments that creates roughness and flow diversity to facility passage for fish of varying species and size (Bates 2003). Roughened channels have been successfully used in a wide variety of settings and is the most stable type of grade control for this site.

Step pool channels are similar to roughened channels, constructed with boulders and other rock gradation, but are formed in a series of steps or cascades, interspersed with low sloped pools. For both a roughened channel or step pools, channel slopes should be in the range of 3 to 8%.

Drops between weirs should be kept to roughly 6 inches to provide passage for juvenile and resident trout and to effectively dissipate the streamflow's energy.

Initial calculations indicated that a roughened channel could be designed to eliminate the drop over the existing bridge apron, provide adequate fish passage, and remain stable up to a relatively high design flow (i.e. 50 or 100 year peak flow). Figure 9 shows a schematic profile of a possible roughened channel alternative starting at the downstream limit of the concrete apron under the bridge and running 130 foot downstream at a 4.5% slope. The roughened channel would end near the upstream limits of the sacrete wall. The existing grouted riprap apron would be removed as part of this alternative. This would allow the top end of the roughened channel to be roughly 0.5 feet lower than the existing apron, which would increase the capacity of the channel under the bridge.

We recommend initiation of conceptual fish passage design phase for the crossing, which should include (1) conducting a detailed topographic survey, (3) field investigation of the structural integrity of the bridge abutments and channel revetment at and adjacent to the crossing, (3) modeling existing hydraulic conditions including channel capacity using HEC-RAS or similar software, (4) exploring the feasibility of various roughened channel or step-pool channel configurations, and (5) developing schematic drawings of a preferred design alternative. Even though there are numerous partial barriers downstream, some of them severe, addressing fish passage at this crossing will likely help persuade CalTrans to address passage at there downstream barriers.

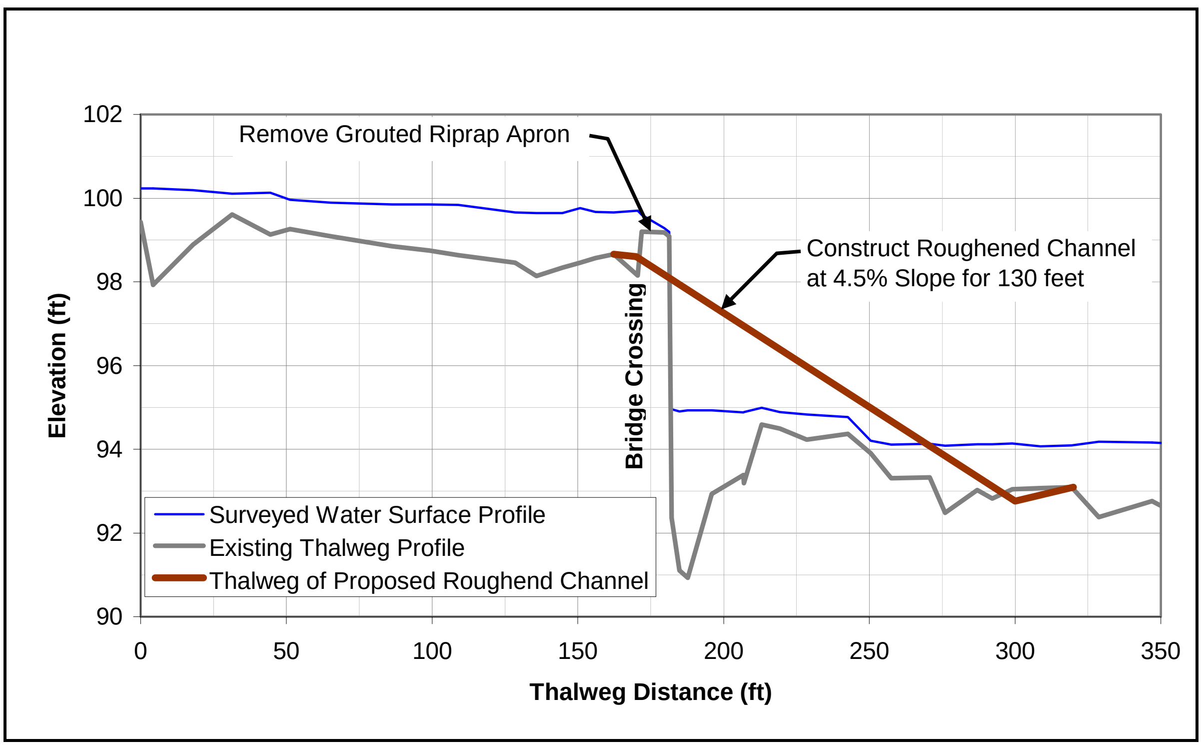

Figure 9 –Potential feasible fish passage retrofit includes construction of a roughened channel that runs from the downstream end of the bridge down to the upstream end of the sacrete revetment. The roughened channel would be approximately 130 long and have an overall slope of 4.5%.

