3 7/11 MINING REACH METHODS AND RESULTS

3.1 Flow Conditions since Project Construction

Tuolumne River flows and the timing of project construction and monitoring are shown in Figure 3-1. Water year conditions since project construction was completed were Below Normal (WY 2003), Dry (WY 2004), and Wet (WY 2005 and 2006). In WY 2003 and WY 2004, flow in the river was maintained at or near minimum flows required by the FSA, and annual peak flows occurred during spring pulses released for outmigrating juvenile Chinook salmon. Annual peak flows[5] were 1,360 cfs ($Q_{1.2}$) in April 2002, 1,760 cfs ($Q_{1.3}$) in April 2003, and 3,100 cfs ($Q_{1.6}$) in March 2004 and did not exceed the 5,000-cfs threshold for post-project monitoring. In WY 2005, daily average flow exceeded 5,000 cfs for 27 days March–May[6]. Annual peak flow was 8,410 cfs (Q_{11}) (April 1, 2005). As of June 25, 2006, daily average flow in WY 2006 flow exceeded 5,000 cfs for 86 days, including 12 days in January and 74 days March–June. Flows are expected to continue to exceed 5,000 cfs into the summer 2006. Daily average flow peaked at 8,850 cfs on May 7, 2006. The effects of flow on interpreting monitoring results are discussed in Section 4.

3.2 Hydraulics and Channel Morphology (H1, H2, H3, H4)

3.2.1 Methods

Hydraulic and geomorphic monitoring included low-altitude aerial photography, cross section and long profile surveys, digital terrain mapping, and flow stage monitoring during high flows (i.e., flows exceeding 1,500 cfs). Pre-project, as-built, and post-project aerial photographs are described in Table 4.

3.2.1.1 <u>Channel and Floodplain Surveys</u>

Pre-project channel morphology was surveyed in 1998 and 1999. On August 10–11, 1998, twelve cross sections were established and surveyed during flows of 944 cfs (Table 28). Cross sections were resurveyed July 28-August 3, 1999, during flows of 254-277 cfs. Cross section elevation was surveyed using an auto-level and stadia rod; horizontal stationing was determined using a 300-foot tape stretched across the channel. Nine as-built cross sections (six pre-project and three newly installed) were surveyed on October 18, 2002, during a flow of 338 cfs (Figure 3-2, Table 28). The as-built thalweg longitudinal profile was surveyed on November 12, 2002, during a flow of 186 cfs. As-built cross sections and channel profile were surveyed using a total station.

All surveys are relative to the NGVD 1929 vertical datum. Post-construction total station surveys and end pin locations are also referenced to the NAD 83, California State Plane, Zone III coordinate system. Cross section endpoints were marked with 1/2-inch rebar. As-built cross section endpoints were also mapped by KSN Engineering using survey-grade kinematic GPS. Cross section naming follows the same stationing described for SRP 9 (Section 2.2.1).

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[5] Annual flow maxima at the U.S. Geological Survey streamflow gauge Tuolumne River below La Grange Dam near La Grange, Ca. (number 11289650).

[6] May 2005 high flows were released for bedload transport monitoring for the Tuolumne River Coarse Sediment Transfusion Project.

Table 28. 7/11 Reach pre-construction and as-built cross sections and years of survey.

Cross Section	Year Surveyed		
	1998	1999	2002
2141+60	●	●	
2147+00		●	
2162+20	●	●	●
2168+40	●	●	●
2176+00	●	●	
2181+00	●	●	●
2194+00	●	●	
2198+30			●
2199+20	●	●	●
2207+00	●	●	●
2208+60			●
2214+50	●	●	●
2221+10			●
2233+00	●	●	
2247+00	●	●	

Flow did not exceed the 5,000-cfs monitoring threshold during the funded monitoring period. Flow stage was surveyed at 1,030 cfs on April 23, 2003, the highest flow during the funded monitoring period. In 2005, flow stage was marked at each cross section in the project reach during flows released to monitor bedload transport for the Coarse Sediment Transfusion Project. Daily average flow during stage observations was 5,690 cfs on March 25 and 6,480 cfs on March 31. On April 1, stage was marked for a flow of approximately 8,400 cfs. Flow at La Grange on this date varied from 6,500 cfs to 8,410 cfs. Stage observations at the 7/11 Reach were timed to coincide with the peak release. Stage was marked with nails driven into trees on or near the cross section (left bank) and/or wooden stakes driven into the floodplain surface. Where possible, stage was measured at cross sections end pins, providing a stage elevation relative to NGVD 1929. Stage markers were not surveyed due to lack of monitoring funds. If funds become available, intact markers could be surveyed to determine stage elevation.

3.2.2 Results

Pre-project, as-built, and post-project aerial photographs and channel surveys will serve as the baseline for future post-project monitoring. Pre-project, as-built, and post-project aerial photographs are shown in Figure 3-3. Pre-project, design, and as-built channel cross sections and channel profile are shown in Figures 3-4 and 3-5, respectively. Post-project aerial photographs, channel bathymetry, and floodplain topography data are available from work completed for the Tuolumne River Coarse Sediment Transfusion Project, including ½-ft resolution aerial photographs taken on September 21, 2005, during a flow of 330 cfs, 2-ft contour channel bathymetry surveyed in July 2005, and 2-ft contour interval floodplain topography constructed from LIDAR surveys conducted in September 2005. These 2005 data have not been analyzed due to lack of monitoring funds.

At 1,030 cfs, flow began to inundate lower portions of constructed lateral bars within the bankfull channel (cross sections 2214+50 and 2281+00) and was 3–4 feet below the constructed floodplain surface that extends from Station 2211+00 to Station 2190+00 (Figure 3-4). Stage was not recorded upstream of Roberts Ferry Bridge or downstream of the 7/11 haul road bridge.

The project constructed floodplains at four locations on the left bank in the project reach. The bankfull channel was designed to convey 5,000 cfs, with higher flows spilling over onto constructed floodplains. At 5,690 cfs, the floodplain upstream of Roberts Ferry Bridge (intersected by cross section 2247+00) was inundated to a depth of approximately 0.5 feet (Figure 3-6). Inundation depth increased to approximately 0.7 feet at 6,500 cfs and 1.6 feet at 8,400 cfs.

The constructed floodplain intersected by cross sections 2198+30 and 2208+60 was inundated during each of the three high flows observed. At 5,690 cfs, inundation extended across the floodplain to the base of the setback dike (Figures 3-7 and 3-8). Inundation depth at cross section 2208+60 was 0.7 feet. Inundation depth at cross section 2208+60 increased to 2.0 feet at 6,500 cfs and 2.5 feet at 8,400 cfs. In the high flow scour channel near cross section 2198+30, inundation depth was 2.5 feet during flows of 5,690 cfs.

The constructed floodplain on the upstream side of the 7/11 haul road was not inundated during flows of 5,690 cfs or 6,500 cfs (Figure 3-9). At 5,690 cfs, the margin of the floodplain was inundated, but most of the surface remained 1–3 feet above the flow stage. At 8,400 cfs, the surface was inundated and water was flowing through the culverts in the reconstructed haul road. Flow depth in the culverts was 0.2 feet (on the downstream side).

The floodplain downstream of the 7/11 haul road was constructed by setting back the dike that isolated a mining pit from the river channel and by filling the portion of the pit on the river-side of the setback dike. Riparian vegetation along the channel was left in place. The constructed floodplain is approximately two feet lower than the riparian berm and connects to the river channel through a breach in the berm at the downstream end. For the flows observed, the floodplain was inundated as flow backed up through the breach. At 5,690 cfs, only the downstream end of this floodplain was inundated; depth was not recorded (Figure 3-10). At 8,400 cfs, inundation extended upstream to the 7/11 haul road.

3.3 Bed Texture and Mobility Thresholds (H2, H5)

3.3.1 Methods

In 1998, bed texture was mapped throughout the reach, and pebble counts were conducted at five locations, including two riffles and three lateral bars, to describe gravel and coarser facies units (Figure 3-2). In 1999, additional pebble counts were conducted at four riffles in the project reach (Figure 3-2). As-built bed texture was not mapped. As-built pebble counts were conducted in 2002 at two locations: cross section 2198+30 (Riffle 29B) and the constructed right bank lateral bar downstream of Roberts Ferry Bridge (cross section 2214+50). The as-built pebble count at Riffle 29B is represents texture of constructed riffles. The as-built pebble count on the lateral bar represents texture of constructed bars.

The Monitoring Plan specifies that tracer rock experiments be installed immediately following construction of each of the Gravel Mining Reach phases and monitored after each high flow event until mobilization is observed, with monitoring of up to three additional flow events to document sediment routing through pools. Tracer rocks experiments were installed on the left-bank bar at cross section 2198+30 (Riffle 29B) and the right bank bar at cross section 2214+50 in January 2005. Tracer rocks were grouped into “sets,” with each set consisting of the D_{84}, D_{50}, and D_{31} particle sizes of the bar surface as determined by the pebble counts at each location. The D_{84} represents the idealized bed framework (Church et al. 1987). The D_{50} and D_{31} represent finer framework particles. Marked rocks were painted yellow and placed at 3-foot intervals along each cross section. Rocks were placed into the bed surface to simulate the surrounding particle embeddedness. Marked rocks were recovered in September 2005; peak flow during the experiment was 8,410 cfs (April 1, 2005).

3.3.2 Results

Pre-project and as-built pebble counts are summarized in Table 29 and Figure 3-11. Complete results from pebble counts are shown in Figure 3-12. Average pre-construction D_{31}, D_{50}, and D_{84} at reconstructed riffles for which pebble counts were conducted (Riffles 30B and 29) were 35 mm, 47 mm, and 86 mm, respectively. As-built D_{31}, D_{50}, and D_{84} at Riffle 29B (a new riffle constructed by the project) was 26 mm, 34 mm, and 58 mm, respectively. Assuming that the texture of the constructed Riffle 29B is representative of riffle texture throughout the reconstructed reach, the project reduced D_{31}, D_{50}, and D_{84} by 9 mm (25%), 13 mm (28%), and 28 mm (32%), respectively, at constructed or reconstructed riffles relative to pre-project riffle texture. Texture at the constructed bar at cross section 2214+50 was coarser than the riffle texture. As-built D_{31}, D_{50}, and D_{84} were 27 mm, 38 mm, and 68 mm, respectively. Prior to construction, alluvial bars in this reach were extremely limited. No pre-project bar texture data are available. The 1998 facies map identifies the only pre-project bar in the reach (a mid-channel bar at Riffle 29) as "medium gravel."

The *Coarse Sediment Management Plan for the Lower Tuolumne River* (McBain & Trush 2004b) recommends using two spawning substrate mixtures for coarse sediment augmentation – a standard mix that is suitable for Chinook salmon spawning and a finer mix that is suitable for both Chinook salmon and *O. mykiss* (Table 30). Coarse sediment used to construct riffles in the project reach (represented by texture at Riffle 29B) was consistent with these recommended mixtures, though the D_{31} was slightly coarser than both mixtures, and the D_{50} was slightly coarser than the finer mixture (Figures 3-11 and 3-12).

"Significant" particle mobilization is considered to have occurred when more than 80% of the D_{84} rocks are mobilized from the cross section. At cross section 2214+50 on the right bank bar , more than 93% of the marked rocks in each size class were mobilized by the 8,410-cfs flow, indicating significant mobilization of the bar (Table 31). At cross section 2198+30, only partial mobilization was observed for the same flow. At this cross section, 53% of the D_{50}, 73% of the D_{31}, and 20% of the D_{84} rocks were mobilized (Table 31). Increased floodplain width in this portion of the project reduces flow depth and bed shear stress during high flows, thus increasing flow magnitude required to mobilize the bed surface.

Table 29. 7/11 Reach pre-construction and as-built pebble count locations.

Station (feet)	Riffle No.	Bed Texture (mm)									Comment
		1998			1999			2002			
		D_{31}	D_{50}	D_{84}	D_{31}	D_{50}	D_{84}	D_{31}	D_{50}	D_{84}	
2135+00	R33B				46	62	95				on riffle
2141+60	R33A				40	71	105				on riffle
2147+00	N/A	33	55	101							on left bank bar
2162+20	R31B	33	43	77							on right bank bar
2162+20	R31B	55	69	99							on left bank bar
2171+00	R31				46	67	99				on riffle
2181+00	R30B	47	54	94							on riffle
2181+00	R30B				31	41	76				on riffle
2198+30	R29B							26	34	58	on riffle
2207+00	R29	30	48	81							on riffle
2207+00	R29				30	46	91				on riffle
2214+00	N/A							27	38	68	on left bank bar

Table 30. Recommended salmonid spawning gravel texture for coarse sediment augmentation.

Mixture	Particle Size (mm)		
	D_{31}	D_{50}	D_{84}
Standard Mix	25	37	77
Finer Mix	22	32	77

Table 31. Marked rocks mobilized in the 7/11 Reach in 2005.

Size Class	% Mobilized	
	XS 2198+30	XS 2214+50
D_{84}	20	93
D_{50}	53	100
D_{31}	73	100

3.4 Chinook Salmon Spawning and Rearing Habitat (H5, H6)

3.4.1 Methods

Habitat mapping recorded three categories of successively more detailed information: (1) mesohabitat based on the classification system developed by Snider et al. (1992), (2) microhabitat features such as flow depth and velocity, substrate facies, wetted channel boundaries, woody debris, and submerged and overhead cover, and (3) Chinook salmon spawning and rearing habitat boundaries. Mesohabitat classification system included four levels of spatial resolution, as follows (Table 32):

- **Level-1** (study reach) consists of the seven Tuolumne River subreaches described in the Restoration Plan.
- **Level-2** (major channel features) includes bar complexes, flatwater areas, and off-channel areas.
- **Level-3** (channel feature types) includes 10 channel types tiered hierarchically from level-2 categories.
- **Level-4** (habitat units) describes mesohabitat units typically found along the Tuolumne River corridor, including: pools (pool head, body, and tail, where distinguishable), riffles, glides, runs, deep and shallow backwaters, side-channels, Special Run Pools (SRPs), and off-channel gravel mining pits (assessed from photographs only).

Mesohabitat was mapped onto laminated aerial photographs. All mesohabitat polygons were digitized and entered into the Tuolumne River GIS. In-channel mesohabitat units were assigned unique identifiers based on their longitudinal distance from the San Joaquin River confluence rounded to the nearest 100 feet. For example, a riffle located 213,527 feet upstream of the San Joaquin confluence (i.e., Station 2135+27) was rounded to Station 2135+00 and named “2135” (the last two digits were dropped).

Chinook salmon spawning and rearing habitat was identified based on the meso- and micro-habitat conditions and habitat suitability criteria developed by the USFWS (1995) (Table 25). Depth and velocity criteria with suitability indices greater than 0.1 were used to define suitable spawning and rearing conditions. All substrate types had suitability indices of 1.0 for juvenile rearing habitat. Substrate type, therefore, was not used as a criterion for defining rearing habitat. Different field methods were used in 1998 and 1999/2002 to quantify Chinook salmon habitat in the project reach. In 1998, Chinook salmon spawning and rearing habitat area was extrapolated from measurements at 12 cross sections in the project reach. Flow depth and velocity were measured at each cross section, and habitat suitability was determined based on the criteria shown in Table 25. Habitat area was then extrapolated between the cross sections. In 1999 and 2002, the cross section approach was abandoned, and habitat was mapped for the entire reach. In 1999, habitat was mapped onto laminated aerial photographs using the criteria in Table 25. The boundaries of each habitat polygon were defined by measuring depth and velocity. Once boundaries were identified, each polygon was mapped by hand onto the aerial photograph map base. The same method was used in 2002, except a total station was used to map polygon boundaries rather than hand mapping onto aerial photographs. For each year, habitat polygons were entered into the Tuolumne River GIS and used to produce a set of habitat maps for the project reaches.

Pre-project habitat was mapped in August 1998 and August 1999 during flows of 1,050–1,680 cfs and 254–265 cfs, respectively. As-built habitat was mapped in October 2002 during a flow of 331 cfs and November 2002 during a flow of 187 cfs.

Table 32. Mesohabitat classification system used to map project reaches. Definitions are based on Snider et al. (1992) with some modification where needed to accommodate Tuolumne River conditions.

MESOHABITAT TYPE (Level)	DEFINITION
BAR COMPLEXES (2)	
Island Complex (3)	Stable island located in main channel; supports established riparian vegetation.
Mid-Channel Bar (3)	Temporary island located in main channel; generally lacks established riparian vegetation.
Lateral Bar (3)	Contiguous with one main-channel bank, does not span channel; less built up than island complex; lacks established riparian vegetation.
Channel-Spanning Bar (3)	Spans entire channel at approximate right angle.
Transverse Bar (3)	Spans entire channel at approximate acute angle.
FLATWATER (2)	
Channel Bend (3)	Main channel primarily curved.
Straight Channel (3)	Main channel primarily without curvature.
Split Channel (3)	Main channel split into two or more channels.
OFF-CHANNEL (2)	
Contiguous (3)	Off-channel area contiguous with main channel.
Non-Contiguous (3)	Off-channel area not contiguous with main channel.
HABITAT UNITS (4)	
Pool Head (4)	Transition area from fast water unit to a pool; water surface slope decreases and bed slope increases.
Pool Body (4)	Very slow velocity; generally contains deepest portion of pool.
Pool Tail (4)	Transition area into fast water unit; depth decreases and velocity increases.
Glide (4)	Relatively low gradient and below average depths and velocities; no turbulence.
Run (4)	Moderate gradient with above average depths and velocities; low to moderate turbulence.
Riffle (4)	Relatively high gradient with above average velocities, below average depths; surface turbulence and channel controls.
Backwater (4)	Low-velocity areas not contiguous with the main channel; often associated with downstream ends of lateral bars, often shaded by riparian vegetation. Can be designated Shallow or Deep Backwater.
Side-channel (4)	Small channel connected to the main channel, often formed as lateral scour channel on backside of gravel bars. Generally shallow depths and velocities, but distinct from backwaters by having some flow velocity.
Special Run Pool (4)	SRPs are in-channel aggregate extraction pits generally located in Subreach 4.
Off-Channel Pond (4)	Off-channel aggregate extraction pits isolated from the main channel by dikes or berms; generally located in Subreach 5.

3.4.2 Results

Habitat was mapped at similar flows in 1999 and 2003 and thus provides a suitable comparison of pre- and post-project conditions (Figure 3-13). Overall, project effects on mesohabitat were (Table 33 and Figure 3-14):

- reduced active channel area by 250,400 ft^2 (14%) by increasing channel confinement;
- reduced pool area from 71% of the reach (pre-project) to 60% of the reach (as-built);
- increased lateral bar area by 508,100 ft^2 (500%);
- increased riffle area by 30,200 ft^2 (62%);
- reduced shallow backwater area by 73,200 ft^2 but replaced this backwater with a high-flow channel on the floodplain;
- reduced mid-channel bar area by 66,600 ft^2 (72%); and
- increased floodway width to 450–500 feet and floodplain area (i.e., the area of floodplains inundated at 4,500–5,000 cfs) by 40 acres by setting back dikes that isolate aggregate mining pits from the river and filling mining pits within the floodway.

Table 33. 7/11 Reach pre-construction and as-built mesohabitat.

UNIT	1999[1]		2002[1]	
	Area (ft^2)	**%**	**Area (ft^2)**	**%**
Mid-channel Bar	92,155	5.0	25,556	1.6
Lateral Bar	1,162	0.1	509,285	32.2
Pool	1,298,877	70.9	941,168	59.5
Run	29,257	1.6	--	0.0
Riffle	48,862	2.7	79,071	5.0
Glide	289,672	15.8	27,733	1.8
Shallow Backwater	73,203	4.0	--	0.0
Total Mapped Channel	**1,833,189**	**100.0**	**1,582,812**	**100.0**

[1] In-channel habitat areas represent the reach from the upstream end of the project reach to the 7/11 haul road bridge. As-built in-channel habitat downstream of the 7/11 haul road bridge was not mapped.

Pre-project habitat mapping identified 236,274 ft^2 of Chinook salmon fry rearing habitat and 1.04 million ft^2 of Chinook salmon juvenile rearing habitat during a flow of 254–265 cfs (Table 34, Figure 3-15). Fry rearing habitat occurred along the margins of glides and pools and in shallow backwaters. Juvenile rearing habitat occurred in pools and along pool margins throughout the project reach. The only areas of the channel not mapped as suitable for juvenile rearing were the center of the channel between Riffle 29 and Riffle 30B, a portion of the pool downstream of Riffle 30B, and portions of Riffles 31B and 32.

During flows of 185 cfs, post-project habitat mapping identified 85,567 ft^2 of Chinook salmon fry rearing habitat and 549,737 ft^2 of juvenile Chinook salmon rearing habitat, 64% and 47% less than pre-project mapped habitat, respectively (Table 34, Figures 3-15 and 3-16). Post-project fry habitat extended in a continuous band along the wetted channel margin throughout the project reach, excluding the bioengineered bank revetment upstream of the 7/11 haul road bridge. Juvenile habitat occurred along the margins of the pool upstream of Riffle 29 and throughout pools and glides downstream of Riffle 29 (Figure s 3-15 and 3-16).

The reduction in low-flow Chinook salmon rearing habitat area may be misleading. The approach to the 7/11 Reach project was to: (1) setback mine-pit dikes from the river to increase floodway width, (2) replace long dredger pools with a more functional channel morphology by constructing riffles and lateral bars, and (3) construct floodplains long the left bank of the channel to increase bankfull

Table 34. Pre- and post-construction fry and juvenile rearing habitat area.

Habitat Type	**Habitat Area (ft^2)[1]**		**% Change**
	1999 (254–265 cfs)	**2002 (185 cfs)**	
Fry Rearing	236,274	85,567	-64
Juvenile Rearing	1,044,253	549,737	-47
Total	1,280,527	635,305	-50

[1] In-channel Chinook salmon habitat areas represent the reach from the Roberts Ferry Bridge to the 7/11 haul road bridge. As-built Chinook salmon habitat was not mapped upstream of the Roberts Ferry bridge or downstream of the 7/11 haul road bridge, where project construction was limited to dike setbacks and floodplain grading.

channel confinement and improve high-flow habitat. By replacing pool area with lateral bars, riffles, and floodplains, the project reduced the total area mapped as suitable juvenile habitat but increased habitat quality. A complex riffle-pool morphology provides higher quality rearing habitat than continuous, long pools by increasing macroinvertebrate production and macroinvertebrate drift available to rearing juveniles. The habitat mapping methods used can quantify change in total habitat area but cannot assess change in habitat quality or carrying capacity. Also, the project is expected to increase fry and juvenile rearing area during flows that inundate constructed lateral bars and floodplains. Habitat mapping during flows of 185 cfs could not detect this effect.

The project increased Chinook salmon spawning habitat area by approximately 22,100 ft^2, or 172% (Table 35, Figure 3-16). Pre-project spawning habitat mapped in 1999 during flows of 254–265 cfs totaled 12,814 ft^2 and was limited to small patches at Riffles 29, 30B, 31A, and 32 (Table 35, Figure 3-15). Riffles 29 and 30 provided limited spawning habitat due to steep riffle slope and high water velocity. At Riffles 31A and 31B, flow depth and velocity were suitable for spawning, but riffle substrate was embedded and poor quality for spawning and incubation.

The project constructed two new riffles (Riffles 28C[7] and 29B), modified two existing riffles (Riffles 29 and 30B), and altered flow depth and velocity by increasing channel confinement at four riffles (Riffles 31, 31A, 31B, and 32). The project also attempted to reconstruct Riffle 30A, which was removed by the 1997 flood. Coarse sediment was added to the channel at the Riffle 30A location, but channel slope was not adequate to form a riffle. Post-project spawning habitat mapped in 2002 during flows of 187 cfs totaled 34,875 ft^2 and occurred at five riffles in the project reach (Table 35, Figure 3-15). All riffles in the project reach, except Riffle 32, provided suitable Chinook salmon spawning depths and velocity. Constructed riffles also provided clean (i.e., unembedded) spawning substrates. Slope at constructed riffles, however, was steeper than at heavily used spawning riffles near La Grange. Typical slope during spawning flows (~ 300 cfs) at project riffles was 0.005–0.01 compared to 0.0035 and 0.0009 at Riffles A7 and 1A, respectively (Figure 3-17).

[7] Stanislaus County placed 200 yds^3 of spawning gravel at Riffle 28C as part of the Roberts Ferry Bridge reconstruction in September 1999 (Dennis Blakeman, CDFG, pers. comm. 2005). The restoration project reconfigured this riffle.

Table 35. Pre-construction and post-project spawning habitat area.

Riffle	Habitat Area				Project Action
	1999 (254–265 cfs)		2002 (185 cfs)		
	Riffle Area (ft^2)	Spawning Area (ft^2)	Riffle Area (ft^2)	Spawning Area (ft^2)	
28C	0	0	11,795	9,060	created riffle
29	8,059	2,526	9,421	5,262	modified riffle
29B	0	0	8,772	4,158	created riffle
30B	4,595	2,792	8,311	2,757	modified riffle
31A	7,049	4,508	11,674	7,130	None
31B	24,461	0	21,227	6,508	None
32	4,734	2,988	7,869	0	None
Total (Entire Project Reach)	**48,898**	**12,814**	**79,069**	**34,875**	

3.5 Spawning Counts

3.5.1 Methods

CDFG monitors Chinook salmon escapement each fall and winter. During the upstream migration and spawning period (mid-October through early January), CDFG conducts weekly surveys to count and tag carcasses, count live fish, and count redds at each riffle. For the survey, the river is divided into four reaches, and redds are counted from a drift boat by CDFG staff. The annual maximum redd count (i.e., the peak number of redds counted at each riffle during a single survey over the duration of each spawning season) was compiled from CDFG redd count data for project and control riffles for the period 1997–2005. Riffles 25, 26, 27, and 28A (all located upstream of the project) were used as controls.

3.5.2 Results

Considering only the reach in which riffles were added or reconstructed, the project appears to have nearly doubled Chinook salmon spawning use in the channel reconstruction reach (Table 36). From Roberts Ferry Bridge to Riffle 30B (i.e., at new and reconstructed riffles), the ratio of the number of redds (annual maximum redd count) to upstream control riffles increased from an average of 0.24 ± 0.09 SE pre-project (1997–2001) to 0.43 ± 0.01 SE post-project (2002–2005) (Table 36). For the entire project reach (i.e., Riffle 28C to Riffle 32), however, no significant difference in spawning use at project riffles relative to control riffles was detected. For the entire reach, the ratio of redds at project and control riffles averaged 0.76 ± 0.26 SE pre-project (1997–2001) to 0.88 ± 0.14 SE post-project (2002–2005) (Table 36).

These results should be interpreted with caution. While these redd counts provide important reach-scale data for assessing spawning distribution, differences in riffle naming systems and potential inaccuracy of the rapid drift boat counts make these data less usable at the individual riffle-scale. The redd counts are from drift boat surveys conducted by various CDFG staff over several years. CDFG recently compared their drift boat counts to site-intensive redd counts and concluded that drift boat surveys can severely undercount redds (CDFG 2004a). At low spawning densities, as occurred in the project reach, CDFG considers the drift counts to be fairly accurate (CDFG 2004b). Detailed redd counts and redd mapping at project and control riffles would provide a more accurate and robust assessment of Chinook salmon spawning. The Washington Salmon Recovery Board (2004) has developed a protocol for this type of monitoring that could be applied to the project with some modifications.

Table 36. Maximum weekly redd counts at project and control riffles.

Riffle No.[a]	**Peak Weekly Redd Count**								
	Pre-project					**Post-project**			
	1997	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Control Riffles									
25 [K2]	13	15	6	27	21	13	11	9	8
26 [L1]	11	12	6	30	19	9	6	5	8
27 [L2]	9	9	2	28	20	12	6	6	2
28A,B [L3]	0	4	1	20	7	0	4	8	5
New or Reconstructed Riffles									
28C [M1]						1	1		
29 [M2]	6	7	3	11	14	4	2	7	4
29B [N1]							3		
30A, B [N/A, N2]	6	5	0	5	0	10	5	5	6
Other Project Riffles									
31A, 31B [N3, N4]	11	10	9	19	47	17	7	8	3
32 [O1]	6	2	1	7	10	0	5	2	1
Reconstructed:Control	0.36	0.30	0.20	0.15	0.21	0.44	0.41	0.43	0.43
Project Reach:Control	0.88	0.60	0.87	0.40	1.06	0.94	0.85	0.79	0.61

[a] Riffle numbers use the “traditional” numbering system used on the Tuolumne River. Revised riffle numbers used by CDFG in 2002–2005 are shown in [brackets].

3.6 Riparian Resources

The Monitoring Plan includes plot-based surveys of species composition, survival and growth in the active channel, floodplain, and terrace. The monitoring schedule includes surveys in Years 0, 2, 3, and 5 or following a high flow event exceeding 5,000 cfs. Very little monitoring of riparian vegetation has occurred at the 7/11 Reach to date. At this site, planting was conducted from February through April 2003, with additional follow-up planting in January 2004. Irrigation and plant maintenance ended September 30, 2004. HDR Engineering has developed as-built maps showing the locations and species of planted vegetation. Post-project monitoring of planted vegetation has been limited to quantifying survival of planted vegetation and replacement of plants as stipulated in the construction contract. Percent cover and growth of planted vegetation has not been monitored. Recruitment of native vegetation on constructed surfaces (H8) and encroachment of riparian vegetation into the active channel (H9) have not been assessed.

The portion of the 7/11 floodplain that was lowered to be inundated at 4,500 cfs could provide a good opportunity to observe floodplain evolution (deposition, inundation frequency and duration, and riparian revegetation response) to compare evolution between the reaches. No monitoring is currently funded to test the effects of this change in floodplain design on riparian vegetation recruitment and establishment.

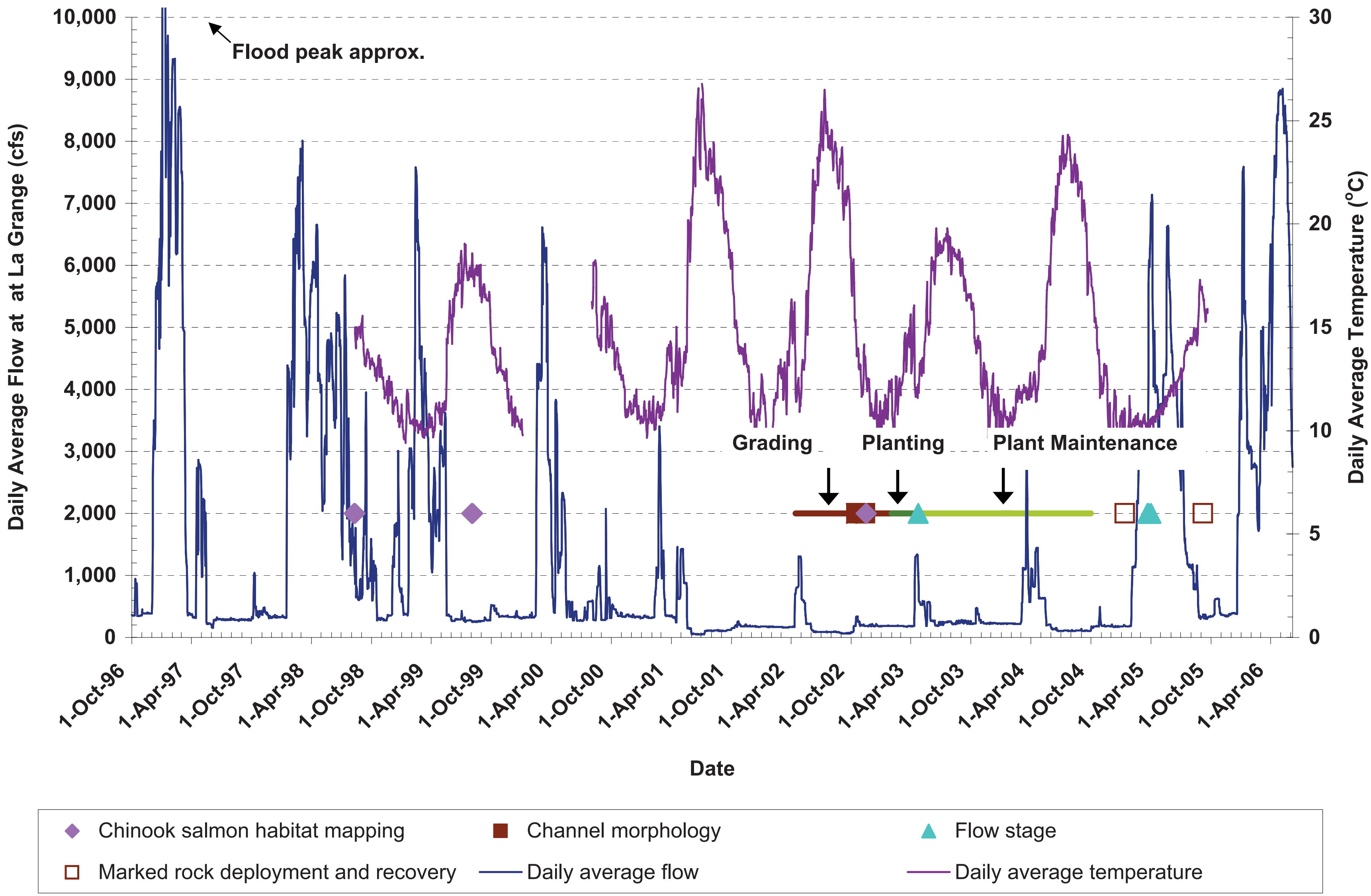

Figure 3-1. Flow and temperature conditions relative to construction and monitoring at the 7/11 Reach. (Flow is daily average flow at USGS gage no. 1289650 Tuolumne R bl La Grange Dam nr La Grange CA. Temperature data are from RM 39.5, TID unpublished data).

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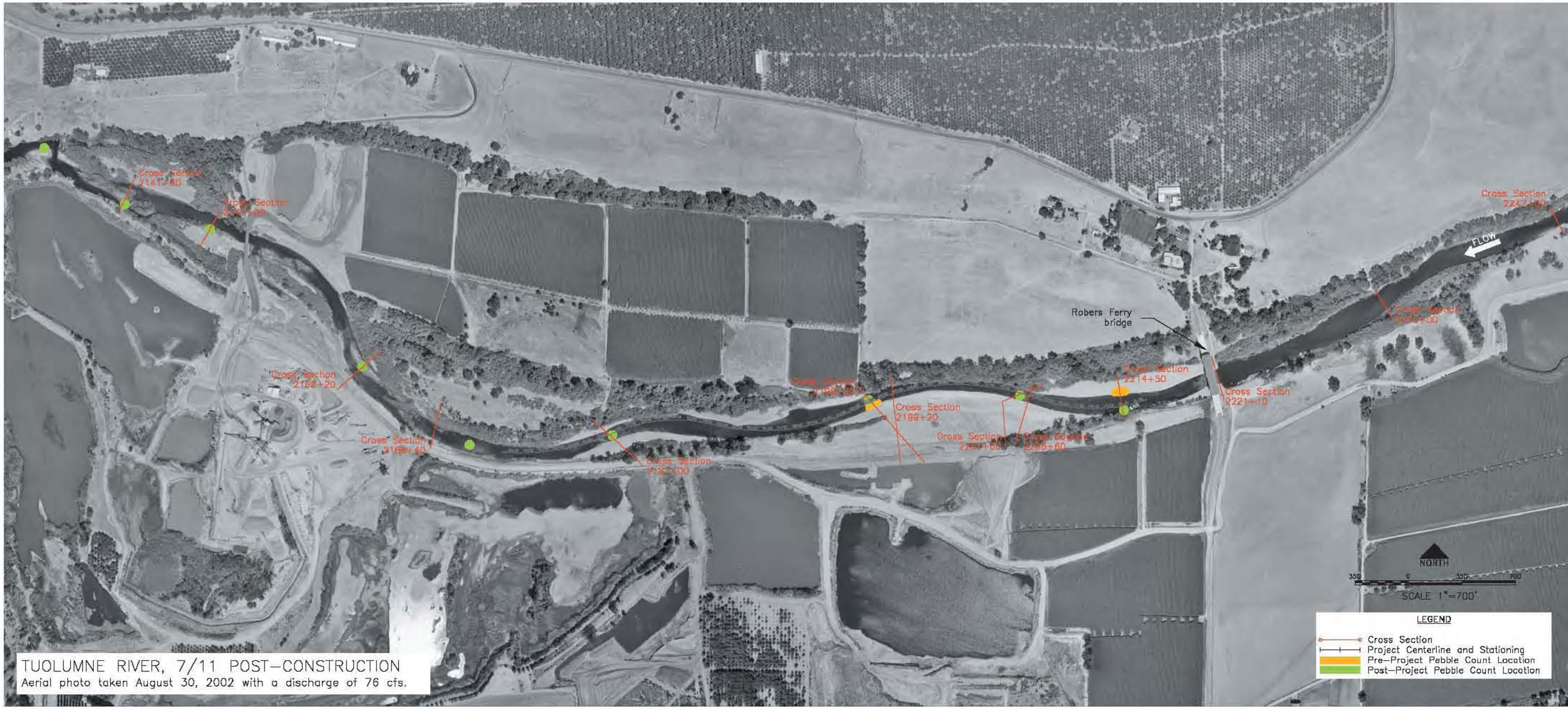

Figure 3-2. *7/11 Reach as-built and post-construction monitoring cross section locations.*

Figure 3-3. *7/11 Reach pre-project (1998), as-built (2002), and post-project (2005) aerial photographs.*

Figure 3-3. 7/11 Reach pre-project (1998), as-built (2002), and post-project (2005) aerial photographs, continued.

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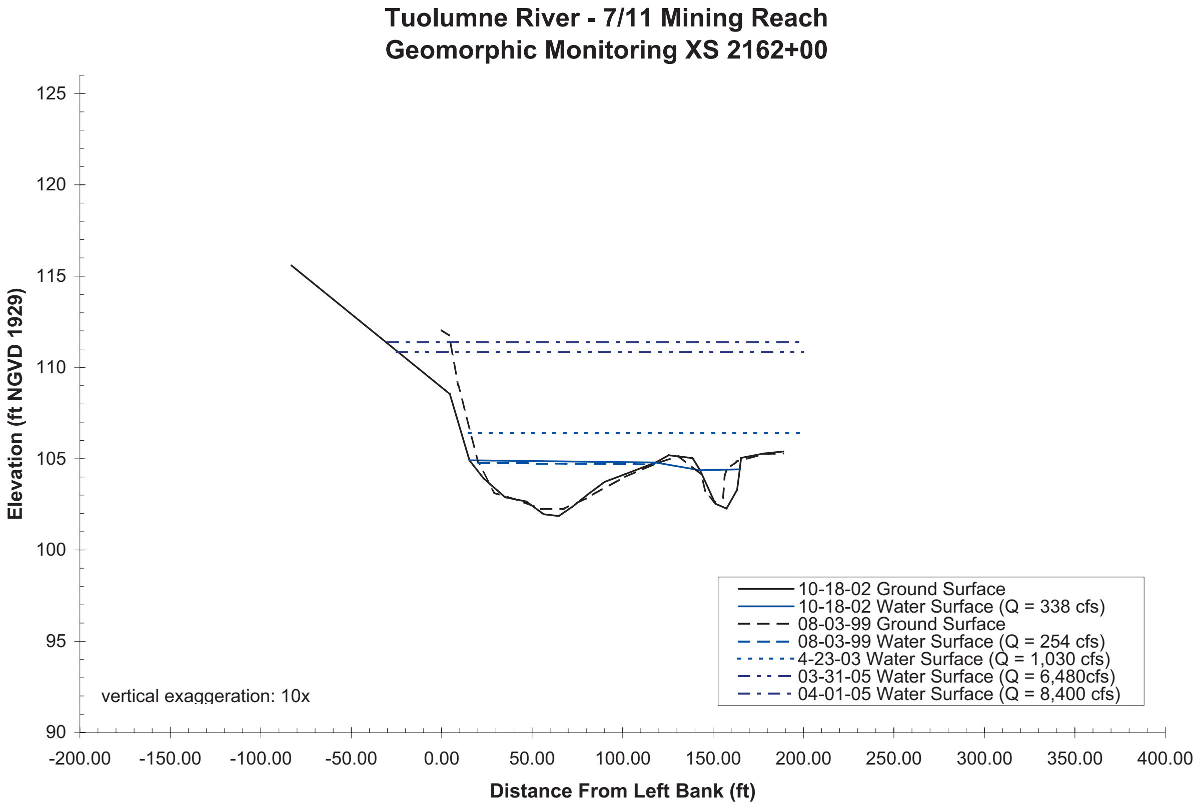


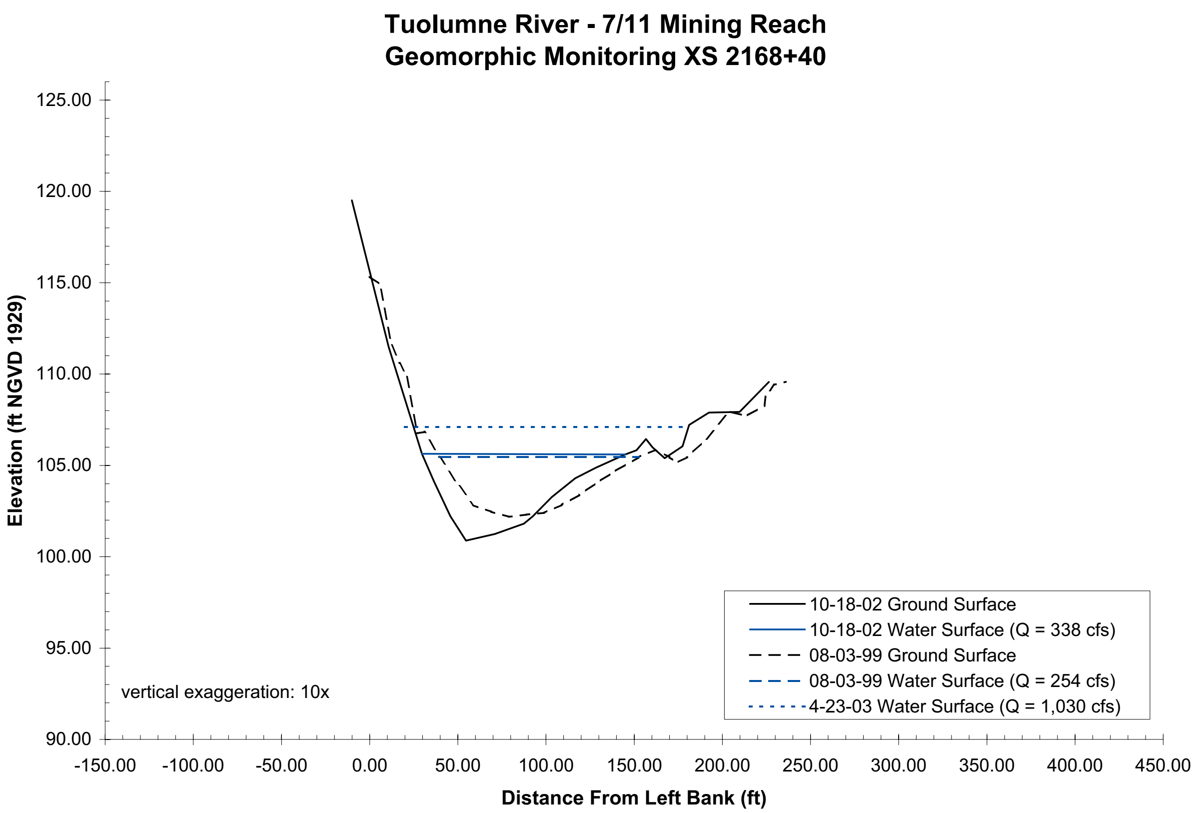
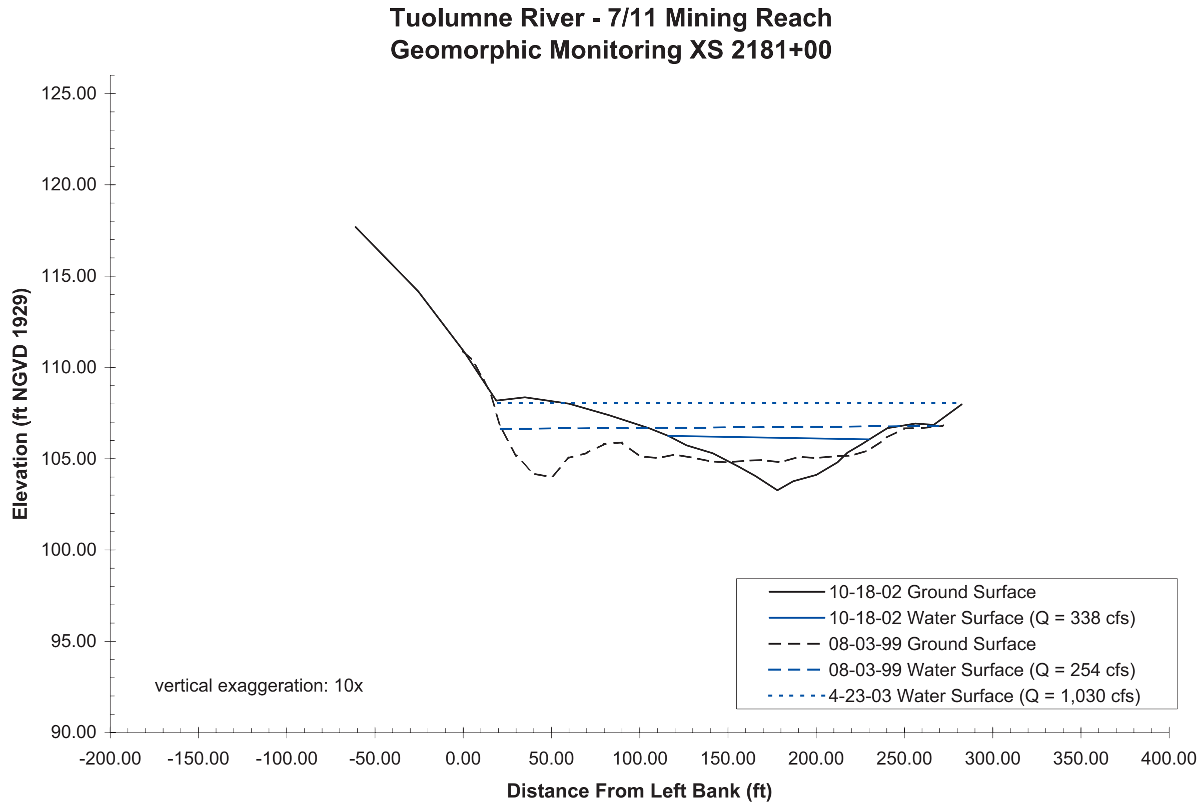


Figure 3-4. 7/11 Reach monitoring cross sections showing pre-project and as-built ground surface and low-flow water surface.



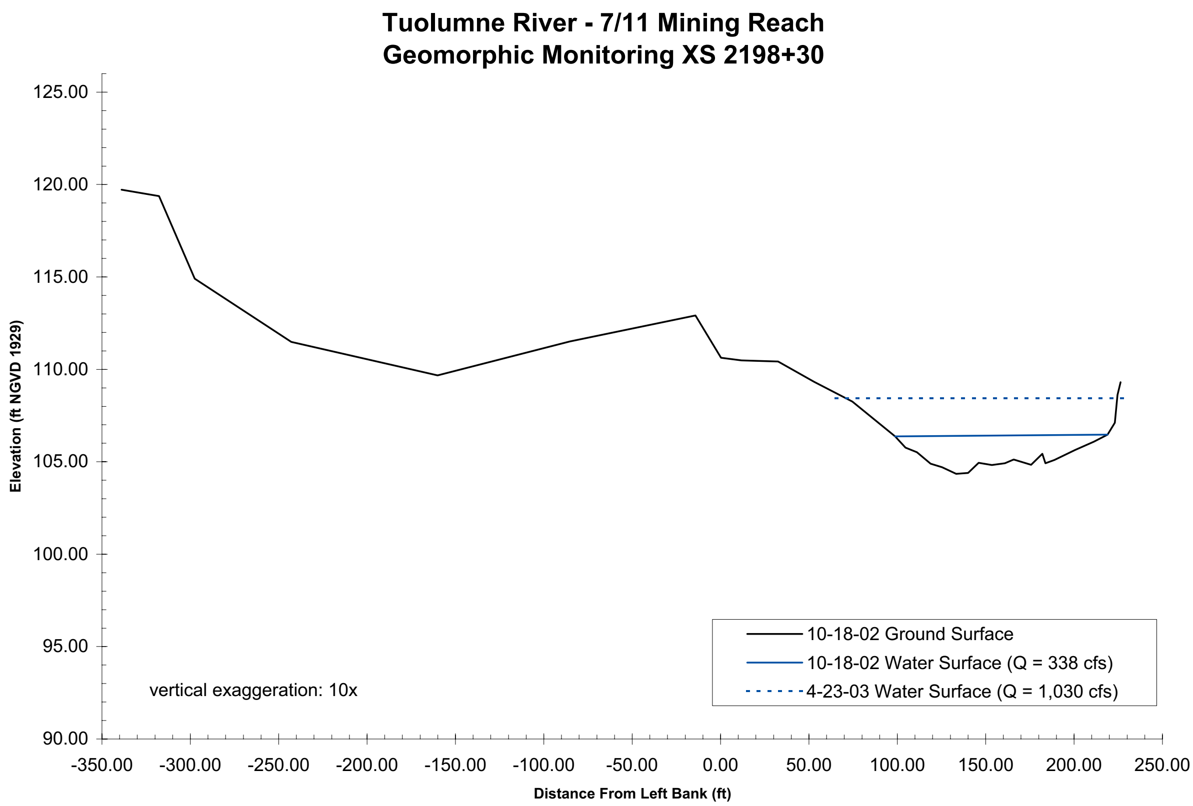
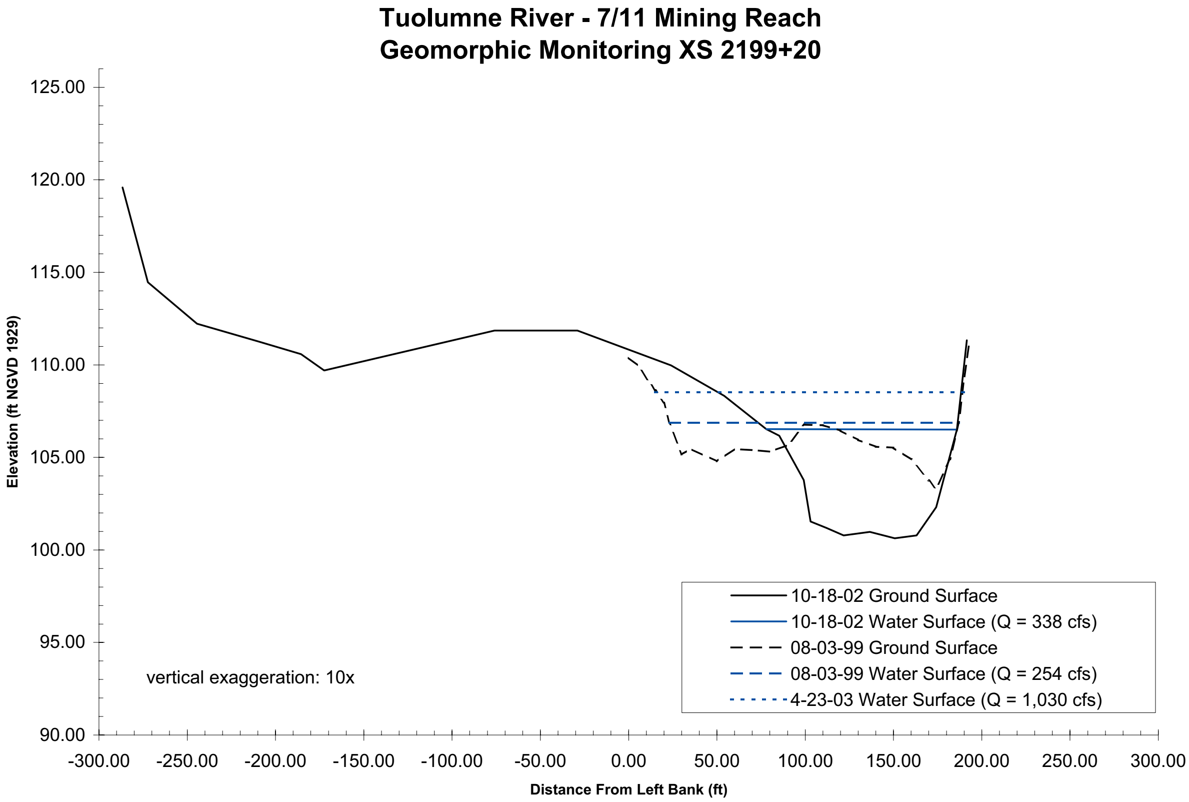


Figure 3-4. 7/11 Reach monitoring cross sections showing pre-project and as-built ground surface and low-flow water surface, continued.



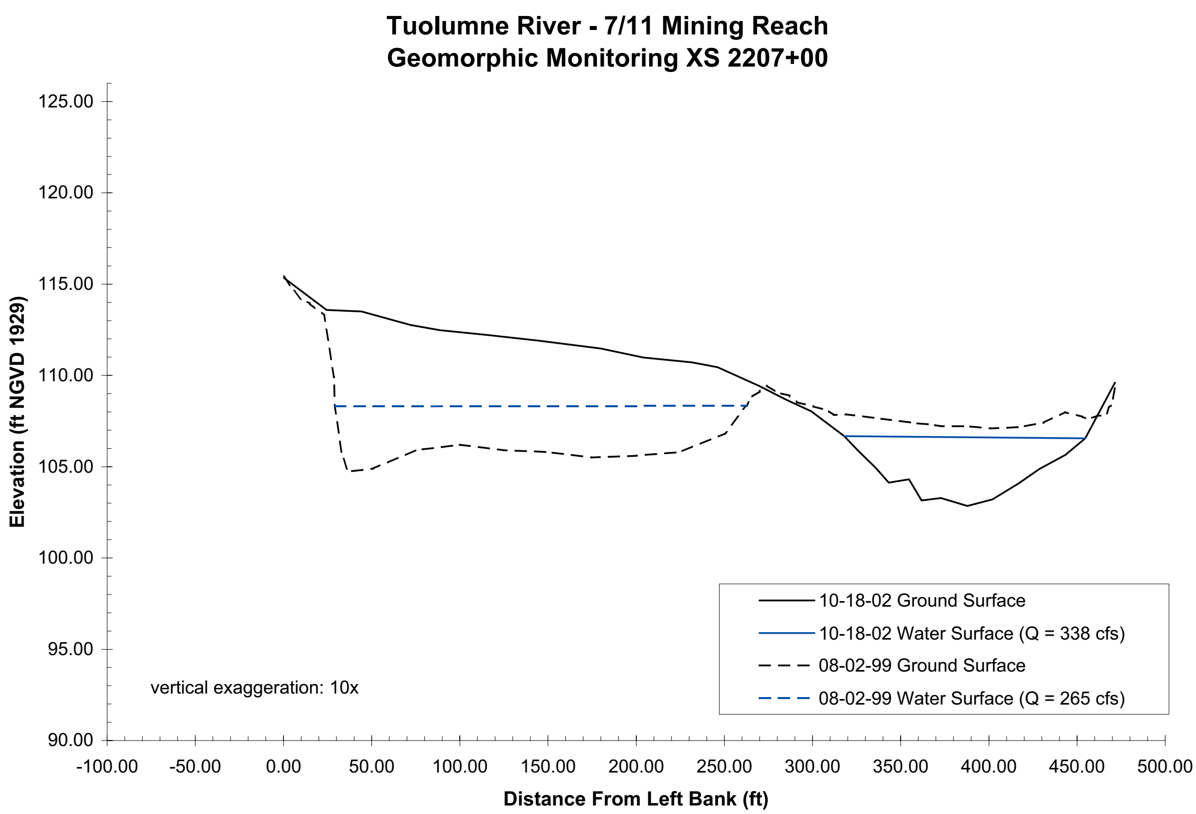
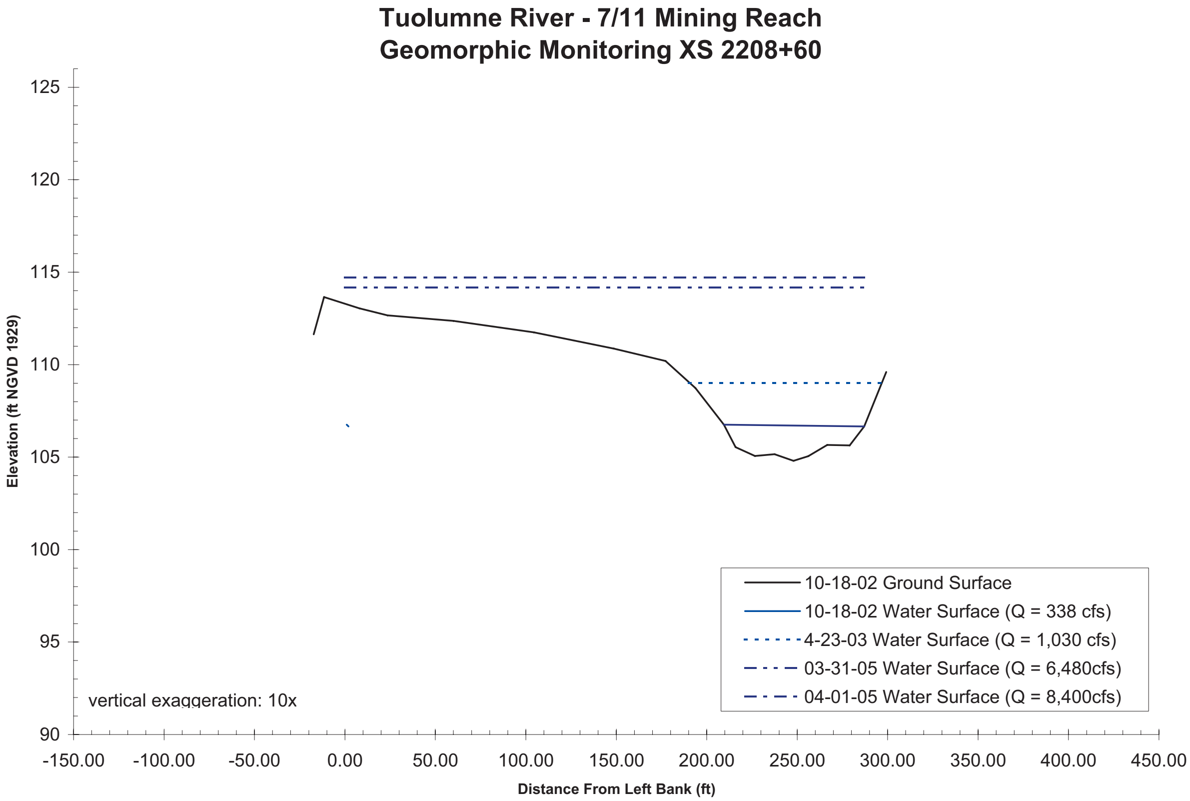


Figure 3-4. 7/11 Reach monitoring cross sections showing pre-project and as-built ground surface and low-flow water surface, continued.



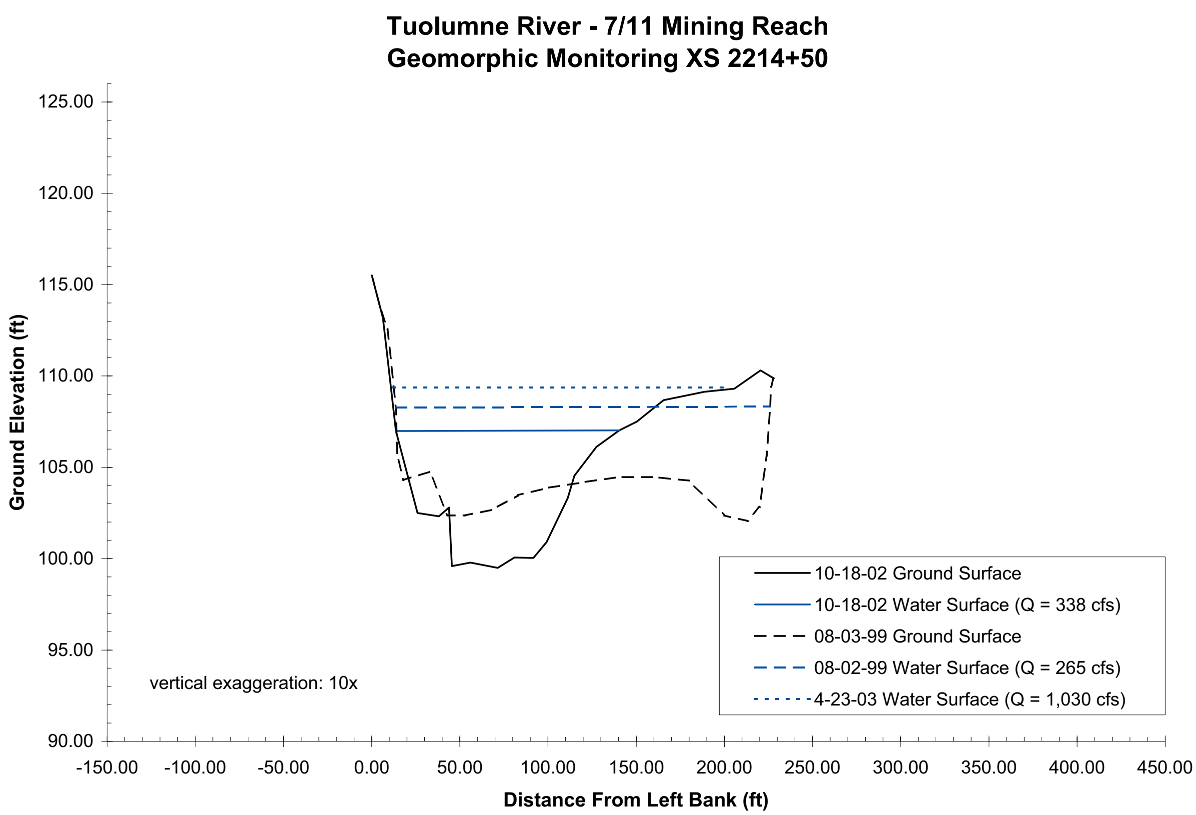


Figure 3-4. 7/11 Reach monitoring cross sections showing pre-project and as-built ground surface and low-flow water surface, continued.

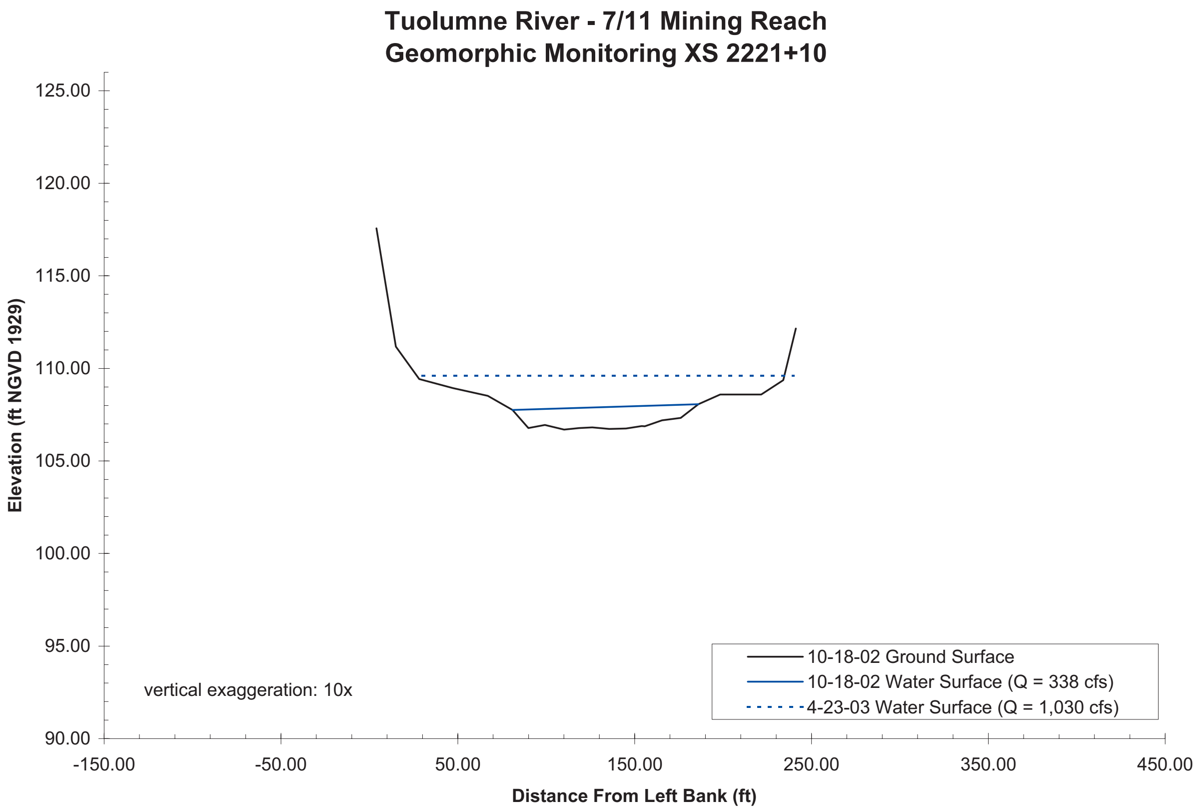


Figure 3-4. 7/11 Reach monitoring cross sections showing pre-project and as-built ground surface and low-flow water surface, continued.

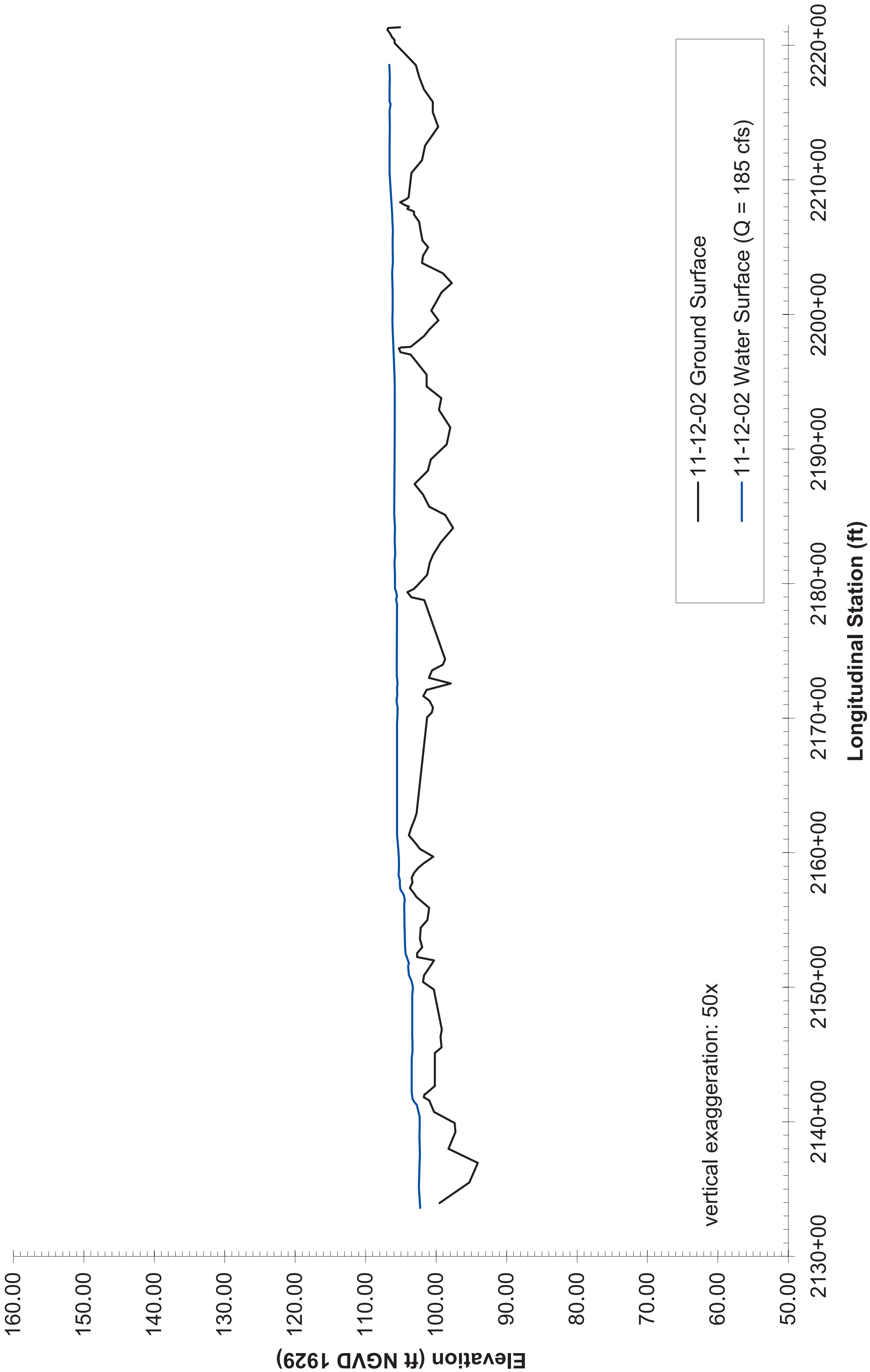


Figure 3-5. 7/11 Reach as-built channel thalweg profile.

Figure 3-6. View of left bank floodplain from cross section 2247+00 during flows of 5,960 cfs [March 25, 2005]. (Flow is daily average flow at USGS gage no. 1289650 Tuolumne River below La Grange Dam nr La Grange CA.)

Figure 3-7. View of left bank floodplain between cross sections 2198+30 and 2208+60 during flows of 5,960 cfs [March 25, 2005]. (Flow is daily average flow at USGS gage no. 1289650 Tuolumne River below La Grange Dam nr La Grange CA.)

Figure 3-8. View from Roberts Ferry Bridge (looking downstream) during flows of 5,960 cfs [March 25, 2005]. (Flow is daily average flow at USGS gage no. 1289650 Tuolumne River below La Grange Dam nr La Grange CA.)

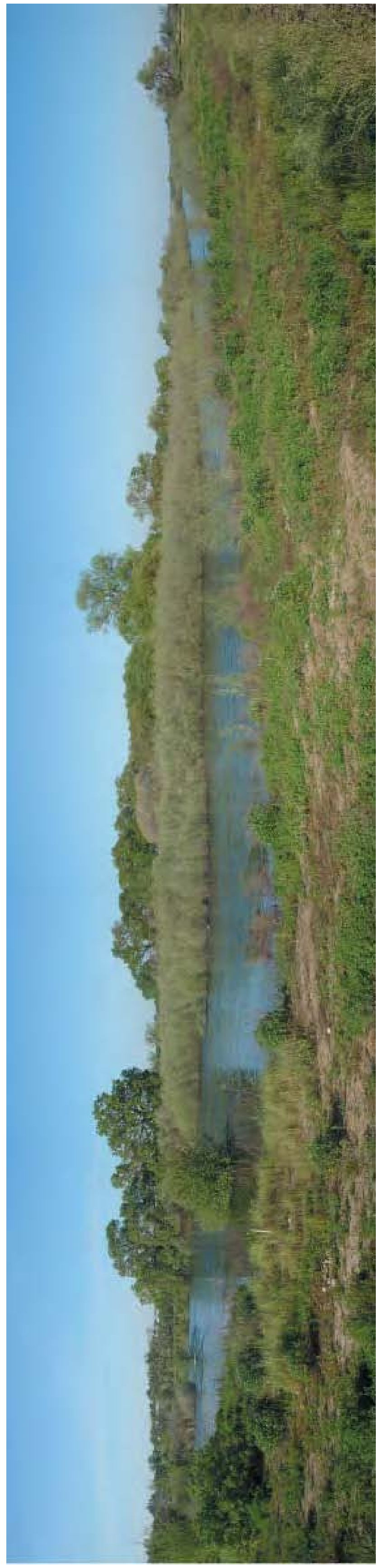
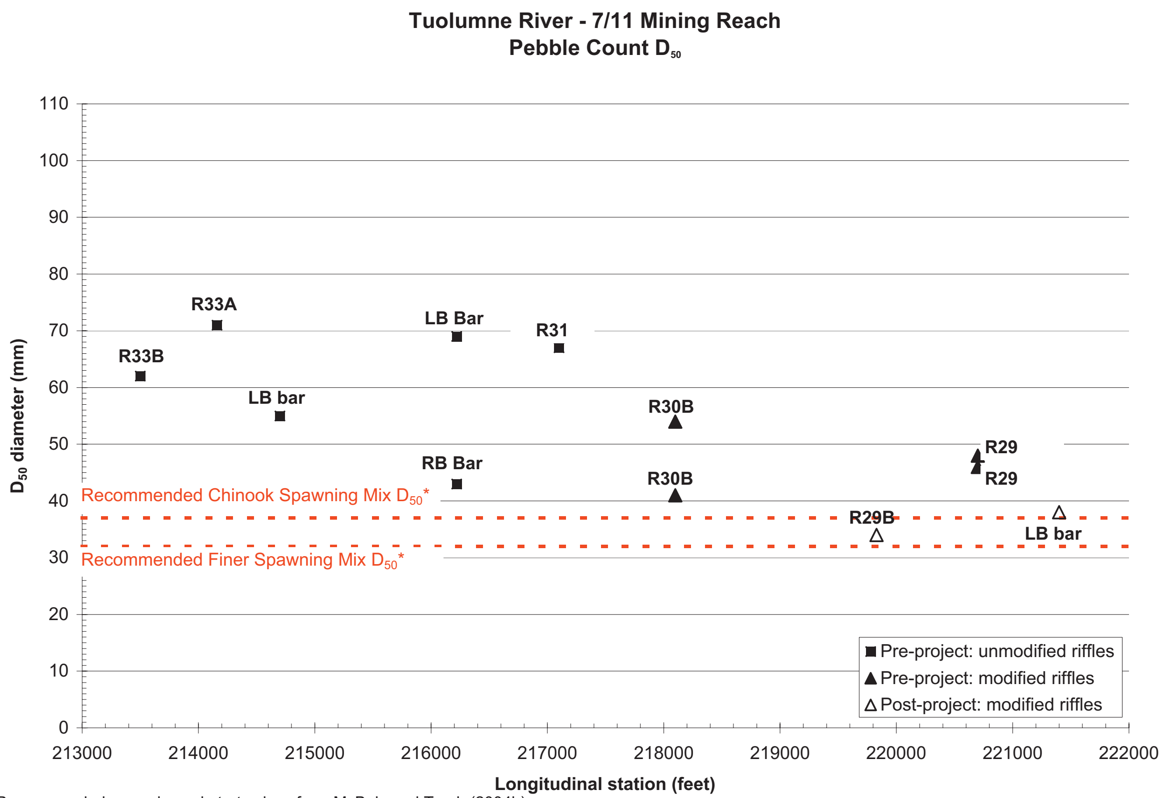
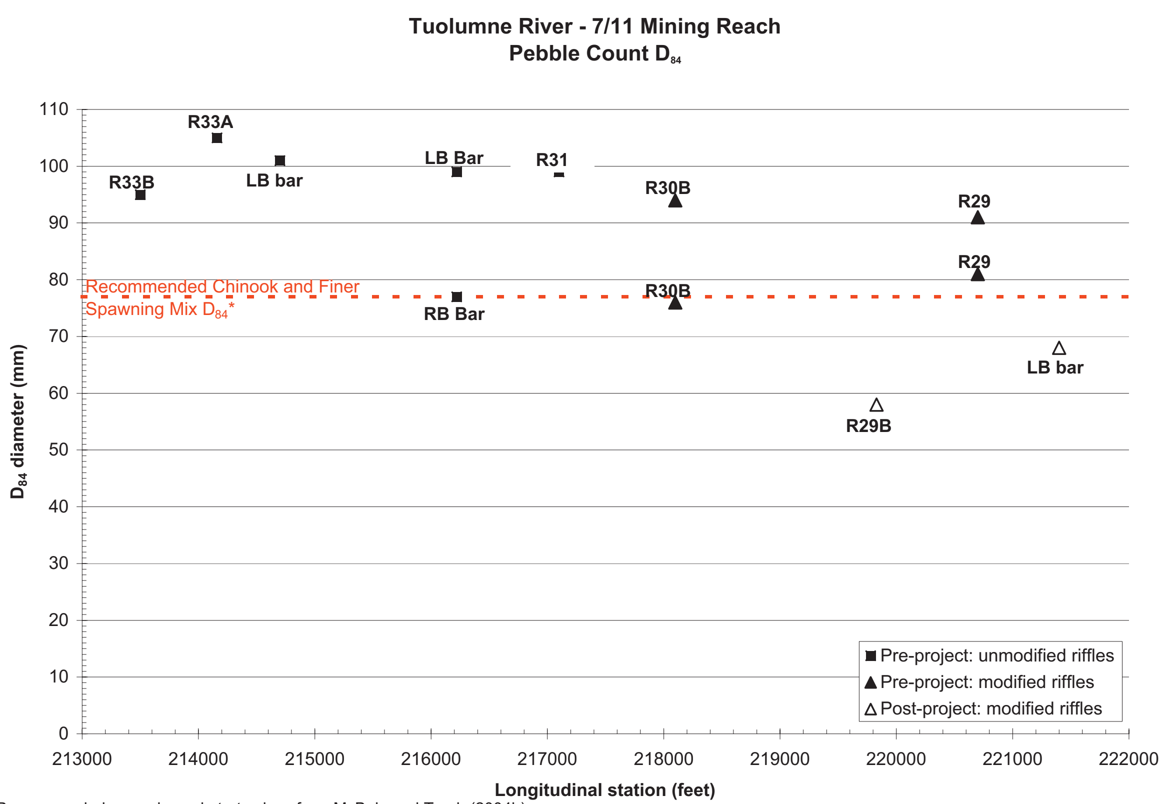


Figure 3-9. View of left bank floodplain upstream of the 7/11 haul road during flows of 5,960 cfs [March 25, 2005]. (Flow is daily average flow at USGS gage no. 1289650 Tuolumne River below La Grange Dam nr La Grange CA.)

Figure 3-10. View of left bank floodplain from downstream project boundary during flows of 5,960 cfs [March 25, 2005]. (Flow is daily average flow at USGS gage no. 1289650 Tuolumne River below La Grange Dam nr La Grange CA.)



*Recommended spawning substrate sizes from McBain and Trush (2004b).



*Recommended spawning substrate sizes from McBain and Trush (2004b).

Figure 3-11. 7/11 Reach pre-project and as-built bed texture – D_{50} and D_{84}.

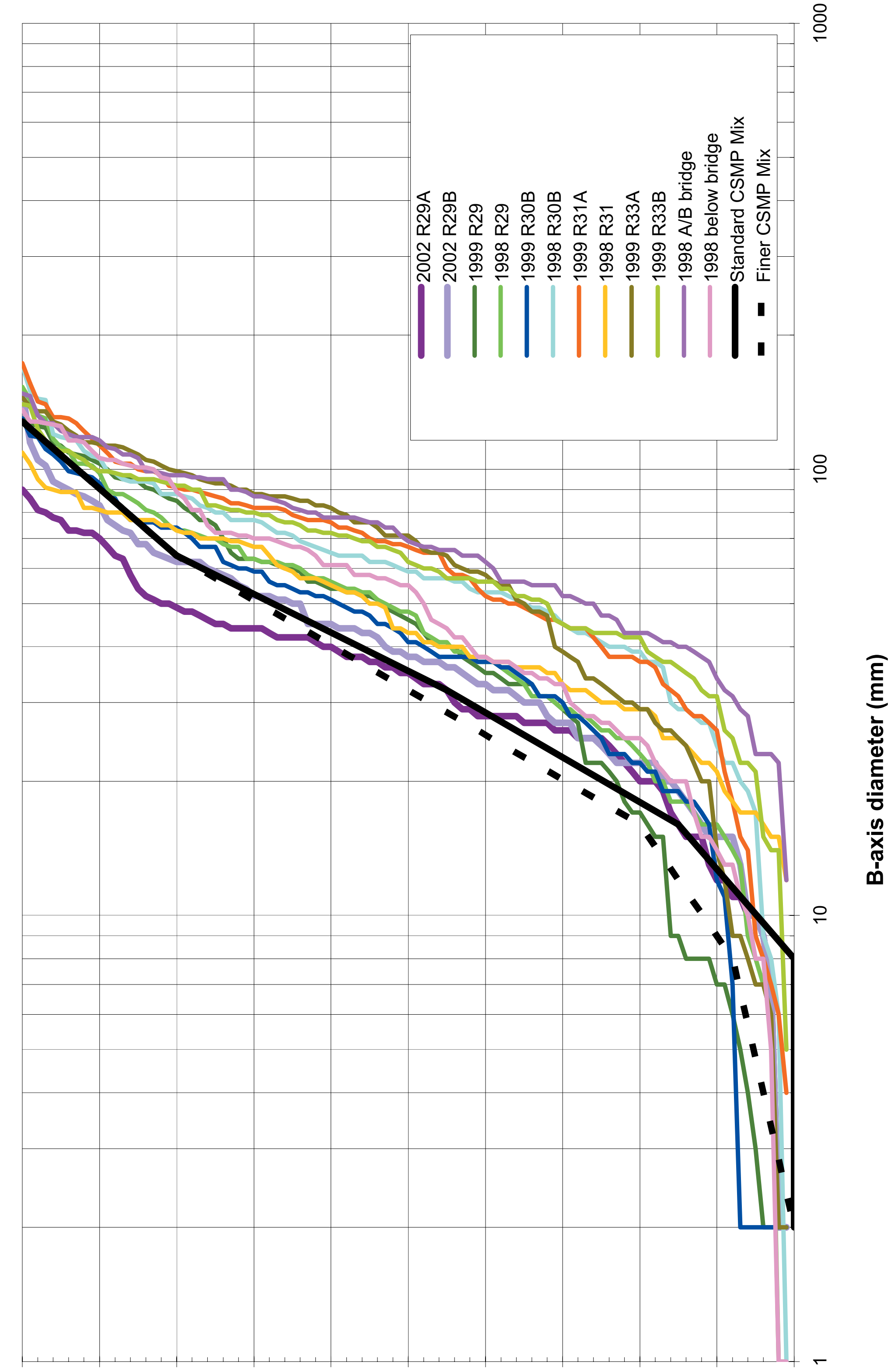


Figure 3-12. 7/11 Reach pre-project and as-built bed texture – cumulative distribution.

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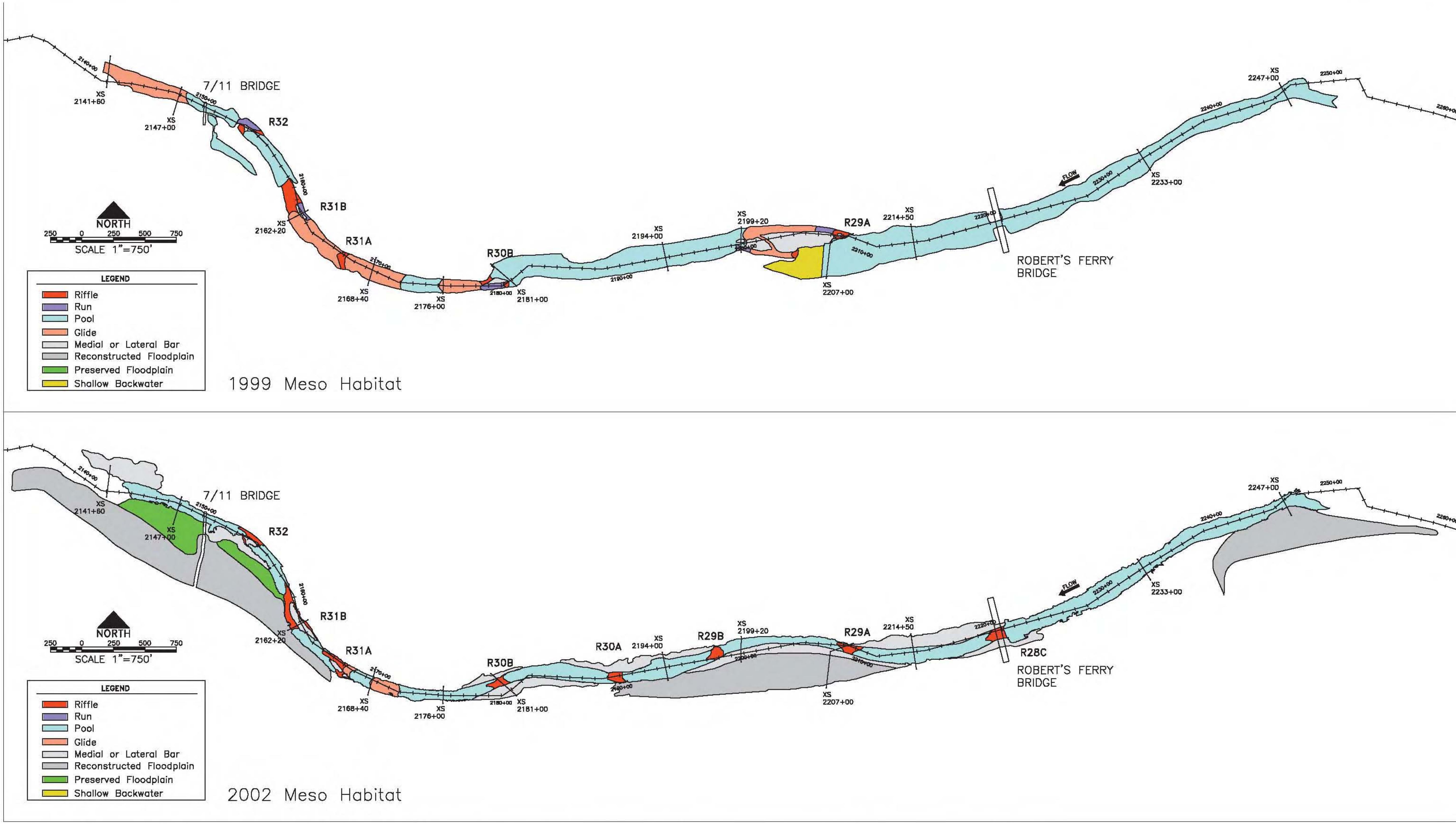

Figure 3-13. 7/11 Reach pre-project meso-habitat mapped at 254–265cfs (pre-project, August 1999) and as-built meso-habitat mapped at 187 cfs (as-built, November 2002).

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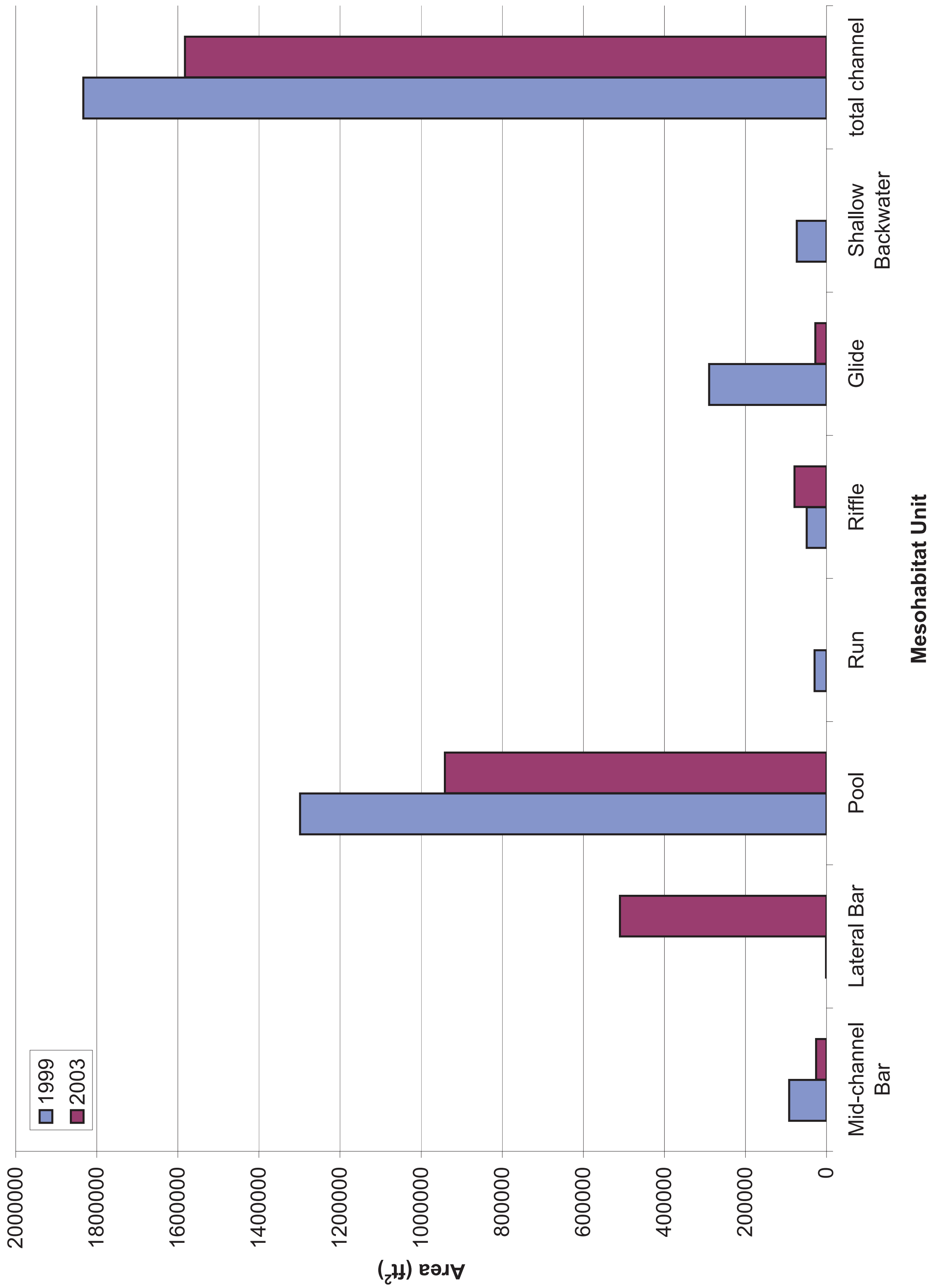

Figure 3-14. Comparison of pre-project and as-built meso-habitat unit areas in the 7/11 Reach.

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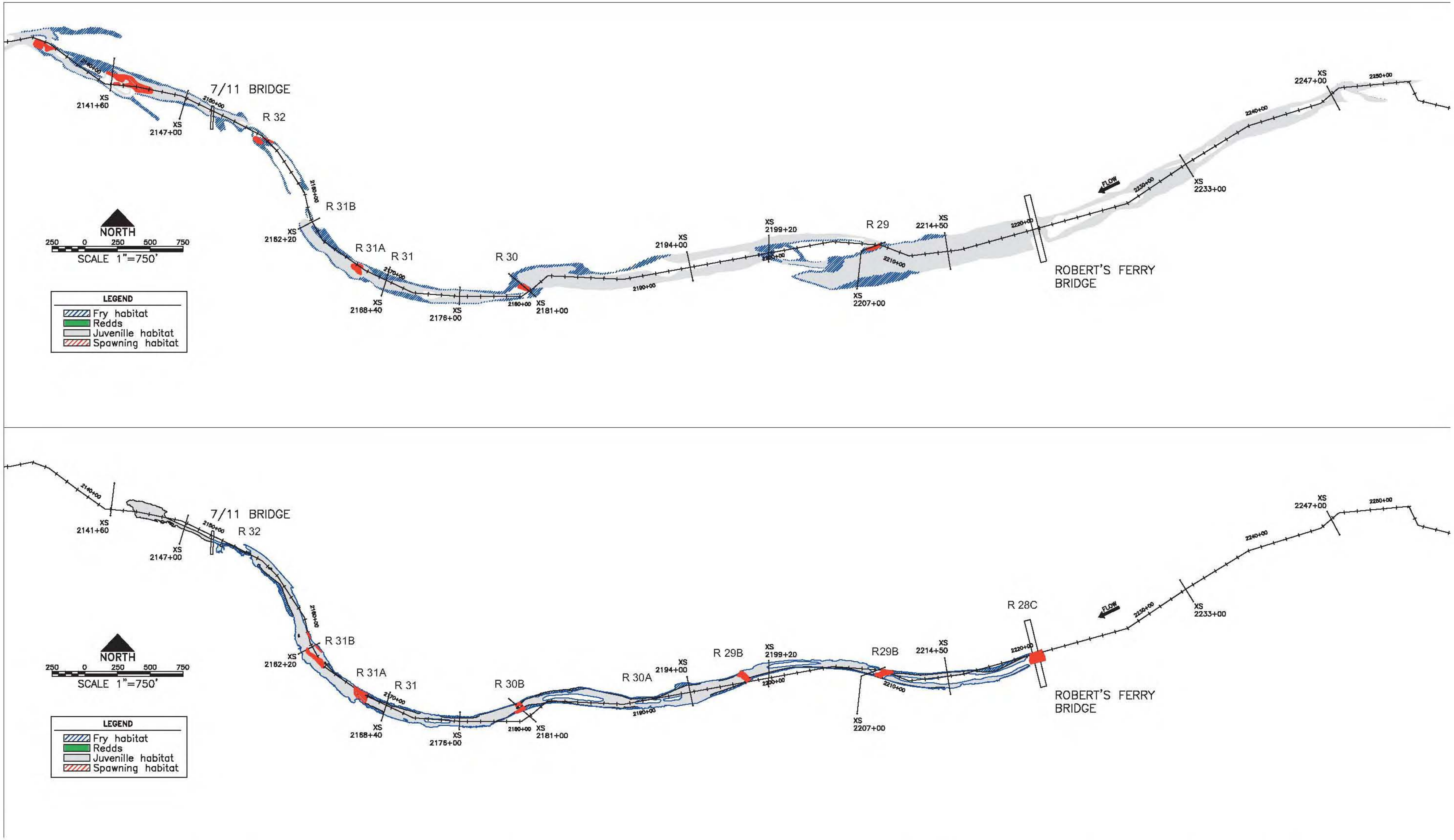

Figure 3-15. 7/11 Reach pre-project and as-built Chinook salmon fry and juvenile rearing and adult spawning habitat mapped at 254–265cfs (pre-project, August 1999) and 187 cfs (post-project, November 2002).

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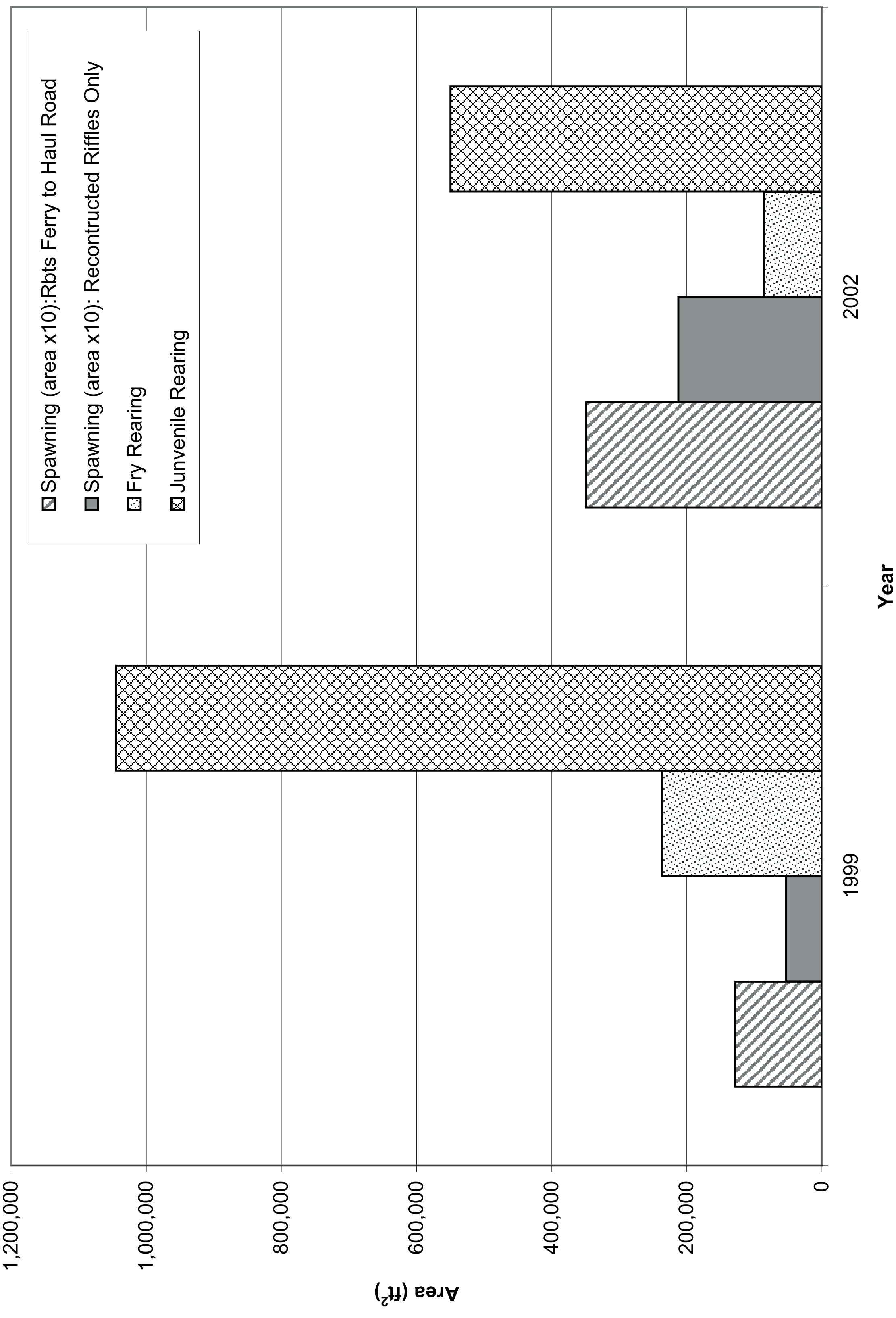


Figure 3-16. Comparison of pre-project and as-built Chinook salmon fry and juvenile rearing and adult spawning habitat area in the 7/11 Reach.

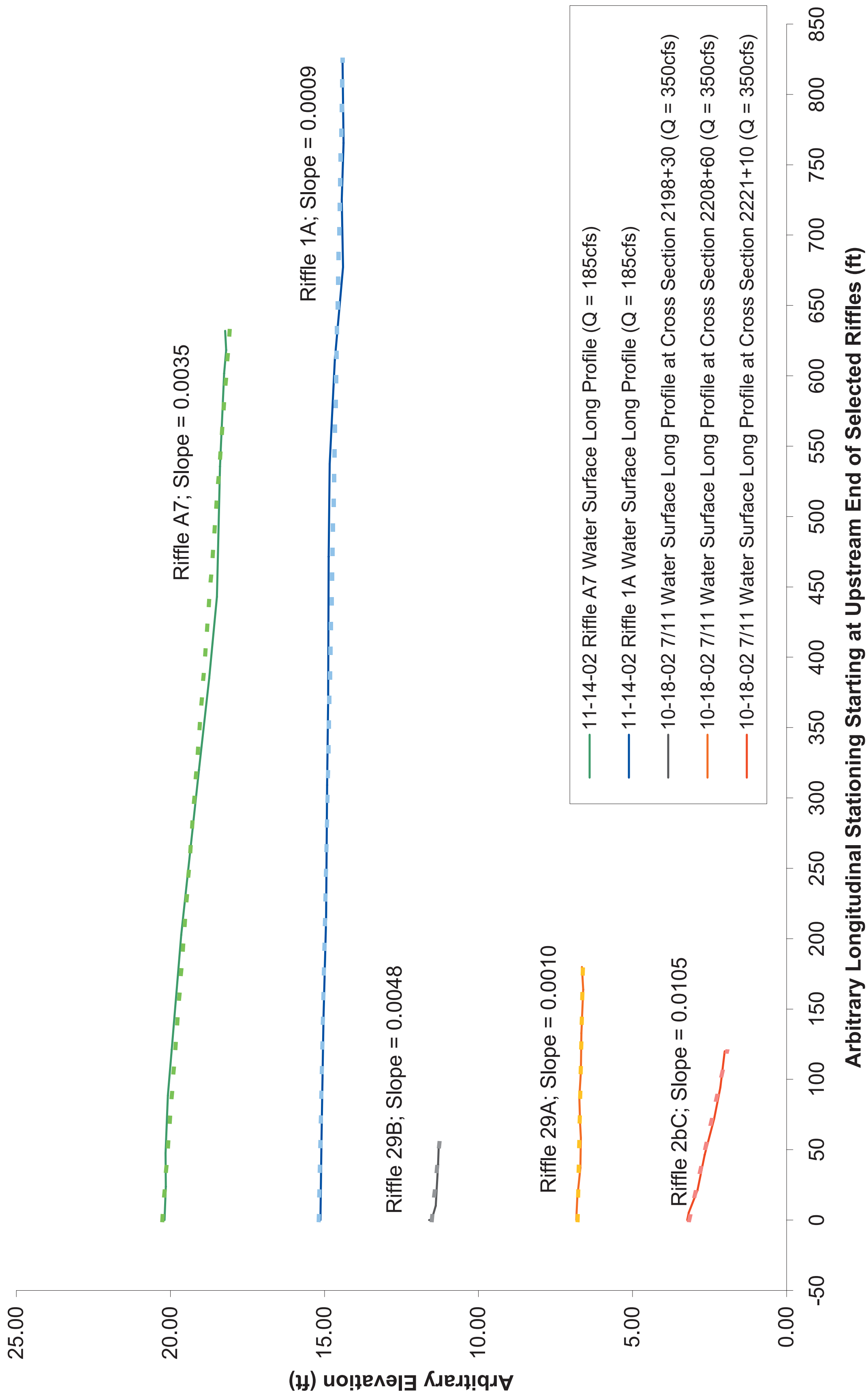


Figure 3-17. Water surface slopes at 7/11 project riffles (Riffles 29A and 29B) and heavily used spawning riffles in the Tuolumne River primary spawning reach (Riffles A7, 1A, and 2bC).

4 DISCUSSION

4.1 Conceptual Models

The Habitat Restoration Plan for the Lower Tuolumne River (McBain & Trush 2000) identifies 10 "Attributes of Alluvial River Integrity." The *Attributes* are: (1) spatially complex channel morphology; (2) variable yet predictable streamflow patterns; (3) frequently mobilized channel bed surface; (4) periodic channel scour and fill; (5) fine and course sediment supply in balance with long-term transport rates; (6) periodic channel migration and/or avulsion; (7) a functional floodplain; (8) infrequent channel resetting floods; (9) self-sustaining, diverse riparian corridor; and (10) naturally fluctuating groundwater table. Based on the *Attributes* and our current understanding of alluvial rivers, one can describe the linkages between **physical inputs** (e.g., sunlight, streamflow, sediment), **physical processes** (e.g., sediment transport, bank erosion, fine sediment deposition), **habitat structure** (e.g., shallow-gradient riffles, well-sorted and clean spawning gravels) and **biological responses** (e.g., healthy incubation, low density-dependent mortality) (Figure 4-1). These *Attributes* and the simple conceptual model shown in Figure 4-1 are the foundation of the conceptual models described below.

In June 2001, the UC Davis Center for the Environment and AFRP sponsored an Adaptive Management Forum to review the science behind the large-scale restoration projects on the Tuolumne River. The TRTAC Monitoring Subcommittee, with assistance and peer review by panel members from the Adaptive Management Forum, developed several interconnected conceptual models depicting our current understanding of (1) the effects of flow regulation and mining on geomorphic processes, habitat structure, and salmonid abundance in the river, (2) the river's Chinook salmon population dynamics, and (3) effects of individual restoration actions on geomorphic processes, habitat structure, and salmonid abundance. These conceptual models are presented in the report *AFRP / CALFED Adaptive Management Forum: Tuolumne River Restoration Summary Report* (Stillwater Sciences 2001b). River-wide and project-specific models relevant to the SRP 9 and 7/11 Reach projects are described below.

