Conceptual Design Recommendations for Improving Steelhead Migration at Cliff Drive Apron on Arroyo Burro

June 25, 2004

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Project Objectives:

URS Corporation requested review of their fish passage weir design at Cliff Drive Bridge and identification of low-cost adult steelhead passage measures with minimal impacts to the bridge apron structure.

Design Parameters/Project Limitations:

Following discussions with George Johnson of the City of Santa Barbara and John Gray of URS the following design parameters and project limitations were established to guide design recommendations for this project.

- The existing bridge and apron at Cliff Drive stay in place.
- Minimal, low-costs modification of the apron are to be developed.
- No construction of structures within the estuary or placement of boulders into the estuary that would result in a loss of estuary habitat.
- Strive to modify and enhance existing apron "pools" to create a series of step pools or roughened channel.
- Within the constraints of the project attempt to satisfy NOAA fisheries and CDFG design criteria for adult steelhead migration.

Scope of Work:

Task 1. Review the fish passage project description, hydraulic report, biological resource report, and design plans (URS) provided by G. Johnson.

Task 2. Assess fish passage conditions at the site and identify effective fish passage measures.

Task 3. Use existing site maps or photographs to hand draw conceptual fish passage design for submittal to URS for further stamped design development. Deliver written summary of proposed fish passage measures with conceptual design.

Task 4. Meet with City, URS, and others as needed to assist with design completion.

Project Activities:

Hard copies of project related documents were obtained from George Johnson from the City of Santa Barbara for review. Documents reviewed included:

URS Corporation, 2003. *Biological Resource Report Upper Arroyo Burro Estuary Restoration Project*. October, 2003.

URS Corporation, 2003. *Project Description Upper Arroyo Burro Estuary Restoration Project*. October, 2003.

Penfield & Smith, 2003. *Hydraulic Report for the Arroyo Burro Estuary Restoration Project*. Revised November, 2003.

URS Corporation, 2003. *Rock Apron Modification Plan- Arroyo Burro Estuary Restoration. Sheet 13 of 13*.

URS Corporation, 2003. *West bank Grading Plan- Arroyo Burro Estuary Restoration. Sheet 7 of 13*.

NOAA Fisheries, 2001. *Guidelines for Salmonid Passage at Stream Crossings. Southwest Region*. September, 2001.

Stoecker et al. 2002. *Steelhead Assessment and Recovery opportunities in Southern Santa Barbara County, California.* June 2002.

Matt Stoecker from Stoecker Ecological visited the Cliff Drive apron structure on June 22 and June 24, 2004. A limited site assessment was conducted to determine apron measurements, diagnose fish passage conditions, and identify fish passage improvement opportunities. Photographs were taken and proposed design recommendations were added to the photographs to simulation modifications. A summary of recommendations are provided with the simulation photographs later in this report.

Existing Conditions at Cliff Drive on Arroyo Burro:

A boulder and concrete rip-rap apron structure occurs immediately downstream from the Cliff Drive Bridge. The structure apparently functions as a grade control feature to limit scour from undermining the bridge footings. The upper extent of the Arroyo Burro estuary occurs at the downstream edge of the apron structure. An embedded concrete curb occurs 14 feet 9 inches upstream from the downstream edge of the apron and spans 75 feet across the stream channel with a longitudinal width of 30 inches and thickness of 24 inches. The curb has a shallow flat-bottom notch that conveys lower flows near the centerline of the channel. Downstream of the concrete curb, low flows are primarily conveyed across the apron within a confined boulder and concrete chute containing a series of poorly defined pools. The apron structure has two main slopes that are separated by the concrete curb. Downstream of the curb the apron drops 58 inches to the estuary's water surface (during encountered low flows) over a longitudinal distance of 14 feet 9 inches. This downstream apron slope measured approximately 15%. The concrete curb surface (30 inches) is similar in slope to the upstream 17 feet of apron that rises 6 inches in elevation to the natural pool surface under Cliff Drive, giving a mild slope of approximately 2.6%. For purposes of description, the features of the main chute and steelhead migration route are described as an upstream migrating steelhead would encounter them during the low flows encountered on June 22, 2004.

Pool #1 (P1) and Jump #1-

P1 is the estuary, which had a measured maximum depth of 3 feet 9 inches downstream of the apron where flows enter the estuary. The first jump height over apron boulders measured 13 inches between the water surfaces of P1 and P2. This Jump #1 height is variable with estuary water surface elevation, but is considered low compared to previous observations in 2001 and 2002 when the jump height was less than 10 inches during low stream flows.

Pool #2 (P2) and Jump #2-

P2 had a maximum measured depth of 27 inches, an upstream downstream length of 36 inches, and width of 72 inches. Jump #2 measured 13 inches between the water surfaces of P2 and P3.

Pool #3 (P3) and Jump #3-

P3 had a maximum measured depth of 29 inches, an upstream downstream length of 36 inches, and width of 54 inches. Jump #3 measured 16 inches between the water surfaces of P3 and P4.

Pool #4 (P4) and Jump #4-

P4 had a maximum measured depth of 12 inches, an upstream downstream length of 30 inches, and width of 66 inches. Jump #4 measured 16 inches between the water surfaces of P4 and P5. This jump occurs over the concrete curb.