8. References

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ATTACHMENTS

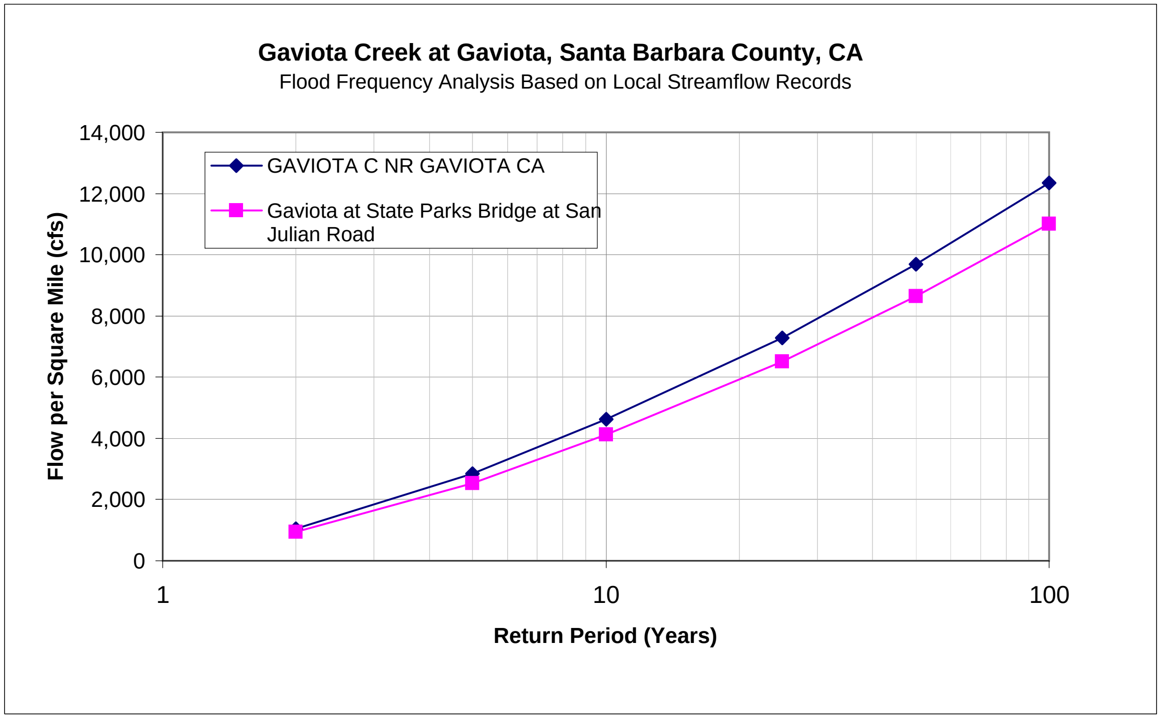
Gaviota Creek at Gaviota, Santa Barbara County, CA