Model G-1. Effects of dams and mining on geomorphic inputs and processes, habitat structure, and population response (Figure 4-2). This model illustrates linkages between physical inputs, geomorphic processes, habitat structure, and salmonid abundance and the effects of dams and mining on these linkages. In this model, dams alter seasonal flow patterns in the lower river, reduce peak flow magnitude, reduce fine sediment supply, and eliminate coarse sediment supply. Aggregate mining and gold dredging further reduce coarse sediment supply to the river by removing stored sediment from the channel and floodplain and by trapping coarse sediment that is in transport. These reductions in flow and sediment supply reduce sediment transport, channel migration and avulsion, recruitment of large wood, and floodplain inundation, and result in channel incision, bed armoring, channel narrowing (through riparian vegetation encroachment), and abandonment of pre-dam floodplains. In-channel mining also creates large, lake-like pits in the river channel. These alterations reduce habitat quality for salmonid spawning, incubation, rearing, and outmigration. In addition, reductions in flow magnitude and alteration of seasonal flow patterns potentially affect salmonid run timing and emigration timing, as well as incubation, rearing, and outmigrant survival.

Model S-1. Factors affecting Chinook salmon population abundance in the Tuolumne River (Figure 4-3). This conceptual model depicts the factors affecting each Chinook salmon life history stage, within and outside of the Tuolumne River basin. Within the basin, research and monitoring have identified three primary factors that limit Chinook salmon population abundance: (1) redd superimposition; (2) low survival-to-emergence resulting from low substrate permeability; and (3) low outmigrant survival resulting from spring flow conditions, predation by largemouth bass, and water temperature. Other factors could also affect Chinook salmon population abundance, but these are not considered to be limiting. Of the limiting factors identified, redd superimposition is the only density-dependent mortality factor. The superimposition model developed by Stillwater Sciences from field studies on the Tuolumne River supports the hypothesis that superimposition and delayed fry emergence is a key factor driving the stock-recruitment curves developed from empirical observations in the Tuolumne River (TID/MID 1992b). Numerous factors outside the Tuolumne River watershed also affect the numbers of Chinook salmon returning to the Tuolumne to spawn. Such factors include (but are not limited to) Delta exports and entrainment in the Delta pumps, ocean harvest, ocean conditions, and predation and water quality in the Delta.

Model P-1. Effects of the Special Run-Pools (SRPs) 9 and 10 Projects on geomorphic process, riparian vegetation, and Chinook salmon survival (Figure 4-4). Past studies of Tuolumne River Chinook salmon population dynamics identified predation by largemouth bass as a major factor limiting outmigrant survival (and thus recruitment) in the Tuolumne River, particularly during drier years (TID/MID 1992a). Largemouth bass prefer deep, low velocity, warm-water habitats with abundant cover. In this model, replacing the large, deep SRP pit with a shallower, narrower channel reduces habitat suitability for adult largemouth bass and, thus, reduces adult bass carrying capacity (and adult bass abundance) and predation pressure on outmigrating salmon at the site. During high flows (>1,400 cfs), reconstructed floodplains provide rearing areas and outmigration routes that may reduce juvenile salmon interactions with adult largemouth bass. The reconstructed floodplain also provides a surface for colonization by riparian vegetation. (Note that the project also includes initial planting and maintenance of riparian vegetation.)

Model P-2. Effects of the Gravel Mining Reach Project on geomorphic processes, riparian vegetation, and Chinook salmon survival (Figure 4-5). In this model, reconstructing a channel and floodplain that are scaled to contemporary flow conditions, combined with planting native riparian vegetation on the reconstructed floodplain and maintaining coarse sediment supply, improves in-channel and floodplain geomorphic and riparian processes and improves Chinook salmon spawning and rearing habitat. Constructing an appropriately scaled channel and maintaining coarse sediment supply balances sediment transport capacity with sediment supply, thus providing a channel and floodplain that functions under contemporary, regulated flow conditions. By providing conditions that allow the channel to construct bars and riffles, the project improves salmon spawning, incubation, and rearing habitats. In addition, by reducing floodplain elevation, increasing floodplain width, and creating high flow channels on the floodplain, the project reduces flow velocities during floods and provides refugia for rearing salmon.

4.2 SRP 9 Project Implementation and Effectiveness

The SRP 9 project was monitored for five years following construction, but monitoring after 2003 was limited to opportunistic observations of high flow stage (due to lack of monitoring funds). Pre-project and post-project monitoring through 2003 partially tested hypotheses related to the primary goal of the project – reducing largemouth and smallmouth bass habitat and increasing Chinook salmon rearing habitat. Geomorphic monitoring thresholds (such as high flow events) were not exceeded until 2005. Several geomorphic hypotheses, therefore, have not yet been tested. Also, vegetation hypotheses have not been tested because riparian vegetation has not been monitored since irrigation ended at the site.

4.2.1 Project Design Process and Implementation

The SRP 9 project design underwent several revisions as it proceeded from conceptual design through implementation. The conceptual design process included participation by scientists from a range of disciplines, including biologists, geomorphologists, and riparian ecologists. As the conceptual design proceeded toward final design, revisions were controlled primarily by engineering and logistical constraints, and revisions were not reviewed in detail by the biologists who had contributed to the conceptual design. While not the sole cause of the extent of largemouth bass habitat at the site, some of the design revisions, such as widening the channel for the infiltration gallery, increased post-project largemouth bass habitat at the site relative to the conceptual design. Better communication between engineers and biologists throughout the design process could help avoid some, though certainly not all, changes to project designs that may reduce the project's ability to meet its biological objectives. Recommended revisions to the project design and implementation process for future restoration projects are discussed in Section 5.1.

Based on preliminary monitoring results from SRP 9, project engineers worked with biologists and geomorphologists to improve the SRP 10 design. Accordingly, the SRP 10 design was revised to reduce channel width, increase channel slope, reduce pool depth, and incorporate multiple floodplain surfaces that will be inundated at flows of 2,000 cfs and 4,500 cfs. The largemouth bass, smallmouth bass, and juvenile Chinook salmon habitat models developed for this project were used to test and iteratively refine the design. Model results and design recommendations are reported in McBain & Trush (2005, 2006a, and 2006b). The revised SRP 10 design also does not rely on off-site sources for construction fill. Construction fill will be obtained by excavating the right-bank terrace at the site, and cut-and-fill volume will be balanced within the project area. Obtaining fill material on-site provides more control over project implementation and design by avoiding unforeseen increases in fill cost and last minute design changes driven by fill material cost, as occurred as SRP 9 and the 7/11 Reach projects. It also substantially reduces project costs, eliminates the traffic and air quality impacts of hauling fill from off-site, and doubles the area of constructed floodplain/riparian surfaces.

4.2.2 Geomorphic Processes

<u>*Relevant Hypotheses:*</u>

H1. The constructed channel conveys 1,500 cfs; flows exceeding 1,500 cfs spill over onto the floodplain.
H2. The channel bed is mobilized at flows of 5,000 cfs.
H3. The constructed bankfull channel morphology is stable, where stable is defined as no net deposition or erosion in channel cross section and profile over the long term.
H4. The channel migrates under the current flow regime, although migration rates will be slow and magnitude will be small.

Post-project monitoring to date has tested hypothesis H1. The effects of high flows on bed mobility (hypothesis H2), channel morphology (hypothesis H3), and channel migration (hypothesis H4) have not been tested because the 5,000-cfs geomorphic monitoring threshold was not exceeded during the funded monitoring period (2001–2003). The geomorphic monitoring threshold was exceeded for long periods in 2005 and 2006. The geomorphic effects of these high flows have not been monitored.

Monitoring during flows of 1,030 cfs suggests that the channel capacity may be slightly less than 1,500 cfs. At flows of 1,030 cfs, floodplain surfaces were not inundated, but high flow scour channels on the floodplains were inundated to a depth of 1.4 feet. At 2,200 cfs, the left-bank floodplain was inundated to a depth of 0.8–2.7 feet, and the right-bank floodplain was inundated to a depth of 1.6–2.3 feet. Stage was not monitored during the design bankfull discharge (1,500 cfs). To more-cost-effectively capture a broader range of flows (including the 1,500-cfs design flow), we suggest replacing field surveys of flow stage with an automated stage recorder.

4.2.3 Bass Habitat and Abundance

Relevant Hypotheses

H10. Elimination of the pits will reduce habitat suitability for largemouth bass.

H11. Reduction in bass habitat suitability will result in reduced largemouth bass abundance at the project sites and an increase in Chinook salmon outmigrant survival at the project sites.

Largemouth and smallmouth bass have been documented in the Tuolumne River from Old La Grange Bridge (RM 50.5) to Shiloh (RM 3.4), but smallmouth bass are typically most abundant downstream of RM 37 and largemouth bass are most abundant downstream of Hickman Bridge (RM 31.6) (Ford and Brown 2001, Ford and Brown 2002). SRPs 9 and 10 and the monitoring control sites are downstream of Hickman Bridge and are in the river reach where both largemouth and smallmouth bass are expected to be abundant.

Pre- and post-project monitoring documents a pattern of largemouth bass population depletion caused by the 1997 flood and subsequent recovery. During extremely wet years, high flows can flush largemouth bass out of a stream, but typically a sufficient number of adults can find shelter in flooded areas to repopulate the stream during lower flow conditions (Moyle 2002). In January 1997, the Tuolumne River experienced its third largest flood of record, with flows downstream of La Grange peaking at 58,900 cfs. The January 1997 flood was sufficient to drive largemouth bass far downstream or into off-channel refugia (such as floodplain mining pits). After the flood, few adult bass remained in the river, but the presence of age 4+ and 5+ adults in 1998 indicated that adult largemouth bass were able to find refuge and move back into the river during lower flows. Floodplain mining pits may have provided refugia for large numbers of adult bass. The 1997 flood breached dikes that separated several floodplain mining pits from the river, allowing bass to move in and out of the pits after flow receded. The floodplain mining pit in the monitoring reach was partially surveyed in September 1998 (one electrofishing pass was completed along less than 25% of the total bank length in the pit). The number of largemouth bass captured during this brief pass exceeded the number of captured on a single pass at any of the SRP monitoring sites and was 25% of the total number of largemouth bass captured at all SRP sites combined.

During the years following the flood, largemouth bass abundance was controlled by spring and summer flow conditions that were unfavorable for reproduction. Largemouth bass require low water velocities and warm water temperatures to reproduce (Moyle 2002, Swingle and Smith 1950, Harlan and Speaker 1956, Mraz 1964, Clugston 1966, Allan and Romero 1975; all as cited in Stuber et al. 1982). In California populations, Moyle (2002) reports that spawning begins when water temperature reaches 59–61°F (15–16°C) (usually in March or April in California) and continues through June at temperatures up to 75°F (24°C). Other authors report slightly broader temperature ranges for spawning and incubation, with suitable temperature ranging from 55 to 79°F (13 to 26°C) (Carr 1942, Kelley 1968), and 68–70°F (20–21°C) reported as optimal (Clugston 1966, Badezhuizenn 1969). During the first two years following the flood (1997 and 1998), reproductive conditions for largemouth bass were poor, and bass abundance remained low. In 1997, water temperature in the monitoring reach was suitable for spawning for only two weeks in late May, after which temperatures exceeded the maximum spawning threshold (Figure 4-6). In 1998, water temperature was below the preferred spawning range until mid-June, and flow fluctuations through spring and summer could have caused sufficient disturbance to reduce egg viability or destroy the nests (Eipper 1975) (Figure 4-7). In fall 1998, adult abundance remained low and few juvenile bass were captured. In 1999, flow and water temperature were favorable for largemouth bass for the first time since the 1997 flood. Water temperature was within the preferred range for spawning from late May throughout the summer, and river discharge was constant (Figure 4-8). In fall 1999, young-of-the-year bass were abundant at all SRP sites and the Riffle 64 site, indicating high reproductive success for that year. Flow and temperature continued to be suitable for largemouth bass reproduction each spring and summer from 2000 through 2003 (Figures 4-9 through 4-12). By September 2003, the capture of adult largemouth bass (>200 mm) increased 254% relative to 1998 and 189% relative to 1999, indicating at least partial recovery of the population.

Smallmouth bass also appear to be recovering from the effects of the 1997 flood. Smallmouth bass spawn in warm waters, moving into shallow-water, low-velocity areas in late spring. In northern California, most spawning occurs in May and June but can extend into July depending on flow and water temperature (Moyle 2002). Nests are constructed in rubble, gravel, and sand bottoms near submerged cover at a depth of approximately three feet, and spawning begins as water temperatures increase to 55–61^{o}F (13–16^{o}C) (Moyle 2002). In 1998 and 1999, very few smallmouth bass were captured at any of the monitoring locations. Estimated abundance for all sites and size classes combined was 33 bass in 1998 and 57 bass in 1999. In 2003, estimated abundance for all sites and size classes combined was 466 bass. This was the first monitoring year for which strong YOY, 1+, and 2+ cohorts occurred. In 2003, 50% of the smallmouth bass captured were estimated to be YOY (2003 cohort), 44% were estimated to be ages 1+ and 2+ (2001 and 2002 cohorts), 3% were estimated to be age 3+ (2000 cohort). This increase in adult abundance and successful reproduction since 2000 illustrates the positive response of smallmouth bass to low flow years.

<u>Project Effects on Largemouth Bass Abundance and Habitat</u>

The SRP 9 project substantially reduced predicted largemouth bass habitat at the site relative to pre-project conditions. Largemouth bass is a warm-water species that prefers low-velocity habitats. Optimal riverine habitat for largemouth bass includes fine-grained (sand or mud) substrates, some aquatic vegetation, and relatively clear water (Trautman 1957, Larimore and Smith 1963, Scott and Crossman 1973, all as cited in Stuber et al. 1982). The SRPs provide extensive low-velocity areas suitable for largemouth bass foraging and reproduction. The SRP 9 project increased flow velocity at the site, and thus reduced largemouth bass habitat area. Compared to pre-project conditions, the project reduced predicted largemouth bass primary habitat at the site by 11–92% (total usable area) and 68–95% (weighted usable area) over the range of flows modeled (i.e., 75–5,000 cfs). For the flow conditions typical of spring and summer 2003, the project reduced predicted largemouth bass primary habitat by 34% (total usable area) and 76% (weighted usable area) compared to pre-project conditions.

Despite reducing habitat area, the SRP 9 project did not reduce piscivore-size largemouth bass abundance at the project site relative to pre- and post-project control sites for the conditions monitored from 1998–2003. For both pre-project and post-project monitoring, density of piscivore-size largemouth bass at SRP 9, while lower than at SRPs 8 and 10, was not statistically different from SRP 7 and was significantly higher than both Charles Road and Riffle 64. Success in reducing bass abundance would have been demonstrated by: (1) post-project bass density at SRP 9 significantly less than density at SRP 7 [minimum measure of success], and/or (2) post-project bass density at SRP 9 not significantly greater than at Charles Rd. and Riffle 64 [higher measure of success]. The period tested (2001–2003) included only dry or below normal years. Since the project increased flow velocity relative to the pre-construction conditions, the project may reduce largemouth bass abundance (relative to control sites) during higher flow years (i.e., years with relatively high late spring and early summer flows). Bass abundance monitoring during years with high spring and early summer flows would be required to test this hypothesis.

Predicted largemouth bass habitat density at SRP 9 (post-project) remained well above predicted density at the channel control sites, and predicted habitat density was consistent with observed bass abundance. Density of piscivore-size largemouth bass at SRP 9 in 2003 (post-project) was 260% of observed density at Charles Rd. and 730% of observed density at Riffle 64. For 2003 summer flows, primary habitat density at SRP 9 was 120% of predicted density at Charles Rd. and 430% of predicted density at Riffle 64 (for total usable area). High flow velocity was more important than depth in limiting largemouth bass habitat area at the channel sites. Flow velocity is controlled by channel slope, confinement, and roughness. The channel control sites were both more confined (i.e., had narrower channels) and steeper than SRP 9. Average low-flow channel width at the control sites was less than 100 feet, and channel gradient was 0.0005 and 0.0006. Channel gradient was 0.00007, an order of magnitude less than the channel control sites. At SRP 9, low-flow channel width in the upstream third of site (i.e., where predicted largemouth bass habitat occurs) was 170 feet, 43% wider than the channel control sites.

Observed bass densities suggest that habitat at SRP 9 pre- and post-project was less favorable for piscivore-size largemouth bass than at SRPs 8 and 10 and similar to SRP 7. Based on similarities in channel morphology, however, pre-project largemouth bass habitat at SRP 9 was expected to be similar to SRPs 8 and 10. Before the project was constructed, channel width and depth at SRP 9 was similar to SRPs 8 and 10.

Bass density at the project and control sites may also be affected by angling pressure. The Tuolumne River is a popular fishing location. The bass fishing season is open for most of the year (January 1–October 31), and there is no limit on the size or number of bass caught (CDFG 2004e). Angling, therefore, could reduce bass abundance in the project area. In the monitoring reach, public access (including a public boat ramp) is provided at Fox Grove County Park, immediately upstream of SRP 9. This is a popular fishing access area, and anglers and bait boxes were often observed at SRP 9 during field surveys. The control sites are also accessible from Fox Grove by boat, but access to SRP 10, Charles Road, and Riffle 64 is difficult during low flows when boats must maneuver over shallow riffles. Due to its close proximity to Fox Grove County Park and easy pedestrian and boat access, fishing pressure is likely more significant at SRP 9 than at the other monitoring sites. If this is the case, bass density at SRP 9 may have been underestimated. While the effects of angling on bass density at the monitoring sites cannot be determined, underestimation of bass density at SRP 9 would not change the conclusion that the project did not reduce bass density to levels similar to the channel control sites or less than SRP 7 over the monitoring period.

Project Effects on Smallmouth Bass Abundance and Habitat

Effects of the SRP 9 project on smallmouth bass are not clear. Monitoring did not identify any statistically significant trends in smallmouth bass density among the project and control sites, but it is clear that SRP 9 supports a relatively high density of piscivore-size smallmouth bass — significantly higher than all other SRP sites and similar to channel control sites. While smallmouth bass distribution and habitat utilization at the site have not been assessed, incidental observations during monitoring surveys suggest that some features of the SRP 9 project may further enhance smallmouth bass habitat. In 2003, most smallmouth bass captures at SRP 9 were along the rock revetment on the left bank. The revetment provides usable or preferred cover in and adjacent to swift water velocities preferred by smallmouth bass. The revetment may also support crayfish, a preferred prey item for adult smallmouth bass (Moyle 2002). Crayfish prefer habitats with cover provided by interstitial spaces (Saiki and Tash 1979) and may be abundant in the revetment.

In past studies on the Tuolumne River, observed smallmouth bass predation rates on juvenile Chinook salmon were 2.5 times observed largemouth bass predation rates (TID/MID 1992a). The study, however, concluded that smallmouth bass were a less important predator than largemouth bass due to their low abundance in the river. Converting deep, low-velocity SRP units to shallower, steeper channels with higher flow velocities could potentially replace largemouth bass habitat with smallmouth bass habitat, in essence exchanging one non-native predator for another.

4.2.4 Predation on Juvenile Chinook Salmon

Relevant Hypothesis

H11. Reduction in bass habitat suitability will result in reduced largemouth bass abundance at the project sites and an increase in Chinook salmon outmigrant survival at the project sites.

The most important goal of the project was to increase Chinook salmon outmigrant survival. Several studies have identified a positive relationship between spring flows and Chinook salmon outmigrant survival from the Tuolumne River, as well as recruitment to the population in subsequent years (e.g., TID/MID 1992b, 2004a). This restoration project was based on studies conducted in the early 1990s that concluded that predation by largemouth and smallmouth bass was a significant source of density-independent mortality for outmigrant salmon (TID/MID 1992a). It is notable that this study was conducted during low flow years, when bass are expected to be most abundant (Brown and Ford 2002) and predator efficiency is expected to be high. The results may be most applicable to dry year conditions.

Despite the continued high abundance of smallmouth and largemouth bass at the SRP 9, the River 2D model provides a new conceptual model and tool for identifying and testing the effects of projects such as SRP 9 on juvenile Chinook salmon outmigration success. The SRP 9 project replaced the wide, deep SRP 9 mining pit with a narrower and shallower channel and floodplain. By creating a smaller channel cross section, the project increased flow velocity relative to pre-project conditions. The River 2D model suggests that the post-project channel and floodplain morphology at SRP 9 provides a "safe velocity corridor" for Chinook salmon outmigrants through the site during typical spring outmigration flows. Within this safe velocity corridor, higher flow velocities that exclude largemouth and smallmouth bass from the center of the channel segregate outmigrant salmon from these non-native predators and reduce bass predation efficiency. Based on the River 2D model for SRP 9, this safe velocity corridor is expected to occur at flows of 300 cfs and higher for post-project conditions, compared to 2,000 cfs and higher for pre-project conditions. (Pre- and post-project flow velocity profiles are shown in Appendices D and E.)

The FSA requires pulse flows to be released each spring in the Tuolumne River to stimulate outmigration and increase outmigrant survival. The total volume of the pulse flow release specified in the FSA ranges from 12,000 acre-feet to 90,000 acre-feet depending on the water year type. The timing, duration, and magnitude of pulse flows are determined by the Districts in coordination with the Vernalis Adaptive Management Plan managers on a year-by-year basis and are coordinated with pulse flows from other San Joaquin River tributaries. Pulse flows are typically released over a two-week period in April and/or May and generally consist of two steps—a higher pulse held for approximately seven days followed by a lower pulse of the same duration. In many but not all years, peak outmigration of wild juvenile Chinook salmon coincides with the pulse flow release (e.g., CDFG 2004c, 2004d; Stillwater Sciences 2000, 2001a).

The pulse flows benefit Chinook salmon by reducing water temperature and increasing flow velocity. In 2002 and 2003 (i.e., after project construction), spring pulse flows consisted of two steps of approximately 1,300 and 600 cfs each year. In 2002, spring pulse flows reduced water temperature in the project reach from 66^{o}F (19^{o}C) to 55^{o}F (13^{o}C) during the 1,300 cfs pulse and 63^{o}F (17^{o}C) during the 600 cfs pulse. In 2003, pulse flows reduced water temperature in the project reach from 64^{o}F (18^{o}C) to 55^{o}F (13^{o}C) during the 1,300 cfs pulse and 59^{o}F (15^{o}C) during the 600 cfs pulse.

Largemouth bass foraging rates are positively correlated with water temperature up to a maximum, at which point consumption declines. Foraging begins at 41^{o}F (5^{o}C) and increases until water temperatures reach 79–81^{o}F (26–27^{o}C) (Coutant 1975, Zweifel et al. 1999) (Figure 4-13). At temperatures exceeding 81^{o}F (27^{o}C), foraging rapidly declines and adult bass remain quiescent in low velocity, shaded areas (Coutant 1975). For smallmouth bass, maximum prey consumption rate peaks at approximately 72°F (22°C) and declines at higher temperatures (Zweifel et al. 1999). Estimated largemouth bass foraging rates during Chinook salmon outmigration in 2002 and 2003, based on the data presented in Coutant (1975), are shown in Figures 4-14 and 4-15. While spring water temperatures in the Tuolumne River are never low enough to preclude bass foraging, the reduction in temperature during the pulse flows was sufficient to depress expected foraging rates. The reduction in water temperature provided by the pulse flows provides a river-wide benefit to outmigrating salmon and probably is not greatly affected by conversion of the SRP to a narrower channel. Wide-scale elimination of the SRPs could conceivably contribute to further reduction in water temperature, but the potential for such an effect has not been analyzed.

By segregating suitable bass from outmigrant salmon, the SRP 9 project provides an additive benefit to the required spring minimum flows and pulse flows. To illustrate the improvement in outmigration conditions before and after restoration, the timing of the safe-velocity window for 2002 and 2003 is illustrated in Figures 4-14 and 4-15. For the 2002 and 2003 spring pulse flows, the River 2D model predicted that at 600 cfs pulse (represented by the 500 cfs model), largemouth and smallmouth bass are restricted to the right bank floodplain and the left bank along the pool and that at 1,300 cfs (represented by the 1,000 cfs model) largemouth and smallmouth bass are pushed further onto the right bank floodplain. Assuming that the safe velocity corridor begins at flows of 300 cfs, flow velocity provided habitat segregation during outmigration for 57–75% the 61-day outmigration period (defined as April 1 through May 31) in 2002–2004. The pre-project 2,000 cfs threshold was not met or exceeded during the 2002–2004 outmigration periods.

Increased flow velocity in the reconstructed channel may also reduce energetic expenditure for outmigrating salmon. Outmigrating juvenile Chinook salmon seek high velocity portions of the channel and orient facing upstream as the flow carries them down the river. In unmined reaches of the river, velocities are likely sufficient to carry the outmigrants downstream with minimal energy expenditure (i.e., without swimming). Flow velocity in the SRP units (pre-restoration), however, is near zero until flows exceed 1,000 cfs. Assuming that salmon will shift from passive outmigration to active swimming when flow velocity is less than their sustained swimming speed, flow velocity can be a reasonable indicator of salmon swimming behavior and energy expenditure. A review of the literature did not identify a sustained swimming speed for outmigrating juvenile Chinook salmon. Brett et al. (1958) found that juvenile coho salmon (54 mm FL) could sustain a speed of 1 ft/s at a temperature of 68°F (20°C), and larger juveniles (69 mm FL) could sustain a swimming speed of 1.4 ft/s at the same temperature. At lower temperatures, the maximum sustained swimming performance was reduced for both size classes, with peak sustained speeds of 0.7 ft/s and 1.1 ft/s for the smaller and larger juveniles, respectively at 50°F (10°C) (Brett et al. 1958). These results should be comparable to Chinook salmon.

Using flow velocity as an indicator, Chinook salmon in the Tuolumne River could be expected to actively swim through SRP 9 during flows less than 2,000 cfs under pre-project conditions (see velocity profiles provided in Appendix D). Modeled pre-project flow velocity through SRP 9 at this flow was less than the maximum expected swimming speed of juvenile Chinook salmon in the temperature range typically experienced during the outmigration period (Appendix E and Figures 4-14 and 4-15). With the new channel configuration, flow velocity through the majority of SRP 9 exceed the 1.0 ft/s swimming speed threshold at flows of 300 cfs and higher. Conversion of SRPs to shallower, narrower channels, therefore, could reduce the energetic costs of outmigration by allowing Chinook salmon to passively migrate. Given the short length of the project, the project-scale benefit of this energy conservation is likely minor. The cumulative effects of restoring additional SRPs, however, could be substantial.

The analyses presented herein are based on model results and have not been validated with field observations. In fall 2004, the CBDA provided funds to conduct a pilot predation study at SRP 9. Because spring flows in 2005 and 2006 were well above the 300-cfs threshold, the study assessed predation on juvenile Chinook salmon during high flow conditions. The objectives of the study were to:

- document the predation rate in SRP 9 and compare with predation rates at SRP and riffle control sites; and
- document velocity-driven or temperature-driven spatial distribution of predators and salmon at SRP 9 and an SRP control site, and determine whether the two species are spatially segregated.

The predation assessment was conducted from May 3–24, 2006, at three sites on the Tuolumne River between RM 25.9 and RM 24.8: (1) the project site (restored SRP 9), (2) an SRP control site (SRP 10), and (3) a riffle control site (Charles Rd.). All of the sites were located downstream of the Geer Road bridge and were accessed by boat via the Fox Grove fishing access. Predator capture and marking, as well as seine surveys and temperature monitoring, occurred during a three day period from May 3–5, 2006. Subsequent monitoring (tracking) of marked predators occurred weekly thereafter, concluding on May 24, 2006. Study results are will be provided in a separate report available in July 2006.

4.2.5 Chinook Salmon Rearing Habitat

<u>*Relevant Hypothesis*</u>

H10. Elimination of the pits will reduce habitat suitability for largemouth bass and will increase habitat suitability for Chinook salmon rearing.

The restoration project increased predicted Chinook salmon fry and juvenile habitat for all flows modeled, except fry habitat at 75 cfs. The increase in fry habitat was small for flows less than bankfull, but exceeded 180% for flows from 1,000 to 3,000 cfs. Predicted juvenile Chinook salmon habitat increased 46–121% for flows less than bankfull and 50–392% for flows exceeding bankfull.

The FSA requires minimum flows from October 16 through May 31 ranging from 150 cfs for “median dry” and drier water years to 300 cfs for “intermediate below normal/above normal” and wetter water years. During these flows, fry and juvenile Chinook salmon rearing habitat overlaps considerably with bass habitat. Once water temperatures reach suitable foraging ranges for largemouth and smallmouth bass, predation risk would limit the in-channel rearing habitat value at the site. In 2002 and 2003, suitable bass foraging temperatures at the site (represented by 55^{o}F [13^{o}C]) were reached by February. Successful rearing at the site during these years, therefore, was likely very low.

The greatest benefits of the project for rearing salmon occur during flows $\geq$ 1,500 cfs, when rearing habitat becomes available on the floodplains and in the high flow channels. Recently, Central Valley researchers have reported the benefits of floodplain rearing habitats for Chinook salmon (e.g., Sommer et al. 2000). During the period for which the FSA flow schedule has been in place during the Chinook salmon rearing period (1997–2006), flow was sufficient to inundate the SRP 9 constructed floodplain during January 1–March 31 (early rearing) in nine of ten years and April 1–June 15 (late rearing) in six of ten years. Most benefit is expected during above normal and wetter years, when flow exceeds 1,500 cfs for long periods during the rearing season. For 1997–1999 and 2005–2006 (all above normal and wetter years), flow exceeded 1,500 cfs for 45–90 days during the early rearing period and 19–76 days during the late rearing period. During dry and below normal years (2001–2004), flow exceeded 1,500 cfs for a maximum of only eight days during the early rearing period. Flow did not exceed 1,500 cfs during the late rearing period.

Flow sufficient to inundate the floodplain also is expected to maintain suitable Chinook salmon rearing temperature at the site. Temperatures of 55–65°F (13–18°C) are optimal for rearing Chinook salmon, but positive growth can occur at temperatures of 41–66°F (5–19°C) (Marine 1997, McCullough 1999, both as cited in Moyle 2002). The SNTEMP model developed for the Tuolumne River predicts 5-day average water temperature throughout the river. Meteorological inputs to the model are from 1978 through 1988. Using average meteorological conditions for the 11-year period for which the model was constructed, predicted flow required to maintain temperatures ≤65°F (18°C) at the project site in May and June range from 300 cfs to 800 cfs, much lower than the bankfull flow (Figure 4-16). This analysis may over-represent habitat suitability by relying on 5-day average temperature. Juvenile Chinook salmon, however, can withstand brief exposure to temperatures exceeding preferred rearing conditions but cannot survive even brief exposure to temperatures exceeding 75°F (24°C). Mortality in wild populations has been observed at temperatures of 71–73°F (22–23°C) (Baker et al. 1995, McCullough 1999 as cited in Moyle 2002). Also, water on the floodplain would likely be warmer than predicted by the model. The 5-day average temperature should be interpreted with caution but could adequately represent chronic temperature exposure for rearing Chinook salmon at the site.

The importance of this reach for rearing juvenile Chinook salmon varies among years. TID has conducted seine surveys from January through May at several locations throughout the river to monitor juvenile salmon distribution, outmigration timing, and growth since 1986. Peak fry and juvenile densities for 1999 through 2004 for all locations in the river are shown in Figure 4-17. TID/MID (2004a) divides the river into three reaches and has developed a rearing abundance index to compare rearing in each reach. The monitoring sites are located in each reach as follows: upper reach (RM 50.5 to RM 42.4), middle reach (RM 31.6 to RM 17.2), and the lower reach (RM 7.4 to RM 3.4). During four of the six years analyzed (1999–2003), rearing abundance was highest in the upper reach (TID/MID 2004b). In 1999, rearing abundance was highest in the middle reach. In 2001, rearing abundance was highest in the lower reach. These results indicate that the potential importance of the site for rearing, therefore, will vary among years and likely will be most important during wetter years. Actual rearing use cannot be determined because Chinook salmon fry and juvenile rearing at the site is not currently being monitored.

4.2.6 Other Native Fish Species (Fish Community Species Composition)

<u>*Relevant Hypothesis*</u>

- The project did not include specific objectives for fish community composition or native fish, other than Chinook salmon, at the site. No specific hypothesis was included in the monitoring plan.

Species composition can be an important indicator of ecosystem health, with dominance by native species indicating positive trends in health. Several researchers have shown that, in California rivers, altered flow regimes are linked to invasion success of non-native fish species (Baltz and Moyle 1993, Brown and Moyle 1997, and Marchetti and Moyle, 2001, as cited in Brown and Ford 2002). On the Tuolumne River, Brown and Ford (2002) analyzed twelve years (1986–1997) of spring/summer seining data from throughout the river to identify trends in non-native versus native fish abundance. The surveys documented 28 taxa (including Chinook salmon), ten of which were native and 18 of which were non-native. The combination of longitudinal location in the river and mean April–May flow during the year prior to sampling was a good predictor of relative non-native to native fish abundance. Non-native species occurred in greatest abundance at downstream locations, with abundance increasing and distribution extending further upstream in drier years. This model explained nearly two-thirds of the variance in non-native species abundance. Brown and Ford (2002) conclude that spring spawning success is the primary life history mechanism controlling relative abundance of non-native and native fish. The more abundant native species (Sacramento sucker, Sacramento pikeminnow, and riffle sculpin) are riffle spawners. Under natural flow conditions with which these species evolved, spring flows were high, driven by mountain snowmelt. These species, therefore, spawn successfully in high flow years. Conversely, the most abundant non-native species are bottom-nesting and require low-velocity areas for nest building. High spring flows reduce the availability of suitable nesting sites for these species, and these species do not spawn successfully in high flow years.

The project monitoring reach is located at the transition from native to non-native dominance (Brown and Ford 2002), and is best represented by monitoring locations at Hickman Bridge (RM 31.6) and Charles Road (RM 24.9). Electrofishing data from the SRP 9 monitoring extend the data set analyzed by Brown and Ford to include a range of wet and dry years occurring after the FSA flow schedule was implemented. These data also provide an opportunity to compare the effects of habitat structure on fish community composition, which was not analyzed by Brown and Ford (2002). Patterns observed at the SRP and channel sites follow the same pattern as documented by Brown and Ford (2002), with the dominance of non-native fish increasing in lower flow years. The ratio of introduced to non-native fish increased at all sites in 2003 relative to 1998 and 1999. At the channel sites, native fish were more abundant than non-native fish in 1998 and 1999, but were less abundant than non-native fish following the low spring flows experienced from 2000 through 2003. As would be expected based on habitat requirements for these species, the SRPs support more non-native fish than native fish. In 2003, the ratio of non-native to native fish at the SRP sites for which abundance could be estimated (SRPs 9 and 10) was one-to-two orders of magnitude larger than at the channel sites. Non-native species at the SRP sites in all years were primarily centrarchids (sunfish and bass), cyprinids (goldfish and carp), and ictalurids (catfish). Striped bass (Family Percichthyidae), inland silverside (Family Atherinidae), American and threadfin shad (Family Clupeidae), and bigscale logperch (Family Percidae) were also present at the sites. Centrarchids were consistently the most abundant family at the SRPs in all years.

Converting SRP 9 from a mined pit to a channel and floodplain was expected to increase native fish abundance at the site. Native fish abundance and diversity at the site, however, decreased relative to pre-project conditions and relative to SRP control sites. Native species found at the site prior to construction but absent following construction included lamprey, sculpin, hardhead, hitch, Sacramento pikeminnow, and Sacramento splittail. Of these species, lamprey, Sacramento blackfish, Sacramento pikeminnow, and sculpins were present at other SRP units in 2003. Hardhead and hitch were present at the channel control sites but not at the SRP sites. This reduction in native fish could be due to several factors, including: (1) low reproductive success of native fish during low flow years since the project was completed, (2) low cover that was only beginning to establish at the site by 2003, (3) predation by non-native fish at the site, (3) angling pressure (two dead suckers were observed on the banks during 2004 field surveys), and (4) low site gradient and extensive pool habitat which provided poor habitat for native fish. Native fish abundance at SRP 9 might increase with improved river-wide reproductive success during higher flow years. Due to the low channel gradient at SRP 9 relative to the channel control sites, the non-native:native fish ratio is expected to stabilize at a level lower than unrestored SRP sites but higher than the channel control sites.

4.2.7 Riparian Vegetation

<u>Relevant hypotheses</u>

H7. Planted riparian vegetation will become established on the constructed floodplain.
H8. Natural recruitment of native riparian plant species will occur on the constructed floodplain.
H9. Riparian vegetation will not encroach into the constructed channel.

No post-project vegetation monitoring at the 7/11 Reach has been conducted to date. Survival of planted vegetation, therefore, can not be determined.

Natural recruitment of native vegetation on the constructed floodplain has not been monitored. Throughout the Tuolumne River corridor, the area of frequently inundated floodplains has been reduced by a combination of flow regulation and levee construction. Several projects currently being designed and implemented in this reach will construct floodplains that are inundated at flows exceeding 5,000 cfs, approximately the 3-year flood. Floodplain elevation at SRP 9 was lowered to reduce the volume of fill needed to construct the project. The constructed floodplain is designed to be inundated at flows exceeding 1,500 cfs (slightly less than the 1.3-year flood). This site provides an opportunity to test riparian plant recruitment on frequently inundated surfaces. Monitoring should include measures of plant establishment and recruitment, species composition (including invasion by non-native species), and plant health. Factors that are thought to control native plant establishment and recruitment at the site should also be monitored, including flow timing, magnitude and elevation; groundwater elevation and drawdown rates; and seed availability at the site. These data would be useful for future restoration project design and for identifying flow measures that support native riparian ecosystems on the river.

4.3 7/11 Project Implementation and Effectiveness

The 7/11 Reach project was monitored for four years following construction, but monitoring after 2002 was limited to opportunistic observations of high flow stage and one bed mobility experiment. Pre-project and post-project monitoring through 2006 partially tested hypotheses related to Chinook salmon habitat, bed mobility thresholds, and floodplain inundation. The 5,000-cfs geomorphic monitoring threshold was not exceeded until 2005, and follow-up surveys have not been conducted due to lack of monitoring funds. Basic geomorphic hypotheses, therefore, have not been tested. Riparian vegetation also has not been monitored since irrigation ended. Riparian vegetation hypotheses, therefore, have not been tested.

4.3.1 Project Design Process and Implementation

From channel cross section surveys and review of the as-built aerial photographs, the project construction seems to adhere to the modified final design. Because as-built floodplain topography was not surveyed, floodplain construction relative to design has not been evaluated. If funds become available, analysis of floodplain topography generated from the 2005 LIDAR surveys could assess as-built floodplain elevation.

During final design and construction, the project design downstream of the 7/11 haul road was modified to reduce construction cost. Design modifications included: (1) replacing the preferred bridge span with a fill and culverts for the portion of the haul road that crosses the floodplain, and (2) narrowing floodplain width by approximately 50 feet (10%) and lowering floodplain elevation downstream of the 7/11 haul road bridge. The effects of these modifications on project performance were expected to be minor and included:

- The 7/11 haul road will require maintenance to prevent the accumulated debris from blocking the culverts. If kept clear of debris, the culverts can provide flood conveyance, but there is substantial risk that they will be partially or wholly blocked by debris that accumulates during a flood. The hydraulic model developed for the project predicted that flows up to 15,000 cfs can be conveyed through the bridge span (i.e., without requiring conveyance through the culverts) if the culverts get plugged. Conveying all flow through the bridge spawn, however, may pose increased risk of damage to the bridge and potential scour and deposition at the upstream side of the culverts.
- Reduced floodway width downstream of the 7/11 haul road could slightly increase flow depth and velocity during high flows in this portion of the project.
- The reduced floodway width downstream of the 7/11 haul road bridge reduced the area of new riparian vegetation by approximately three acres.

Some effects of the design modifications and project implementation were observed during high flows in spring 2005. Because high flow stage was not surveyed or analyzed for the project reach, these field observations are preliminary only. Observed effects included:

- The floodplain upstream of the 7/11 haul road bridge was not inundated until flow was between 6,500 cfs and 8,400 cfs. The floodplain was designed to be inundated when flow exceeds 5,000 cfs.
- Water does not begin to flow through the culverts in the 7/11 haul road (i.e., the fill-and-culvert berm) until flow exceeds 8,400 cfs. At lower flows, the haul road blocks flow from reaching the downstream constructed floodplain. Even at 8,400 cfs, flow depth in the culverts was only 0.2 feet, and only minimal flow reached the downstream floodplain. With upstream flow blocked, the downstream floodplain functions as a backwater channel, with flow backing up onto the constructed surface from the scour channel at the downstream end until flow exceeds at least 8,400 cfs.

4.3.2 Geomorphic Processes

<u>*Relevant hypotheses*</u>

H1. The constructed channel conveys 5,000 cfs; flows exceeding 5,000 cfs spill over onto the floodplain.

H2. The channel bed is mobilized at flows of 5,000 cfs.

H3. The constructed bankfull channel morphology is stable, where stable is defined as no net deposition or erosion in channel cross section and profile over the long term.

H4. The channel migrates under the current flow regime, although migration rates will be slow and magnitude will be small.

Most geomorphic hypotheses for the 7/11 Reach have not been tested because the 5,000-cfs geomorphic monitoring threshold was not exceeded during the funded monitoring period (1998–2002). The monitoring threshold was exceeded for long periods in 2005 and 2006, but monitoring was limited to opportunistic surveys due to lack of monitoring funds.

Channel conveyance (hypothesis H1) and bed mobility thresholds were partially tested in 2002 and 2005. The channel was designed to convey a 5,000-cfs bankfull discharge through most of the project reach. Downstream of the 7/11 haul road, the modifications to the floodplain design reduced expected bankfull flow to 4,500 cfs. Flow stage was marked during flows of 5,690 cfs, slightly above the bankfull discharge. Upstream of the 7/11 haul road, this flow slightly exceeded channel conveyance, and floodplains were shallowly inundated. Downstream of the 7/11 haul road, bankfull conveyance exceeds 8,410 cfs because the 7/11 haul road and the riparian berm left in place to preserve existing vegetation downstream of the 7/11 haul road bridge confine flow to the channel.

The project design attempted to achieve bed mobilization at the 5,000-cfs bankfull discharge (hypothesis H2). During project design, flow depth required to mobilize the river bed in the project reach was estimated to be 5.8 feet assuming a D_{84} of 74 mm and a 0.0015 water surface slope during flows of 5,400 cfs (based on surveys in the Ruddy Reach) (McBain & Trush 2004a). To achieve bed mobilization at the bankfull discharge, the design bankfull depth was six feet. Marked rock experiments in 2005 tested bed mobilization during a flow of 8,410 cfs, the post-NDPP 11-year flood. The as-built D_{84} (as represented by two as-built pebble counts) was finer than the D_{84} assumed for design calculations (68 mm on constructed bars and 58 mm at constructed riffles). Even with the finer bed texture, bed mobilization was achieved at only one of the two sites where marked rock experiments were conducted. The bed surface was fully mobilized at the constructed bar at the upstream end of the reach (cross section 2214+50), where the channel is confined by adjacent terraces. Further downstream at cross section 2198+30, where setback dikes and constructed floodplains provide less channel confinement, the constructed bar surface was only partially mobilized.

The effects of the 2005 and 2006 flows on the stability of the constructed bankfull channel (hypothesis H3) and channel migration (hypothesis H4) have not been tested. The 2005 high flows were significant. Peak flow was an 11-year flood (8,410 cfs), and the 5,000-cfs geomorphic monitoring threshold was exceeded on 27 days. Flow in 2006 was even higher. Daily average flow peaked at 8,850 cfs (to 14-year annual maximum flood), and the 5,000-cfs geomorphic monitoring threshold was exceeded on 86 days (as of June 25). The instantaneous peak was likely higher, but instantaneous peak flow data are not yet available. Data are available to partially test effects of the 2005 high flows on channel morphology (hypothesis H3) and channel migration. Available data include high flow stage markers placed in 2005 during flows of 5,690 cfs, 6,500 cfs, and 8,400 cfs, and aerial photographs, floodplain topography, and channel bathymetry (provided by the Coarse Sediment Transfusion Project). No data are available to test the effects of the 2006 flows. These flows provide an opportunity to test many aspects of the restoration design. If geomorphic monitoring specified in the Monitoring Plan is not be conducted before winter of WY 2007, learning opportunities may be lost due to removal or degradation of high flow stage markers placed in 2005, high water marks from 2006, and other field evidence of the effects of these high flows on the channel. Moreover, if flows are higher in WY 2007, it will not be possible to isolate the effects of the WY2005–2006 from higher flows in WY 2007.

4.3.3 Chinook Salmon Spawning Habitat

<u>*Relevant hypothesis*</u>

H5. The extent and quality of Chinook salmon spawning habitat is increased.

The project increased Chinook salmon spawning habitat area by 22,100 ft^2 (172%). Assuming a defended redd size of 200 ft^2/redd for Chinook salmon (TID/MID 1992c), pre-project spawning habitat area could support 64 spawning pairs, and post-project habitat could support 174 spawning pairs, an increase of 172% relative to pre-project conditions. For the 2002–2005 post-project monitoring period, CDFG redd counts did not detect a significant change in Chinook salmon spawning at riffles in the project reach relative to control riffles. These drift boat counts, however, are not appropriate for assessing spawning use at the scale of individual riffles. Changes in the riffle naming system among years also complicate the analysis. More detailed redd counts at project and control riffles would provide a better means of assessing the effects of the project on spawning use in the project reach.

Monitoring also should include other habitat factors known to affect selection of the spawning sites and egg and alevin survival-to-emergence from redds. The habitat mapping used to quantify changes in spawning habitat area defined suitable habitat based on flow depth, flow velocity, and surface substrate texture. Other factors, such as substrate permeability, hydraulic downwelling and upwelling, and intragravel dissolved oxygen, also affect salmon selection of spawning sites and egg and alevin survival-to-emergence. Many researchers believe that salmon select these sites based on downwelling caused by bed morphology and woody debris, which provides oxygen-rich water to the incubating eggs and alevin in the redds (Bjornn and Reiser 1991, Healey 1991). These areas also typically offer nearby cover in the form of deep water, large woody debris, or overhanging vegetation (Bjornn and Reiser 1991). Subsurface substrate texture also affects site selection and incubation success. Substrates preferred by Chinook salmon range from 0.5 inches to four inches in diameter and contain less than 25% fines less than 2 mm in diameter (Platts et al. 1979; Bell 1986, as cited in Bjornn and Reiser 1991). Accumulation of fine sediment in subsurface substrate reduces substrate permeability and can reduce survival-to-emergence from redds. These factors were not included in the Monitoring Plan.

4.3.4 Chinook Salmon Rearing Habitat

Relevant hypothesis:
H6. The extent and quality of Chinook salmon rearing habitat is increased.

Compared to 1999 pre-project mapping, post-project habitat mapped in 2002 was reduced by 150,700 ft^2 (64%) for fry and 494,500 ft^2 (47%) for juveniles. A portion of this reduction is likely attributable to the difference in flows during pre- and post-project mapping. Project monitoring compared pre- and post-project Chinook salmon fry and juvenile rearing habitat during conditions typical of minimum flows required by the FSA. Pre-project habitat, mapped at 254–265 cfs, represents minimum spring flows during “intermediate below normal/above normal” and wetter water years. Post-project habitat, mapped at 185 cfs, represents minimum spring flows during “median below normal” and drier water years.

Following emergence, Chinook salmon fry occupy low velocity, shallow areas near stream margins, including backwater eddies and areas associated with bank cover or large woody debris, where they aggregate in schools of 20 to 40 (Lister and Genoe 1970, Everest and Chapman 1972, McCain 1992). Fry also use pool margins and pool tails associated with bedrock obstructions, rootwads, and overhanging banks. Both pre- and post-project, suitable fry habitat occurred in a narrow band along the channel margins. For most of the reach, the project increased the length of channel margin suitable for fry rearing relative to pre-project conditions but reduced the width of the suitable habitat band. Fry habitat area is expected to increase at higher flows relative to pre-project conditions as lateral bars and floodplains are inundated. The project replaced steep banks and dikes throughout the project reach with lateral bars and floodplains. These steep banks and dikes that confined the channel would not have provided suitable fry habitat during high flows. Conversion of these steep banks to gently sloping bars and floodplains maintains low-velocity zones along the channel margins during flows up to and exceeding the bankfull discharge.

As fry increase in size and become juveniles, they shift from using channel margins to using pools, where they feed on invertebrate drift near the surface (Lister and Genoe 1970, Everest and Chapman 1972, Hillman et al. 1987, McCain 1992). Juvenile chinook salmon appear to prefer pools with cover provided by banks, overhanging vegetation, larger substrates, or large woody debris (Steward and Bjornn unpublished data, as cited in Bjornn and Reiser 1991). Maximum summer rearing densities occur in the heads of pools, where juvenile chinook form schools (Reedy 1995). During higher flows, juveniles have been observed to move to deeper areas in pools and may also move laterally toward channel margins in search of velocity refuge (Steward and Bjornn 1987, Shirvell 1994). Shirvell (1994) suggests that preferred habitat locations vary according to activity. For feeding, juvenile Chinook and other salmonids are likely to select positions with optimal velocity conditions, whereas for predator avoidance, optimal light conditions are more likely to be important (Shirvell 1994). While the project reduced suitable low-flow rearing habitat area, it likely increased habitat quality by increasing food production area (i.e., riffles) and increasing the area of pool heads suitable for drift foraging. Moreover, during higher flows, the project is expected to increase juvenile rearing habitat area and quality relative to pre-project conditions by replacing the steep banks and confined floodway with gently sloping banks and a broader, vegetated floodplain. During flows exceeding 5000 cfs, constructed floodplains are expected to provide an additional 33 acres of rearing habitat.

The Monitoring Plan did not include direct observations of the Chinook salmon juvenile and fry use of different habitats in the project reach. TID has conducted winter and spring seine surveys at several locations throughout the river since 1986. Adding sites within the 7/11 Reach would be a cost-effective way of building on long-term, river-wide data to conduct site-specific monitoring. Sites already included in the river-wide surveys provide control sites needed to isolate project-related effects from other factors affecting fry and juvenile density and conditions in the river.

4.3.5 Riparian Vegetation

<u>*Relevant hypotheses:*</u>

H7. Planted riparian vegetation will become established on the constructed floodplain.
H8. Natural recruitment of native riparian plant species will occur on the constructed floodplain.
H9. Riparian vegetation will not encroach into the constructed channel.

Post-irrigation success of planted vegetation and natural recruitment of native vegetation on the constructed floodplain has not been monitored. The 7/11 Project provides an opportunity to evaluate riparian plant survival and recruitment on constructed floodplains with different inundation characteristics. Monitoring should include measures of plant establishment and recruitment, species composition (including invasion by non-native species), and plant health. Factors that are thought to control native plant establishment and recruitment at the site should also be monitored, including flow timing, magnitude and elevation; groundwater elevation and drawdown rates; and seed availability at the site. These data would be useful for future restoration project design and for identifying flow measures that support native riparian ecosystems on the river.

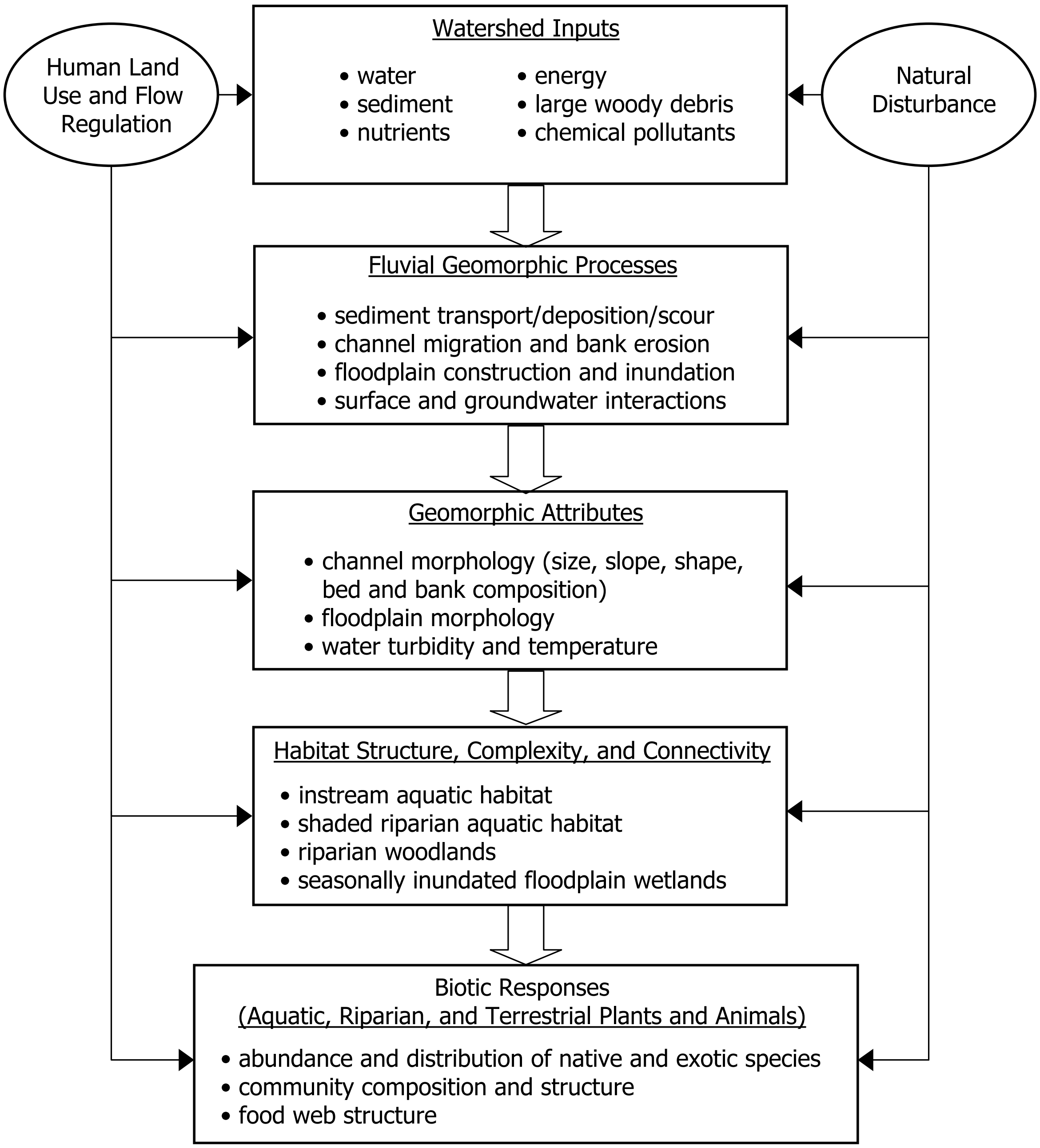


Figure 4.1. A simplified conceptual model of the physical and ecological linkages in alluvial river–floodplain systems. SOURCE: Stillwater Sciences.

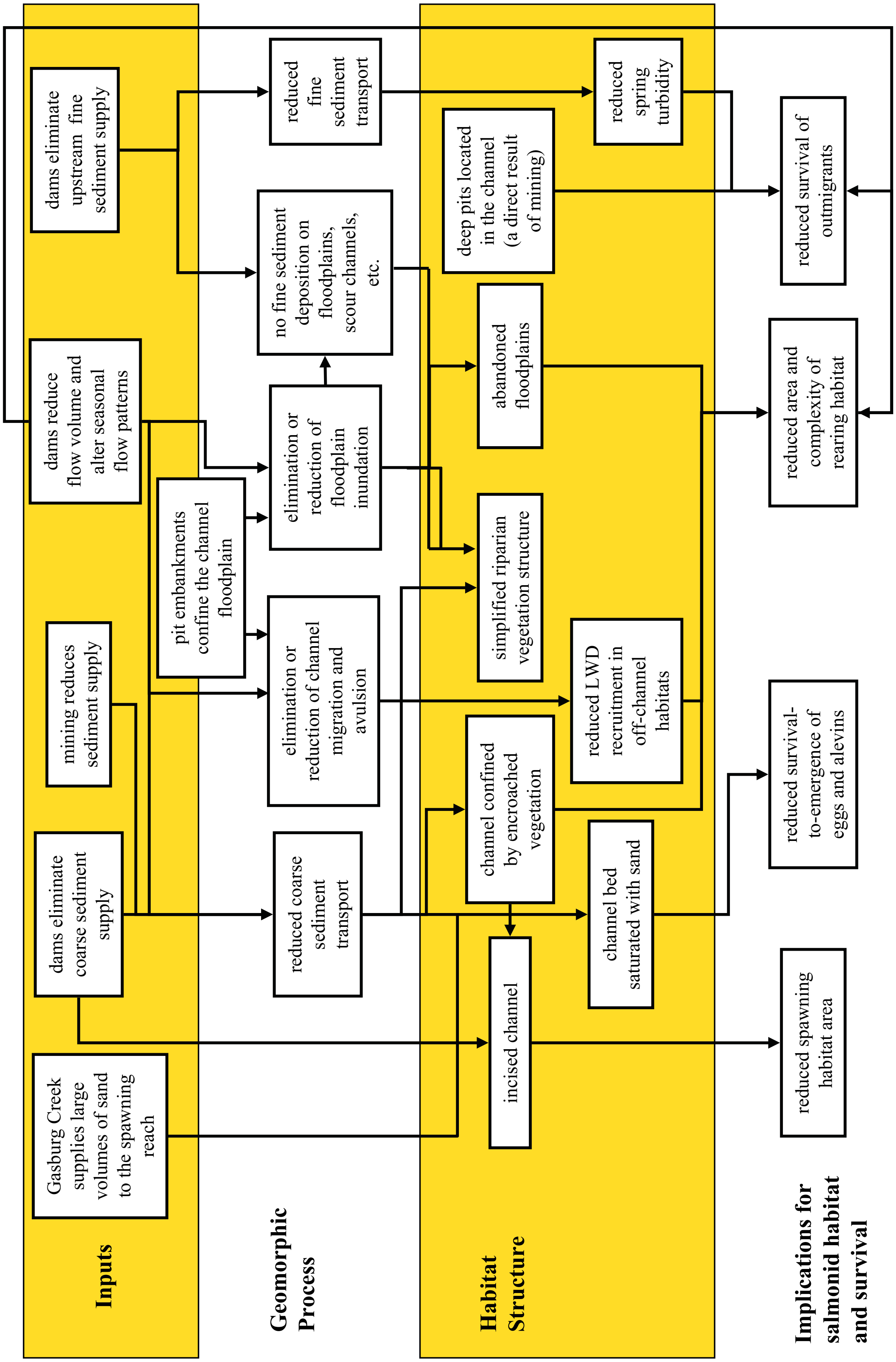


Figure 4-2. Conceptual model of the effects of dams and mining on geomorphic inputs and processes, habitat structure, and population response

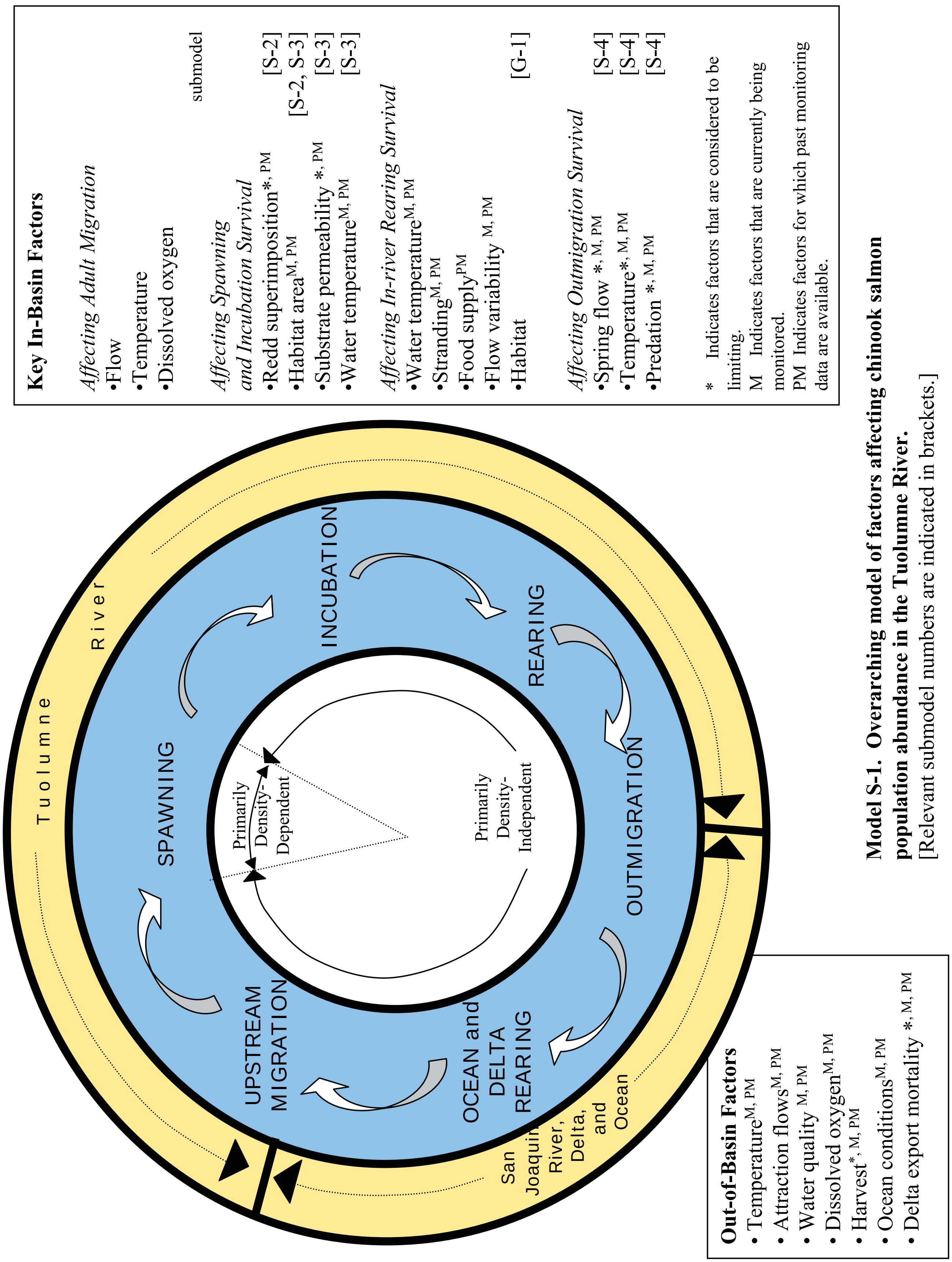


Figure 4-3. Conceptual model of the factors affecting Chinook salmon population abundance in the Tuolumne River

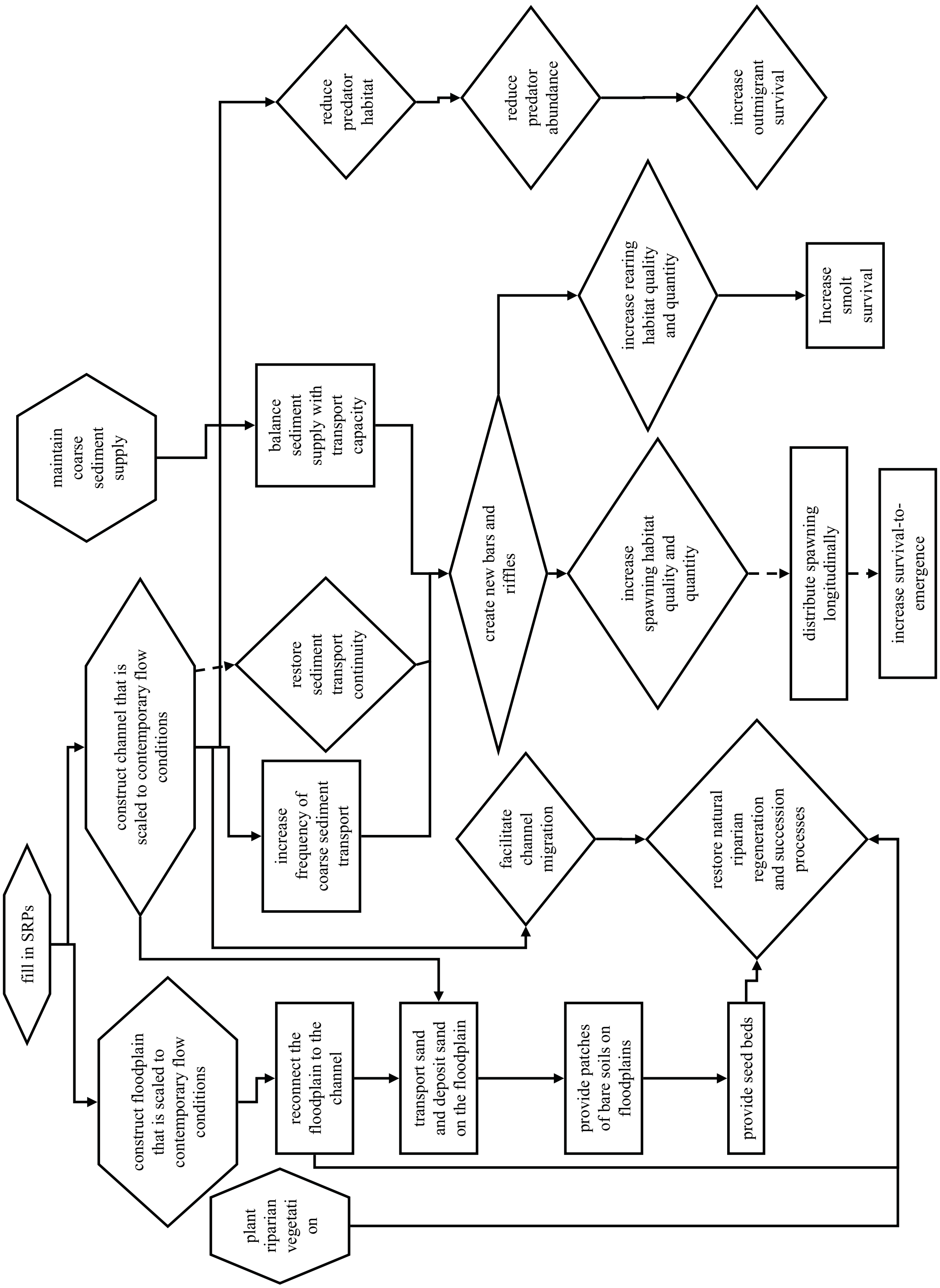


Figure 4-4. Conceptual model of the effects of reconstruction of Special Run Pools (SRPs) on geomorphic processes, riparian vegetation, and Chinook salmon survival.

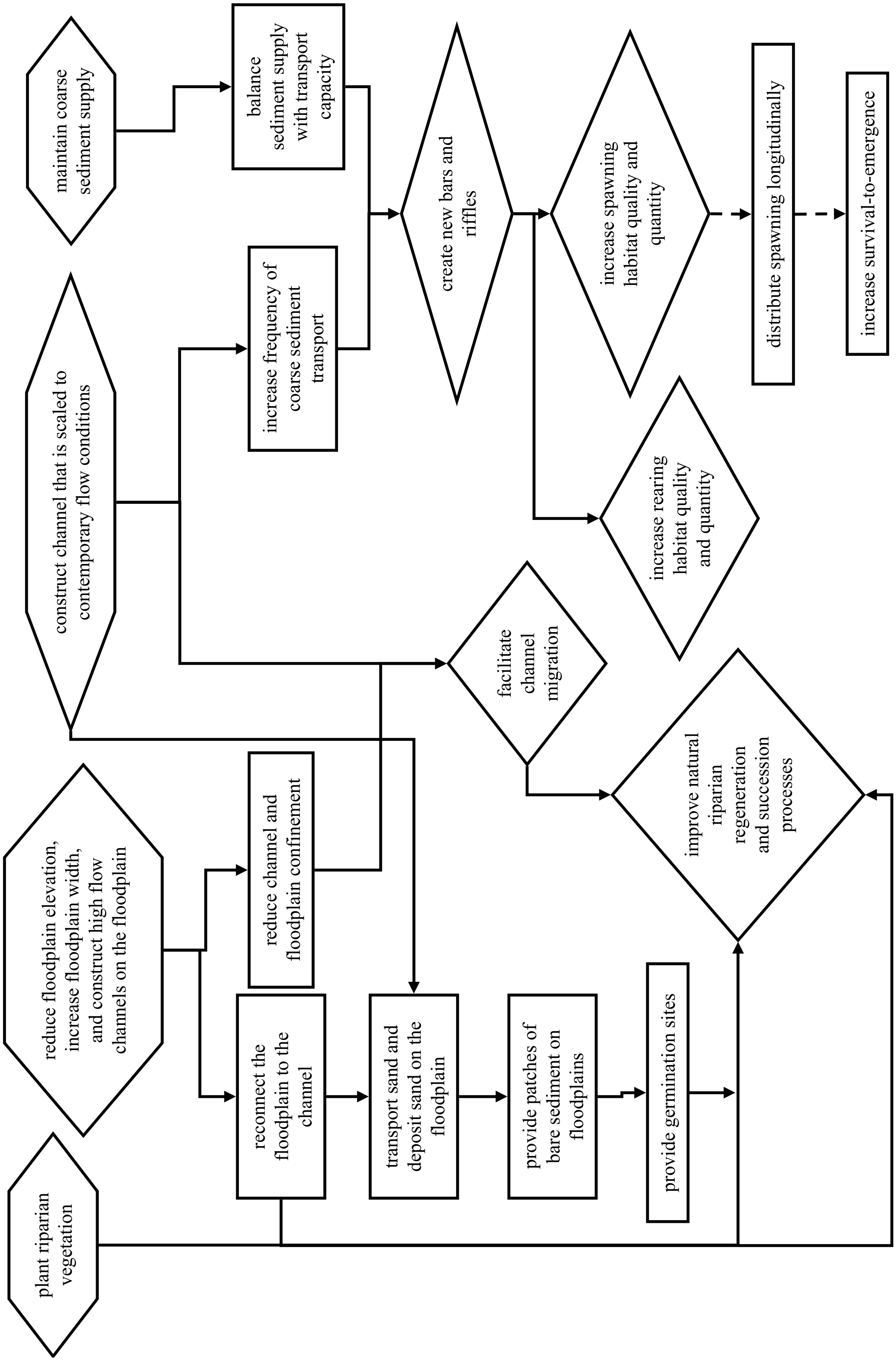


Figure 4-5. Conceptual model of the effects of the Gravel Mining Reach Project on geomorphic processes, riparian vegetation, and Chinook salmon survival

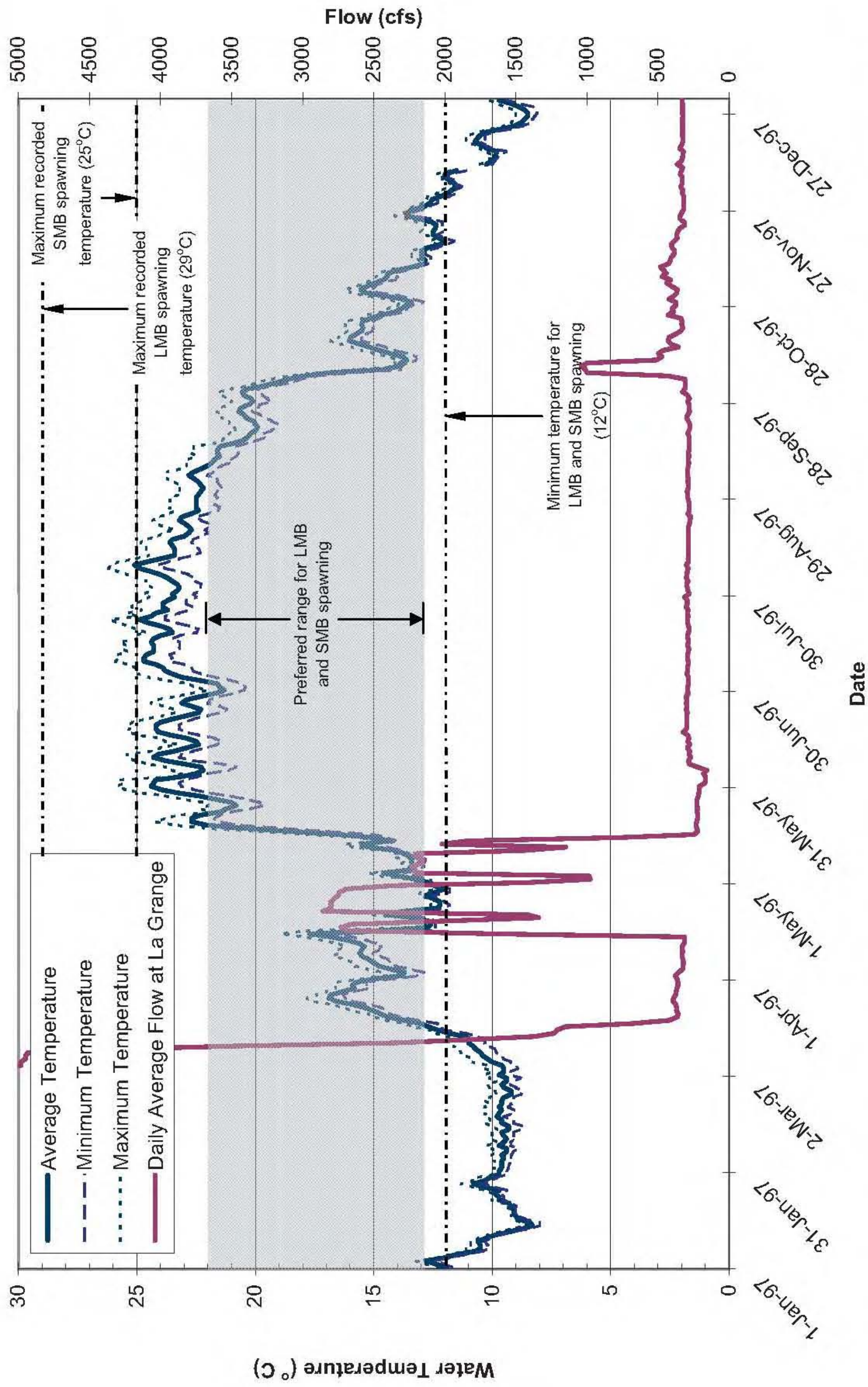


Figure 4-6. 1997 flow and temperature conditions in the project reach, with bass spawning temperatures. (Sources: USGS gage no. 1289650 Tuolumne R bl La Grange Dam nr La Grange CA.; TID/MID thermographs at RM 23.6 and 3.4.)

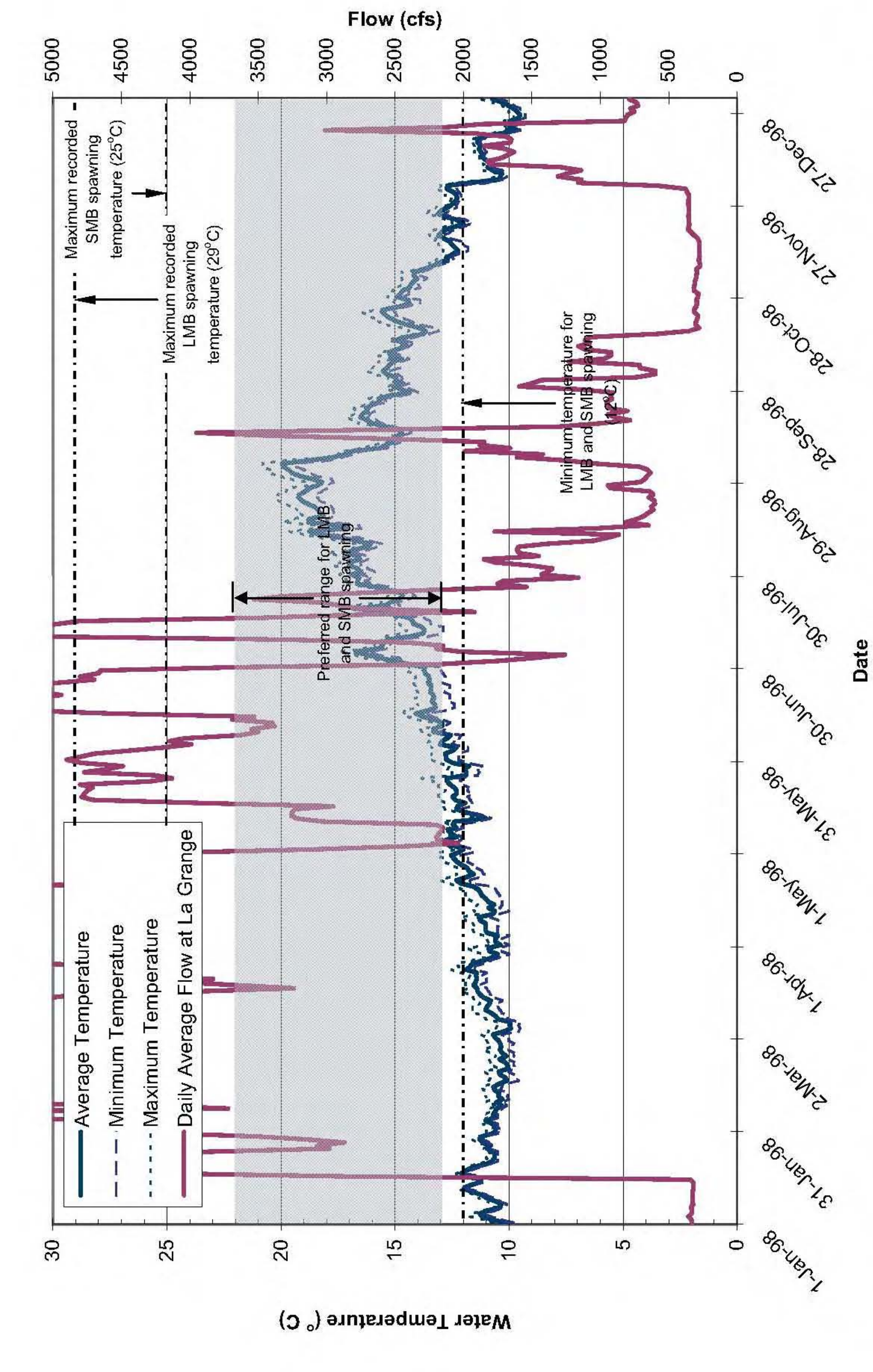


Figure 4-7. 1998 flow and temperature conditions in the project reach, with bass spawning temperatures. (Sources: USGS gage no. 1289650 Tuolumne R bl La Grange Dam nr La Grange CA.; TID/MID thermographs at RM 23.6 and 3.4.)

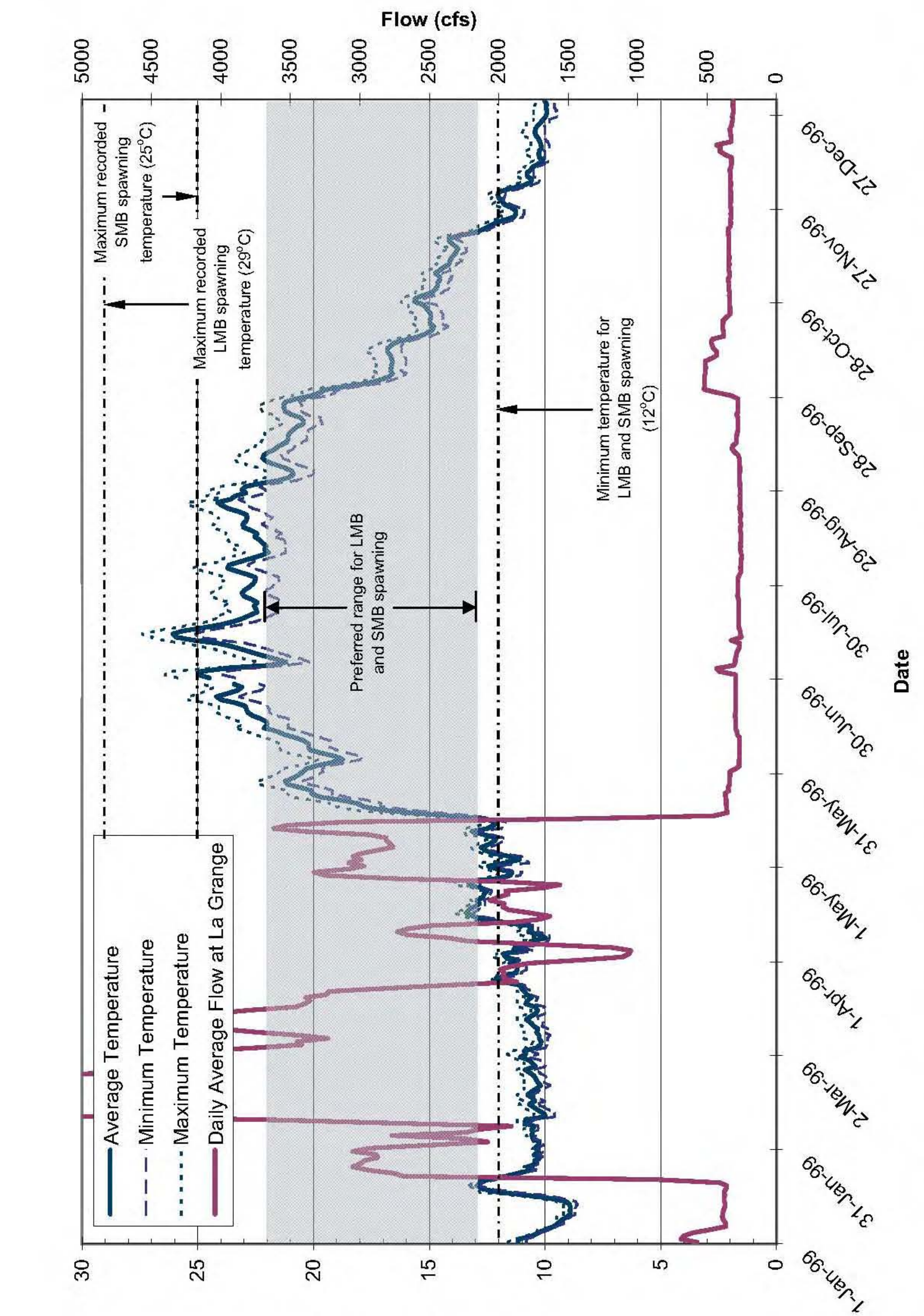


Figure 4-8. 1999 flow and temperature conditions in the project reach, with bass spawning temperatures. (Sources: USGS gage no. 1289650 Tuolumne R bl La Grange Dam nr La Grange CA.; TID/MID thermographs at RM 23.6 and 3.4.)

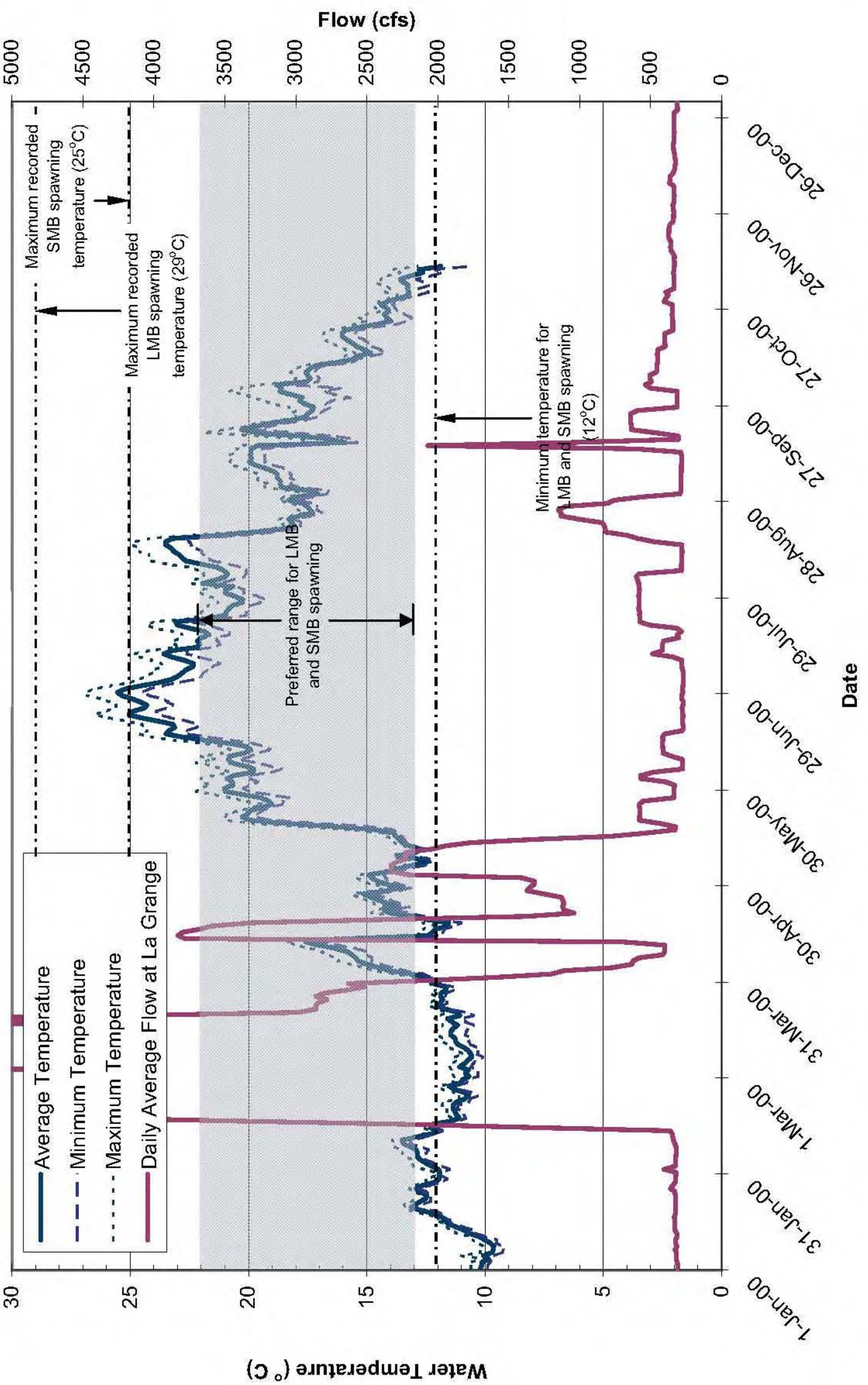


Figure 4-9. 2000 flow and temperature conditions in the project reach, with bass spawning temperatures. (Sources: USGS gage no. 1289650 Tuolumne R bl La Grange Dam nr La Grange CA.; TID/MID thermographs at RM 23.6 and 3.4.)

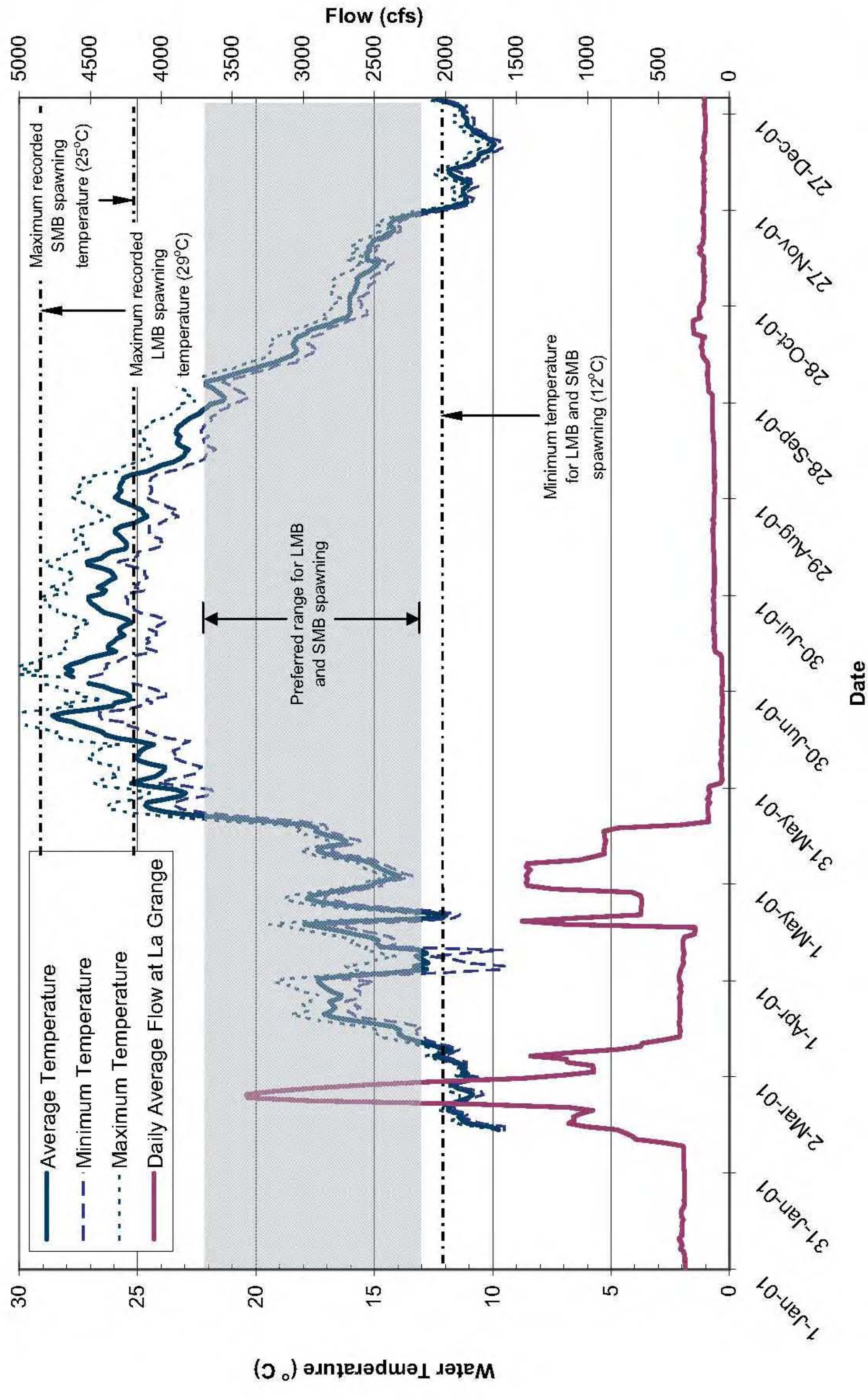


Figure 4-10. 2001 flow and temperature conditions in the project reach, with bass spawning temperatures. (Sources: USGS gage no. 1289650 Tuolumne R bl La Grange Dam nr La Grange CA.; TID/MID thermographs at RM 23.6 and 3.4.)

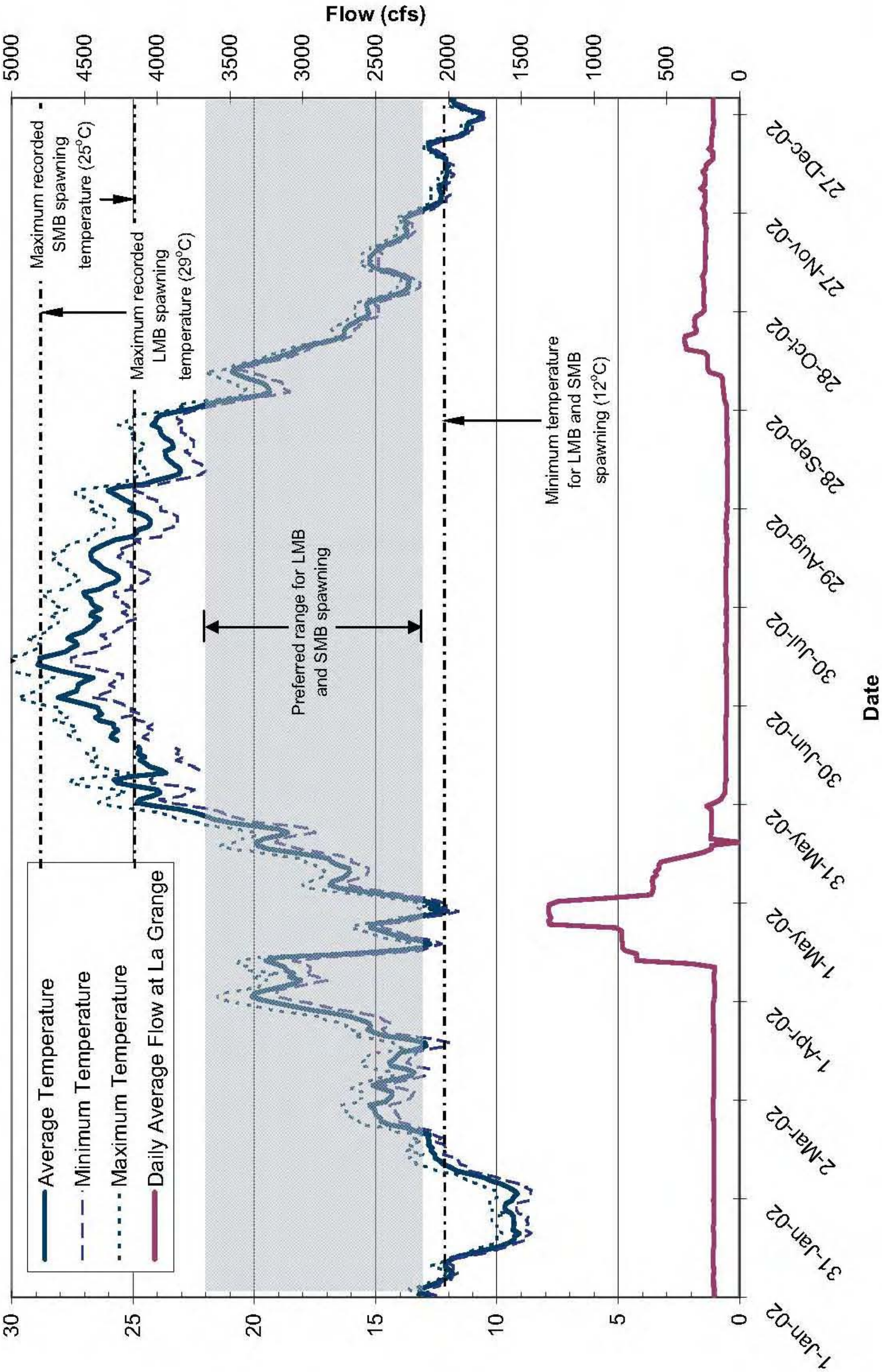


Figure 4-11. 2002 flow and temperature conditions in the project reach, with bass spawning temperatures. (Sources: USGS gage no. 1289650 Tuolumne R bl La Grange Dam nr La Grange CA.; TID/MID thermographs at RM 23.6 and 3.4.)

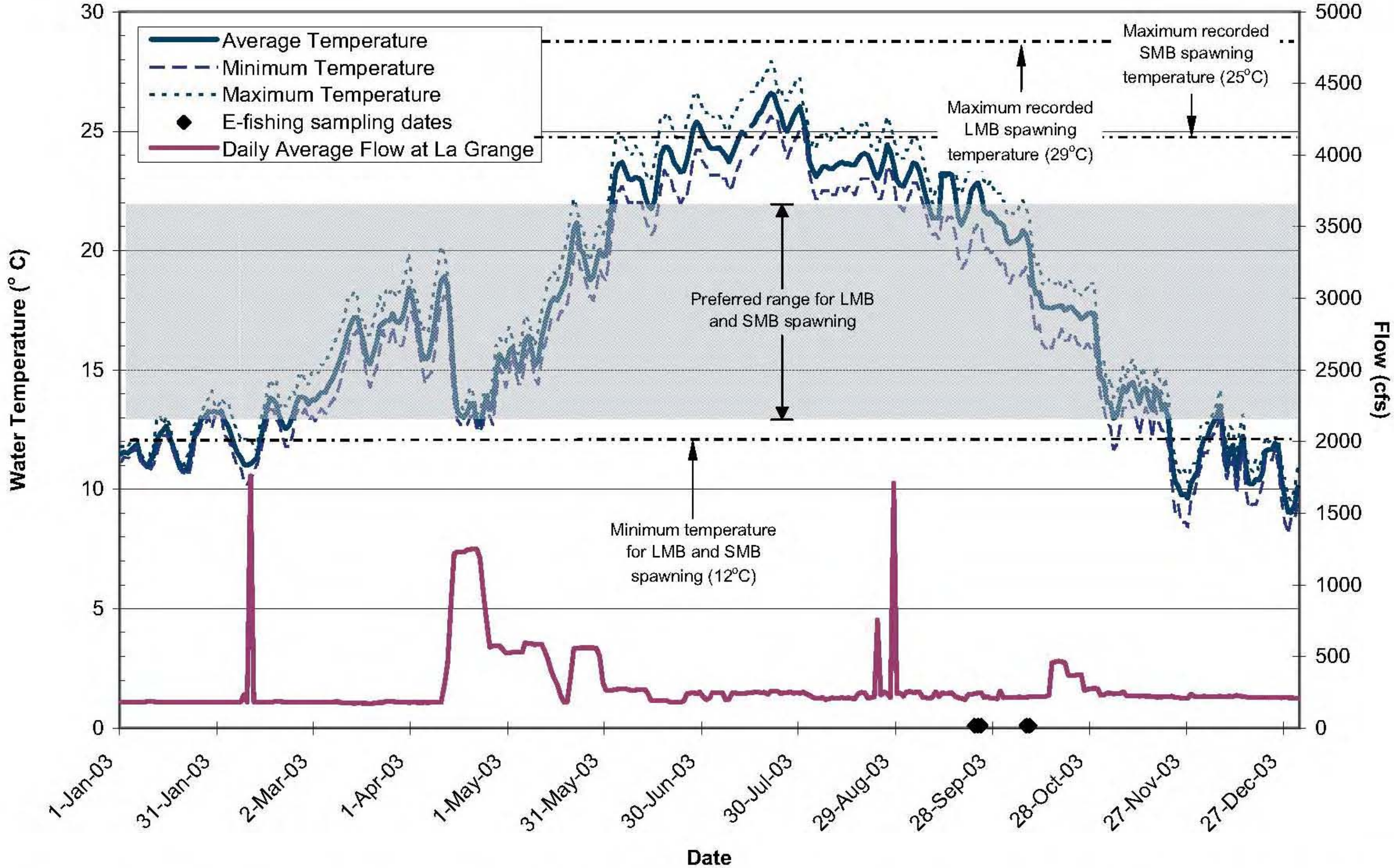


Figure 4-12. 2003 flow and temperature conditions in the project reach, with bass spawning temperatures. (Sources: USGS gage no. 1289650 Tuolumne R bl La Grange Dam nr La Grange CA.; TID/MID thermographs at RM 23.6 and 3.4.)

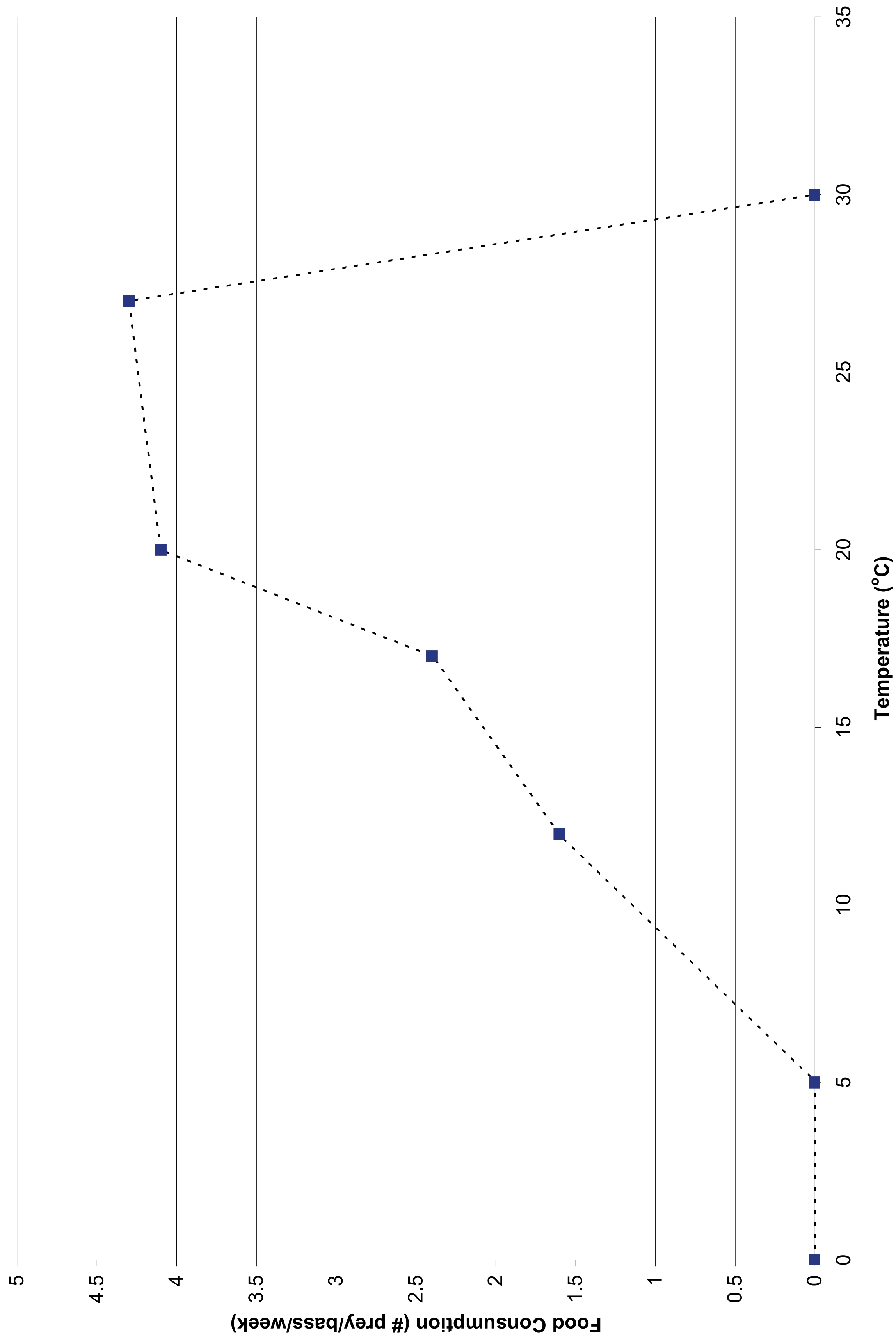


Figure 4-13. Relationship between water temperature and largemouth bass foraging rates, modified from Coutant 1975.