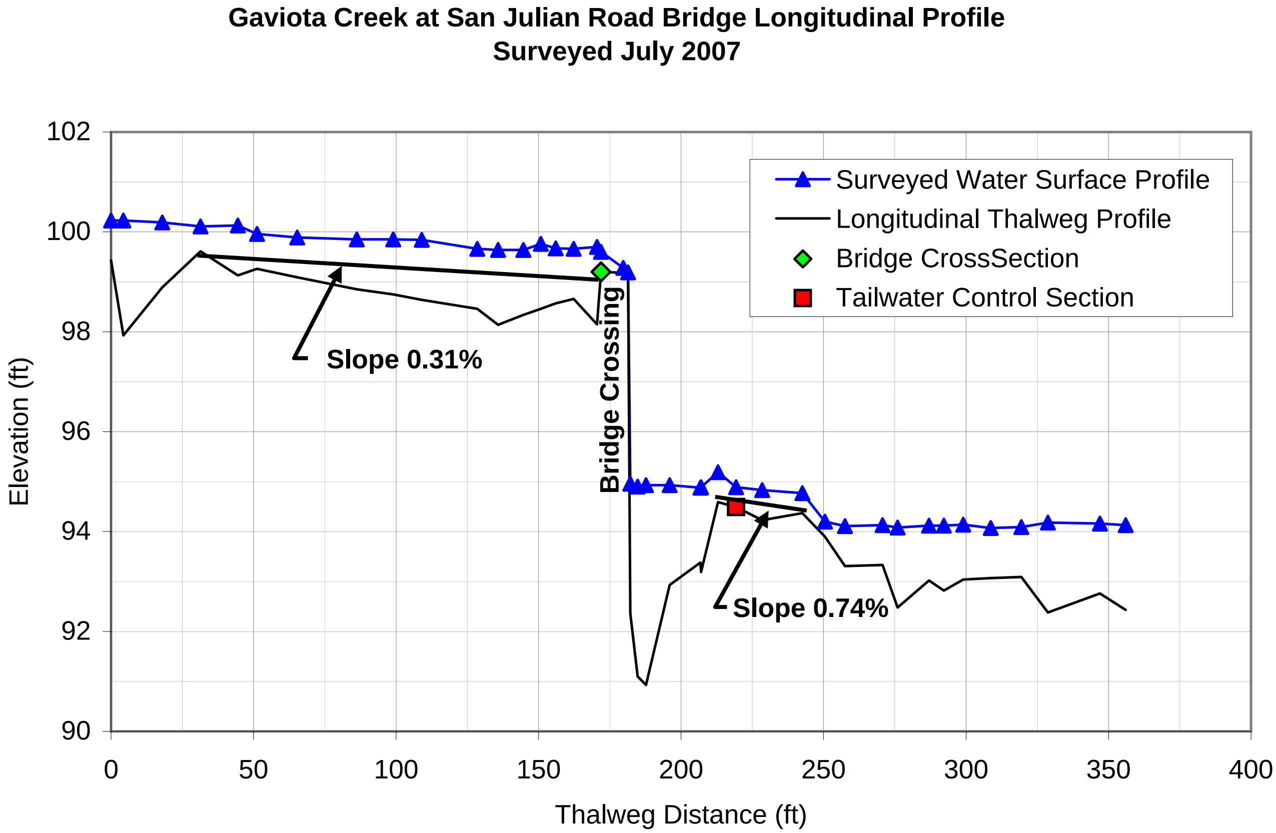
Flood Frequency Analysis Based on Local Streamflow Records

Peak flows associated with the 2-yr, 25-yr, 50-yr, and 100-yr recurrence intervals were estimated using a Log-Pearson type III distribution as described in Bulletin 17B (Guidelines for Determining Flood Flow Frequency, USGS, 1982).

Site Name	Location		Drainage Area (mi^2)	Record Length (yrs)	Recurrence Interval of Peak Flows 2-yr (cfs)	5-yr (cfs)	10-yr (cfs/mi^2)	25-yr (cfs/mi^2)	50-yr (cfs/mi^2	100-yr (cfs/mi^2
GAVIOTA C NR GAVIOTA CA	34°29'16"	120°13'34"	18.8	20	1,048	2,843	4,632	7,291	9,684	12,348
Average Discharge per Sq. Mi. (cfs/mi^2)					55.7	151.2	246.4	387.8	515.1	656.8

					Recurrence Interval of Peak Flows (cfs)					
Gaviota at State Parks Bridge at San Julian Road			16.761		934	2535	4130	6500	8634	11009





Gaviota Creek at San Julian Road Bridge Longitudinal Profile
Surveyed July 2007
Surveyed Water Surface Profile
Longitudinal Thalweg Profile
Bridge CrossSection
Tailwater Control Section
Slope 0.31%
Bridge Crossing
Slope 0.74%
Elevation (ft)
Thalweg Distance (ft)
102
100
98
96
94
92
90
0
50
100
150
200
250
300
350
400

San Julian Bridge on Gaviota Creek
Long Profile Surveyed July 2008

Assumed Elevations

TBM1	100	ft	on rock of apron

TP#	Survey Stn	FS/BS	Ht of Rod	Ht of Inst.	Elev	Notes
TBM1	1	BS	4.61	104.61	**100.00**	on rock of apron
1	1	FS	4.72	104.61	**99.89**	
1	2	BS	4.87	104.76	**99.89**	
2	2	FS	5.41	104.76	**99.35**	
2	3	BS	0.76	100.11	**99.35**	
3	3	FS	5.31	100.11	**94.80**	
3	4	BS	4.14	98.94	**94.80**	TBM2, station 261.2

Survey Profile

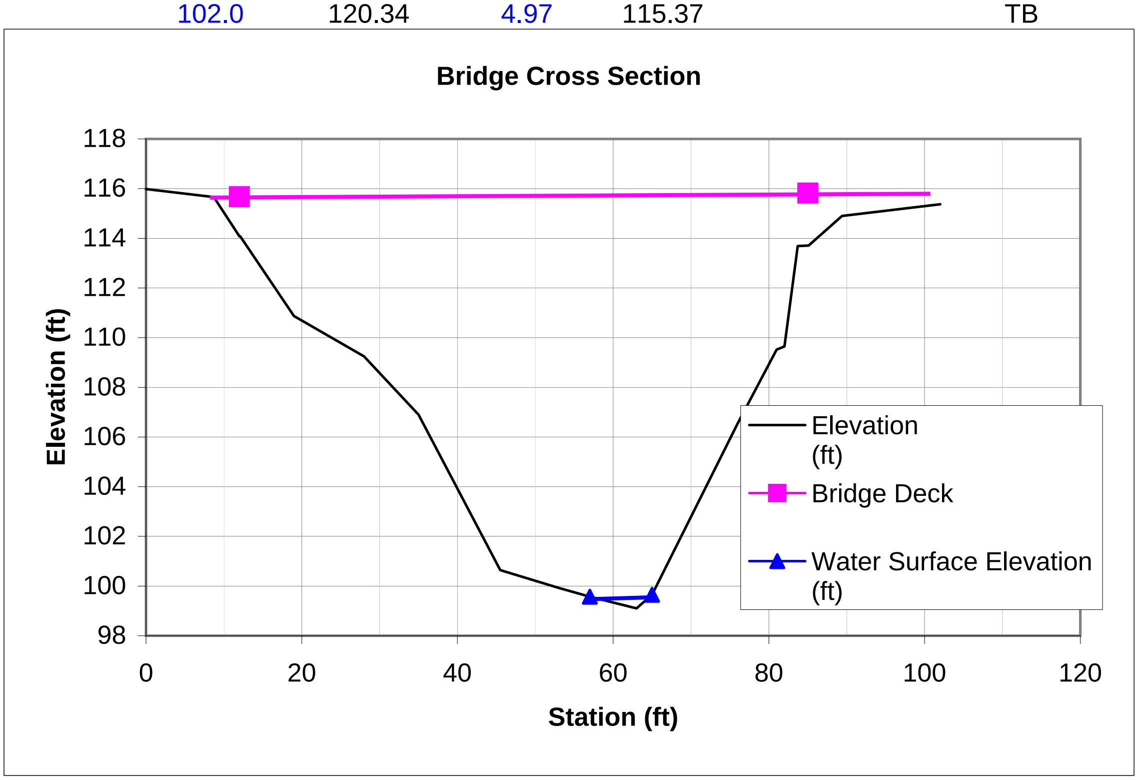
Suvey Stn	**Station (ft)**	**Ht of Instrument (ft)**	**Ht of Rod (ft)**	**Elevation (ft)**	**Water Depth (ft)**	**WS Elev (ft)**	**Note**
1	0.0	104.61	5.18	99.43	0.80	100.23	TH
1	4.3	104.61	6.68	97.93	2.30	100.23	TH
1	18.0	104.61	5.72	98.89	1.30	100.19	TH
1	31.4	104.61	5.00	99.61	0.50	100.11	TH
1	44.5	104.61	5.48	99.13	1.00	100.13	TH
1	51.2	104.61	5.35	99.26	0.70	99.96	TH on conc revet wall
1	65.3	104.61	5.52	99.09	0.80	99.89	TH on conc toe
1	86.2	104.61	5.76	98.85	1.00	99.85	TH on conc wall
1	99.0	104.61	5.86	98.75	1.10	99.85	TH on conc wall
1	109.0	104.61	5.97	98.64	1.20	99.84	TH on conc wall
1	128.5	104.61	6.15	98.46	1.20	99.66	TH on conc wall
2	135.81	104.76	6.62	98.14	1.50	99.64	TH
2	144.7	104.76	6.42	98.34	1.30	99.64	TH US end of missing slab chunk
2	150.8	104.76	6.30	98.46	1.30	99.76	US end bridge deck
2	156.0	104.76	6.19	98.57	1.10	99.67	missing slab chunk
2	162.3	104.76	6.10	98.66	1.00	99.66	end of broken slab
2	170.5	104.76	6.61	98.15	1.55	99.70	DS end bridge, on conc
2	171.9	104.76	5.56	99.20	0.40	99.60	on conc of RSP & wakk
2	179.7	104.76	5.58	99.18	0.10	99.28	
2	181.4	104.76	5.67	99.09	0.10	99.19	top of drop
2	182.2	104.76	12.40	92.36	2.60	94.96	toe drop in pool
2	184.8	104.76	13.66	91.10	3.80	94.90	TH, pool
2	187.7	104.76	13.83	90.93	4.00	94.93	TH, pool
2	196.0	104.76	11.83	92.93	2.00	94.93	TH, pool
2	206.8	104.76	11.38	93.38	1.50	94.88	TH, pool
3	207.0	100.11	6.92	93.19	1.70	94.89	TH, pool, close to shot as 206.8
3	213.0	100.11	5.52	94.59	0.60	95.19	TH, pool
3	219.3	100.11	5.62	94.49	0.40	94.89	TH-TWC
3	228.5	100.11	5.88	94.23	0.60	94.83	TH-CHNL
3	242.6	100.11	5.74	94.37	0.40	94.77	TH-gravel and cobbles
3	250.5	100.11	6.21	93.90	0.30	94.20	TH-veg, cattails and willows
3	257.5	100.11	6.80	93.31	0.80	94.11	TH
4	270.7	98.94	5.61	93.33	0.80	94.13	TH
4	276.0	98.94	6.46	92.48	1.60	94.08	TH
4	287.0	98.94	5.92	93.02	1.10	94.12	TH (BR on chnl sides)
4	292.2	98.94	6.12	92.82	1.30	94.12	TH (BR on chnl sides)
4	299.0	98.94	5.90	93.04	1.10	94.14	TH US end sacrete on RT side
4	308.7	98.94	5.87	93.07	1.00	94.07	TH
4	319.4	98.94	5.85	93.09	1.00	94.09	TH
4	328.7	98.94	6.56	92.38	1.80	94.18	TH on sacreteTH
4	347.0	98.94	6.18	92.76	1.40	94.16	TH
4	356.0	98.94	6.51	92.43	1.70	94.13	TH on conc @ DS end of sacrete on RT bank