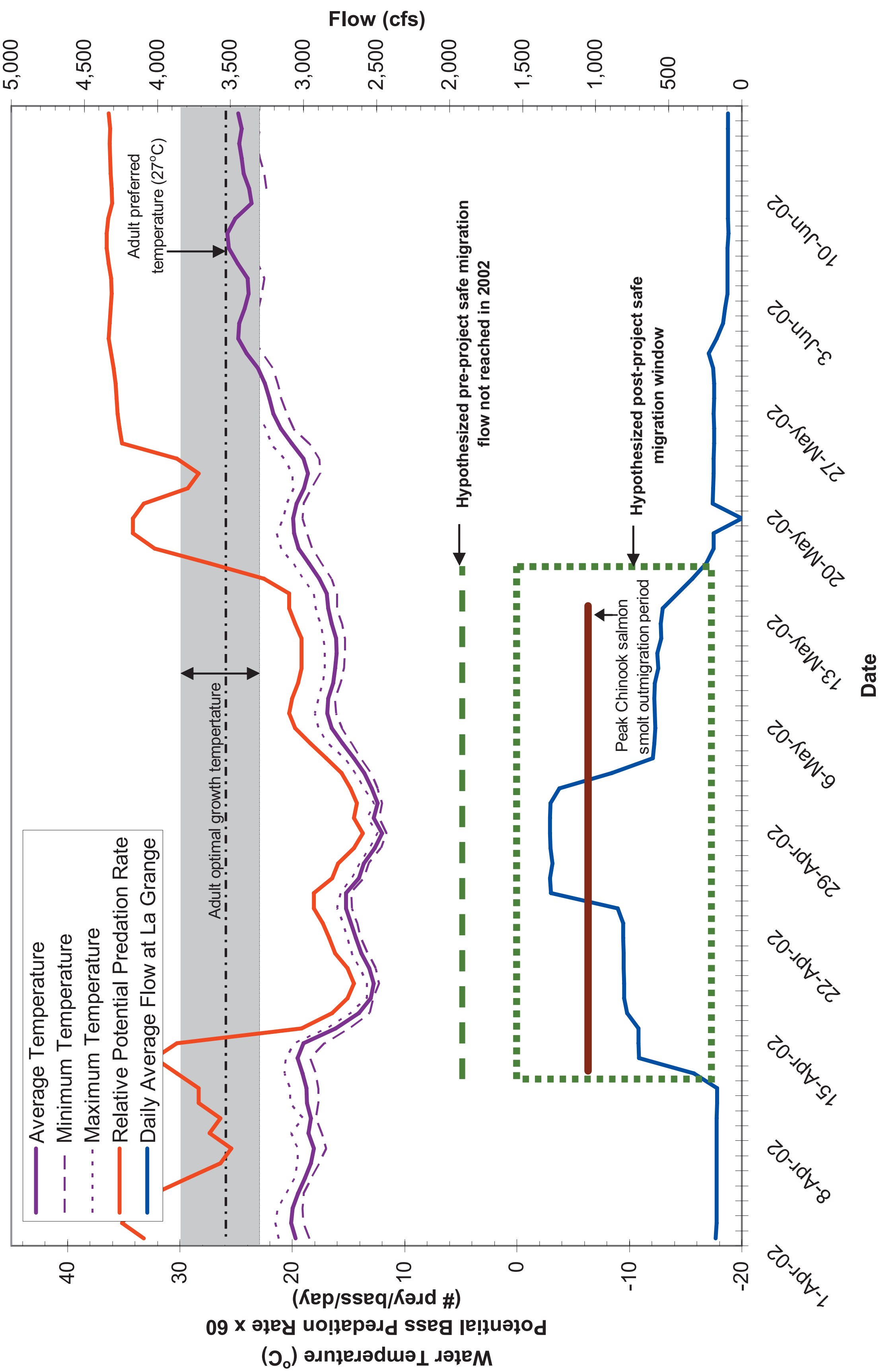


Figure 4-14. Flow, temperature, and predicted relative bass predation rates during peak Chinook salmon outmigration in 2002.

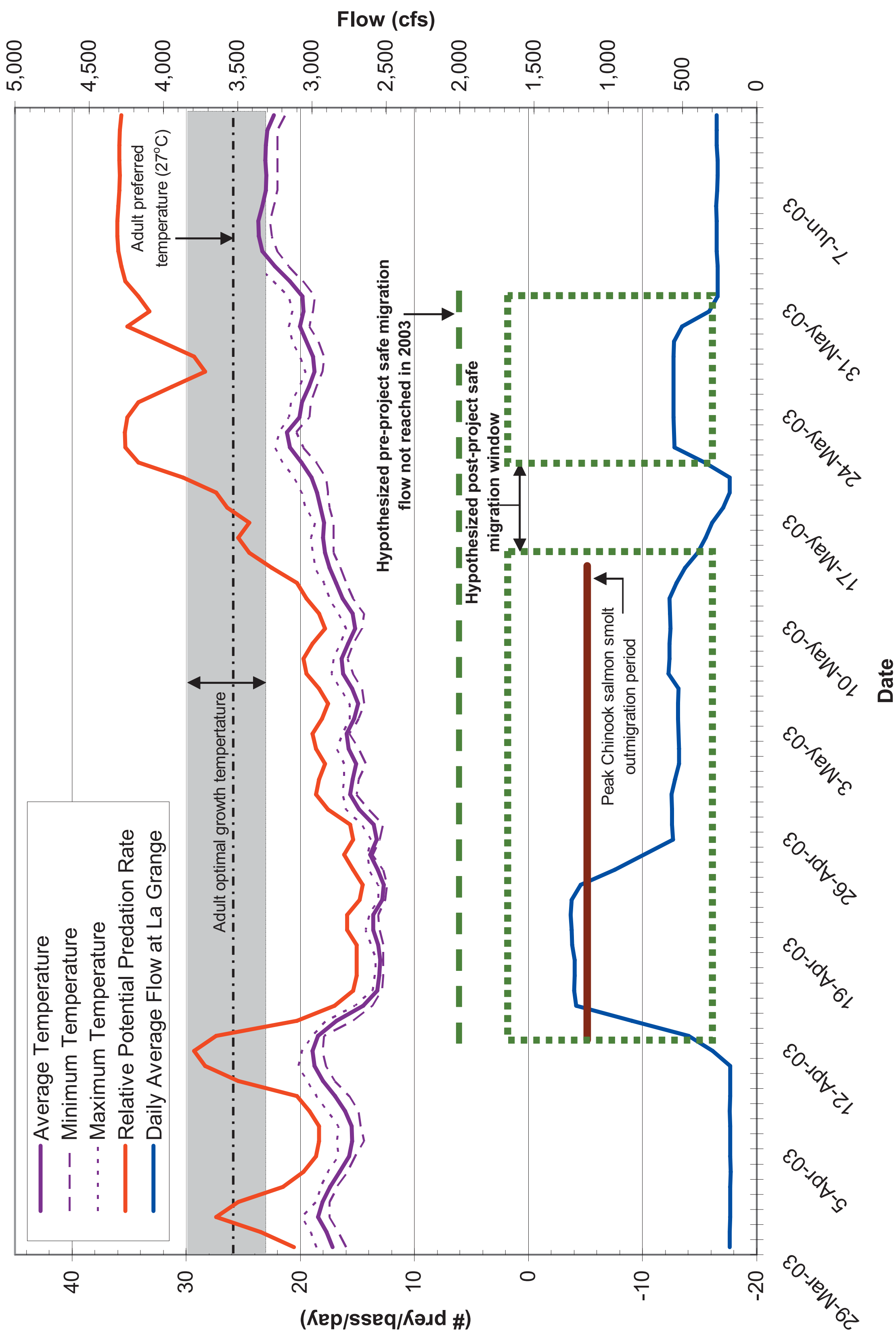


Figure 4-15. Flow, temperature, and predicted relative bass predation rates during peak Chinook salmon outmigration in 2003.

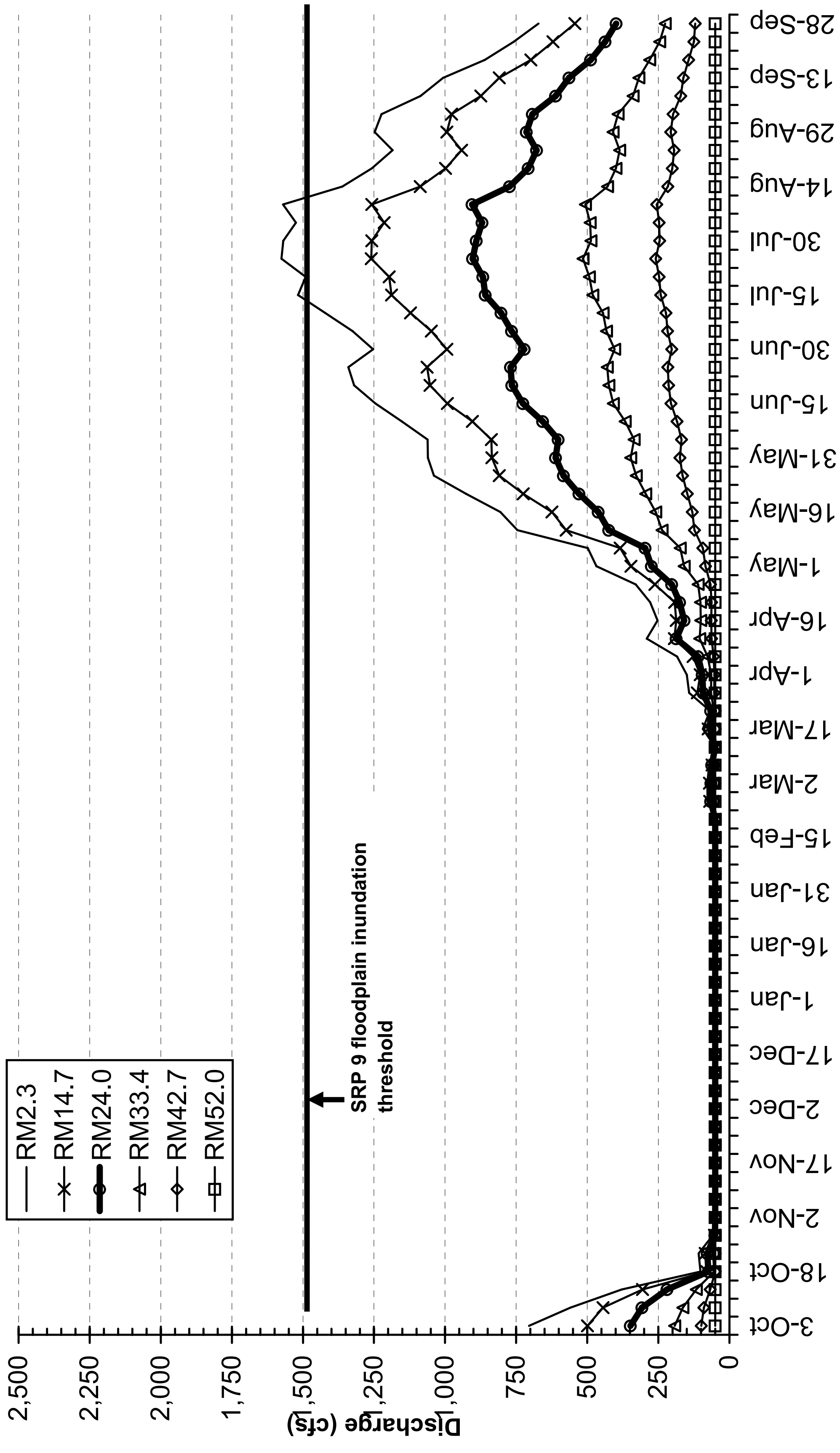
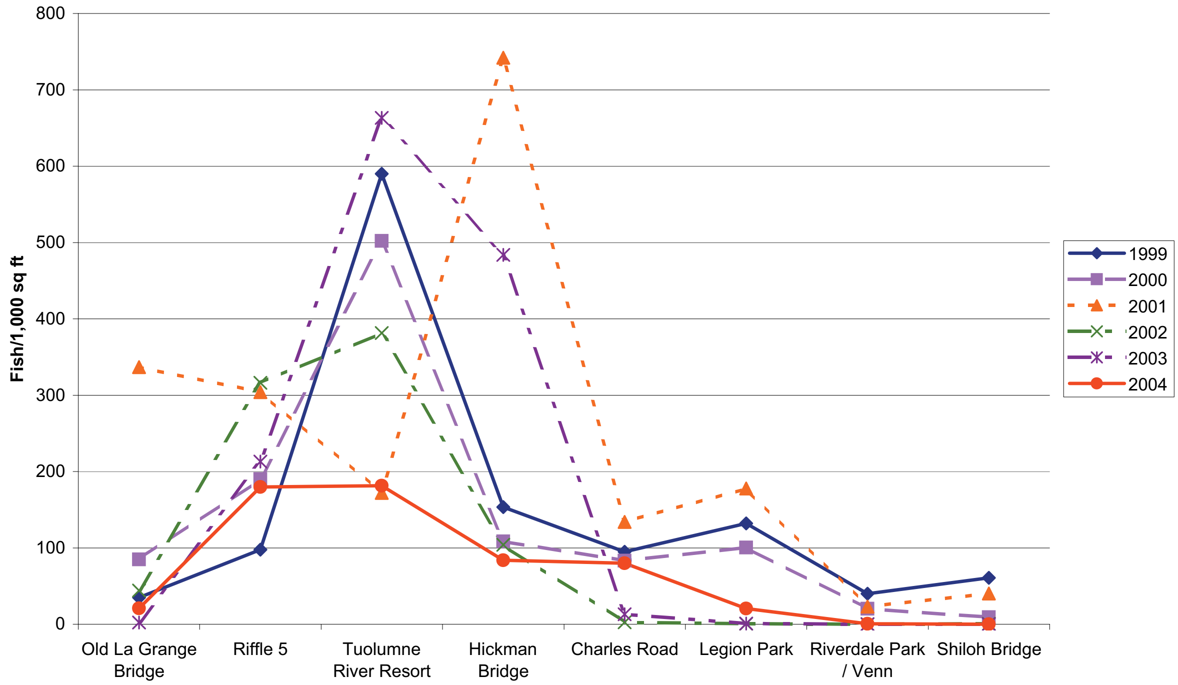


Figure 4-16. SNTEMP assessment of flow needed to maintain water temperature <65 F from La Grange Dam (RM 52) to Shilo Bridge (RM 2.3) for mean 1978-88 meteorological conditions.



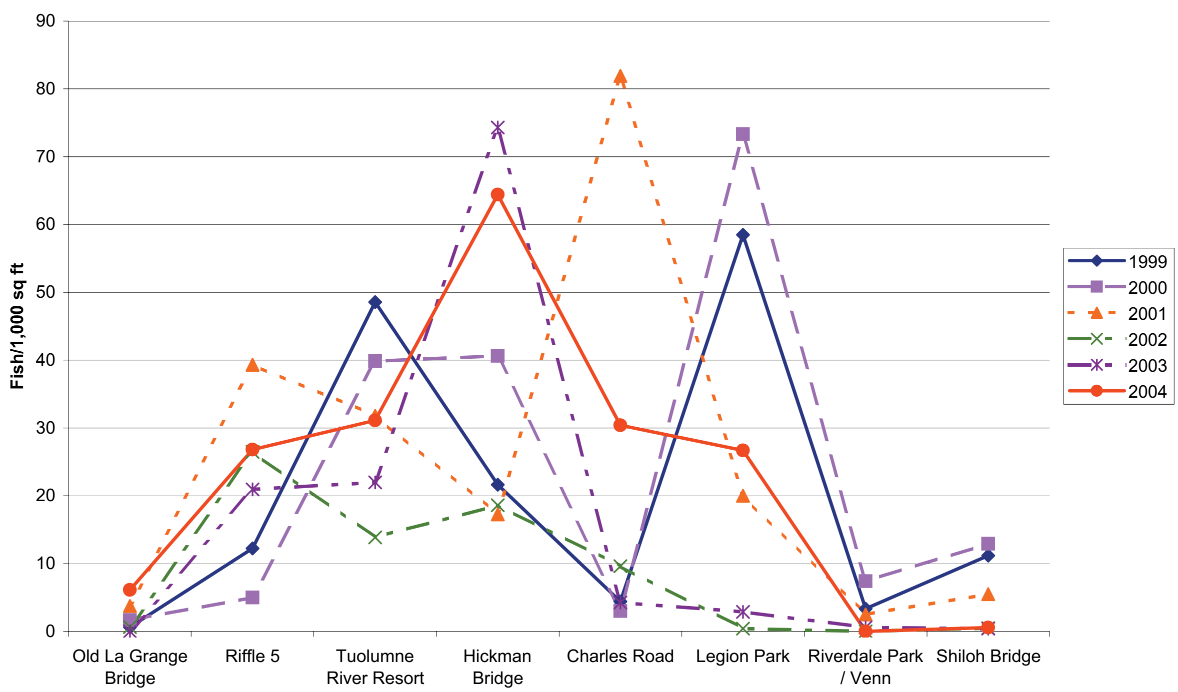


Figure 4-17. (A) Peak fry rearing distribution in the Tuolumne River 1999-2004 (B) Peak juvenile rearing distribution in the Tuolumne River 1999-2004. (Source-TID)

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5 RECOMMENDATIONS

5.1 Restoration Project Design Process

A more inclusive design review process would improve project designs and broaden the base of support for designs. Recommendations for improving interdisciplinary participation in project design and implementation are:

Conceptual Design Review: Provide a brief opportunity (such as a workshop and/or 2-week review period) for stakeholders to review and provide comments prior to completion of the conceptual design. Concurrently, obtain peer review from 1–3 professionals in relevant fields. Peer reviewers should be selected and scheduled prior to Step 3 below. The design schedule should allow 2–3 weeks for peer and stakeholder review. This step in the conceptual design process is intended to facilitate and incorporate where possible stakeholder and peer reviewer comments. The final conceptual plan should be the foundation and basis for the detailed construction plans and specifications and the associated monitoring program used to evaluate the effectiveness or success of the project. The final conceptual design should include: (1) quantitative objectives, (2) identification of site specific concerns to be addressed in the construction plans and specifications, such as grading methods and locations, access routes, and other construction features, (3) revegetation planting design features, including soil preparation, (4) detailed information on existing habitat conditions at the site and habitat conditions to be created, and (5) the objectives, elements, and methodologies to be included in a monitoring plan for the project.

Final Design Development and Review: To ensure that the conceptual design objectives are carried through to final design and implementation, the conceptual design team should have opportunities to review or collaborate on the construction designs at key milestones. At a minimum, the conceptual design team should review the 30% construction designs. Reviews can be formal or informal, as dictated by the design schedule and complexity, and should be scheduled to facilitate construction scheduling constraints.

Project Implementation: In addition to the construction management engineer, professionals such as a fisheries biologist, geomorphologist, and/or vegetation ecologist should be present during relevant construction phases to support the construction manager and help ensure that implementation best meets the project's geomorphic and biological objectives.

5.2 River-wide and Population-level Monitoring

With their large size and cost, the SRPs 9 and 10 and Gravel Mining Reach projects require thoughtful design, experimentation, and adaptive management to maximize their benefits both to the river and to restoration science. The Adaptive Management Forum, in their review of Tuolumne River restoration projects, emphasized the need for integration of monitoring across spatial scales (i.e., from site-specific to river-wide) (AMF 2001). In combination with project-specific monitoring, river-wide and population-level monitoring is essential for identifying the individual and cumulative effects of current and planned restoration actions on ecosystem health and target species recovery.

In the past, river-wide monitoring was funded by the Districts and CCSF (through the FSA) and CDFG. As of 2005, FSA river-wide monitoring funds were fully expended and are no longer available. To continue gathering data needed to evaluate these restoration projects and other restoration actions, we recommend continuation of the following river-wide monitoring:

- juvenile Chinook salmon production and outmigration timing;
- juvenile Chinook salmon and *O. mykiss* distribution, abundance, and size (winter and spring);
- juvenile Chinook salmon and *O. mykiss* distribution (summer);
- Chinook salmon adult escapement;
- *O. mykiss* adult distribution; and

- benthic macroinvertebrate composition, abundance, and diversity indices.

5.3 Improvements to SRP 9 Implementation

The SRP 9 project was implemented as a pilot to test the benefits of SRP restoration on geomorphic processes, fish communities, and riparian habitat. Though the project is still relatively young, it has provided important information for improving future SRP designs and the design of the SRP 9 project. Several measures for increasing flow velocity and reducing largemouth bass habitat at the site were considered, including: (1) removing the flow constriction at the upstream end of the site, (2) reducing channel width, (3) reducing pool depth at the meander apex to 3 feet or less, and (4) increasing channel slope. Narrowing the channel and reducing pool depth both conflict with the infiltration gallery and were determined to be infeasible. Given this constraint, we recommend removing the flow constriction to reduce the right-bank eddy at the upstream end of the site (Figure 5-1).

5.4 Improvements to SRP 9 Monitoring

Based on results from pre- and post-project monitoring, we recommend continued monitoring to test hypotheses presented in Section 2. We also recommend revisions to portions of the existing monitoring, as well as additional monitoring to test new hypotheses. Revised hypotheses and new hypotheses are listed below. Recommended monitoring is shown in Table 37.

Revised monitoring hypotheses for SRP 9:

H6. The extent and quality of Chinook salmon rearing habitat is increased. Chinook salmon utilize the constructed floodplain at flows exceeding approximately 1,200 cfs. Rearing density on the SRP 9 floodplain during flows exceeding 1,200 cfs but less than 2,000 cfs is significantly greater than rearing density at the Charles Rd. seining monitoring site where floodplain rearing habitat is not available until flows exceed 2,000 cfs.

H8. Natural recruitment of native riparian plant species occurs on the constructed floodplain. Natural recruitment of native riparian vegetation on the floodplain is controlled by: (1) spring and summer depth to groundwater, (2) spring and early summer surface water and groundwater drawdown rates, and (3) spring high flows during seed release by native riparian plants.

New monitoring hypotheses for SRP 9:

H12. During years with high spring flows, the abundance of non-native fish relative to native fish at SRP 9 is significantly lower relative to pre-project conditions and SRP control sites but higher than channel control sites.
This hypothesis can be tested using data from H10 and H6, above.

H13. In SRP 9, habitat segregation between outmigrating Chinook salmon and foraging largemouth and smallmouth bass occurs at flows exceeding 300 cfs. Bass predation rates at flows ≥ 1,500 cfs are significantly less at SRP 9 than at SRP control sites. Predation rates by smallmouth bass are significantly higher than predation rates by largemouth bass.

H14. At flows exceeding 300 cfs, high flow velocity increases Chinook salmon migration rates relative to SRP control sites. At flows exceeding 300 cfs, juvenile Chinook salmon migration rates are significantly faster at SRP 9 than at the SRPs 7, 8, and 10. During these flows, juvenile Chinook salmon remain oriented facing upstream as they migrate through SRP 9 but orient facing downstream and must actively swim through SRP control sites.

5.5 Improvements to 7/11 Reach Implementation

No corrective actions at the 7/11 Reach are recommended at this time. Corrective actions may be identified after further post-project monitoring. Management recommendations for the site are to:

- Use monitoring results from hypotheses H2 and H3 (see below) to identify long-term coarse sediment maintenance needs (volume and timing) for the project reach.
- Monitor and clear vegetation and debris from the culverts in the 7/11 haul road bridge and floodplain crossing to prevent clogging and ensure continued conveyance capacity.

5.6 Improvements to 7/11 Reach Monitoring

Monitoring recommendations for the 7/11 Reach project focus on continuation of existing monitoring, improvements in monitoring methods, and addition of one new monitoring hypothesis related to bird nesting in restored riparian stands. Recommended monitoring is shown in Table 38.

Table 37. SRP 9 Monitoring Recommendations.
(Modifications to existing monitoring are indicated by an asterisk next to the hypothesis number.)*

Hypothesis	Metric	Method	Timing
H1*	• Floodplain inundation and depth at flows ≥1,500 cfs.	• Survey high flow markers placed in 2005. • Replace level surveys during high flows with automated and semi-automated recording gages. Establish and maintain one continuously recording stage gage at the site and a minimum of three crest gages, with each gage placed on a monitored channel/floodplain cross section.[1]	• Survey high flow stage markers as soon as possible. • Download the recording gage a minimum of once/month from November through March and every other month from April through October. Maintain crest gages after each flow event exceeding 1,500 cfs. • If automated recorders or crest gages are not installed, water surface elevation should be recorded in conjunction with predation studies to be conducted during pulse flows in spring 2005. Ideally, water surface elevation should be recorded for each step in the pulse flow event exceeding 1,000 cfs. The bankfull threshold should also be documented during the ramping up or down of the pulse flow.
H2	• Flow magnitude that mobilizes 80% of D_{84} tracer rocks at monitoring cross sections.	• Conduct tracer rock experiments at the riffle at the upstream end of SRP 9.	• Install tracer rocks immediately and monitor after at least one high flow event exceeding 5,000 cfs.
H3, H9, H4	• Net, reach-averaged aggradation and incision. Net bed elevation change ≥2 feet would be considered an indicator of instability. • Change in bankfull cross section width at monitoring cross sections. Change in cross section or bank erosion ≥5 horizontal feet without corresponding deposition on the opposite bank would be considered an indicator of possible instability. • Establishment of woody vegetation in the active channel. Establishment of willows or alders in the active channel ≥3 years old	• Continue periodic surveys of monitoring cross sections and longitudinal profile. For woody vegetation within the active channel, record vegetation species, location on cross section, and age.	• Resurvey channel cross sections and profile immediately to assess the effects of the 2005 and 2006 high flows. • Resurvey cross sections and profile after each high flow event exceeding 5,000 cfs.

Hypothesis	Metric	Method	Timing
	below the 1,500 cfs water surface elevation would be considered an indicator of vegetation encroachment.		
H5*	Chinook salmon do not typically spawn this far downstream. Eliminate this measure from the monitoring program.		
H6*	• Juvenile Chinook salmon size and density relative to upstream and downstream control sites.	• Add seining locations at SRP 9 (post-project) and an SRP control site to the long-term river-wide seining surveys.	• Biweekly surveys conducted from January through May each year. Floodplain surveys should be conducted during flows exceeding 1,200 cfs.
H7*	• Survival, percent cover, canopy height, and vigor of planted riparian vegetation through post-project year 5.	• Use plots or band transects to monitor survival, percent cover, canopy height, and vigor of planted riparian vegetation through post-project year 5 (i.e., 2006). • Add groundwater elevation and rate of change as monitoring parameters. Install and monitor five groundwater wells on reconstructed floodplains within the project reach. • Using portable probes, monitor soil moisture.	• Survey vegetation as soon as possible to establish 2005 condition relative to as-built planting. • Monitor groundwater wells weekly during April through October. • Monitor soil moisture weekly during April through October.
H8*	• Density of naturally recruited native woody riparian vegetation on constructed floodplains.	• Conduct annual plot-based monitoring of natural riparian vegetation recruitment and establishment on the reconstructed floodplains for three years. • Add groundwater elevation and rate of change as monitoring parameters. Install and monitor five groundwater wells on reconstructed floodplains within the project reach.	• Conduct vegetation surveys annually in late summer or early fall (after seed dispersal has ceased but leaf drop has not begun). • Continuously monitor at least one groundwater well (using a datalogger) April through June. Adjust the period of continuous groundwater monitoring based on observed seed release, as needed.
H10, H11, H12	• Linear density of piscivorous-size largemouth bass relative to channel and SRP control sites.	• Multiple-pass depletion surveys at project and control sites.	• Conduct surveys in September to maintain consistency with previous years of monitoring in one year during which water temperate at the site remains above 60°F (15.5°C) through July 15.
H13*	Measures to test these hypotheses will be considered in the report for the pilot predation study conducted in 2006. This reported will be available in July 2006.		
H14*			

[1]These data will be used to back-calculate Manning's roughness coefficient and test the hydraulic model developed for the site. The results will be applied to improve the hydraulic model developed for the SP 10 design.

Table 38. 7/11 Reach Monitoring Recommendations.
(Modifications to existing monitoring are indicated by an asterisk next to the hypothesis number.)*

Hypothesis	Metric	Method	Timing
H1*	• Floodplain inundation and depth at flows ≥5,000 cfs.	• Survey high flow markers placed in 2005. • Replace level surveys conducted during high flows with automated and semi-automated recording gages. • Establish and maintain one continuously recording stage gage at or near Roberts Ferry Bridge and a minimum of three crest gages, with each gage placed on a monitored channel/floodplain cross section.	• Survey high flow stage markers as soon as possible. • Download the recording gage a minimum of once/month from November through March and every other month from April through October. • Maintain crest gages after each flow event exceeding 4,500 cfs.[1]
H2	• Flow magnitude that mobilizes 80% of D_{84} tracer rocks on monitoring transects.	• Continue to deploy and monitor tracer rocks, but increase the number of cross sections monitored to include locations upstream and downstream of Riffle 30B (i.e., within and downstream of the channel reconstruction reach.	• Check and replace rocks after each flow exceeding 4,500 cfs. Implement a minimum of tracer rock deployments at each site.
H3, H4, H9	• Net, reach-averaged aggradation and incision. Net bed elevation change ≥ 2 feet would be considered an indicator of instability. • Change in bankfull cross section width at monitoring cross sections. Change in cross section or bank erosion ≥ 5 horizontal feet without corresponding deposition on the opposite bank would be considered an indicator of possible instability. • Establishment of woody vegetation in the active channel. Establishment of willows or alders in the active channel ≥3 years old below the 5,000 cfs water surface elevation would be considered an indicator of vegetation encroachment.	• Continue periodic surveys of monitoring cross sections and longitudinal profile. For woody vegetation within the active channel, record vegetation species, location on cross section, and age. • Analyze 2005 aerial photographs, channel bathymetry, and floodplain topography surveys to isolate the effects of the 2005 flows from the 2006 flows.	• Resurvey channel cross sections and profile immediately to assess the effects of the 2005 and 2006 high flows. • Resurvey cross sections and profile after each of two high flow events exceeding 4,500 cfs.

Hypothesis	Metric	Method	Timing
H4	• Bank erosion/channel migration rates throughout the reach.	• Analyze 2005 aerial photographs, channel bathymetry, and floodplain topography surveys to isolate the effects of the 2005 flows from the 2006 flows. • In addition to channel surveys above, continue aerial photograph interpretation. Aerial photographs should be true color, stereo pairs, and at suitable resolution for printing and interpretation at a scale of 1:6,000 or larger.	• Based on review of 2005 photographs and field surveys, determine the need for additional photographs to capture the effects of the 2006 high flows. • Obtain additional photographs following one flow exceeding 9,000 cfs or if noticeable changes in channel location occur.
H5*	• Chinook salmon spawning density and distribution at project riffles relative to control riffles.	• Supplement habitat mapping with detailed redd counts and habitat characterization in the channel reconstruction reach (Roberts Ferry Bridge to Riffle 30B), downstream riffles within the project reach, and upstream control riffles. • At least one time during spawning flows, quantify habitat characteristics at each monitoring riffles.	• Biweekly from approximately November 1 through December 31 each year.
H6*	• Rearing fry and juvenile density relative to upstream and downstream monitoring sites and control sites in pre-project future project reaches in the Gravel Mining Reach.	• Supplement habitat mapping with seine surveys.	• Biweekly surveys conducted from January through May each year.
H7*	• Survival, percent cover, canopy height, and vigor of planted riparian vegetation through post-project year 5.	• Use plots or band transects to monitor survival, percent cover, canopy height, and vigor of planted riparian vegetation through post-project year 5 (i.e., 2008). • Add groundwater elevation and rate of change as monitoring parameters. Install and monitor five groundwater wells on reconstructed floodplains within the project reach.	• Survey vegetation as soon as possible to establish 2005 condition relative to as-built planting. Resurvey in project year 5 (2008). • Monitor groundwater wells weekly during April through October. • Monitor soil moisture weekly during April through October.
H8*	• Density of naturally recruited native woody riparian vegetation on constructed floodplains.	• Conduct annual plot-based monitoring of natural riparian vegetation recruitment and establishment on the reconstructed floodplains for three years. Add groundwater elevation and rate of change as monitoring parameters. • Install and monitor five groundwater wells on	• Conduct vegetation surveys annually in late summer or early fall (after seed dispersal has ceased but leaf drop has not begun). • Continuously monitor at least one groundwater well (using a datalogger) April through June. Adjust the period of continuous groundwater monitoring based on observed seed

Hypothesis	Metric	Method	Timing
		reconstructed floodplains within the project reach. • Using portable probes, monitor soil moisture.	release, as needed.
H10*	• Riparian nesting bird species composition, abundance and associations with vegetation structure.	• Conduct repeat point count bird surveys and associated riparian vegetation relevée surveys during the breeding season (May and June) on at least one restored floodplain location in the project site and at least two control sites (i.e., one "natural" riparian forest and one unrestored site) for three years.	• Monthly surveys at each site for a period of three years.

[1]These data will be used to back-calculate Manning's roughness coefficient and test the hydraulic model developed for the site. The results will be applied to improve the hydraulic model developed for the design of subsequent phases.

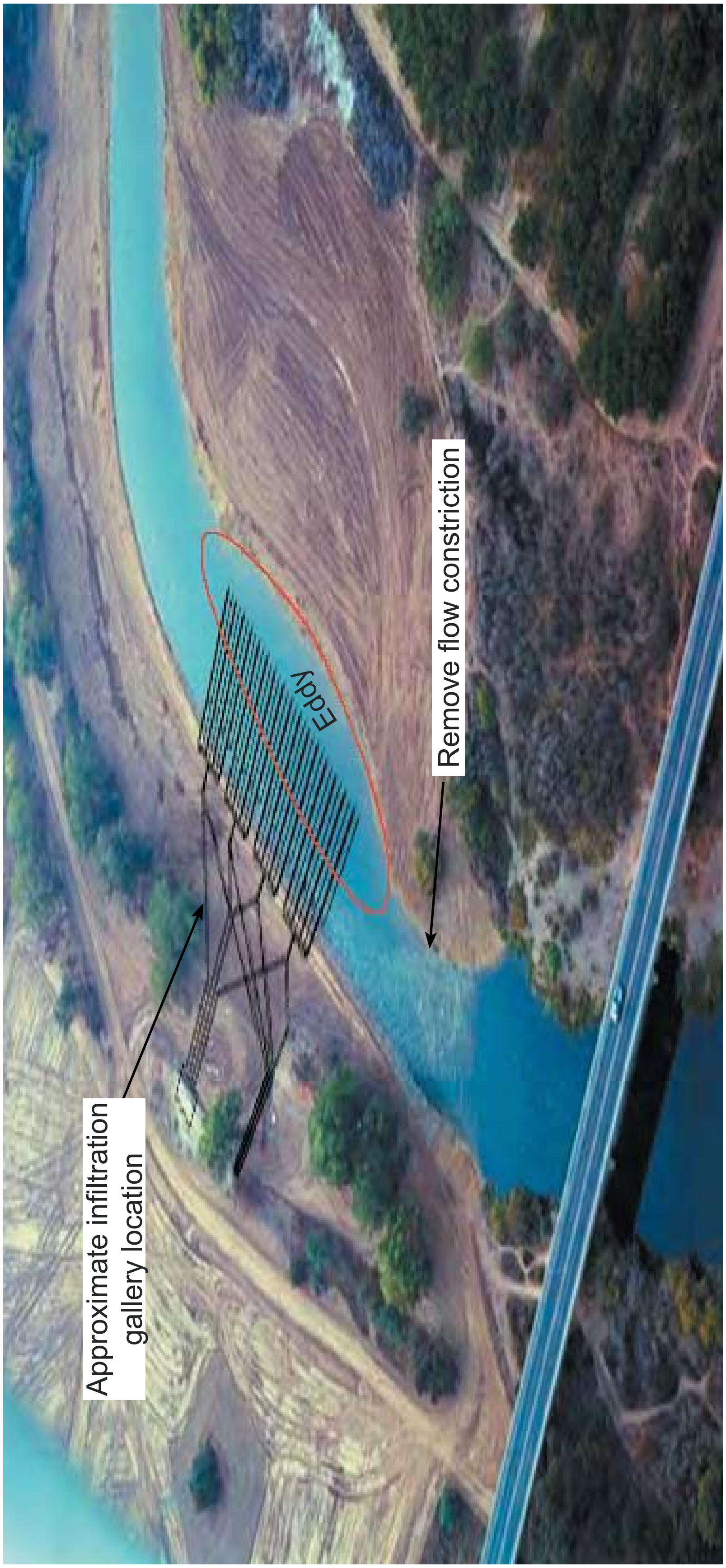

Figure 5-1. Proposed retroactive modifications to SRP 9 to reduce largemouth bass habitat.

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Appendix A.

Abundance and Density of Largemouth and Smallmouth Bass at Project and Reference Sites in 1998, 1999, 2003.

Table A-1. 1998 estimates of abundance and density of largemouth bass (all size clases combined) at project and control sites

							CARLE-STRUB ESTIMATOR				PROFILE-LIKELIHOOD (SEBER) ESTIMATOR			
Location	Sample date	Bank length (ft)	Site area (sq ft)	Pass No.	No. Captured	Mean fork length (mm)	Probability of Capture	Population abundance (95% C.I.)	Fish per unit bank length (no./ft)	Fish per unit site area (no./ft^2)	Probability of Capture	Population abundance (95% C.I.)	Fish per unit bank length (no./10^3ft)	Fish per unit site area (no./10^6ft^2)
Project Sites														
SRP 9	09/21/98	1,830	284,653	1	7	336	0.4857	19	0.0104	6.67E-05	0.4474	20	3.2	6.69
				2	8	242		(14-25)				(14-46)		
				3	2	257								
SRP 10	09/23/98	2,498	429,703	1	12	281	0.4110	37	0.0148	8.61E-05	0.3947	38	4.6	8.54
				2	14	220		(27-51)				(27-89)		
				3	4	230								
Reference Sites														
SRP 7	09/25/98	3,847	418,518	1	9	237	0.3385	30	0.0078	7.17E-05	0.2651	36	2.9	8.29
				2	7	195		(18-44)				(17-INF)		
				3	6	255								
SRP 8	09/24/98	3,172	575,161	1	23	302	0.5211	41	0.0129	7.13E-05	0.5211	41	3.5	6.52
				2	6	254		(34-50)				(34-52)		
				3	8	213								
Charles Rd	09/26/98	2,950	147,684	1	0		NE[1]	NE[1]	NE[1]	NE[1]	NE[1]	NE[1]	NE[1]	NE[1]
				2	1	140								
				3	1	115								
South Pit														
South Pit	09/26/98	5,224	NA	1	26	296	NE[1]	NE[1]	NE[1]	NE[1]	NE[1]	NE[1]	NE[1]	NE[1]
				2	NA									
				3	NA									
All Sites Combined:		*19,521*	*1,855,719.00*	*1*	*77*	*292*	*0.5038*	*152*			*0.4981*	*153*		
				2	*36*	*223*		*(137-173)*				*(137-175)*		
				3	*21*	*228*								

[1] NE = Not Estimable

Table A-2. 1998 estimates of abundance and density of largemouth bass 180 - 380 mm FL at project and control sites

						CARLE-STRUB ESTIMATOR				PROFILE-LIKELIHOOD (SEBER) ESTIMATOR			
Location	Sample date	Bank length (ft)	Site area (sq ft)	Pass No.	No. Captured	Probability of Capture	Population (95% C.I.)	Fish per unit length (1,000 ft)	Fish per unit area (10^5 ft^2)	Probability of Capture	Population (95% C.I.)	Fish per unit length (1,000 ft)	Fish per unit area (10^5 ft^2)
Project Sites													
SRP 9	09/21/98	1,830	284,653	1	3	0.80	4	2.2	1.4	0.80	4	2.2	1.4
				2	1		(3-4)				(3-4)		
				3	0								
SRP 10	09/23/98	2,498	429,703	1	5	0.45	15	6.0	3.5	0.41	16	6.4	3.7
				2	6		(10-21)				(9-inf)		
				3	2								
Reference Sites													
SRP 7	09/25/98	3,847	418,518	1	4	0.40	12	3.1	2.9	0.32	14	3.6	3.3
				2	3		(6-16)				(6-inf)		
				3	3								
SRP 8	09/24/98	3,172	575,161	1	12	0.67	18	5.7	3.1	0.67	18	5.7	3.1
				2	3		(15-19)				(16-20)		
				3	3								
Charles Rd	09/26/98	2,950	147,684	1	0	NE	0	0.0	0.0	NE	0	0.0	0.0
				2	0								
				3	0								
All Sites Combined:													
		14,297	*1,855,717.44*	*1*	*24*								
				2	*13*								
				3	*8*								

Table A-3. 1998 estimates of abundance and density of smallmouth bass (all size clases combined) at project and control sites

							CARLE-STRUB ESTIMATOR				PROFILE-LIKELIHOOD (SEBER) ESTIMATOR			
Location	Sample date	Bank length (ft)	Site area (ft2)	Pass No.	No. Captured	Mean fork length (mm)	Probability of Capture	Population abundance (95% C.I.)	Fish per unit bank length (no./10^3ft)	Fish per unit site area (no./10^6ft^2)	Probability of Capture	Population abundance (95% C.I.)	Fish per unit bank length (no./10^3ft)	Fish per unit site area (no./10^6ft^2)
Project Sites														
SRP 9	09/21/98	1,830	284,653	1	4	153.75	0.6000	9 (7-10)	4.92E-03	3.16E-05	0.6000	9 (7-12)	1.4	3.01
				2	4	193.25								
				3	1	120.00								
SRP 10	09/23/98	2,498	429,703	1	0		NE[1]	NE[1]	NE[1]	NE[1]	NE[1]	NE[1]	NE[1]	NE[1]
				2	1	138.00								
				3	0									
Control Sites														
SRP 7	09/25/98	3,847	418,518	1	2	132.50	0.5455	6 (4-7)	1.56E-03	1.43E-05	0.5455	5 (4-13)	0.4	1.15
				2	3	199.33								
				3	1	150.00								
SRP 8	09/24/98	3,172	575,161	1	0		NE[1]	NE[1]	NE[1]	NE[1]	NE[1]	NE[1]	NE[1]	NE[1]
				2	0									
				3	0									
Charles Rd	09/26/98	2,950	147,684	1	12	152.82	0.7500	15 (14-16)	5.08E-03	1.02E-04	0.7500	15 (14-16)	1.4	8.47
				2	1	160.00								
				3	2	128.50								
All Sites Combined:		5,224												
		14,297	*1,855,719.00*	*1*	*18*	*150.77*	*0.5741*	*33 (28-38)*			*0.5741*	*33 (27-40)*		
				2	*9*	*185.44*								
				3	*4*	*131.75*								

[1] NE = Not Estimable

Table A-4. 1998 estimates of abundance and density of smallmouth bass 180 - 380 mm FL at project and control sites

						CARLE-STRUB ESTIMATOR				PROFILE-LIKELIHOOD (SEBER) ESTIMATOR			
Location	Sample date	Bank length (ft)	Site area (sq ft)	Pass No.	No. Captured	Probability of Capture[1]	Population (95% C.I.)	Fish per unit length (1,000 ft)	Fish per unit area (10^5 ft^2)	Probability of Capture[1]	Population (95% C.I.)	Fish per unit length (1,000 ft)	Fish per unit area (10^5 ft^2)
Project Sites													
SRP 9	09/21/98	1,830	284,653	1	1	0.67	2	1.1	0.7	0.67	2	1.1	0.7
				2	1		(1-2)				(1-2)		
				3	0								
SRP 10	09/23/98	2,498	429,703	1	0	NE	0	0.0	0.0	NE	0	0.0	0.0
				2	0								
				3	0								
Control Sites													
SRP 7	09/25/98	3,847	418,518	1	0	0.50	1	0.3	0.2	0.50	1	0.3	0.2
				2	1		(0-1)				(0-1)		
				3	0								
SRP 8	09/24/98	3,172	575,161	1	0	NE	0	0.0	0.0	NE	0	0.0	0.0
				2	0								
				3	0								
Charles Rd	09/26/98	2,950	147,684	1	2	1.00	2	0.7	1.4	1.00	2	0.7	1.4
				2	0		(2-2)				(2-2)		
				3	0								
All Sites Combined:													
		14,297	*1,855,717*	*1*	*3*								
				2	*2*								
				3	*0*								

[1] NE = Not Estimable

Table A-5. 1999 estimates of abundance and density of largemouth bass (all size clases combined) at project and control sites

Site	Bank Length (ft)	Area (ft²)	Date	Pass	Count	Mean Length (mm)	Carle-Strub Estimator Population (95% C.I.)	Carle-Strub Estimator Fish per unit length (ft)	Carle-Strub Estimator Fish per unit area (ft²)	Carle-Strub Estimator Probability of Capture	Profile-likelihood Estimator Population (95% C.I.)	Profile-likelihood Estimator Fish per unit length (ft)	Profile-likelihood Estimator Fish per unit area (ft²)	Profile-likelihood Estimator Probability of Capture
Project Sites														
SRP 9	1,830	284,653	09/13/99	1	61	125.9	165	0.09016	5.80E-04	0.3800	167	0.0913	5.87E-04	0.3700
				2	40	122.4	(135-214)				(137-231)			
				3	25	100.4								
SRP 10	2,498	429,703	09/14/99	1	52	194.8	179	0.07166	4.17E-04	0.2800	189	0.0757	4.40E-04	0.2600
				2	30	123.7	(129-248)				(132-536)			
				3	31	109.5								
Control Sites														
U/S Riffle	2,682	157,863	09/17/99	1	26	128.9	124	0.04623	7.85E-04	0.2400	145	0.0541	9.19E-04	0.2000
				2	28	130.3	(75-206)				(82-inf)			
				3	17	121.8								
SRP 7	3,847	418,518	09/16/99	1	210	122.4	767	0.19938	1.83E-03	0.2800	777	0.2020	1.86E-03	0.2800
				2	164	118.0	(637-955)				(644-1,015)			
				3	109	110.5								
SRP 8	3,172	575,161	09/15/99	1	263	105.7	1,007	0.31745	1.75E-03	0.2600	1,020	0.3216	1.77E-03	0.2500
				2	183	89.7	(837-1,243)				(843-1,373)			
				3	150	88.4								
Charles Road	2,950	147,684	09/18/99	1	15	135.3	24	0.00814	1.63E-04	0.6100	24	0.0081	1.63E-04	0.6100
				2	4	96.8	(20-28)				(20-28)			
				3	4	178.3								
South Pit[1]	5,224		09/19/99	1	14	210.1	NE[2]	NE[2]	NE[2]	NE[2]	NE[2]	NE[2]	NE[2]	NE[2]
				2	9	227.7								
				3										
All Sites Combined														
	17,876	*1,299,225*		*1*	*641*	*124.2*		0.00E+00	*0.00E+00*			*0.0000*	*0.00E+00*	
				2	*458*	*110.2*								
				3	*336*	*101.2*								

[1] Only two passes were made on a portion of the bank in the South Pond. No population estimate can be obtained from these passes.
[2] NE = not estimable

Table A-6. 1999 estimates of abundance and density of largemouth bass 180 - 380 mm FL at project and control sites

Site	Bank Length (ft)	Area (ft²)	Date	Pass	Count	Carle-Strub Estimator: Population (95% C.I.)	Carle-Strub Estimator: Fish per unit length (1,000 ft)	Carle-Strub Estimator: Fish per unit area (10^5 ft²)	Carle-Strub Estimator: Probability of Capture[1]	Profile-likelihood Estimator: Population (95% C.I.)	Profile-likelihood Estimator: Fish per unit length (1,000 ft)	Profile-likelihood Estimator: Fish per unit area (10^5 ft²)	Profile-likelihood Estimator: Probability of Capture[1]
Project Sites													
SRP 9	1,830	284,653	09/13/99	1	4	7	3.8	2.5	0.70	7	3.8	2.5	0.70
				2	3	(6-7)				(6-8)			
				3	0								
SRP 10	2,498	429,703	09/14/99	1	17	23	9.2	5.4	0.74	23	9.2	5.4	0.74
				2	4	(21-24)				(21-24)			
				3	2								
Control Sites													
R64	2,682	157,863	09/17/99	1	2	2	0.7	1.3	1.00	2	0.7	1.3	1.00
				2	0	(2-2)				(2-2)			
				3	0								
SRP 7	3,847	418,518	09/16/99	1	10	18	4.7	4.3	0.57	18	4.7	4.3	0.57
				2	4	(14-21)				(14-25)			
				3	3								
SRP 8	3,172	575,161	09/15/99	1	10	40	12.6	7.0	0.30	50	15.8	8.7	0.23
				2	10	(23-60)				(24-inf)			
				3	7								
Charles Road	2,950	147,684	09/18/99	1	3	3	1.0	2.0	1.00	3	1.0	2.0	1.00
				2	0	(3-3)				(3-3)			
				3	0								
All Sites Combined													
	12,652	*1,299,225*		*1*	*46*								
				2	*21*								
				3	*12*								

[1] NE = not estimable

Table A-7. 1999 estimates of abundance and density of smallmouth bass (all size clases combined) at project and control sites

							Carle-Strub Estimator				Profile-likelihood Estimator			
Site	Bank Length (ft)	Area (ft²)	Date	Pass	Count	Mean Length (mm)	Population (95% C.I.)	Fish per unit length (ft)	Fish per unit area (ft²)	Probability of Capture	Population (95% C.I.)	Fish per unit length (ft)	Fish per unit area (ft²)	Probability of Capture
Project Sites														
SRP 9	1,830	284,653	09/13/99	1	10	204.60	13	0.0071	4.57E-05	0.7600	13	0.0071	4.57E-05	0.7600
				2	2	243.00	(12-13)				(12-13)			
				3	1	260.00								
SRP 10	2,498	429,703	09/14/99	1	19	195.00	20	0.0080	4.65E-05	0.9500	20	0.0080	4.65E-05	0.9500
				2	1	222.00	(20-20)				(20-20)			
				3	0									
Control Sites														
U/S Riffle	2,682	157,863	09/17/99	1	0		NE[2]	NE[2]	NE[2]	NE[2]	NE[2]	NE[2]	NE[2]	NE[2]
				2	1	257.70								
				3	0									
SRP 7	3,847	418,518	09/16/99	1	1	305.00	1	0.0003	2.39E-06	1.0000	1	0.0003	2.39E-06	1.0000
				2	0		(1-1)				(1-1)			
				3	0									
SRP 8	3,172	575,161	09/15/99	1	0		NE[2]	NE[2]	NE[2]	NE[2]	NE[2]	NE[2]	NE[2]	NE[2]
				2	0									
				3	0									
Charles Road	2,950	147,684	09/18/99	1	11	209.60	23	0.0078	1.56E-04	0.5300	23	0.0078	1.56E-04	0.5300
				2	7	123.90	(18-29)				(18-33)			
				3	3	241.00								
South Pit[1]	5,224		09/19/99	1	0		NE[2]	NE[2]	NE[2]	NE[2]	NE[2]	NE[2]	NE[2]	NE[2]
				2	0									
				3										
All Sites Combined														
	17,876	*2,013,580*		*1*	*41*	*203.94*		0.0000	0.00E+00			0.0000	0.00E+00	
				2	*11*	*166.64*								
				3	*4*	*245.75*								

[1] Only two passes were made on a portion of the bank in the South Pond. No population estimate can be obtained from these passes.
[2] NE = not estimable

Table A-8. 1999 estimates of abundance and density of smallmouth bass 180 - 380 mm FL at project and control sites

						Carle-Strub Estimator				Profile-likelihood Estimator			
Site	Bank Length (ft)	Area (ft^2)	Date	Pass	Count	Population (95% C.I.)	Fish per unit length (1,000 ft)	Fish per unit area (10^5 ft^2)	Probability of Capture[1]	Population (95% C.I.)	Fish per unit length (1,000 ft)	Fish per unit area (10^5 ft^2)	Probability of Capture[1]
Project Sites													
SRP 9	1,830	284,653	09/13/99	1	5	7	3.8	2.5	0.70	7	3.8	2.5	0.70
				2	1	(6-7)				(6-8)			
				3	1								
SRP 10	2,498	429,703	09/14/99	1	8	9	3.6	2.1	0.90	9	3.6	2.1	0.90
				2	1	(9-9)				(9-9)			
				3	0								
Control Sites													
R64	2,682	157,863	09/17/99	1	0	1	0.4	0.6	0.50	1	0.4	0.6	0.50
				2	1	(0-1)				(0-1)			
				3	0								
SRP 7	3,847	418,518	09/16/99	1	1	1	0.3	0.2	1.00	1	0.3	0.2	1.00
				2	0	(1-1)				(1-1)			
				3	0								
SRP 8	3,172	575,161	09/15/99	1	0	0	0.0	0.0	NE	0	0.0	0.0	NE
				2	0								
				3	0								
Charles Road	2,950	147,684	09/18/99	1	9	13	4.4	8.8	0.65	13	4.4	8.8	0.65
				2	1	(11-15)				(11-16)			
				3	3								
All Sites Combined													
	12,652	*2,013,580*		*1*	*23*								
				2	*4*								
				3	*4*								

[1] NE = not estimable

Table A-9. 2003 estimates of abundance and density of largemouth bass (all size clases combined) at project and control sites

							Carle-Strub Estimator				Profile-likelihood Estimator			
Site	Bank Length (ft)	Area (ft^2)	Date	Pass	Count	Mean Length (mm)	Population (95% C.I.)	Fish per unit length (1000 ft)	Fish per unit area (10^5 ft^2)	Probability of Capture	Population (95% C.I.)	Fish per unit length (1000 ft)	Fish per unit area (10^5 ft^2)	Probability of Capture
Project Sites														
SRP 9	1,727	98,473	10/08/03	1	39	165.23	60	34.74	60.93	0.6200	60	34.74	60.93	0.6200
				2	10	167.30	(54-65)				(54-66)			
				3	8	164.88								
SRP 10	2,498	429,703	10/09/03	1	77	236.12	149	59.65	34.68	0.4800	149	59.65	34.68	0.4800
				2	24	256.67	(132-173)				(132-174)			
				3	27	242.56								
Control Sites														
Riffle 64	2,682	157,863	09/24/03	1	9	141.78	14	5.22	8.87	0.7000	14	5.22	8.87	0.7000
				2	4	149.75	(12-15)				(12-15)			
				3	1	61.00								
SRP 7	3,847	418,518	09/22/03	1	46	190.33	205	53.29	48.98	0.2400	225	58.49	53.76	0.2100
				2	41	171.32	(138-325)				(144-1,089)			
				3	29	114.07								
SRP 8	3,172	575,161	09/23/03	1	79	222.13	257	81.02	44.68	0.2900	265	83.54	46.07	0.2800
				2	42	152.79	(197-380)				(199-473)			
				3	45	169.49								
Charles Road	2,950	147,684	10/08/03	1	10	203.50	40	13.56	27.08	0.3400	45	15.25	30.47	0.2900
				2	14	246.86	(25-58)				(27-inf)			
				3	5	85.60								
All Sites Combined														
	16,877	*1,827,401*		*1*	*260*	*208.6*								
				2	*135*	*187.6*								
				3	*115*	*167.8*								

Table A-10. 2003 estimates of abundance and density of largemouth bass 180 - 380 mm FL at project and control sites

						Carle-Strub Estimator				Profile-likelihood Estimator			
Site	Bank Length (ft)	Area (ft^2)	Date	Pass	Count	Abundance (95% C.I.)	Fish per unit length (1,000 ft)	Fish per unit area (10^5 ft^2)	Probability of Capture	Abundance (95% C.I.)	Fish per unit length (1,000 ft)	Fish per unit area (10^5 ft^2)	Probability of Capture
Project Sites													
SRP 9	1,727	98,473	10/08/03	1	15	24	13.9	24.4	0.61	24	13.9	24.4	0.61
				2	4	(20-28)				(20-29)			
				3	4								
SRP 10	2,498	429,703	10/09/03	1	44	93	37.2	21.6	0.44	94	37.6	21.9	0.43
				2	15	(77-117)				(78-123)			
				3	18								
Control Sites													
Riffle 64	2,682	157,863	09/24/03	1	3	5	1.9	3.2	0.71	5	1.9	3.2	0.71
				2	2	(4-5)				(4-6)			
				3	0								
SRP 7	3,847	418,518	09/22/03	1	21	48	12.5	11.5	0.46	49	12.7	11.7	0.45
				2	13	(38-59)				(38-78)			
				3	7								
SRP 8	3,172	575,161	09/23/03	1	47	95	29.9	16.5	0.45	96	30.3	16.7	0.44
				2	14	(80-115)				(81-123)			
				3	19								
Charles Road	2,950	147,684	10/08/03	1	5	16	5.4	10.8	0.54	17	5.8	11.5	0.48
				2	10	(12-20)				(12-34)			
				3	0								

Table A-11. 2003 estimates of abundance and density of smallmouth bass (all size clases combined) at project and control sites

							Carle-Strub Estimator				Profile-likelihood Estimator			
Site	Bank Length (ft)	Area (ft^2)	Date	Pass	Count	Mean Length (mm)	Population (95% C.I.)	Fish per unit length (1000 ft)	Fish per unit area (10^5 ft2)	Probability of Capture	Population (95% C.I.)	Fish per unit length (1000 ft)	Fish per unit area (10^5 ft2)	Probability of Capture
Project Sites														
SRP 9	1,727	98,473	10/08/03	1	32	142.56	191	110.60	193.96	0.1900	254	147.08	257.94	0.1300
				2	32	138.09	(107-298)				(113-inf)			
				3	25	132.04								
SRP 10	2,498	429,703	10/09/03	1	8	178.13	14	5.60	3.26	0.5200	14	5.60	3.26	0.5200
				2	1	254.00	(10-17)				(10-22)			
				3	4	176.50								
Control Sites														
Riffle 64	2,682	157,863	09/24/03	1	32	132.41	71	26.47	44.98	0.4500	72	26.84	45.61	0.4400
				2	17	175.00	(58-90)				(58-102)			
				3	11	202.00								
SRP 7	3,847	418,518	09/22/03	1	11	93.14	102	26.51	24.37	0.2500	122	31.71	29.15	0.2000
				2	44	92.18	(61-162)				(63-inf)			
				3	4	122.50								
SRP 8	3,172	575,161	09/23/03	1	1	182.00	2	0.63	0.35	0.5000	2	0.63	0.35	0.5000
				2	0	n/a	(1-2)				(1-2)			
				3	1	200.00								
Charles Road	2,950	147,684	10/08/03	1	23	204.96	86	29.15	58.23	0.3000	94	31.86	63.65	0.2700
				2	21	137.38	(58-130)				(61-527)			
				3	13	133.85								
All Sites Combined														
	16,877	*1,827,401*		*1*	*107*	*150.88*								
				2	*115*	*126.86*								
				3	*58*	*149.29*								

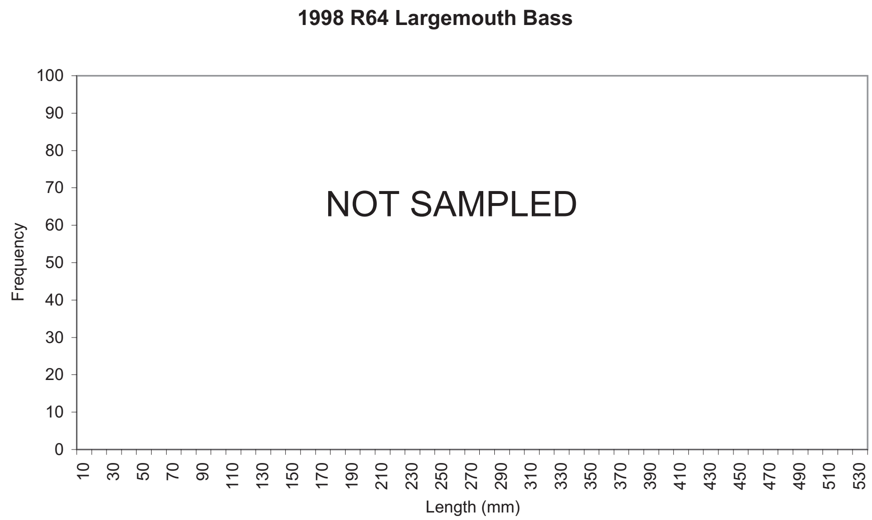
Table A-3. 1998 estimates of abundance and density of smallmouth bass (all size clases combined) at project and control sites

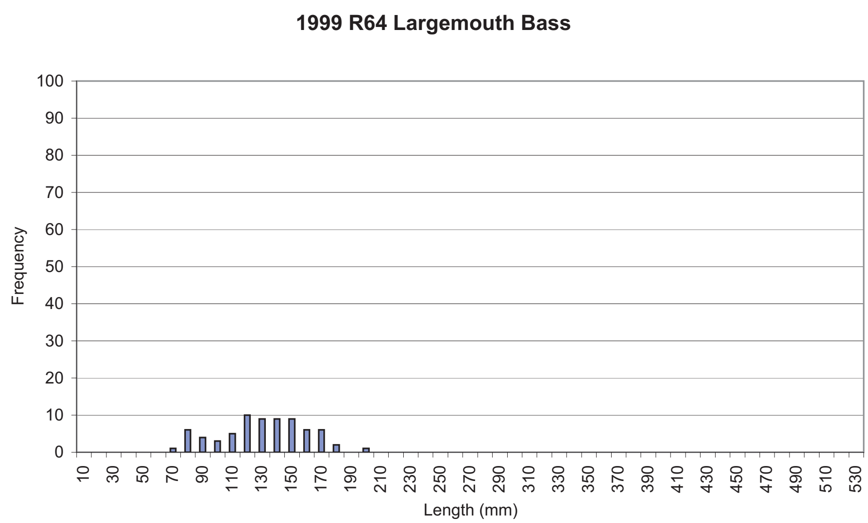
							CARLE-STRUB ESTIMATOR				PROFILE-LIKELIHOOD (SEBER) ESTIMATOR			
Location	Sample date	Bank length (ft)	Site area (ft2)	Pass No.	No. Captured	Mean fork length (mm)	Probability of Capture	Population abundance (95% C.I.)	Fish per unit bank length (no./10^3ft)	Fish per unit site area (no./10^6ft^2)	Probability of Capture	Population abundance (95% C.I.)	Fish per unit bank length (no./10^3ft)	Fish per unit site area (no./10^6ft^2)
Project Sites														
SRP 9	09/21/98	1,830	284,653	1	4	153.75	0.6000	9	4.92E-03	3.16E-05	0.6000	9	1.4	3.01
				2	4	193.25		(7-10)				(7-12)		
				3	1	120.00								
SRP 10	09/23/98	2,498	429,703	1	0		NE[1]	NE[1]	NE[1]	NE[1]	NE[1]	NE[1]	NE[1]	NE[1]
				2	1	138.00								
				3	0									
Control Sites														
SRP 7	09/25/98	3,847	418,518	1	2	132.50	0.5455	6	1.56E-03	1.43E-05	0.5455	5	0.4	1.15
				2	3	199.33		(4-7)				(4-13)		
				3	1	150.00								
SRP 8	09/24/98	3,172	575,161	1	0		NE[1]	NE[1]	NE[1]	NE[1]	NE[1]	NE[1]	NE[1]	NE[1]
				2	0									
				3	0									
Charles Rd	09/26/98	2,950	147,684	1	12	152.82	0.7500	15	5.08E-03	1.02E-04	0.7500	15	1.4	8.47
				2	1	160.00		(14-16)				(14-16)		
				3	2	128.50								
All Sites Combined:		5,224												
		14,297	*1,855,719.00*	*1*	*18*	*150.77*	*0.5741*	*33*			*0.5741*	*33*		
				2	*9*	*185.44*		*(28-38)*				*(27-40)*		
				3	*4*	*131.75*								

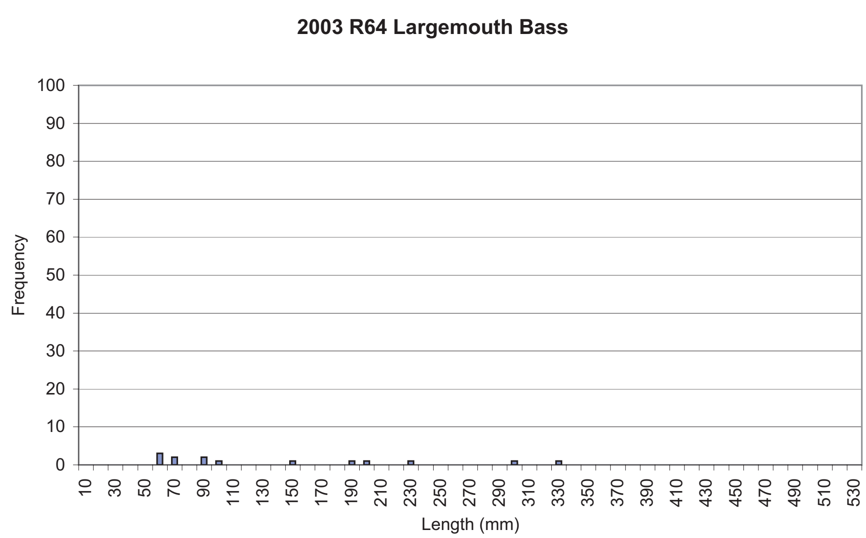
[1] NE = Not Estimable

Appendix B

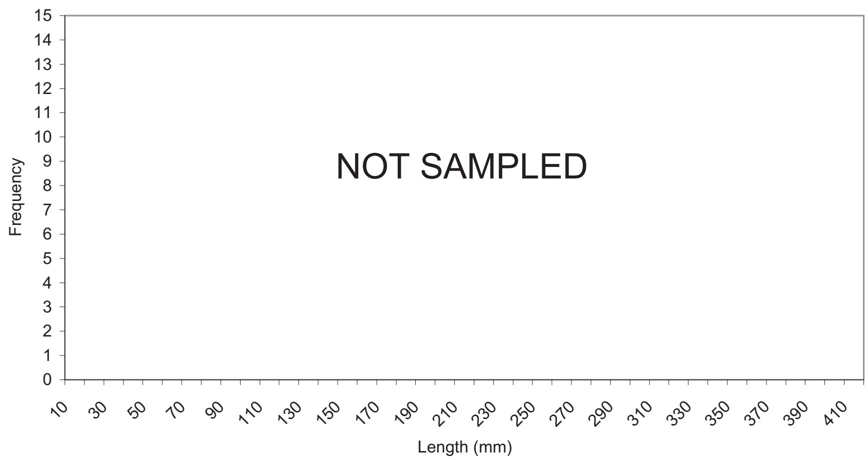
Length Frequencies of Largemouth and Smallmouth Bass Captured at Project and Reference Sites in 1998, 1999, and 2003.


1998 R64 Largemouth Bass
NOT SAMPLED
Frequency
Length (mm)

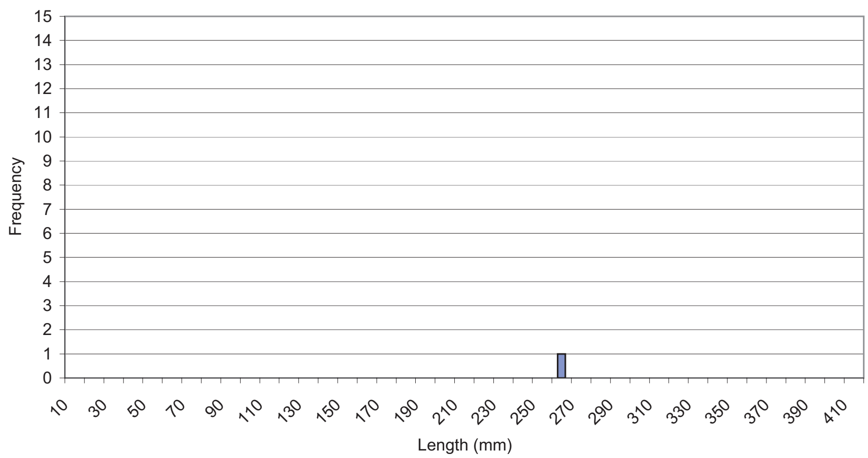

1999 R64 Largemouth Bass
Frequency
Length (mm)


2003 R64 Largemouth Bass
Frequency
Length (mm)

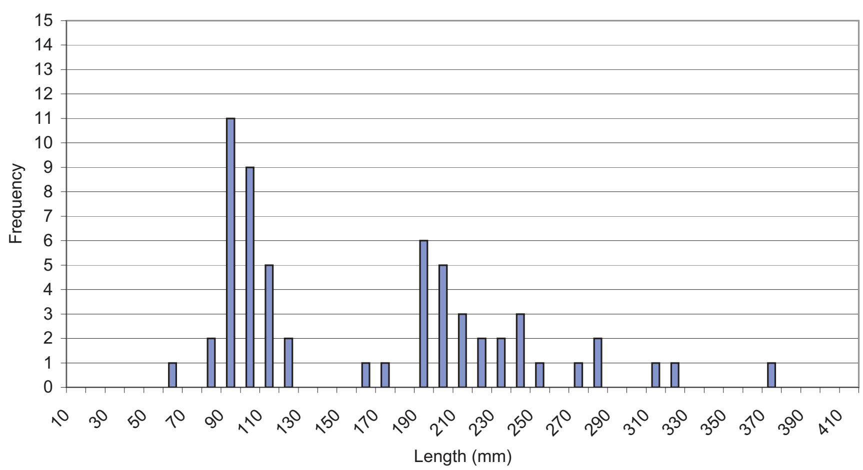
1998 R64 Smallmouth Bass



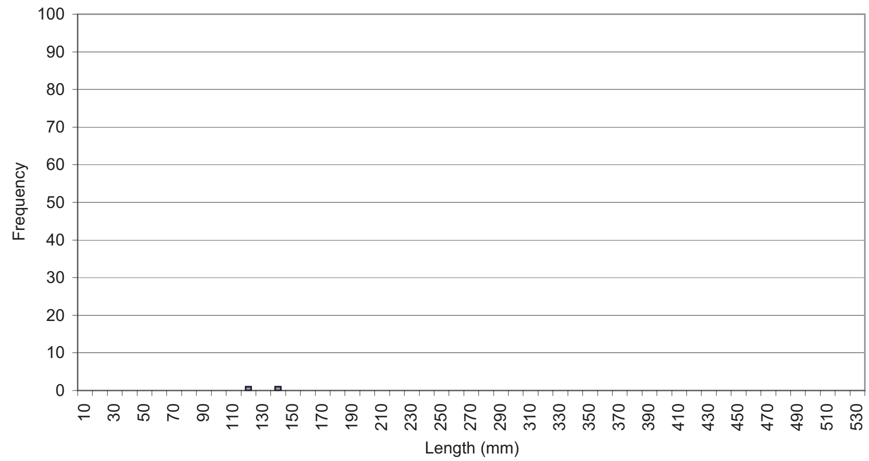
1999 R64 Smallmouth Bass



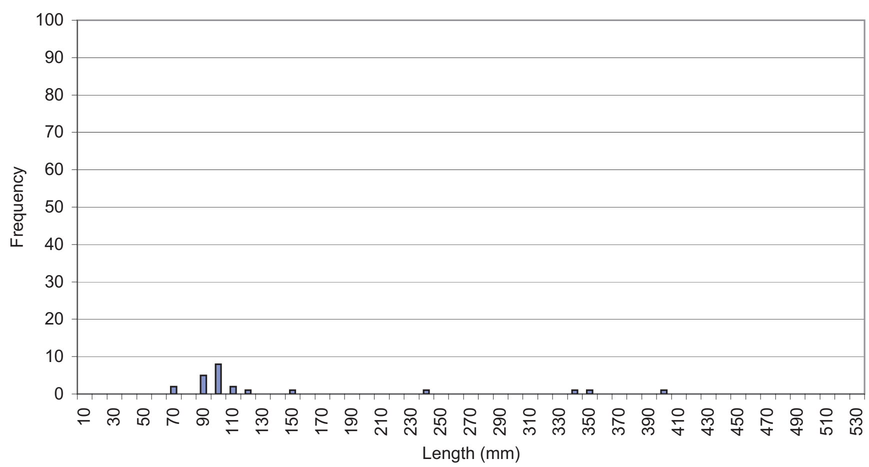
2003 R64 Smallmouth Bass



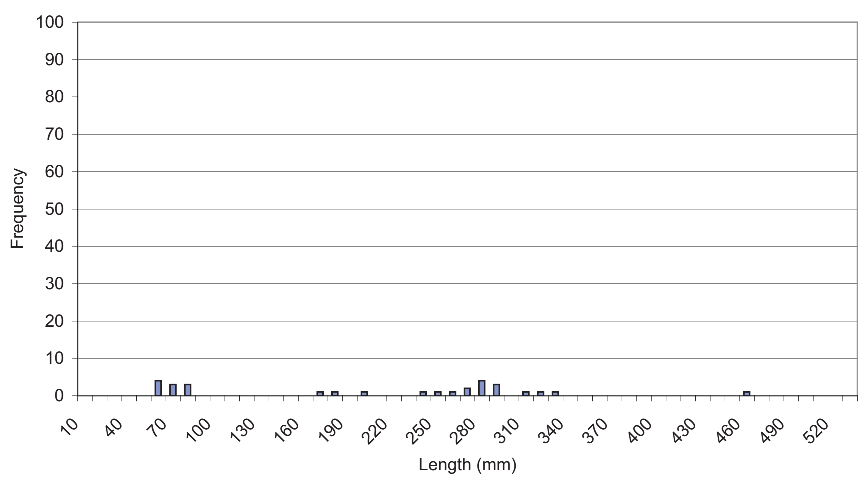
1998 Charles Road Largemouth Bass



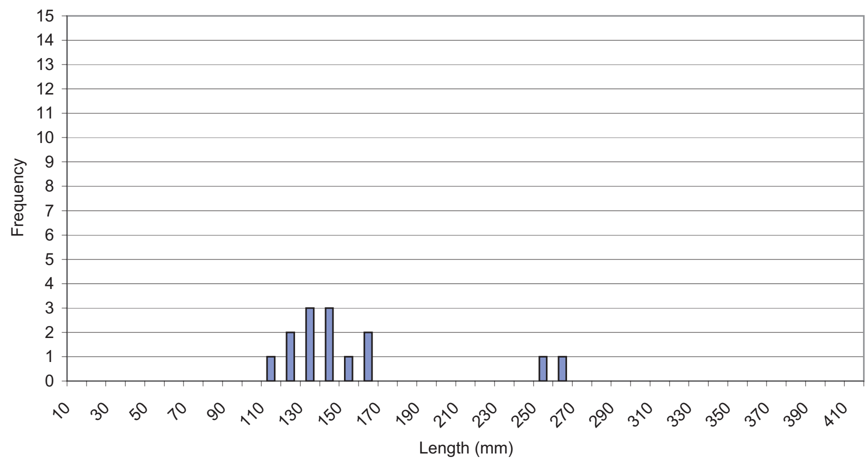
1999 Charles Road Largemouth Bass



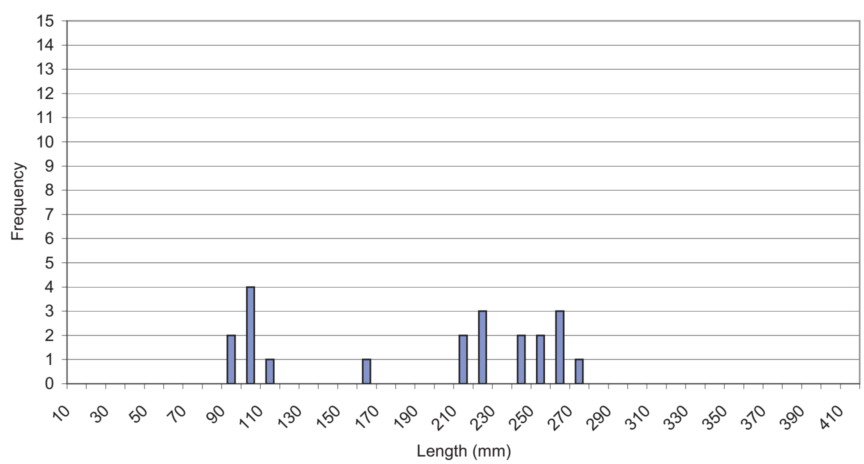
2003 Charles Road Largemouth Bass



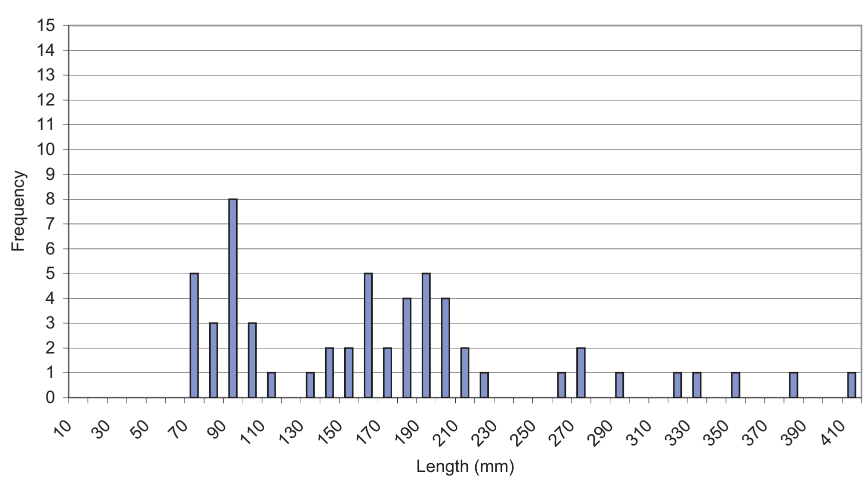
1998 Charles Road Smallmouth Bass

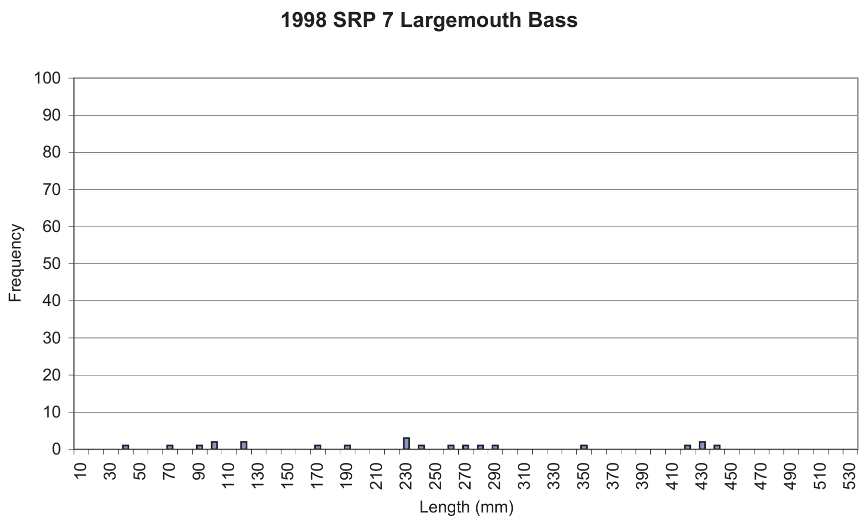


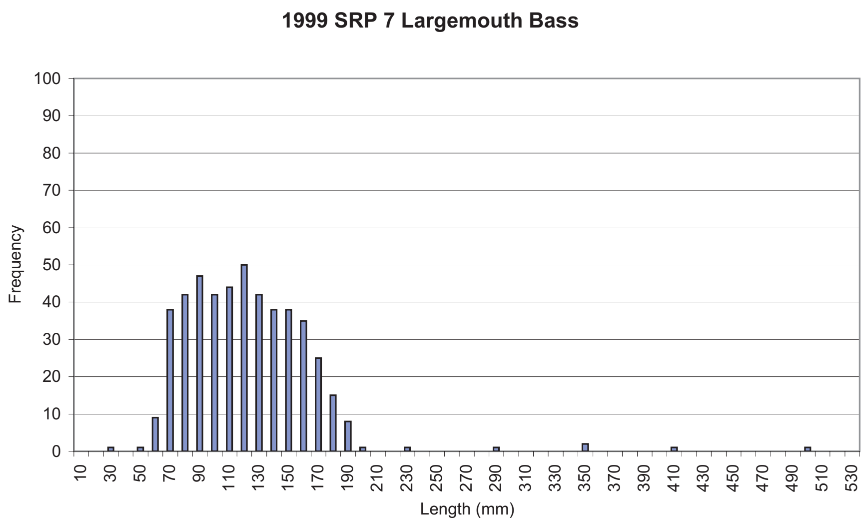
1999 Charles Road Smallmouth Bass

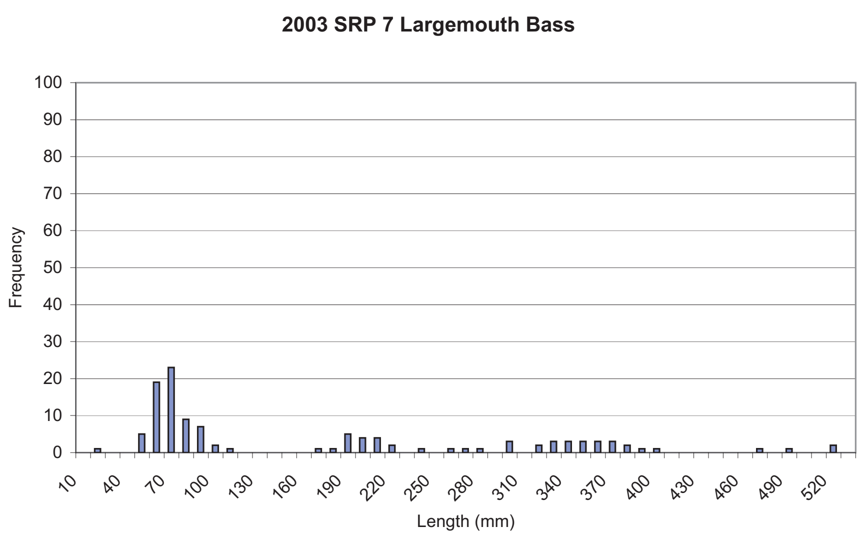


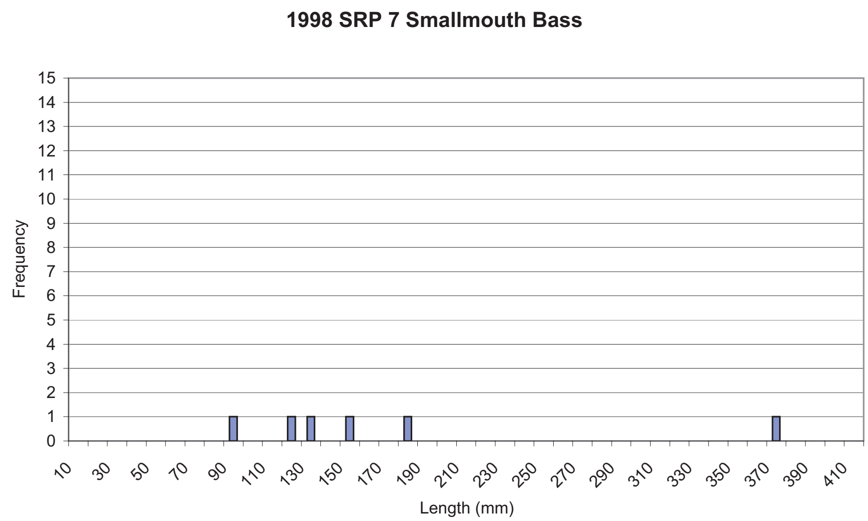
2003 Charles Road Smallmouth Bass

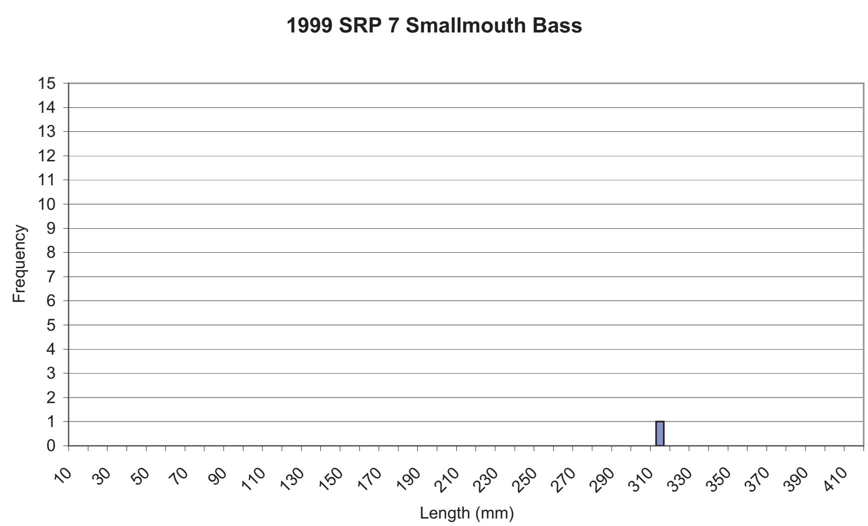


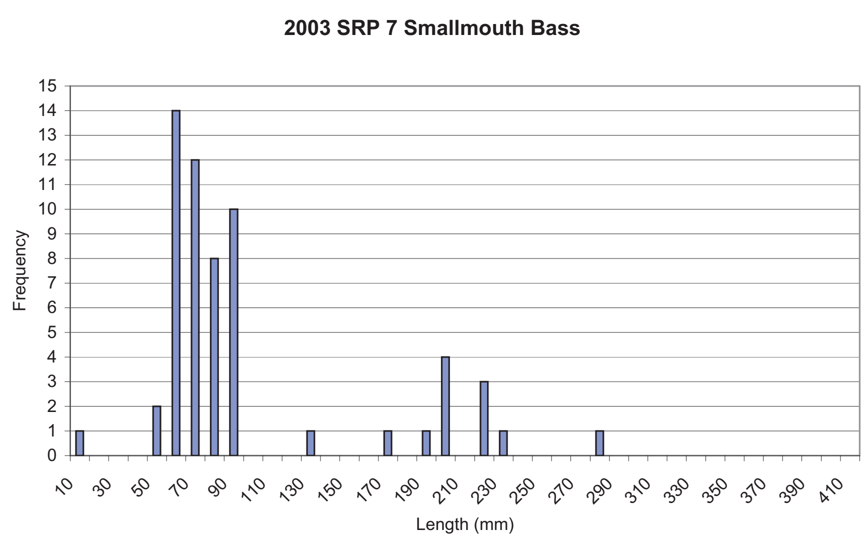

1998 SRP 7 Largemouth Bass
Frequency
Length (mm)


1999 SRP 7 Largemouth Bass
Frequency
Length (mm)

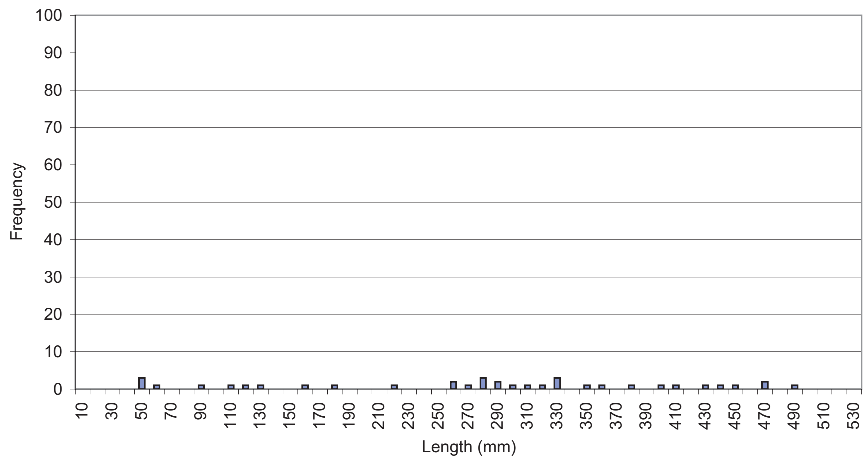

2003 SRP 7 Largemouth Bass
Frequency
Length (mm)


1998 SRP 7 Smallmouth Bass
Frequency
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
10 30 50 70 90 110 130 150 170 190 210 230 250 270 290 310 330 350 370 390 410
Length (mm)

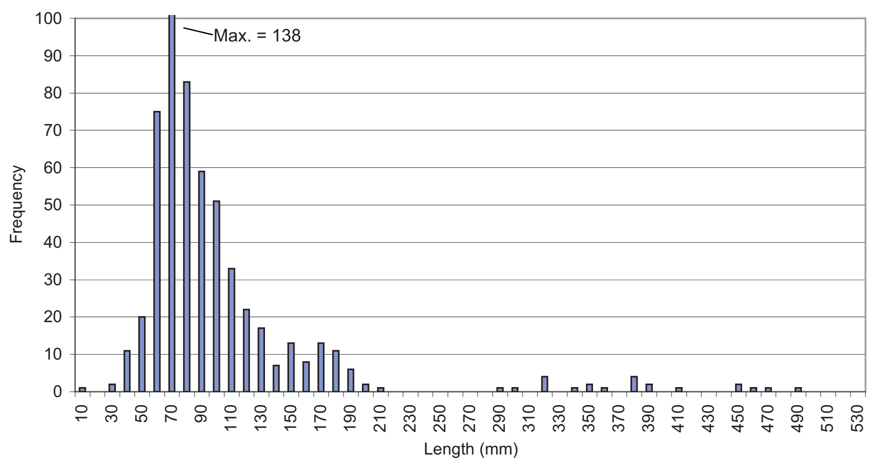

1999 SRP 7 Smallmouth Bass
Frequency
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
10 30 50 70 90 110 130 150 170 190 210 230 250 270 290 310 330 350 370 390 410
Length (mm)


2003 SRP 7 Smallmouth Bass
Frequency
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
10 30 50 70 90 110 130 150 170 190 210 230 250 270 290 310 330 350 370 390 410
Length (mm)

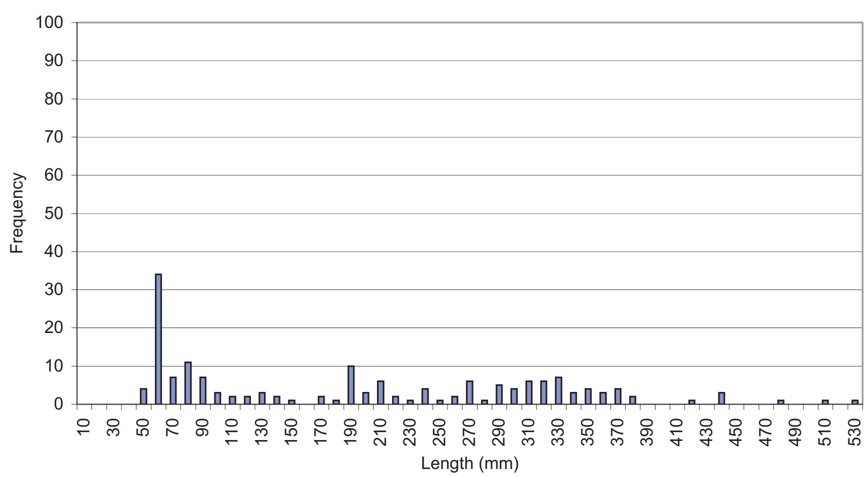
1998 SRP 8 Largemouth Bass



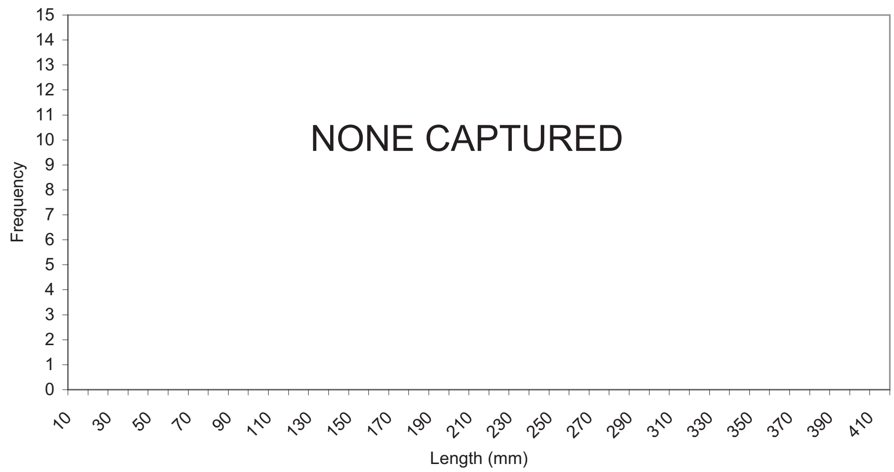
1999 SRP 8 Largemouth Bass



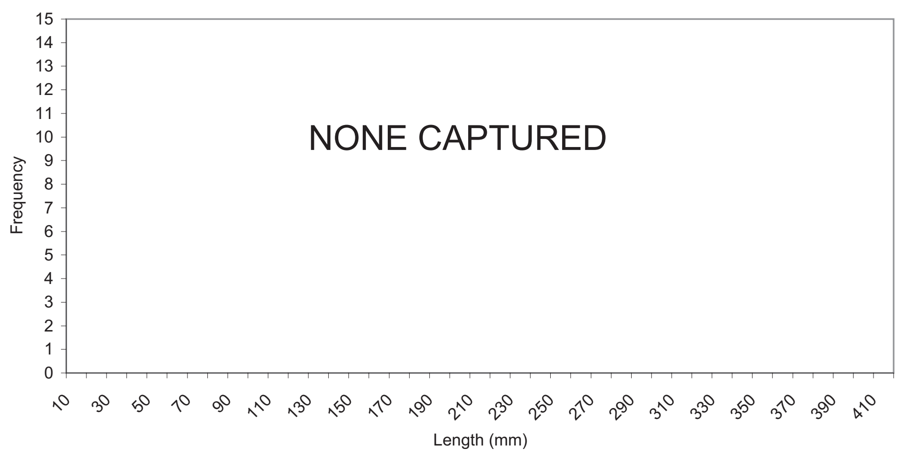
2003 SRP 8 Largemouth Bass



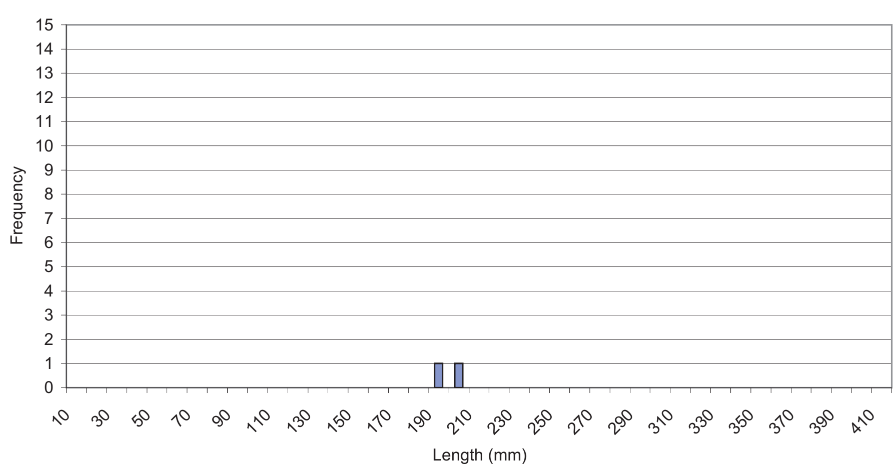
1998 SRP 8 Smallmouth Bass



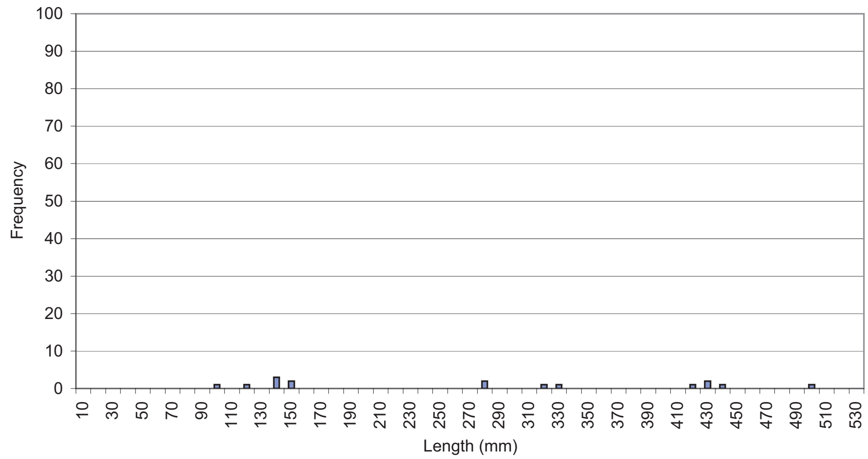
1999 SRP 8 Smallmouth Bass



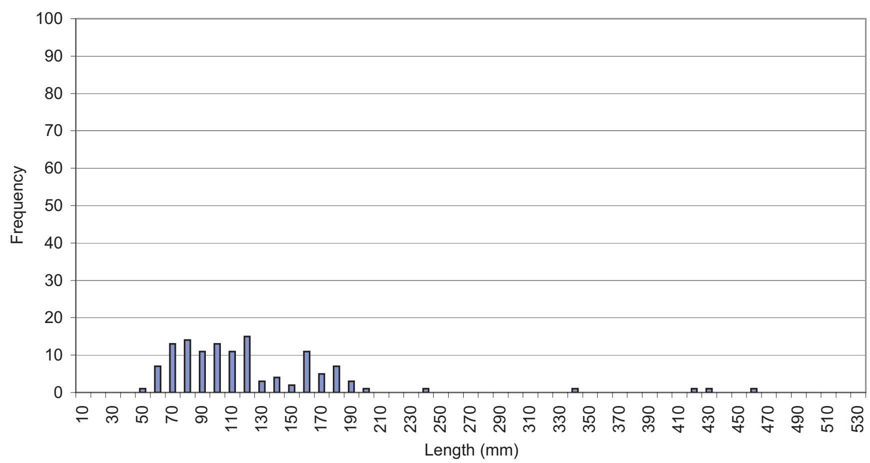
2003 SRP 8 Smallmouth Bass



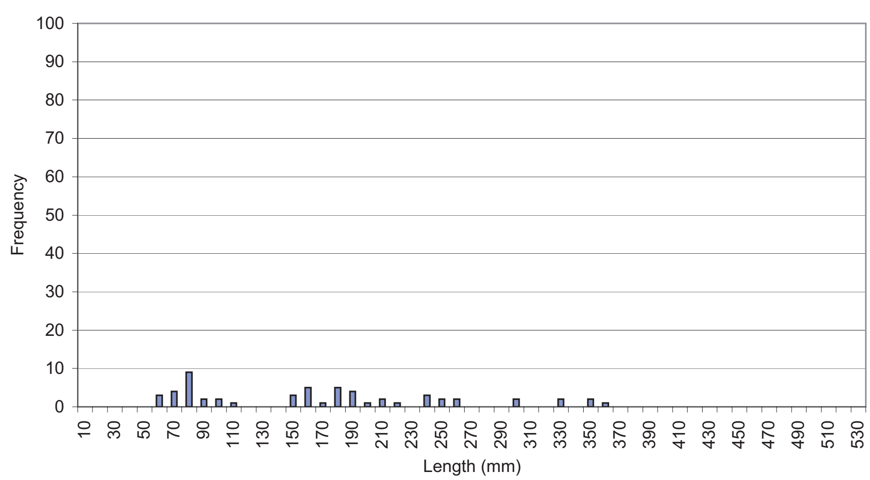
1998 SRP 9 Largemouth Bass



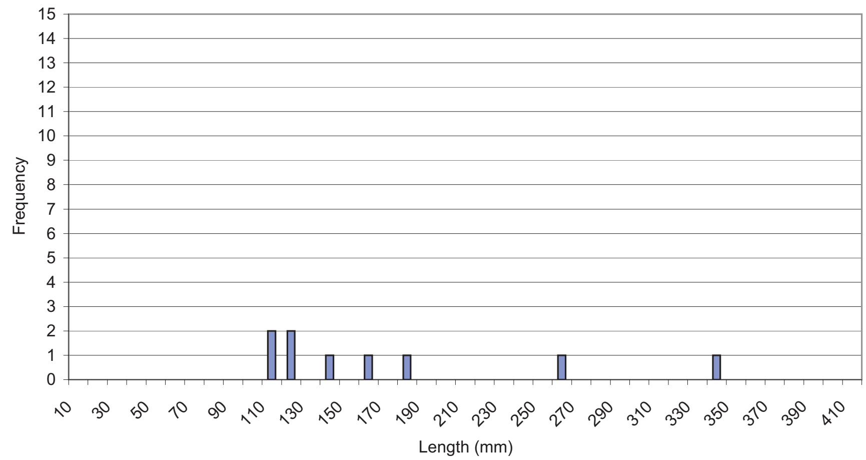
1999 SRP 9 Largemouth Bass



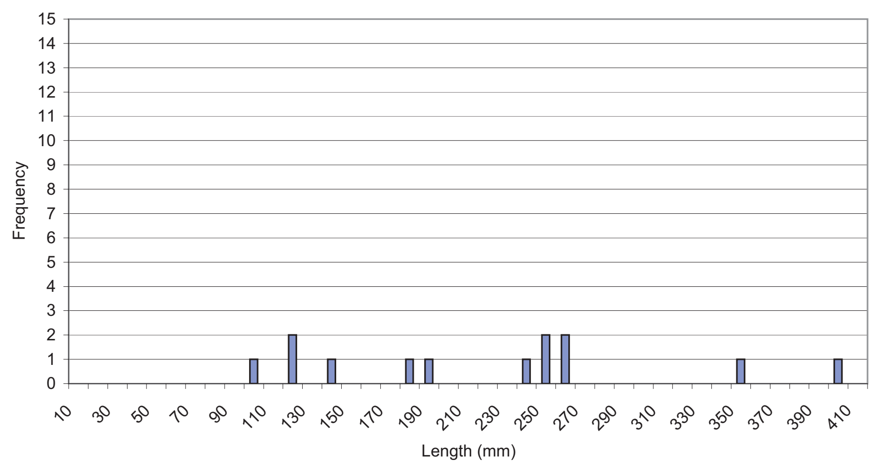
2003 SRP 9 Largemouth Bass



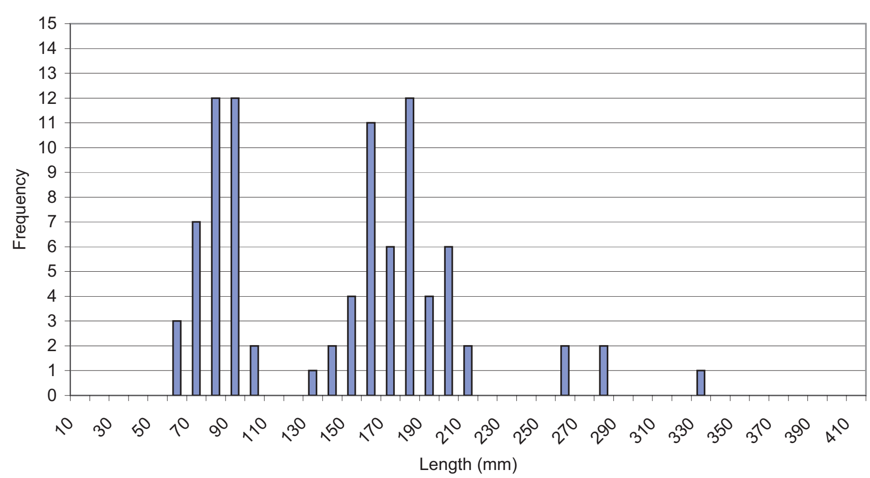
1998 SRP 9 Smallmouth Bass



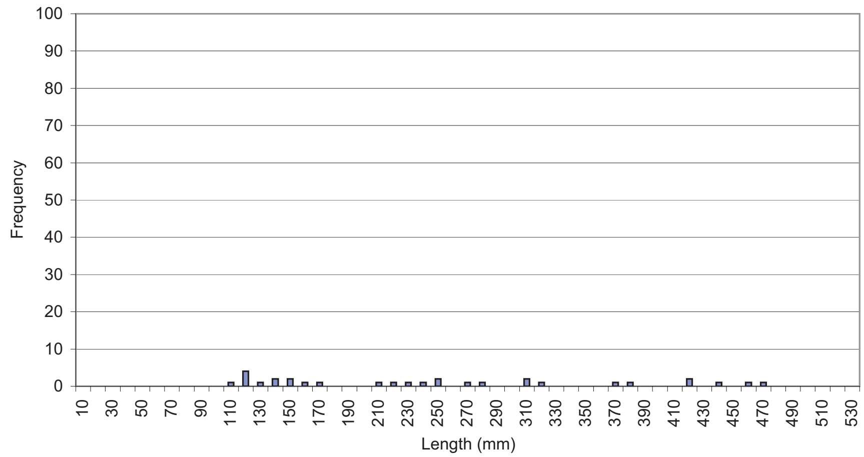
1999 SRP 9 Smallmouth Bass



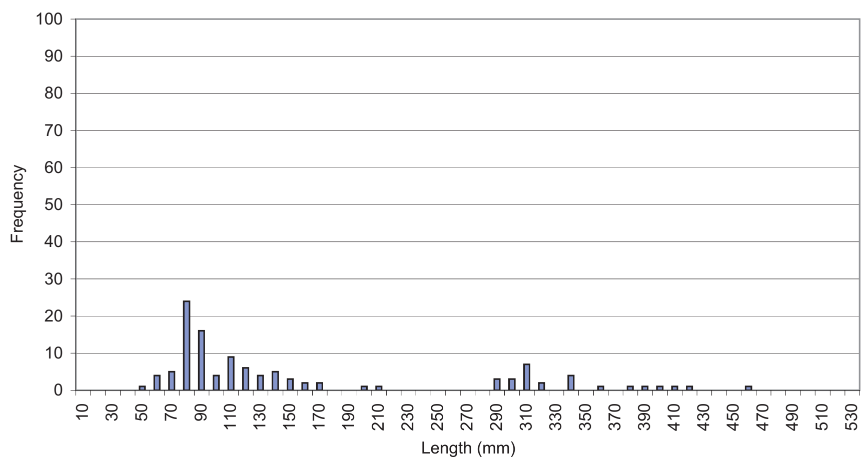
2003 SRP 9 Smallmouth Bass



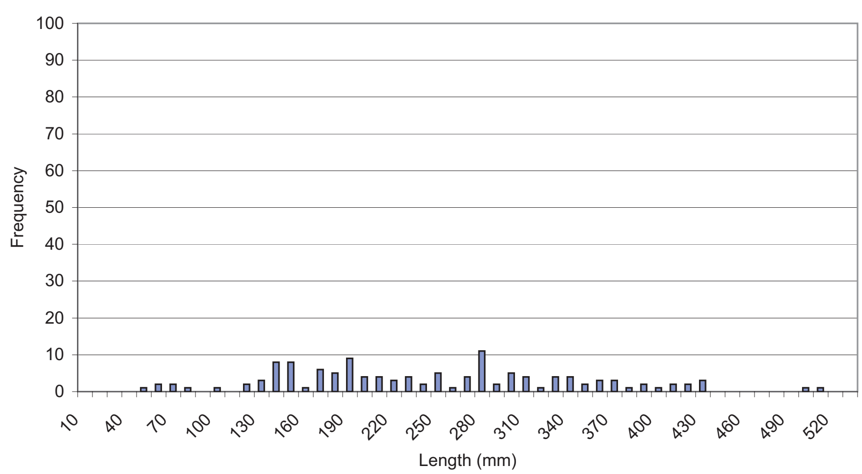
1998 SRP 10 Largemouth Bass

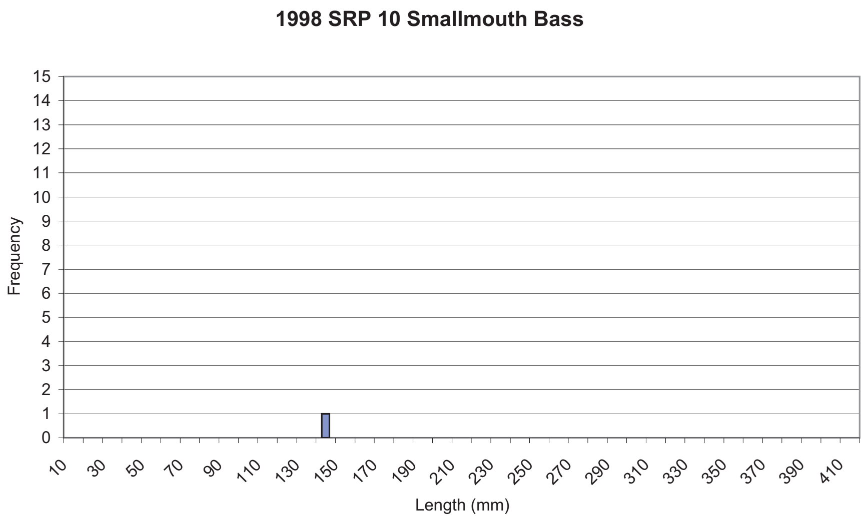


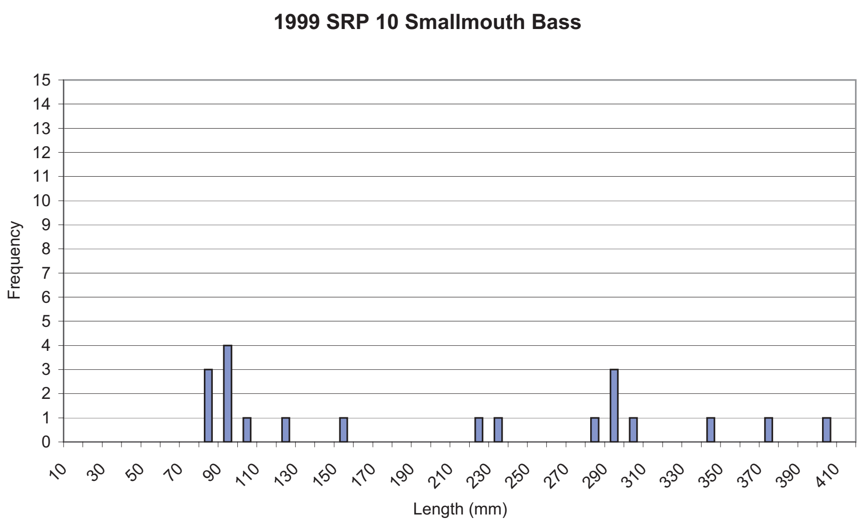
1999 SRP 10 Largemouth Bass

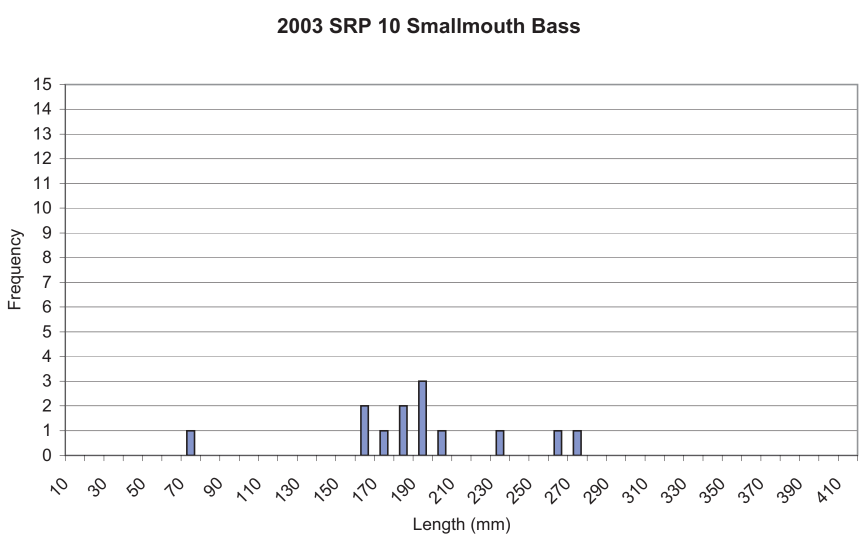


2003 SRP 10 Largemouth Bass




1998 SRP 10 Smallmouth Bass
Frequency
Length (mm)


1999 SRP 10 Smallmouth Bass
Frequency
Length (mm)


2003 SRP 10 Smallmouth Bass
Frequency
Length (mm)

Appendix C

Abundance and Density of All Fish Species Captured at Project and Reference Sites in 1998, 1999, 2003.

Table C-1. 1998 abundance and density estimates for all non-bass fish species captured at the channel restoration and reference sites

Species	Native or Introduced	Location	No. Captured/Pass			Total No. Captured	CARLE-STRUB ESTIMATOR[1] Probability of Capture	Population Abundance			Population Density		PROFILE-LIKELIHOOD (SEBER) ESTIMATOR[1] Probability of Capture	Population Abundance			Population Density	
			1	2	3			estimate	lower 95% CI	upper 95% CI	Fish per unit bank length (no./10^3ft)	Fish per unit site area (no./10^6ft^2)		estimate	lower 95% CI	upper 95% CI	Fish per unit bank length (no./10^3ft)	Fish per unit site area (no./10^6ft^2)
Family Atherinidae																		
inland silverside	I	South Pit	3	0	0	3	1.00	3	3	3	0.5	NA	1.00	3	3	3	0.5	NA
Family Catostomidae																		
Sacramento sucker	N	Charles Road	62	31	10	103	0.59	110	101	120	10.5	62.1	0.58	111	102	122	10.5	62.7
		South Pit	1	0	0	1	1.00	1	1	1	0.2	NA[2]	1.00	1	1	1	0.2	NA[2]
		SRP 10	0	3	9	12	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		SRP 7	6	6	0	12	0.67	12	10	13	1.0	2.8	0.67	12	10	14	1.0	2.8
		SRP 8	5	3	3	11	0.42	13	8	17	1.1	2.1	0.38	14	8		1.2	2.2
		SRP 9	8	3	3	14	0.54	15	11	19	2.4	5.0	0.54	15	11	22	2.4	5.0
Family Centrarchidae																		
black crappie	I	SRP 10	0	6	3	9	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		SRP 7	3	2	0	5	0.71	5	4	5	0.4	1.2	0.71	5	4	6	0.4	1.2
		SRP 8	7	5	2	14	0.54	15	11	19	1.3	2.4	0.54	15	11	25	1.3	2.4
bluegill	I	Charles Road	2	2	2	6	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		South Pit	1	0	0	1	1.00	1	1	1	0.2	NA[2]	1.00	1	1	1	0.2	NA[2]
		SRP 10	138	75	45	258	0.44	311	280	349	37.3	69.9	0.44	312	281	355	37.4	70.2
		SRP 7	139	72	44	255	0.45	304	275	341	24.5	70.0	0.45	305	275	345	24.6	70.3
		SRP 8	224	118	139	481	0.25	843	674	1107	71.9	134.1	0.24	860	688	1227	73.4	136.8
		SRP 9	63	37	17	117	0.48	135	119	156	21.7	45.1	0.48	136	119	162	21.9	45.5
green sunfish	I	SRP 10	1	2	11	14	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		SRP 7	2	0	1	3	0.60	3	2	3	0.2	0.7	0.60	3	2	5	0.2	0.7
		SRP 8	2	2	4	8	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		SRP 9	2	2	6	10	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
hybrid sunfish	I	SRP 9	1	1	0	2	0.67	2	1	2	0.3	0.7	0.67	2	1	2	0.3	0.7
redear sunfish	I	Charles Road	0	1	0	1	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		South Pit	2	0	0	2	1.00	2	2	2	0.3	NA	1.00	2	2	2	0.3	NA
		SRP 10	18	4	7	29	0.52	32	26	40	3.8	7.2	0.49	33	26	47	4.0	7.4
		SRP 7	17	12	16	45	0.19	96	45	144	7.7	22.1	0.08	203	50	Infinite	16.4	46.8
		SRP 8	9	5	8	22	0.27	35	18	50	3.0	5.6	0.16	54	19	Infinite	4.6	8.6
		SRP 9	20	12	6	38	0.49	43	35	53	6.9	14.4	0.48	44	35	61	7.1	14.7
warmouth	I	SRP 8	0	1	0	1	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

Table C-1. 1998 abundance and density estimates for all non-bass fish species captured at the channel restoration and reference sites

Species	Native or Introduced	Location	No. Captured/Pass			Total No. Captured	CARLE-STRUB ESTIMATOR[1]						PROFILE-LIKELIHOOD (SEBER) ESTIMATOR[1]					
							Probability of Capture	Population Abundance			Population Density		Probability of Capture	Population Abundance			Population Density	
			1	2	3			estimate	lower 95% CI	upper 95% CI	Fish per unit bank length (no./10^3ft)	Fish per unit site area (no./10^6ft^2)		estimate	lower 95% CI	upper 95% CI	Fish per unit bank length (no./10^3ft)	Fish per unit site area (no./10^6ft^2)
Family Clupeidae																		
threadfin shad	I	SRP 8	0	1	0	1	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Family Cottidae																		
sculpin	N	Charles Road	0	0	1	1	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		SRP 10	0	1	5	6	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		SRP 7	25	12	15	52	32	75	51	113	6.1	17.3	0.29	81	53	426	6.5	18.7
		SRP 8	4	15	14	33	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		SRP 9	0	3	0	3	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Family Cyprinidae																		
carp	I	Charles Road	2	5	1	8	0.44	9	5	11	0.9	5.1	0.38	10	5	Infinite	1.0	5.6
		SRP 10	6	7	2	15	0.47	17	12	23	2.0	3.8	0.43	18	12	81	2.2	4.0
		SRP 7	14	5	7	26	0.43	31	22	43	2.5	7.1	0.39	33	23	89	2.7	7.6
		SRP 8	5	4	4	13	0.35	17	9	23	1.5	2.7	0.25	22	9	Infinite	1.9	3.5
		SRP 9	3	4	0	7	0.64	7	5	7	1.1	2.3	0.64	7	5	8	1.1	2.3
goldfish	I	SRP 10	0	0	1	1	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		SRP 7	4	4	1	9	0.60	9	7	10	0.7	2.1	0.60	9	7	12	0.7	2.1
		SRP 8	5	4	2	11	0.50	12	8	15	1.0	1.9	0.50	12	8	27	1.0	1.9
		SRP 9	0	0	1	1	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
hardhead	N	SRP 7	5	2	0	7	0.78	7	6	7	0.6	1.6	0.78	7	6	7	0.6	1.6
		SRP 8	0	1	0	1												
		SRP 9	6	4	2	12	0.52	13	9	17	2.1	4.3	0.52	13	9	23	2.1	4.3
mirror carp	I	SRP 8	0	1	0	1	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Sacramento pikeminnow	N	Charles Road	0	1	0	1	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		South Pit	1	0	0	1	1.00	1	1	1	0.2	NA[2]	1.00	1	1	1	0.2	NA[2]
		SRP 10	12	1	1	14	0.82	14	13	14	1.7	3.1	0.82	14	13	14	1.7	3.1
		SRP 8	1	1	0	2	0.67	2	1	2	0.2	0.3	0.67	2	1	2	0.2	0.3
		SRP 9	3	3	0	6	0.67	6	5	6	1.0	2.0	0.67	6	5	8	1.0	2.0

Table C-1. 1998 abundance and density estimates for all non-bass fish species captured at the channel restoration and reference sites

Species	Native or Introduced	Location	No. Captured/Pass 1	No. Captured/Pass 2	No. Captured/Pass 3	Total No. Captured	Carle-Strub Estimator[1] Probability of Capture	Carle-Strub Population Abundance estimate	Carle-Strub Population Abundance lower 95% CI	Carle-Strub Population Abundance upper 95% CI	Carle-Strub Population Density Fish per unit bank length (no./10^3ft)	Carle-Strub Population Density Fish per unit site area (no./10^6ft^2)	Profile-Likelihood (Seber) Estimator[1] Probability of Capture	Profile-Likelihood Population Abundance estimate	Profile-Likelihood Population Abundance lower 95% CI	Profile-Likelihood Population Abundance upper 95% CI	Profile-Likelihood Population Density Fish per unit bank length (no./10^3ft)	Profile-Likelihood Population Density Fish per unit site area (no./10^6ft^2)
Family Ictaluridae																		
brown bullhead	I	Charles Road	0	0	1	1	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		SRP 7	0	1	0	1	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		SRP 8	1	2	0	3	0.60	3	2	3	0.3	0.5	0.60	3	2	5	0.3	0.5
channel catfish	I	Charles Road	2	0	2	4	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		SRP 10	1	0	0	1	1.00	1	1	1	0.1	0.2	1.00	1	1	1	0.1	0.2
		SRP 7	0	0	1	1	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
white catfish	I	Charles Road	5	0	0	5	1.00	5	5	5	0.5	2.8	1.00	5	5	5	0.5	2.8
		SRP 10	23	4	8	35	0.55	38	32	46	4.6	8.5	0.55	38	32	48	4.6	8.5
		SRP 7	15	6	3	24	0.62	25	21	29	2.0	5.8	0.62	25	21	29	2.0	5.8
		SRP 8	8	4	4	16	0.47	18	13	23	1.5	2.9	0.43	19	13	51	1.6	3.0
		SRP 9	12	11	4	27	0.44	32	23	44	5.1	10.7	0.42	33	24	73	5.3	11.0
Family Percichthyidae																		
striped bass	I	Charles Road	1	0	0	1	1.00	1	1	1	0.1	0.6	1.00	1	1	1	0.1	0.6
		South Pit	1	0	0	1	1.00	1	1	1	0.2	NA[2]	1.00	1	1	1	0.2	NA[2]
		SRP 8	0	0	1	1	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Family Percidae																		
bigscale logperch	I	SRP 10	1	0	0	1	1.00	1	1	1	0.1	0.2	1.00	1	1	1	0.1	0.2
Family Salmonidae																		
chinook salmon	N	Charles Road	2	0	0	2	1.00	2	2	2	0.2	1.1	1.00	2	2	2	0.2	1.1
		SRP 10	1	0	0	1	1.00	1	1	1	0.1	0.2	1.00	1	1	1	0.1	0.2
		SRP 9	1	1	0	2	0.67	2	1	2	0.3	0.7	0.67	2	1	2	0.3	0.7

[1] NE indicates populations that are not estimable because the number of fish captured in the first pass (n_1) was less than or equal to the number of fish captured in the third pass (n_3).

[2] Only a small portion of the bank of the South Pit was sampled. Densities, therefore, were not extrapolated to the whole pit for this site.

Table C-2. 1999 abundance and density estimates for all fish species captured at the project and reference sites

Species	Native or Introduced	Location	Number Captured			Carle-Strub Estimator						Profile Likelihood Estimator					
							Population Abundance			Population Density			Population Abundance			Population Density	
			Pass 1	Pass 2	Pass 3	Probability of Capture	Estimate	Lower 95% C.I.	Upper 95% C.I.	Fish per Unit Bank Length (No./10^3 ft)	Fish per Unit Site Area (No./10^5 ft^2)	Probability of Capture	Estimate	Lower 95% C.I.	Upper 95% C.I.	Fish per Unit Bank Length (No./10^3 ft)	Fish per Unit Site Area (No./10^5 ft^2)
Family Petromyzontidae																	
Lamprey (unidentified species)	N	Charles Road	0	1	0	.	.	.	.	NE	NE	.	.	.	.	NE	NE
		SRP-7	1	0	7	.	.	.	.	NE	NE	.	.	.	.	NE	NE
		SRP-9	3	0	2	0.56	5	3	6	2.7	1.8	0.56	5	3	13	2.7	1.8
		Upstream Riffle	5	2	1	0.67	8	6	9	3.0	5.1	0.67	8	6	9	3.0	5.1
Lamprey ammocoetes (unidentified species)	N	SRP-7	1	11	0	0.38	15	8	21	3.9	3.6	0.27	19	8	Inf	4.9	4.5
		SRP-8	1	2	2	.	.	.	.	NE	NE	.	.	.	.	NE	NE
Family Clupeidae																	
American shad	I	Charles Road	3	5	5	.	.	.	.	NE	NE	.	.	.	.	NE	NE
		SRP-10	0	1	1	.	.	.	.	NE	NE	.	.	.	.	NE	NE
		SRP-7	2	0	0	1.00	2	2	2	0.5	0.5	1.00	2	2	2	0.5	0.5
		SRP-9	1	0	1	.	.	.	.	NE	NE	.	.	.	.	NE	NE
Threadfin shad	I	SRP-10	2	0	0	1.00	2	2	2	0.8	0.5	1.00	2	2	2	0.8	0.5
		SRP-8	3	10	1	0.40	17	10	23	5.4	3.0	0.32	20	10	Inf	6.3	3.5
		Upstream Riffle	0	0	1	.	.	.	.	NE	NE	.	.	.	.	NE	NE
Family Salmonidae																	
Chinook salmon	N	Upstream Riffle	0	1	1	.	.	.	.	NE	NE	.	.	.	.	NE	NE
Family Cyprinidae																	
Carp	I	Charles Road	11	18	7	0.27	57	33	84	19.3	38.6	0.21	71	36	Inf	24.1	48.1
		SRP-10	26	9	8	0.54	47	40	56	18.8	10.9	0.52	48	40	64	19.2	11.2
		SRP-7	10	5	6	0.38	27	17	39	7.0	6.5	0.34	29	17	Inf	7.5	6.9
		SRP-8	14	11	4	0.48	33	26	42	10.4	5.7	0.46	34	26	55	10.7	5.9
		SRP-9	5	5	5	.	.	.	.	NE	NE	.	.	.	.	NE	NE
		Upstream Riffle	8	5	5	0.38	23	14	33	8.6	14.6	0.32	26	14	Inf	9.7	16.5
Goldfish	I	SRP-10	0	2	0	.	.	.	.	NE	NE	.	.	.	.	NE	NE
		SRP-7	20	9	10	0.39	50	36	71	13.0	11.9	0.36	52	36	111	13.5	12.4
		SRP-8	94	50	47	0.33	272	222	355	85.8	47.3	0.32	276	223	394	87.0	48.0
		SRP-9	49	51	26	0.27	203	147	292	110.9	71.3	0.26	214	151	484	116.9	75.2
Sacramento blackfish	N	SRP-10	4	6	6	.	.	.	.	NE	NE	.	.	.	.	NE	NE
		SRP-7	2	2	1	0.56	5	3	6	1.3	1.2	0.56	5	3	13	1.3	1.2
		SRP-8	22	9	6	0.55	40	34	48	12.6	7.0	0.55	40	33	50	12.6	7.0
Hardhead	N	Charles Road	0	1	2	.	.	.	.	NE	NE	.	.	.	.	NE	NE
		SRP-7	43	28	26	0.28	155	107	232	40.3	37.0	0.25	166	110	490	43.2	39.7
		SRP-9	2	0	0	1.00	2	2	2	1.1	0.7	1.00	2	2	2	1.1	0.7
		Upstream Riffle	10	7	9	0.25	44	21	64	16.4	27.9	0.14	73	24	Inf	27.2	46.2
Hitch	N	Charles Road	2	0	1	0.60	3	2	3	1.0	2.0	0.60	3	2	5	1.0	2.0
		SRP-10	0	2	1	.	.	.	.	NE	NE	.	.	.	.	NE	NE
		SRP-7	12	1	0	0.93	13	13	13	3.4	3.1	0.93	13	13	13	3.4	3.1
		SRP-8	8	4	3	0.54	16	12	21	5.0	2.8	0.48	17	12	36	5.4	3.0
		SRP-9	7	1	1	0.75	9	8	9	4.9	3.2	0.75	9	8	9	4.9	3.2
		Upstream Riffle	0	0	1	.	.	.	.	NE	NE	.	.	.	.	NE	NE

Table C-2. 1999 abundance and density estimates for all fish species captured at the project and reference sites

			Number Captured			Carle-Strub Estimator						Profile Likelihood Estimator					
							Population Abundance			Population Density			Population Abundance			Population Density	
Species	Native or Introduced	Location	Pass 1	Pass 2	Pass 3	Probability of Capture	Estimate	Lower 95% C.I.	Upper 95% C.I.	Fish per Unit Bank Length (No./10^3 ft)	Fish per Unit Site Area (No./10^5 ft^2)	Probability of Capture	Estimate	Lower 95% C.I.	Upper 95% C.I.	Fish per Unit Bank Length (No./10^3 ft)	Fish per Unit Site Area (No./10^5 ft^2)
Sacramento pikeminnow	N	Charles Road	1	0	1	.	.	.	.	NE	NE	.	.	.	.	NE	NE
		SRP-7	128	34	17	0.68	185	178	191	48.1	44.2	0.68	185	178	192	48.1	44.2
		SRP-8	46	34	13	0.45	111	95	136	35.0	19.3	0.44	112	95	144	35.3	19.5
		SRP-9	17	8	4	0.57	31	26	36	16.9	10.9	0.57	31	26	38	16.9	10.9
		Upstream Riffle	31	20	17	0.32	99	71	149	36.9	62.7	0.30	104	72	285	38.8	65.9
Sacramento splittail	N	SRP-9	0	1	0	.	.	.	.	NE	NE	.	.	.	.	NE	NE
Family Catostomidae																	
Sacramento sucker	N	Charles Road	99	80	31	0.41	264	232	309	89.5	178.8	0.40	266	232	326	90.2	180.1
		SRP-10	41	22	23	0.31	126	93	180	50.4	29.3	0.29	132	94	286	52.8	30.7
		SRP-7	298	161	134	0.35	813	728	924	211.3	194.3	0.35	816	721	936	212.1	195.0
		SRP-8	25	44	34	.	.	.	.	NE	NE	.	.	.	.	NE	NE
		SRP-9	22	21	17	0.21	115	63	182	62.8	40.4	0.15	154	69	Inf	84.2	54.1
		Upstream Riffle	289	190	171	0.25	1129	935	1420	421.0	715.2	0.24	1145	947	1510	426.9	725.3
Family Ictaluridae																	
Channel catfish	I	Charles Road	11	8	5	0.42	29	21	39	9.8	19.6	0.38	31	21	90	10.5	21.0
		SRP-10	3	0	0	1.00	3	3	3	1.2	0.7	1.00	3	3	3	1.2	0.7
		SRP-7	2	2	4	.	.	.	.	NE	NE	.	.	.	.	NE	NE
		SRP-8	1	1	0	0.67	2	1	2	0.6	0.3	0.67	2	1	2	0.6	0.3
		Upstream Riffle	5	4	1	0.63	10	8	11	3.7	6.3	0.63	10	8	12	3.7	6.3
White catfish	I	Charles Road	5	4	4	0.35	17	9	23	5.8	11.5	0.25	22	9	Inf	7.5	14.9
		SRP-10	2	3	0	0.63	5	4	5	2.0	1.2	0.63	5	4	6	2.0	1.2
		SRP-7	15	6	9	0.36	40	27	56	10.4	9.6	0.32	43	27	388	11.2	10.3
		SRP-8	14	11	5	0.43	36	27	49	11.3	6.3	0.42	37	27	77	11.7	6.4
		SRP-9	11	10	8	0.28	45	25	68	24.6	15.8	0.21	57	26	Inf	31.1	20.0
		Upstream Riffle	9	4	2	0.65	15	13	17	5.6	9.5	0.65	15	13	17	5.6	9.5
Brown bullhead	I	SRP-7	0	3	2	.	.	.	.	NE	NE	.	.	.	.	NE	NE
Black bullhead	I	Upstream Riffle	0	2	0	.	.	.	.	NE	NE	.	.	.	.	NE	NE
Family Atherinidae																	
Inland silverside	I	Charles Road	2	0	1	0.60	3	2	3	1.0	2.0	0.60	3	2	5	1.0	2.0
		SRP-10	7	6	6	0.28	29	14	42	11.6	6.7	0.18	42	15	Inf	16.8	9.8
		SRP-7	0	0	1	.	.	.	.	NE	NE	.	.	.	.	NE	NE
		SRP-8	9	8	4	0.43	25	17	35	7.9	4.3	0.38	27	17	187	8.5	4.7
		SRP-9	0	0	1	.	.	.	.	NE	NE	.	.	.	.	NE	NE
Family Percichthyidae																	
Striped bass	I	SRP-10	2	0	0	1.00	2	2	2	0.8	0.5	1.00	2	2	2	0.8	0.5
Family Centrarchidae																	
White crappie	I	SRP-10	2	2	0	0.67	4	3	4	1.6	0.9	0.67	4	3	4	1.6	0.9
		SRP-8	1	0	0	1.00	1	1	1	0.3	0.2	1.00	1	1	1	0.3	0.2
Green sunfish	I	Charles Road	3	0	1	0.67	4	3	4	1.4	2.7	0.67	4	3	4	1.4	2.7
		SRP-10	2	5	2	.	.	.	.	NE	NE	.	.	.	.	NE	NE
		SRP-7	1	1	1	.	.	.	.	NE	NE	.	.	.	.	NE	NE
		SRP-8	0	2	2					NE	NE					NE	NE

Table C-2. 1999 abundance and density estimates for all fish species captured at the project and reference sites

			Number Captured			Carle-Strub Estimator						Profile Likelihood Estimator					
							Population Abundance			Population Density			Population Abundance			Population Density	
Species	Native or Introduced	Location	Pass 1	Pass 2	Pass 3	Probability of Capture	Estimate	Lower 95% C.I.	Upper 95% C.I.	Fish per Unit Bank Length (No./10^3 ft)	Fish per Unit Site Area (No./10^5 ft^2)	Probability of Capture	Estimate	Lower 95% C.I.	Upper 95% C.I.	Fish per Unit Bank Length (No./10^3 ft)	Fish per Unit Site Area (No./10^5 ft^2)
Bluegill	I	Charles Road	3	5	1	0.47	10	6	13	3.4	6.8	0.47	10	6	40	3.4	6.8
		SRP-10	38	41	44	.	.	.	.	NE	NE	.	.	.	.	NE	NE
		SRP-7	23	16	12	0.34	71	50	102	18.5	17.0	0.31	75	51	247	19.5	17.9
		SRP-8	49	16	39	0.20	215	127	375	67.8	37.4	0.15	264	140	Inf	83.2	45.9
		SRP-9	9	20	20	.	.	.	.	NE	NE	.	.	.	.	NE	NE
		Upstream Riffle	0	0	1	.	.	.	.	NE	NE	.	.	.	.	NE	NE
Redear sunfish	I	Charles Road	2	1	0	0.75	3	2	3	1.0	2.0	0.75	3	2	3	1.0	2.0
		SRP-10	3	3	2	0.44	9	5	11	3.6	2.1	0.38	10	5	Inf	4.0	2.3
		SRP-7	3	3	2	0.44	9	5	11	2.3	2.2	0.38	10	5	Inf	2.6	2.4
		SRP-8	3	5	3	.	.	.	.	NE	NE	.	.	.	.	NE	NE
		Upstream Riffle	0	0	1	.	.	.	.	NE	NE	.	.	.	.	NE	NE
Largemouth bass	I	Charles Road	15	4	4	0.61	24	20	27	8.1	16.3	0.61	24	20	29	8.1	16.3
		SRP-10	52	30	31	0.28	179	130	278	71.7	41.7	0.26	189	134	451	75.7	44.0
		SRP-10 South Pit	14	9	.	.	.	.	.	NE	NE	.	.	.	.	NE	NE
		SRP-7	210	164	109	0.28	767	642	946	199.4	183.3	0.28	777	647	1000	202.0	185.7
		SRP-8	263	183	150	0.26	1007	827	1288	317.5	175.1	0.25	1020	847	1349	321.6	177.3
		SRP-9	61	40	25	0.38	165	135	206	90.2	58.0	0.37	167	138	240	91.3	58.7
		Upstream Riffle	26	28	17	0.24	124	76	195	46.2	78.5	0.20	145	79	Inf	54.1	91.9
Smallmouth bass	I	Charles Road	11	7	3	0.53	23	18	29	7.8	15.6	0.53	23	18	38	7.8	15.6
		SRP-10	19	1	0	0.95	20	20	20	8.0	4.7	0.95	20	20	20	8.0	4.7
		SRP-7	1	0	0	1.00	1	1	1	0.3	0.2	1.00	1	1	1	0.3	0.2
		SRP-9	10	2	1	0.76	13	12	13	7.1	4.6	0.76	13	12	14	7.1	4.6
		Upstream Riffle	0	1	0	.	.	.	.	NE	NE	.	.	.	.	NE	NE
Sunfish (unidentified species)	I	SRP-10	23	0	2	0.86	25	24	25	10.0	5.8	0.86	25	24	25	10.0	5.8
		SRP-7	0	1	0	.	.	.	.	NE	NE	.	.	.	.	NE	NE
		SRP-8	5	21	2	0.29	43	24	64	13.6	7.5	0.22	53	25	Inf	16.7	9.2
		SRP-9	13	12	0	0.63	26	22	29	14.2	9.1	0.63	26	22	29	14.2	9.1
Family Percidae																	
Bigscale logperch	I	SRP-10	4	3	2	0.47	10	6	13	4.0	2.3	0.47	10	6	40	4.0	2.3
		SRP-8	7	1	6	0.33	19	10	26	6.0	3.3	0.23	25	10	Inf	7.9	4.3
Family Cottidae																	
Prickly sculpin	N	Charles Road	0	1	0	.	.	.	.	NE	NE	.	.	.	.	NE	NE
		SRP-10	0	1	4	.	.	.	.	NE	NE	.	.	.	.	NE	NE
		SRP-7	17	22	26	.	.	.	.	NE	NE	.	.	.	.	NE	NE
		SRP-8	17	14	30	.	.	.	.	NE	NE	.	.	.	.	NE	NE
		SRP-9	1	0	1	.	.	.	.	NE	NE	.	.	.	.	NE	NE
		Upstream Riffle	3	5	5	.	.	.	.	NE	NE	.	.	.	.	NE	NE
Riffle sculpin	N	Upstream Riffle	10	4	5	0.45	22	15	29	8.2	13.9	0.42	23	15	63	8.6	14.6
Sculpin (unidentified species)	N	Charles Road	0	2	0	.	.	.	.	NE	NE	.	.	.	.	NE	NE
		SRP-7	1	0	0	1.00	1	1	1	0.3	0.2	1.00	1	1	1	0.3	0.2
		Upstream Riffle	21	1	14	0.35	49	34	73	18.3	31.0	0.30	54	34	502	20.1	34.2

Table C-3. 2003 abundance and density estimates for all fish species captured at the project and reference sites

						Carle-Strub Estimator						Profile Likelihood Estimator					
			Number Captured				Population Abundance			Population Density			Population Abundance			Population Density	
Species	Native or Introduced	Location	Pass 1	Pass 2	Pass 3	Probability of Capture	Estimate	Lower 95% C.I.	Upper 95% C.I.	Fish per Unit Bank Length (No./1000 ft)	Fish per Unit Site Area (No./10^5 ft^2)	Probability of Capture	Estimate	Lower 95% C.I.	Upper 95% C.I.	Fish per Unit Bank Length (No./1000 ft)	Fish per Unit Site Area (No./10^5 ft^2)
Family Petromyzontidae																	
Unspecified Ammocoete	N	CR	1	1	0	0.67	2	1	2	1	1	0.67	2	1	2	1	1
		R64	2	0	1	0.60	3	2	3	1	2	0.60	3	2	5	1	2
		SRP10	0	0	1	0.33	1	0	1	0	0	0.33	1	0	1	0	0
		SRP7	0	1	0	0.50	1	0	1	0	0	0.50	1	0	1	0	0
Family Clupeidae																	
American Shad	I	SRP10	0	0	2	0.33	2	0	2	1	0	0.00	undefined	NE	NE	NE	NE
Family Cyprinidae																	
Carp	I	CR	8	10	5	0.33	32	18	46	11	22	0.26	38	20	infinite	13	26
		R64	7	1	2	0.67	10	8	11	4	6	0.67	10	8	12	4	6
		SRP10	1	1	2	0.44	4	2	4	2	1	0.19	8	1	infinite	3	2
		SRP7	27	18	29	0.12	231	86	333	60	55	0.00	undefined	NE	NE	NE	NE
		SRP8	10	1	5	0.48	18	13	25	6	3	0.48	18	13	34	6	3
		SRP9	2	6	2	0.34	13	6	17	8	13	0.20	20	6	infinite	12	20
Goldfish	I	SRP8	0	3	0	0.50	3	1	3	1	1	0.50	3	1	5	1	1
Sacramento Blackfish	N	SRP10	0	1	0	0.50	1	0	1	0	0	0.50	1	0	1	0	0
Hardhead	N	R64	22	0	2	0.86	24	23	24	9	15	0.86	24	23	24	9	15
Hitch	N	CR	0	1	0	0.50	1	0	1	0	1	0.50	1	0	1	0	1
Sacramento Pikeminnow	N	CR	1	1	1	0.50	3	1	3	1	2	0.50	3	1	5	1	2
		R64	4	5	1	0.59	10	8	12	4	6	0.50	11	7	32	4	7
		SRP10	2	0	0	1.00	2	2	2	1	0	1.00	2	2	2	1	0
		SRP7	0	1	1	0.40	2	0	2	1	0	0.40	2	0	2	1	0
		SRP8	0	0	2	0.33	2	0	2	1	0	0.00	undefined	NE	NE	NE	NE
Family Catostomidae																	
Sacramento Sucker	N	CR	45	26	33	0.21	201	125	367	68	136	0.18	233	131	infinite	79	158
		R64	33	42	20	0.24	169	110	272	63	107	0.21	190	115	3491	71	120
		SRP10	1	0	2	0.43	3	1	3	1	1	0.23	5	1	infinite	2	1
		SRP7	2	5	4	0.23	19	7	23	5	5	0.00	undefined	NE	NE	NE	NE
		SRP8	0	0	1	0.33	1	0	1	0	0	0.33	1	0	1	0	0
		SRP9	5	8	5	0.26	29	13	39	17	29	0.12	57	14	infinite	33	58

Table C-3. 2003 abundance and density estimates for all fish species captured at the project and reference sites

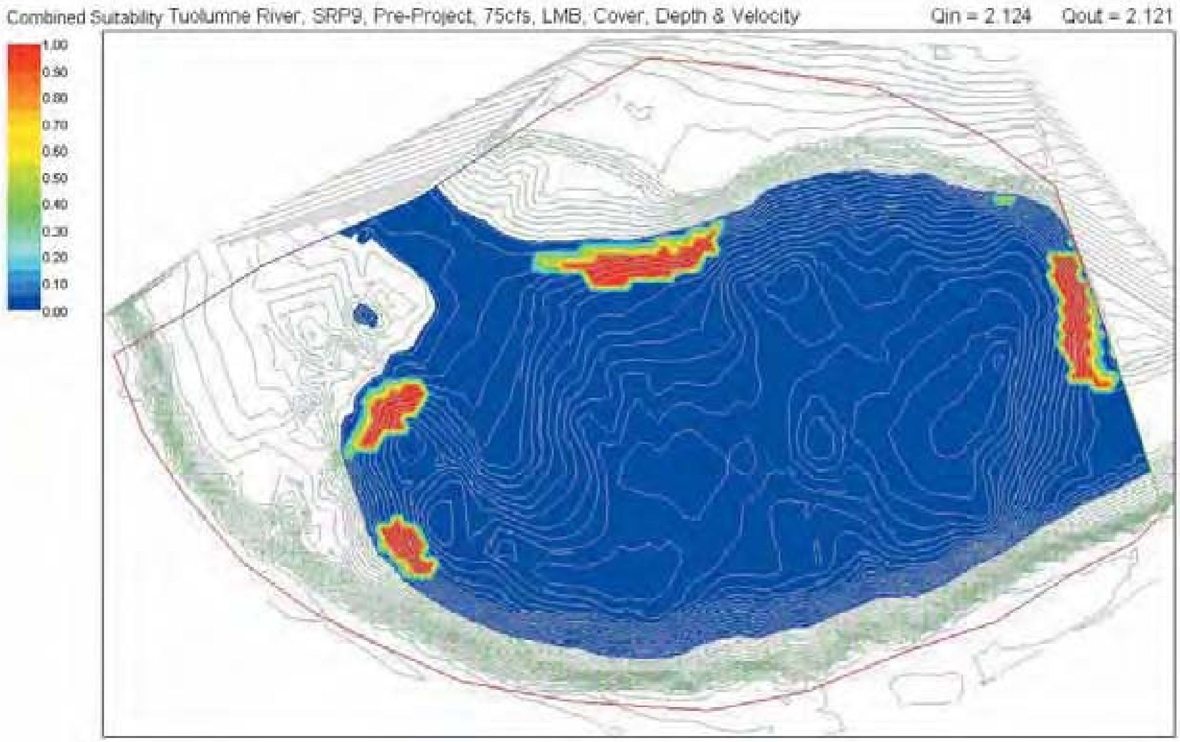
			Number Captured			Carle-Strub Estimator						Profile Likelihood Estimator					
							Population Abundance			Population Density			Population Abundance			Population Density	
Species	Native or Introduced	Location	Pass 1	Pass 2	Pass 3	Probability of Capture	Estimate	Lower 95% C.I.	Upper 95% C.I.	Fish per Unit Bank Length (No./1000 ft)	Fish per Unit Site Area (No./10^5 ft^2)	Probability of Capture	Estimate	Lower 95% C.I.	Upper 95% C.I.	Fish per Unit Bank Length (No./1000 ft)	Fish per Unit Site Area (No./10^5 ft^2)
Family Ictaluridae																	
Channel Catfish	I	CR	30	32	28	0.14	245	112	365	83	166	0.06	560	131	infinite	190	379
		R64	1	2	2	0.36	6	2	7	2	4	0.14	13	2	infinite	5	8
		SRP10	9	3	1	0.72	13	11	14	5	3	0.72	13	11	14	5	3
		SRP7	1	0	4	0.23	8	2	9	2	2	0.00	undefined	NE	NE	NE	NE
		SRP8	5	3	1	0.64	9	7	10	3	2	0.64	9	7	12	3	2
		SRP9	12	6	5	0.45	27	19	37	16	27	0.45	27	19	49	16	27
Black Bullhead	I	SRP8	0	1	0	0.50	1	0	1	0	0	0.50	1	0	1	0	0
White Catfish	I	CR	30	22	12	0.39	82	64	110	28	56	0.38	84	66	144	28	57
		R64	9	19	8	0.21	70	34	98	26	44	0.10	133	38	infinite	50	84
		SRP10	1	2	1	0.50	4	2	4	2	1	0.50	4	2	8	2	1
		SRP7	11	6	6	0.39	29	19	42	8	7	0.35	31	20	206	8	7
		SRP8	0	1	0	0.50	1	0	1	0	0	0.50	1	0	1	0	0
		SRP9	8	26	10	0.15	114	45	155	66	116	0.00	undefined	NE	NE	NE	NE
Brown Bullhead	I	CR	2	0	1	0.60	3	2	3	1	2	0.60	3	2	5	1	2
		R64	1	0	0	1.00	1	1	1	0	1	1.00	1	1	1	0	1
		SRP10	1	0	0	1.00	1	1	1	0	0	1.00	1	1	1	0	0
		SRP7	1	6	3	0.23	17	5	21	4	4	0.00	undefined	NE	NE	NE	NE
		SRP8	0	1	1	0.40	2	0	2	1	0	0.40	2	0	2	1	0
Family Atherinidae																	
Inland Silverside	I	SRP10	6	2	1	0.69	9	8	10	4	2	0.69	9	7	10	4	2
		SRP7	0	2	0	0.50	2	1	2	1	0	0.50	2	1	2	1	0
		SRP8	4	1	6	0.23	19	7	23	6	3	0.00	undefined	NE	NE	NE	NE
Family Percichthyidae																	
Striped Bass	I	CR	2	0	0	1.00	2	2	2	1	1	1.00	2	2	2	1	1
		R64	0	1	0	0.50	1	0	1	0	1	0.50	1	0	1	0	1
Family Centrarchidae																	
Bluegill	I	CR	92	109	63	0.18	590	387	968	200	400	0.16	648	409	2821	220	439
		R64	72	8	2	0.87	82	81	82	31	52	0.87	82	81	82	31	52
		SRP10	681	305	200	0.48	1380	1323	1441	552	321	0.48	1380	1330	1447	552	321
		SRP7	145	156	107	0.15	1046	683	1676	272	250	0.14	1152	734	4227	299	275
		SRP8	335	225	234	0.18	1744	1346	2417	550	303	0.18	1793	1386	2656	565	312
		SRP9	90	0	68	0.22	296	199	444	171	301	0.20	321	207	1771	186	326
Redear Sunfish	I	CR	1	8	1	0.34	13	6	17	4	9	0.20	20	6	infinite	7	14
		R64	5	1	0	0.86	6	6	6	2	4	0.86	6	6	6	2	4
		SRP10	27	8	9	0.52	49	41	61	20	11	0.52	49	42	65	20	11
		SRP7	20	33	12	0.24	113	69	177	29	27	0.20	134	72	infinite	35	32
		SRP8	27	7	23	0.21	113	61	168	36	20	0.14	161	66	infinite	51	28
		SRP9	3	32	1	0.23	65	34	94	38	66	0.14	101	36	infinite	58	103

Table C-3. 2003 abundance and density estimates for all fish species captured at the project and reference sites

						Carle-Strub Estimator						Profile Likelihood Estimator					
			Number Captured				Population Abundance			Population Density			Population Abundance			Population Density	
Species	Native or Introduced	Location	Pass 1	Pass 2	Pass 3	Probability of Capture	Estimate	Lower 95% C.I.	Upper 95% C.I.	Fish per Unit Bank Length (No./1000 ft)	Fish per Unit Site Area (No./10^5 ft^2)	Probability of Capture	Estimate	Lower 95% C.I.	Upper 95% C.I.	Fish per Unit Bank Length (No./1000 ft)	Fish per Unit Site Area (No./10^5 ft^2)
Pumpkinseed	I	R64	2	0	0	1.00	2	2	2	1	1	1.00	2	2	2	1	1
		SRP8	5	0	0	1.00	5	5	5	2	1	1.00	5	5	5	2	1
Green Sunfish	I	CR	4	0	6	0.23	17	6	21	6	12	0.00	undefined	NE	NE	NE	NE
		R64	1	0	0	1.00	1	1	1	0	1	1.00	1	1	1	0	1
		SRP10	24	12	6	0.54	46	38	55	18	11	0.54	46	39	56	18	11
		SRP7	2	3	4	0.26	14	5	18	4	3	0.00	undefined	NE	NE	NE	NE
		SRP8	8	3	0	0.79	11	10	11	3	2	0.79	11	10	11	3	2
		SRP9	30	111	23	0.13	488	241	833	283	496	0.07	787	277	infinite	456	799
Warmouth	I	CR	0	2	0	0.50	2	1	2	1	1	0.50	2	1	2	1	1
		SRP10	4	1	0	0.83	5	5	5	2	1	0.83	5	4	5	2	1
		SRP8	0	6	3	0.21	16	4	19	5	3	0.00	undefined	NE	NE	NE	NE
White Crappie	I	SRP8	4	1	1	0.67	6	5	6	2	1	0.67	6	5	8	2	1
Black Crappie	I	SRP10	1	1	0	0.67	2	1	2	1	0	0.67	2	1	2	1	0
		SRP8	0	0	3	0.25	4	0	4	1	1	0.00	undefined	NE	NE	NE	NE
Largemouth Bass	I	CR	10	14	5	0.34	40	25	58	14	27	0.29	45	27	infinite	15	30
		R64	9	4	1	0.70	14	12	15	5	9	0.70	14	12	15	5	9
		SRP10	77	24	27	0.48	149	132	173	60	35	0.48	149	132	174	60	35
		SRP7	46	41	29	0.24	205	138	325	53	49	0.21	225	144	1089	58	54
		SRP8	79	42	45	0.29	257	197	380	81	45	0.28	265	199	473	84	46
		SRP9	39	10	8	0.62	60	54	65	35	61	0.62	60	54	66	35	61
Smallmouth Bass	I	CR	23	21	13	0.30	86	58	130	29	58	0.27	94	61	527	32	64
		R64	32	17	11	0.45	71	58	90	26	45	0.44	72	58	102	27	46
		SRP10	8	1	4	0.52	14	10	17	6	3	0.52	14	10	22	6	3
		SRP7	11	44	4	0.25	102	61	162	27	24	0.20	122	63	infinite	32	29
		SRP8	1	0	1	0.50	2	1	2	1	0	0.50	2	1	2	1	0
		SRP9	32	32	25	0.19	191	107	298	111	194	0.13	254	113	infinite	147	258
Family Percidae																	
Bigscale Logperch	I	SRP7	0	1	0	0.50	1	0	1	0	0	0.50	1	0	1	0	0
		SRP8	1	0	1	0.50	2	1	2	1	0	0.50	2	1	2	1	0
		SRP9	2	0	0	1.00	2	2	2	1	2	1.00	2	2	2	1	2
Family Cottidae																	
Unspecified Sculpin	N	CR	0	2	0	0.50	2	1	2	1	1	0.50	2	1	2	1	1
		R64	3	1	3	0.41	8	4	10	3	5	0.27	11	4	infinite	4	7
		SRP10	1	0	0	1.00	1	1	1	0	0	1.00	1	1	1	0	0
		SRP7	0	2	0	0.50	2	1	2	1	0	0.50	2	1	2	1	0
		SRP8	0	0	1	0.33	1	0	1	0	0	0.33	1	0	1	0	0

Appendix D

Predicted Largemouth Bass, Smallmouth Bass, and Chinook Salmon Habitat at SRP 9 Pre-project..


Combined Suitability Tuolumne River, SRP9, Pre-Project, 75cfs, LMB, Cover, Depth & Velocity
Qin = 2.124
Qout = 2.121
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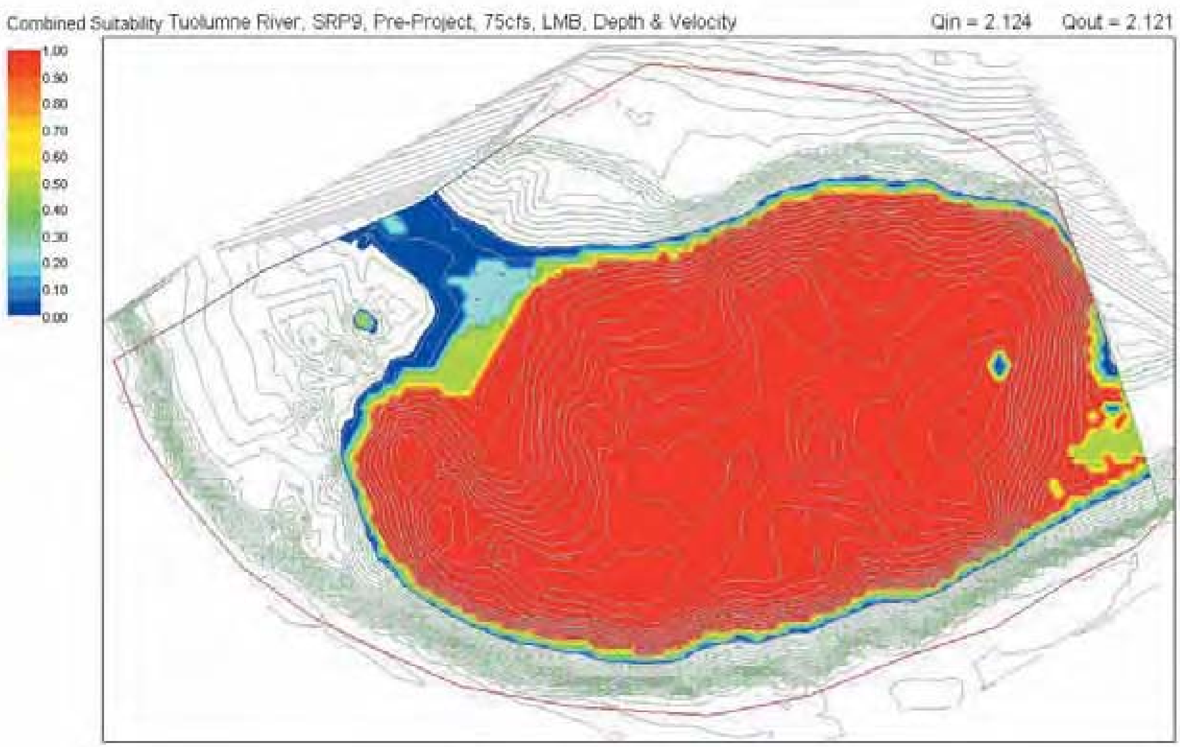
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability Tuolumne River, SRP9, Pre-Project, 75cfs, LMB, Depth & Velocity
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Qout = 2.121
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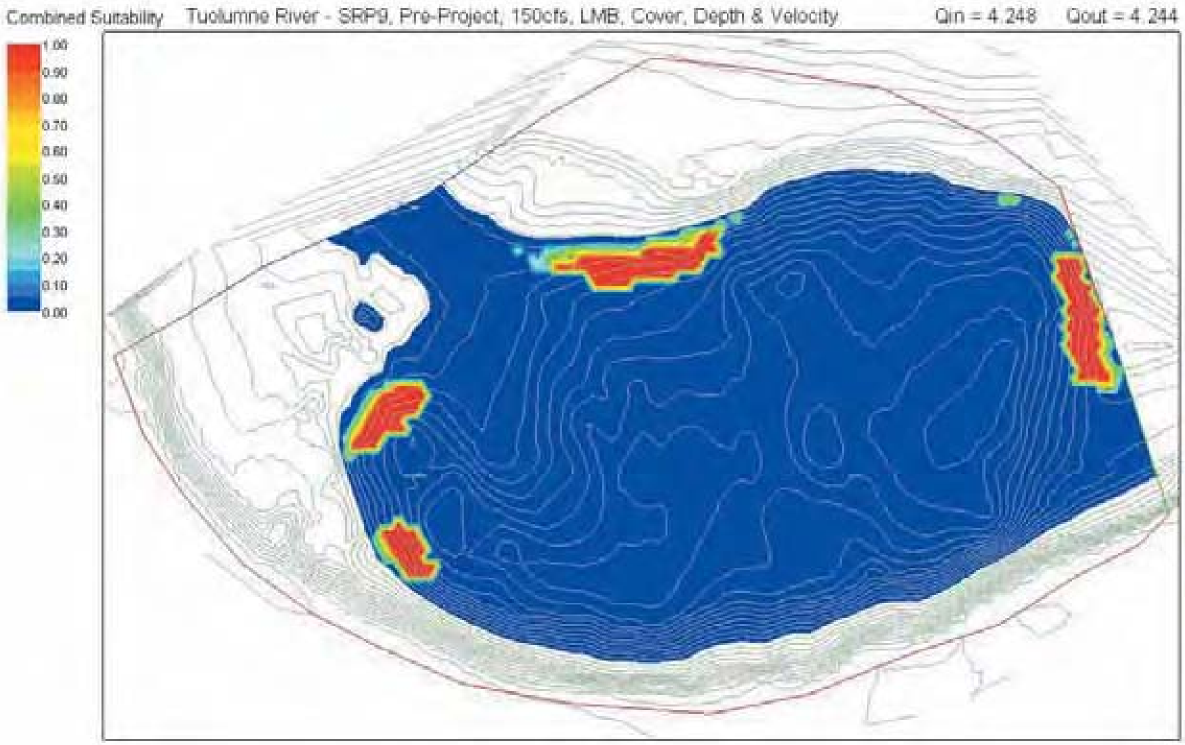
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability
Tuolumne River - SRP9, Pre-Project, 150cfs, LMB, Cover, Depth & Velocity
Qin = 4.248
Qout = 4.244
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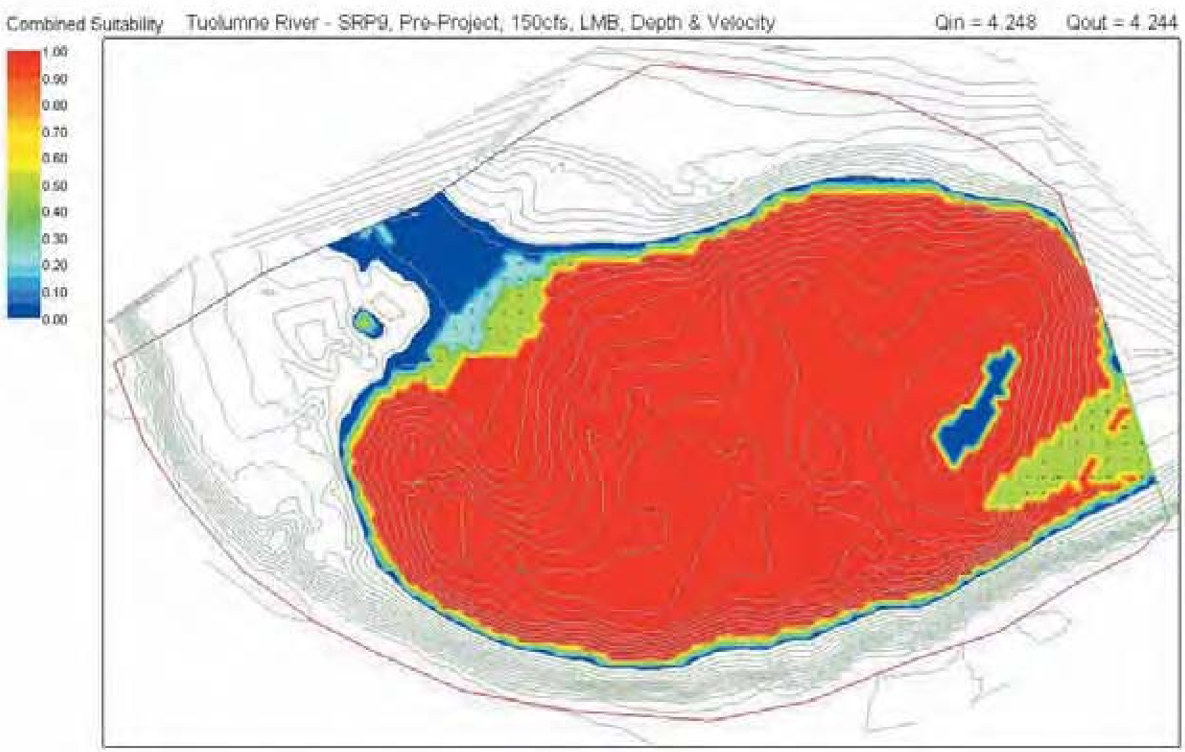
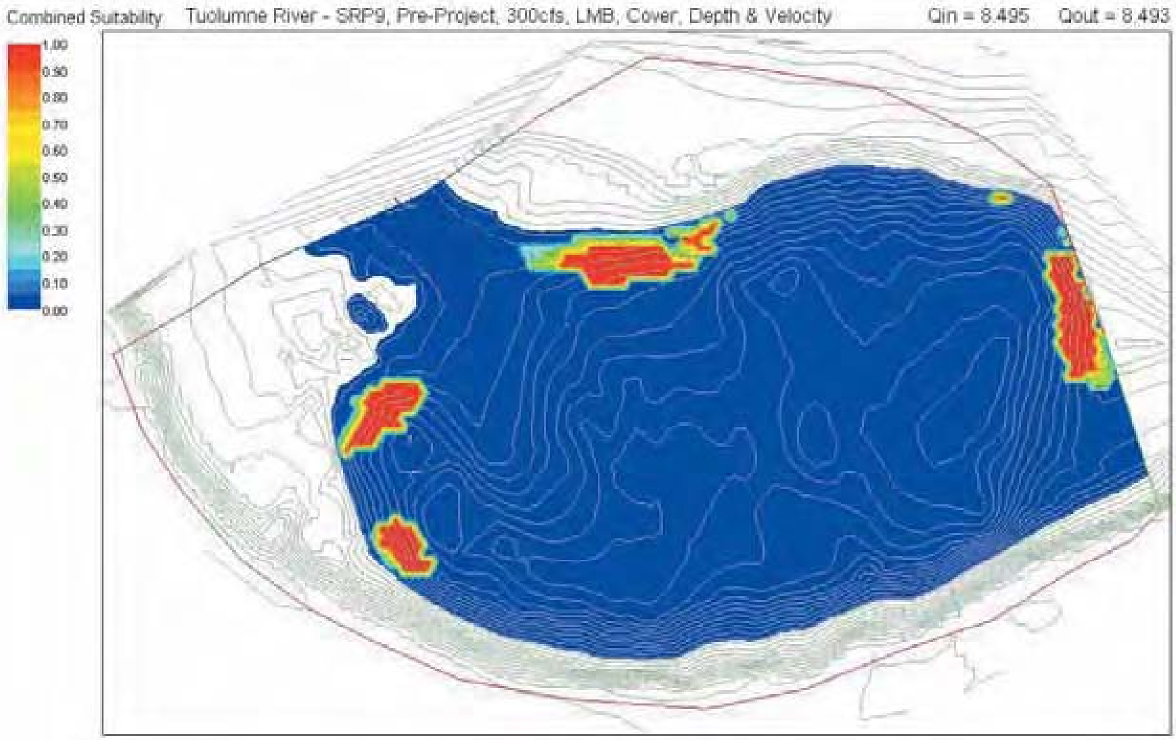
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability
Tuolumne River - SRP9, Pre-Project, 150cfs, LMB, Depth & Velocity
Qin = 4.248
Qout = 4.244
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability
Tuolumne River - SRP9, Pre-Project, 300cfs, LMB, Cover, Depth & Velocity
Qin = 8.495
Qout = 8.493
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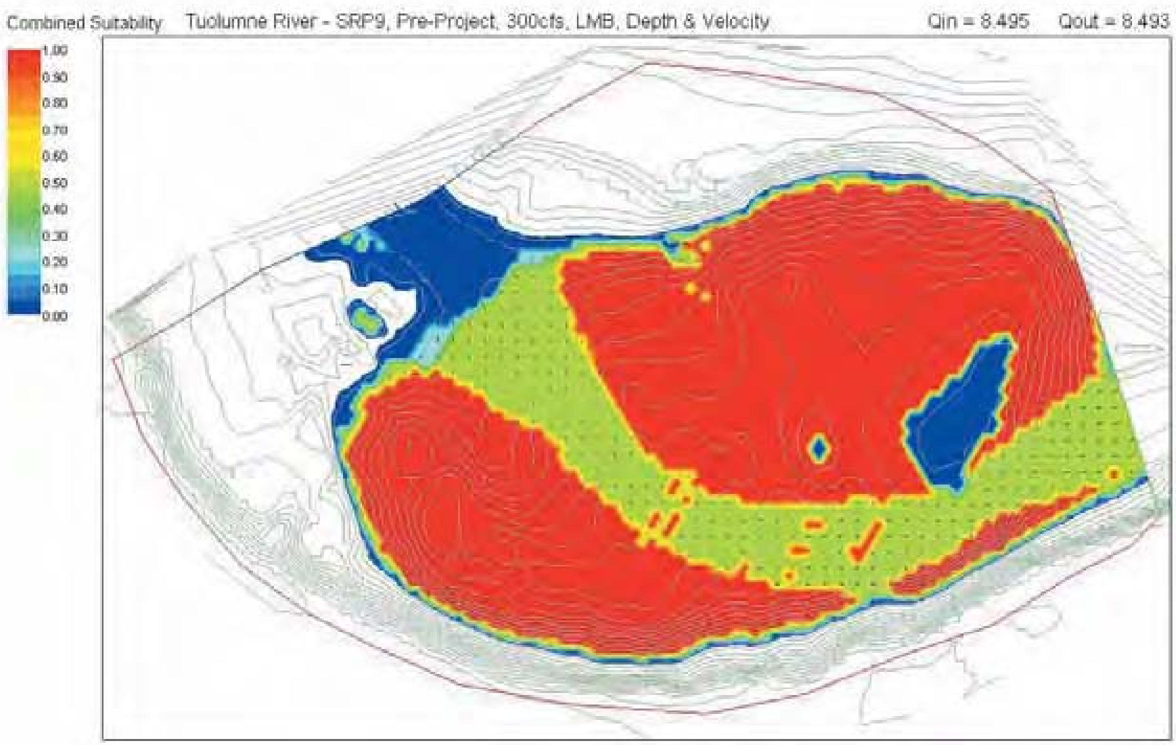
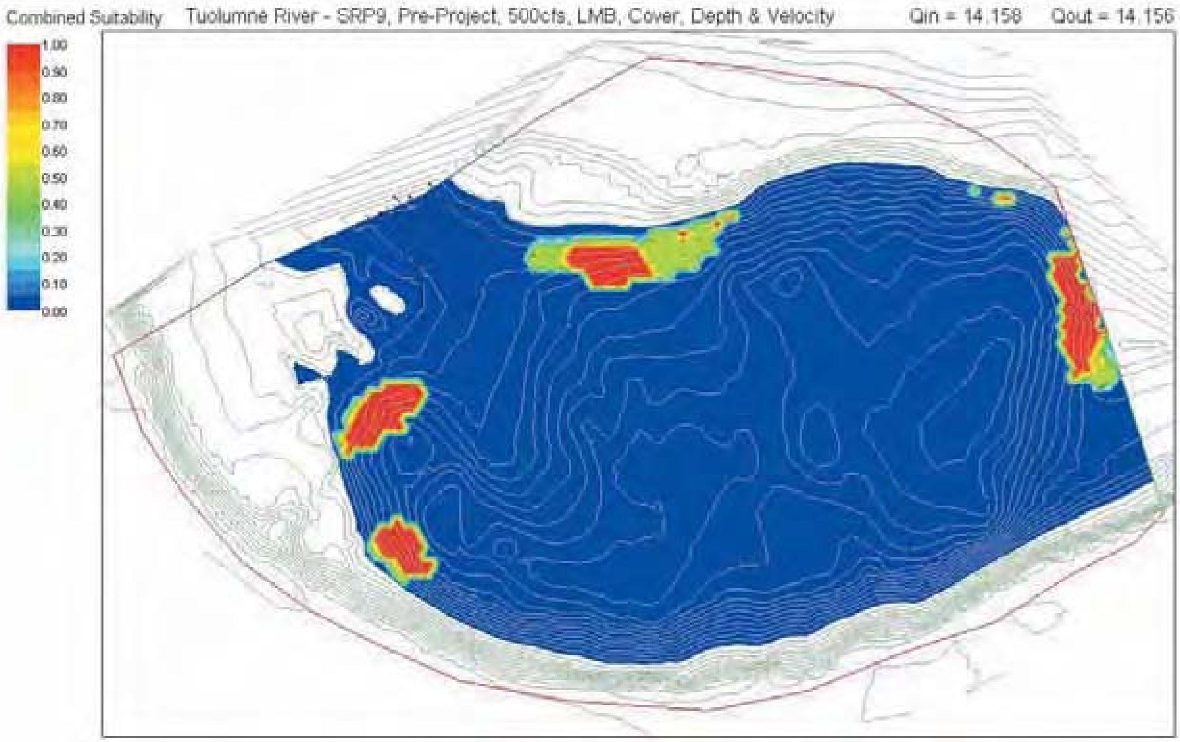
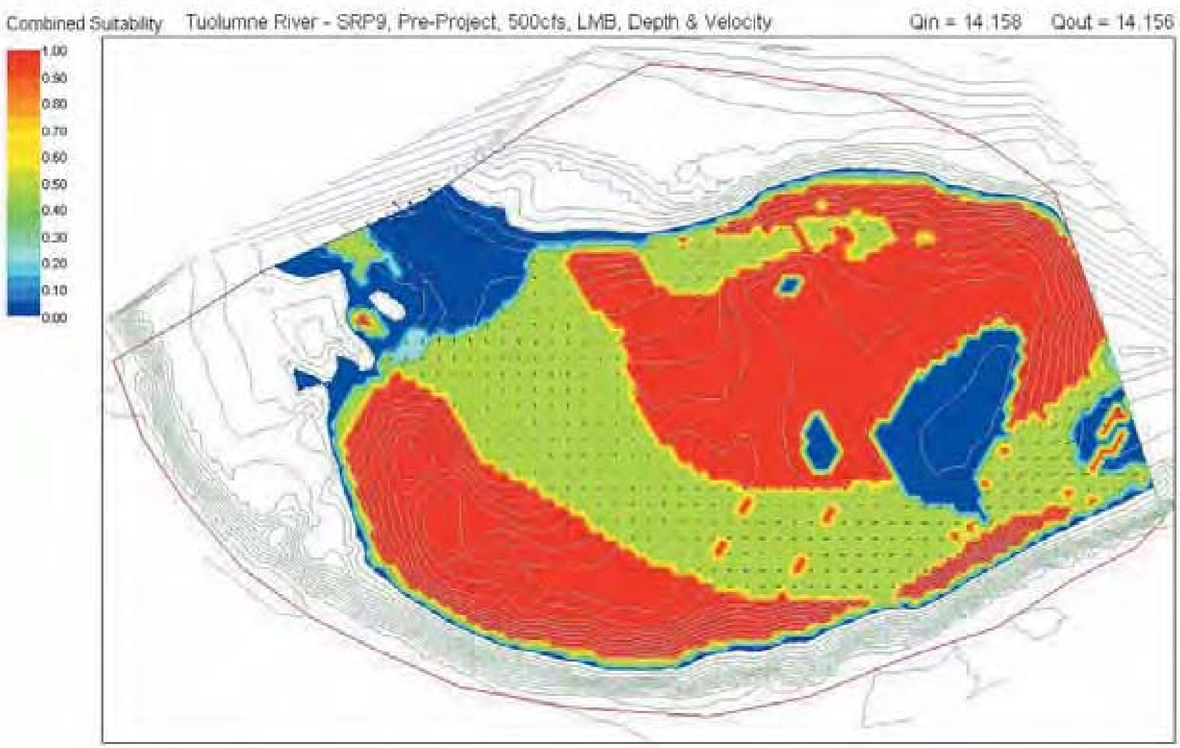
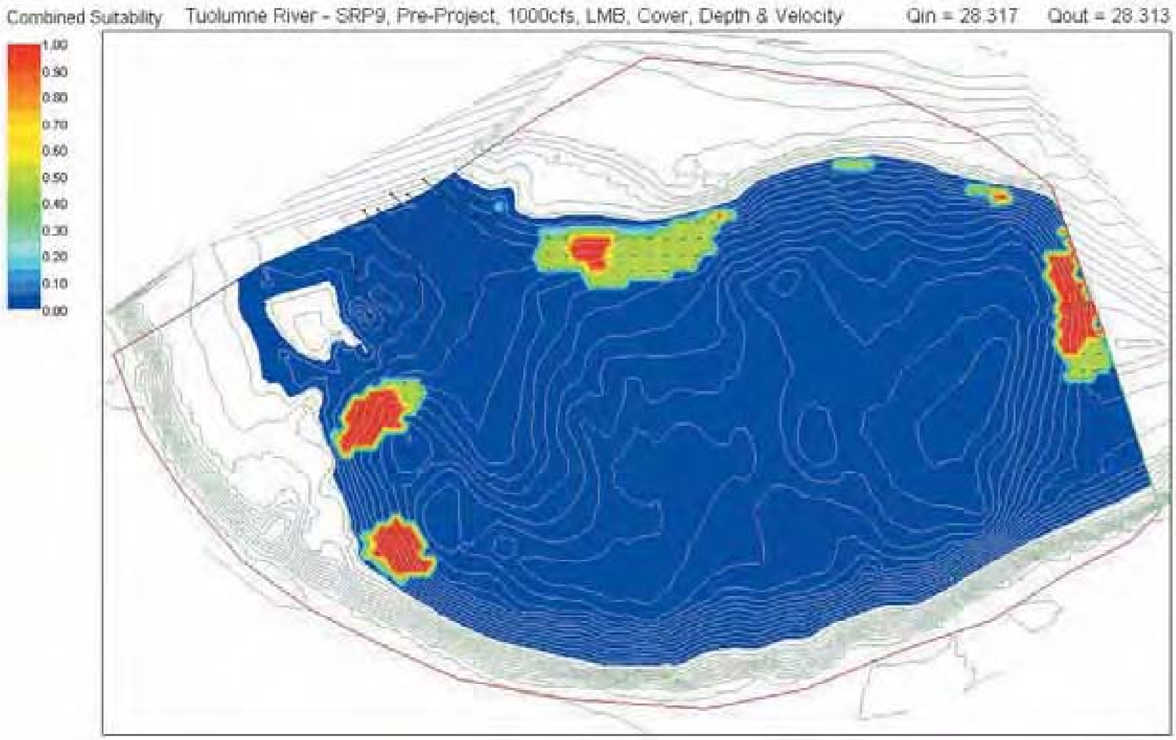
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability
Tuolumne River - SRP9, Pre-Project, 300cfs, LMB, Depth & Velocity
Qin = 8.495
Qout = 8.493
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability
Tuolumne River - SRP9, Pre-Project, 500cfs, LMB, Cover, Depth & Velocity
Qin = 14.158 Qout = 14.156
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability
Tuolumne River - SRP9, Pre-Project, 500cfs, LMB, Depth & Velocity
Qin = 14.158 Qout = 14.156
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability
Tuolumne River - SRP9, Pre-Project, 1000cfs, LMB, Cover, Depth & Velocity
Qin = 28.317
Qout = 28.313
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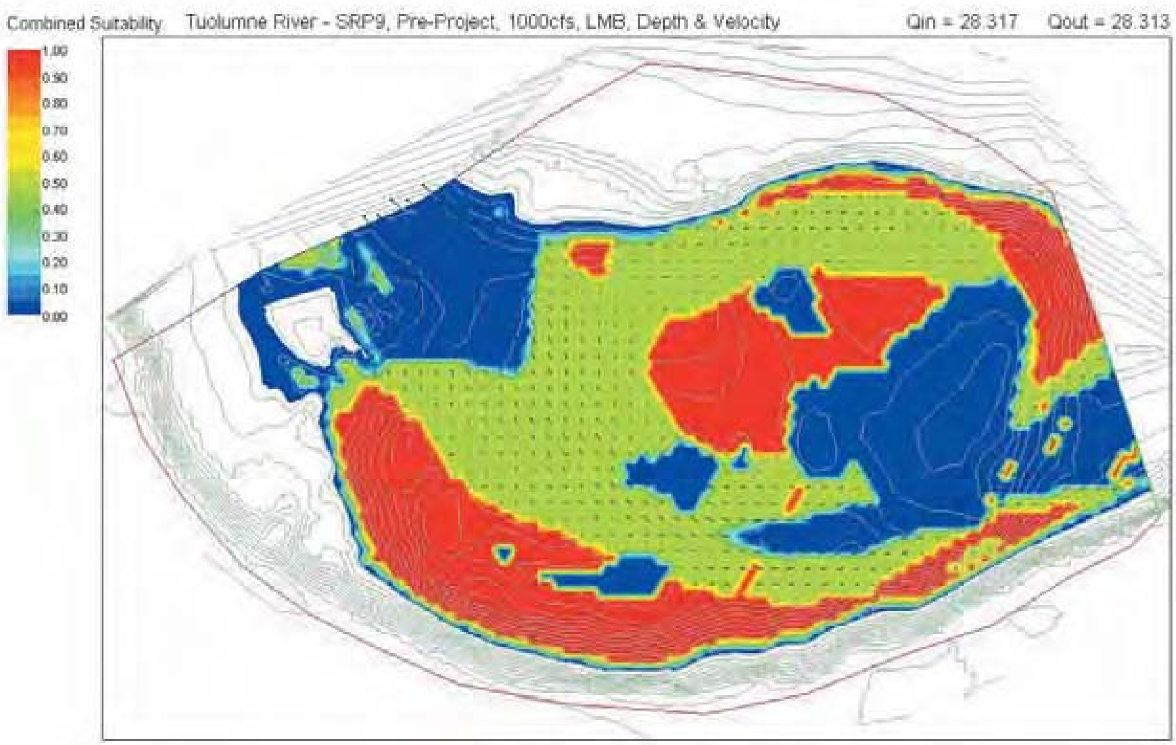
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability
Tuolumne River - SRP9, Pre-Project, 1000cfs, LMB, Depth & Velocity
Qin = 28.317
Qout = 28.313
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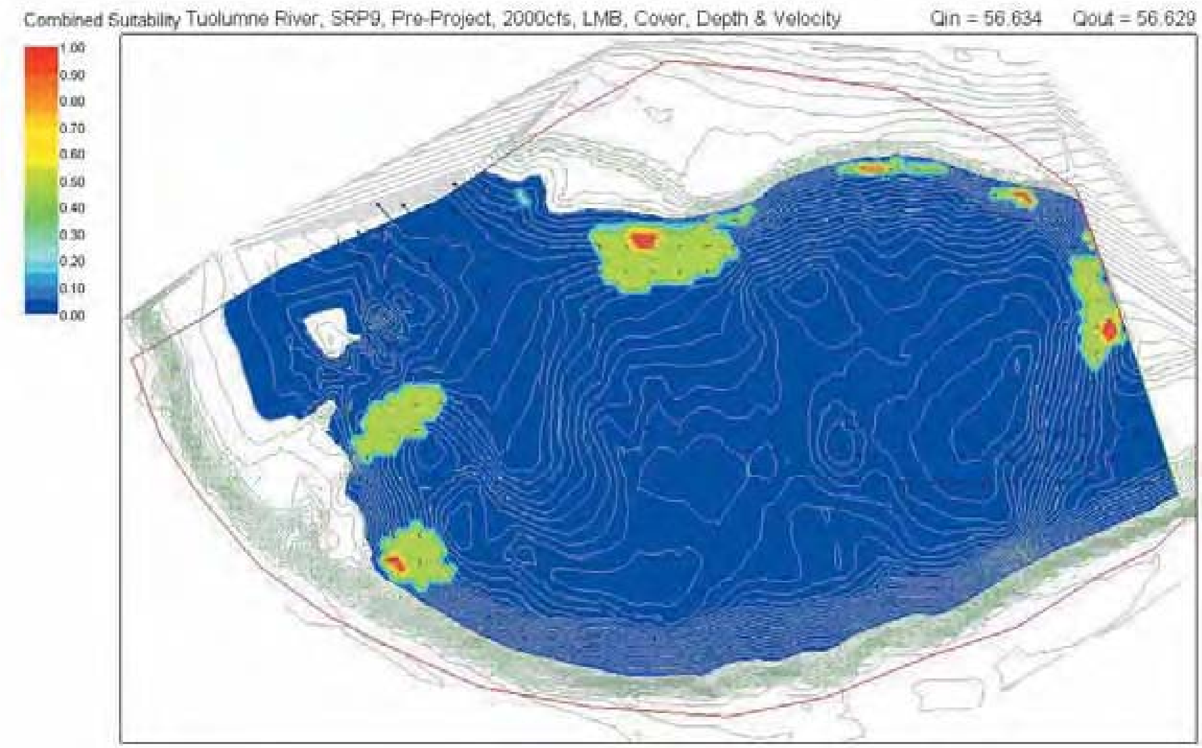
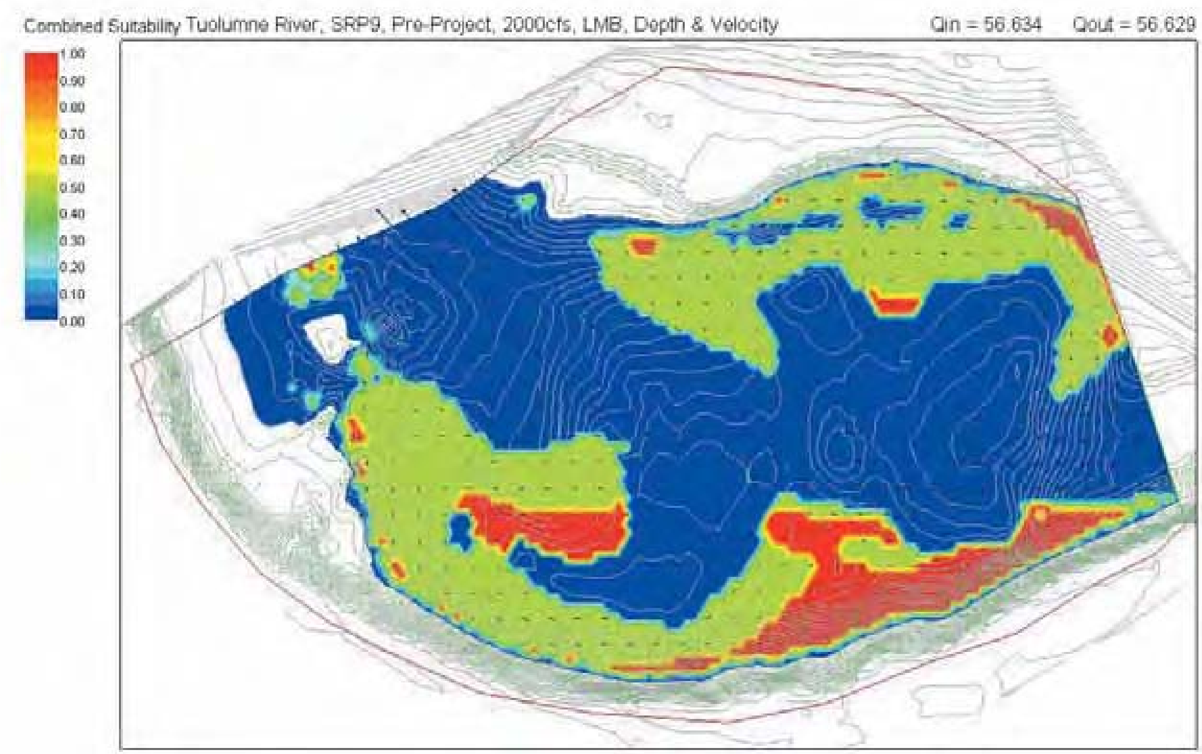
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability Tuolumne River, SRP9, Pre-Project, 2000cfs, LMB, Cover, Depth & Velocity
Qin = 56.634 Qout = 56.629
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability Tuolumne River, SRP9, Pre-Project, 2000cfs, LMB, Depth & Velocity
Qin = 56.634 Qout = 56.629
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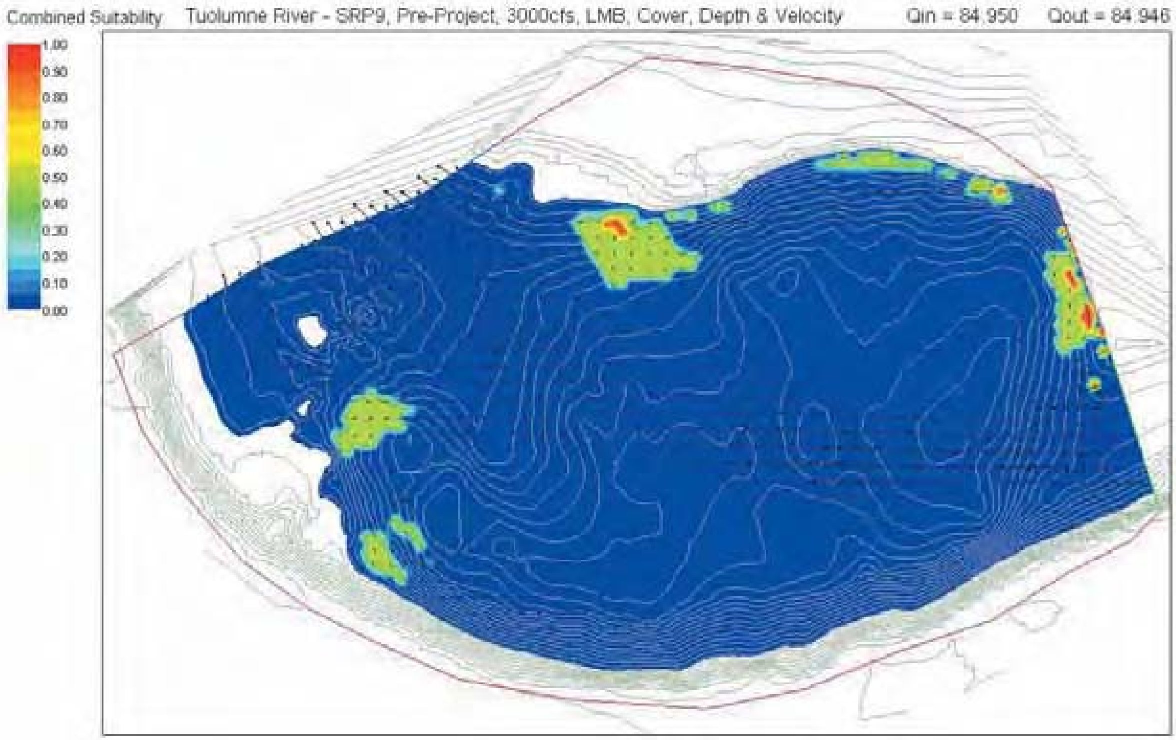
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability
Tuolumne River - SRP9, Pre-Project, 3000cfs, LMB, Cover, Depth & Velocity
Qin = 84.950
Qout = 84.946
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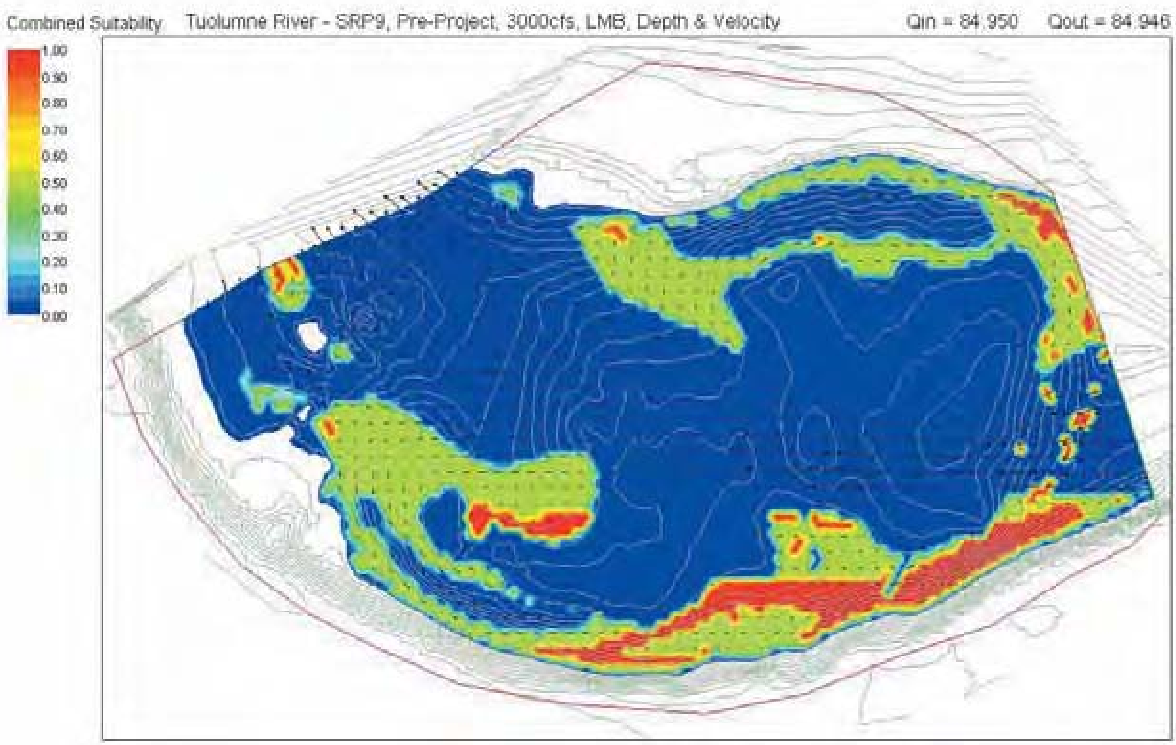
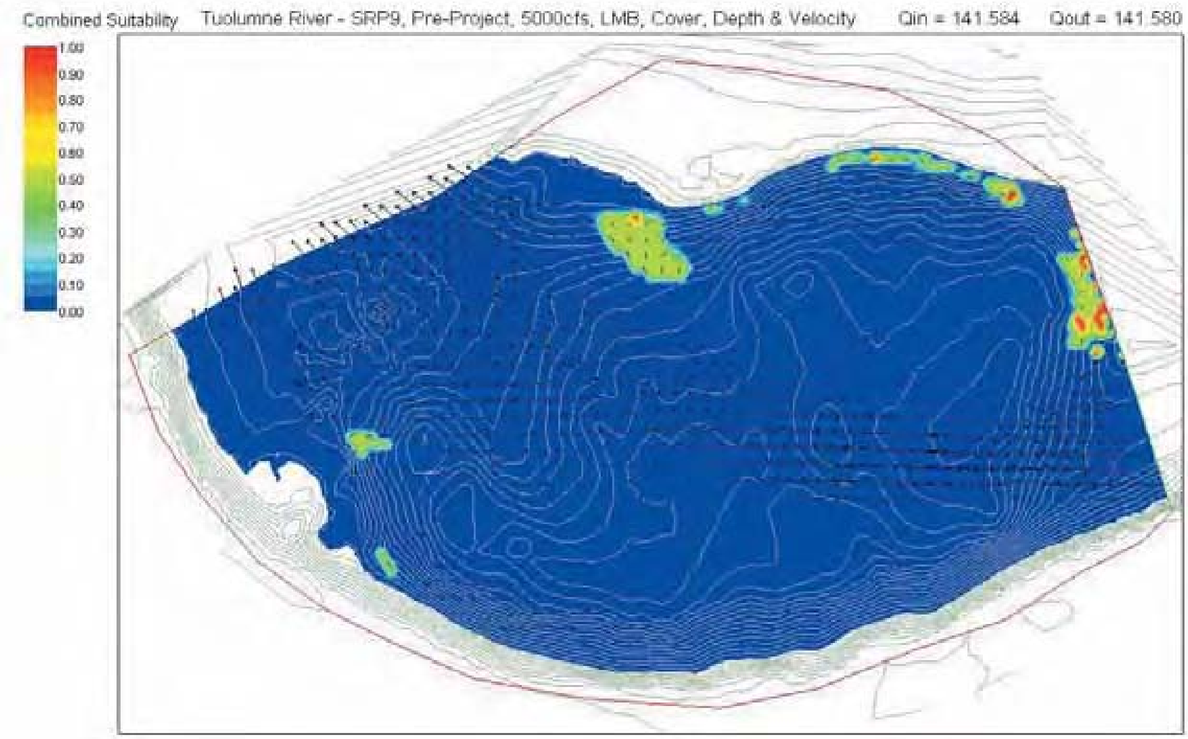
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability
Tuolumne River - SRP9, Pre-Project, 3000cfs, LMB, Depth & Velocity
Qin = 84.950
Qout = 84.946
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability
Tuolumne River - SRP9, Pre-Project, 5000cfs, LMB, Cover, Depth & Velocity
Qin = 141.584
Qout = 141.580
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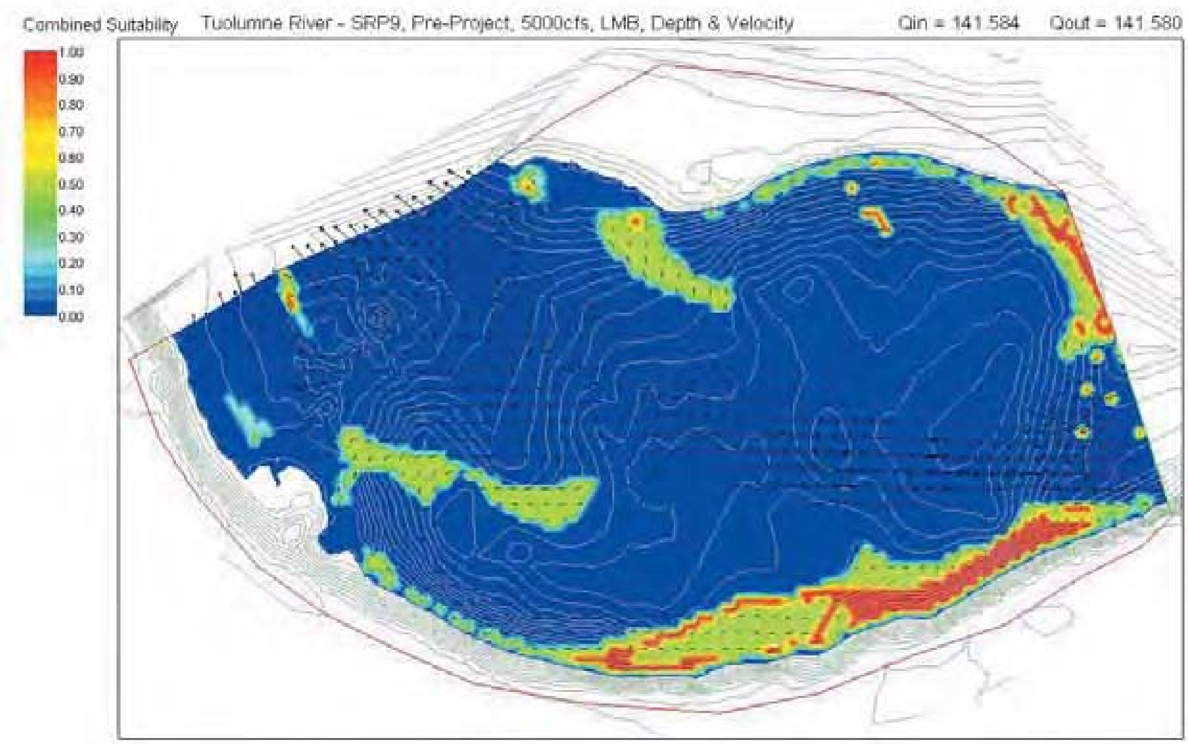
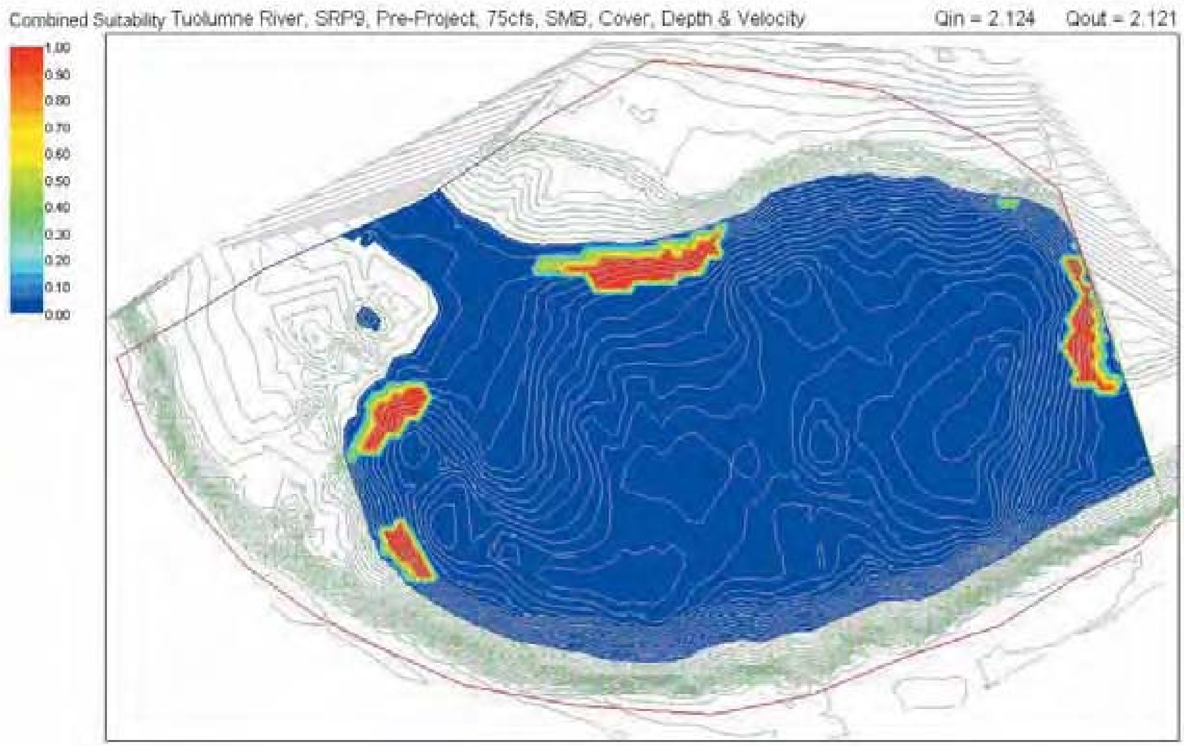
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability
Tuolumne River - SRP9, Pre-Project, 5000cfs, LMB, Depth & Velocity
Qin = 141.584
Qout = 141.580
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability Tuolumne River, SRP9, Pre-Project, 75cfs, SMB, Cover, Depth & Velocity
Qin = 2.124
Qout = 2.121
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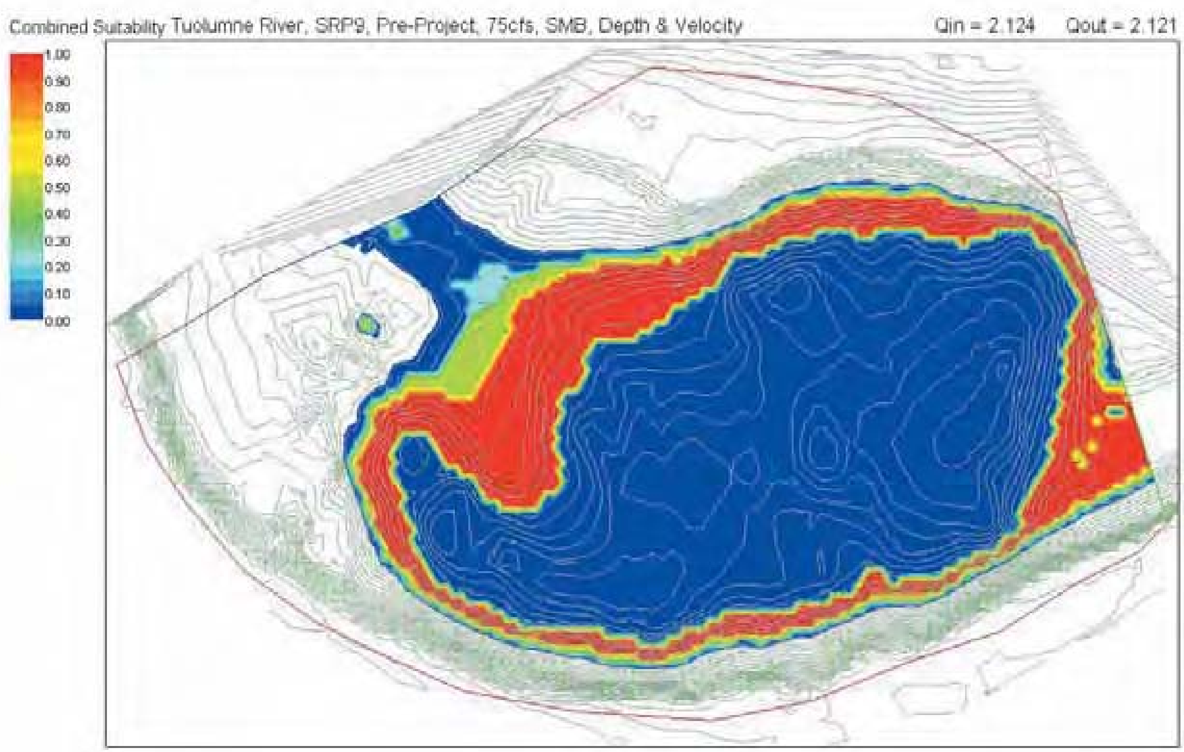
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability Tuolumne River, SRP9, Pre-Project, 75cfs, SMB, Depth & Velocity
Qin = 2.124
Qout = 2.121
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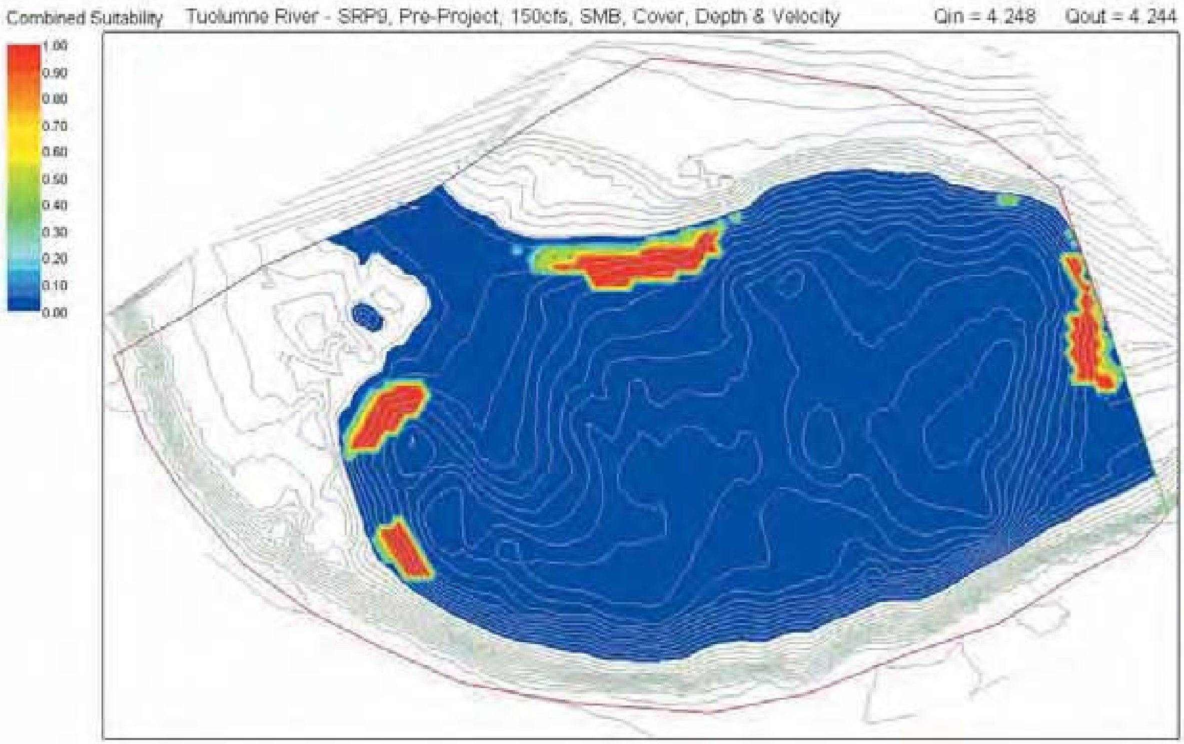
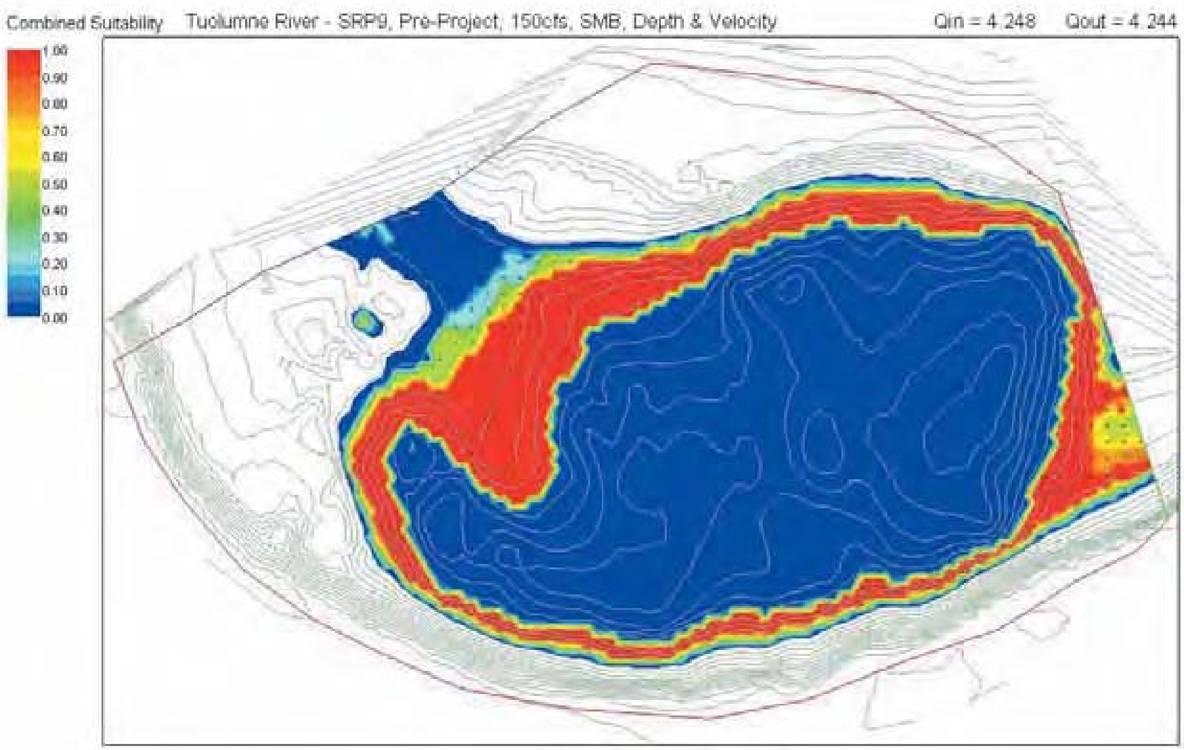
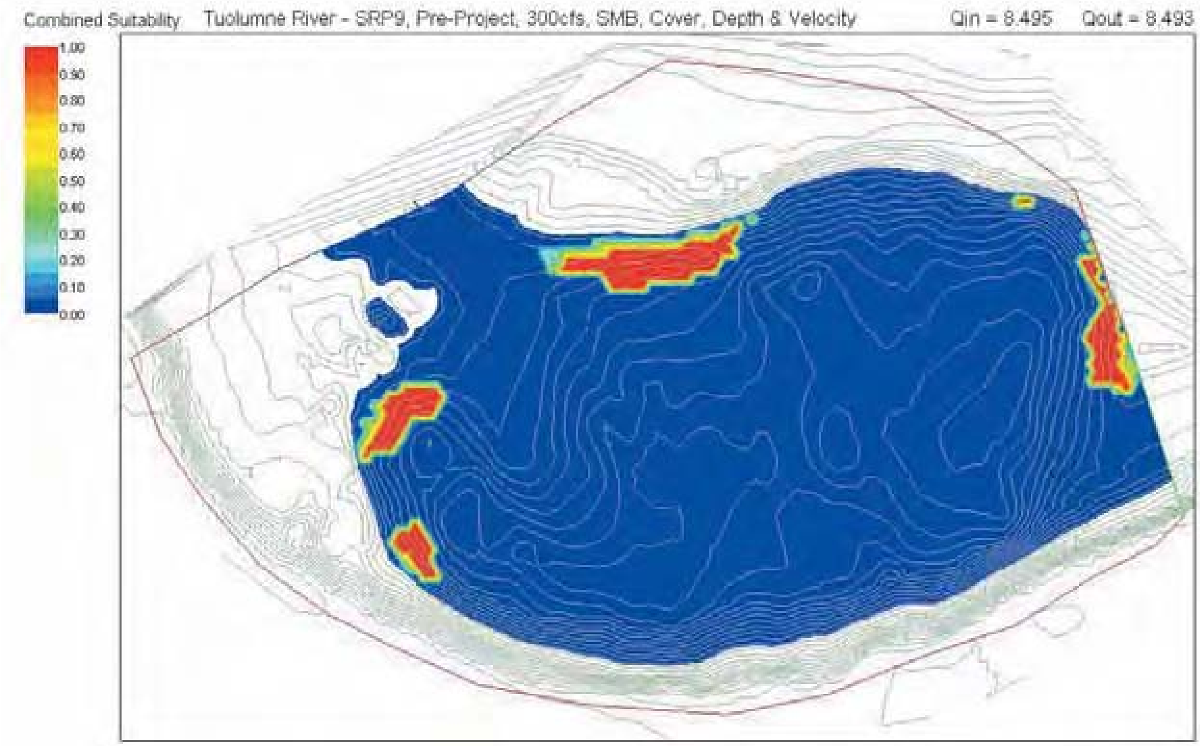
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability
Tuolumne River - SRP9, Pre-Project, 150cfs, SMB, Cover, Depth & Velocity
Qin = 4.248
Qout = 4.244
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability
Tuolumne River - SRP9, Pre-Project, 150cfs, SMB, Depth & Velocity
Qin = 4.248
Qout = 4.244
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability
Tuolumne River - SRP9, Pre-Project, 300cfs, SMB, Cover, Depth & Velocity
Qin = 8.495 Qout = 8.493
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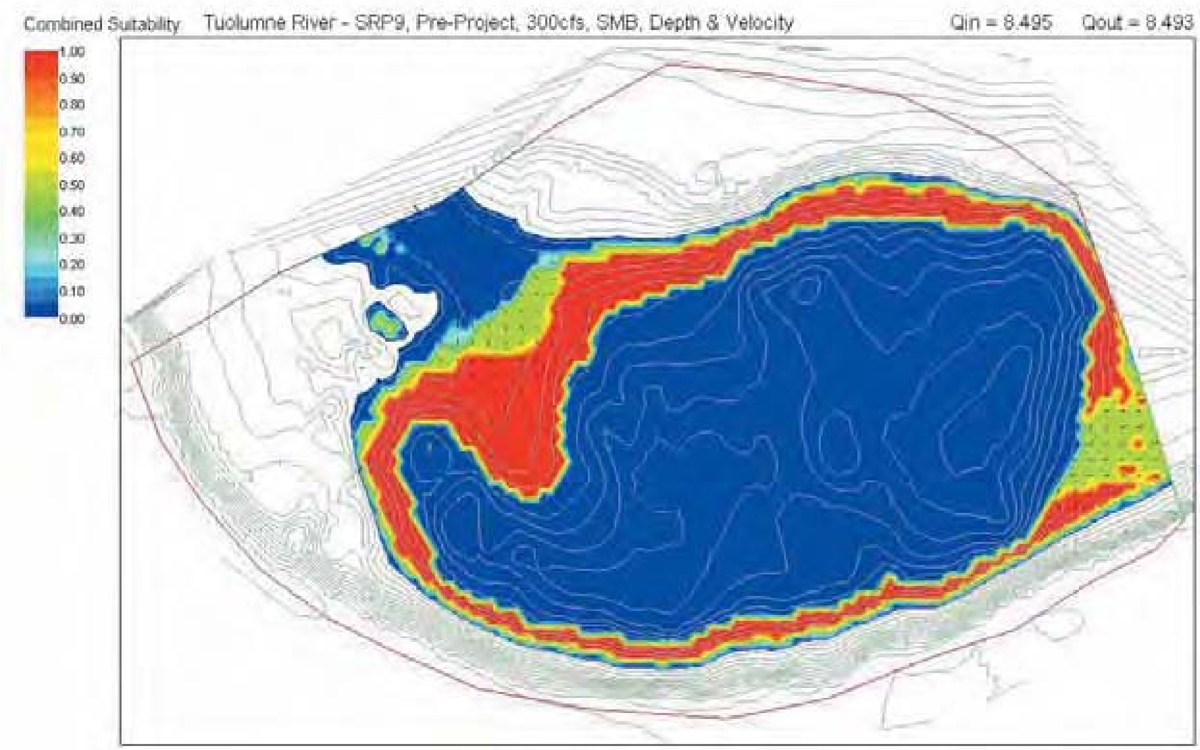
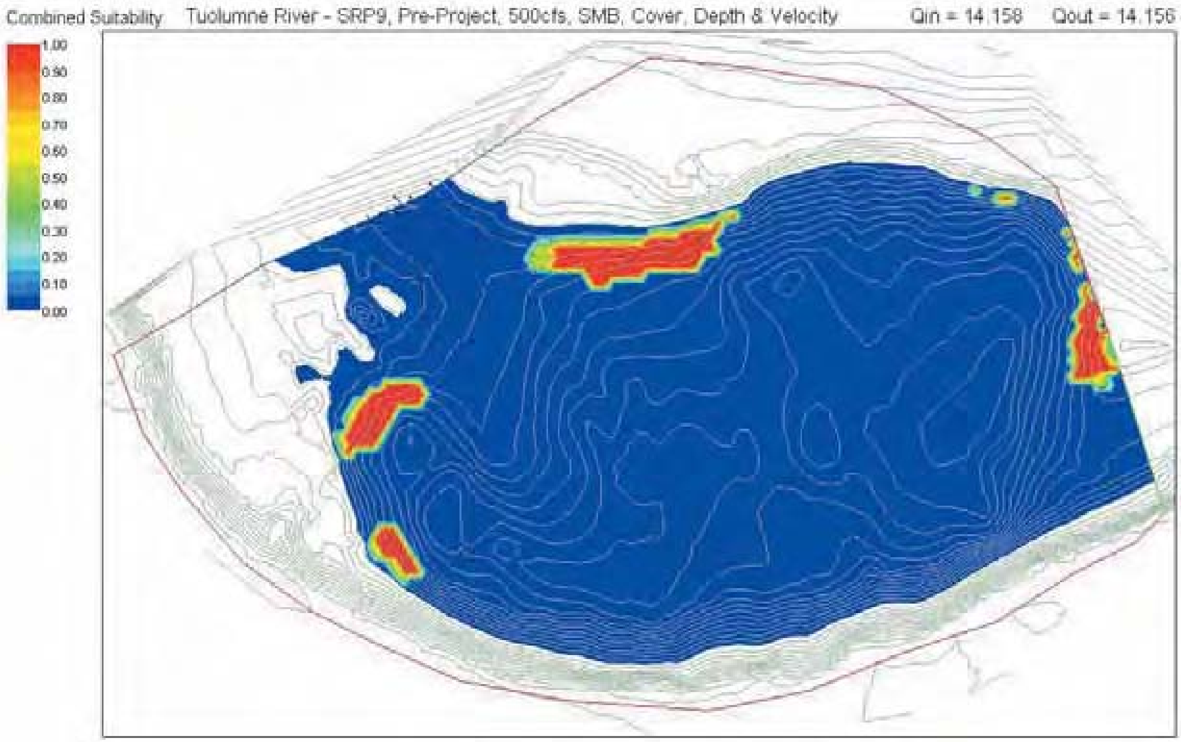
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability
Tuolumne River - SRP9, Pre-Project, 300cfs, SMB, Depth & Velocity
Qin = 8.495 Qout = 8.493
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability
Tuolumne River - SRP9, Pre-Project, 500cfs, SMB, Cover, Depth & Velocity
Qin = 14.158 Qout = 14.156
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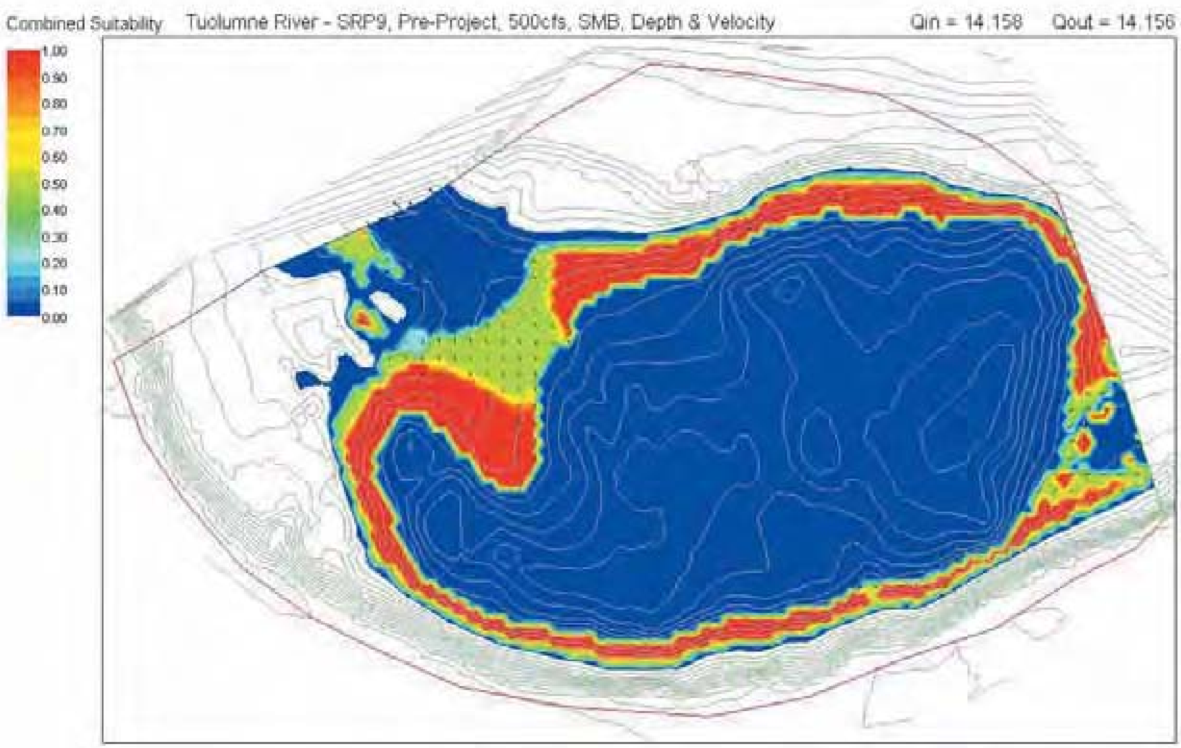
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability
Tuolumne River - SRP9, Pre-Project, 500cfs, SMB, Depth & Velocity
Qin = 14.158 Qout = 14.156
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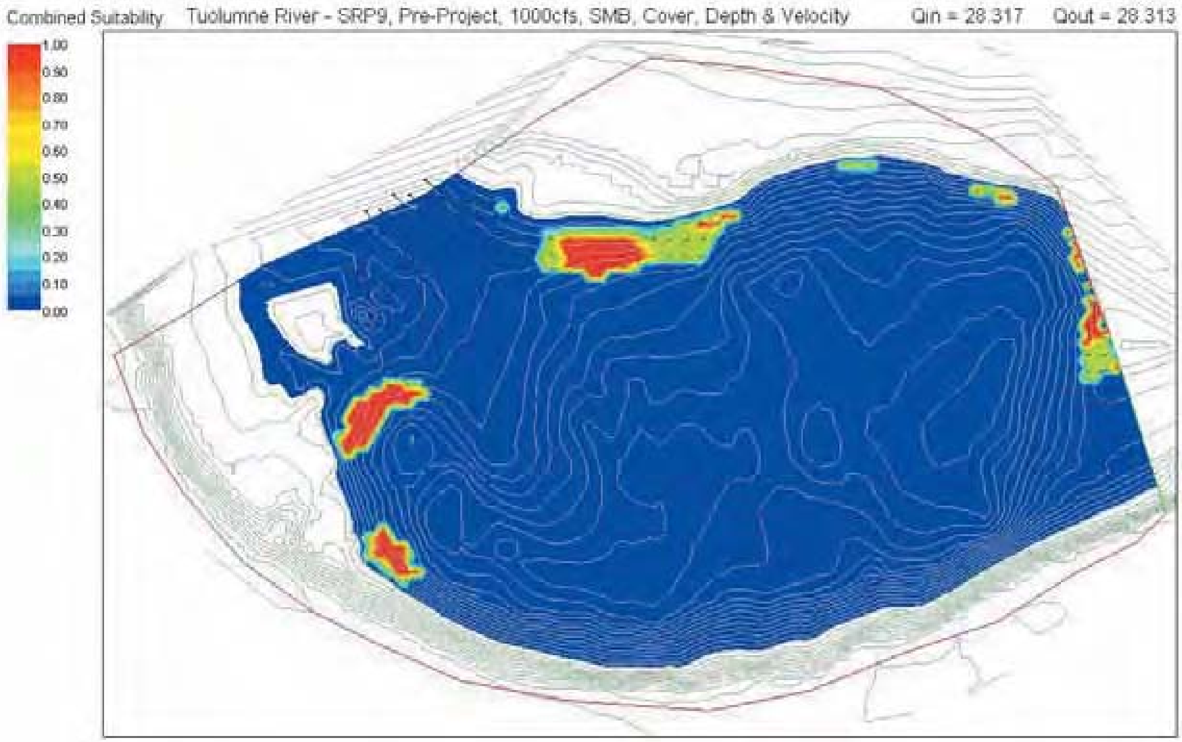
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability
Tuolumne River - SRP9, Pre-Project, 1000cfs, SMB, Cover, Depth & Velocity
Qin = 28.317
Qout = 28.313
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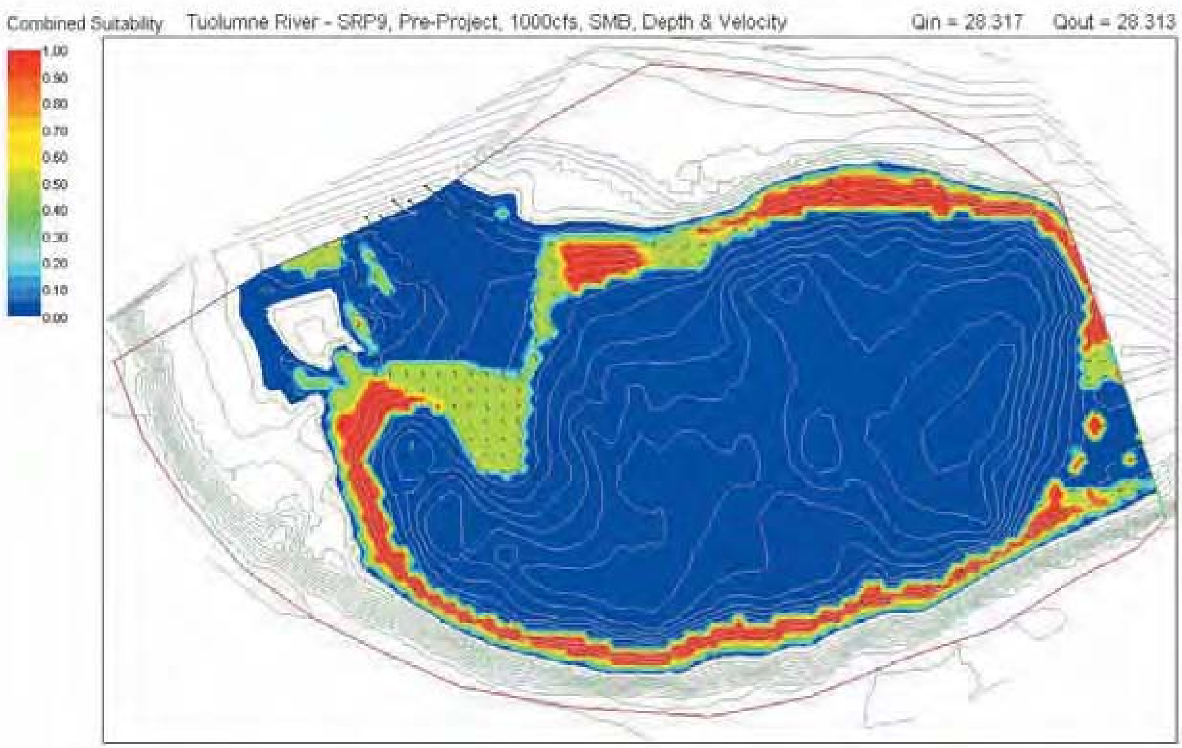
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability
Tuolumne River - SRP9, Pre-Project, 1000cfs, SMB, Depth & Velocity
Qin = 28.317
Qout = 28.313
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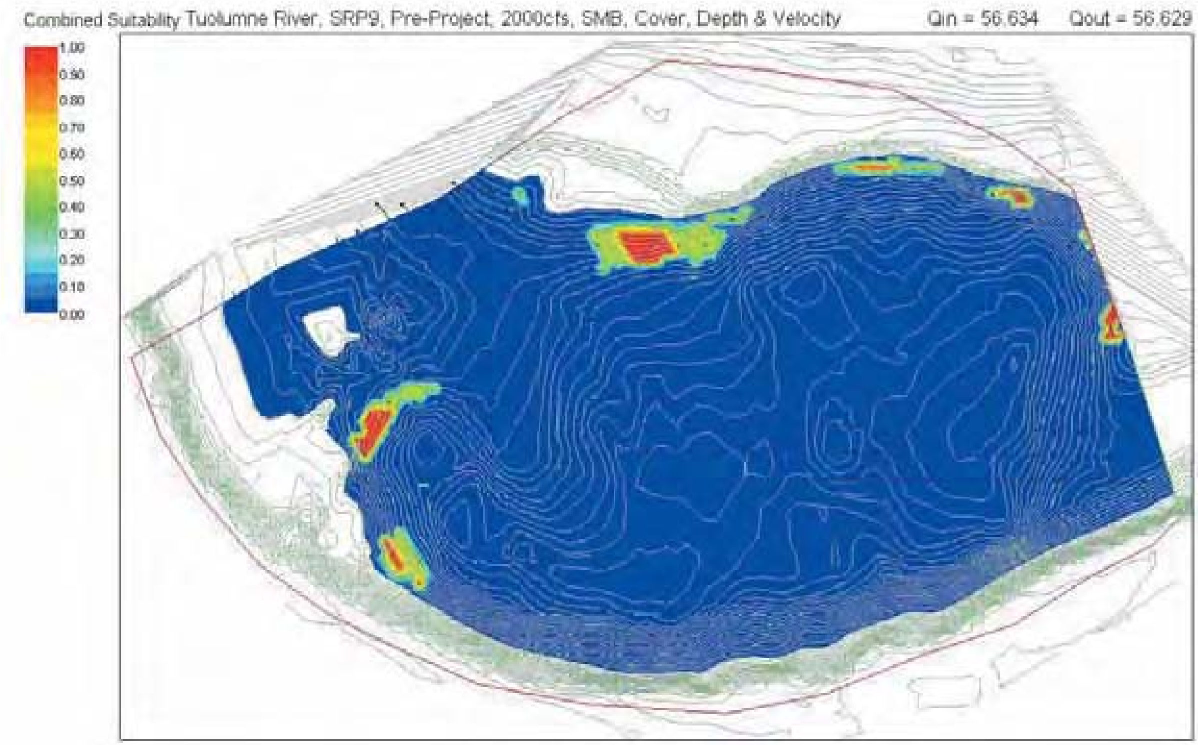
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability Tuolumne River, SRP9, Pre-Project, 2000cfs, SMB, Cover, Depth & Velocity
Qin = 56.634 Qout = 56.629
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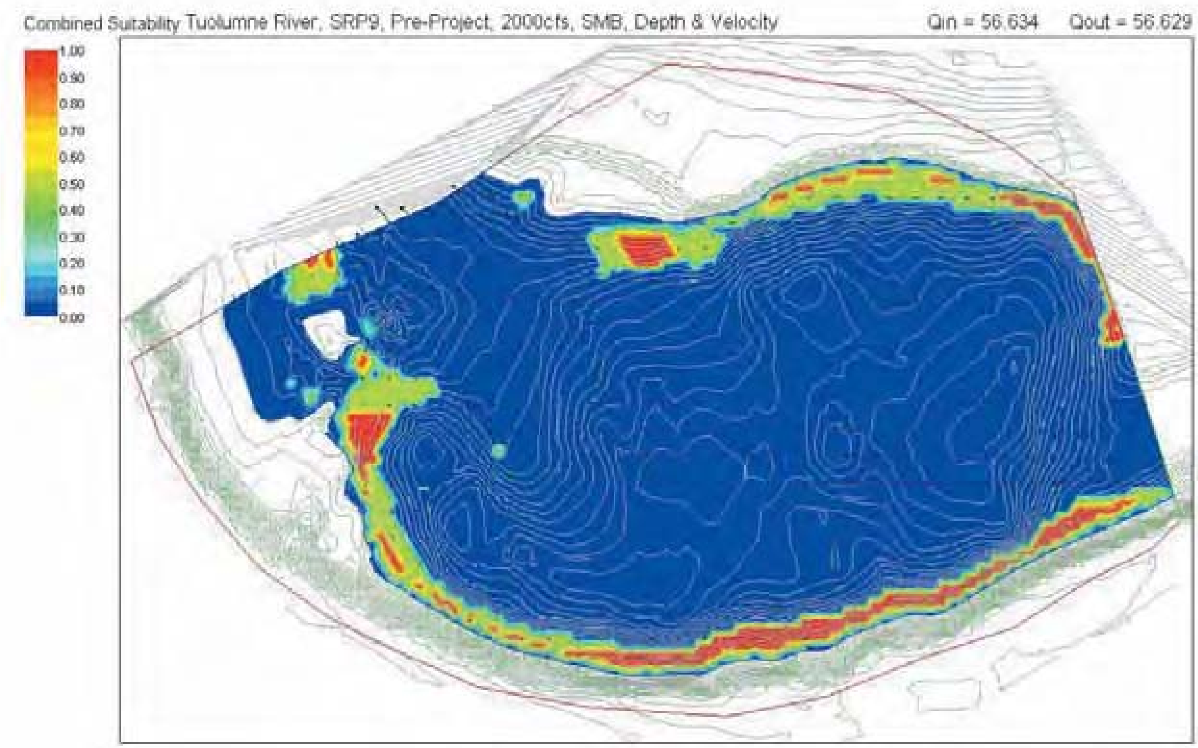
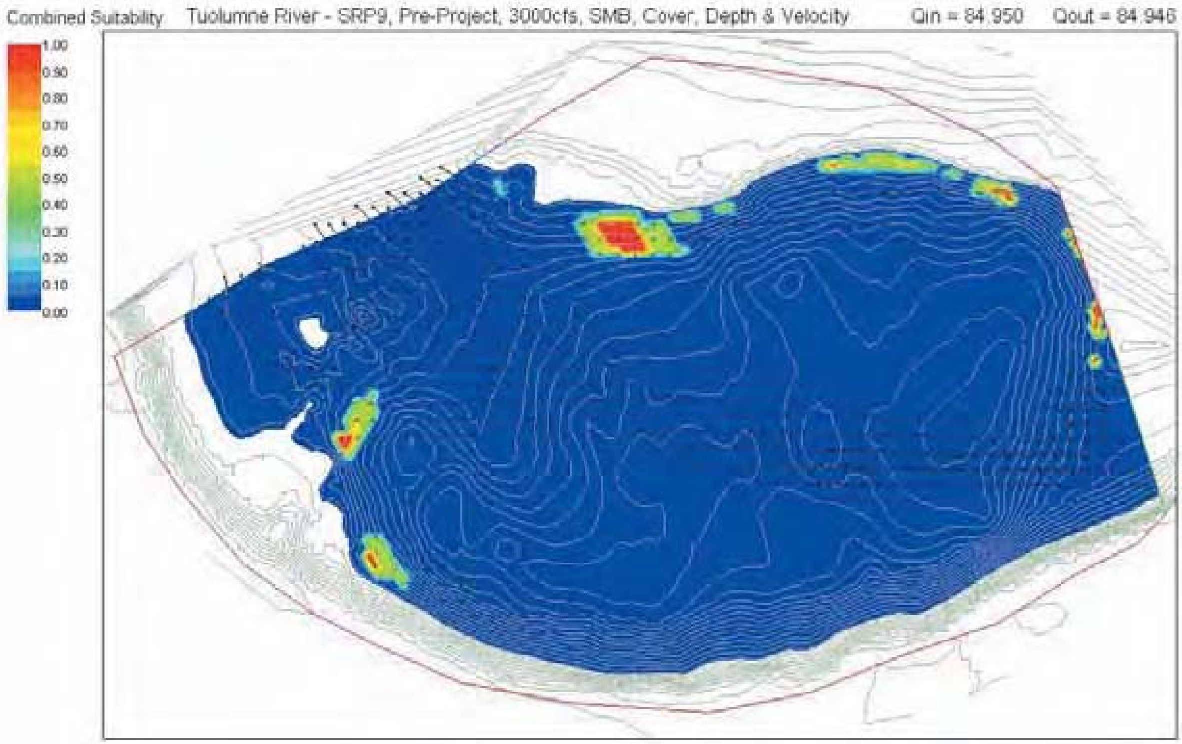
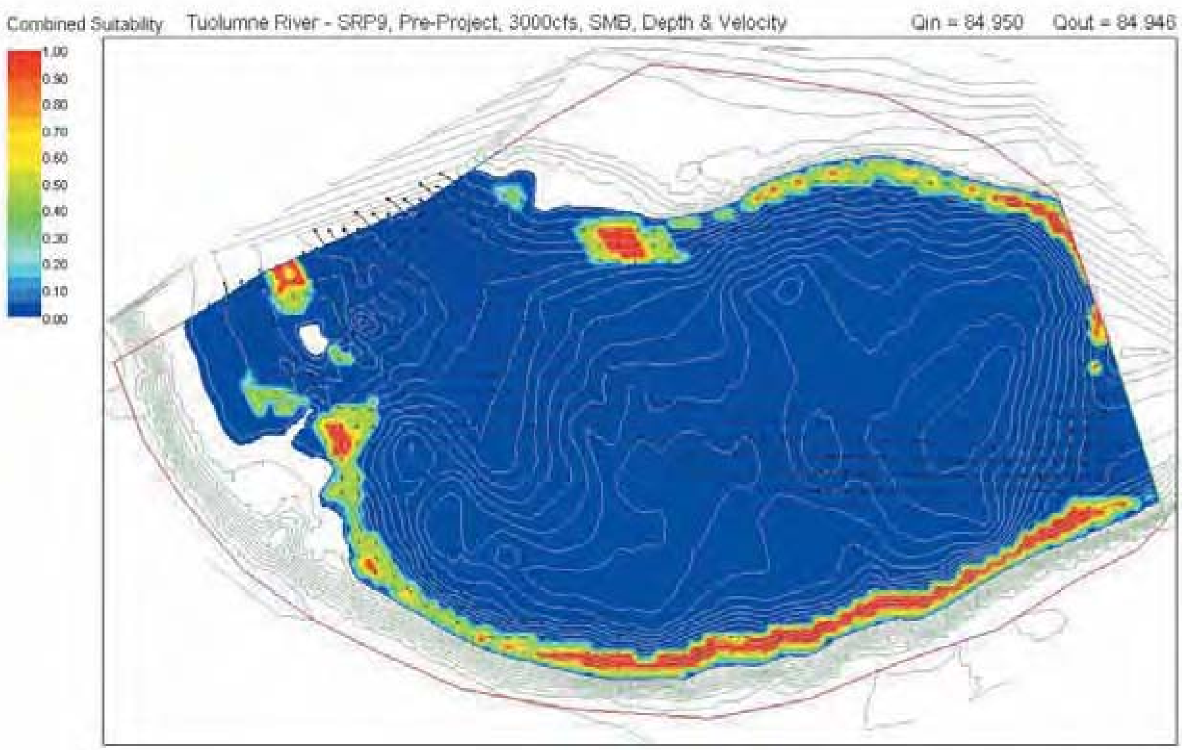
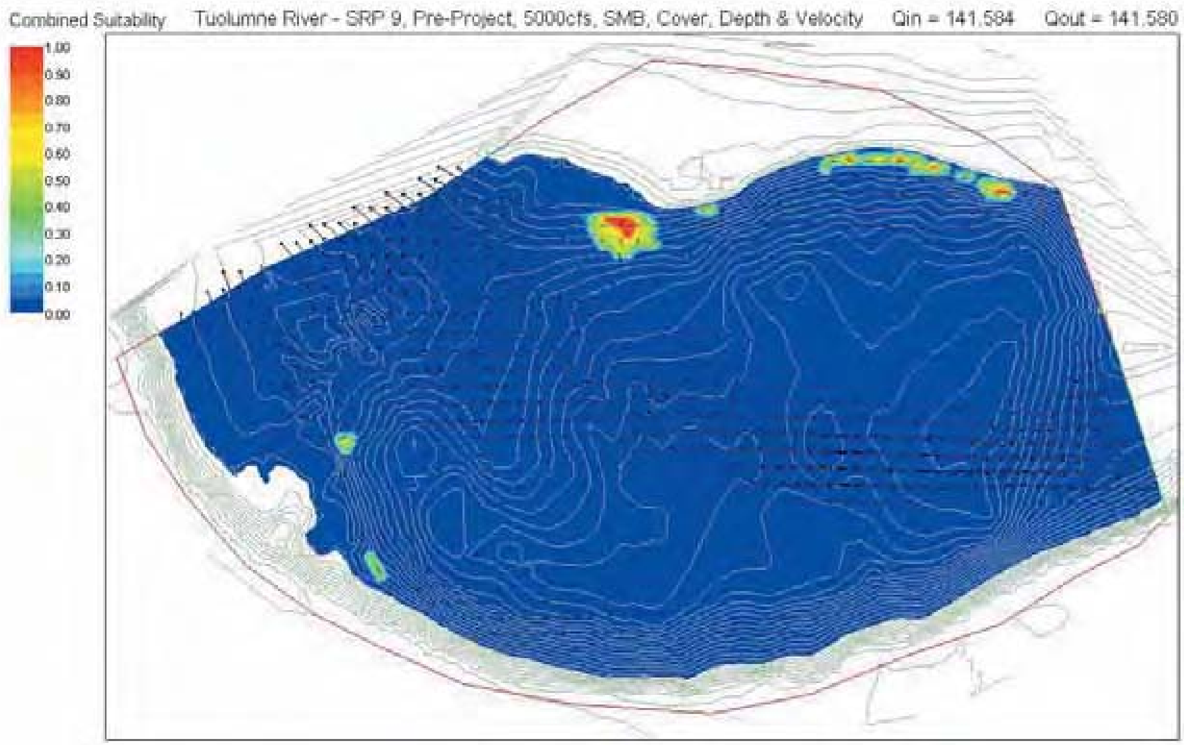
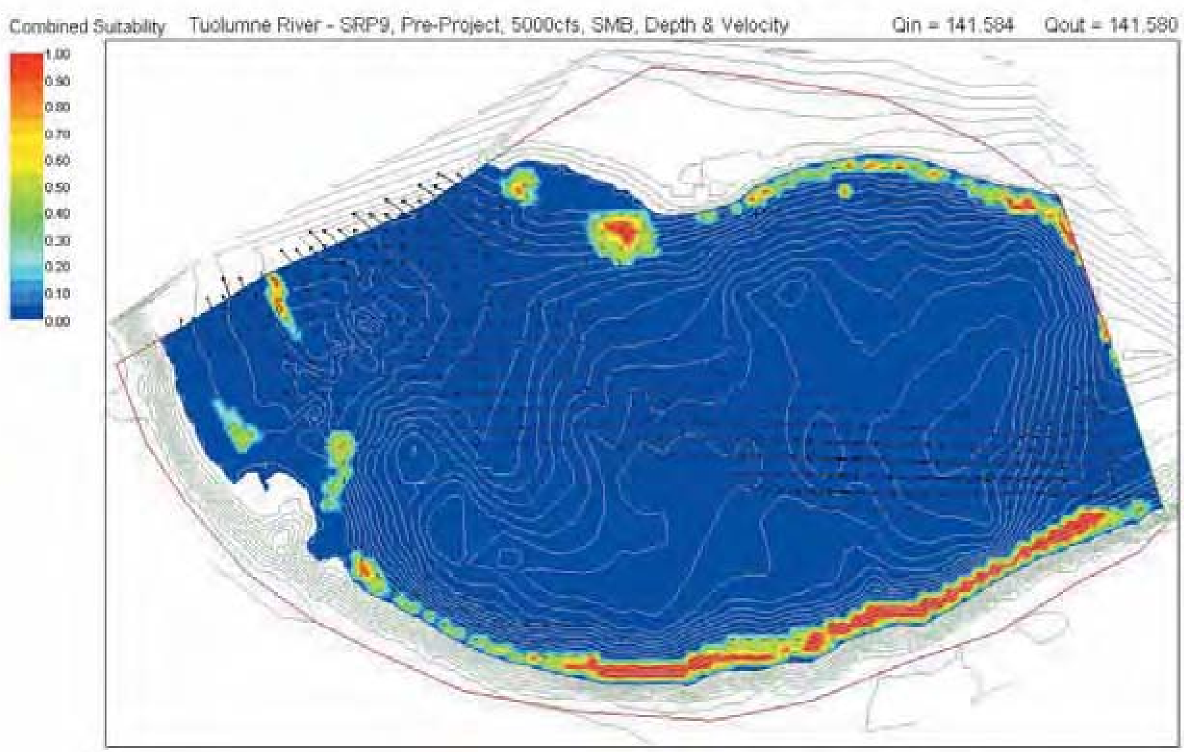
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