Assumed Elevations

	TBM1	100	ft	rock of apron
Rod to TBM	20.34	120.34	HI	

DS Bridge Face, Profile Stn. 170.5

Station (ft)	Ht of Instrument (ft)	Ht of Rod (ft)	Elevation (ft)	Bridge Deck	Water Surface Elevation (ft)	Note
0.0	120.34	4.36	115.98			on asphalt
8.7	120.34	4.68	115.66			G
12.0	120.34	6.26	114.08	115.67		G @ right side bridge
12.1	120.34	4.67	114.08			bridge deck
19.0	120.34	9.47	110.87			G
28.0	120.34	11.09	109.25			TB
35.0	120.34	13.44	106.90			G
45.5	120.34	19.70	100.64			RAC, edge grout
53.0	120.34	20.41	99.93			
57.0	120.34	20.77	99.57		99.57	REW
63.0	120.34	21.24	99.10			TW on slab
65.0	120.34	20.69	99.65		99.65	LEW on slab
76.0	120.34	13.79	106.55			3/4 way up slab
81.0	120.34	10.82	109.52			Top of LB slab
82.0	120.34	10.69	109.65			L edge concrete top
83.7	120.34	6.65	113.69			bridge footing
85.0	120.34	6.63	113.71	115.82		end bridge left
85.1	120.34	4.52	113.71			end bridge deck
89.4	120.34	5.44	114.90			top EMB
102.0	120.34	4.97	115.37			TB



Assumed Elevations

	TBM1	100 ft	rock of apron
Rod to TBM1	4.28	104.28 HI	

TW EX at Profile STN 220.5

Station (ft)	Ht of Instrument (ft)	Ht of Rod (ft)	Elevation (ft)	Water Depth (ft)	Water Surface Elevation (ft)	Note
-3			108.63			TB from shot info stn 0 (5'UP, 3'OUT)
0.0	104.28	0.65	103.63			midway up bank, top is 5'up, 3-out
7.0	104.28	7.80	96.48			TOE RB
17.4	104.28	8.45	95.83			TOE RAC
18.8	104.28	9.51	94.77		94.77	TOE REW
23.8	104.28	9.87	94.41	0.30	94.71	TH
27.7	104.28	9.70	94.58		94.58	LEW
30.0	104.28	8.92	95.36			CH
38.6	104.28	9.04	95.24			CH
50.6	104.28	8.05	96.23			CH
62.0	104.28	7.97	96.31			CH
66.0	104.28	9.10	95.18			
75.7	104.28	8.25	96.03			TOE LAC
83.5	104.28	6.35	97.93			
84.7	104.28	4.50	99.78			TOP TERRACE & DEBRIS LINE
104.3	104.28	3.00	101.28			TOE OF VERT BANK
111.0	104.28	0.24	104.04			TERRACE FILLED W/ WILLOW
123.0			120.04			TB from shot info stn 111 (16'UP, 12'OUT)