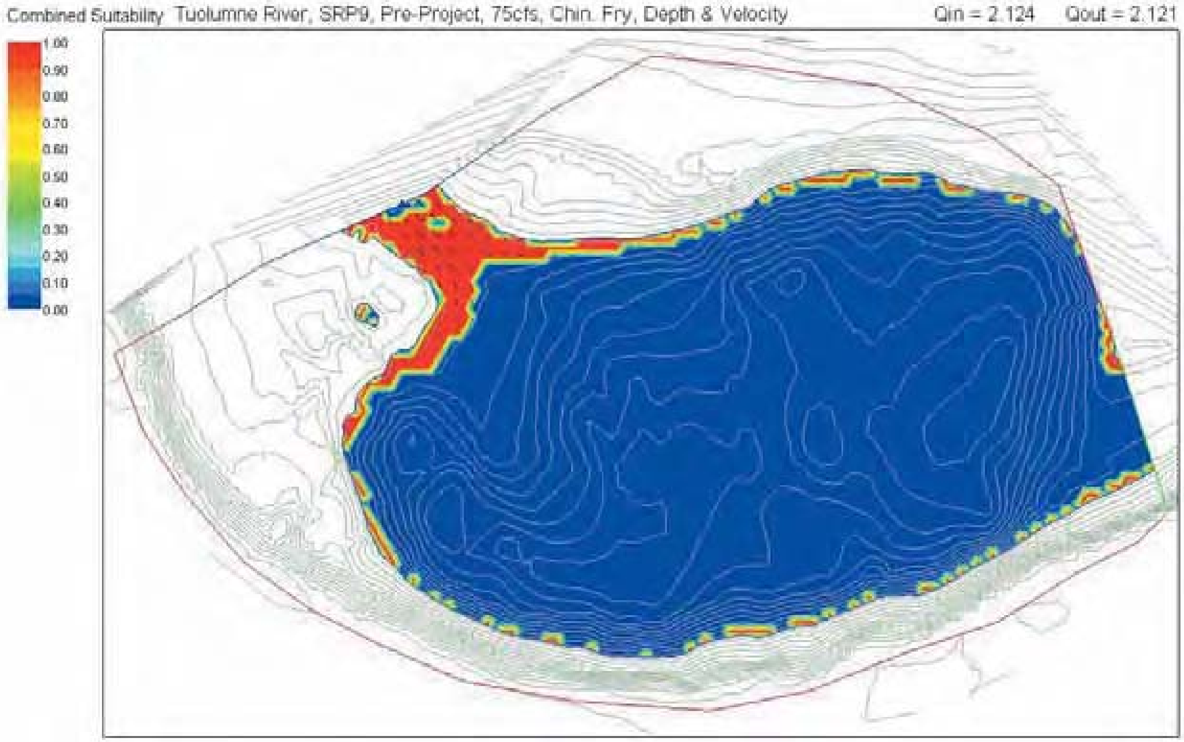

Combined Suitability Tuolumne River, SRP9, Pre-Project, 2000cfs, SMB, Depth & Velocity
Qin = 56.634 Qout = 56.629
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

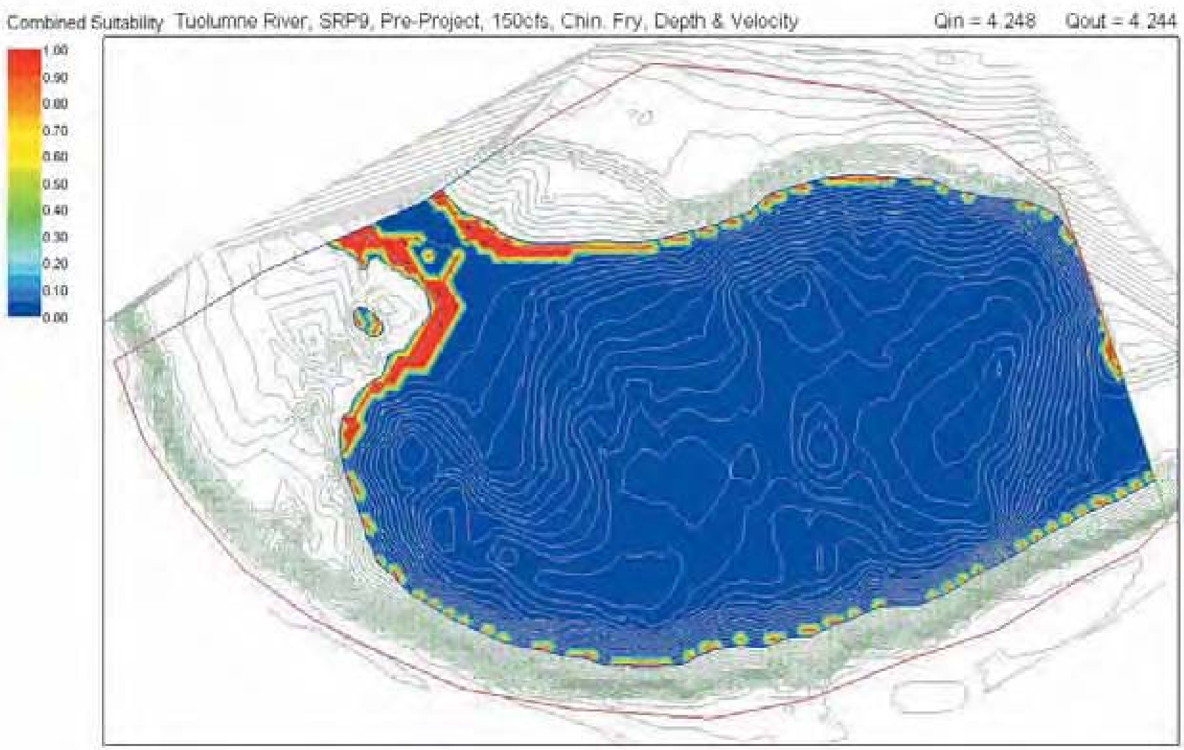

Combined Suitability
Tuolumne River - SRP9, Pre-Project, 3000cfs, SMB, Cover, Depth & Velocity
Qin = 84.950
Qout = 84.946
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

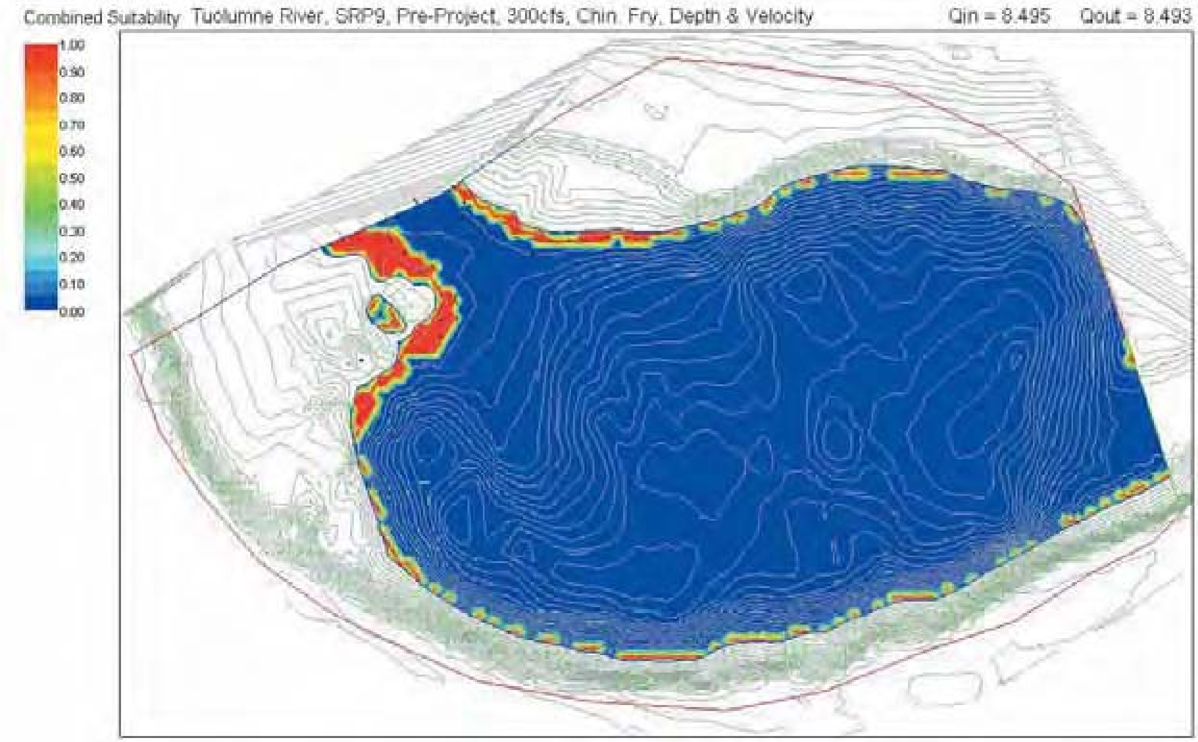

Combined Suitability
Tuolumne River - SRP9, Pre-Project, 3000cfs, SMB, Depth & Velocity
Qin = 84.950
Qout = 84.946
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

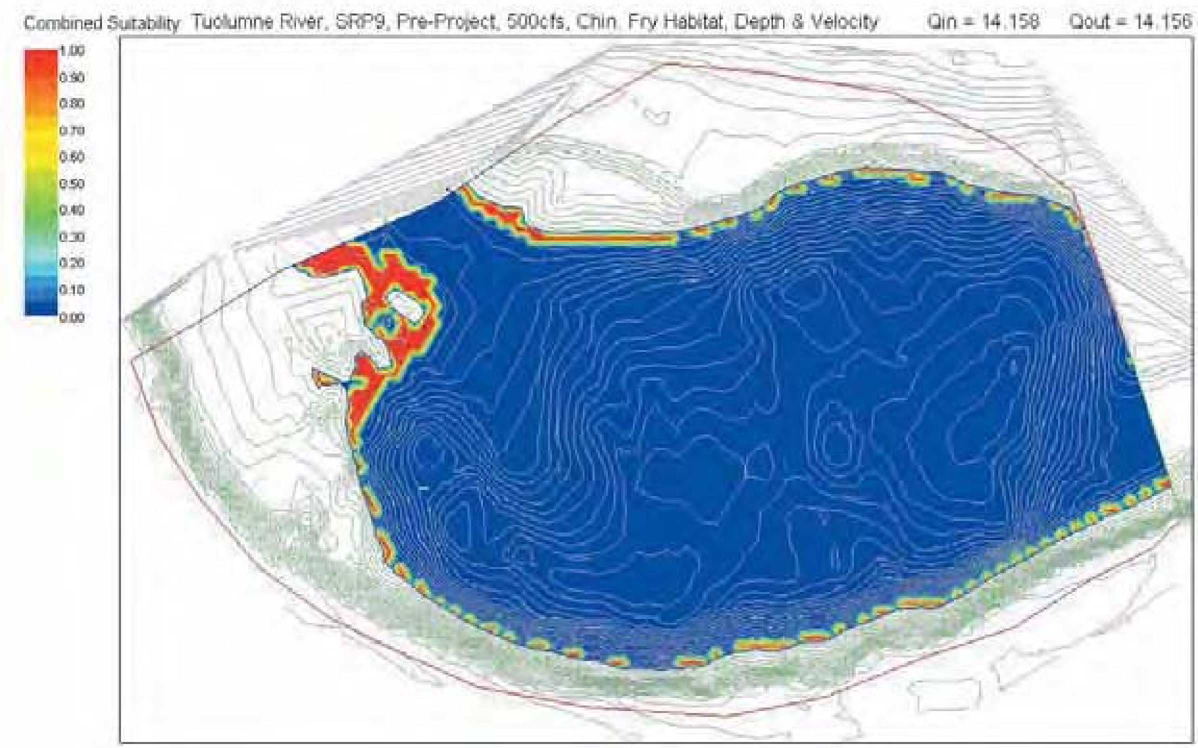

Combined Suitability
Tuolumne River - SRP 9, Pre-Project, 5000cfs, SMB, Cover, Depth & Velocity
Qin = 141.584
Qout = 141.580
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

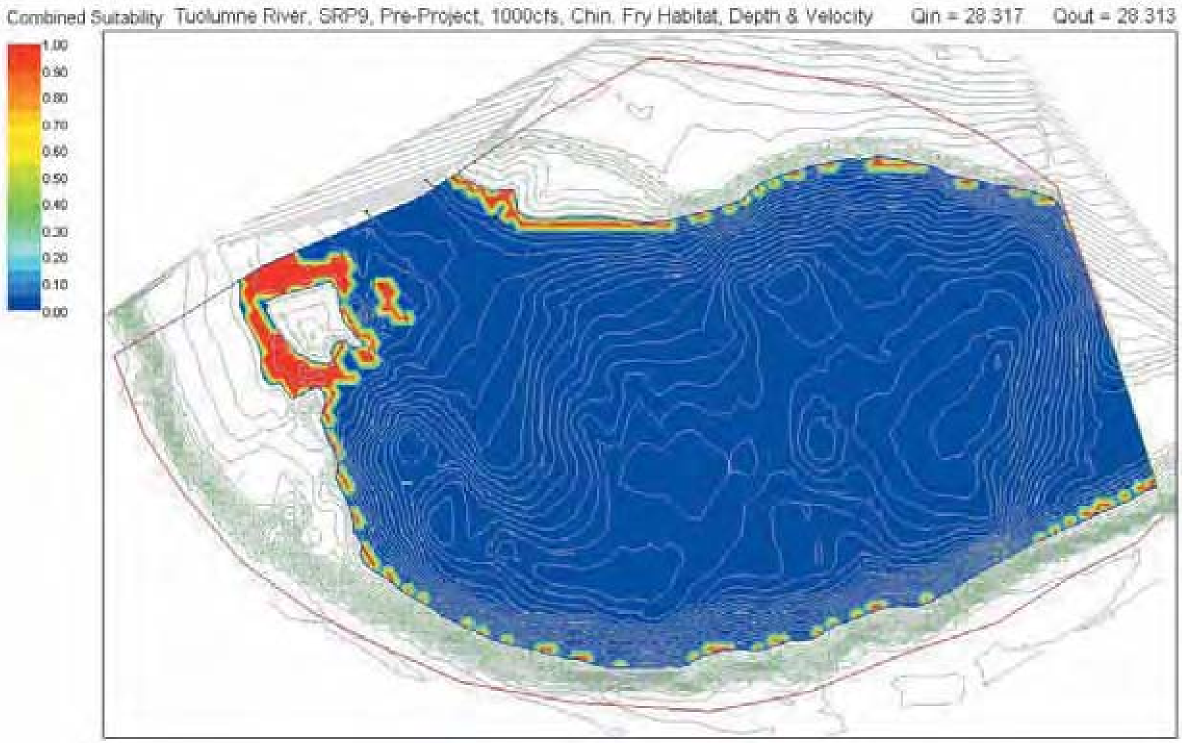

Combined Suitability
Tuolumne River - SRP9, Pre-Project, 5000cfs, SMB, Depth & Velocity
Qin = 141.584
Qout = 141.580
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

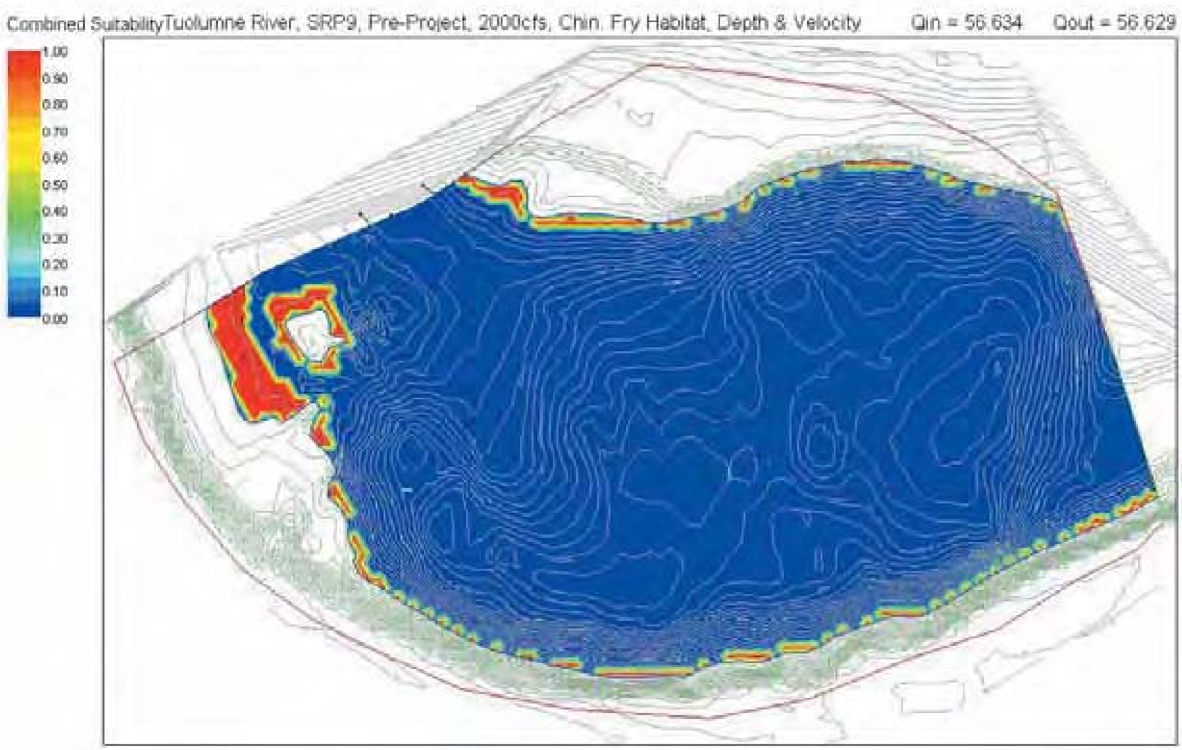

Combined Suitability Tuolumne River, SRP9, Pre-Project, 75cfs, Chin. Fry, Depth & Velocity
Qin = 2.124 Qout = 2.121
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

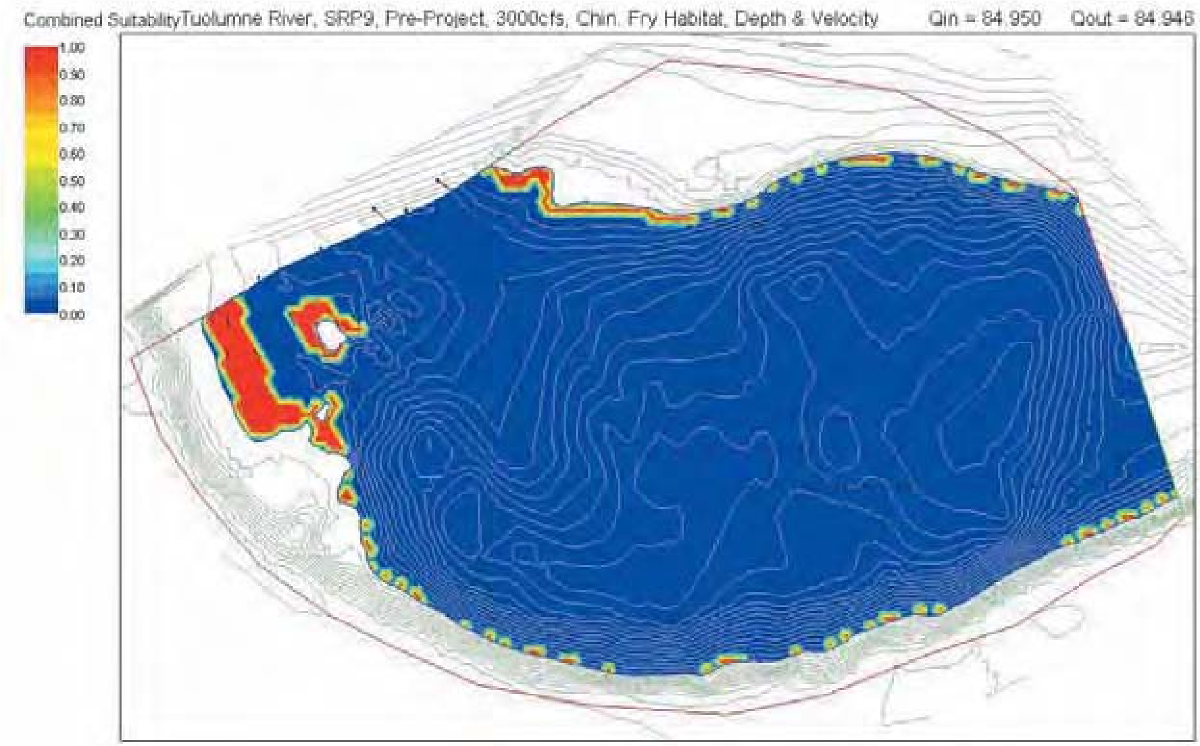

Combined Suitability Tuolumne River, SRP9, Pre-Project, 150cfs, Chin. Fry, Depth & Velocity
Qin = 4.248 Qout = 4.244
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

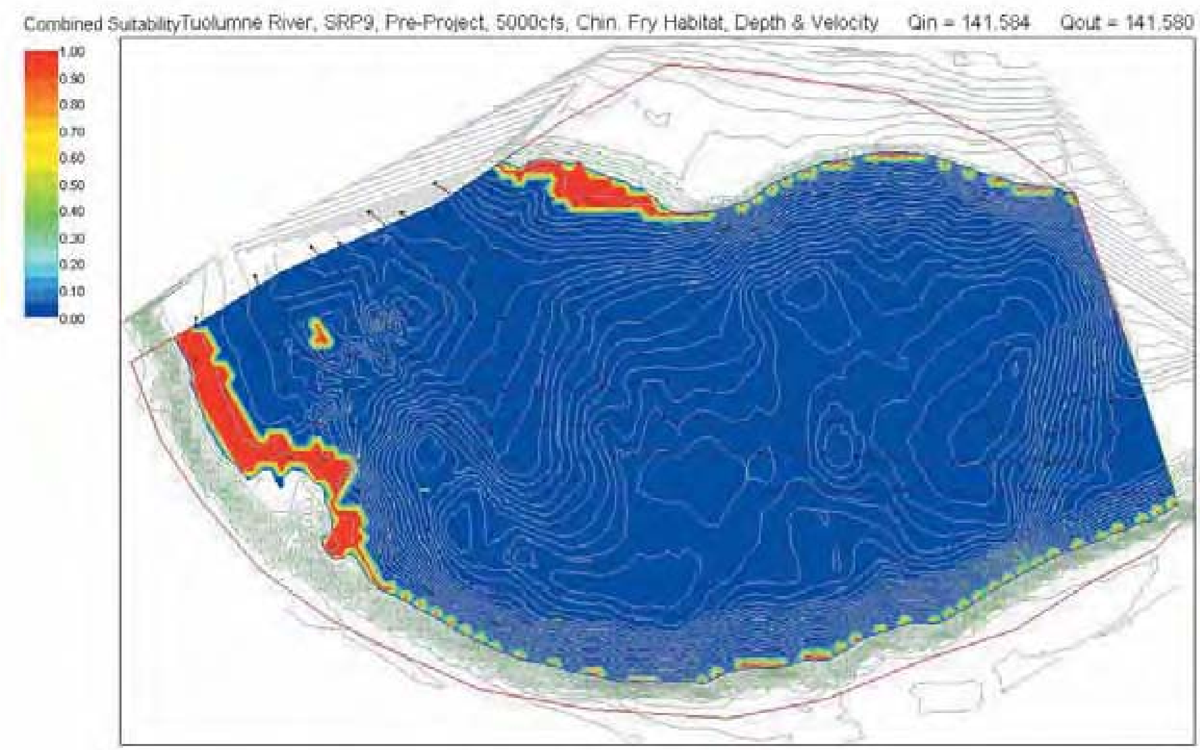

Combined Suitability Tuolumne River, SRP9, Pre-Project, 300cfs, Chin. Fry, Depth & Velocity
Qin = 8.495 Qout = 8.493
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

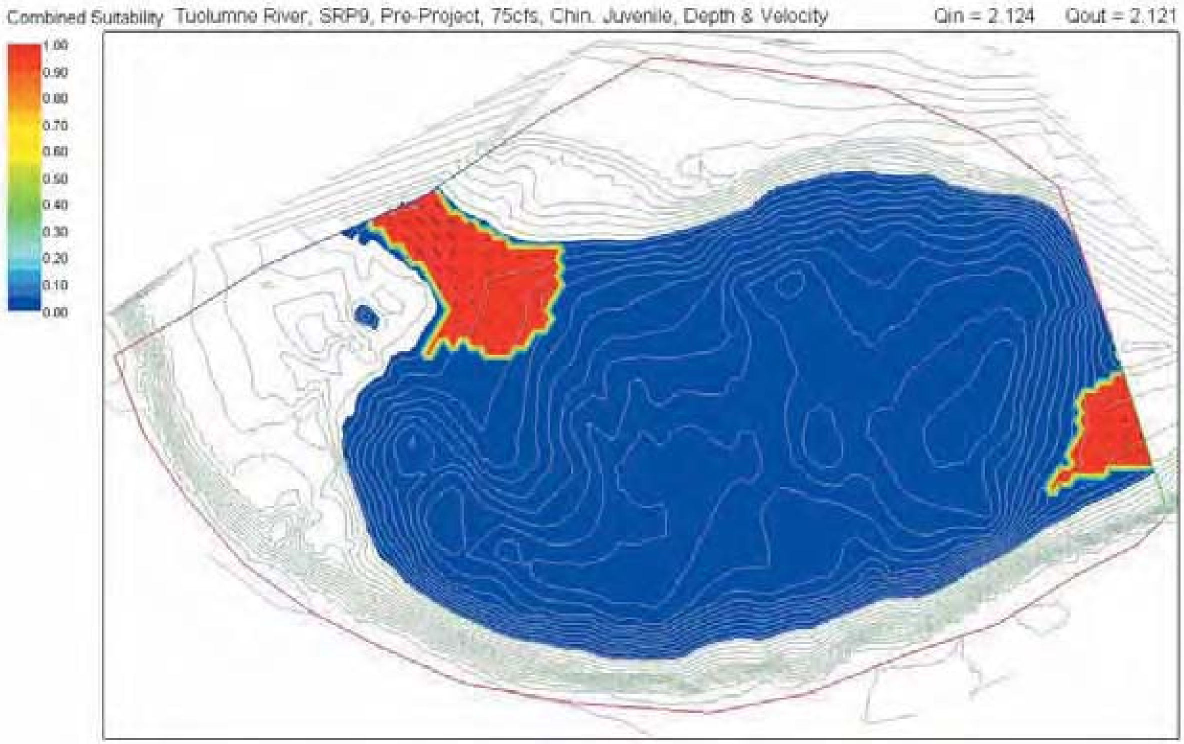

Combined Suitability Tuolumne River, SRP9, Pre-Project, 500cfs, Chin. Fry Habitat, Depth & Velocity
Qin = 14.158 Qout = 14.156
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

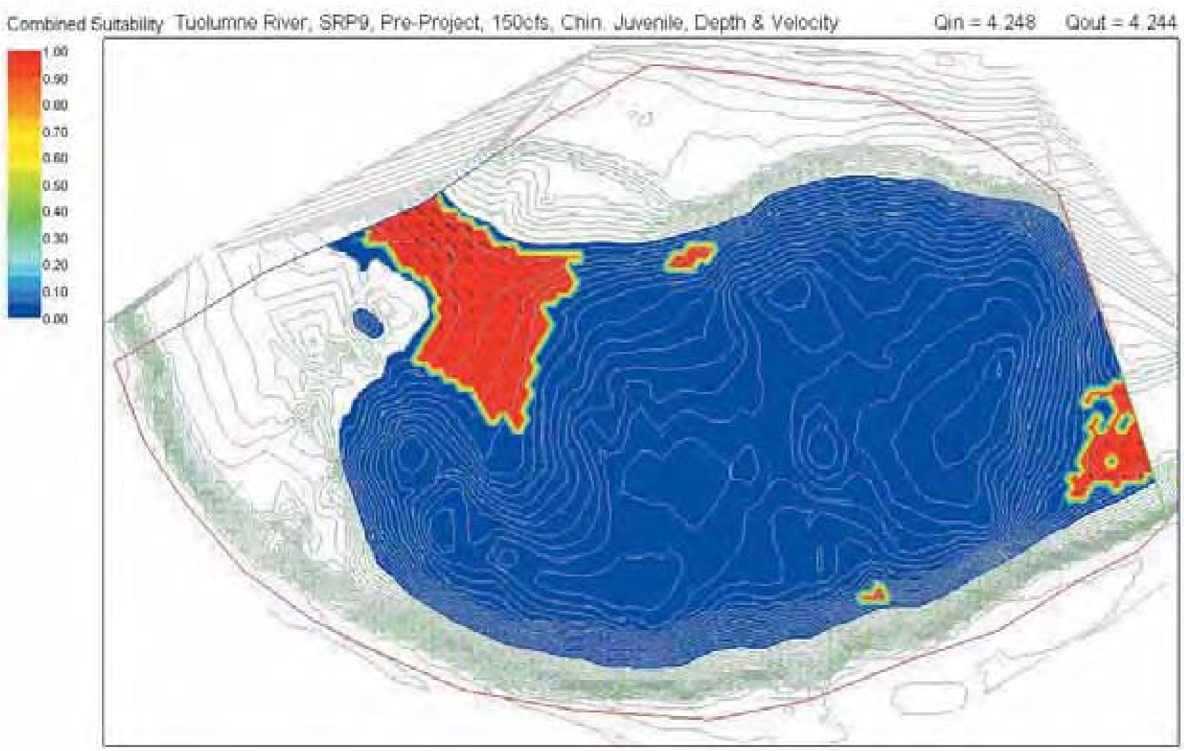

Combined Suitability Tuolumne River, SRP9, Pre-Project, 1000cfs, Chin. Fry Habitat, Depth & Velocity
Qin = 28.317
Qout = 28.313
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

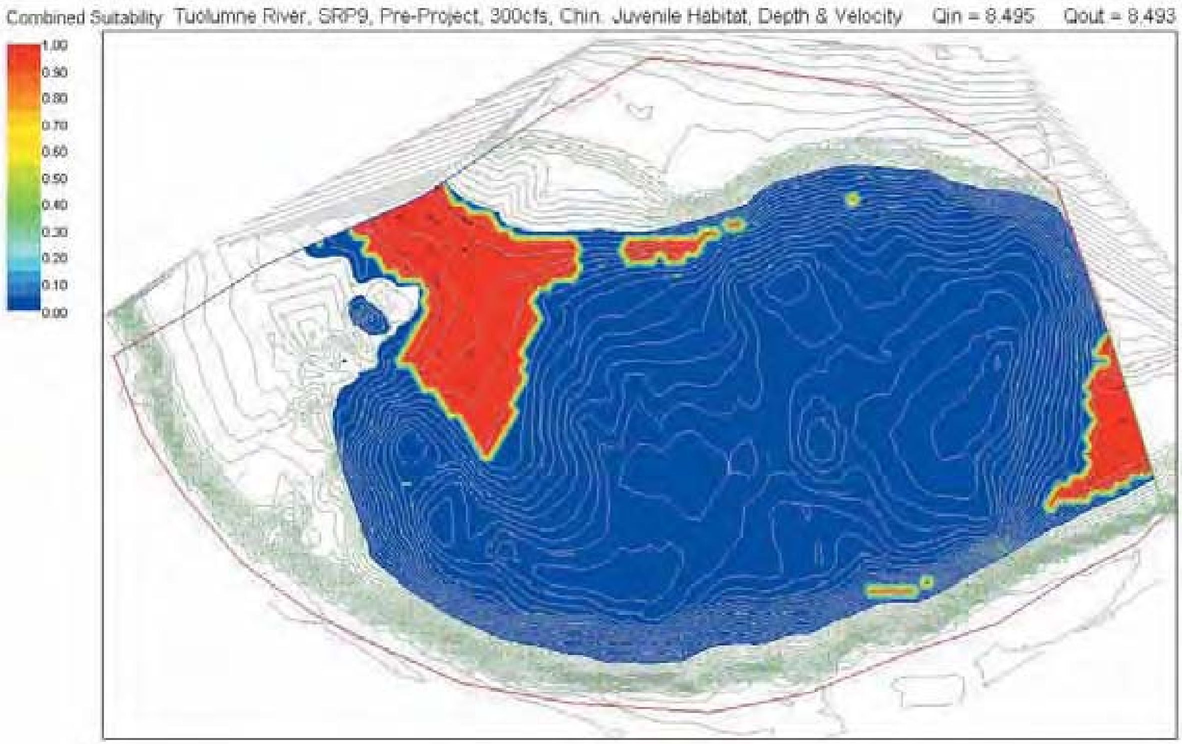

Combined Suitability Tuolumne River, SRP9, Pre-Project, 2000cfs, Chin. Fry Habitat, Depth & Velocity
Qin = 56.634
Qout = 56.629
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

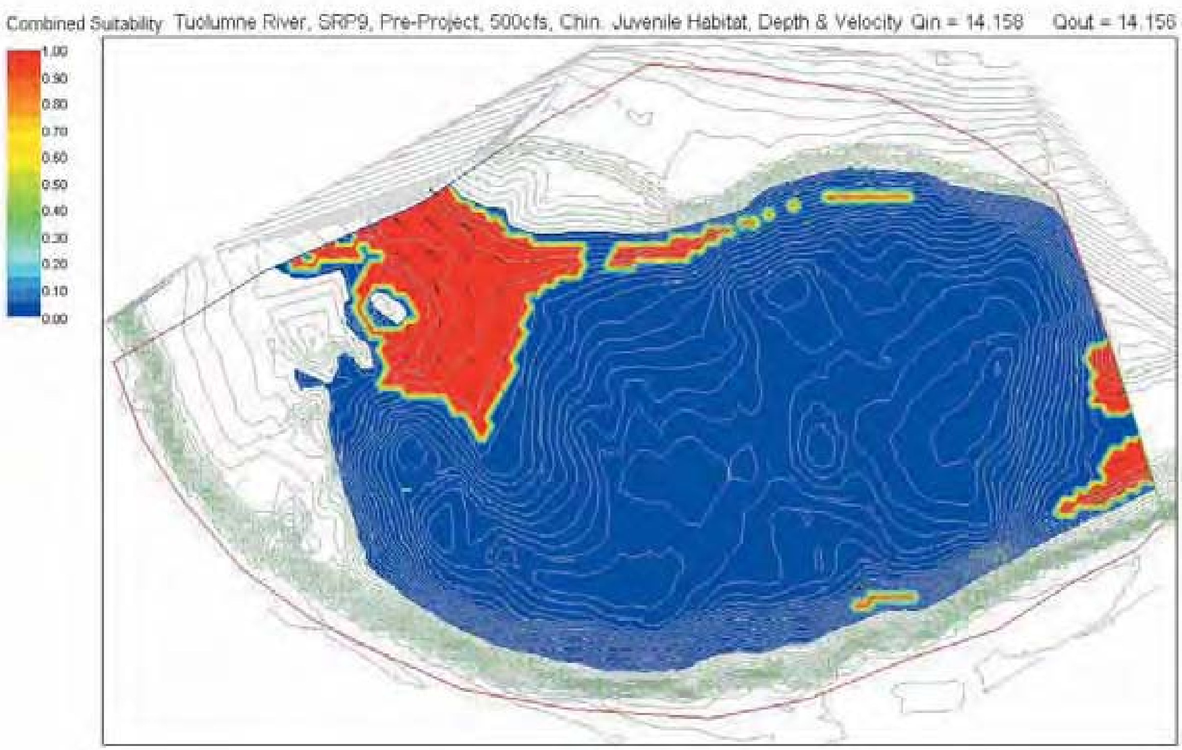

Combined Suitability Tuolumne River, SRP9, Pre-Project, 3000cfs, Chin. Fry Habitat, Depth & Velocity
Qin = 84.950
Qout = 84.946
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

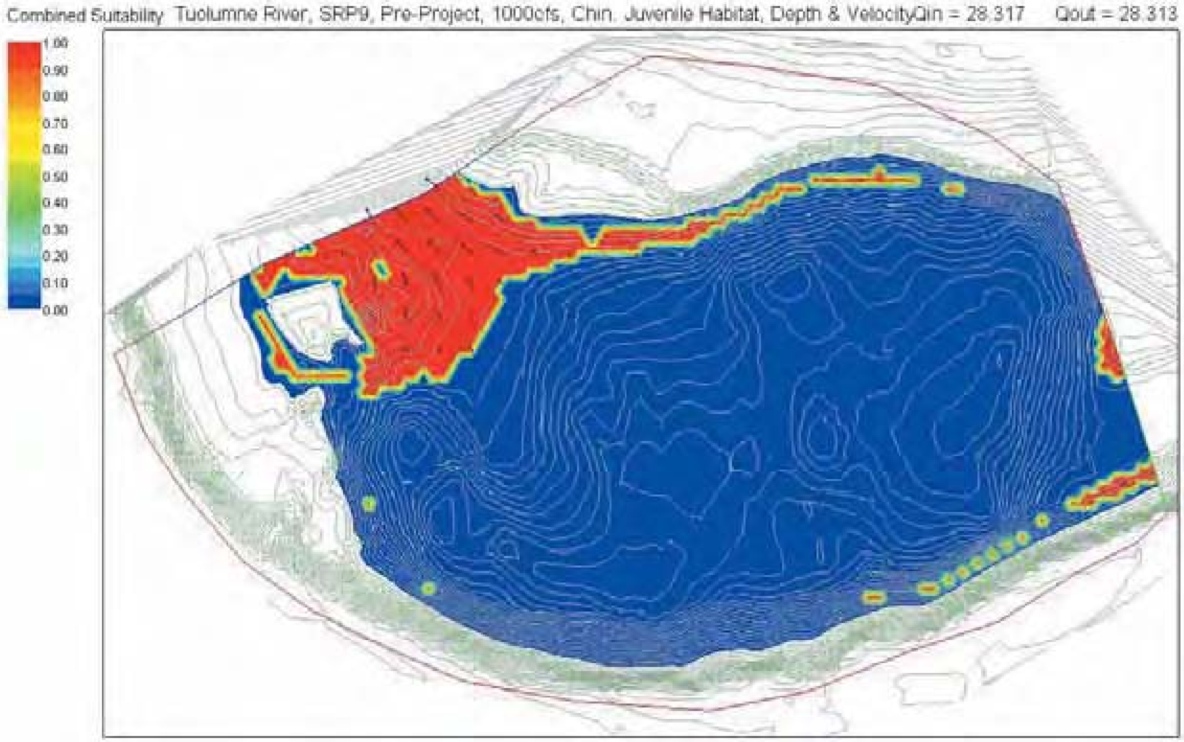

Combined Suitability Tuolumne River, SRP9, Pre-Project, 5000cfs, Chin. Fry Habitat, Depth & Velocity
Qin = 141.584
Qout = 141.580
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

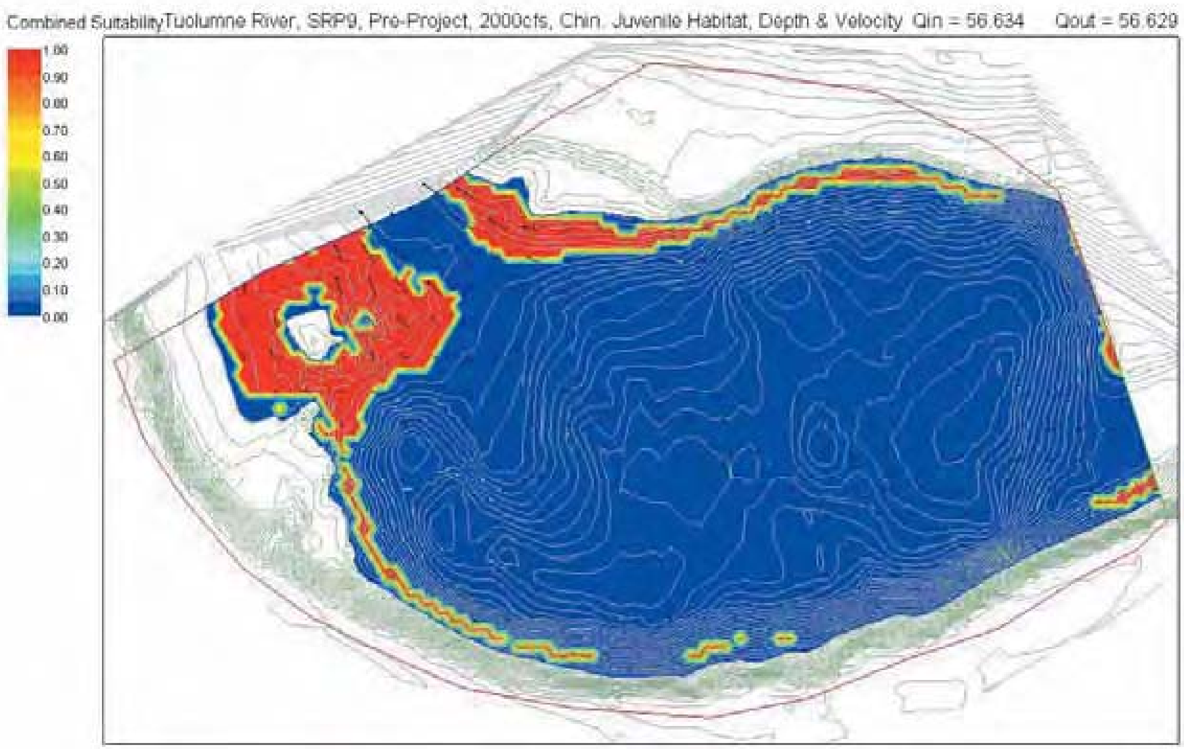

Combined Suitability Tuolumne River, SRP9, Pre-Project, 75cfs, Chin. Juvenile, Depth & Velocity
Qin = 2.124 Qout = 2.121
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

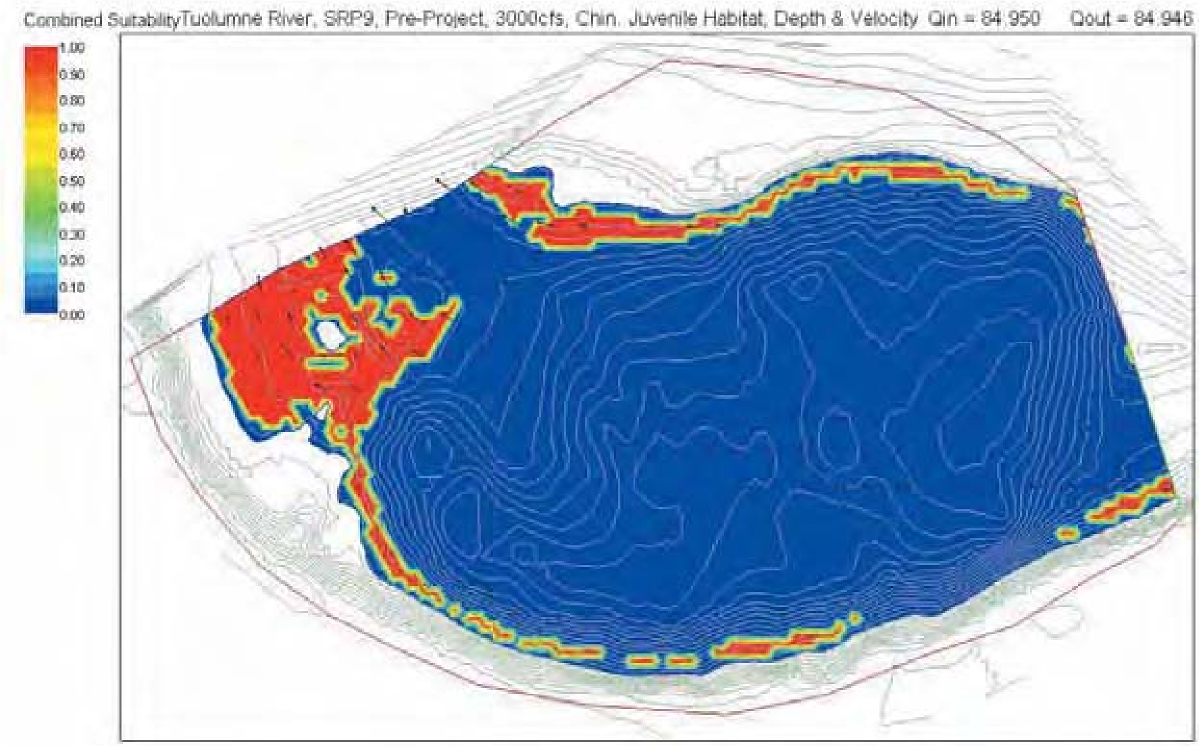

Combined Suitability Tuolumne River, SRP9, Pre-Project, 150cfs, Chin. Juvenile, Depth & Velocity
Qin = 4.248 Qout = 4.244
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

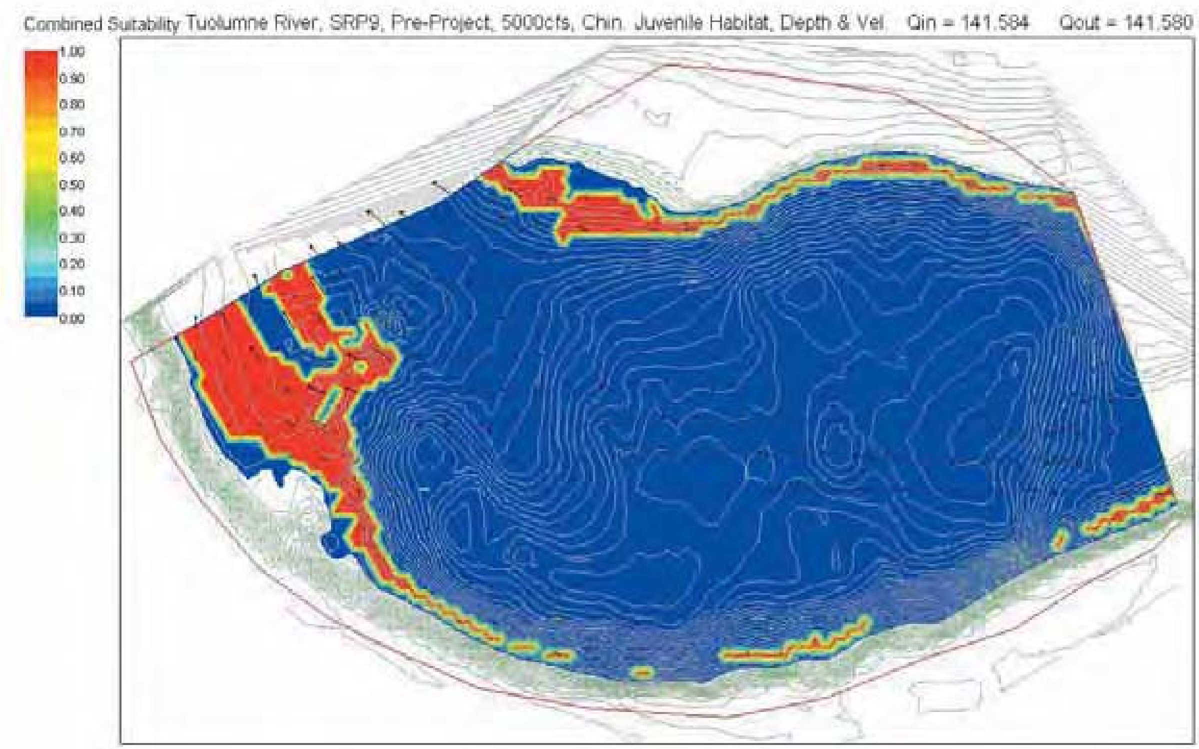

Combined Suitability Tuolumne River, SRP9, Pre-Project, 300cfs, Chin. Juvenile Habitat, Depth & Velocity Qin = 8.495 Qout = 8.493
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

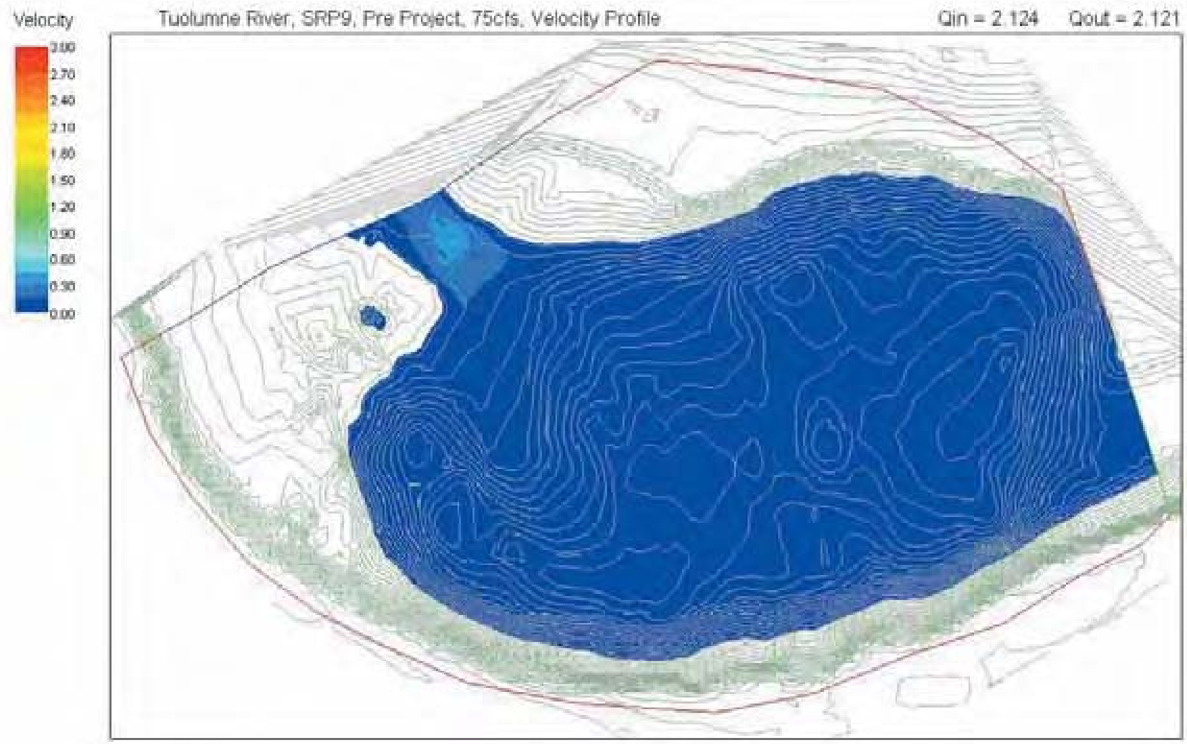

Combined Suitability Tuolumne River, SRP9, Pre-Project, 500cfs, Chin. Juvenile Habitat, Depth & Velocity Qin = 14.158 Qout = 14.156
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

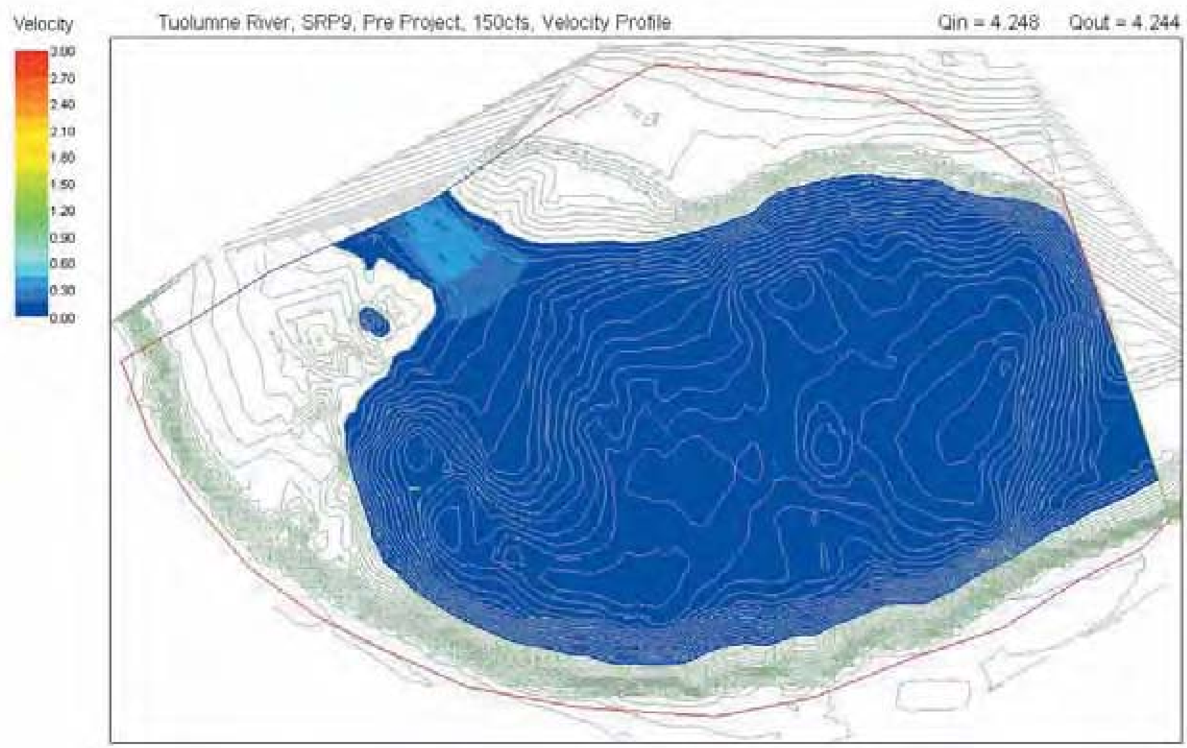

Combined Suitability Tuolumne River, SRP9, Pre-Project, 1000cfs, Chin. Juvenile Habitat, Depth & VelocityQin = 28.317 Qout = 28.313
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

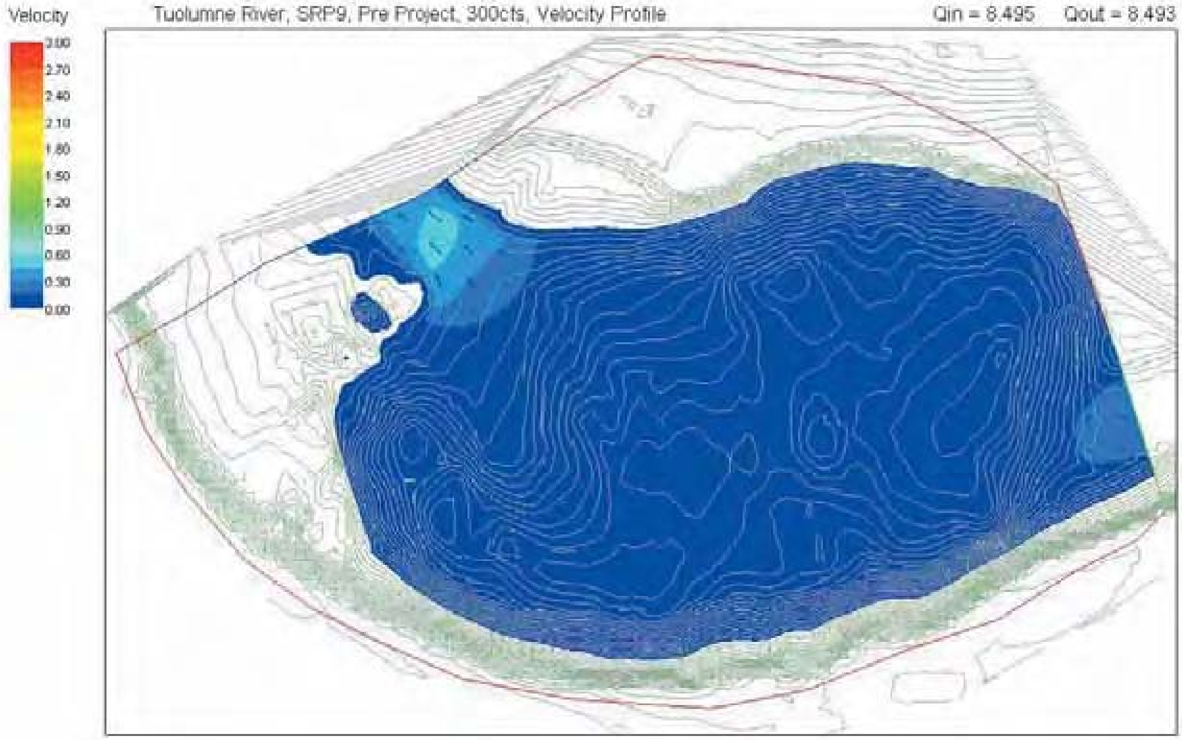

Combined SuitabilityTuolumne River, SRP9, Pre-Project, 2000cfs, Chin. Juvenile Habitat, Depth & Velocity Qin = 56.634 Qout = 56.629
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

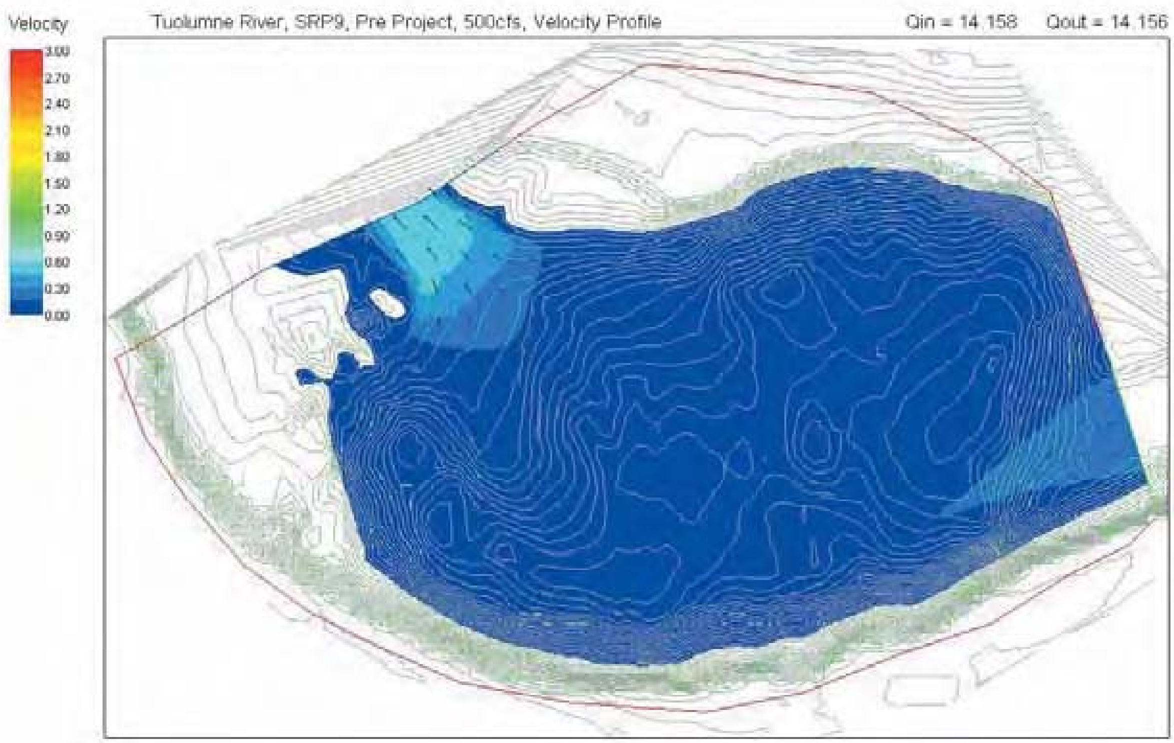

Combined Suitability Tuolumne River, SRP9, Pre-Project, 3000cfs, Chin. Juvenile Habitat, Depth & Velocity Qin = 84.950 Qout = 84.946
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

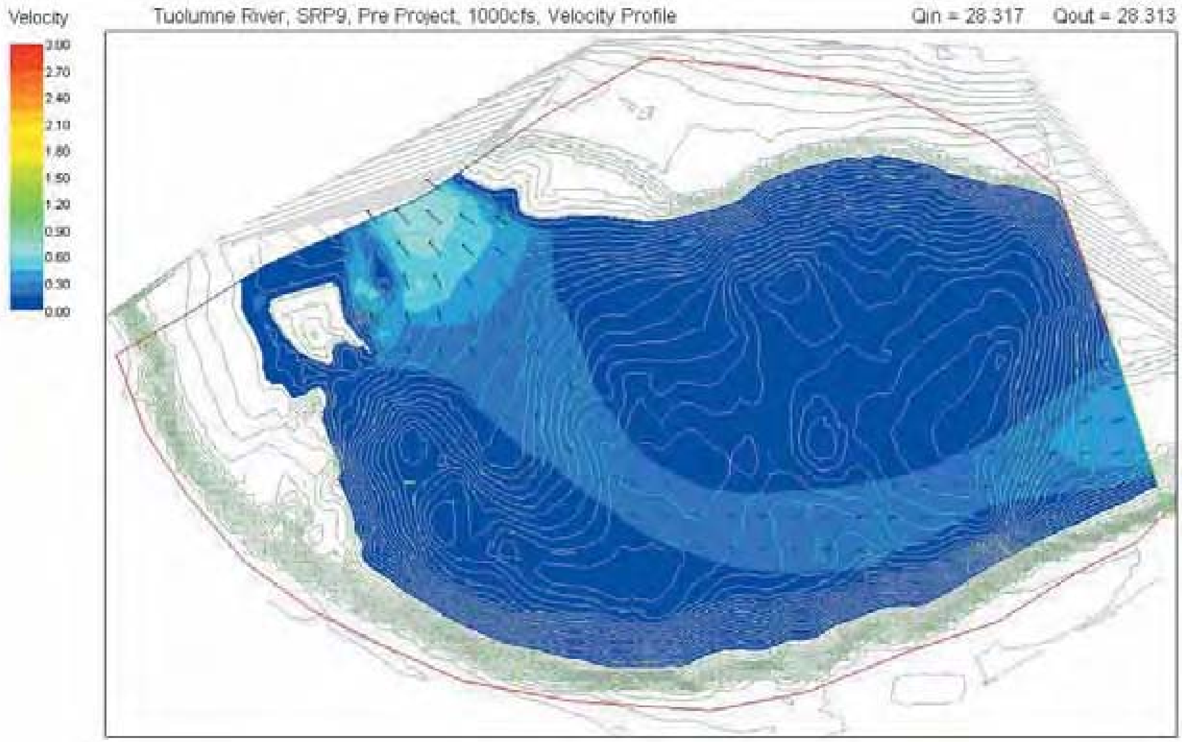

Combined Suitability Tuolumne River, SRP9, Pre-Project, 5000cfs, Chin. Juvenile Habitat, Depth & Vel. Qin = 141.584 Qout = 141.580
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

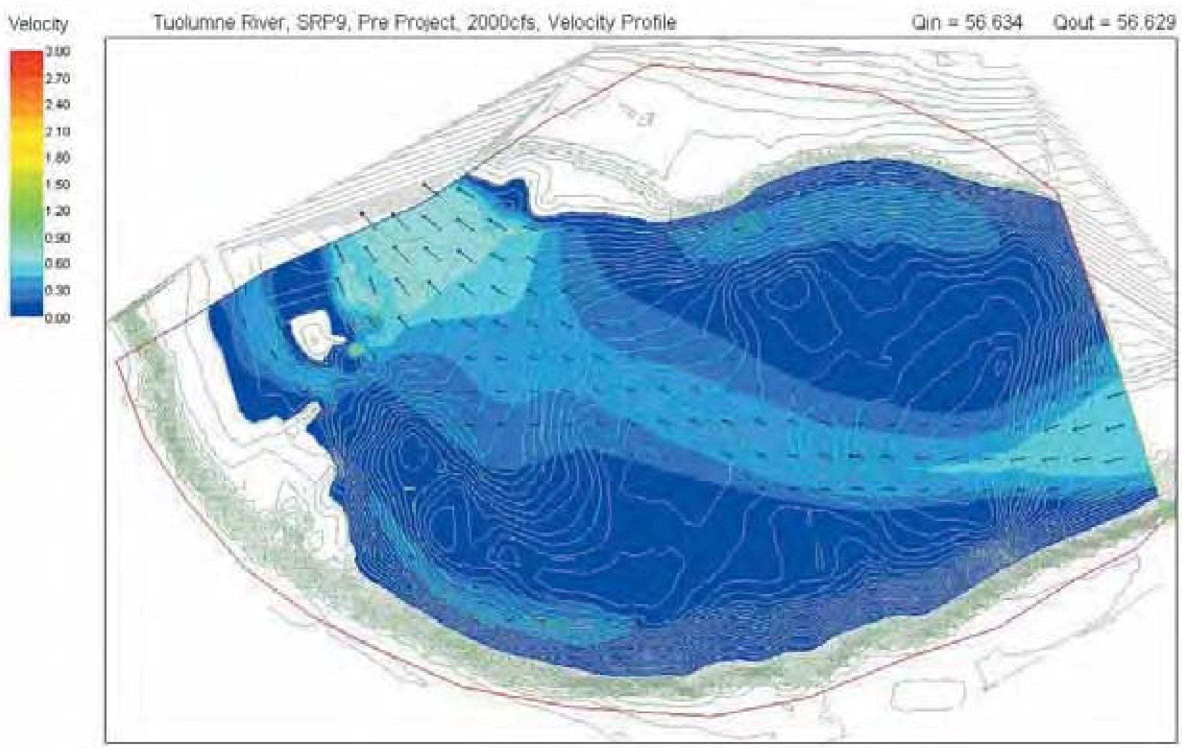

Velocity
3.00
2.70
2.40
2.10
1.80
1.50
1.20
0.90
0.60
0.30
0.00
Tuolumne River, SRP9, Pre Project, 75cfs, Velocity Profile
Qin = 2.124
Qout = 2.121

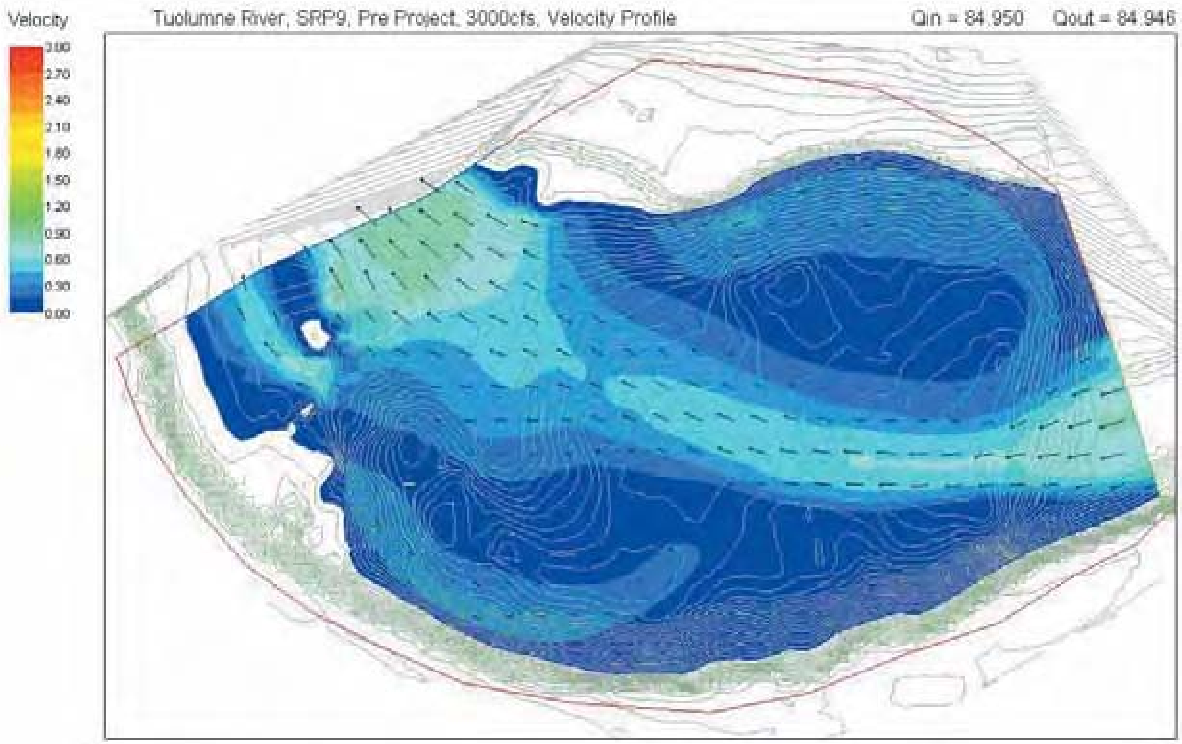

Velocity
3.00
2.70
2.40
2.10
1.80
1.50
1.20
0.90
0.60
0.30
0.00
Tuolumne River, SRP9, Pre Project, 150cfs, Velocity Profile
Qin = 4.248
Qout = 4.244

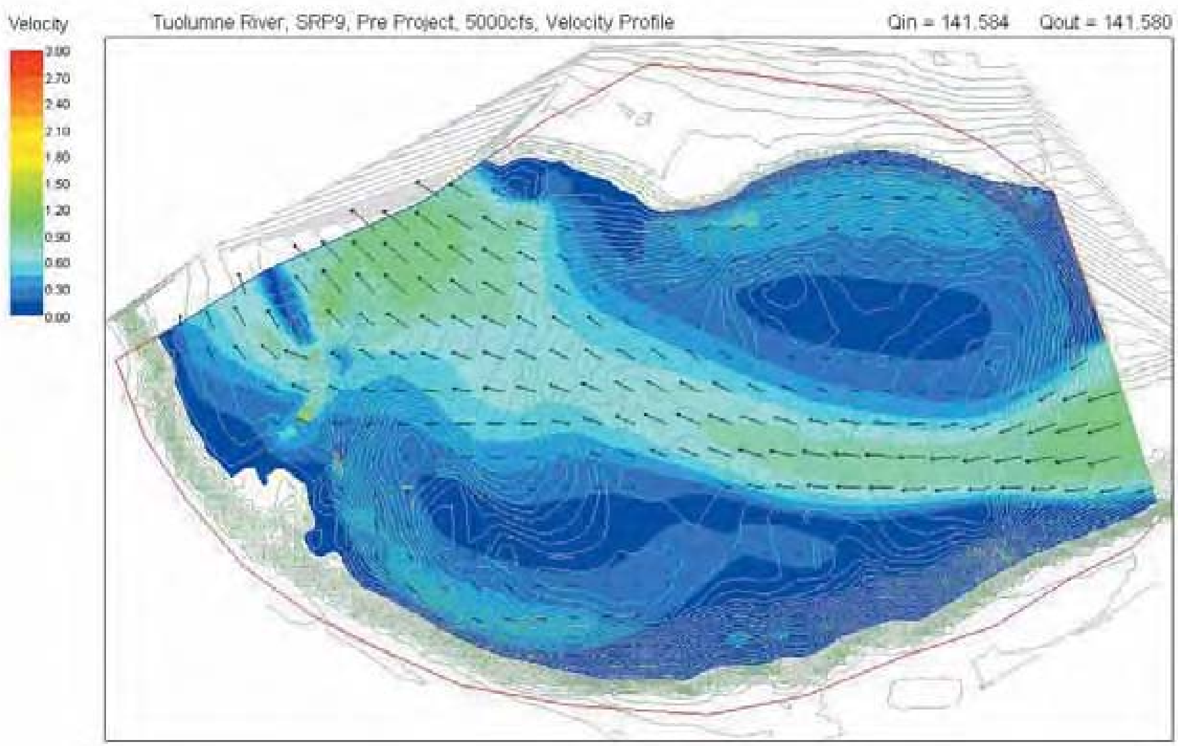

Velocity
3.00
2.70
2.40
2.10
1.80
1.50
1.20
0.90
0.60
0.30
0.00
Tuolumne River, SRP9, Pre Project, 300cfs, Velocity Profile
Qin = 8.495
Qout = 8.493


Velocity
3.00
2.70
2.40
2.10
1.80
1.50
1.20
0.90
0.60
0.30
0.00
Tuolumne River, SRP9, Pre Project, 500cfs, Velocity Profile
Qin = 14.158
Qout = 14.156


Velocity
3.00
2.70
2.40
2.10
1.80
1.50
1.20
0.90
0.60
0.30
0.00
Tuolumne River, SRP9, Pre Project, 1000cfs, Velocity Profile
Qin = 28.317
Qout = 28.313

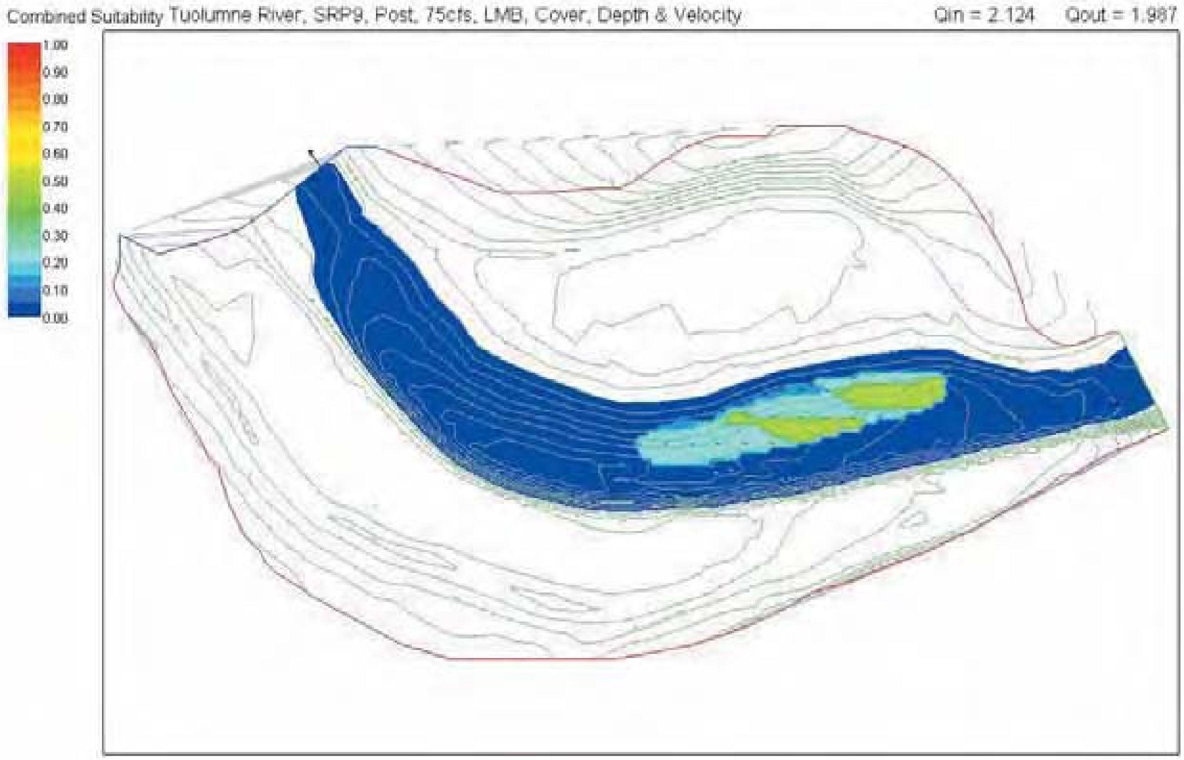

Velocity
3.00
2.70
2.40
2.10
1.80
1.50
1.20
0.90
0.60
0.30
0.00
Tuolumne River, SRP9, Pre Project, 2000cfs, Velocity Profile
Qin = 56.634
Qout = 56.629

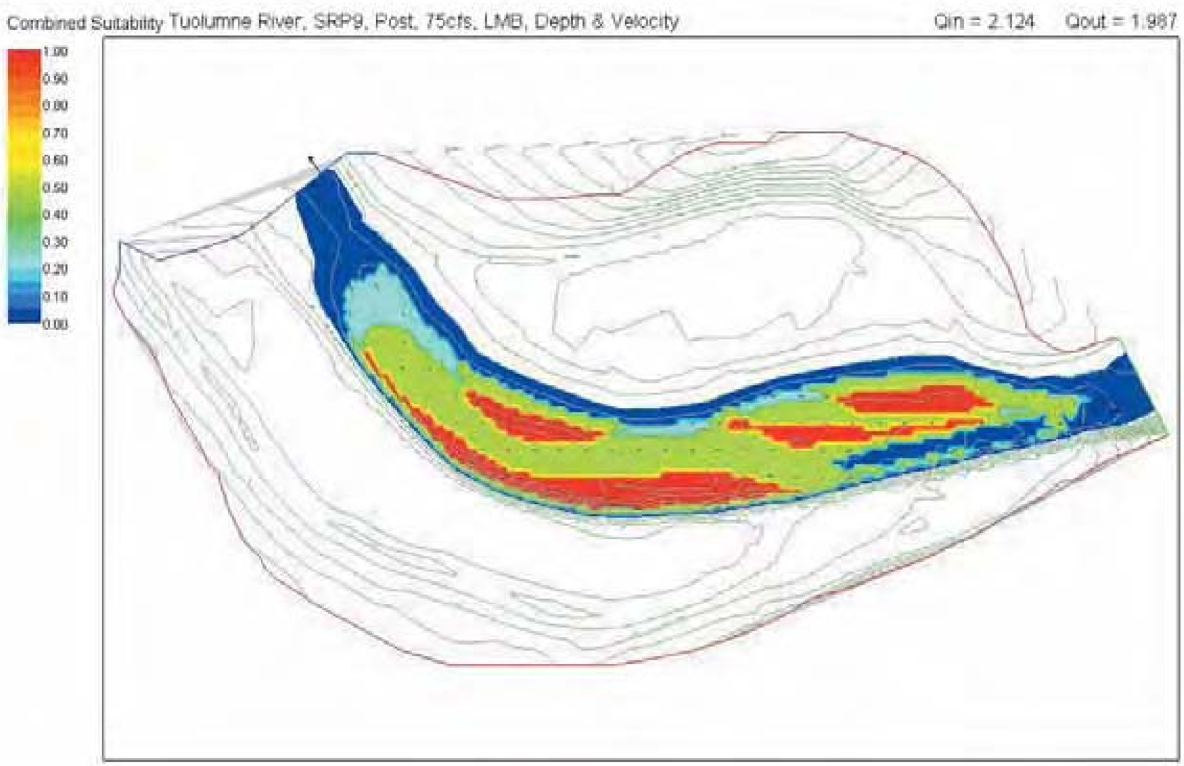

Velocity
3.00
2.70
2.40
2.10
1.80
1.50
1.20
0.90
0.60
0.30
0.00
Tuolumne River, SRP9, Pre Project, 3000cfs, Velocity Profile
Qin = 84.950
Qout = 84.946

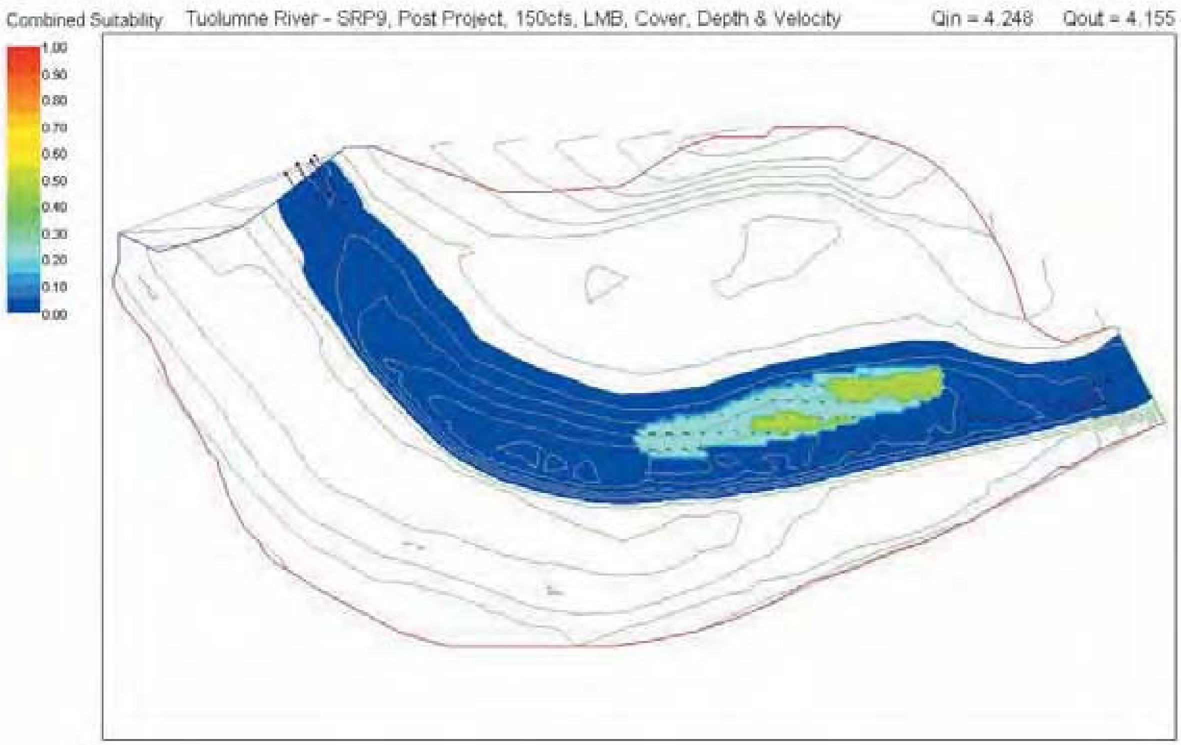

Velocity
3.00
2.70
2.40
2.10
1.80
1.50
1.20
0.90
0.60
0.30
0.00
Tuolumne River, SRP9, Pre Project, 5000cfs, Velocity Profile
Qin = 141.584
Qout = 141.580

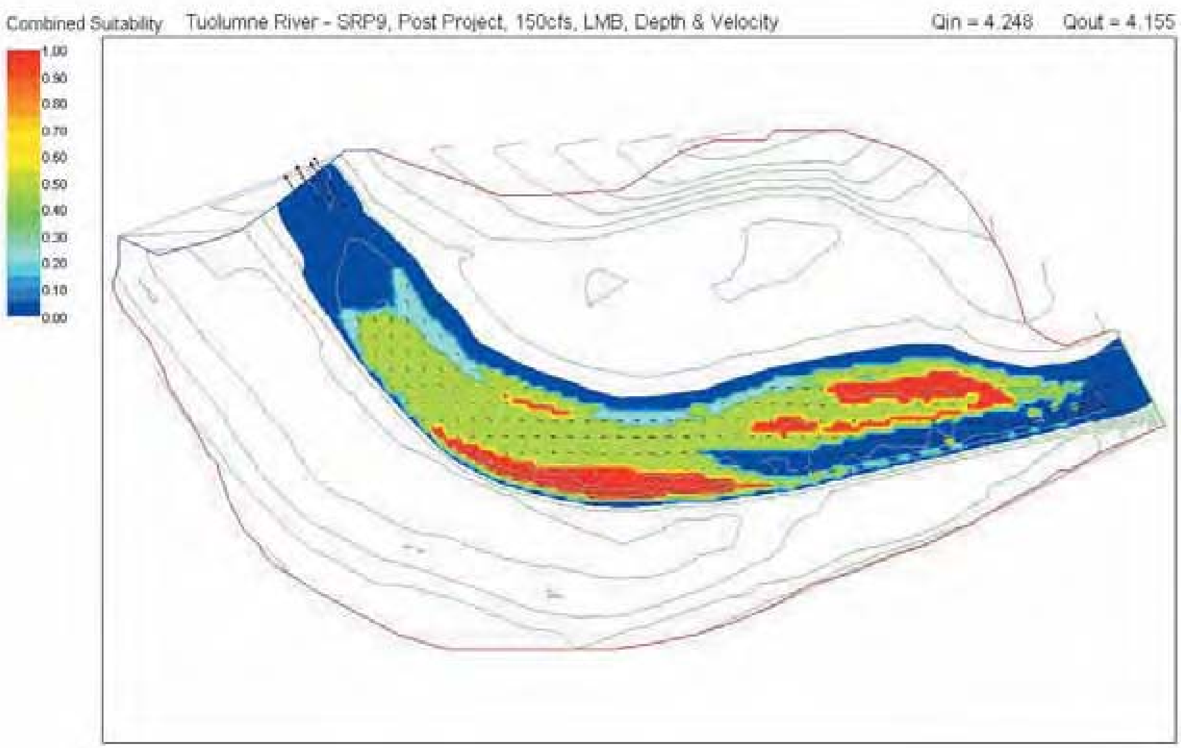
Appendix E

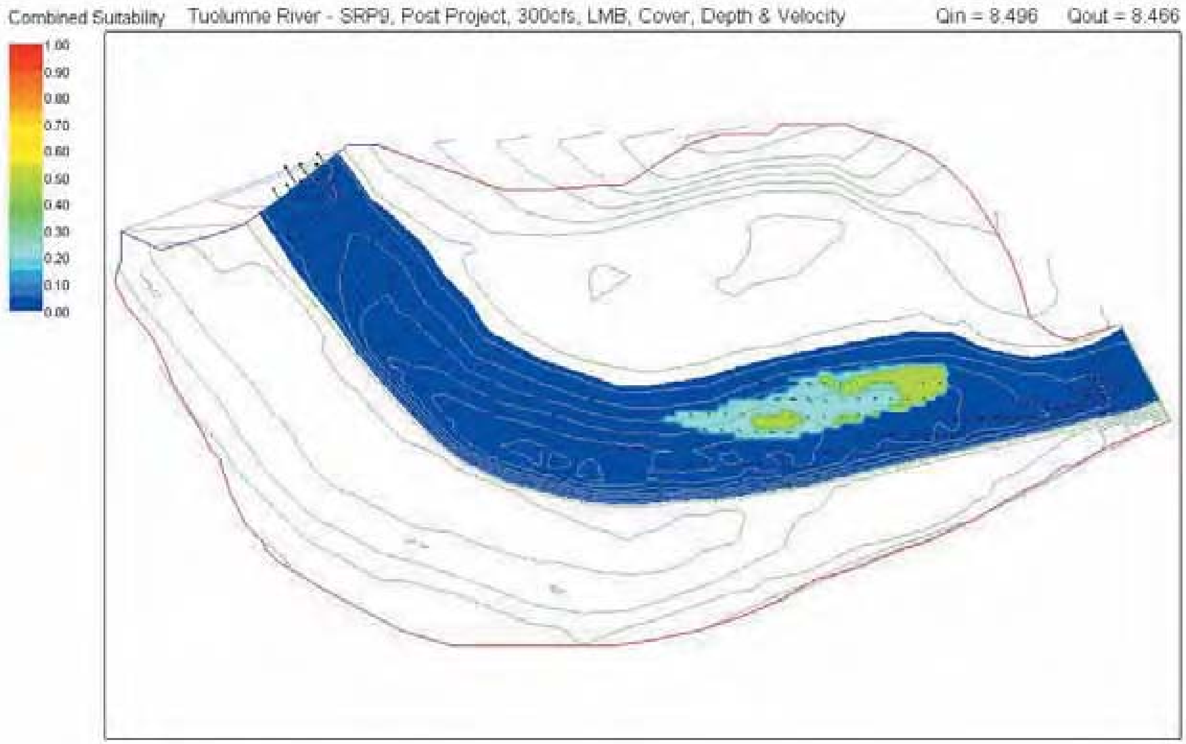
Predicted Largemouth Bass, Smallmouth Bass, and Chinook Salmon Habitat at SRP 9 Post-project.

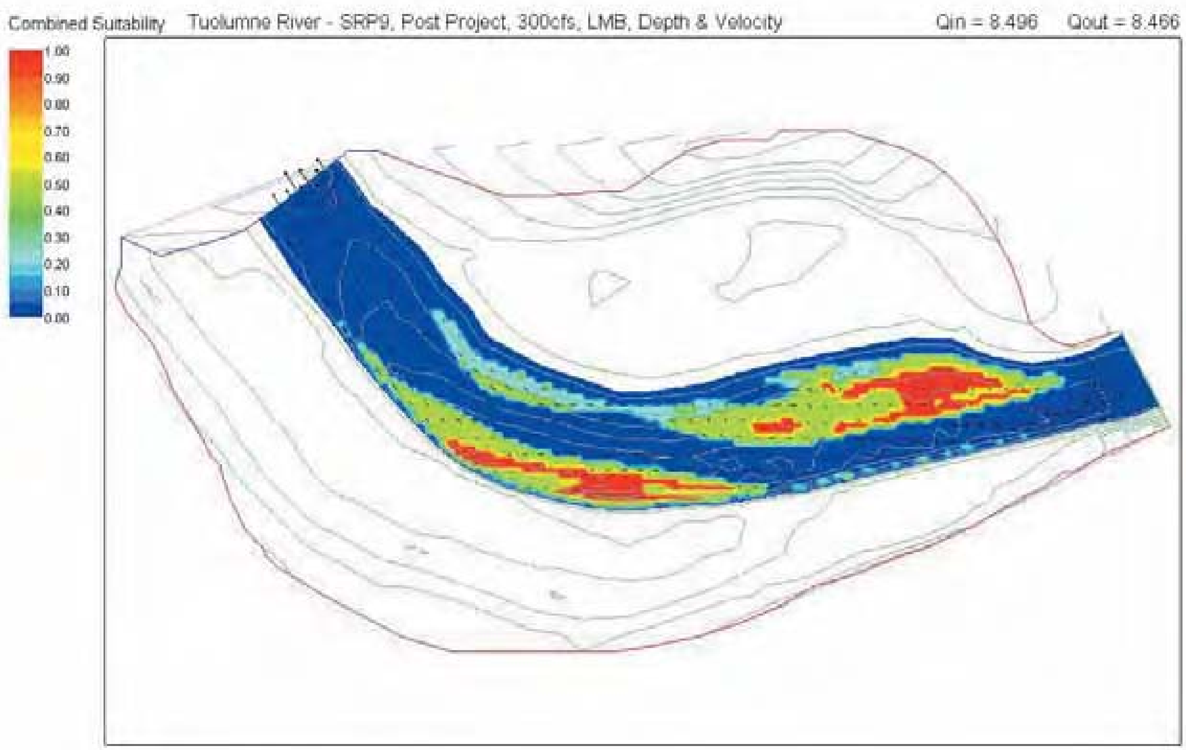

Combined Suitability Tuolumne River, SRP9, Post, 75cfs, LMB, Cover, Depth & Velocity
Qin = 2.124 Qout = 1.987
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

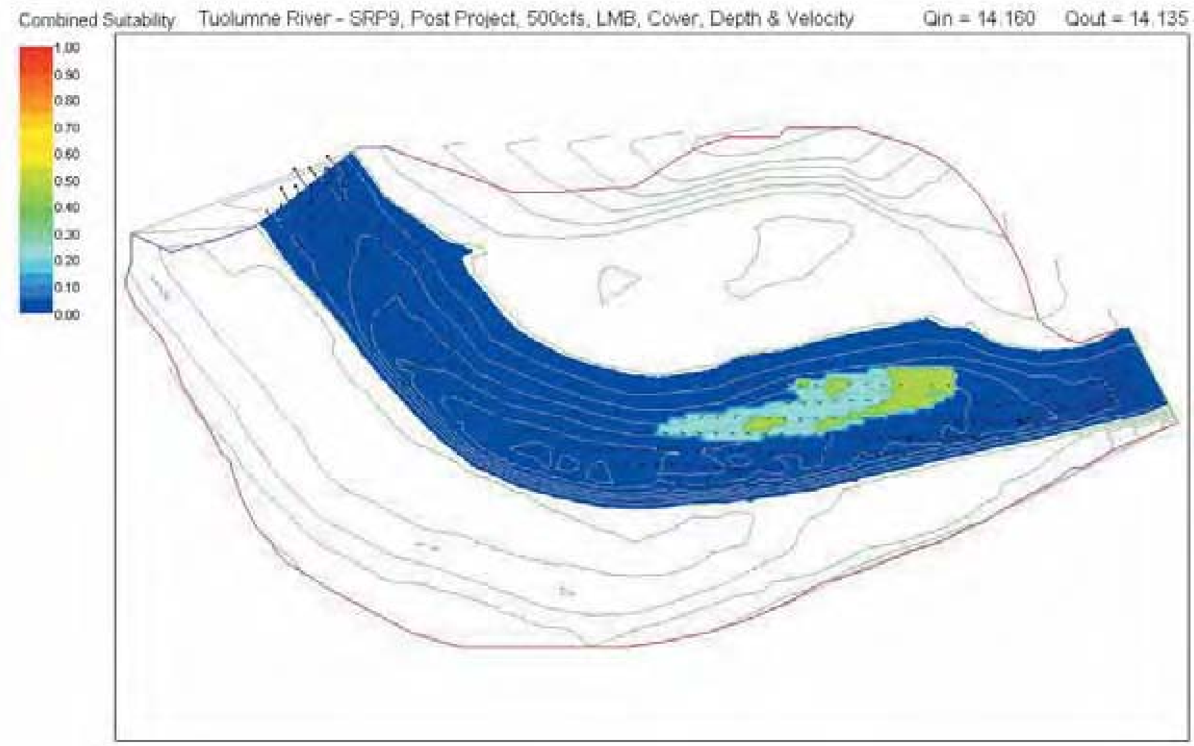

Combined Suitability Tuolumne River, SRP9, Post, 75cfs, LMB, Depth & Velocity
Qin = 2.124 Qout = 1.987
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

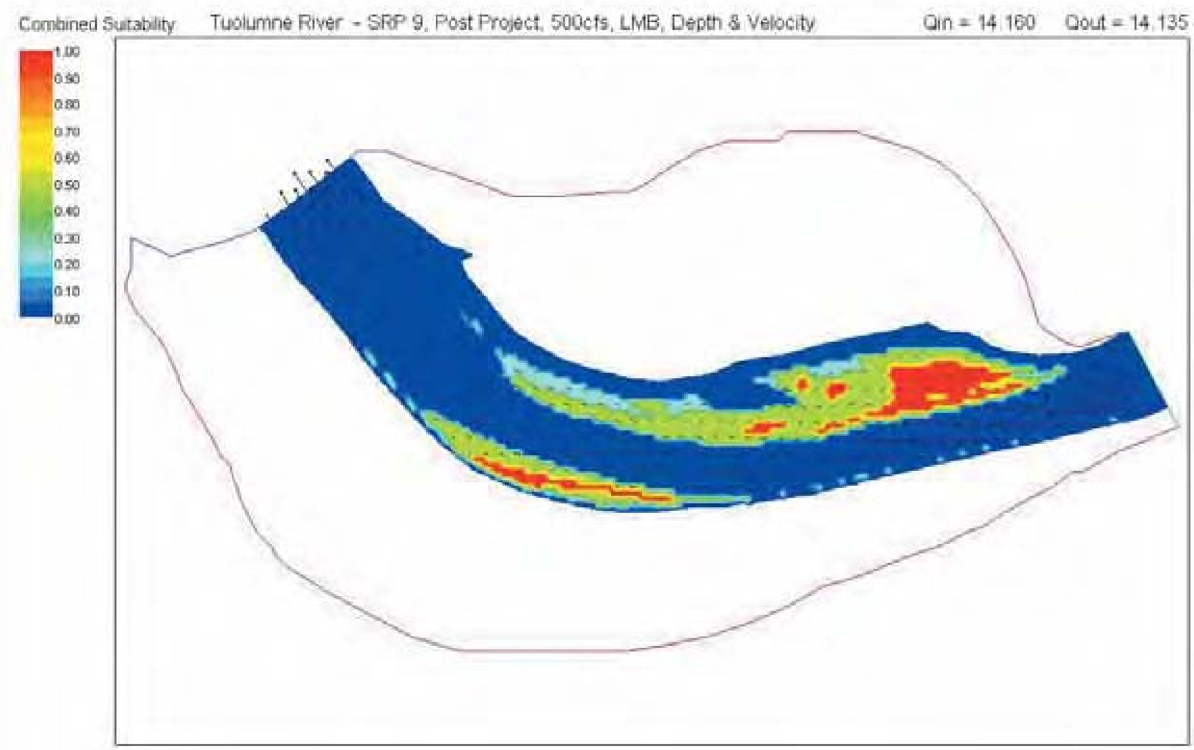

Combined Suitability
Tuolumne River - SRP9, Post Project, 150cfs, LMB, Cover, Depth & Velocity
Qin = 4.248 Qout = 4.155
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

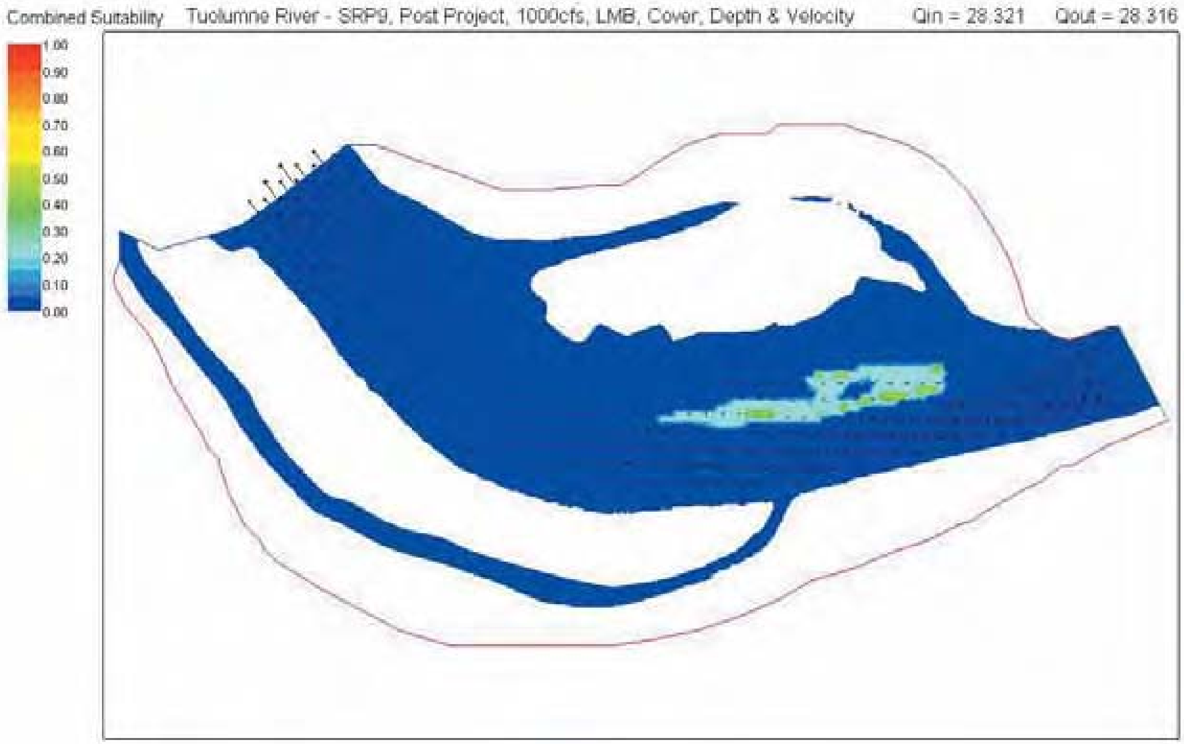

Combined Suitability
Tuolumne River - SRP9, Post Project, 150cfs, LMB, Depth & Velocity
Qin = 4.248 Qout = 4.155
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

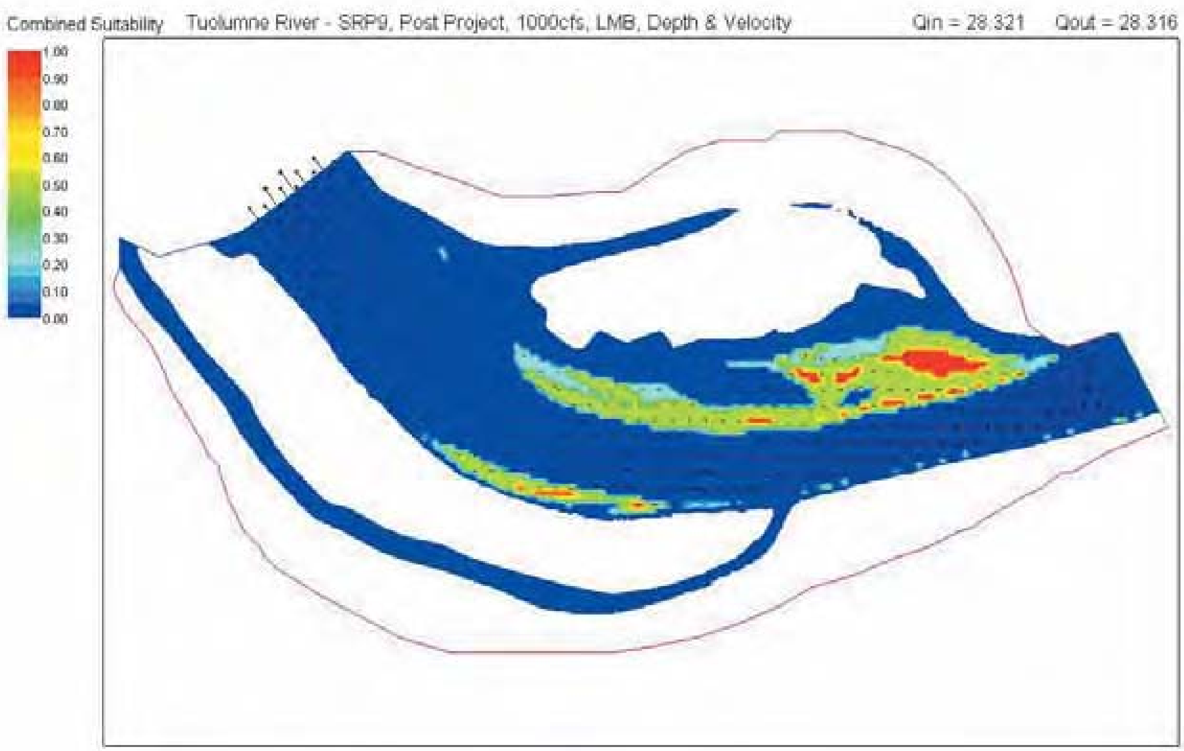

Combined Suitability
Tuolumne River - SRP9, Post Project, 300cfs, LMB, Cover, Depth & Velocity
Qin = 8.496
Qout = 8.466
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

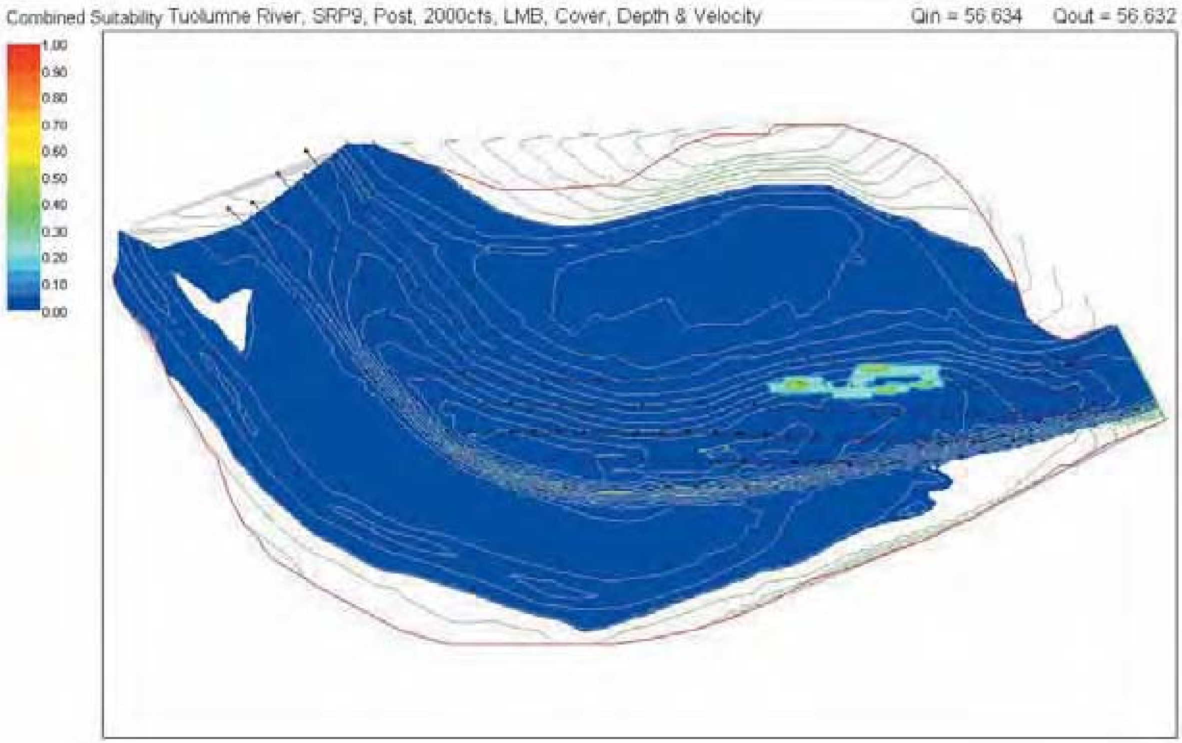

Combined Suitability
Tuolumne River - SRP9, Post Project, 300cfs, LMB, Depth & Velocity
Qin = 8.496
Qout = 8.466
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

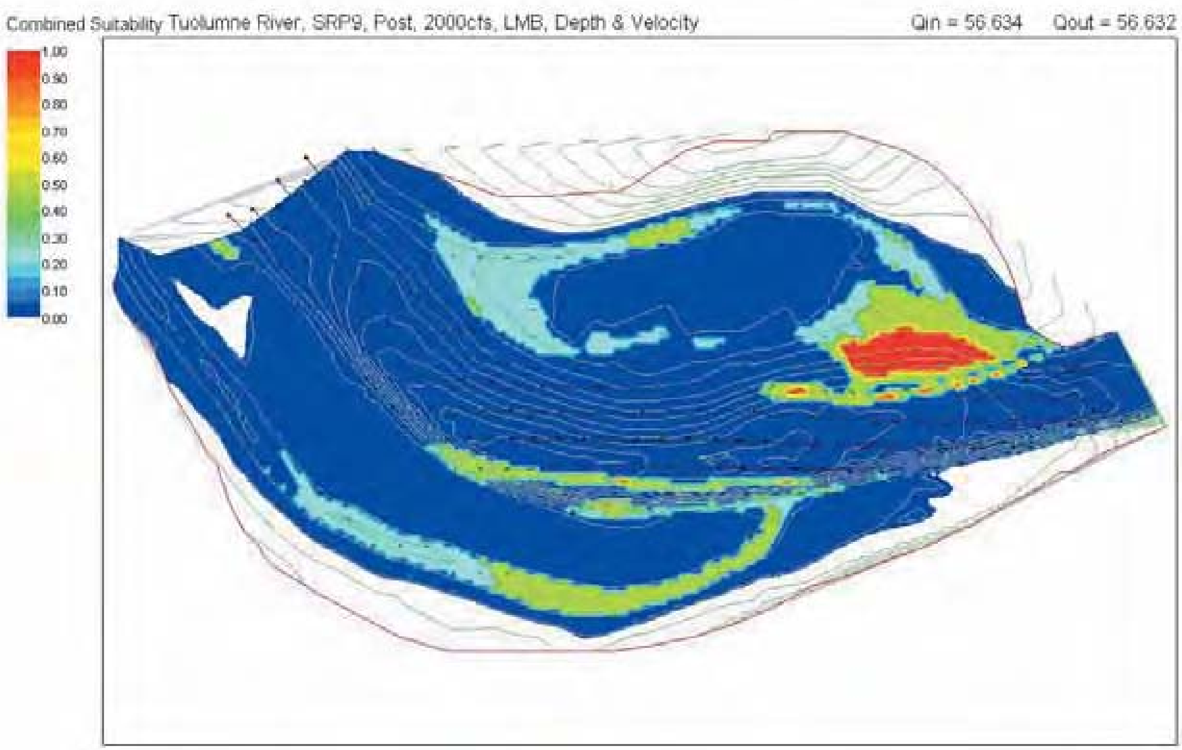

Combined Suitability
Tuolumne River - SRP9, Post Project, 500cfs, LMB, Cover, Depth & Velocity
Qin = 14.160
Qout = 14.135
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

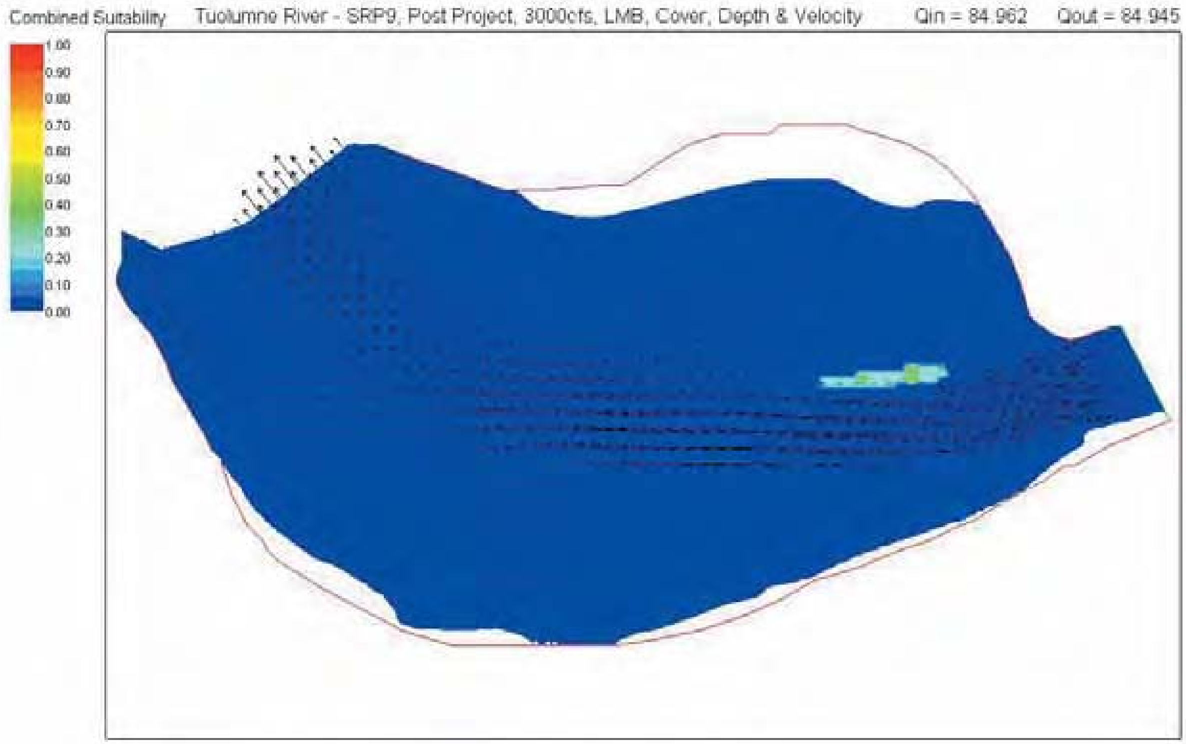

Combined Suitability
Tuolumne River - SRP 9, Post Project, 500cfs, LMB, Depth & Velocity
Qin = 14.160
Qout = 14.135
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

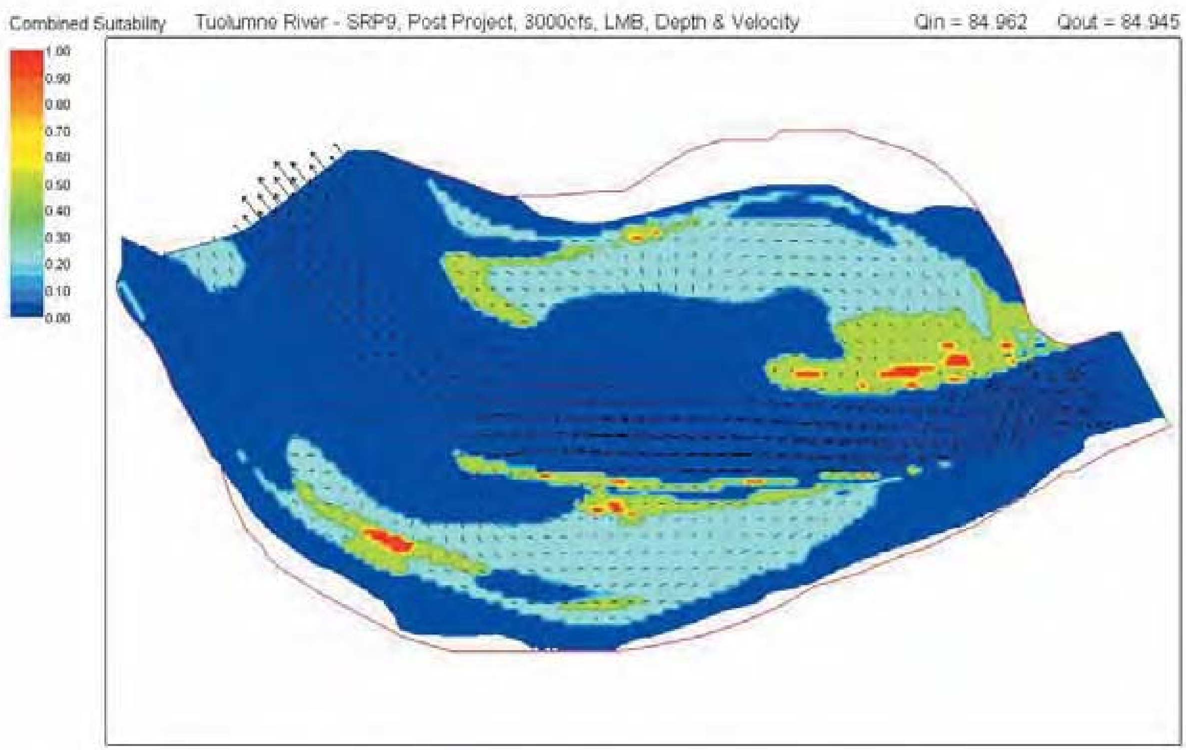

Combined Suitability
Tuolumne River - SRP9, Post Project, 1000cfs, LMB, Cover, Depth & Velocity
Qin = 28.321
Qout = 28.316
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

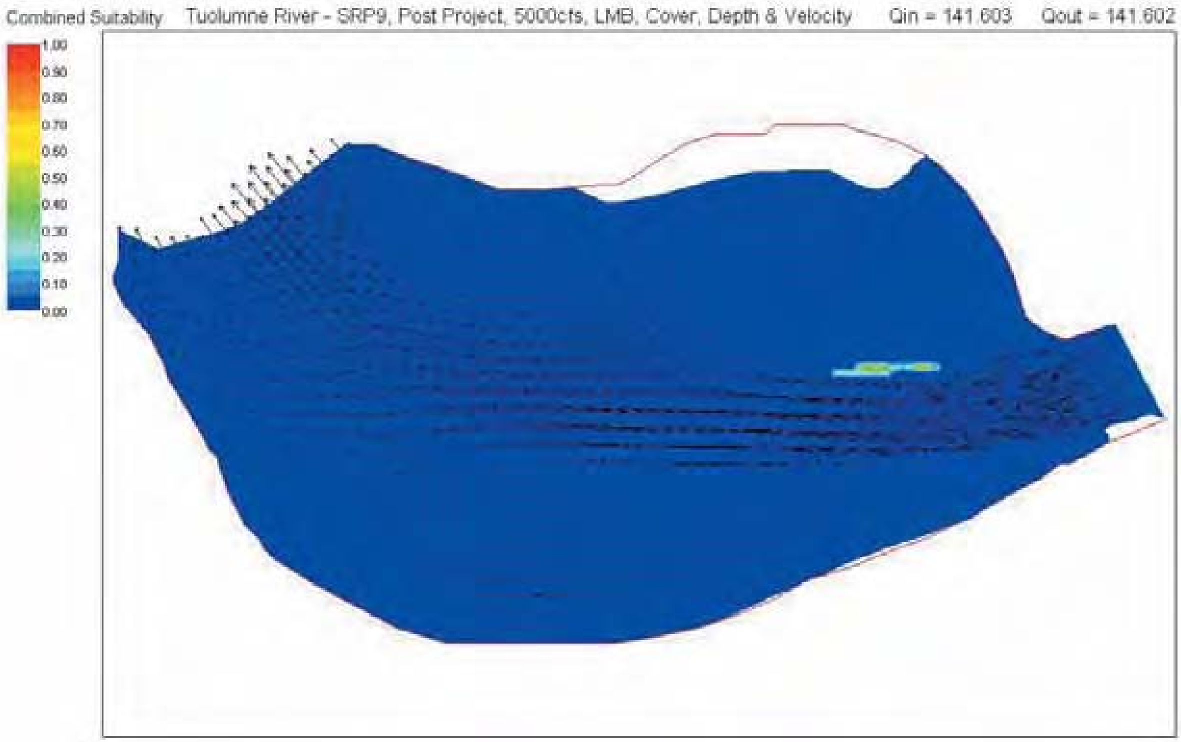

Combined Suitability
Tuolumne River - SRP9, Post Project, 1000cfs, LMB, Depth & Velocity
Qin = 28.321
Qout = 28.316
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

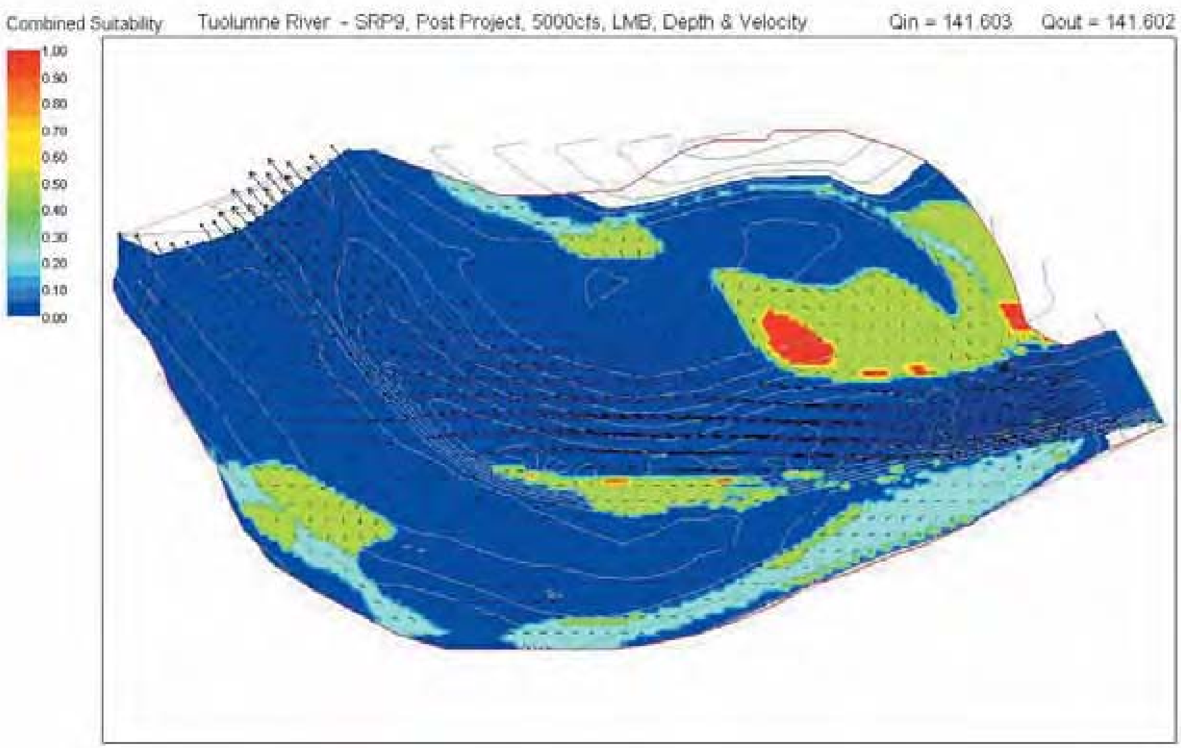

Combined Suitability Tuolumne River, SRP9, Post, 2000cfs, LMB, Cover, Depth & Velocity
Qin = 56.634
Qout = 56.632
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

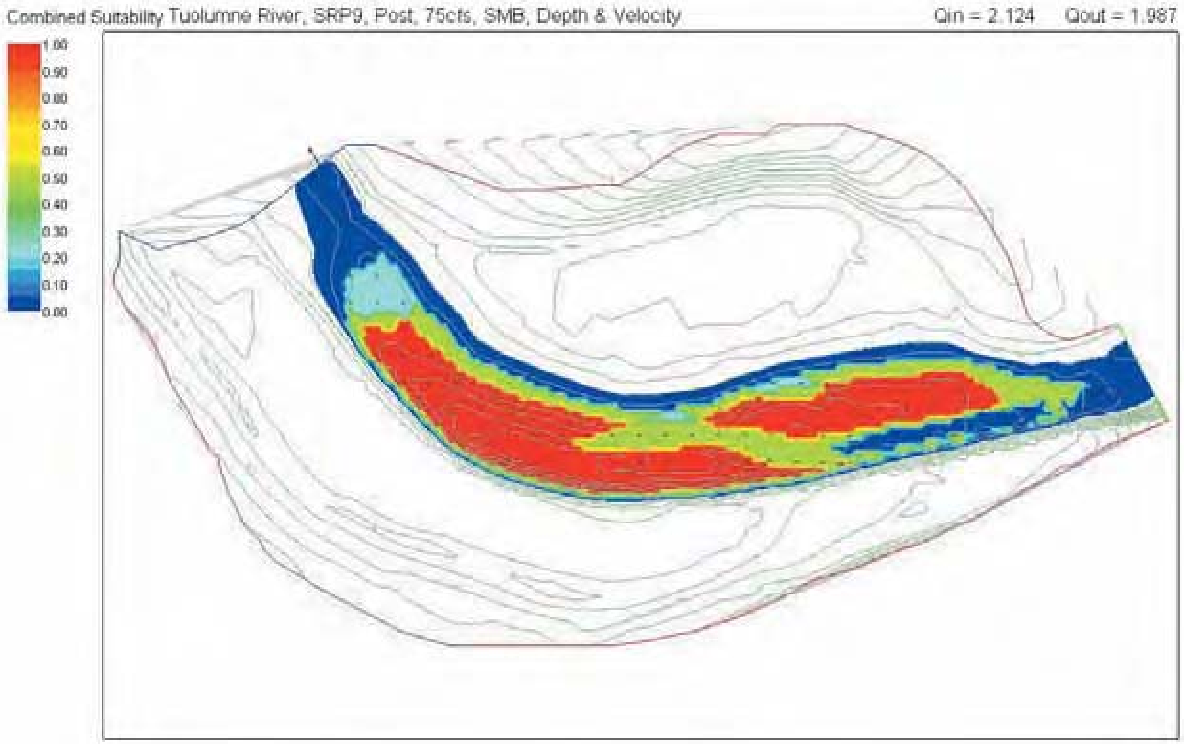

Combined Suitability Tuolumne River, SRP9, Post, 2000cfs, LMB, Depth & Velocity
Qin = 56.634
Qout = 56.632
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

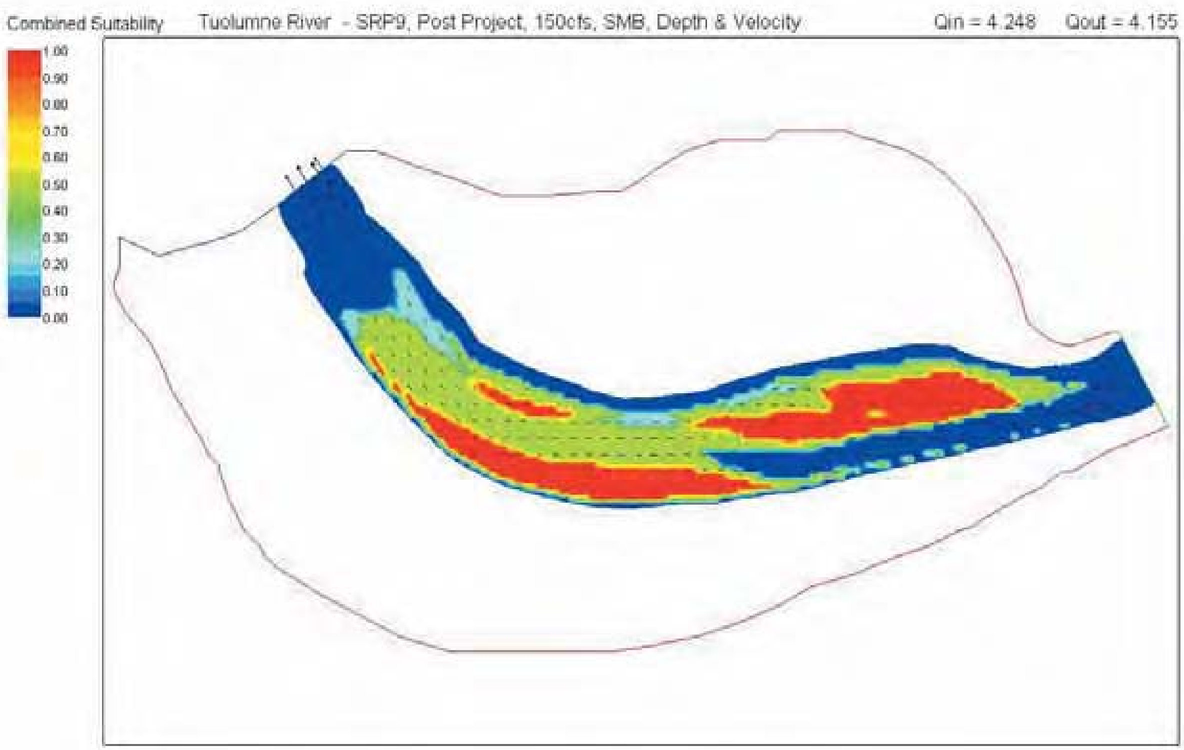

Combined Suitability
Tuolumne River - SRP9, Post Project, 3000cfs, LMB, Cover, Depth & Velocity
Qin = 84.962
Qout = 84.945
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

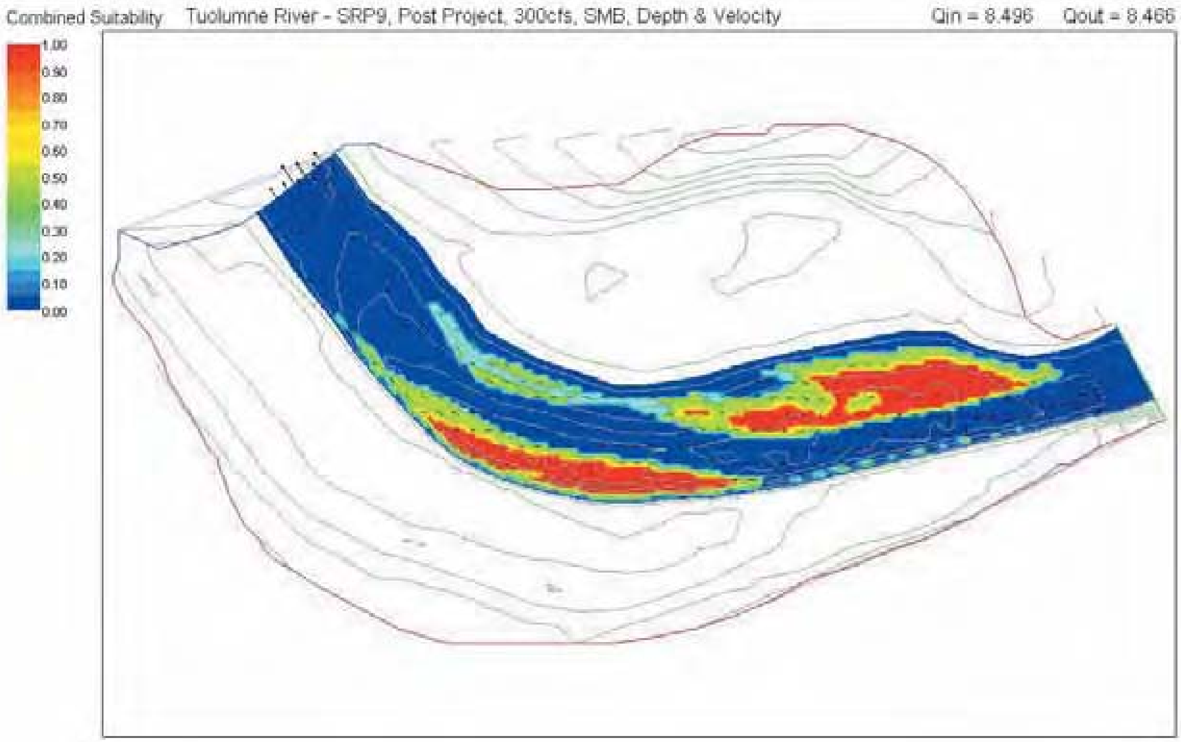

Combined Suitability
Tuolumne River - SRP9, Post Project, 3000cfs, LMB, Depth & Velocity
Qin = 84.962
Qout = 84.945
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

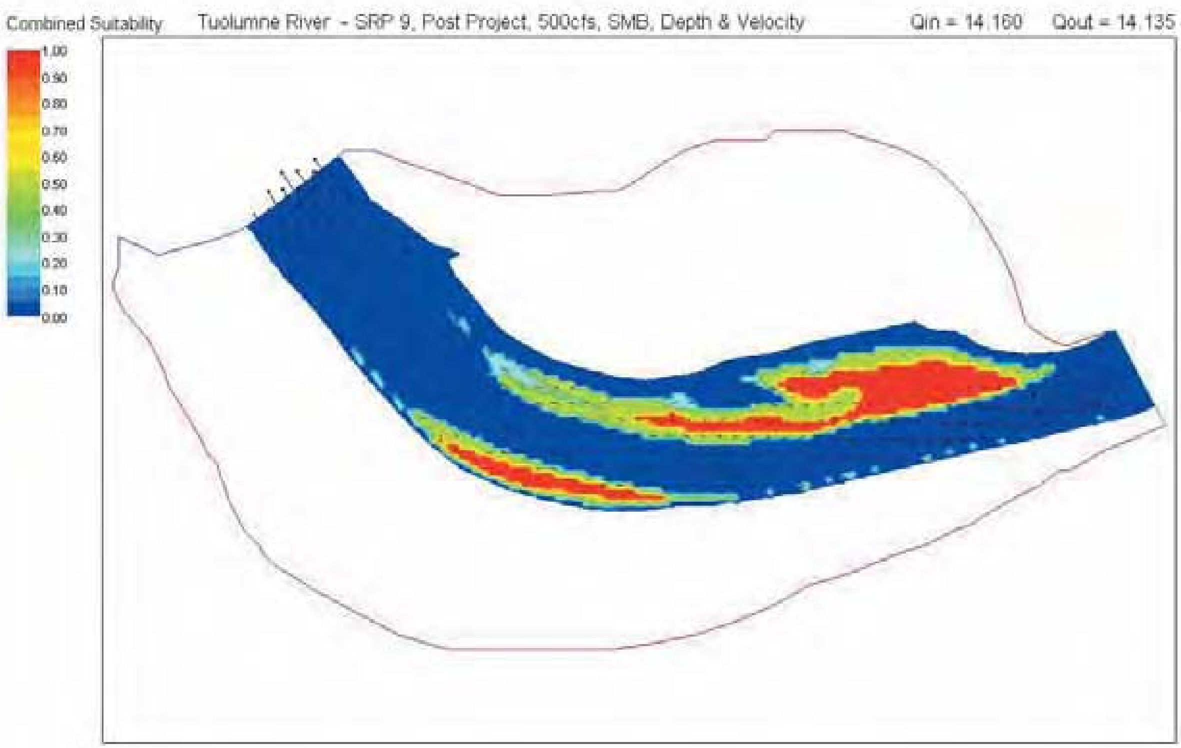

Combined Suitability
Tuolumne River - SRP9, Post Project, 5000cfs, LMB, Cover, Depth & Velocity
Qin = 141.603
Qout = 141.602
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

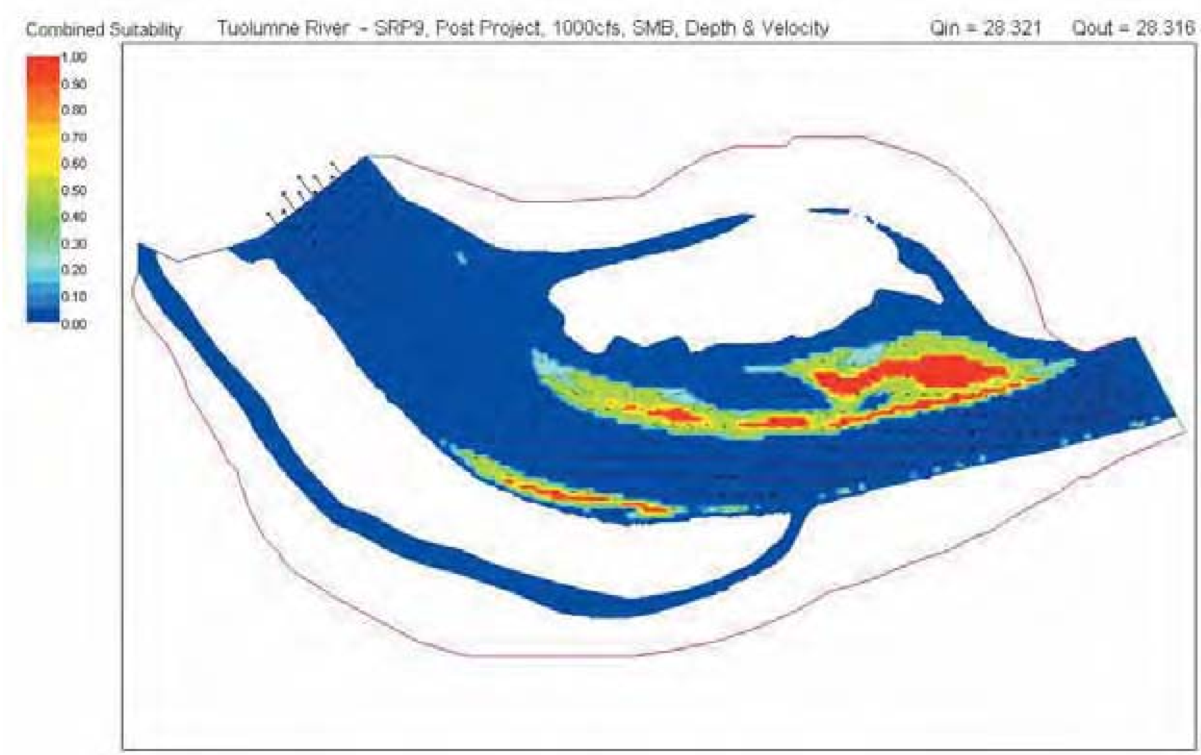

Combined Suitability
Tuolumne River - SRP9, Post Project, 5000cfs, LMB, Depth & Velocity
Qin = 141.603
Qout = 141.602
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

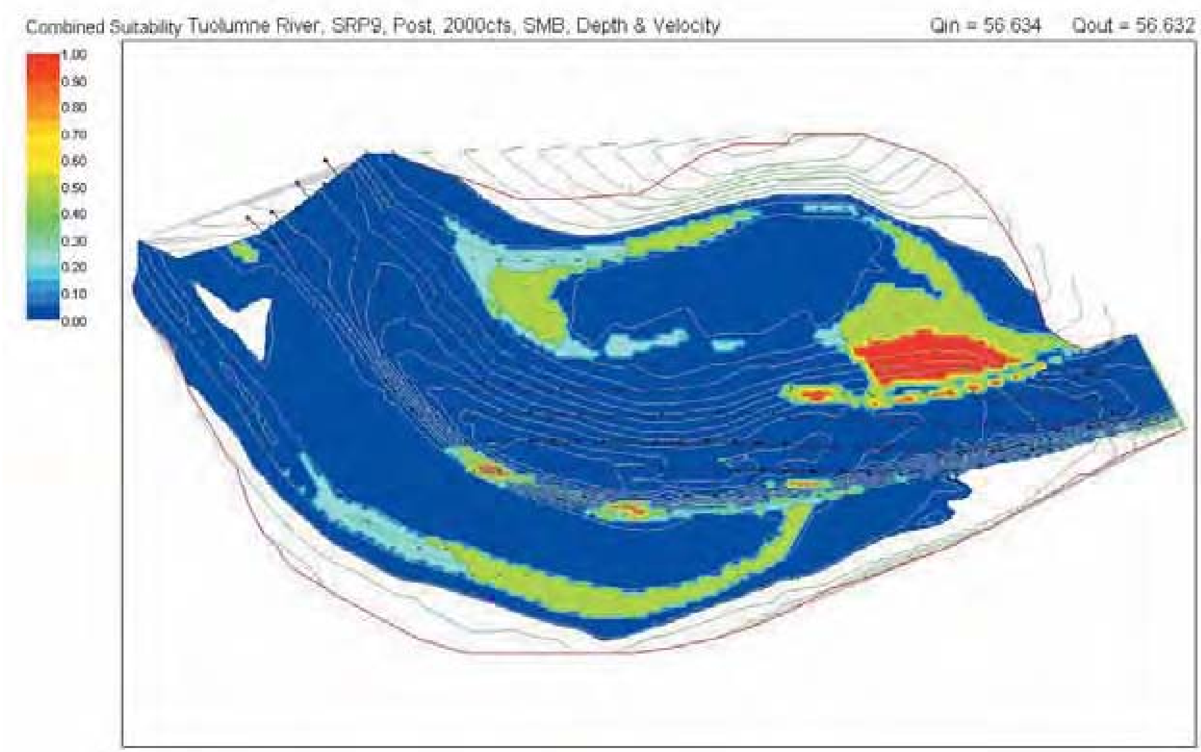

Combined Suitability Tuolumne River, SRP9, Post, 75cfs, SMB, Depth & Velocity
Qin = 2.124 Qout = 1.987
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

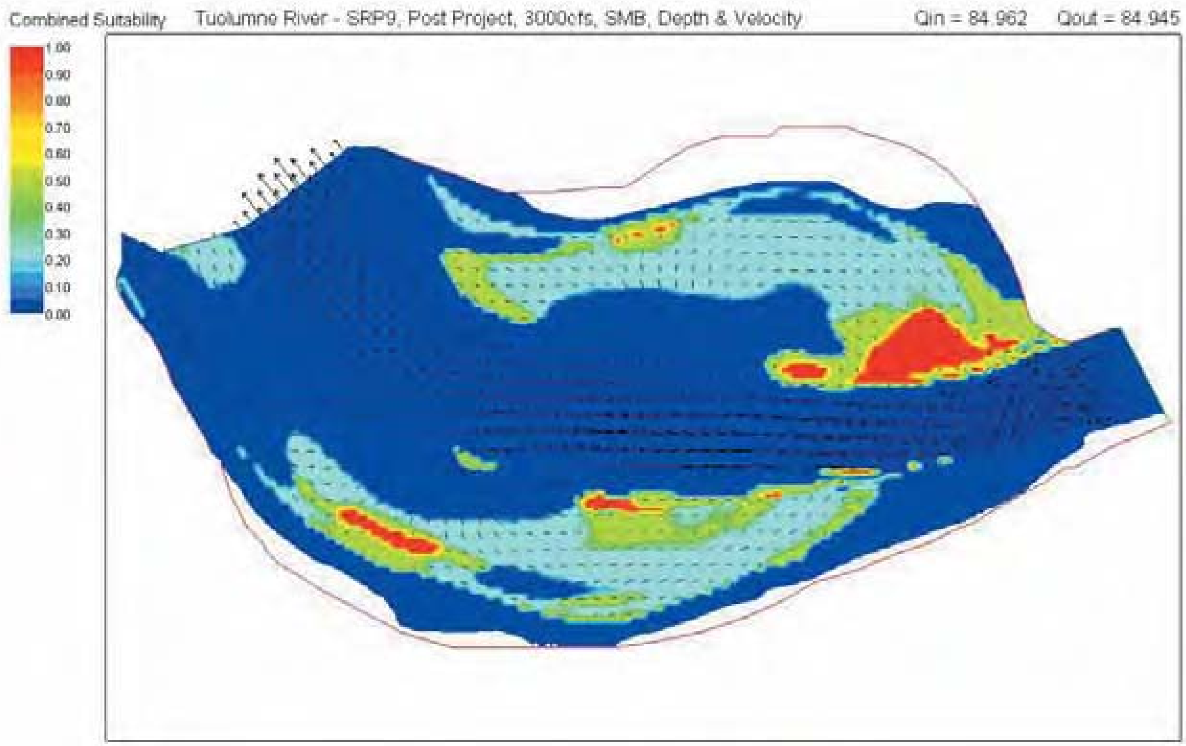

Combined Suitability
Tuolumne River - SRP9, Post Project, 150cfs, SMB, Depth & Velocity
Qin = 4.248 Qout = 4.155
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

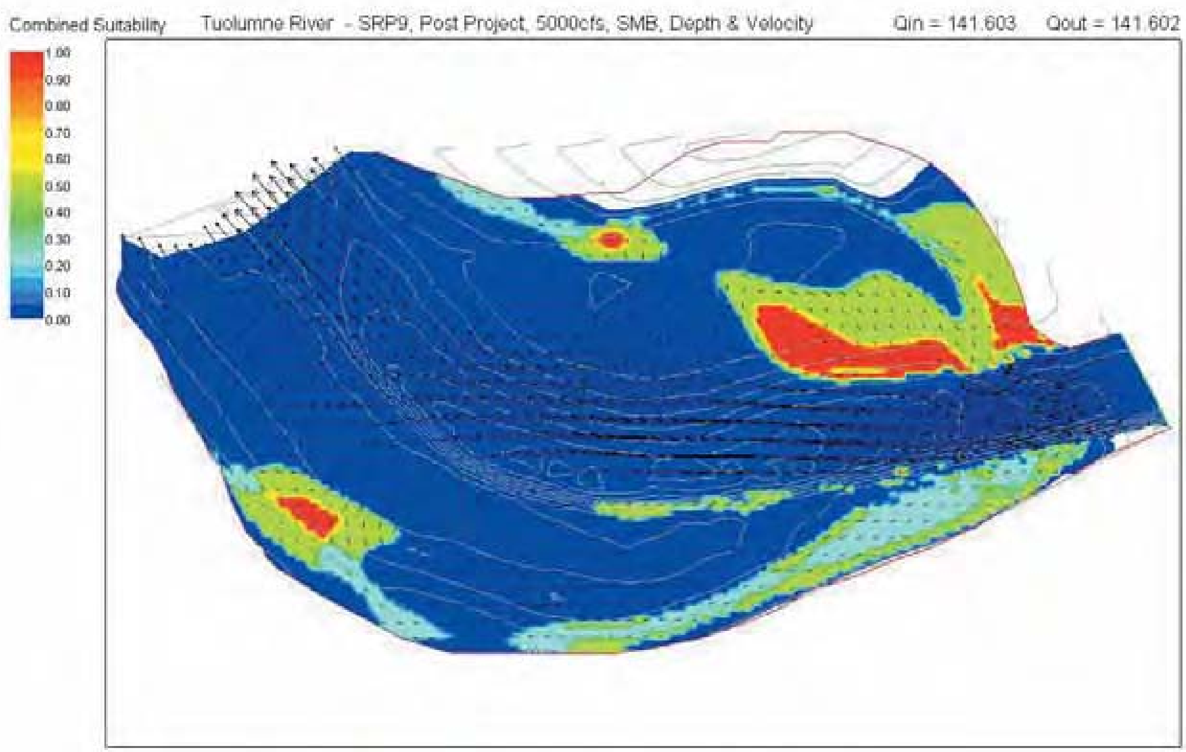

Combined Suitability
Tuolumne River - SRP9, Post Project, 300cfs, SMB, Depth & Velocity
Qin = 8.496
Qout = 8.466
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

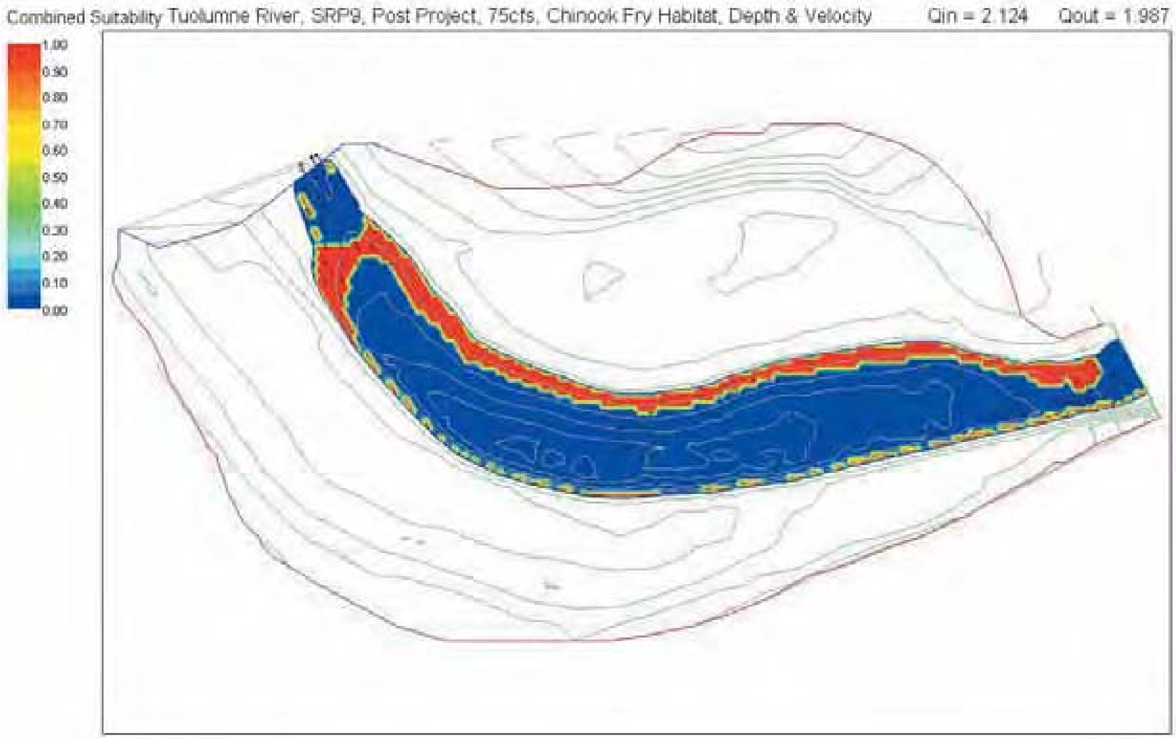

Combined Suitability
Tuolumne River - SRP 9, Post Project, 500cfs, SMB, Depth & Velocity
Qin = 14.160
Qout = 14.135
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

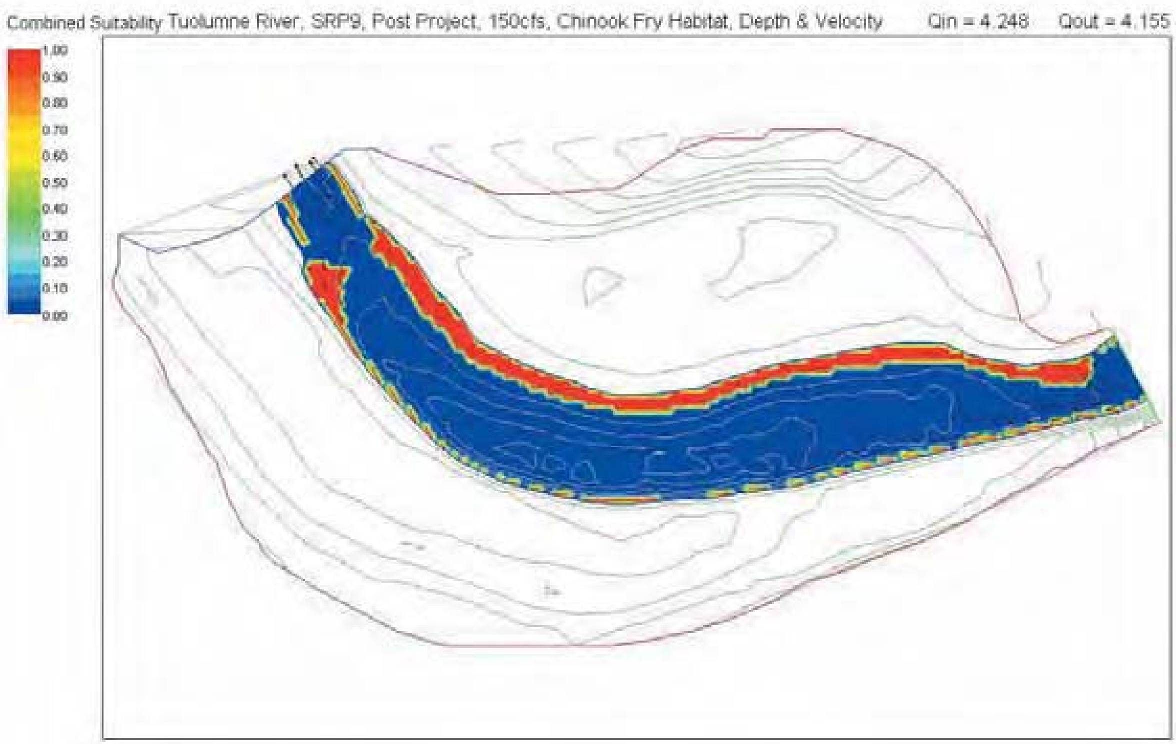

Combined Suitability
Tuolumne River - SRP9, Post Project, 1000cfs, SMB, Depth & Velocity
Qin = 28.321
Qout = 28.316
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability
Tuolumne River, SRP9, Post, 2000cfs, SMB, Depth & Velocity
Qin = 56.634
Qout = 56.632
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

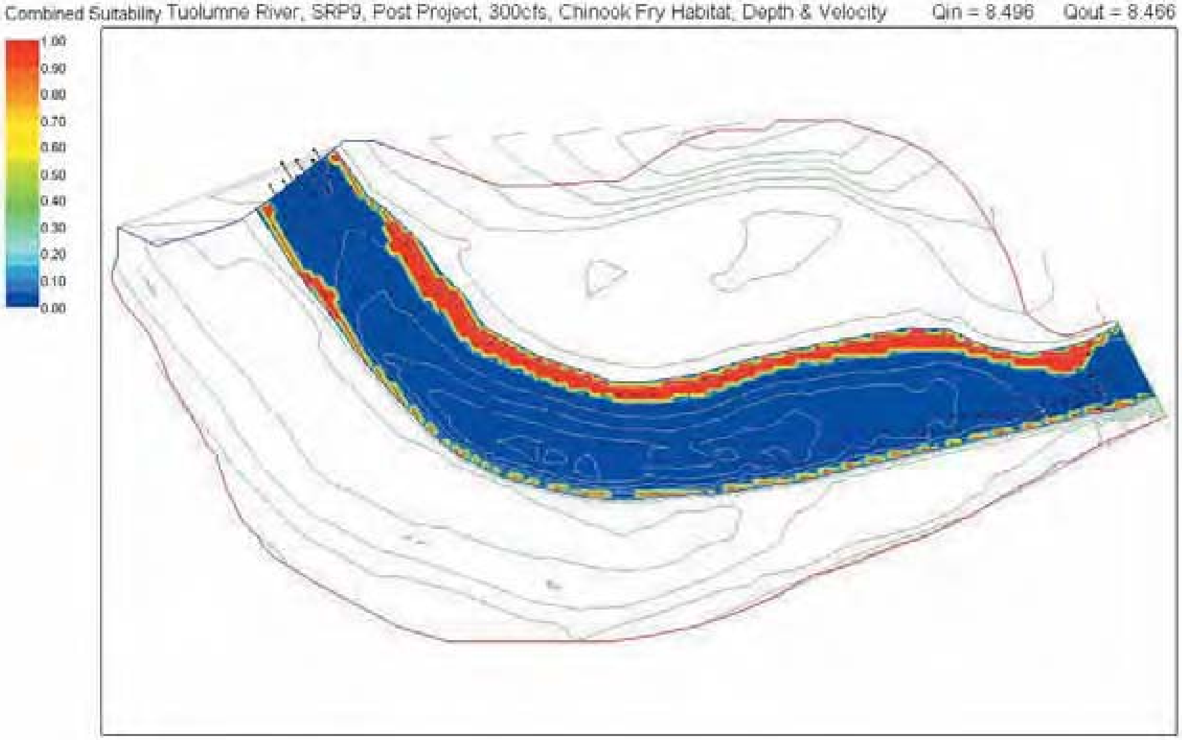

Combined Suitability
Tuolumne River - SRP9, Post Project, 3000cfs, SMB, Depth & Velocity
Qin = 84.962
Qout = 84.945
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability
Tuolumne River - SRP9, Post Project, 5000cfs, SMB, Depth & Velocity
Qin = 141.603
Qout = 141.602
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

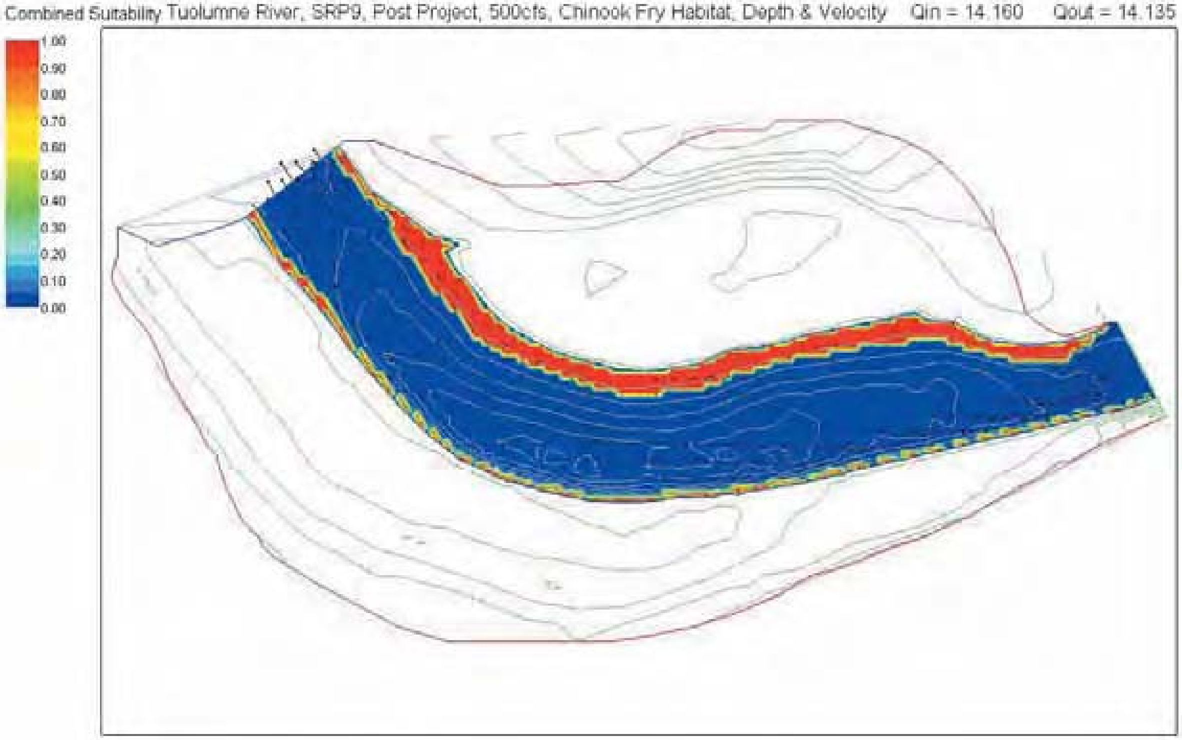

Combined Suitability Tuolumne River, SRP9, Post Project, 75cfs, Chinook Fry Habitat, Depth & Velocity
Qin = 2.124
Qout = 1.987
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

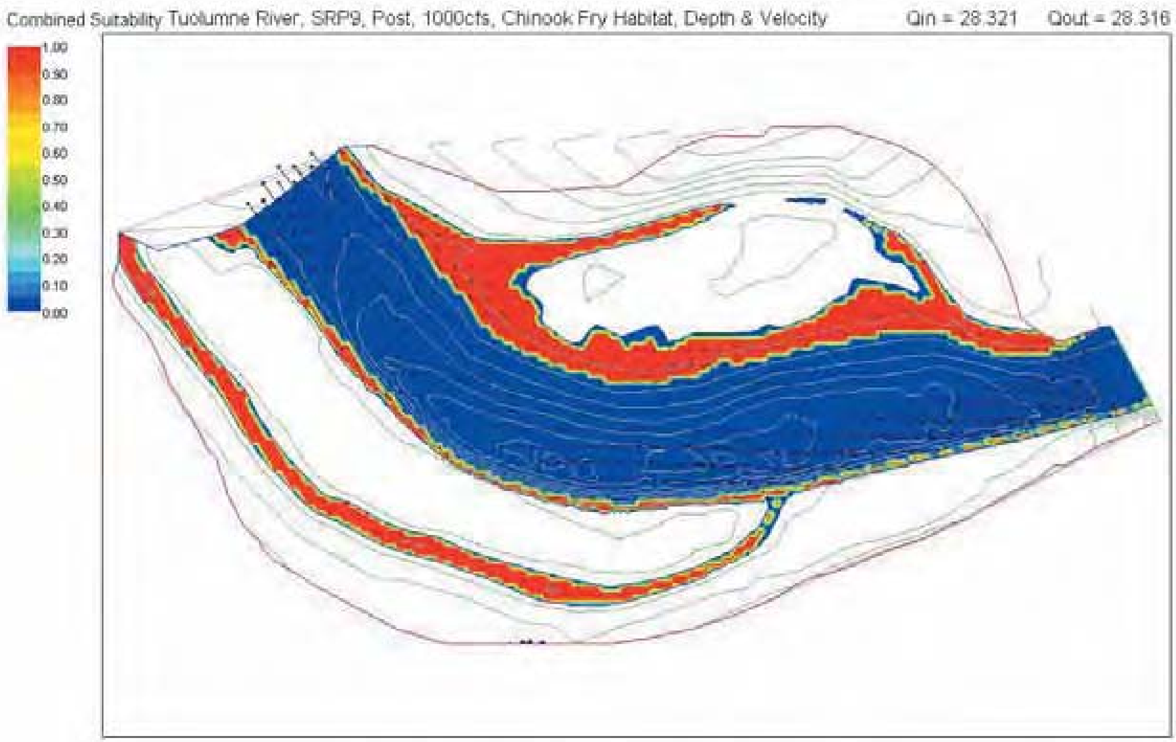

Combined Suitability Tuolumne River, SRP9, Post Project, 150cfs, Chinook Fry Habitat, Depth & Velocity
Qin = 4.248
Qout = 4.155
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

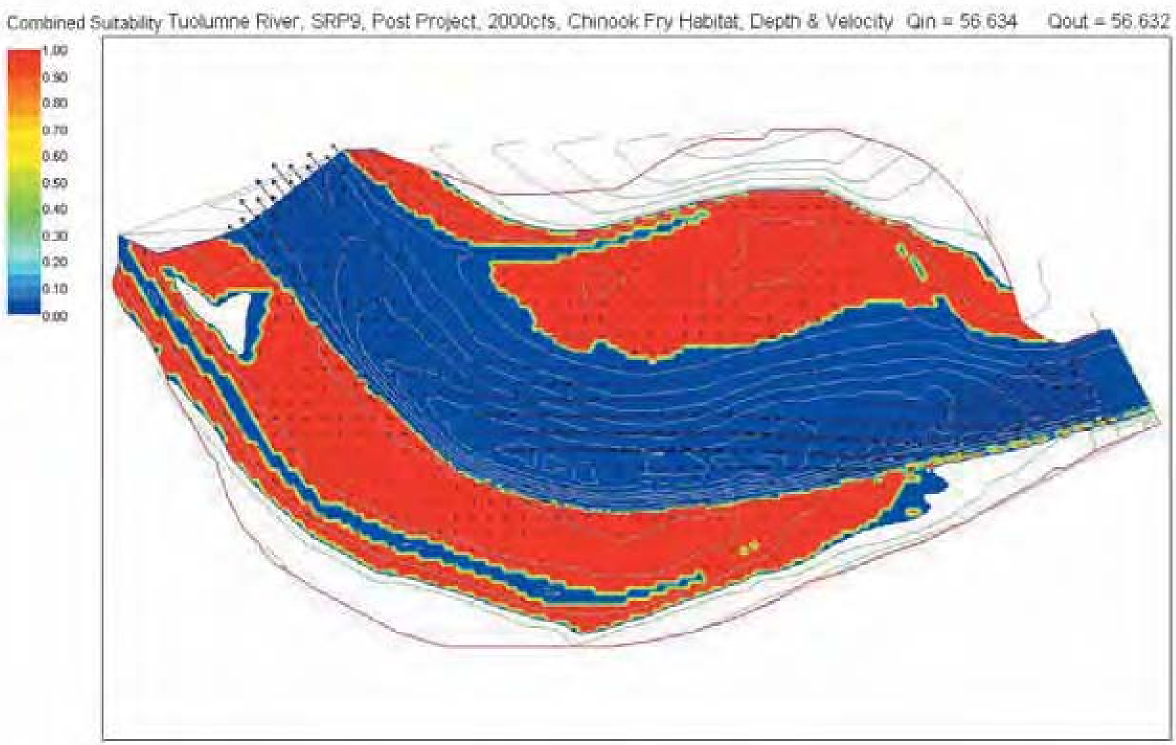
Combined Suitability Tuolumne River, SRP9, Post Project, 300cfs, Chinook Fry Habitat, Depth & Velocity Qin = 8.496 Qout = 8.466

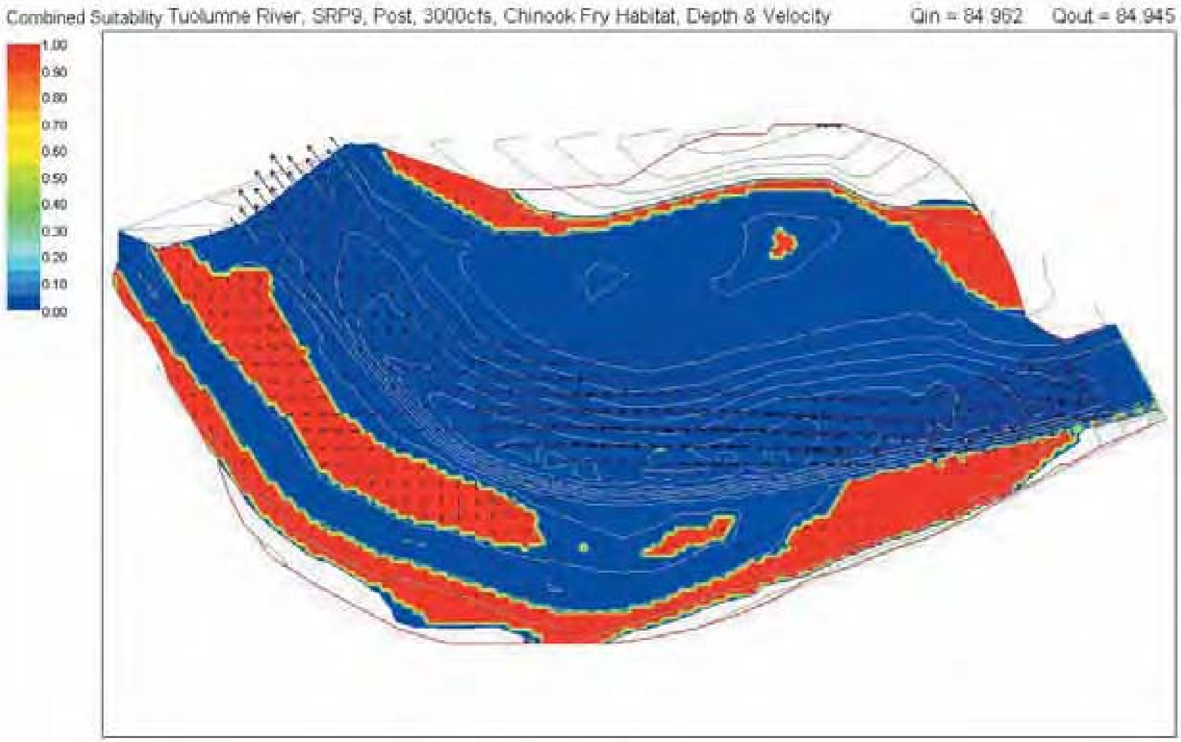


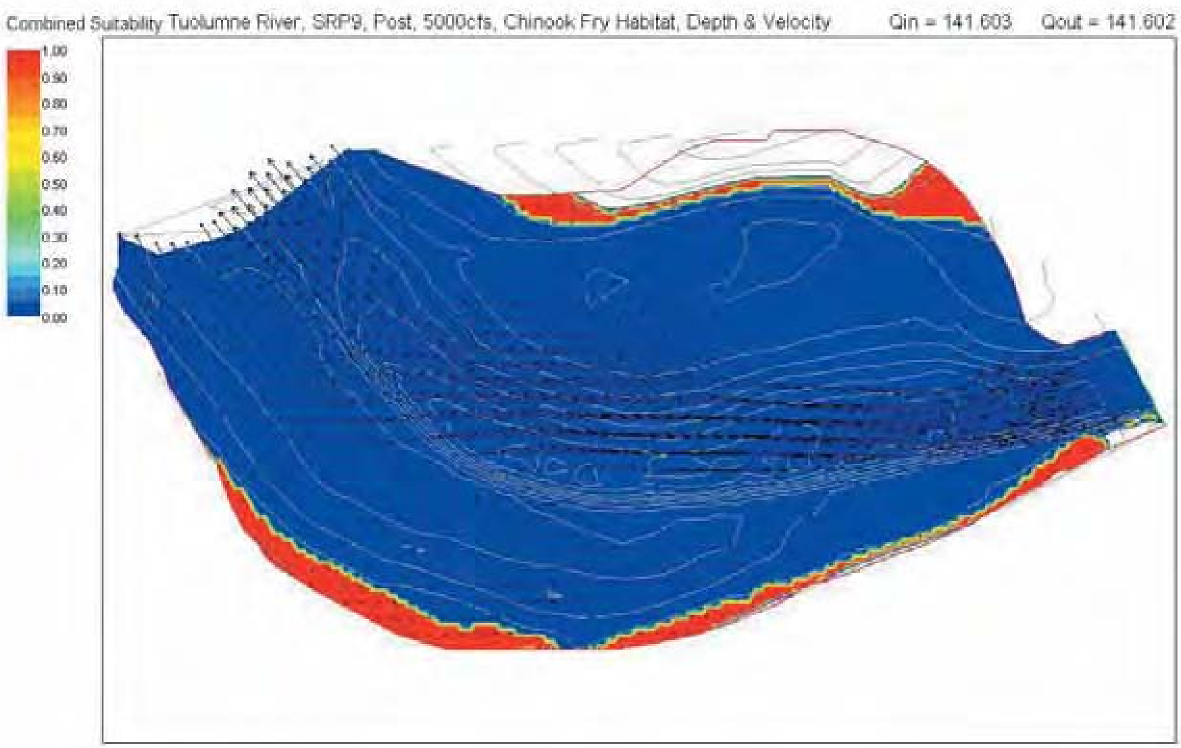
Combined Suitability Tuolumne River, SRP9, Post Project, 500cfs, Chinook Fry Habitat, Depth & Velocity Qin = 14.160 Qout = 14.135

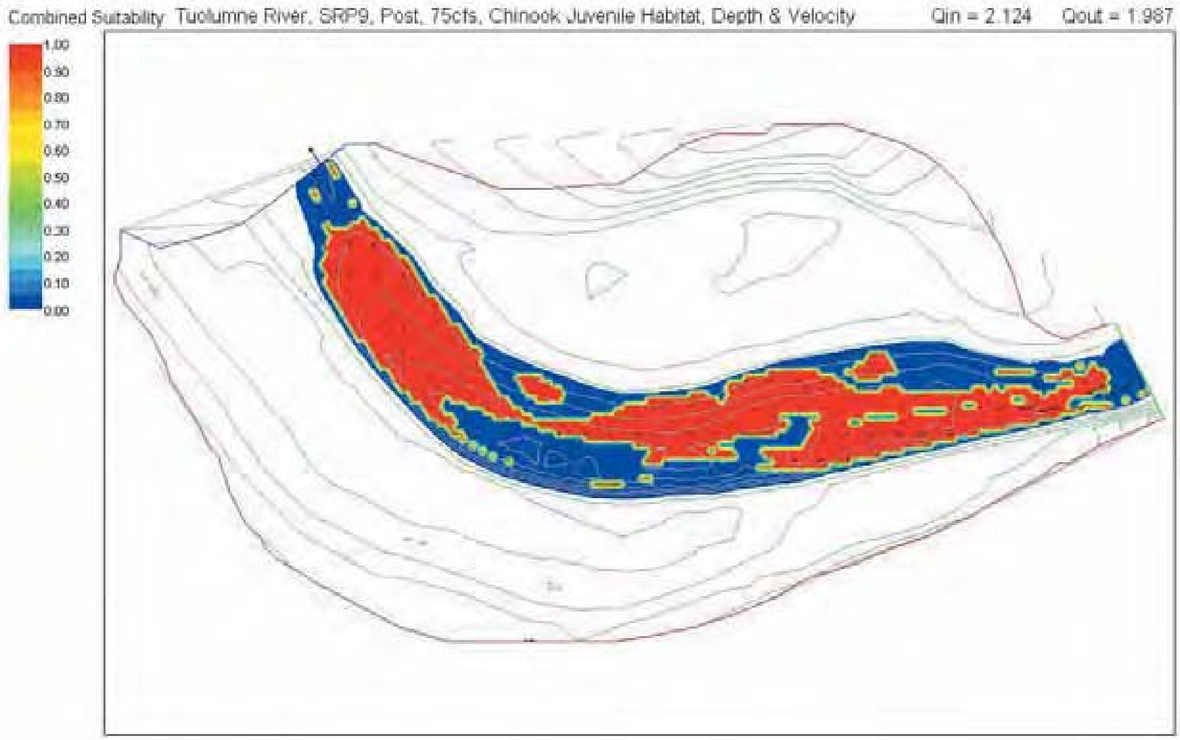


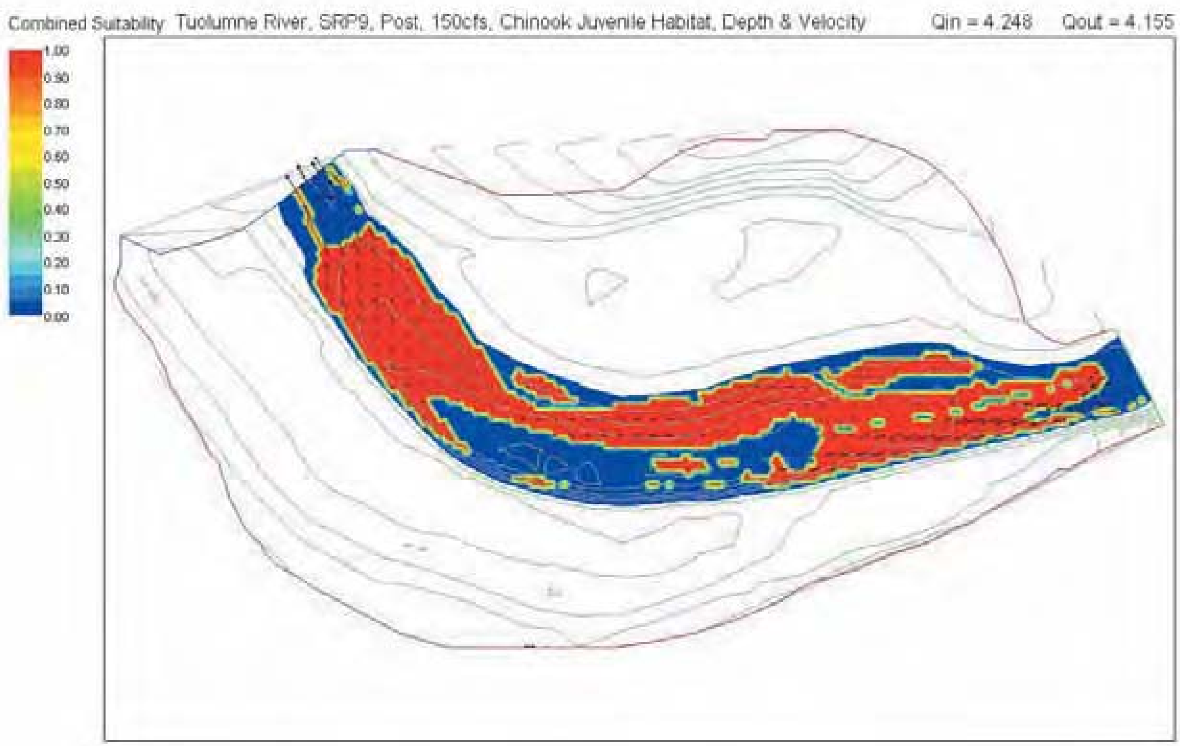

Combined Suitability Tuolumne River, SRP9, Post, 1000cfs, Chinook Fry Habitat, Depth & Velocity
Qin = 28.321
Qout = 28.316
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability Tuolumne River, SRP9, Post Project, 2000cfs, Chinook Fry Habitat, Depth & Velocity
Qin = 56.634
Qout = 56.632
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

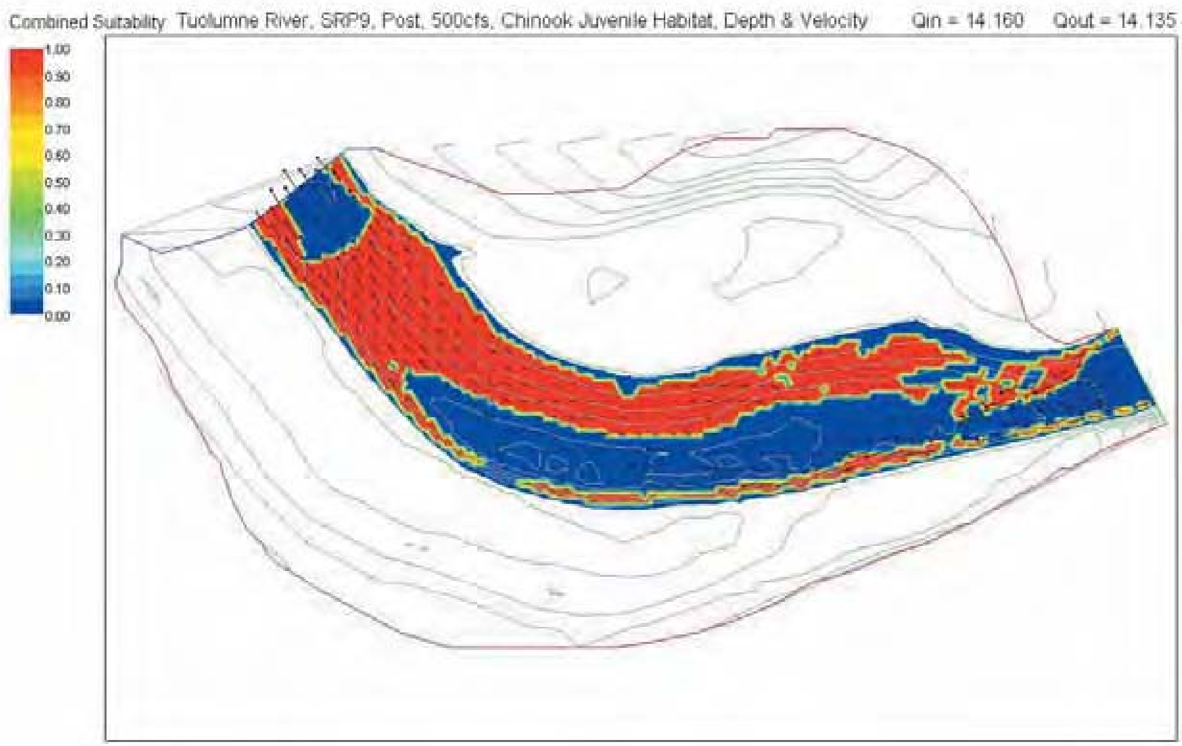

Combined Suitability Tuolumne River, SRP9, Post, 3000cfs, Chinook Fry Habitat, Depth & Velocity
Qin = 84.962 Qout = 84.945
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

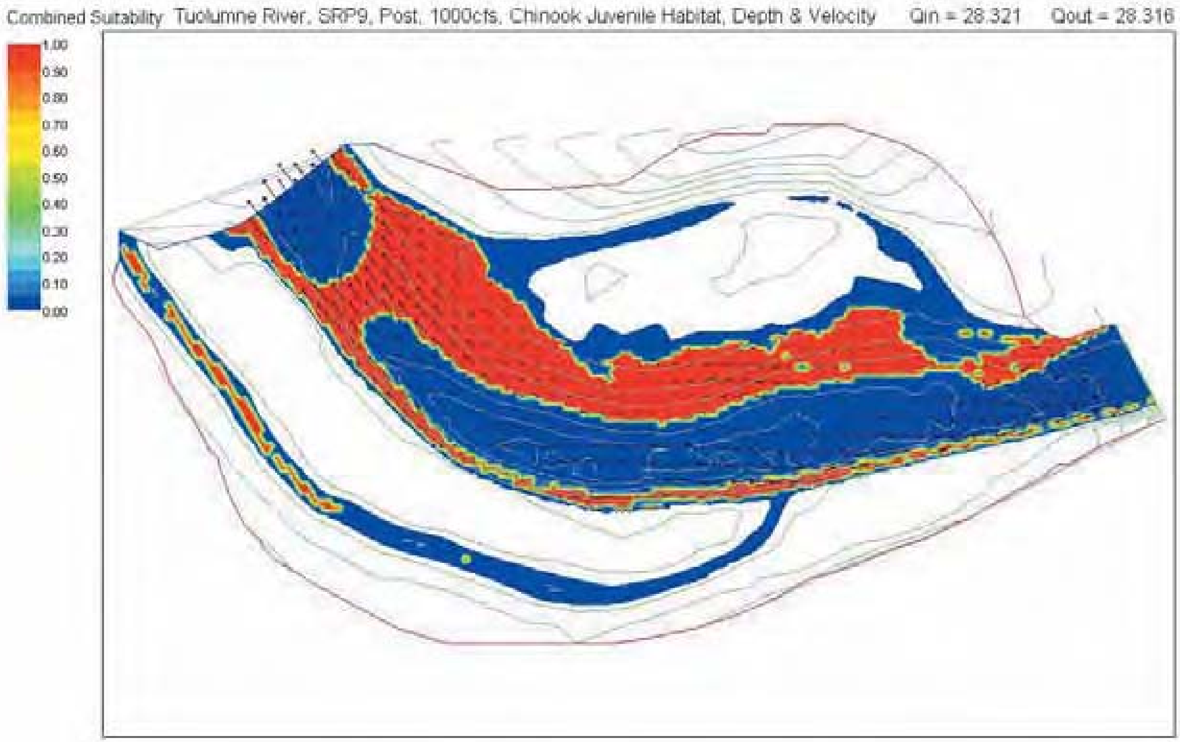

Combined Suitability Tuolumne River, SRP9, Post, 5000cfs, Chinook Fry Habitat, Depth & Velocity
Qin = 141.603 Qout = 141.602
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

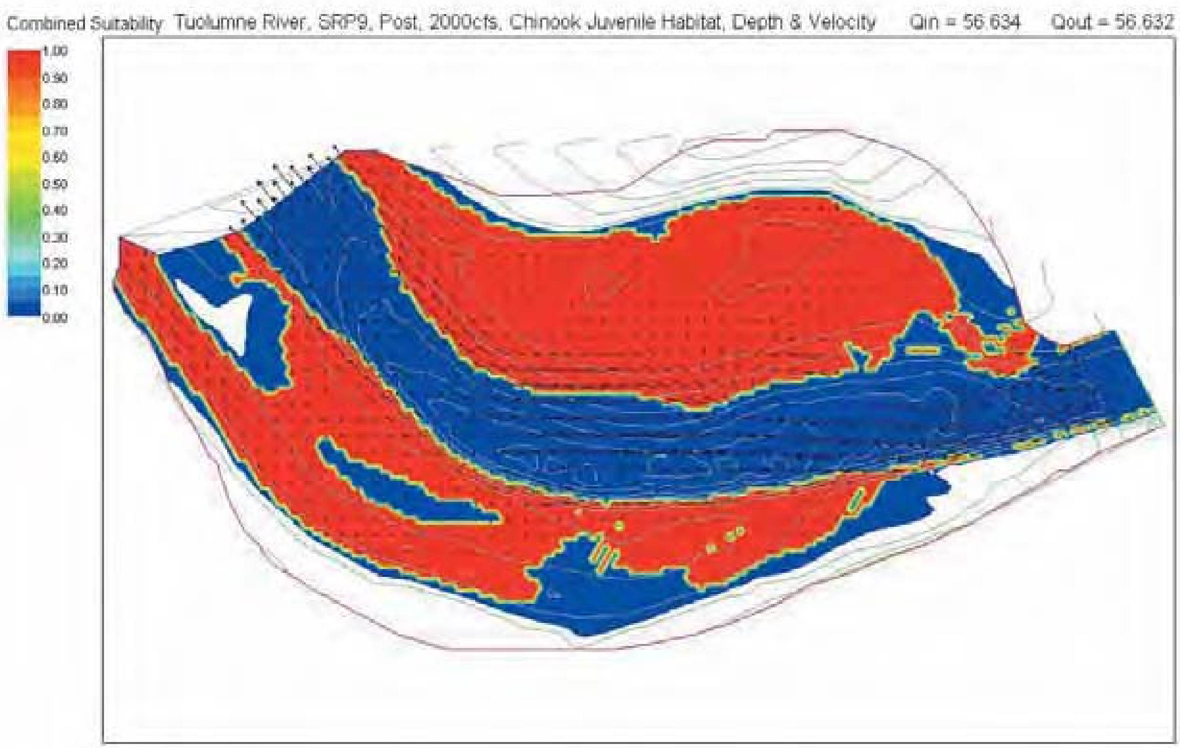

Combined Suitability: Tuolumne River, SRP9, Post, 75cfs, Chinook Juvenile Habitat, Depth & Velocity
Qin = 2.124 Qout = 1.987
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

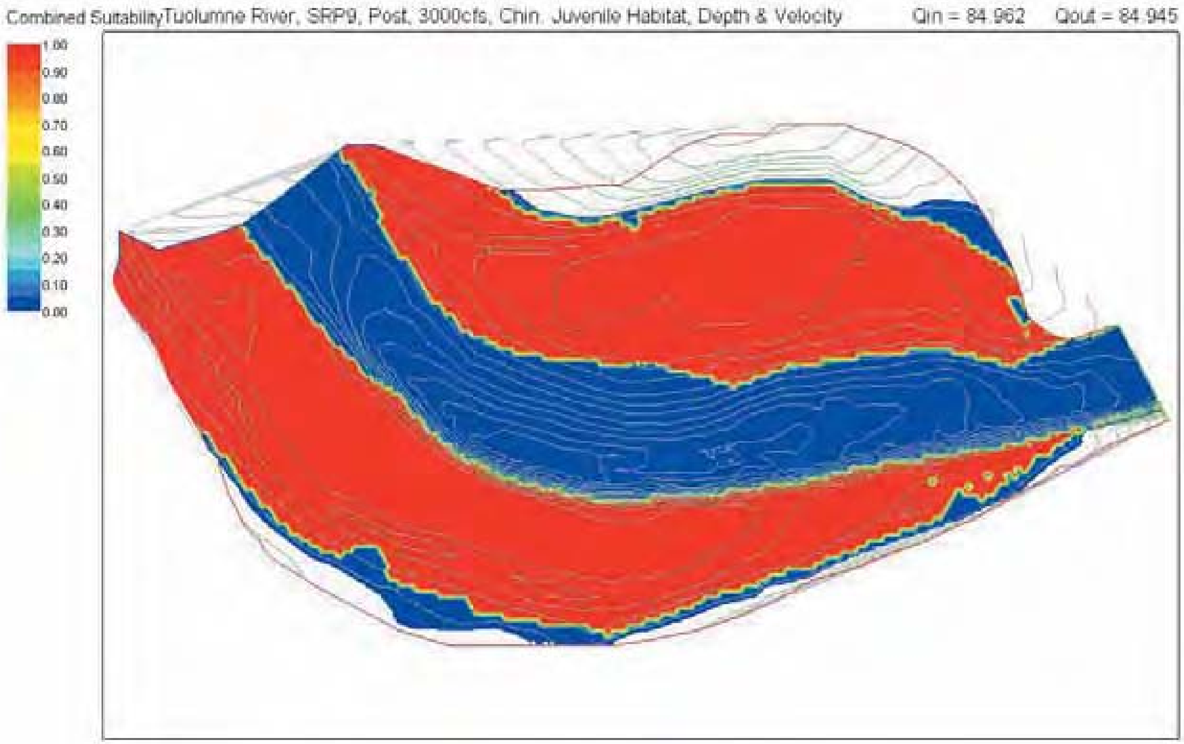

Combined Suitability: Tuolumne River, SRP9, Post, 150cfs, Chinook Juvenile Habitat, Depth & Velocity
Qin = 4.248 Qout = 4.155
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

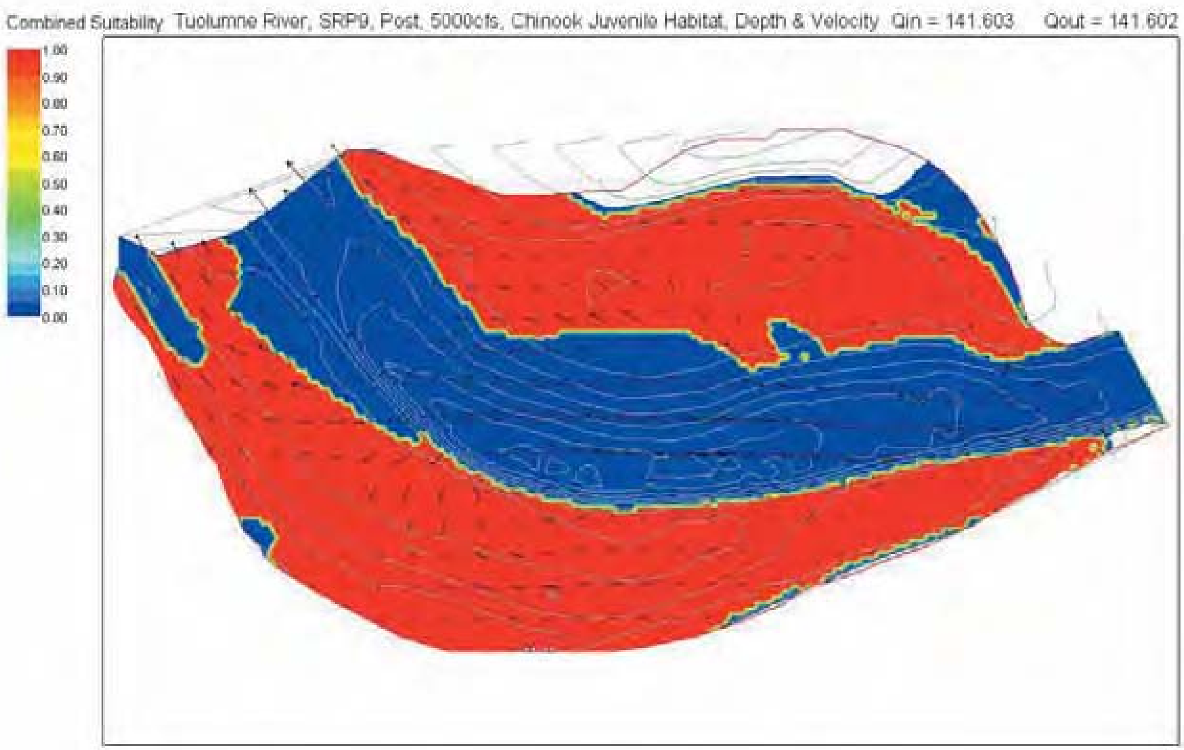

Combined Suitability Tuolumne River, SRP9, Post, 300cfs, Chinook Juvenile Habitat, Depth & Velocity
Qin = 8.496 Qout = 8.466
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

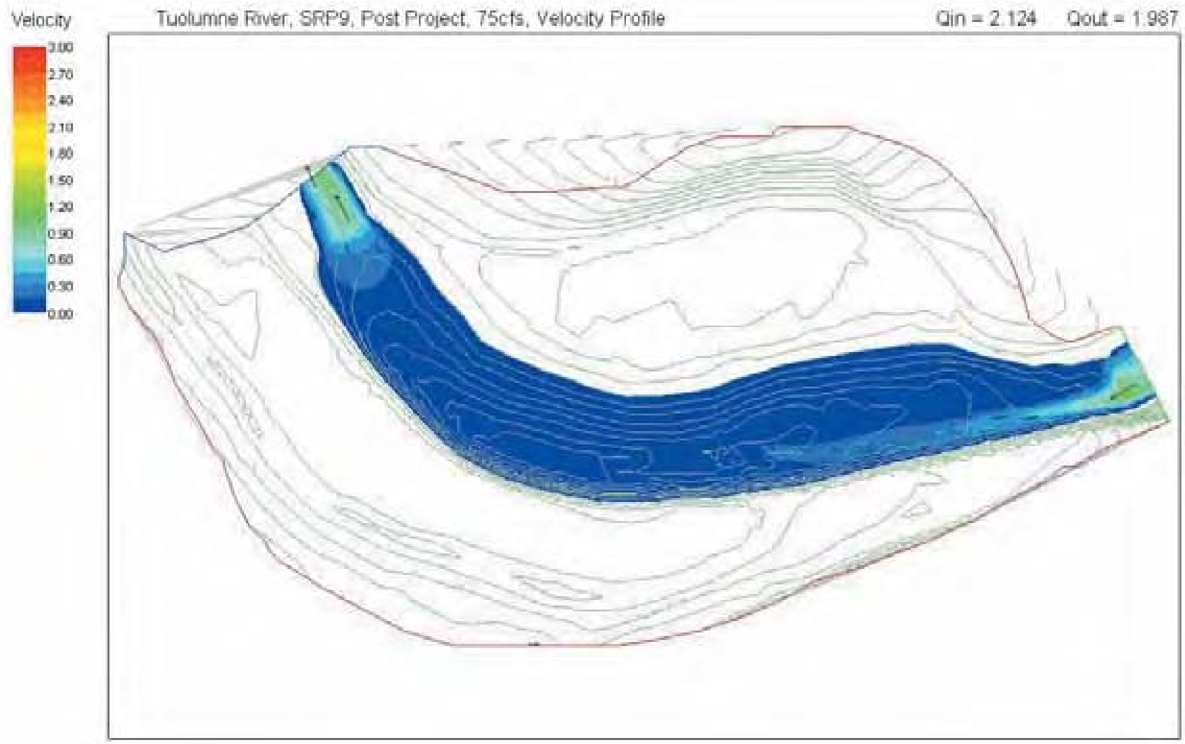

Combined Suitability Tuolumne River, SRP9, Post, 500cfs, Chinook Juvenile Habitat, Depth & Velocity
Qin = 14.160 Qout = 14.135
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

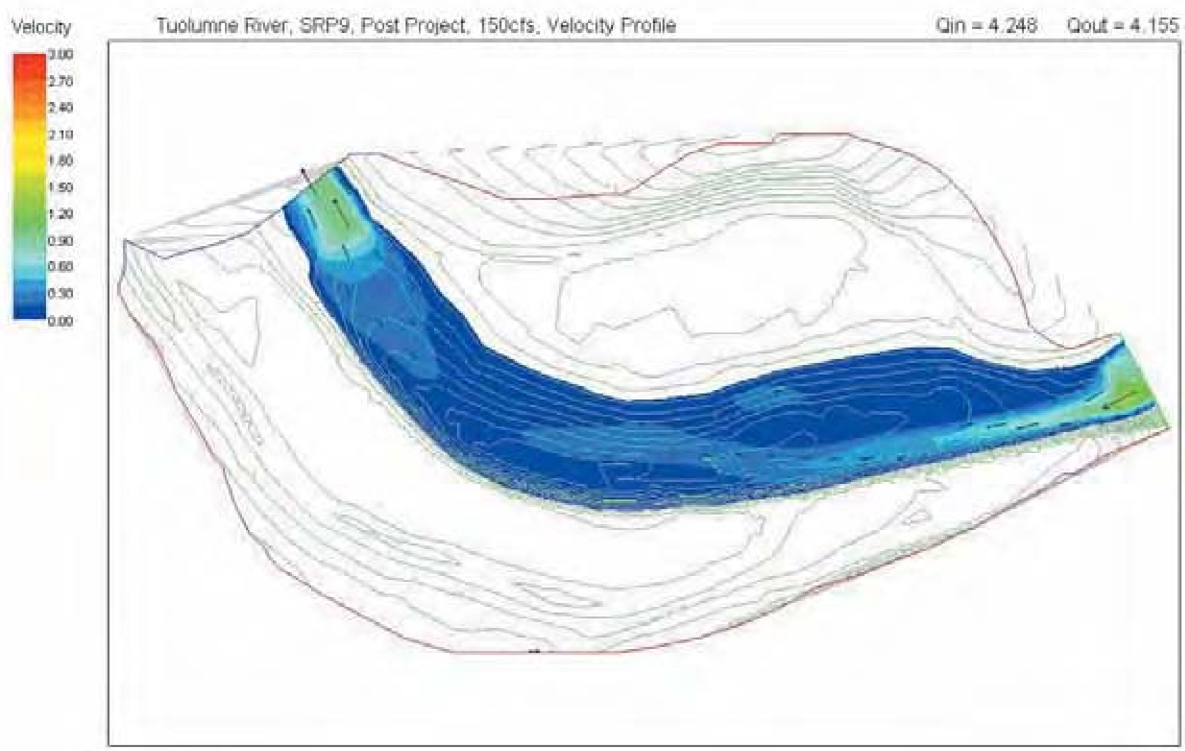

Combined Suitability Tuolumne River, SRP9, Post, 1000cfs, Chinook Juvenile Habitat, Depth & Velocity
Qin = 28.321
Qout = 28.316
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

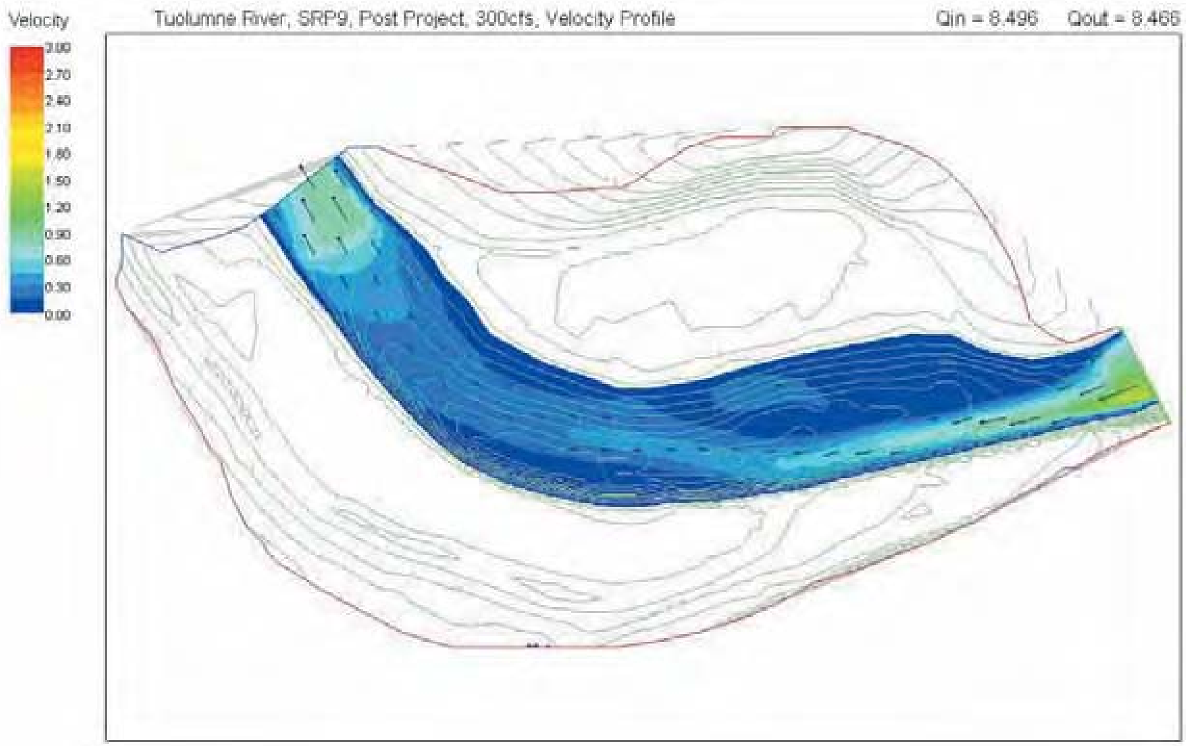

Combined Suitability Tuolumne River, SRP9, Post, 2000cfs, Chinook Juvenile Habitat, Depth & Velocity
Qin = 56.634
Qout = 56.632
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

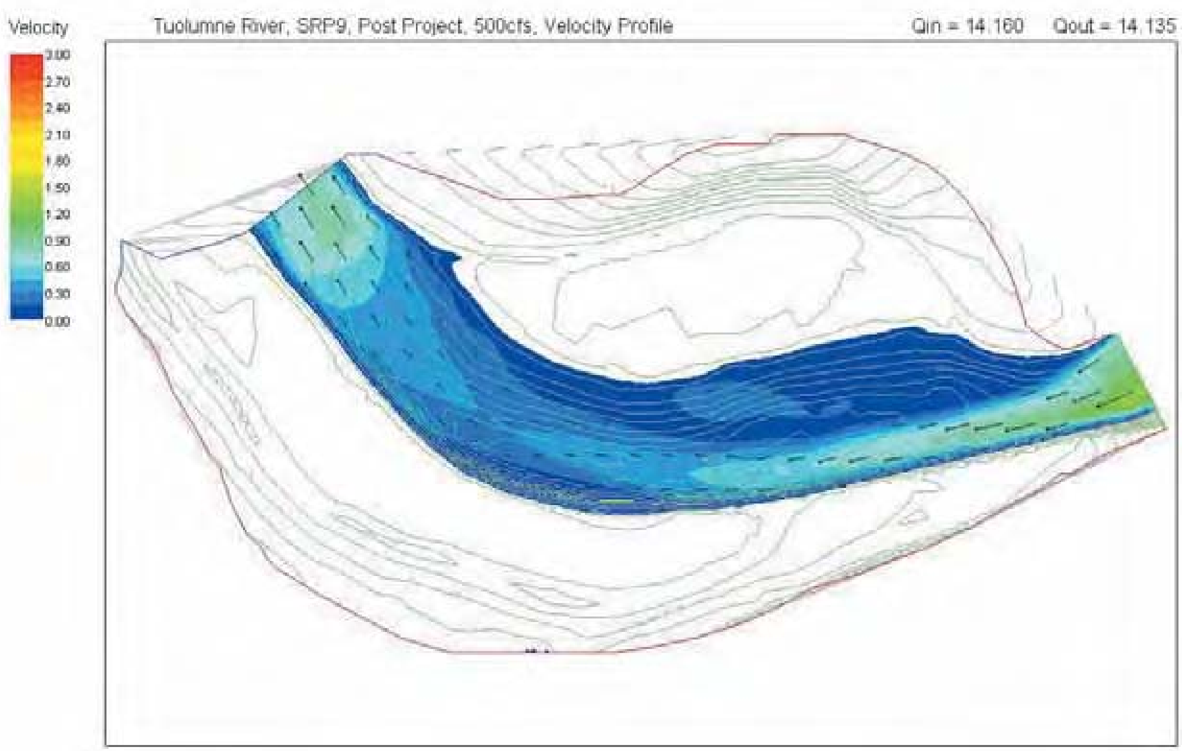

Combined Suitability
Tuolumne River, SRP9, Post, 3000cfs, Chin. Juvenile Habitat, Depth & Velocity
Qin = 84.962
Qout = 84.945
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

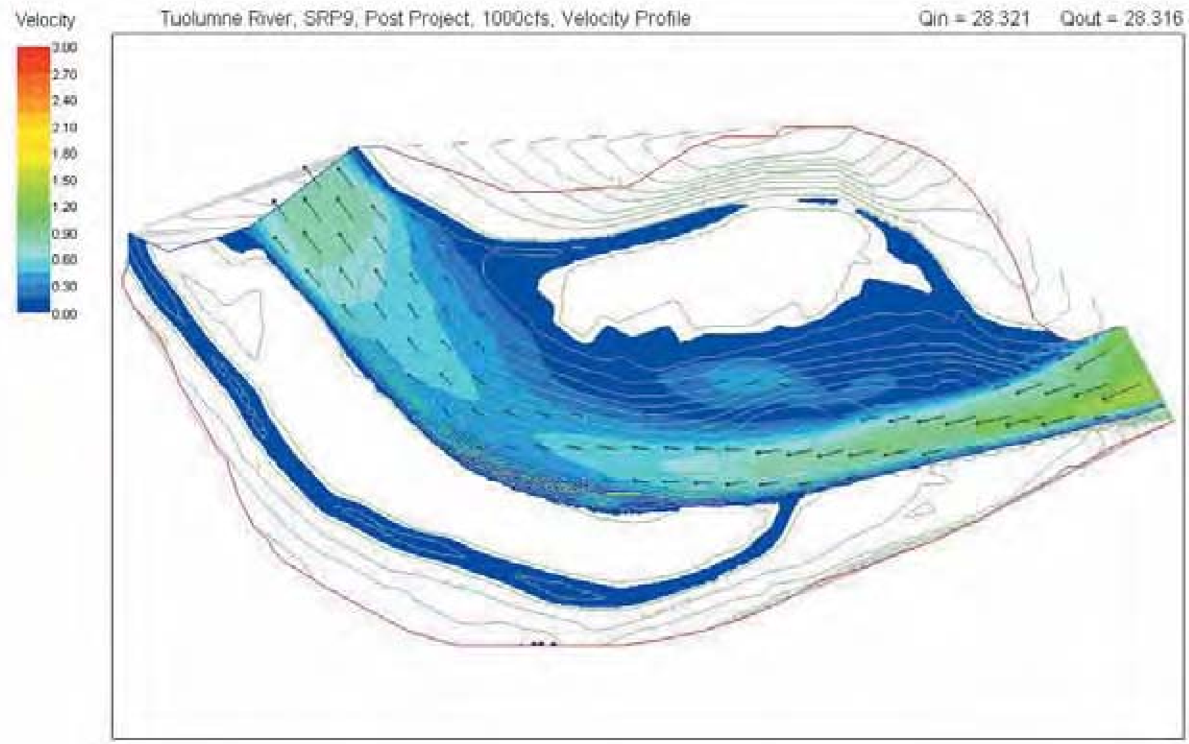

Combined Suitability
Tuolumne River, SRP9, Post, 5000cfs, Chinook Juvenile Habitat, Depth & Velocity
Qin = 141.603
Qout = 141.602
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

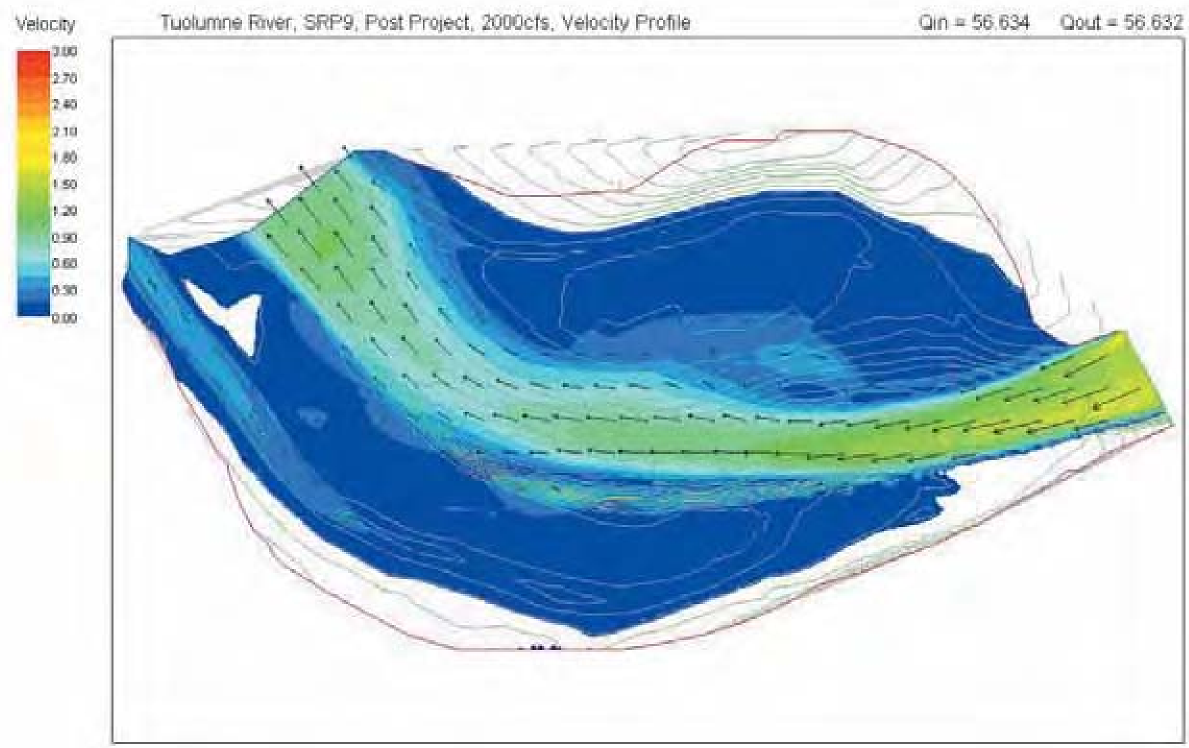

Velocity
3.00
2.70
2.40
2.10
1.80
1.50
1.20
0.90
0.60
0.30
0.00
Tuolumne River, SRP9, Post Project, 75cfs, Velocity Profile
Qin = 2.124
Qout = 1.987

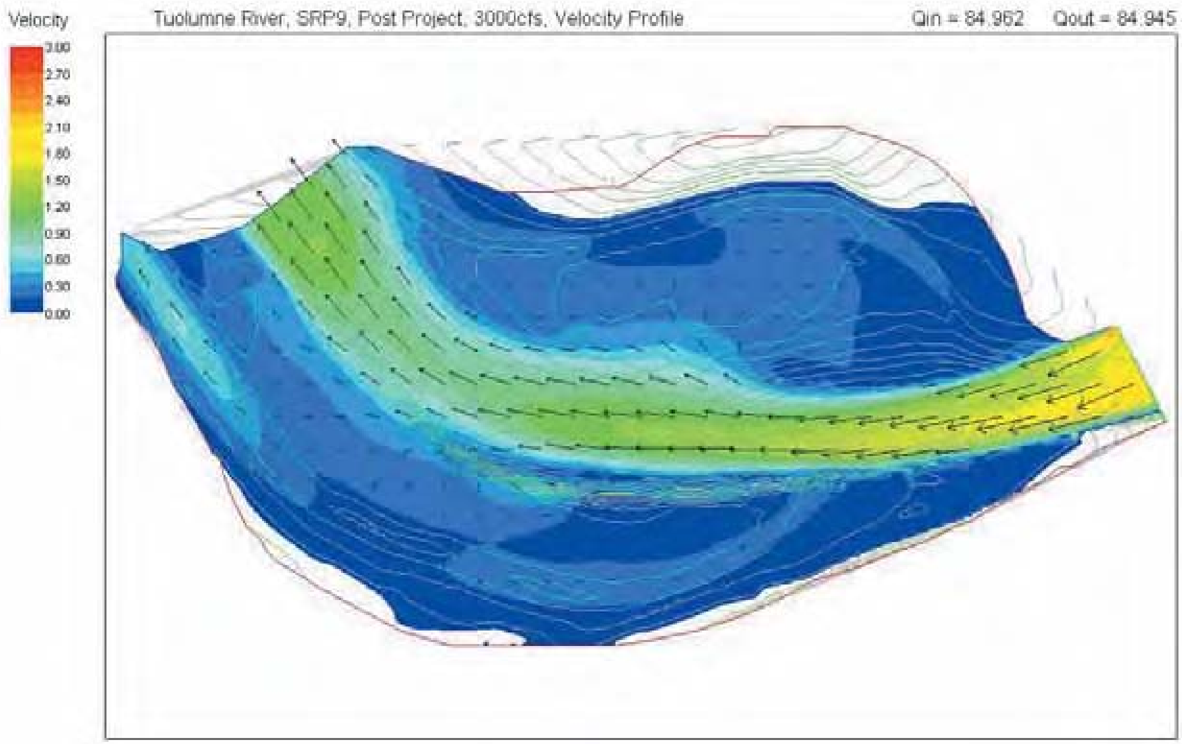

Velocity
3.00
2.70
2.40
2.10
1.80
1.50
1.20
0.90
0.60
0.30
0.00
Tuolumne River, SRP9, Post Project, 150cfs, Velocity Profile
Qin = 4.248
Qout = 4.155

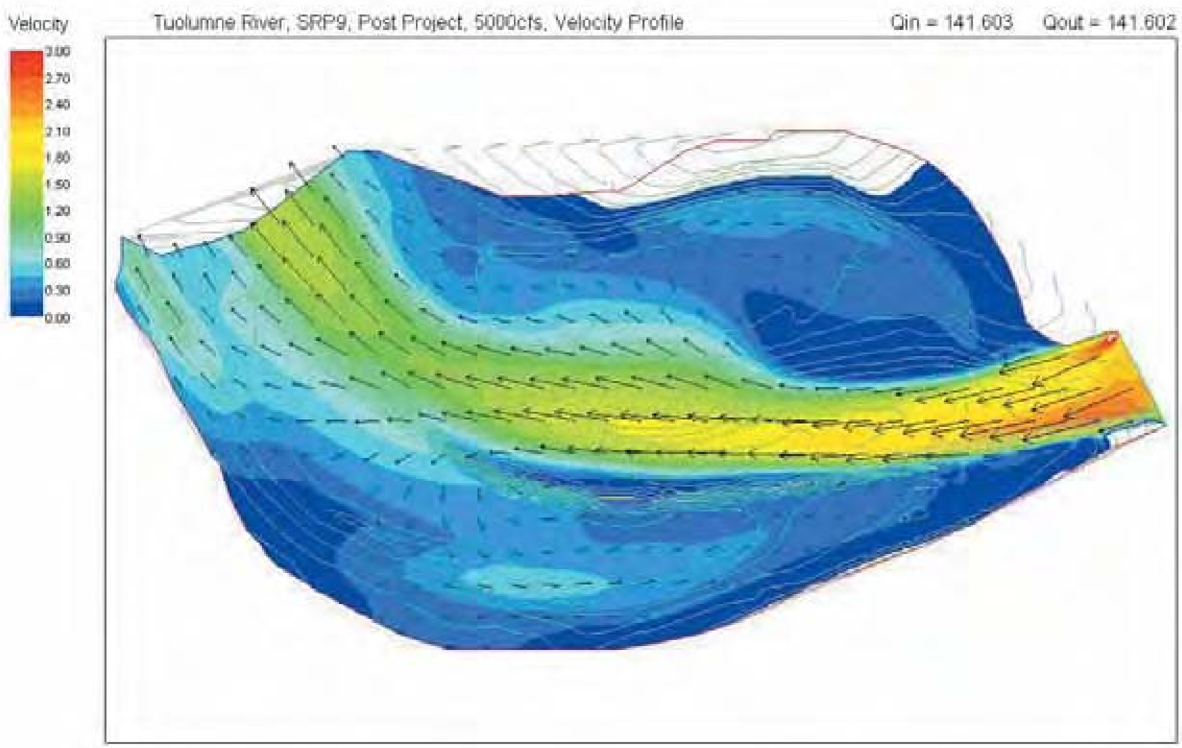

Velocity
3.00
2.70
2.40
2.10
1.80
1.50
1.20
0.90
0.60
0.30
0.00
Tuolumne River, SRP9, Post Project, 300cfs, Velocity Profile
Qin = 8.496 Qout = 8.466


Velocity
3.00
2.70
2.40
2.10
1.80
1.50
1.20
0.90
0.60
0.30
0.00
Tuolumne River, SRP9, Post Project, 500cfs, Velocity Profile
Qin = 14.160 Qout = 14.135


Velocity
3.00
2.70
2.40
2.10
1.80
1.50
1.20
0.90
0.60
0.30
0.00
Tuolumne River, SRP9, Post Project, 1000cfs, Velocity Profile
Qin = 28.321 Qout = 28.316


Velocity
3.00
2.70
2.40
2.10
1.80
1.50
1.20
0.90
0.60
0.30
0.00
Tuolumne River, SRP9, Post Project, 2000cfs, Velocity Profile
Qin = 56.634 Qout = 56.632

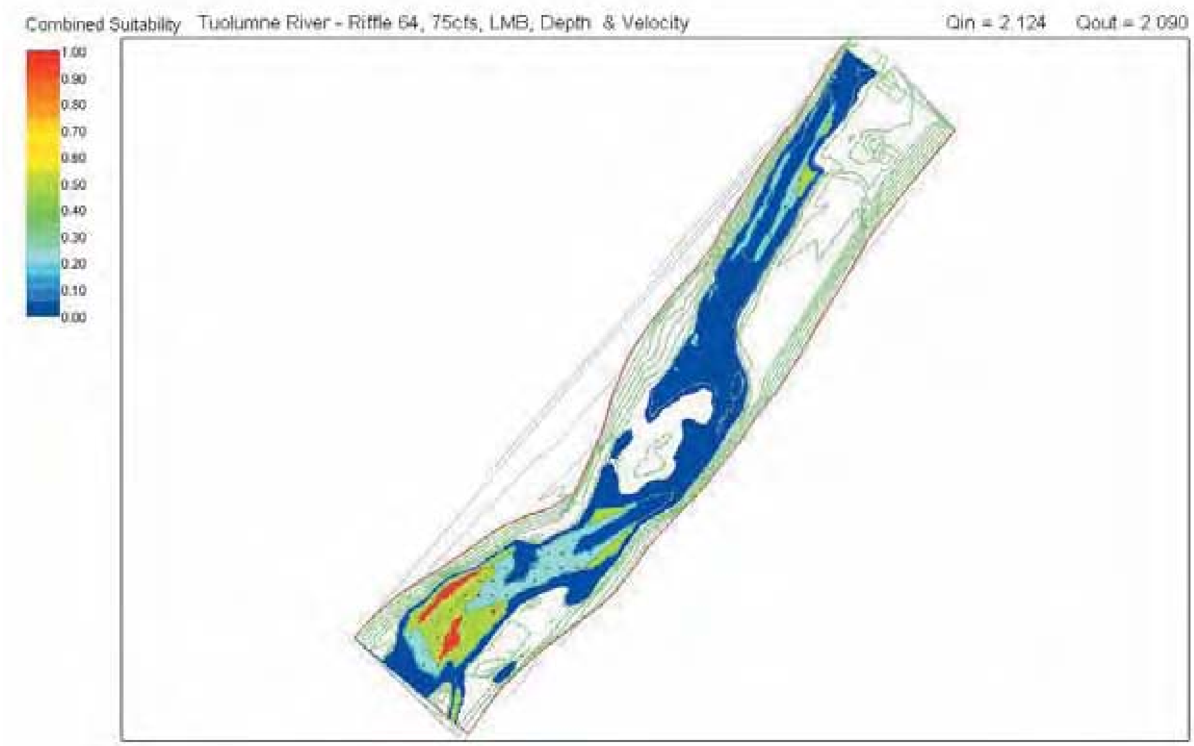

Velocity
3.00
2.70
2.40
2.10
1.80
1.50
1.20
0.90
0.60
0.30
0.00
Tuolumne River, SRP9, Post Project, 3000cfs, Velocity Profile
Qin = 84.962
Qout = 84.945


Velocity
3.00
2.70
2.40
2.10
1.80
1.50
1.20
0.90
0.60
0.30
0.00
Tuolumne River, SRP9, Post Project, 5000cfs, Velocity Profile
Qin = 141.603
Qout = 141.602

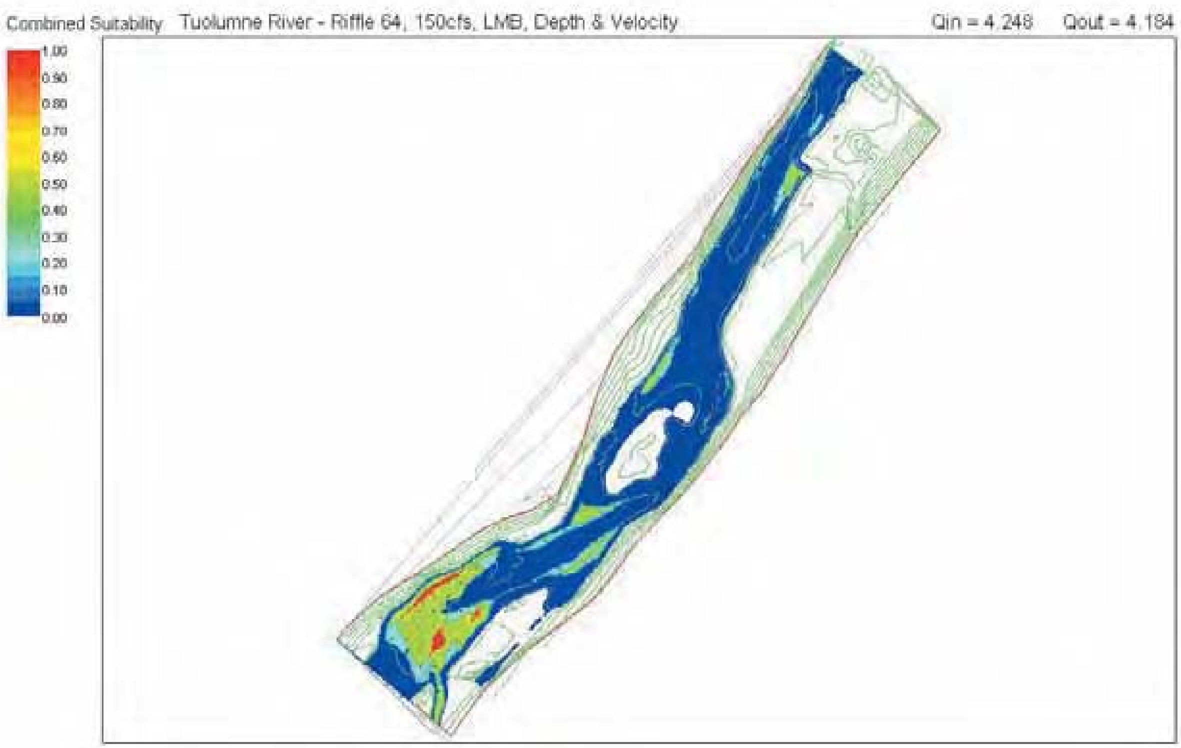
Appendix F

Predicted Largemouth Bass, Smallmouth Bass, and Chinook Salmon Habitat at Riffle 64.

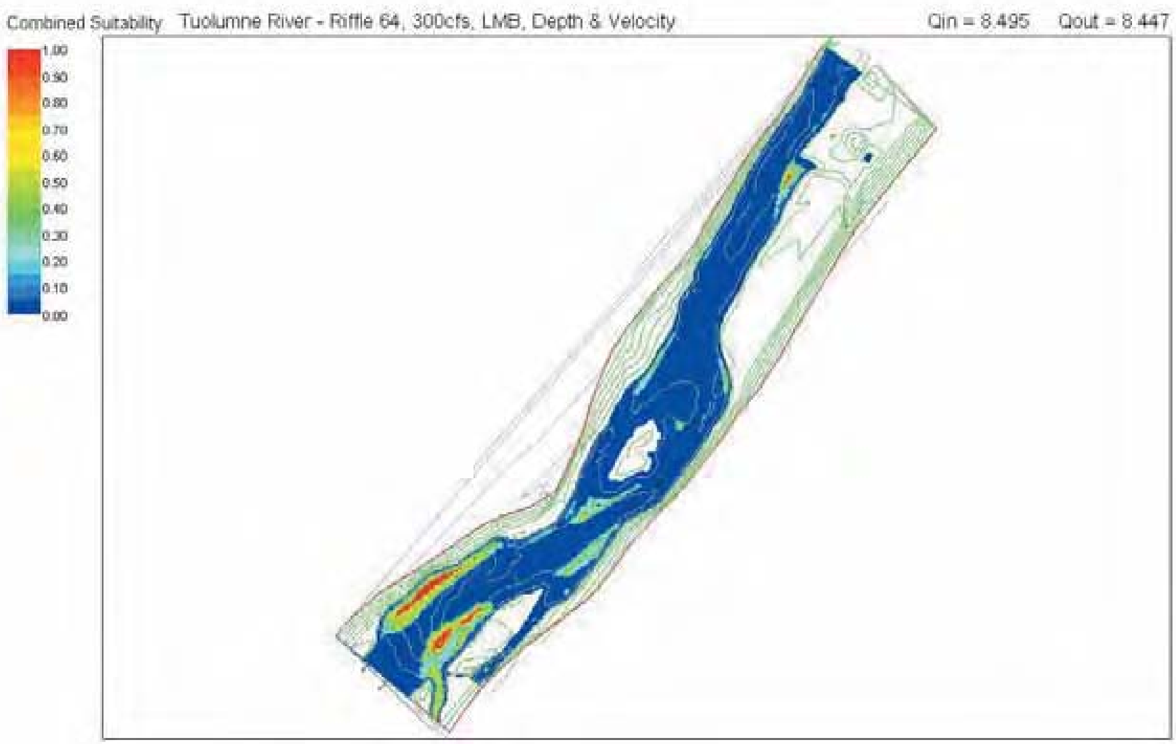

Combined Suitability
Tuolumne River - Riffle 64, 75cfs, LMB, Cover, Depth & Velocity
Qin = 2.124
Qout = 2.090
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

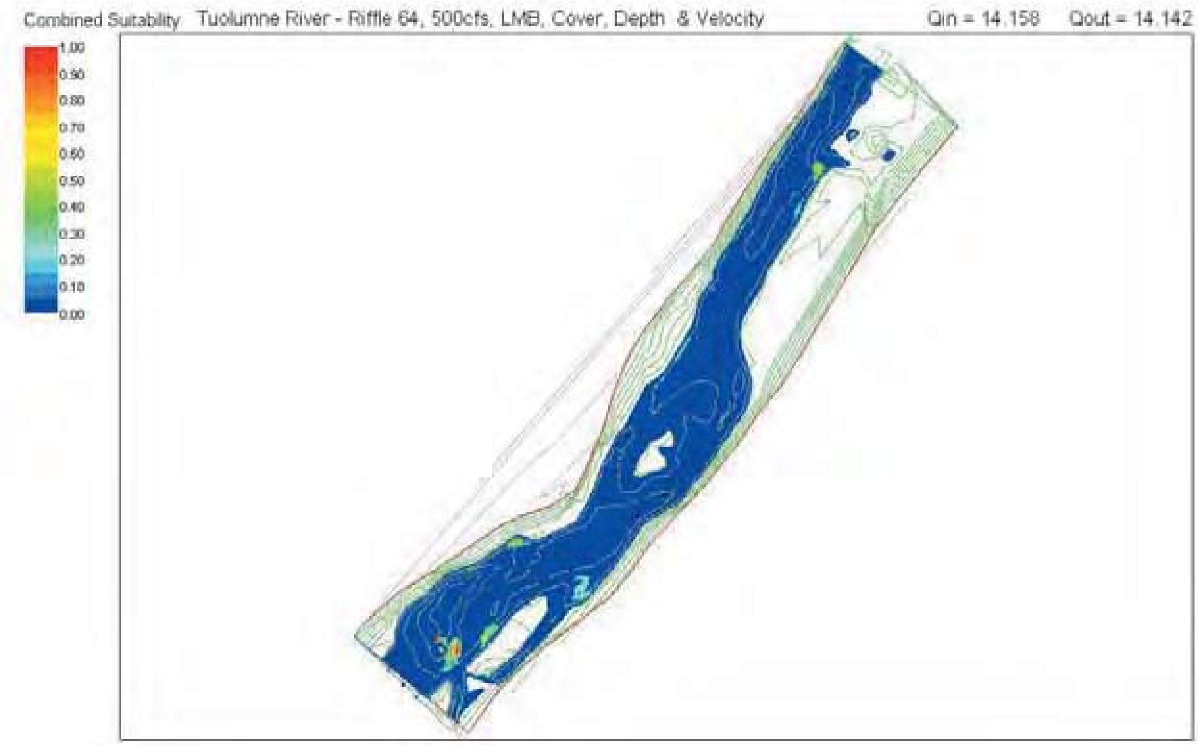

Combined Suitability
Tuolumne River - Riffle 64, 75cfs, LMB, Depth & Velocity
Qin = 2.124
Qout = 2.090
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

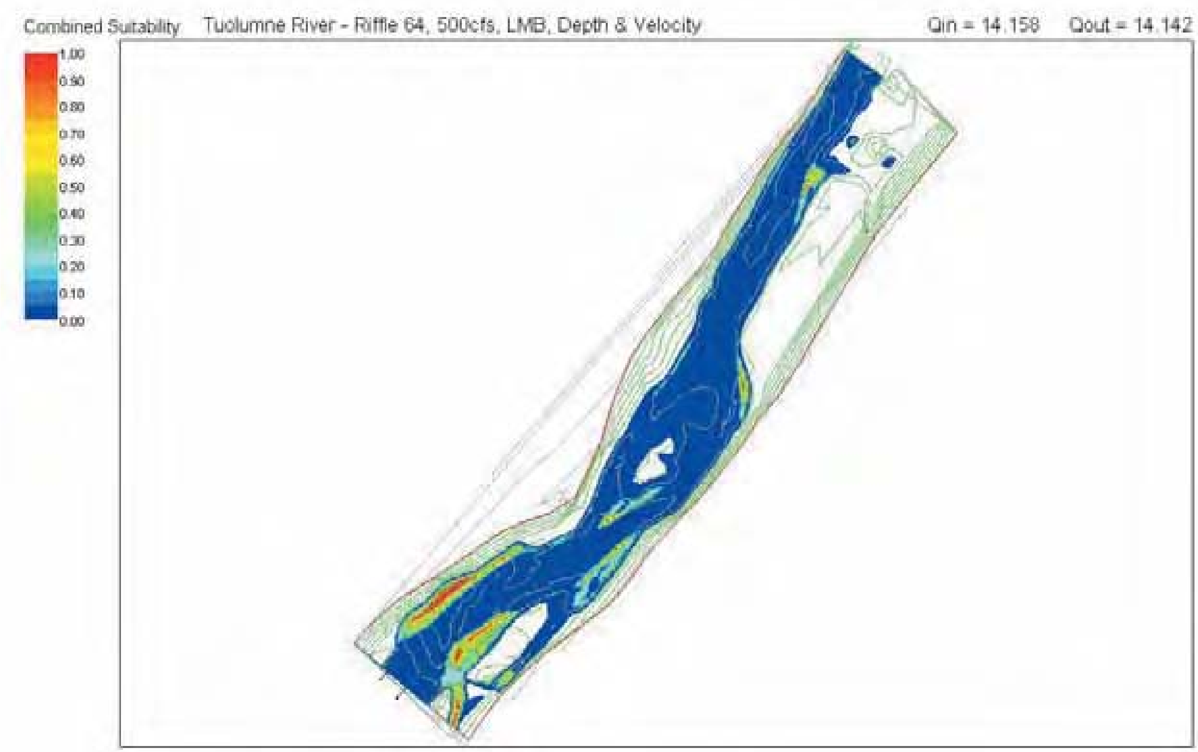

Combined Suitability
Tuolumne River - Riffle 64, 150cfs, LMB, Cover, Depth & Velocity
Qin = 4.248
Qout = 4.184
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

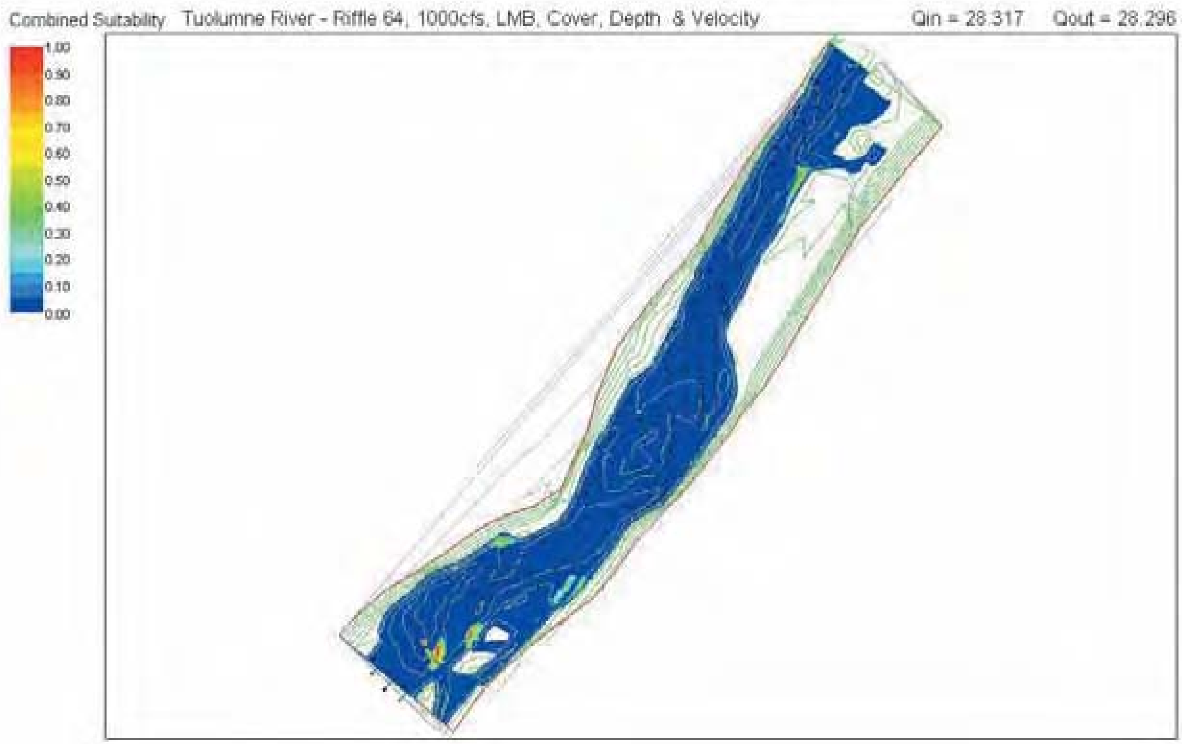

Combined Suitability
Tuolumne River - Riffle 64, 150cfs, LMB, Depth & Velocity
Qin = 4.248
Qout = 4.184
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

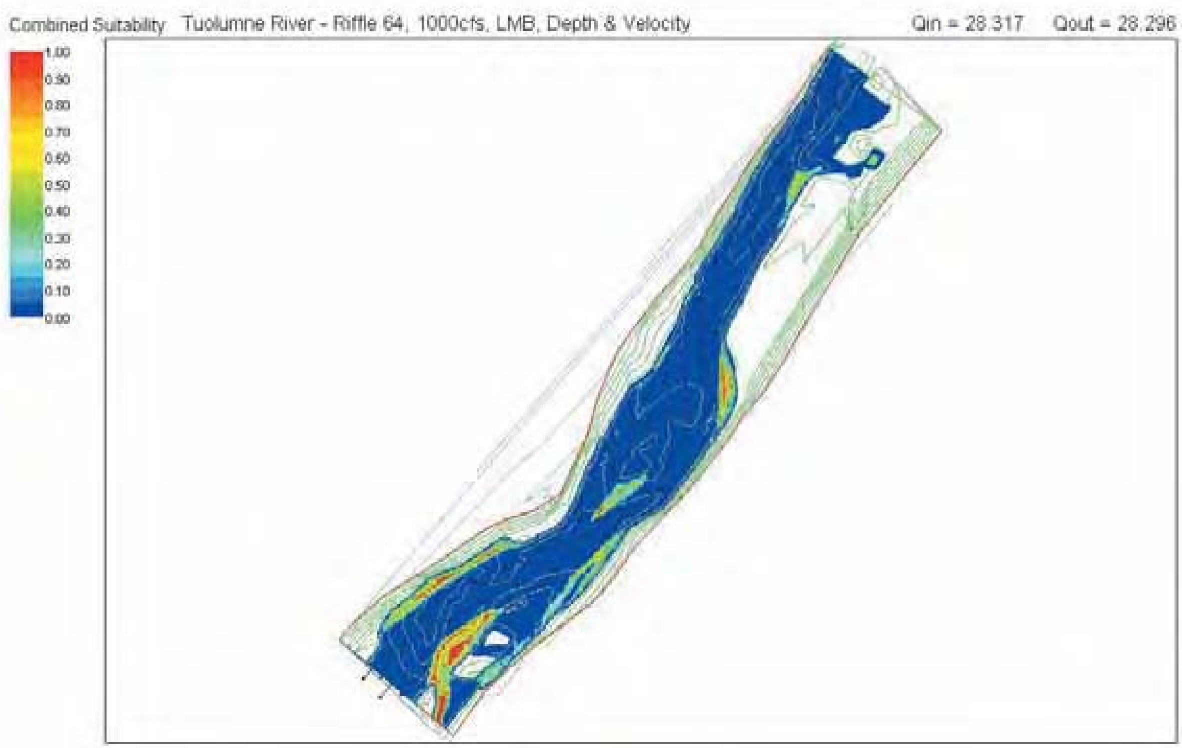

Combined Suitability
Tuolumne River - Riffle 64, 300cfs, LMB, Cover, Depth & Velocity
Qin = 8.495
Qout = 8.447
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

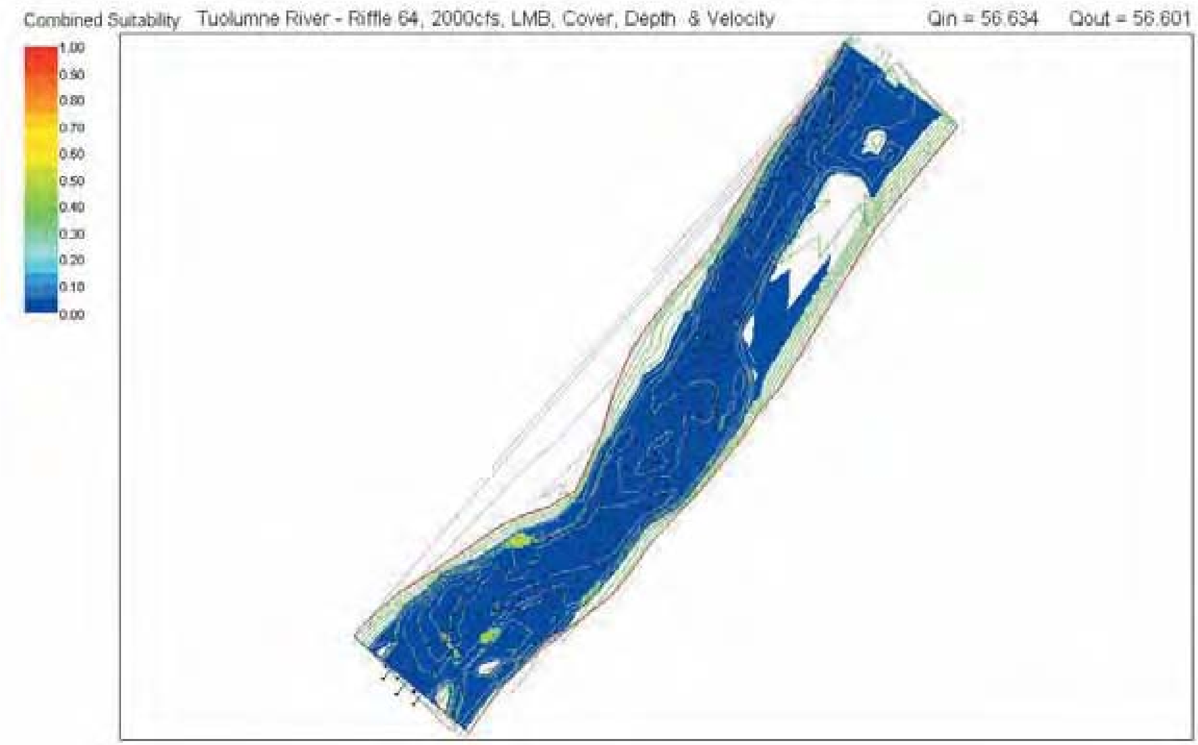

Combined Suitability
Tuolumne River - Riffle 64, 300cfs, LMB, Depth & Velocity
Qin = 8.495
Qout = 8.447
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

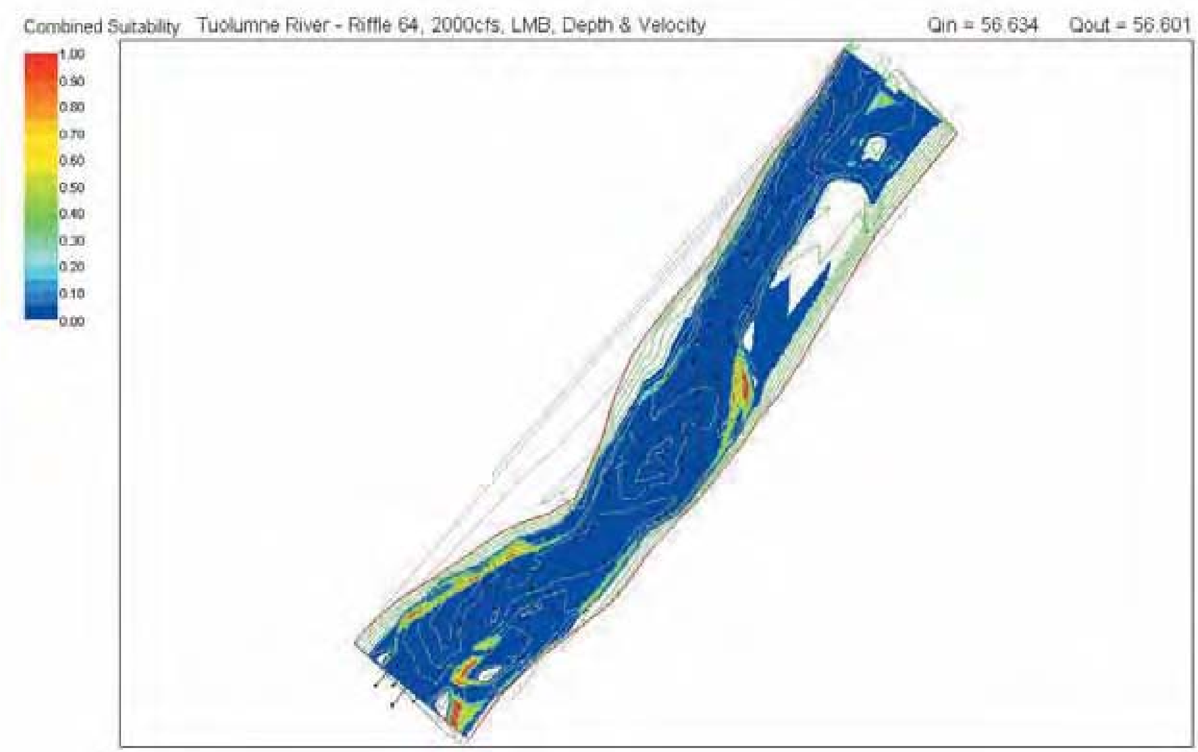

Combined Suitability
Tuolumne River - Riffle 64, 500cfs, LMB, Cover, Depth & Velocity
Qin = 14.158
Qout = 14.142
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

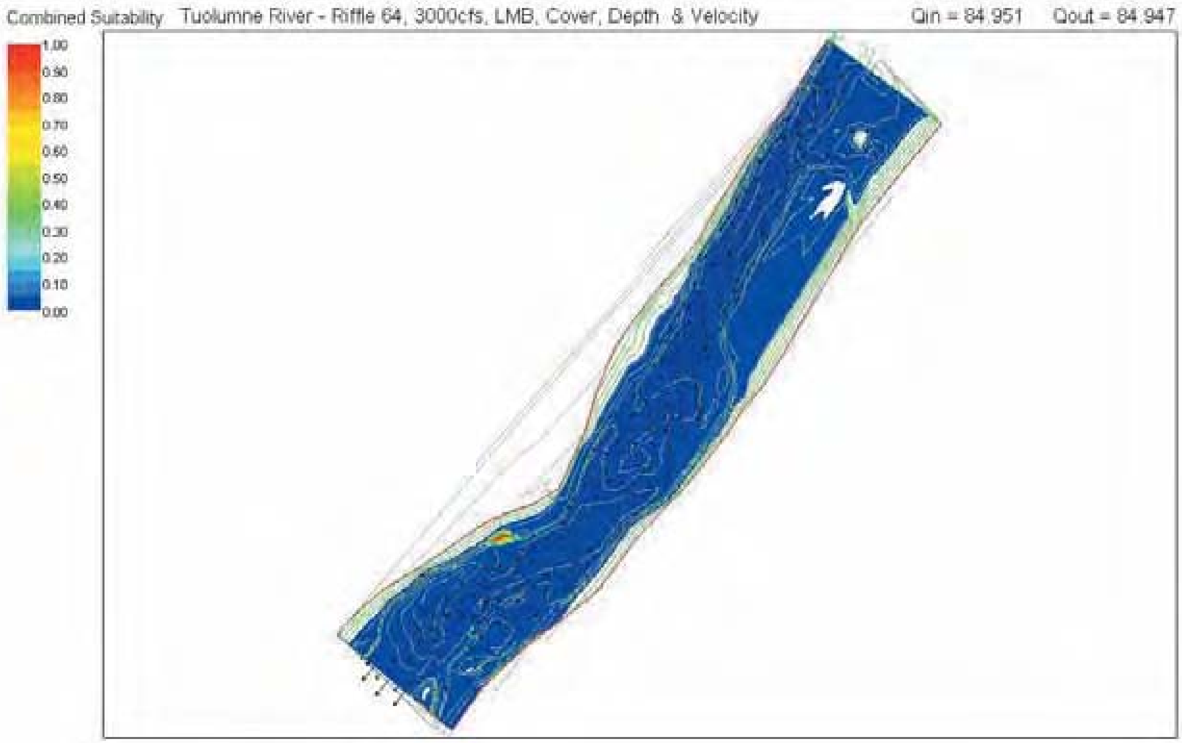

Combined Suitability
Tuolumne River - Riffle 64, 500cfs, LMB, Depth & Velocity
Qin = 14.158
Qout = 14.142
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

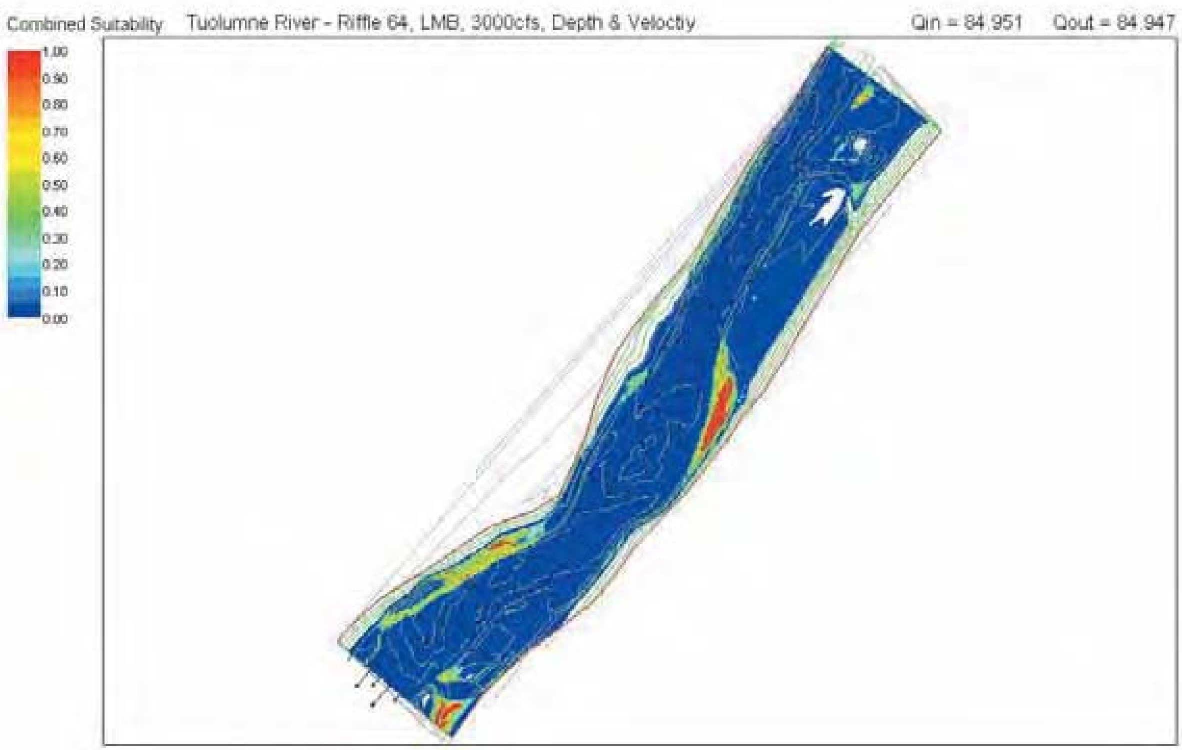

Combined Suitability
Tuolumne River - Riffle 64, 1000cfs, LMB, Cover, Depth & Velocity
Qin = 28.317
Qout = 28.296
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

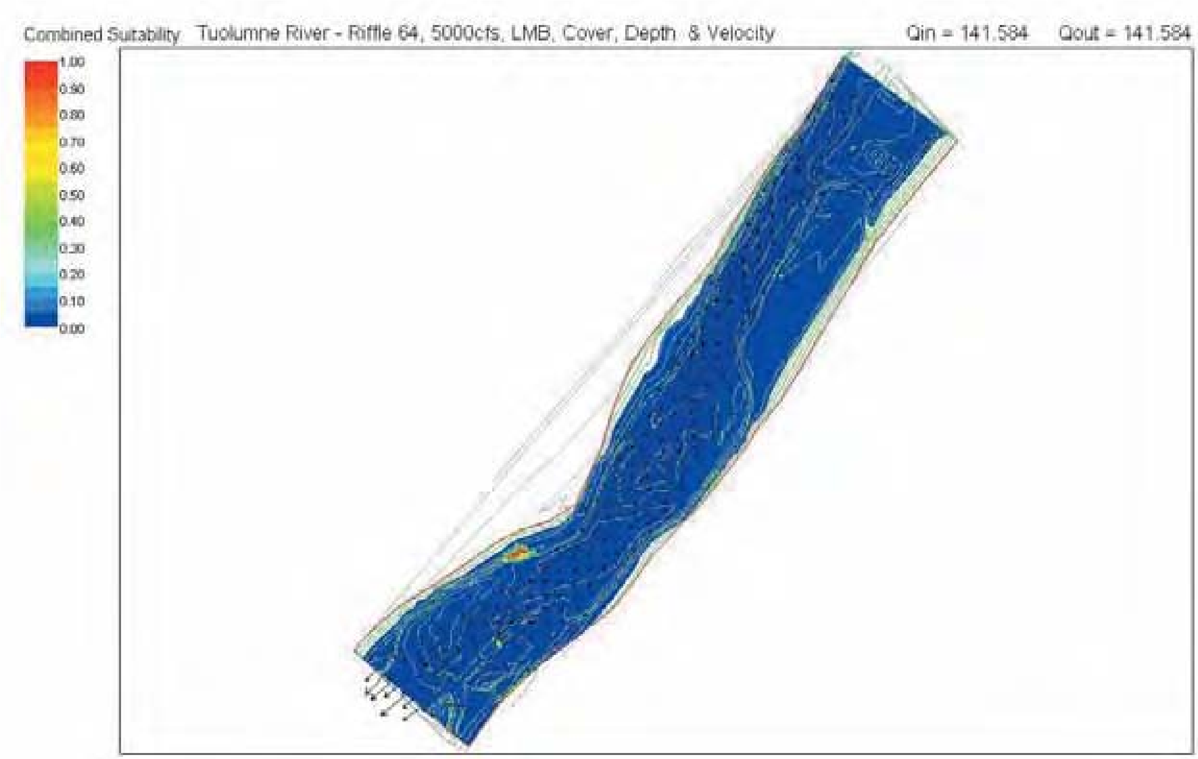

Combined Suitability
Tuolumne River - Riffle 64, 1000cfs, LMB, Depth & Velocity
Qin = 28.317
Qout = 28.296
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

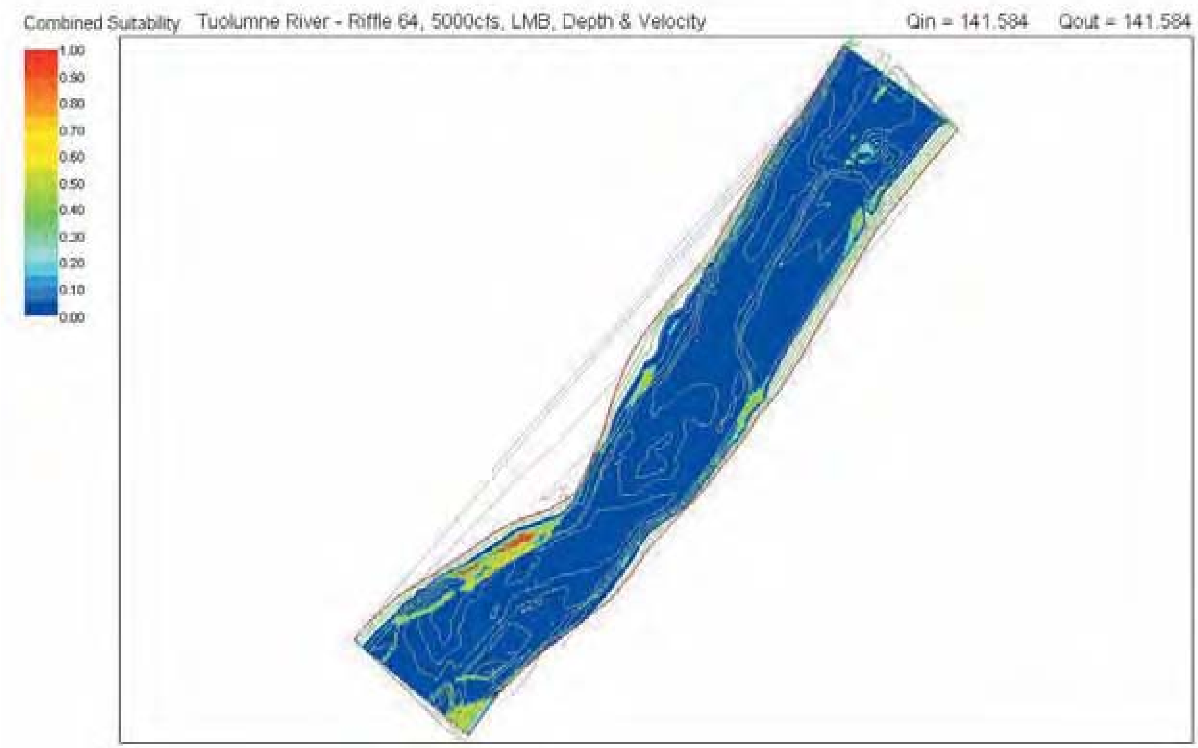

Combined Suitability
Tuolumne River - Riffle 64, 2000cfs, LMB, Cover, Depth & Velocity
Qin = 56.634
Qout = 56.601
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability
Tuolumne River - Riffle 64, 2000cfs, LMB, Depth & Velocity
Qin = 56.634
Qout = 56.601
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

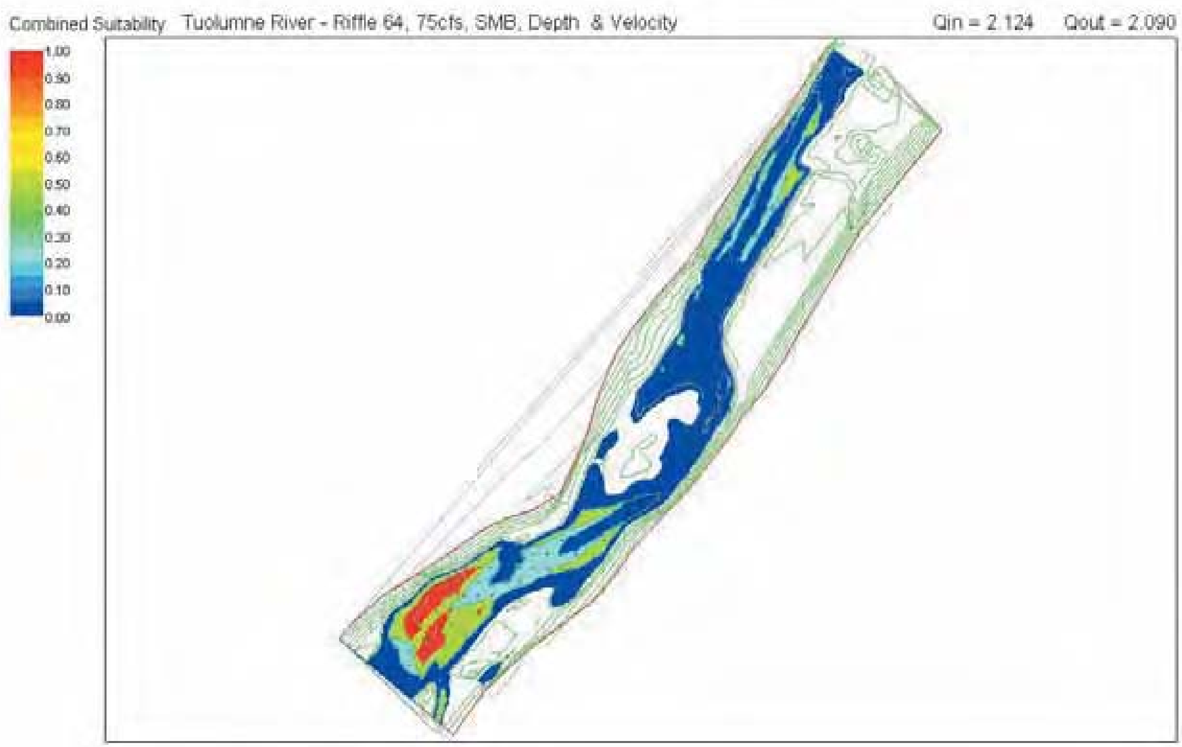

Combined Suitability
Tuolumne River - Riffle 64, 3000cfs, LMB, Cover, Depth & Velocity
Qin = 84.951
Qout = 84.947
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability
Tuolumne River - Riffle 64, LMB, 3000cfs, Depth & Velocity
Qin = 84.951
Qout = 84.947
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

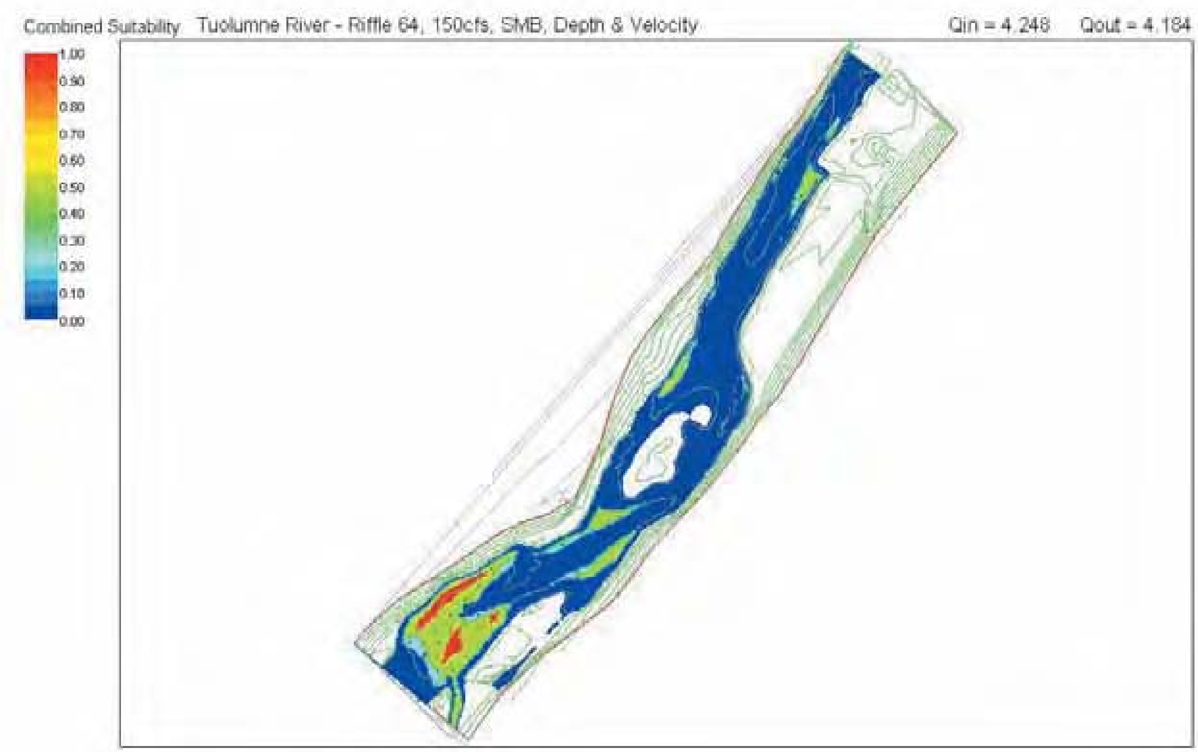

Combined Suitability
Tuolumne River - Riffle 64, 5000cfs, LMB, Cover, Depth & Velocity
Qin = 141.584
Qout = 141.584
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability
Tuolumne River - Riffle 64, 5000cfs, LMB, Depth & Velocity
Qin = 141.584
Qout = 141.584
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

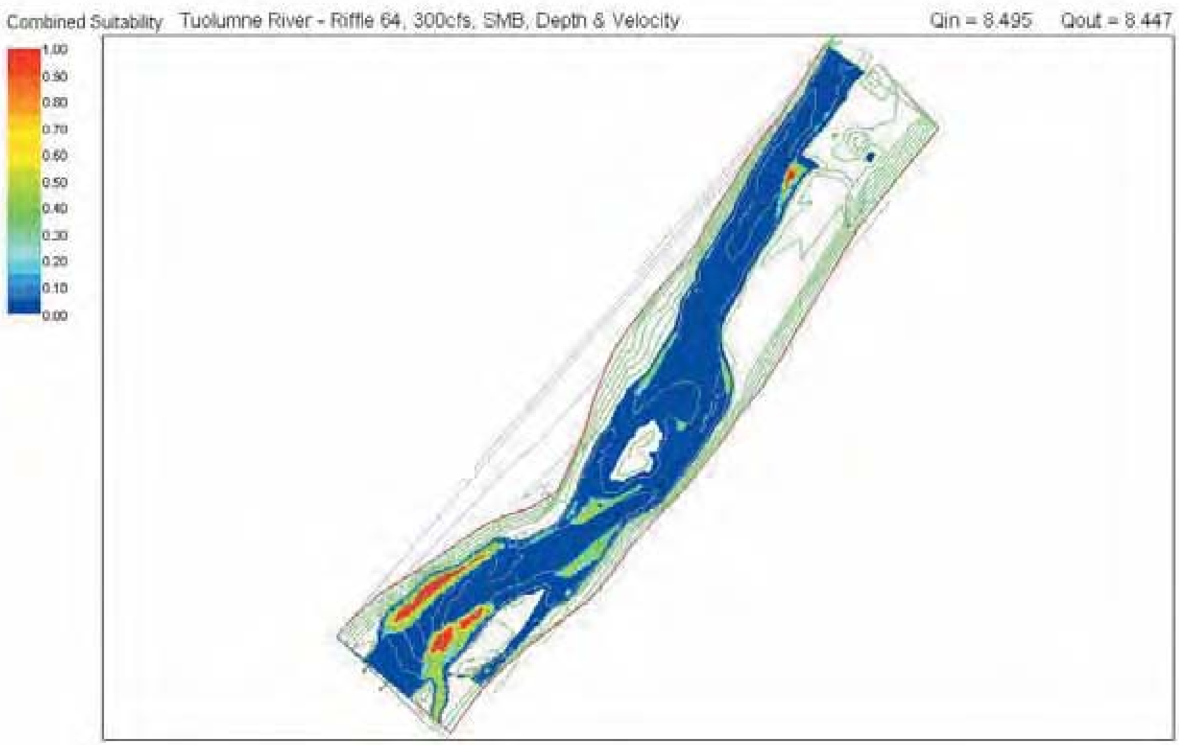

Combined Suitability
Tuolumne River - Riffle 64, 75cfs, SMB, Cover, Depth & Velocity
Qin = 2.124
Qout = 2.090
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

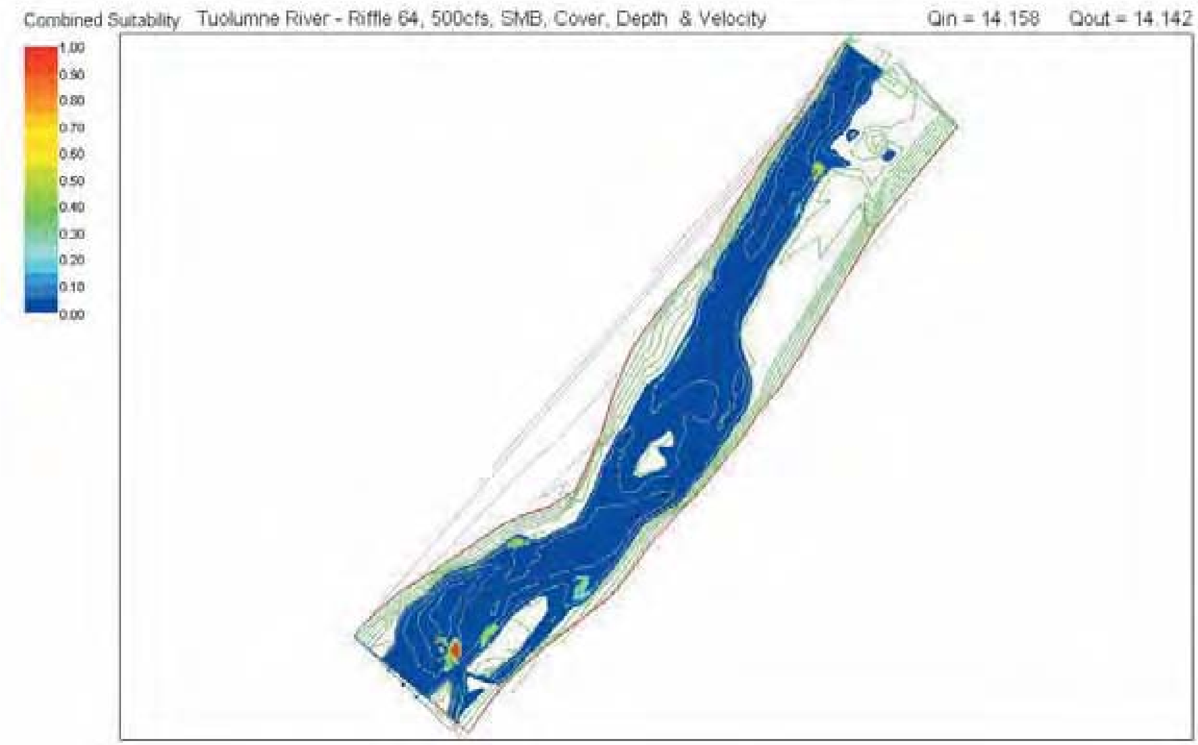

Combined Suitability
Tuolumne River - Riffle 64, 75cfs, SMB, Depth & Velocity
Qin = 2.124
Qout = 2.090
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

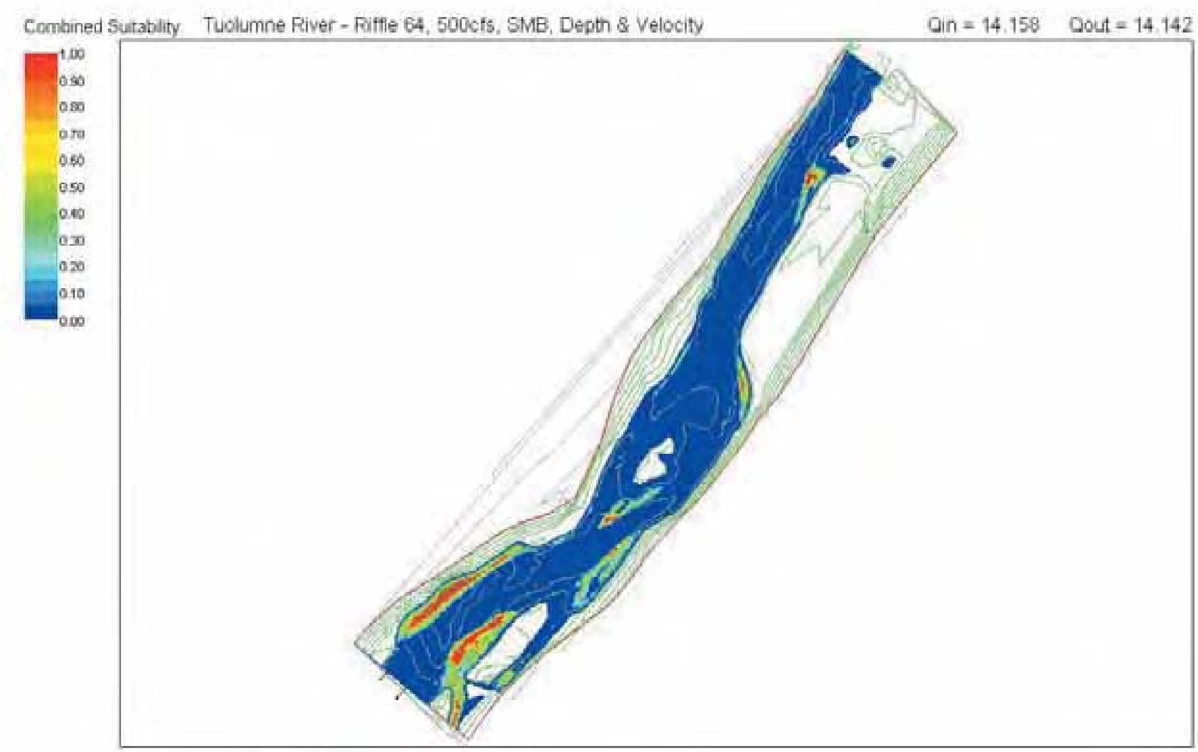

Combined Suitability
Tuolumne River - Riffle 64, 150cfs, SMB, Cover, Depth & Velocity
Qin = 4.248
Qout = 4.184
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

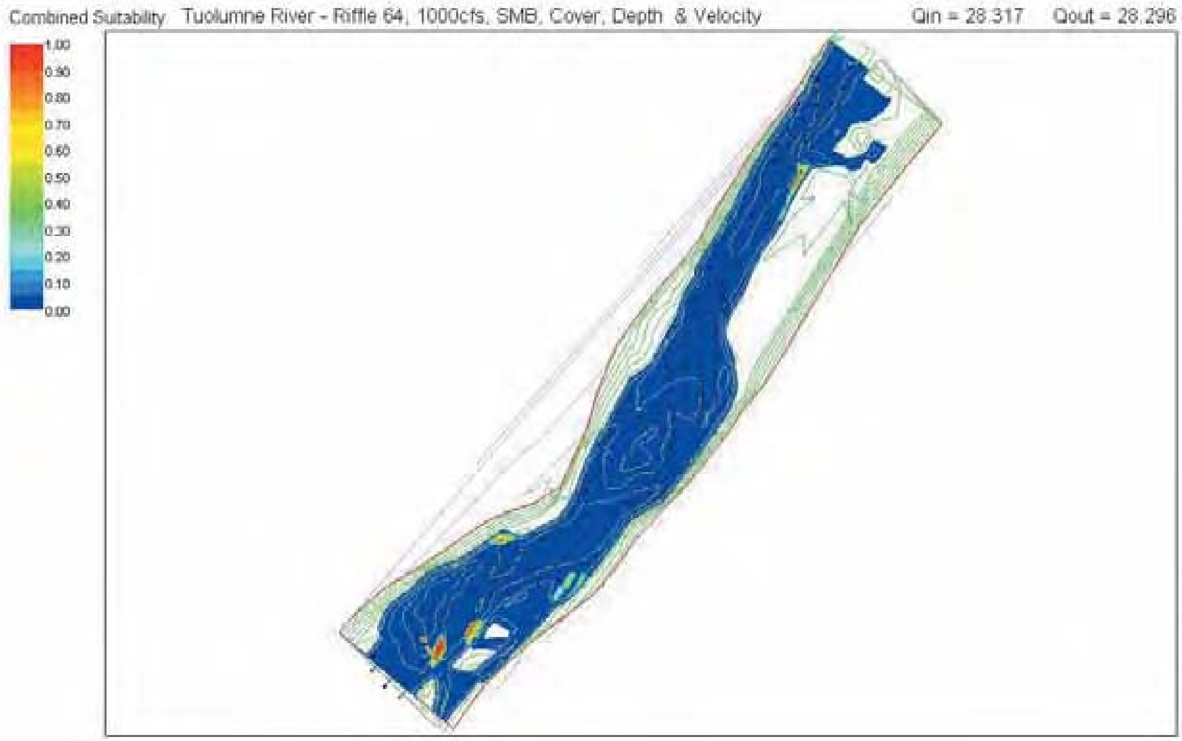

Combined Suitability
Tuolumne River - Riffle 64, 150cfs, SMB, Depth & Velocity
Qin = 4.248
Qout = 4.184
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

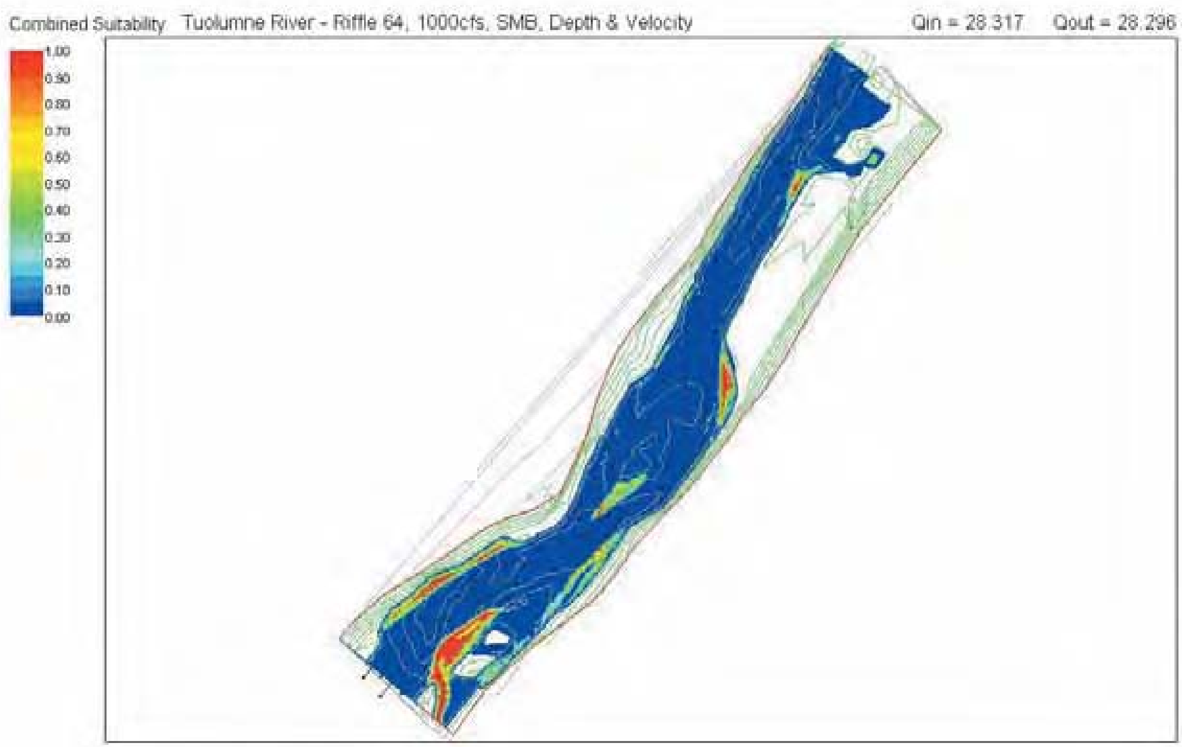

Combined Suitability
Tuolumne River - Riffle 64, 300cfs, SMB, Cover, Depth & Velocity
Qin = 8.495
Qout = 8.447
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

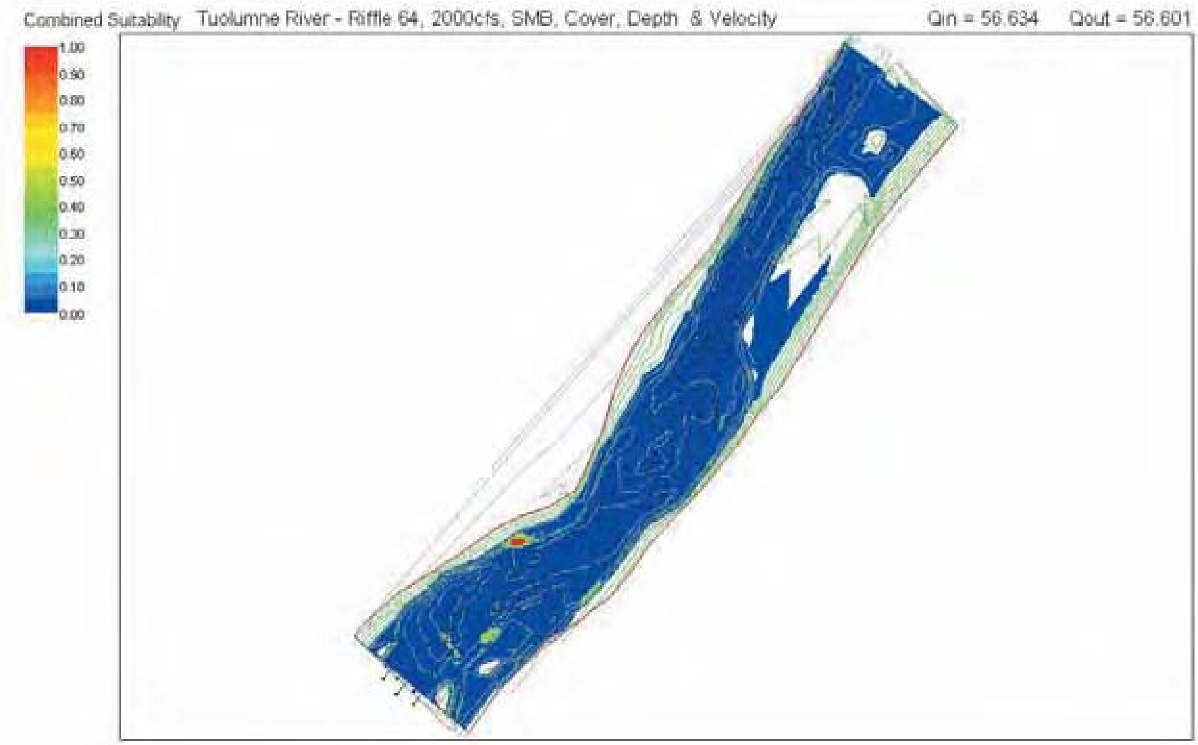

Combined Suitability
Tuolumne River - Riffle 64, 300cfs, SMB, Depth & Velocity
Qin = 8.495
Qout = 8.447
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

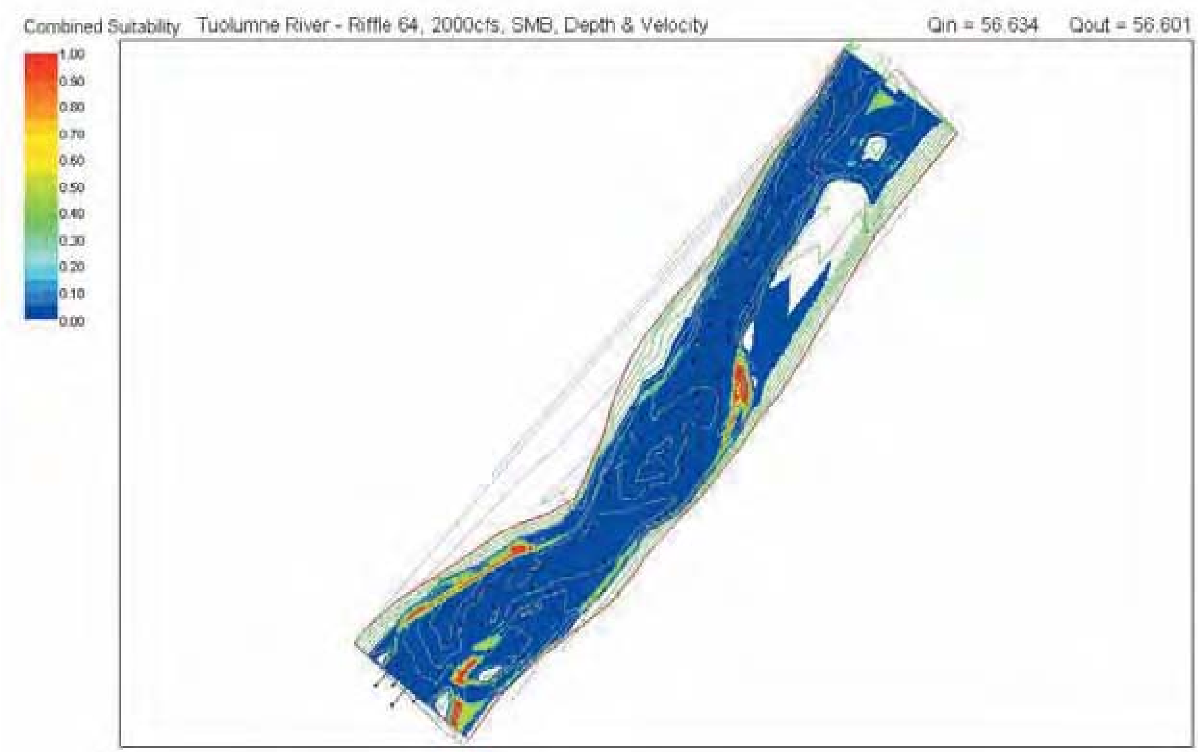

Combined Suitability
Tuolumne River - Riffle 64, 500cfs, SMB, Cover, Depth & Velocity
Qin = 14.158
Qout = 14.142
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

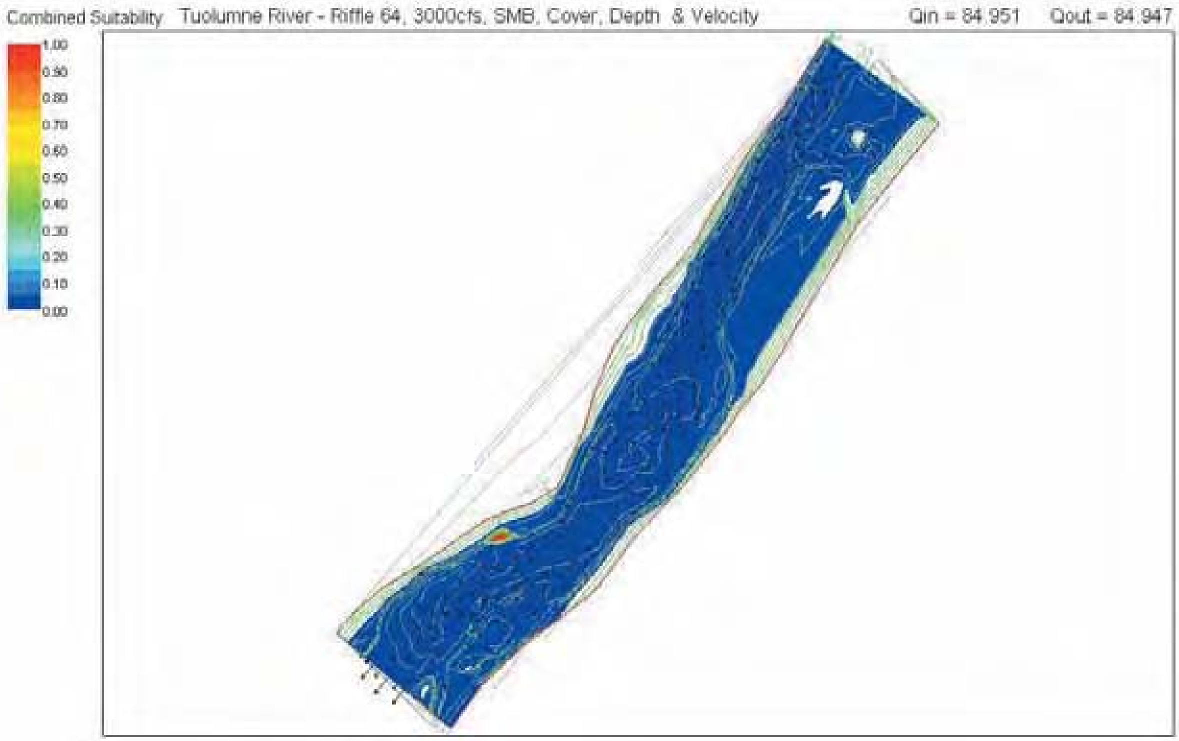

Combined Suitability
Tuolumne River - Riffle 64, 500cfs, SMB, Depth & Velocity
Qin = 14.158
Qout = 14.142
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

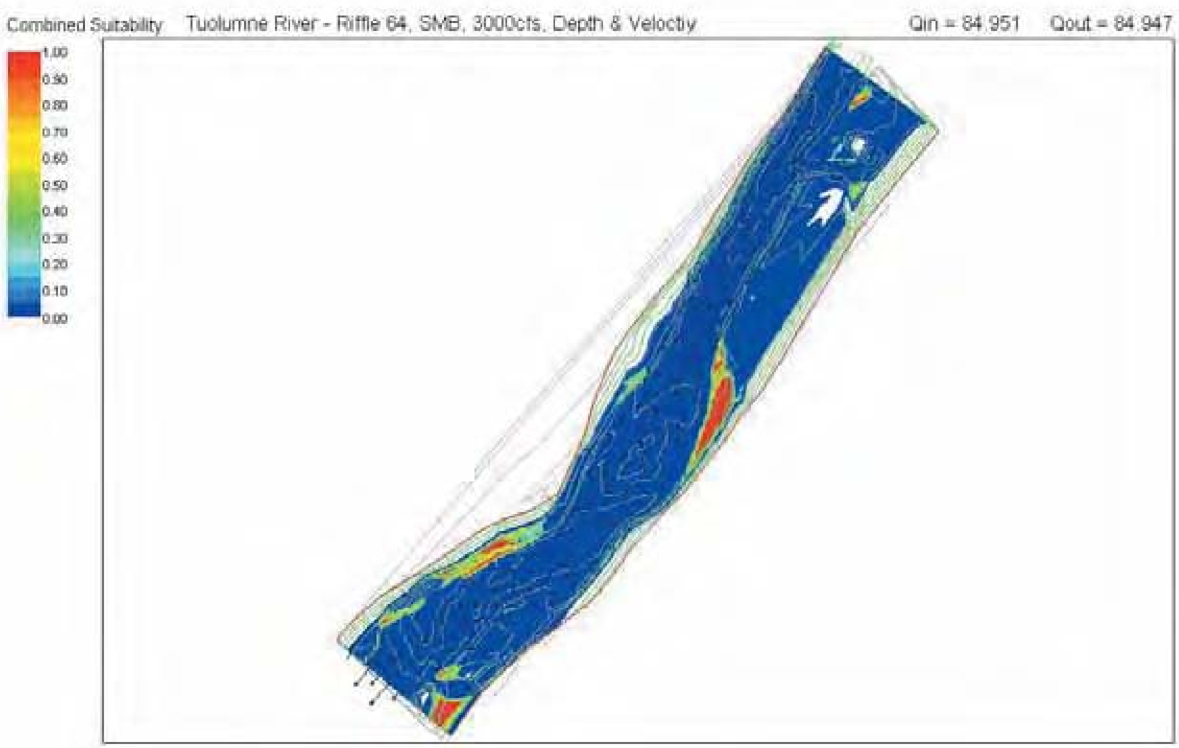

Combined Suitability
Tuolumne River - Riffle 64, 1000cfs, SMB, Cover, Depth & Velocity
Qin = 28.317
Qout = 28.296
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

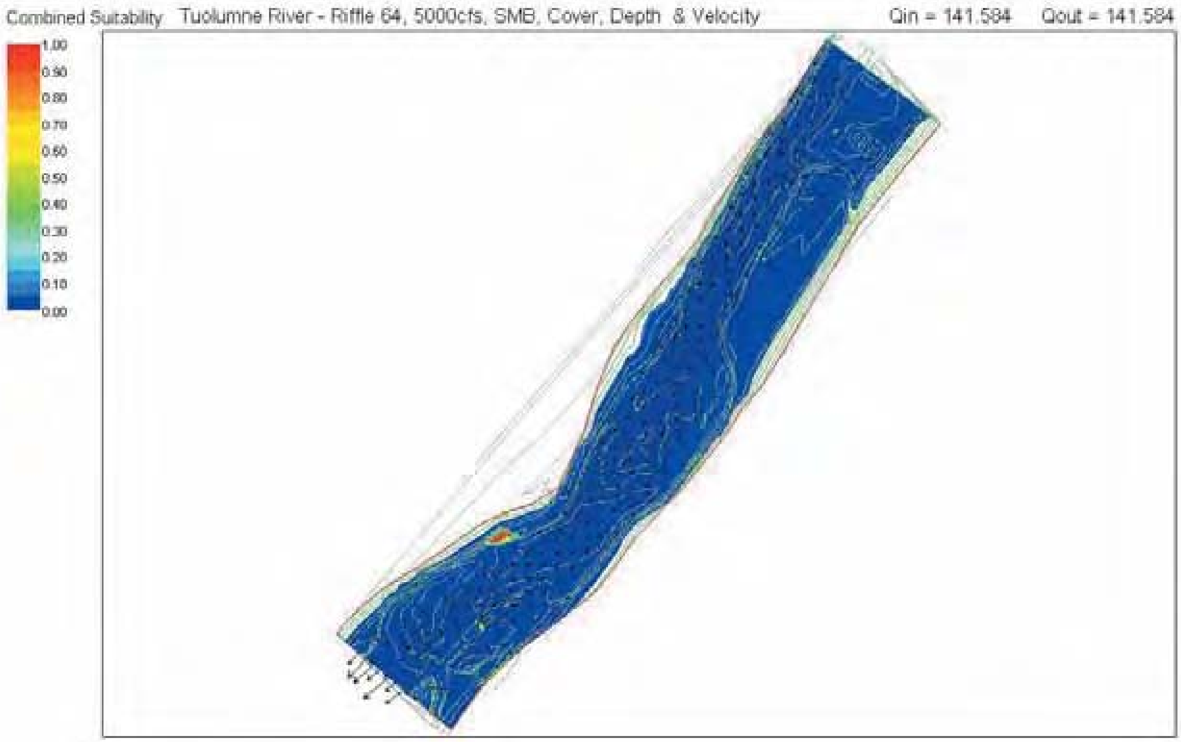

Combined Suitability
Tuolumne River - Riffle 64, 1000cfs, SMB, Depth & Velocity
Qin = 28.317
Qout = 28.296
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

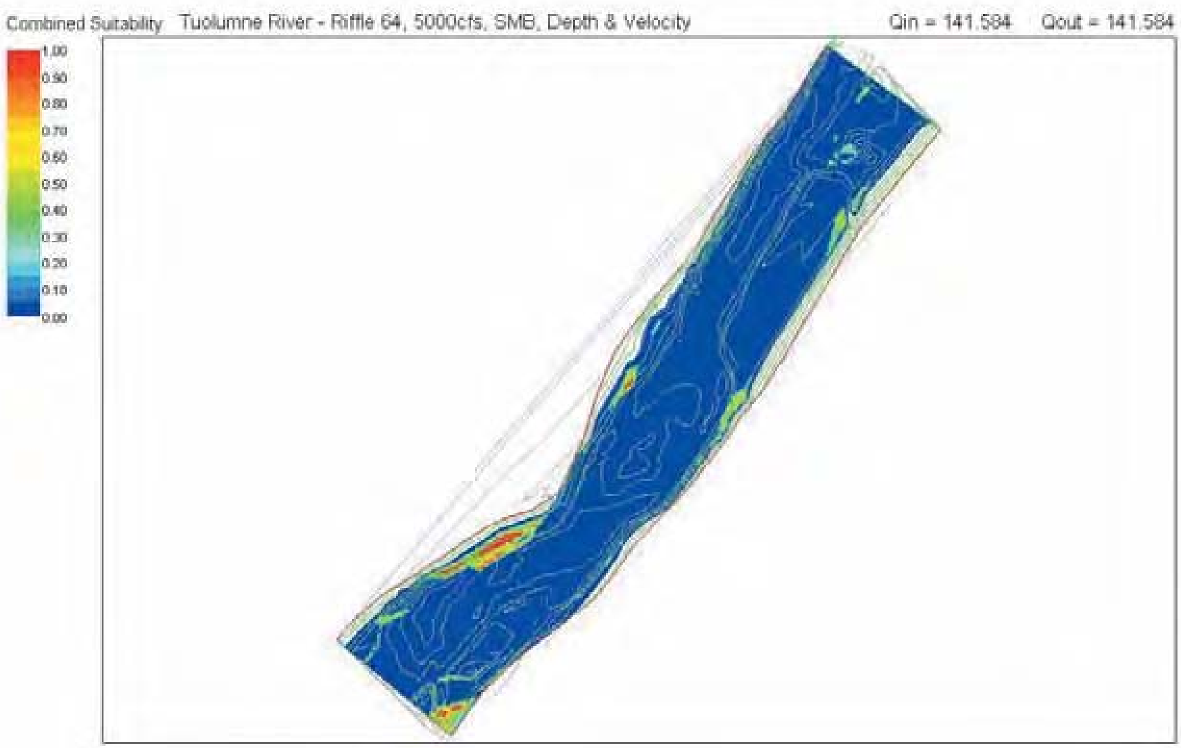

Combined Suitability
Tuolumne River - Riffle 64, 2000cfs, SMB, Cover, Depth & Velocity
Qin = 56.634
Qout = 56.601
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability
Tuolumne River - Riffle 64, 2000cfs, SMB, Depth & Velocity
Qin = 56.634
Qout = 56.601
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability
Tuolumne River - Riffle 64, 3000cfs, SMB, Cover, Depth & Velocity
Qin = 84.951
Qout = 84.947
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability
Tuolumne River - Riffle 64, SMB, 3000cfs, Depth & Veloctiy
Qin = 84.951
Qout = 84.947
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

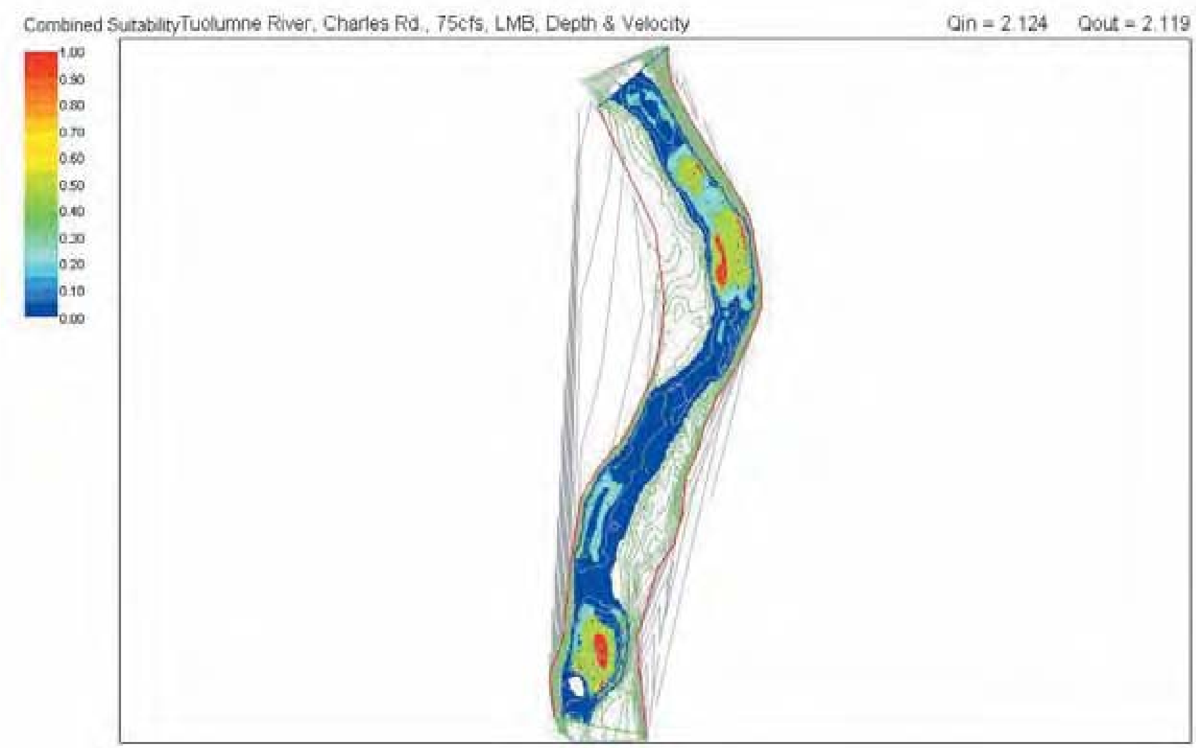

Combined Suitability
Tuolumne River - Riffle 64, 5000cfs, SMB, Cover, Depth & Velocity
Qin = 141.584
Qout = 141.584
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

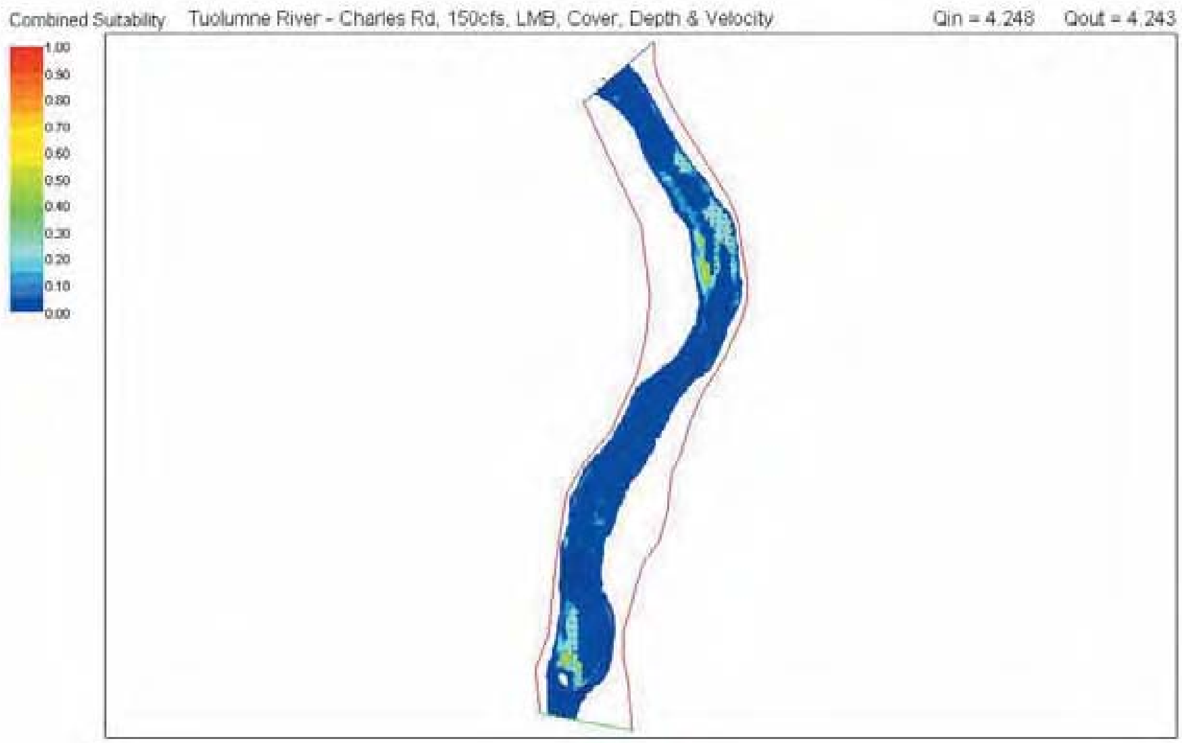

Combined Suitability
Tuolumne River - Riffle 64, 5000cfs, SMB, Depth & Velocity
Qin = 141.584
Qout = 141.584
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

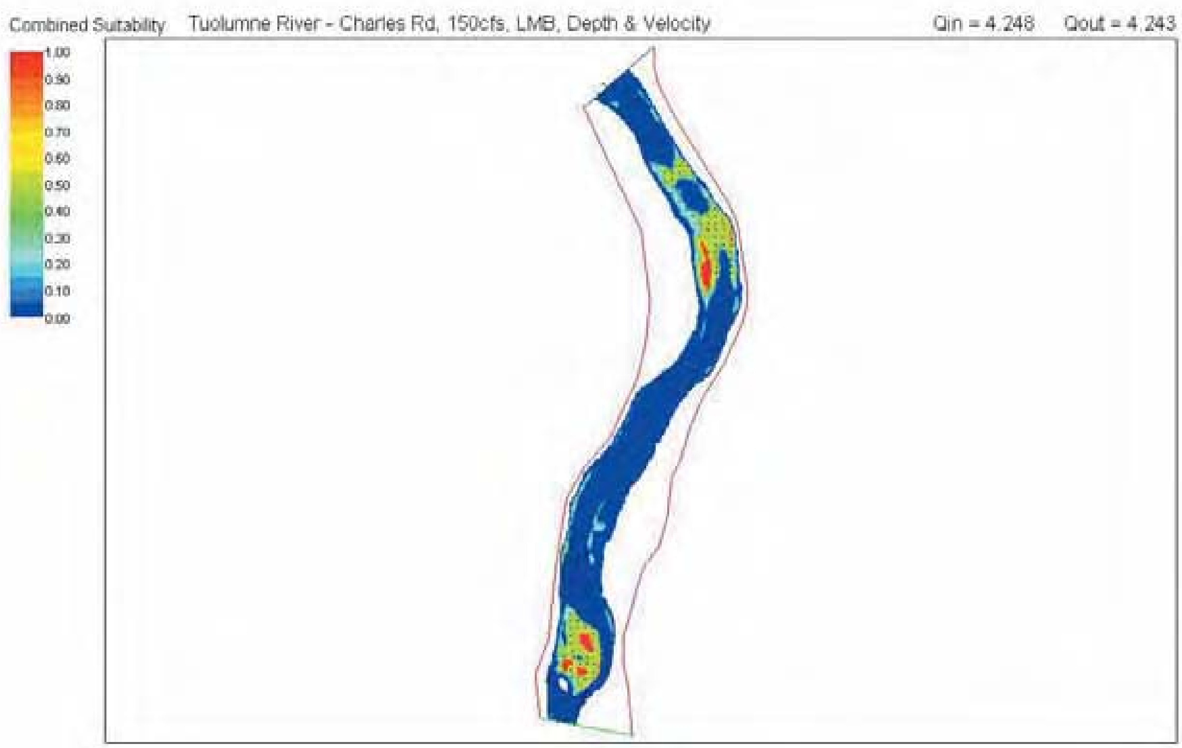
Appendix G

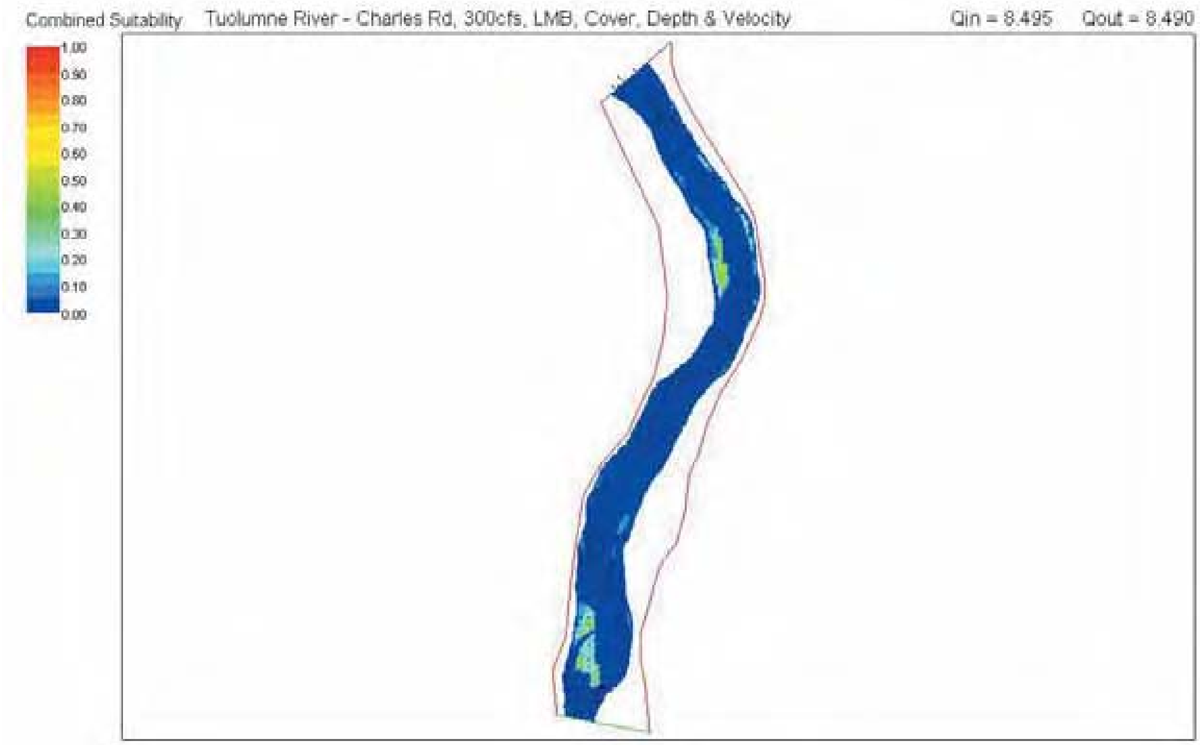
Predicted Largemouth Bass, Smallmouth Bass, and Chinook Salmon Habitat at Charles Road.

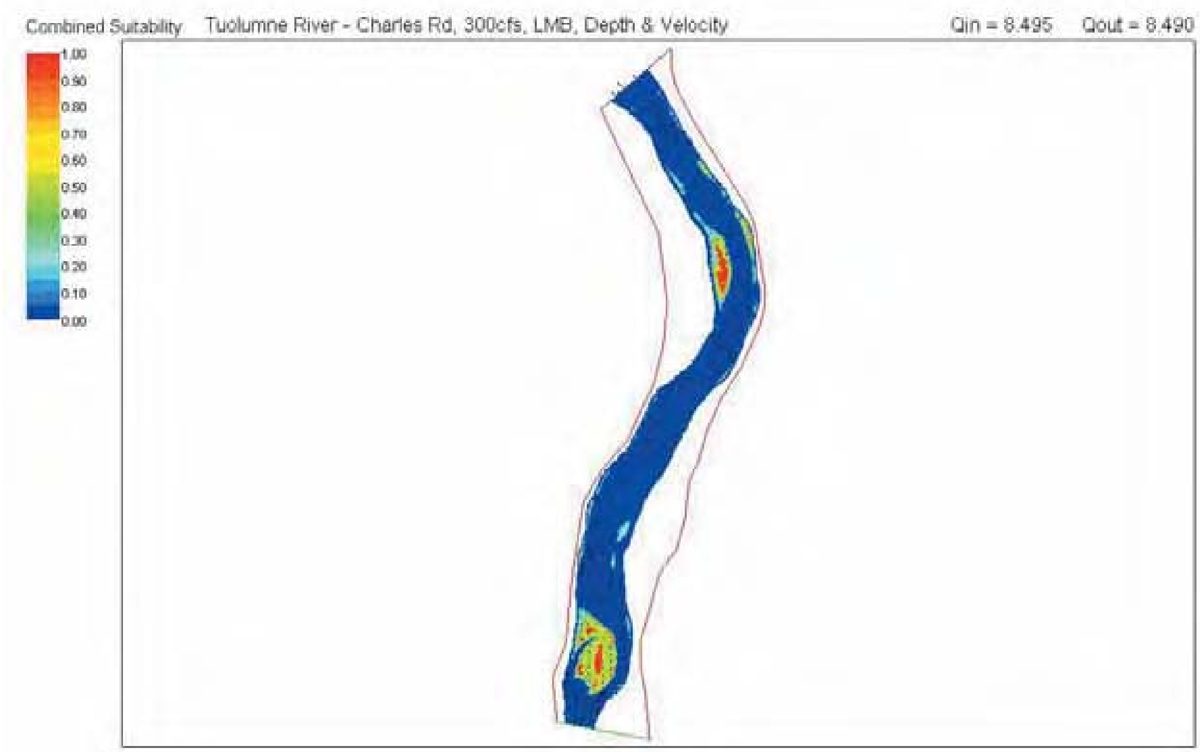

Combined Suitability Tuolumne River - Charles Road, 75 cfs, LMB, Cover, Depth and Velocity
Qin = 2.124 Qout = 2.119
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability Tuolumne River, Charles Rd., 75cfs, LMB, Depth & Velocity
Qin = 2.124 Qout = 2.119
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

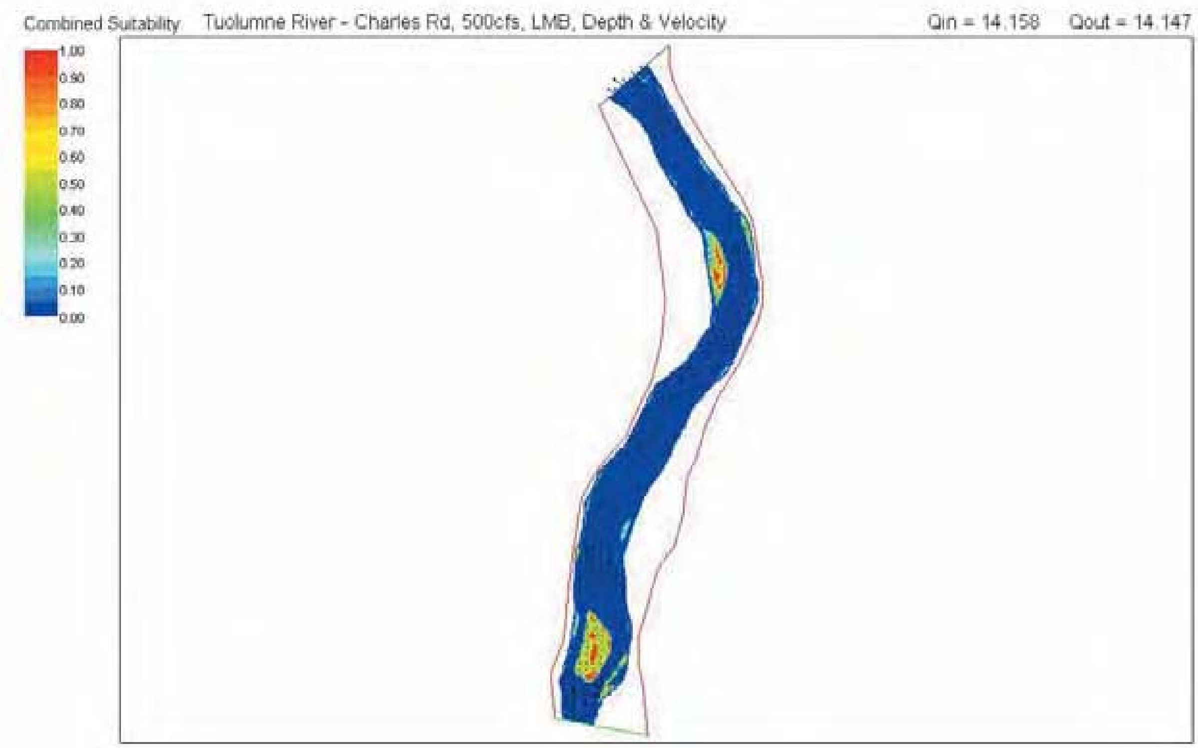

Combined Suitability
Tuolumne River - Charles Rd, 150cfs, LMB, Cover, Depth & Velocity
Qin = 4.248
Qout = 4.243
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

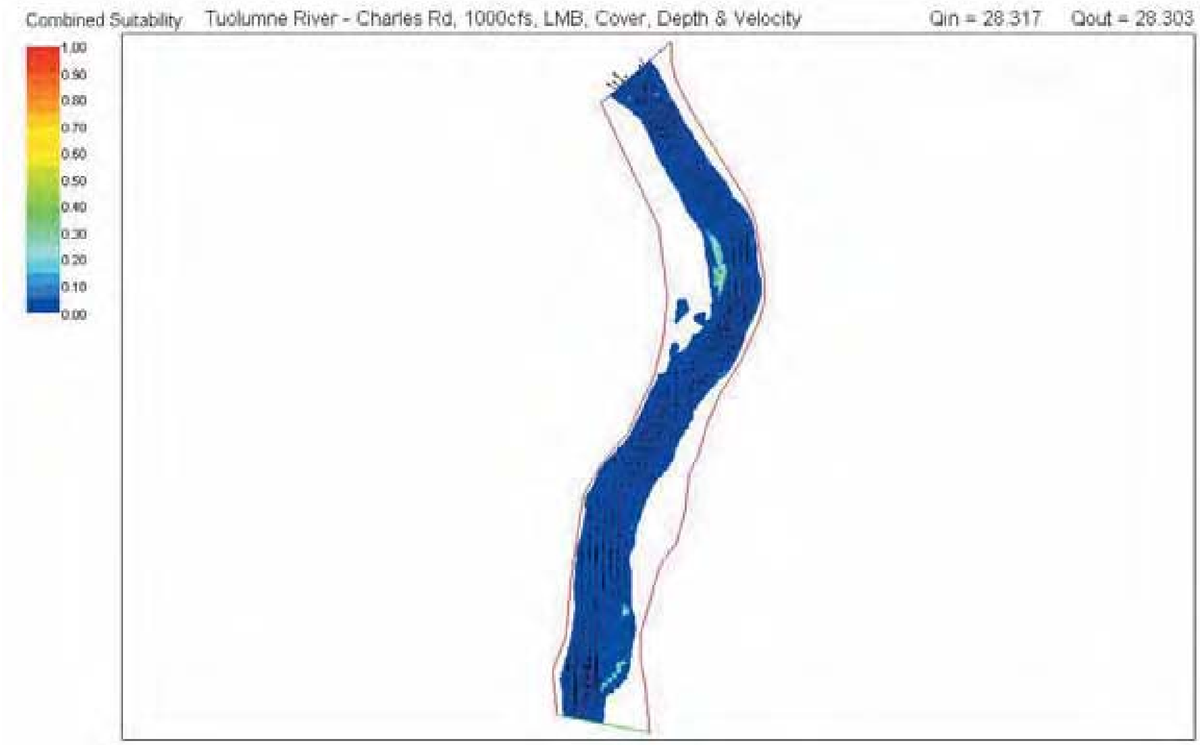

Combined Suitability
Tuolumne River - Charles Rd, 150cfs, LMB, Depth & Velocity
Qin = 4.248
Qout = 4.243
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

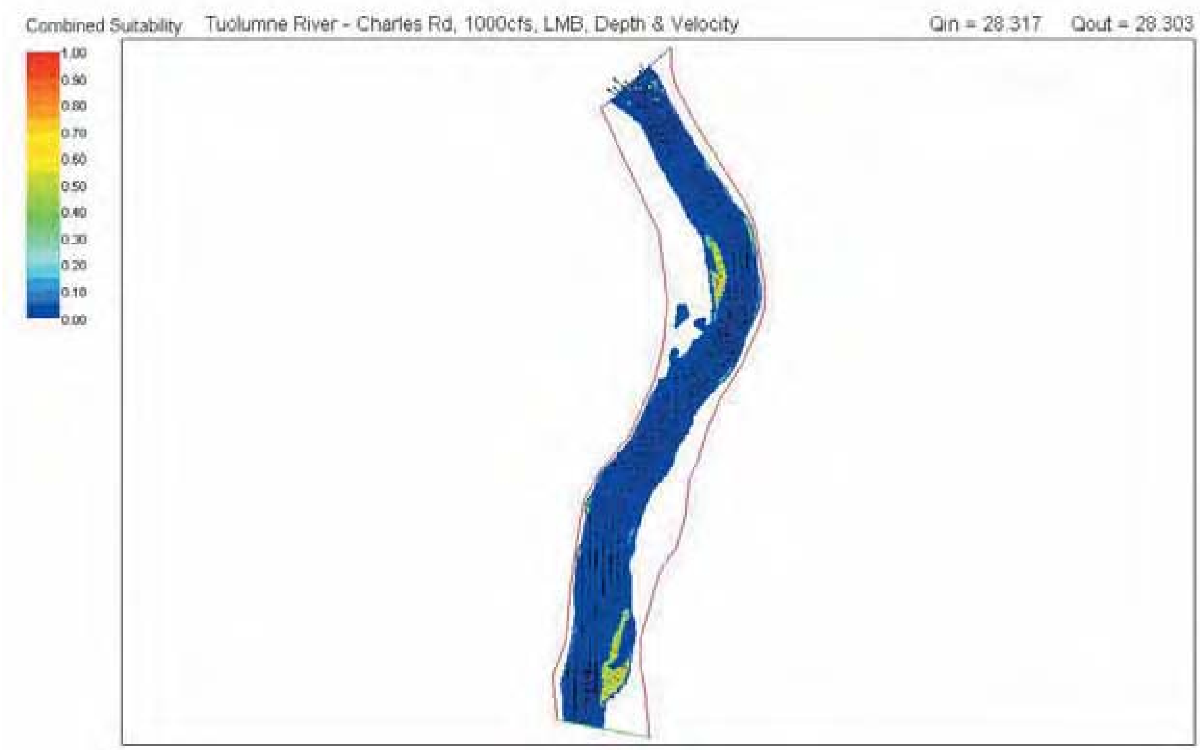

Combined Suitability
Tuolumne River - Charles Rd, 300cfs, LMB, Cover, Depth & Velocity
Qin = 8.495
Qout = 8.490
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability
Tuolumne River - Charles Rd, 300cfs, LMB, Depth & Velocity
Qin = 8.495
Qout = 8.490
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability
Tuolumne River - Charles Rd, 500cfs, LMB, Cover, Depth & Velocity
Qin = 14.158
Qout = 14.147
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

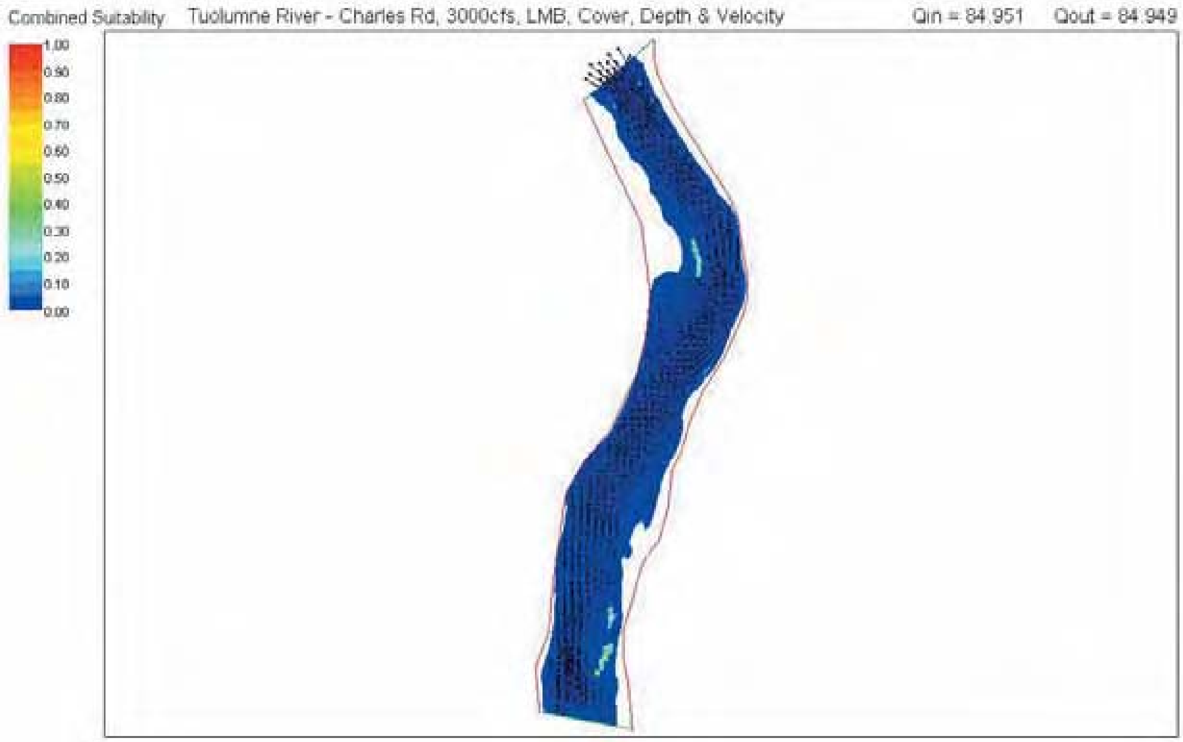

Combined Suitability
Tuolumne River - Charles Rd, 500cfs, LMB, Depth & Velocity
Qin = 14.158
Qout = 14.147
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability
Tuolumne River - Charles Rd, 1000cfs, LMB, Cover, Depth & Velocity
Qin = 28.317
Qout = 28.303
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

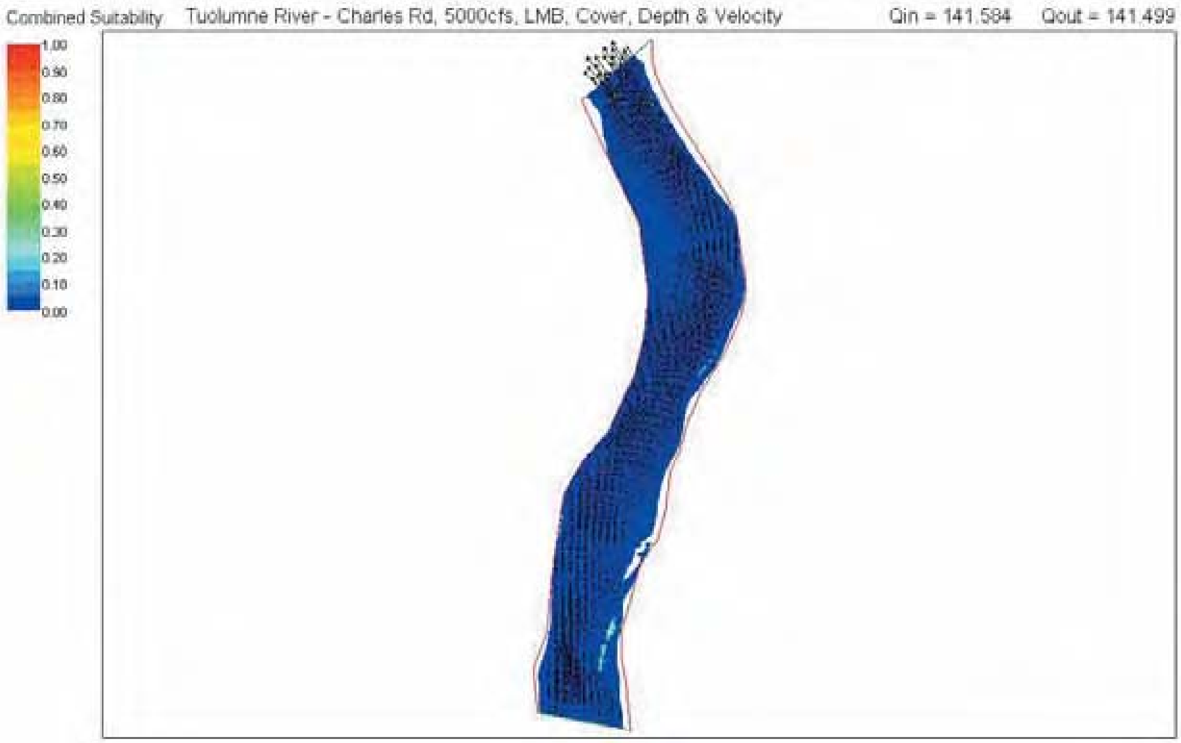

Combined Suitability
Tuolumne River - Charles Rd, 1000cfs, LMB, Depth & Velocity
Qin = 28.317
Qout = 28.303
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

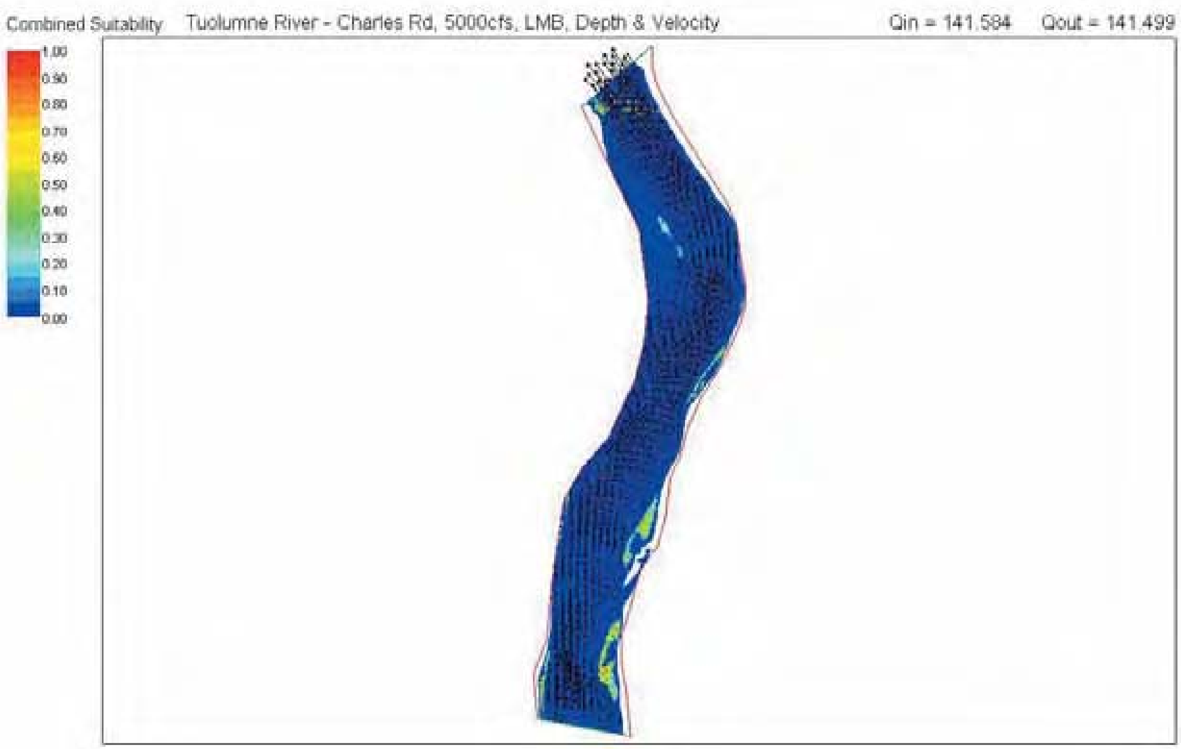

Combined Suitability Tuolumne River, Charles Rd., 2000cfs, LMB, Cover, Depth & Velocity
Qin = 56.634
Qout = 56.630
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability Tuolumne River, Charles Rd., 2000cfs, LMB, Depth & Velocity
Qin = 56.634
Qout = 56.630
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability
Tuolumne River - Charles Rd, 3000cfs, LMB, Cover, Depth & Velocity
Qin = 84.951
Qout = 84.949
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability
Tuolumne River - Charles Rd, 3000cfs, LMB, Depth & Velocity
Qin = 84.951
Qout = 84.949
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability
Tuolumne River - Charles Rd, 5000cfs, LMB, Cover, Depth & Velocity
Qin = 141.584
Qout = 141.499
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Combined Suitability
Tuolumne River - Charles Rd, 5000cfs, LMB, Depth & Velocity
Qin = 141.584
Qout = 141.499
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00

Appendix H

Draft Monitoring Plan

TUOLUMNE RIVER SPECIAL RUN POOLS 9 & 10 AND GRAVEL MINING REACH RESTORATION PROJECTS

---DRAFT MONITORING PLAN---

Prepared by:
McBain & Trush
P.O. Box 663
Arcata, CA 95518

and

EDAW
10423 Old Placerville Road, Suite 100
Sacramento CA 95827

Prepared for:
Turlock Irrigation District and
Modesto Irrigation District
333 East Canal Drive
Turlock, CA 95381

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1. PURPOSE AND NEEDS

This monitoring plan describes methods to evaluate the SRP 9, SRP 10, and Gravel Mining Reach restoration projects on the Tuolumne River. The plan recommends monitoring objectives and proposes field techniques, data management and analysis protocols, budget and funding needs, and an example timeline for implementing the monitoring plan. The plan is a culmination of ideas and efforts originally formulated by the Monitoring Subcommittee of the Tuolumne River Technical Advisory Committee (TRTAC) and is provided to accompany the CEQA/NEPA documents and permit applications for the restoration projects. Several important issues were considered when selecting the proposed monitoring protocols, including: (1) how to interpret the effectiveness of specific restoration actions, (2) appropriate target species and life stages capable of elucidating expected population responses, (3) integrating project-specific monitoring proposals into existing river-wide programs or other requirements with similar objectives or methods, (4) specific requirements of environmental permits and mitigation monitoring, and (5) funding source requirements.

The monitoring plan is designed to evaluate two important aspects of the restoration projects: first, to test whether stated project objectives have been met, and to guide future restoration design (project performance), and second, to evaluate success of the mitigation measures (mitigation success). Project performance monitoring is organized into three sections: fluvial geomorphic processes, fisheries resources and riparian resources. Where possible, the restoration objectives and associated hypotheses for each section were stated with enough specificity that they could be related to the proposed monitoring objectives. Because some of the hypothesized benefits of the restoration projects are predicated on assumptions of salmonid limiting factors (e.g., bass predation), we propose testing specific hypotheses in the monitoring phase of these projects. Using a hypothesis-based approach for some aspects of the monitoring program, we will generate information that will guide future project design and selection (adaptive management).

The monitoring plan attempts to meet CEQA/NEPA requirements, and integrate with the FERC Settlement Agreement (FSA), the CVPIA- AFRP and CAMP programs, and the CALFED program. Monitoring data will be collected and analyzed according to standardized techniques and stored in a common database, under the purview of either TID, USFWS-AFRP or CAMP, or CALFED'S CMARP program. The data will be reviewed by technical personnel and published annually in reports submitted to resource and funding agencies, and will emphasize data interpretation and adaptive recommendations. Because some of the monitoring approaches are considered experimental, modification of technique or approach may occur after the first year of monitoring, especially for some of the proposed fisheries techniques.

The restoration projects are scheduled for implementation over several years, beginning in summer/fall of 1998 and continuing through 2002 (assuming all funding needs are provided). The monitoring plan assumes project implementation will follow the proposed schedule, but can be adapted to changes in the implementation schedule. Because the reconstructed channel morphology may respond to high discharge events by adjusting channel dimensions, several geomorphic monitoring protocols are triggered by exceedence of discharge thresholds. Field experience in 1987-1992 on the Tuolumne River showed that geomorphic monitoring during drought years (or years without significant flow events) is unnecessary, as no useful data are collected. Therefore, geomorphic monitoring is designed to evaluate up to three peak flow events, preferably within three different discharge ranges, as a way to guarantee that meaningful data will be collected. The threshold discharge corresponds to the design bankfull discharge, initially assumed at 5,000 cfs. This discharge may occur in any given year, so to illustrate a potential monitoring schedule, we assigned an example annual peak discharge to each future year, and then linked monitoring responses to these threshold events. For example, in 2003 the hypothesized peak discharge of 10,400 cfs follows two dry years and triggers numerous geomorphic monitoring elements, but these elements will have been monitored in previous years if peak discharge exceeds the threshold. The third example threshold event occurs in 2005, so budget outlays and scheduling timelines for geomorphic monitoring are projected through 2005, but would be prolonged beyond 2005 in the absence of threshold-exceeding flows. Revegetated riparian zones will be monitored for 5 years following each construction phase. There is no guarantee, however, that desired flow events will occur as hypothesized in this monitoring plan. No artificial flow releases will be made to create conditions for such monitoring. Table 1 shows the project implementation schedule and the proposed monitoring components for each year.

Annual funding requirements were estimated by determining the monitoring required after each example water year, and then estimating time and expenses to conduct that monitoring. The budget allocates funding based on the assumption that all monitoring components would be implemented, but not necessarily in the example year. While wet years require more funds than dry years due to additional monitoring tasks, the average annual cost estimated through 2007 is approximately $102,000 per year. Budget estimates are based on prevailing labor rates, and time estimates based on our monitoring experience on similar projects, and assume no inflation. Costs for each monitoring component were estimated independent of other activities, but would be reduced by coordinating monitoring activities (for example, monitoring geomorphic and riparian cross sections together, etc). [References to budget edited out]

2. SRP 9 AND 10

Aggregate mining at the SRP 9 and 10 sites has left in-channel pits disproportionately larger than the natural channel scale, eliminated a functional floodplain, and created preferred habitat for non-native predatory fish (largemouth and smallmouth bass). The SRP 9 site is 400 feet wide and up to 19 feet deep, and SRP 10 is up to 36 feet deep. The combined length of these reaches is less than one mile, but because of the severity of the channel and floodplain alterations and their strategic location below the primary chinook salmon spawning grounds, the SRP 9 and 10 sites severely impair channel geomorphic and riparian processes and limit chinook salmonid production by increasing smolt mortality (EA 1992). The goal of restoring this reach is to create a functionally scaled channel morphology in (or near) equilibrium with the contemporary hydrologic and geomorphic processes, which will improve chinook salmon survival by reducing predator habitat, abundance and predation rate. Specifically, the SRP 9 and 10 project objectives are to:

- Reduce non-native predator species abundance and habitat.
- Restore and increase salmonid habitat.
- Rebuild a natural channel geometry scaled to current channel forming flows and sediment supply.
- Restore and increase native riparian plant communities, establishing each species within the predicted hydrological niche of the contemporary hydrologic regime.

Because of the distinct biological objectives of the SRP projects, project monitoring prioritizes quantifying biological responses to hypothesized limiting factors. Thus geomorphic and riparian monitoring are less intensive in the SRP sites than in the Gravel Mining Reach.

2.1. FLUVIAL GEOMORPHIC PROCESSES

Restoring the SRP 9 and 10 reaches will require large volumes of fill to meet specific project objectives of *creating a functionally scaled channel geometry*. Design and construction phases of the project must meet as-built performance criteria. Following final construction evaluation, the monitoring plan assumes responsibility for fluvial geomorphic monitoring of two objectives:

- document hydraulic design performance (project performance)
- document channel adjustment after construction

The monitoring timeline is built upon threshold flow events triggering specific monitoring actions. Channel morphology will be monitored prior to construction and then again immediately after construction to document as-built conditions. Subsequent monitoring will occur after each of three threshold high flow events. Three target discharge ranges are proposed: 4,000 to 7,000 cfs, 7,000 to 10,000 cfs, and 10,000 to 15,000 cfs; geomorphic monitoring will attempt to evaluate a flow event in each of these classes, for a maximum of three monitoring sequences. Flows exceeding 9,000 cfs are contingent upon Army Corp of Engineers issuing a variance in discharge limits, currently set at 9,000 cfs at Ninth Street, Modesto. More detailed descriptions of the proposes monitoring schedule are provided in the following sections.

2.1.1. Project performance

2.1.1.1. Topography

In the project design phase, a topographic map (digital terrain model) of the restoration site will be surveyed prior to construction. Cross section endpoints will be installed at fixed locations for future channel morphology monitoring. A digital terrain model depicting the design channel will then be used to develop construction specifications and to construct the project. Immediately after construction, a digital terrain topographic map will be re-surveyed to evaluate project compliance (compares as-built topography to design topography for contractual sign-off). The "as-built" topographic model will then help compare future channel adjustments revealed by monitoring cross sections (see Section 2.1.2). Bed surface particle size distribution will be documented at 1 or 2 selected reconstructed riffles immediately after construction as a baseline for comparing particle size adjustment from future high flow events.

Schedule: Topographic maps will be surveyed immediately after construction (tentatively winter 1999-2000 for SRP 9 and winter 2001-02 for SRP 10).

2.1.1.2. Hydraulics

Computations of floodway conveyance and geomorphic surface design (floodplains and terraces) depend on hydraulic roughness values. Manning's *n* is typically the roughness variable of choice, and is a function of particle size, bedforms (bars), sinuosity, vegetation, and other channel obstructions. When channel restoration projects are constructed, the initial Manning's *n* is smaller (0.025 to 0.030) than it is after vegetation matures (0.035 and higher). These roughness values are typically estimated by back-calculation from other sites or from professional experience. By monitoring water surface elevations during discreet high flow events immediately after construction, we can back-calculate roughness values using HEC-RAS to compare observed versus design values, which can then be used to improve future designs. Additionally, we can evaluate floodplain and terrace inundation during discreet high flow events to determine if floodplains were inundated by discharges exceeding the design bankfull discharge. This monitoring will occur on SRP 9 only, and information will be used to aid in determining floodplain elevations in the final design phase of SRP 10. Because the period in which riparian vegetation will begin to significantly increase Manning's *n* will exceed five years, the change in roughness as vegetation matures will not be included in this monitoring plan.

Schedule: Water surface elevations will be monitored during the first high flow after SRP 9 construction that equals or exceeds the design bankfull discharge. O*ne flow event monitored.*

2.1.1.3. Bed mobility at design bankfull discharge

A fundamental characteristic of properly functioning alluvial rivers is the initiation of bed surface mobility and bedload transport of the larger particle clasts at streamflows approaching bankfull discharge. Based on the anticipated future high flow regime, one objective of the project is to mobilize the bed surface particles by flows approaching and exceeding the design bankfull discharge. Evaluation of this objective will be monitored by placing painted tracer rocks on two riffle cross sections in the restored SRP 9 reach, or immediately downstream. Bed mobility in the SRP 10 reach will be inferred from SRP 9 monitoring results. The tracer rocks representing the D_{84} and D_{50} particle sizes will be placed on cross sections and monitored until a discharge large enough to initiate movement is observed. This discharge will then be compared to the design bankfull discharge to evaluate whether the design bankfull discharge would achieve the objective of mobilizing the bed surface. Water surface elevation and slopes will be measured to estimate the hydraulic variables of the discharge that mobilizes the bed surface particles.

Schedule: Tracer rocks will be installed immediately after SRP 9 construction, and monitored after each high flow event until mobilization is observed. Some periodic maintenance will be required (i.e., repainting tracer rocks that fade, periodically checking for movement) if the mobilization flow does not occur in a reasonable time. O*ne flow event monitored.*

2.1.2. <u>Channel adjustment</u>

2.1.2.1. Channel migration/planform adjustment

Small-scale planform adjustments such as lateral movement will be documented by surveying cross sections at locations susceptible to lateral movement (apex of meanders). Large-scale planform adjustments will be documented by a combination of cross section evaluations and low-altitude aerial photographs (1”=500’ or better contact print). Cross sections established during the pre-and post-construction topographic surveys will be relocated and surveyed with engineers levels and tapes to document channel adjustment. This objective will be monitored in both SRP 9 and SRP 10 restored reaches.

Schedule: Cross sections will be surveyed immediately after <u>each</u> of three high flow events that exceeds a threshold that causes channel adjustment (initially assumed at 5,000 cfs). Low-altitude aerial photos will be obtained once after a flow exceeding 10,000 cfs (and assumes flight costs are covered by other programs). Monitoring channel migration after each threshold high flow event is needed to evaluate any potential threat to human structures that requires maintenance. The magnitude of the threshold event will be estimated during the design phase. *Up to three flow events monitored.*

2.1.2.2. Channel degradation/aggradation

Vertical adjustment of the channel bed (bed aggradation/degradation) and floodplain (fine sediment deposition) will be documented at specific locations by surveying cross sections on bend of apex (pools) and at meander crossovers (riffles). A thalweg profile surveyed with an engineers level or total station will document changing bed elevation and pool/riffle sequencing (e.g., determine if pools are filling or readjusting longitudinally).

Schedule: Cross sections will be surveyed immediately after each of three high flow events that exceeds a threshold that causes channel adjustment (initially assumed at 5,000 cfs). *Up to three flow events monitored.*

2.2. FISHERIES RESOURCES

The SRP 9 and 10 sites currently provide habitat to predatory fish species, including non-native largemouth and smallmouth bass, striped bass, and the native Sacramento squawfish. A pilot predation study in the lower Tuolumne River (EA 1992, Appendix 22) identified twelve potential chinook salmon predator species, and subsequent studies at other SRP's estimated largemouth bass abundance in SRP's ranged from 133 to 181 fish per site (and projected to more than 10,000 largemouth bass river-wide) and predation rates as high as 3.6 to 5.3 salmon per predator per day for smallmouth bass during pulse flows. In sum, conditions are potentially unfavorable to emigrating juvenile chinook salmon. In addition, salmonid spawning and rearing habitat is lacking. The SRP restoration projects are predicated in part on the hypothesis that these large pits contribute to an increase in juvenile salmon mortality and a consequent reduction in total salmon production. The principal biological objectives of the SRP 9 and 10 projects are to *reduce salmon mortality by reducing predator habitat and abundance, and provide improved salmonid spawning and rearing habitat conditions.*

Recommended biological monitoring protocols for the SRP sites include:

- field experiments comparing survival of juvenile chinook salmon passing through the project reaches before and after restoration.
- evaluation of bass species abundance before and after restoration, by electrofishing techniques and standardized statistical methods.
- comparison of habitat availability by habitat mapping before and after restoration, for various life history stages of predator species and chinook salmon.

An initial investigation of each monitoring approach is recommended during the first year to determine the relative utility of each monitoring effort and its ability to detect hypothesized responses. Findings from this initial effort can then focus resource expenditure in the following years (adaptive management approach).

2.2.1. Juvenile salmonid survival estimates

Non-native bass species prey on emigrating chinook juveniles and smolts. A direct measure of project efficacy would be to quantify salmonid survival through the project reaches before and after project implementation. Our study plan emphasizes replicated field tests of marked-recapture survival estimates, based on releases of test groups of natural chinook smolts above the restoration site, and recapture below the test site using fyke nets or rotary screw traps (RST) to generate an index of smolt survival. The survival index is based on the proportion of released fish recaptured, adjusted by the estimated trap efficiency. This recommendation follows an evaluation of various sampling methods and gear types, and recognition that these efforts can be partially incorporated into other monitoring programs currently employed on the Tuolumne River.

Test fish will be collected at an upstream site currently used in river-wide monitoring programs, and marked using PanJet dye inoculation, fin clips or other methods. The marking systems will be coordinated with other Tuolumne River programs. The number of distinct experiments will depend on the availability of test fish and personnel for marking fish, but may include 2 to 3 test runs each season. The availability of fish may limit this work. The number of fish per test may need to be modified (increased or decreased) in subsequent years depending on results of the first year's results. Tests should target peak periods of smolt movement, and use only migrating fish captured in upstream screw traps or fyke nets, since these fish show a propensity to move downstream. Tests should also target pulse flows and non-pulse flow periods to test hypotheses about the utility of pulse flows.

Smolt survival studies (and similar production estimates) using marked recapture methodologies and rotary screw trapping have been implemented annually on the Tuolumne by CDFG, and contain considerable uncertainty in their estimates of survival and river-wide production. In addition, they often depend on hatchery-produced juvenile chinook for release groups large enough to satisfy statistical requirements. Other problems such as differences in diel movement of smolts, trap avoidance, and comparisons of behavioral differences between hatchery and naturally produced smolts have not been resolved. Pending the outcome of the initial year of study, we recommend considering other methods to obtain survival estimates.

Schedule: Survival estimates will be conducted for four years, beginning in 1998 before SRP 9 construction, and continuing for two years after completion of SRP 10 (through 2002).

2.2.2. Bass abundance

Bass population densities are expected to decline as a result of project implementation, and changes in fish abundance can potentially be detected using a variety of monitoring methods . The monitoring plan includes a statistical comparison of predator abundance before and after project implementation, estimated by electrofishing, to document changes that result from restoration. Predator populations will be sampled in the SRP 9 and 10 treatment sites, in an undisturbed control site at SRP 7 or SRP 8, and in one or two sites similar to post-restoration conditions. Reference sites will be useful to isolate specific project-related responses from annual local variability in population abundance, and may also help determine if population responses in treatment reaches are redirected to other sites (e.g., increased abundance in other SRP's as a result of project-site displacement). The SRP treatment and reference sites will be electrofished at night to estimate abundance of adult largemouth, smallmouth and striped basses, and Sacramento squawfish. Field methods will employ gillnets and blocking nets when needed, and use multiple-pass depletion removal or marked-recapture methods for estimating fish abundance. The electrofishing equipment best suited to sampling in the large SRP units is a boat shocker (e.g., Smith-Root). Snorkeling may also be used.

Our initial approach to surveying predator abundance during the first year of monitoring, will be to conduct a multiple marked-recapture experiment over a several week period (at fewer sites) and then if feasible, conduct a multiple pass depletion removal test on the last marked-recapture run to obtain two separate abundance estimates. This pilot study approach would help determine which method has the most merit for reliable estimates of predator density or abundance and would allow a determination of subsequent effort required to accurately estimate abundance. Fish species and counts other than those specified above will be recorded for presence or absence, but abundance estimates will not be attempted for those species.

Reference sites selected that resemble anticipated post-project conditions will be monitored by electrofishing and/or snorkeling according to the above schedule. As there are no riffles in the vicinity upstream of the project site, these references sites will be located below SRP 10 in the vicinity of riffle 73A, 73B or 74 (RM 25.0). Some modifications to field techniques may be required at these reference sites and in post-construction SRP 9 and 10 reaches, dictated primarily by water depths and velocities.

Schedule: Electrofishing will take place during spring/summer 1998 to establish pre-project abundance and suitable techniques, and then again in May/Junespring/summer of the following 3 years (1999, 2000, and 2001) to evaluate post-restoration conditions and to track short-term trends in bass abundance. Pre- and post-restoration sampling in SRP 10 will perform the dual function of providing two years of reference conditions for comparison to SRP 9 and also to establish baseline conditions for SRP 10, scheduled for restoration in 1999. SRP 10 and accompanying reference sites will be monitored through 2002. At least one year of monitoring should accompany a high-flow event to provide insight into predator persistence in relation to high flows in reconstructed habitat. We also recommend continued sampling of SRP 7 or 8 reference sites and SRP's 9 and 10 project sites to track long-term trends in abundance, particularly if other channel reconstruction projects are anticipated (e.g., SRP 5 and 6) but recognize that funding is not presently allocated for this monitoring.

2.2.3. Bass and Salmonid habitat availability

Methods to quantify habitat availability generally rely on data collected from cross-section transects and IFIM models, which can be labor intensive and provide data of limited use. Our study plan will quantify habitat availability and changes in pre-and post-restoration conditions by field mapping habitat area onto aerial photographs. Maps showing physical habitat boundaries of greater resolution for fish species such as pools, riffles, runs, SRP's and backwater areas will be produced from aerial photos, and will provide the physical backdrop for delineating habitat boundaries for impacted fish species such as chinook salmon and bass. Identifying habitat boundaries will be based on specified criteria for species habitat preferences, and will focus on predator species spawning and rearing habitat in addition to salmonid habitat preferences. These criteria will include variables such as depth and velocity preferences for each species, determined according to site-specific information when available, or otherwise will refer to published literature values of habitat preferences. A full set of criteria will be defined for each species of interest prior to field mapping. High resolution aerial photographs available from project construction (1"=2,000 ft or better) will provide field templates for mapping habitat boundaries. These maps offer the flexibility of later incorporating habitat boundaries for other fish species, amphibians, migratory birds, etc. Data will be digitized for comparing habitat areas before and after construction, and presented in planform color format. Where possible, we recommend quantifying habitat boundaries in reference to a common denominator such as alternate bar sequences, which are repeatable geomorphic features that can be treated statistically and compared to other river reaches.

Verification of habitat use by various life stages of fish species will provide important information for evaluating the success of project objectives. We will employ direct observation or seining during field mapping to establish the presence of juvenile salmonids and bass. These activities will be done systematically to allow testing hypotheses about habitat preferences. Additionally, seining efforts similar to those conducted by the Districts will be used in the SRP 9 and 10 reaches to assess habitat use by rearing salmonids during subsequent seasons. CDFG seasonal spawning surveys will also incorporate newly created spawning habitat within the project boundaries. Two field days will be provided for CDFG personnel for field calibration of redd counts to spawner surveys.

Schedule: Pre-construction habitat maps will be prepared in summer 1998 for SRP 9 and summer 1999 for SRP 10, and post construction maps will be prepared in 1999 for SRP 9 and in 2000 for SRP 10. Spawning and seining surveys will begin during the appropriate season following construction, and continue indefinitely for spawning surveys, and for four years post-construction for seining.

2.3. RIPARIAN RESOURCES

A major component of the SRP 9 and SRP 10 projects is riparian revegetation. Native riparian vegetation consists of different plant assemblages called plant series (Sawyer 1995). Currently these sites have fragmented native vegetation and many exotic plant species created by a legacy of land alteration. Project construction will disturb some riparian vegetation and will be mitigated through extensive revegetation. The revegetation objective is to *establish different plant series on reconstructed surfaces with inundation patterns characteristic of that plant series, provide continuity between remnant riparian stands, and increase natural regeneration.*

2.3.1. Project performance

Riparian monitoring will evaluate project performance using plot-based descriptions of species composition, survival, and cover to evaluate recruitment, survival and growth. Potential performance standards for plantings are: 90 % plant survival in year 0, 70% plant survival to year 2, and 60% survival to year 3, a 10% increase in cover and growth annually for surviving plants, and no more than ten planted hardwoods dead in a 3 meter radius. Plantings will be irrigated in the first and second growing season after revegetation. Trends in survival will be documented and used to evaluate project success in establishing self sustaining vegetation series. Quantitative performance standards will be correlated to revegetation techniques such as design, planting, and irrigation methods, fertilizer, root stock quality, and environmental causes.

Plot descriptions will sample plant series on each restored geomorphic surface, including the active channel, floodplain and terrace. Three permanent plots will be established within each restored series type, with each plot located along cross sections established for geomorphic monitoring. Data collected within plots will include dominant species, plant vigor, and plant size in the tree, shrub, and herb strata. Plant vigor will be assessed using visual decline indicators (for example, yellowing or burnt leaves, leaf abscission, stunted growth, irregular plant morphology or stem death). Plant size assessment will be based on root collar or breast height diameter and height. Plant density, and survivorship will also be calculated. Changes in plant size, vigor or species composition will be used to evaluate revegetation success. It will be necessary to protect young trees from beavers, and this may include temporary depredation permits from CDFG.

Schedule: Monitoring will begin immediately after construction (year-0) to evaluate planting success and document as-built conditions, and again at year-2 at the end of irrigation (contractual signed off pending results). Additional monitoring will occur in years 3 and 5, or potentially after a high flow event that exceeds the channel geomorphic design flow (assumed to be 5,000 cfs) and inundates reconstructed floodplains, for a maximum 4 monitoring seasons for the first 5 years after construction. The final riparian vegetation monitoring will occur in 2004 for SRP 9 and 2006 for SRP 10.

2.4. THREATENED AND ENDANGERED SPECIES

Surveys are recommended to identify the occurrence of threatened, endangered, and special status species at the restoration and source material sites. At the restoration sites, surveys are recommended for the following species: Delta button-celery, California hibiscus, Merced monardella, Hartweg's golden sunburst, and Sanford's arrowhead, valley elderberry longhorn beetle, California red-legged frog, foothill yellow-legged frog, western pond turtle, giant garter snake (habitat survey), Clark's/western grebe, double-crested cormorant (nesting), great blue heron (nesting), great egret (nesting), snowy egret (nesting), osprey (nesting), white-tailed kite (nesting), Swainson's hawk (nesting), golden eagle (nesting), Forster's tern (nesting), western burrowing owl, and tricolored blackbird. If access roads are constructed through grasslands, surveys are recommended for the California tiger salamander and western spadefoot.

If surveys document the occurrence of any of these species or their protected habitats at the restoration or source material sites, the U.S. Fish and Wildlife Service (USFWS) and the California Department of Fish and Game (CDFG) should be consulted and avoidance measures should be undertaken. If these species or their protected habitats cannot be avoided, the U.S. Fish and Wildlife Service and the California Department of Fish and Game should be consulted to identify appropriate mitigation measures.

2.5. CULTURAL RESOURCES

In the vicinity of the Gravel Mining Reach project area, prehistoric and historical archaeological sites, as well as other cultural resources are evident. A majority of the project was once part of the historic dredger mining operations along the Tuolumne River which now supply the waste gravels mined by the aggregate companies. The historic landscape of this former mining area has been thoroughly altered and is no longer identifiable as a cultural resource. However, it is possible that buried features may be located during construction activities. A second resource area is located adjacent to, but outside the current project, based on surface indications. The prehistoric and historic Roberts Ferry included two historic bridges, several buildings and structures, a prehistoric activity area, an Indian burial ground, and more. Only bridge footings for the 1887 Roberts Ferry bridge are located within the current Tuolumne River channel and project area. However, there is potential for discovering subsurface archaeological deposits and human burials remains during the proposed restoration. Thus, based on the possibility of encountering buried or unidentified resources, monitoring provisions are outlined below.

2.5.1. Subsurface archaeological deposits and human burials remains

With a project like the Gravel Mining Reach Restoration, involving substantial excavation and ground disturbance, it is always possible that previously undiscovered resources may be uncovered. Generally, federal agencies prepare plans for the treatment of such resources discovered in their Memoranda of Agreement which conclude the Section 106 process. In this case, such a plan remains undeveloped. Provisions for a Gravel Mining Reach Monitoring Plan are proposed until a federal plan can be implemented; the procedures for treatment are laid out at 36CFR Part 800, the Advisory Council on Historic Preservation (ACHP) regulations for Section 106 (see §800.11).

The 1887 Roberts Ferry bridge footings will be protected during the project by creating a buffer of no less than 50 meters (165 feet) surrounding the resource. Such a buffer can be identified with orange fencing or a similar mechanism which prevents encroachment by construction equipment.

Undiscovered resources may be a simple artifacts, located out of context or without association, or they may be intact archaeological deposits. In the case of the former, simple documentation may be sufficient to resume project activities. Treatment in the latter may prove more complex. As treatment must be assessed by a qualified professional, there are several measures outlined to meet this goal.

1. The USFWS will retain a professional archaeologist who meets the Secretary of Interior Professional Qualification Standards for Archeology for the duration of the project.

2. Prior to project construction, the USFWS will insure that either an Inadvertent Discoveries Plan has been developed among the lead federal agency, the California SHPO, and the ACHP, or that if such an agreement does not exist, that such a plan will be developed which meets both the requirements of the State of California and the intent of Section 106 of the National Historic Preservation Act (36CFR 800.11). This document will discuss the documentation, evaluation, and treatment of resources discovered inadvertently during the life of the project. The plan must address the possibility of encountering human remains.

3. The USFWS will insure that all contractors and equipment operators are instructed and required to watch for potential archaeological artifacts and sites, along with human remains. Evidence includes skeletal remains, chipped stone, shaped stone (bowls, pestles), shell and bone artifacts, metal and glass artifacts, concentrations of fire-affected rock and/or charcoal, trash pits, foundations, pits, rock alignments, and other cultural materials. In addition, the USFWS will insure that construction inspectors are instructed about the potential for finding artifacts and archaeological deposits, and are supplied with a list of contact individuals with numbers to telephone in the event of discovery.

4. The USFWS will insure that in the event prehistoric or historic resources are located within the project, all work will stop within a circumference of 10 meters (33 feet) of the find until a qualified professional (meeting the terms of 1, supra) has assessed the find and developed treatment, if appropriate.

5. In the event that human remains other than dissociated teeth or bones are encountered during Project activities, all work will stop (4, supra) and the responsible field supervisor will issue immediate notification of the find to the USFWS, the retained archaeologist, and, as required by law, to the Stanislaus County Coroner/Sheriff. In addition, if the remains are determined to be Native American, the USFWS will notify the Native American Heritage Commission, the landowner, and any appropriate Project personnel

(California Health and Safety Code §7050.5(b) and (c); California Public Resources Code §5097.94-99).

Schedule: Coordination between lead federal agency and retained archaeologist will occur prior to construction in 1998 to insure an Inadvertent Discoveries Plan is agreed upon and duly executed. Instruction of responsible construction managers and contractors will occur prior to ground disturbance and mobilization in 1998. Archaeologist will remain on call through 2005.

3. GRAVEL MINING REACH

Off-channel mining for aggregate on the Tuolumne River began in the 1950's, and is presently concentrated into a six mile river reach (RM 40.3 to 34.3) referred to as the Gravel Mining Reach. Agricultural encroachment and aggregate mining in this reach have reduced the floodway capacity, and the reach represents a potential bottleneck to river ecosystem and chinook salmon recovery. Mining activity has changed the natural channel morphology and physical processes, reduced floodway capacity by narrowing the channel with dikes and berms that are subject to frequent and costly failures from minor flood events, and eliminated extensive areas of floodplain and terrace riparian habitat. In addition, mining has created extensive lentic aquatic habitat in off-channel ponded pits, which are occasionally "captured" by the main channel when dikes fail (as in the January 1997 flooding). These ponds harbor non-native predator species, particularly bass, and subject juvenile chinook salmon to high in-river mortality. The project proposes to restore a riparian floodway by rebuilding and setting back dikes to increase floodway width to 500 ft minimum, and safely convey discharge of at least 15,000 cfs (minimum). Increased width and flood capacity should significantly reduce risks of dike failure, thus protecting human resources (structures and mining operations). Restoration will also reduce mortality to chinook salmon by reducing exposure to predation in captured off-channel pits. The project also proposes to restore native riparian communities on rebuilt floodplains and terraces. In addition, a principle objective of restoring this reach is to improve chinook spawning and rearing habitats. Specifically, the objectives of the Gravel Mining Reach project as stated in the conceptual design are:

- Improve salmonid spawning and rearing habitats by restoring an alternate bar (pool-riffle) morphology, and filling in-channel mining pits
- Reduce the potential for future production losses to juvenile salmon by preventing future connection between the Tuolumne River mainstem and off-channel mining pits
- Restore native riparian communities on appropriate geomorphic surfaces (i.e., active channel, floodplains, terraces) within the restored floodway
- Restore habitats for special status species (e.g., egrets, ospreys, herons)
- Restore a floodway width that will safely convey floods of at least 15,000 cfs
- Establish migratory corridor within the restored floodway to improve and maintain riparian and salmonid habitat
- Remove floodway "bottleneck" created by inadequate dikes (i.e., prevent dike failure above a certain discharge threshold)

- Protect aggregate extraction operations, bridges, and other human structures from future flood damage

Due to the large scale of the Gravel Mining Reach project, implementation of channel and riparian restoration will occur in four phases beginning in 1998, and follow the proposed completion dates outlined below:

Phase I (7/11) to be completed by May 1999
Phase II (MJ Ruddy) to be completed by May 2000
Phase III (Warner/Deardorff) to be completed by May 2001
Phase IV (Reed) to be completed by May 2002

The project objectives emphasize restoring the floodway and riparian zones and isolating the off-channel pits, and requires that monitoring prioritize geomorphologic and riparian components. The monitoring period will extend through 2007. Most monitoring will occur immediately after threshold hydrologic events (e.g., whenever floods exceed 5,000 cfs).

3.1. FLUVIAL GEOMPORPHIC PROCESSES

Fluvial geomorphic objectives of the project are to *create a functional floodway that safely conveys flows of at least 15,000 cfs, create functional floodplains that begin to inundate at design bankfull discharges, establish a channel migratory corridor, restore the alternate bar (pool-riffle) morphology, and restore bedload continuity*. Specific monitoring objectives related to geomorphic processes are:

- document channel adjustment after construction
- document success of hydraulic design variables
- document channel dynamics as a function of discharge (e.g., bedload mobility and routing).

As with the SRP 9 and 10 projects, the monitoring schedule is built upon threshold flow events triggering specific monitoring actions. The threshold flow is initially assumed at 5,000 cfs. Channel morphology will be monitored prior to construction, and then again immediately after construction, to document as-built conditions. Subsequent monitoring will occur after a maximum of three threshold high flow events. We propose three target discharge ranges: 4,000 to 7,000 cfs, 7,000 to 10,000 cfs, and 10,000 to 15,000 cfs, and suggest that geomorphic monitoring evaluate a flow event in each of these classes if possible, for a maximum of three monitoring sequences. Flows exceeding 9,000 cfs are contingent upon Army Corp of Engineers issuing a variance in discharge limits, currently set at 9,000 cfs at Ninth Street, Modesto. More detailed descriptions of the proposes monitoring schedule is provided in the following sections.

3.1.1. Project performance

3.1.1.1. Topography

As with the SRP 9 and SRP 10 designs, the project design phase in the Gravel Mining Reach will develop a topographic map (digital terrain model) of the site immediately prior to construction. Cross sections will be established at locations appropriate for future channel morphology monitoring. A digital terrain model depicting the design channel will then be developed and used to construct the project. Immediately after each phase of construction is completed, another topographic map will be surveyed to document as-built conditions (compares as-built topography to design topography for contractual sign-off). The as-built topography will then serve as the basis for comparing subsequent channel adjustment (see Section 3.1.2). Bed surface particle size distribution will be documented at two selected riffles immediately after each construction phase for later comparison of particle size adjustment resulting from high flow events.

Schedule: Topographic maps will be surveyed immediately after completing each construction phase (Winter 1998 for Phase I, Winter 1999 for Phase II, Winter 2000 for Phase III, and Winter 2001 for Phase IV).

3.1.1.2. Hydraulics

Because floodway conveyance is a primary objective of the Gravel Mining Reach project, hydraulic floodway computations and geomorphic surface design (floodplains and terraces) are of primary importance. During a 5,400 cfs flow in 1996, hydraulic variables at the M.J. Ruddy Restoration Project (Delta Pumps) channel restoration project showed that as-built Manning's *n* values were consistently between 0.028 and 0.029 based on HEC-RAS water surface profile modeling. By monitoring water surface elevations during discreet high flow events immediately after construction, we can re-evaluate roughness values using HEC-RAS, improving our estimates for later phases of construction. Because the period in which riparian vegetation will begin to significantly increase Manning's *n* will be in excess of five years, the change in roughness as vegetation matures will not be included in this monitoring plan.

Floodplains and terraces will be constructed at elevations inundated at designed discharges. Their proper inundation discharge is dependent on channel geometry, energy, slope, and Manning's *n* values. As part of the water surface elevation monitoring, elevations will be marked on the monitoring cross sections to evaluate floodplain and terrace inundation at the appropriate discharges, and hydraulic explanations can be provided for sites where inundation objectives are not met.

Schedule: Water surface elevations will be monitored during the first high flow after construction that equals or exceeds the design bankfull discharge. *One flow event monitored*

3.1.1.3. Bed mobility at design bankfull discharge

A fundamental characteristic of properly functioning alluvial rivers is the initiation of bed surface mobility and bedload transport of the larger particle clasts at streamflows approaching bankfull discharge. Bedload movement through the system thus depends on flows near or exceeding the design bankfull discharge to at least transport bedload through a riffle-pool-riffle sequence. Bed mobility will be monitored by placing painted tracer rocks on two riffle cross sections on each phase of the Gravel Mining Reach project. The tracer gravels, representing the D_{84} and D_{50} particle sizes, will be monitored for mobility threshold and travel distance (i.e., are the particles moving, and if so, are they moving through pools and onto the next downstream riffle). For each construction phase the marked rock experiments will be in place until a discharge just large enough to initiate movement is observed. This discharge will then be compared to the design bankfull discharge, to evaluate bed surface mobility objectives. Once the tracer rocks are mobilized, their deposition location will be mapped to document travel distance, and left to monitor future movement through pools and riffles.

Surface pebble counts and subsurface bulk samples will be collected on each monitoring riffle to document particle size distributions and to track adjustments over time. Water surface elevation and slopes will be measured at monitoring riffles to estimate the hydraulic variables of the discharge that mobilizes the bed.

Schedule: Tracer rocks will be installed immediately after construction of each phase, and monitored after each high flow event until mobility is observed. Once mobility has occurred, marked rocks will continue to be monitored to observe future movement through 2005 to evaluate the extent of coarse bedload routing through pool-riffle sequences. Some periodic maintenance will be required over time (i.e., repainting tracer rocks that fade, periodically checking for movement). *Up to three flow events monitored.*

3.1.2. Channel adjustment

3.1.2.1. Channel migration/planform adjustment

The primary hydraulic objective of the Gravel Mining Reach project is to improve floodway conveyance and reduce risk and damage resulting from channel migration and berm failure. However, channel migration provides important geomorphic, biological, and riparian benefits to the system. Hence, monitoring channel migration and planform evolution are crucial components of monitoring. Small-scale planform adjustment will be documented by level surveys of cross sections placed at locations susceptible to lateral movement (apex of meanders). Large-scale planform adjustments will be documented by a combination of cross section evaluation and low-altitude aerial photographs (1”=500’ or better contact print). Cross sections established during the pre-and post-construction topographic surveys will be re-surveyed with engineers levels and tapes to provide precise documentation of channel adjustment. Cross section monitoring will be conducted during all construction phases.

Schedule: Monitoring will occur immediately after each high flow event that exceeds a threshold that begins to cause channel adjustment (initial target > 5,000 cfs). Monitoring channel migration after each threshold high flow event will be needed to evaluate whether project maintenance is required to further protect human structures adjacent to the floodway. *Up to three flow events monitored.*

3.1.2.2. Channel degradation/aggradation

Vertical adjustment for both inner channel (bed aggradation/degradation) and floodplain (fine sediment deposition) will be documented at specific locations by surveying cross sections at apex of meanders (pools) and at meander crossovers (riffles). A thalweg profile surveyed through all phases with an engineers level or total station will document changes to the bed elevation and pool/riffle sequencing (e.g., are pools filling, riffles steepening, or readjusting longitudinally).

Schedule: Monitoring will occur immediately after the each of three high flow event that exceeds a threshold that begins to cause channel adjustment (initial target > 5,000 cfs). *Up to three flow events monitored.*

3.2. FISHERIES RESOURCES

The six mile long Gravel Mining Reach contains large off-channel and instream gravel extraction pits that negatively impact chinook salmon by stranding juveniles in ponds and harboring predator species, notably bass. Additionally, chinook spawning and rearing habitat is either absent or severely degraded. Restoring these reaches will reverse past trends of habitat degradation. Specific objectives of the Gravel Mining Reach restoration project related to fisheries resources include: *(1) improving salmonid spawning and rearing habitats by restoring an alternate-bar morphology, (2) restoring spawning habitat within the meandering channel, and filling in-channel mining pits, (3) improving juvenile salmonid survival by preventing future connection between the Tuolumne River and off-channel mining pits (that contain introduced predator species).*

In general, biological monitoring protocols will focus on:

- quantifying changes in habitat availability
- documenting habitat use by rearing juveniles and spawning adults
- document potential improvements in juvenile survival in the Gravel Mining Reach by evaluating on-going river-wide survival monitoring

3.2.1. Salmonid and Bass habitat availability

The fisheries study plan will quantifying habitat availability and changes in pre-and post-restoration conditions by field mapping habitat areas onto aerial photographs. Maps showing physical habitat boundaries of pools, riffles, runs, SRPs and backwater areas will be produced from aerial photos, and will provide the physical backdrop for delineation of habitat boundaries for fish species of interest, such as chinook salmon and bass. Identifying habitat boundaries will be based on specified criteria for species habitat preferences, and will focus on predator species spawning and rearing habitat in addition to salmonid habitat preferences. These criteria will include variable such as depth and velocity preferences for each species, determined according to site-specific information when available, or otherwise will refer to published literature values of habitat preferences. A full set of criteria will be defined for each species of interest prior to field mapping. High resolution aerial photographs available from the project construction activities (1"=2,000 ft or better) will provide field templates for mapping habitat boundaries. These maps offer the flexibility of later incorporating habitat boundaries for other fish species, amphibians, migratory birds, etc. Data will be digitized for comparing habitat areas before and after construction, and presented in planform color format. Additional layers incorporating information about particle sizes of sorted bed surface materials can also be added (qualitative facies maps) to quantify changes in physical habitat complexity. Where possible, we recommend quantifying physical habitat boundaries in reference to a common denominator such as alternate bar sequences, which are repeatable geomorphic features that can be treated statistically and compared to other river reaches. Once construction is completed, the habitat maps will be available for monitoring long-term changes (succession) of habitat quantity, quality and use.

Field mapping can also address the added benefits incurred by preventing reconnection of off-channel pits/ponds that remain outside the reconstructed setback levees. These ponded pits will be mapped onto the aerial photos and digitized to quantify the post-construction surface area of isolated ponds altered by project construction.

Verification of habitat use by various life stages of fish species will provide important information for evaluating the success of project objectives. We will employ direct observation or seining during field mapping to establish the presence of juvenile salmonids and bass. Additionally, seining similar to that currently conducted by the Districts will be used for four years after each construction phase to assess habitat use by rearing salmonids in each project reach. CDFG will also extend seasonal spawning surveys to newly created spawning habitat within the project boundaries. Two field days will be provided for CDFG personnel for field calibration of redd counts to spawner surveys.

Schedule: Pre-construction habitat maps will be prepared for all project phases before initiation of phase I construction in 1998. Each project reach will then be re-mapped after construction is finished to document changes in habitat area. Monitoring habitat use will include four years of seining, and annually for spawning.

3.3. RIPARIAN RESOURCES

Similar to the SRP 9 and 10 projects, a major component of the Gravel Mining Reach project is riparian revegetation. Native riparian vegetation consists of different plant assemblages called plant series (Sawyer 1995). Currently the riparian vegetation is restricted to levees and relic stands, and is imbedded with exotic plants. Construction will disturb some riparian vegetation and off-channel wetlands, but will be mitigated by extensive revegetation. The revegetation objectives in the Gravel Mining Reach are to *establish different plant series on reconstructed surfaces with inundation patterns characteristic of that plant series, provide continuity between remnant riparian stands, and increase natural regeneration.*

A major addition to revegetation methods in the Gravel Mining Reach project is use of bioengineered bank protection in Phases I, II and III. Bioengineering uses plant materials together with inert materials during construction to protect and stabilize riverbanks. In the Gravel Mining Reach bioengineering will take two forms: joint plantings and brush mattressing. Joint plantings consist of soil rammed into the spaces between rip-rap, and planted with willow or cottonwood cuttings. Brush mattressing consists of willow cuttings woven into a large "mattresses", and anchored to the riverbank through trenches and backfill and large "pins" made of live willow stakes. Bioengineered banks become stronger over time and provide excellent habitat value. The Gravel Mining Reach includes monitoring to evaluate the integrity of bioengineered structures during the first five years after construction.

3.3.1. Project performance

Riparian monitoring will evaluate project performance using plot-based descriptions of species composition, survival, and cover to evaluate recruitment, survival and growth. Potential performance standards for plantings are: 90 % plant survival in year 0, 70% plant survival to year 2, and 60% survival to year 3, a 10% increase in cover and growth annually for surviving plants, and no more than ten planted hardwoods dead in a 3 meter radius. Plantings will be irrigated in the first and second growing season after revegetation. Trends in survival will be documented and used to evaluate project success in establishing self sustaining vegetation series. Quantitative performance standards will be correlated to revegetation techniques such as design, planting, and irrigation methods, fertilizer, root stock quality, and environmental causes.

Plot descriptions will sample plant series on each restored geomorphic surface, including the active channel, floodplain and terrace. Three permanent plots will be established within each restored series type, with each plot located along cross sections established for geomorphic monitoring. Data collected within plots will include dominant species, plant vigor, and plant size in the tree, shrub, and herb strata. Plant vigor will be assessed using visual decline indicators (for example, yellowing or burnt leaves, leaf abscission, stunted growth, irregular plant morphology or stem death). Plant size assessment will be based on root collar or breast height diameter and height. Plant density, and survivorship will also be calculated. Changes in plant size, vigor or species composition will be used to evaluate revegetation success. It will be necessary to protect young trees from beavers, and this may include temporary depredation permits from CDFG.

3.3.2. Bioengineering response

Each bioengineered structure will be visually inspected to evaluate structural responses to floods. Photo-monitoring points will be established immediately after construction and re-photographed during subsequent monitoring. When possible, photos will be taken at the same time of year and during a similar discharge. Photos will be overlaid and used for photogrammetric analysis to document the extent of plant growth between monitoring and the extent of erosion. Failure nodes will be documented to determine the cause of failure. Bioengineering will be assumed effective if the structure is growing well in all areas and visual inspection indicates there is no erosion.

Schedule: Project performance monitoring will begin immediately after construction (year-0) to evaluate planting success and document as-built conditions, and again at year-2 at the end of irrigation (contractual signed off pending results). Additional monitoring will occur in years 3 and 5, or potentially after a high flow event that exceeds the channel geomorphic design flow (assumed to be 5,000 cfs) and inundates reconstructed floodplains. The final riparian vegetation monitoring will occur in 2004 for Phase I, 2005 for Phase II, 2006 for Phase III, and 2007 for Phase IV, for a maximum 4 monitoring seasons for the first 5 years after construction. Bioengineering will be monitored after each of three high flow events that exceeds the design flow (that may cause bank erosion) for 5 years after construction, or once at years 3 and 5 if no high flow events occur.

3.4. THREATENED AND ENDANGERED SPECIES

Surveys are recommended to identify the occurrence of threatened, endangered, and special status species at the restoration and source material sites. At the restoration sites, surveys are recommended for the following species: Delta button-celery, California hibiscus, Merced monardella, Hartweg's golden sunburst, and Sanford's arrowhead, valley elderberry longhorn beetle, California red-legged frog, foothill yellow-legged frog, western pond turtle, giant garter snake (habitat survey), Clark's/western grebe, double-crested cormorant (nesting), great blue heron (nesting), great egret (nesting), snowy egret (nesting), osprey (nesting), white-tailed kite (nesting), Swainson's hawk (nesting), golden eagle (nesting), Forster's tern (nesting), western burrowing owl, and tricolored blackbird. If access roads are constructed through grasslands, surveys are recommended for the California tiger salamander and western spadefoot.

If surveys document the occurrence of any of these species or their protected habitats at the restoration or source material sites, the U.S. Fish and Wildlife Service (USFWS) and the California Department of Fish and Game (CDFG) should be consulted and avoidance measures should be undertaken. If these species or their protected habitats cannot be avoided, the U.S. Fish and Wildlife Service and the California Department of Fish and Game should be consulted to identify appropriate mitigation measures.

3.5. AIR QUALITY

Construction activities associated with the proposed project could result in the generation of fugitive dust (PM_{10}) emissions and equipment exhaust emissions (ROG and NO_x). Projected emissions of NO_x and PM_{10} could exceed the San Joaquin Valley Unified Air Pollution Control District's (SJVUAPCD) thresholds of 10 tons/year for NO_x and 15 tons/year for PM_{10}. However, implementation of the following mitigation measures, which include the use of fugitive dust and equipment exhaust measures recommended by the SJVUAPD, the modification of the construction schedule to a four-year schedule, and the use of pollution offsets, would reduce this impact to a less-than-significant level is recommended. As discussed in the EA/IS, long-term operational noise impacts would not be significant, because no change in operational activity would occur with project implementation.

3.5.1. Short-term construction fugitive dust emissions

For the purpose of reducing construction emissions of fugitive dust (PM_{10}), the proponent shall implement the following measures during project construction in accordance with SJVUAPCD Regulation VIII and recommended fugitive dust control measures (SJVUAPCD; January 12, 1998):

1. Gravel strips, paved access aprons, wheel washers, or other measures designed to limit mud and dirt deposits on public roads shall be installed where vehicles enter and exit unpaved roads onto paved public roads.

2. The accumulation of mud or dirt on public paved roads, including shoulders, located adjacent to the project sites shall be removed at least once every twenty-four hours when operations are occurring. The use of dry rotary brushes and blower devices for the removal of deposited mud/dirt shall be prohibited.

3. All clearing, grading, earth moving, and excavation activities shall cease during periods of high winds.

4. All soils and fill materials transported to the project site shall either be of sufficient moisture content to limit visible dust emissions, provide at least six inches of freeboard space from the top of the transport container sides, or securely covered to prevent an excessive amount of dust being generated.

5. All soils and fill materials stored at the project site shall either be sufficiently watered or securely covered to prevent an excessive amount of dust being generated.

6. Areas disturbed by clearing, earth moving, or excavation activities shall be minimized at all times. All disturbed areas shall be stabilized using water or chemical dust stabilizers or seeded and watered until vegetation is established.

7. On-site vehicle speeds shall be limited to 15 MPH.

8. Water or petroleum-based palliatives shall be used as a dust control measure for the use of any unpaved roadways constructed or modified as part of this project which exceed one half mile in length.

Implementation of the above mitigation measures, as provided in District Regulation VIII, would reduce short-term construction-related PM_{10} generation to a less-than-significant level, assuming a 50% control efficiency (SCAQMD, 1993).

Schedule: During project construction.

3.5.2. Short-term construction equipment exhaust emissions

For the purpose of reducing construction emissions of NO_x, the proponent shall implement the following mitigation measure, in accordance with the recommendations of the District:

1. All on-site equipment driven by internal combustion engines shall be properly maintained and well tuned according to manufacturers' specifications. Maintenance records demonstrating this shall be kept on-site by the proponent and shall be made available to the County upon request.

2. Limit on-site idle time of heavy equipment to 10 minutes.

3. Encourage employees to rideshare or carpool to job site to reduce the amount of vehicle traffic to and from the project area.

Implementation of the above mitigation measures would reduce NO_x emissions by approximately 5%, which would reduce projected emissions to below the SJVUAPCD's threshold of 10 tons/year for that pollutant.

Schedule: During project construction.

3.6. NOISE

As discussed in the EA/IS, onsite construction equipment use associated with the proposed project could result in the exposure of sensitive receptors to noise levels in excess of adopted policies and standards of the County's Noise Element. Therefore, short-term construction equipment noise impacts are considered potentially significant. Implementation of mitigation measures provided in the Monitoring Plan would achieve compliance with the adopted policies and standards, and would therefore reduce this impact to a less-than-significant level. As explained in the EA/IS, no significant impacts related to offsite construction traffic and long-term operational noise would occur with project implementation.

3.6.1. Short-term construction generated noise impacts

TID shall implement the following measures to achieve compliance with the adopted standards and policies of the Noise element:

1. All construction and related activities within the project sites normally shall be limited to the hours of one-half hour before sunrise, Monday through Saturday, with no excavation to be permitted on Sundays or holidays (Thanksgiving, Christmas, New Years, Fourth of July, Memorial Day, and Labor Day). Should the County determine that additional hour restrictions are needed to minimize construction-related impacts, additional hours and/or seasonal limitations may be added following review of the matter with TID.

2. Construction equipment shall comply with noise level performance standards of the industry and be kept in proper working order to reduce noise impacts.

3. Where possible, noise-generating construction equipment shall be shielded from residential areas by noise-attenuating buffers such as truck trailers or noise barriers with an effective height of seven feet.

4. Stationary noise sources, such as pumps, compressors and generators, shall be located at a reasonable distance from residential areas.

5. Noise associated with the project shall not exceed the performance standards of the County's Noise Element.

Schedule: During project construction.

3.7. CULTURAL RESOURCES

The area of SRP 9 and 10 appears to be within the recent flood plain of the Tuolumne River, thus decreasing the potential for buried archaeological sites. Historic agricultural activities were observed, but no remains greater than 50 years of age were noted during the field investigation. Nonetheless, there is a potential for discovering subsurface archaeological deposits, human burials, and historic structural remains during the proposed restoration. Based on the possibility of encountering buried or unidentified resources, monitoring provisions are outlined below.

3.7.1. Subsurface archaeological deposits and human burials remains

With project restoration in SRP 9 and 10, where the mining activities have probably already removed cultural resources, buried resources are not anticipated. However, it is always possible that previously undiscovered resources may be uncovered.

Undiscovered resources may be a simple artifacts, located out of context or without association, or they may be intact archaeological deposits. In the case of the former, simple documentation may be sufficient to resume project activities. Treatment in the latter may prove more complex. As treatment must be assessed by a qualified professional, there are several measures outlined to meet this goal.

1. The USFWS will retain a professional archaeologist who meets the Secretary of Interior Professional Qualification Standards for Archeology for the duration of the project.

2. Prior to project construction, the USFWS will insure that either an Inadvertent Discoveries Plan has been developed among the lead federal agency, the California SHPO, and the ACHP, or that if such an agreement does not exist, that such a plan will be developed which meets both the requirements of the State of California and the intent of Section 106 of the National Historic Preservation Act (36CFR 800.11). This document will discuss the documentation, evaluation, and treatment of resources discovered inadvertently during the life of the project. The plan must address the possibility of encountering human remains.

3. The USFWS will insure that all contractors and equipment operators are instructed and required to watch for potential archaeological artifacts and sites, along with human remains. Evidence includes skeletal remains, chipped stone, shaped stone (bowls, pestles), shell and bone artifacts, metal and glass artifacts, concentrations of fire-affected rock and/or charcoal, trash pits, foundations, pits, rock alignments, and other cultural materials. In addition, the USFWS will insure that construction inspectors are instructed about the potential for finding artifacts and archaeological deposits, and are supplied with a list of contact individuals with numbers to telephone in the event of discovery.

4. The USFWS will insure that in the event prehistoric or historic resources are located within the project, all work will stop within a circumference of 10 meters (33 feet) of the find until a qualified professional (meeting the terms of 1, supra) has assessed the find and developed treatment, if appropriate.

5. In the event that human remains other than dissociated teeth or bones are encountered during Project activities, all work will stop (4, supra) and the responsible field supervisor will issue immediate notification of the find to the USFWS, the retained archaeologist, and, as required by law, to the Stanislaus County Coroner/Sheriff. In addition, if the remains are determined to be Native American, the USFWS will notify the Native American Heritage Commission, the landowner, and any appropriate Project personnel (California Health and Safety Code §7050.5(b) and (c); California Public Resources Code §5097.94-99).

Schedule: Coordination between lead federal agency and retained archaeologist will occur prior to construction in 1998 to insure an Inadvertent Discoveries Plan is agreed upon and duly executed. Instruction of responsible construction managers and contractors will occur prior to ground disturbance and mobilization in 1998. Archaeologist will remain on call through 2003.

4. LA GRANGE RESERVOIR SOURCE MATERIAL SITE

4.1. FISHERIES RESOURCES

Excavation of material from La Grange Reservoir may increase turbidity downstream of La Grange Dam during the period of excavation and may increase sedimentation in the channel bed. This increase in turbidity and sedimentation may have short-term, adverse impacts to aquatic organisms downstream. The transport of fine sediment over La Grange Dam and delivery to the channel downstream can be minimized by construction a berm to isolate turbid water in the excavation area. Such a berm was successful in minimizing turbidity downstream of the reservoir in October 1997, when the Districts excavated sand from the reservoir. Also, increases in turbidity could be coordinated with the chinook salmon outmigration period (in spring) when turbidity would be high under natural conditions during high flows associated with snowmelt in the Sierra Nevada. Such increases in turbidity may reduce bass predation efficiency and improve juvenile salmon survival. Construction of a berm to minimize turbidity or coordination would prevent adverse impacts downstream of La Grange Dam. Coordination with the spring outmigration period may produce beneficial impacts downstream of La Grange Dam. No impacts to fish resources are anticipated upstream of La Grange Dam.

4.2. VEGETATION/RIPARIAN RESOURCES

No text added.

4.3. WILDLIFE

No text added.

4.4. THREATENED AND ENDANGERED SPECIES

Surveys are recommended to identify the occurrence of threatened, endangered, and special status species at the restoration and source material sites. At the La Grange Reservoir source material site, surveys are recommended for Hoover's calycadenia, beaked clarkia, and Hartweg's golden sunburst, California tiger salamander (habitat), western spadefoot (habitat), western pond turtle, giant garter snake (habitat survey), great blue heron (nesting), great egret (nesting), osprey (nesting), white-tailed kite (nesting), golden eagle (nesting), and Swainson's hawk (nesting).

If surveys document the occurrence of any of these species or their protected habitats at the restoration or source material sites, the U.S. Fish and Wildlife Service (USFWS) and the California Department of Fish and Game (CDFG) should be consulted and avoidance measures should be undertaken. If these species or their protected habitats cannot be avoided, the U.S. Fish and Wildlife Service and the California Department of Fish and Game should be consulted to identify appropriate mitigation measures.

5. <u>REFERENCES</u>

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