Pool #5 and #6 (P5 and P6)-

Upstream of the concrete curb a pool extends approximately 5 feet upstream with variable depths up to 15 inches. Upstream of P5 a short, shallow area 2 inches deep occurs between P6, which has a maximum depth of 11 inches. Flows are confined in several small concrete-lined channels upstream of the concrete curb to a deep natural-bottom pool under Cliff Drive.

Fish Passage Diagnosis:

While surveying this structure, adequate jump depth in the downstream estuary would allow a relatively easy jump onto the apron. Adequate migration onto the apron is dependant on the jump depth of the downstream estuary, which changes seasonally with fluctuations in water surface elevations and sandbar formation at the beach. Several large boulders occur within the apron pools that limit the size and depth of the pools limiting the ability of steelhead to gain adequate jump velocities and interfering with jump routes and landing locations. Large boulders immediately downstream of the concrete curb present the most significant obstacle to migration by limiting jump pool depth needed to jump over the concrete curb. Hydraulic modeling of Mesa Creek and the Arroyo Burro Estuary, completed by Penfield and Smith, shows a potential 7-foot rise in estuary surface elevation during a 100-yr flow event. During moderate to high stream flows, steelhead passage may be obtained as the apron becomes partially submerged and fish can swim up the existing chute or the margins of the river-left side of the apron.

Upstream passage may also be complicated by high flow discharges from the Mesa Creek culvert outlet on the river-left bank, which conveys water perpendicularly to the flow of Arroyo Burro across the apron. This culvert outfall may impede steelhead migration by creating difficult hydraulic conditions and/or contributing poor water quality that might deter upstream migration. Current restoration plans are to remove this culvert and realign a naturalized Mesa Creek downstream into the estuary. The apron also likely prevents upstream passage of other native fish species that occur in the estuary such as the Tidewater Goby, which was observed in the estuary but not upstream of the apron.

Review of URS Proposed Fish Passage Weir Design:

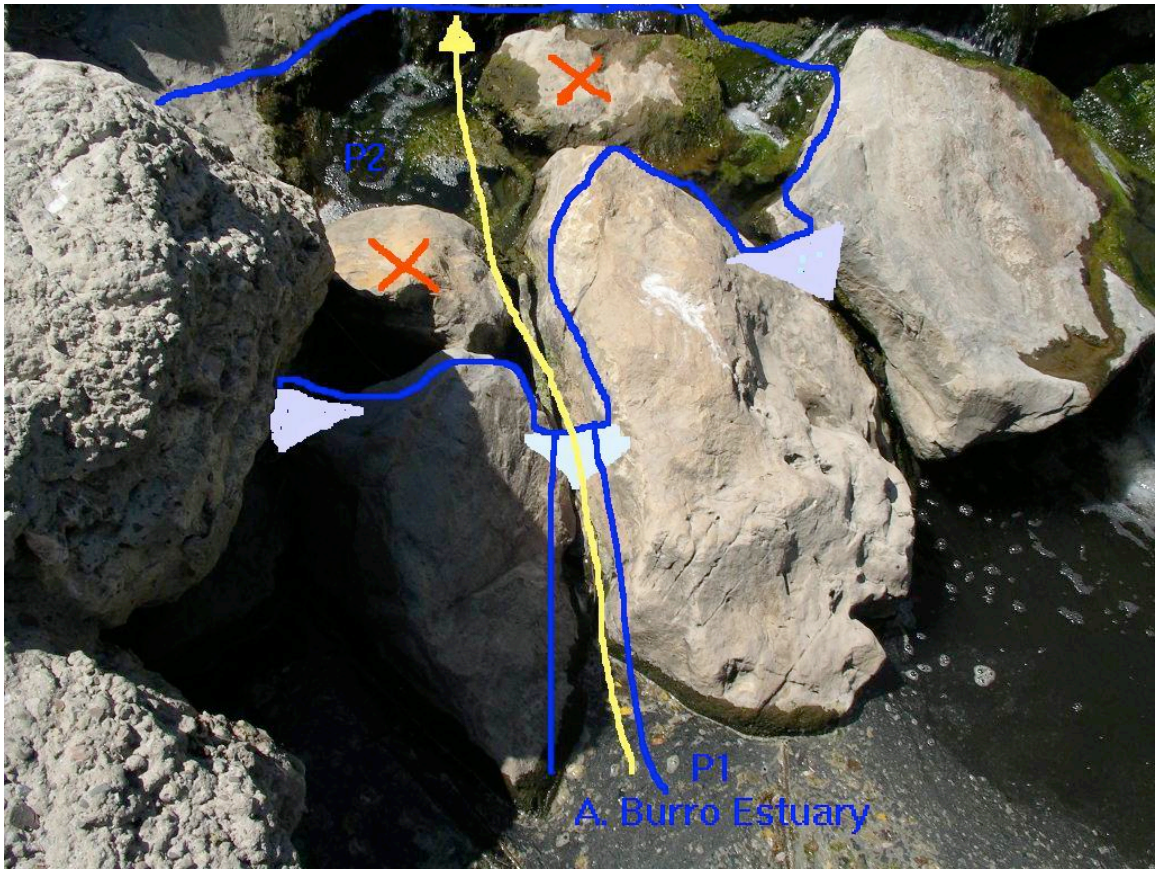
Within the *Project Description Upper Arroyo Burro Estuary Restoration Report* (2003) URS proposed that, "The City will install three concrete, rock-like weirs on the existing grouted rock rip-rap apron downstream of Cliff Drive bridge to create small jump pools that will enhance the passage conditions for steelhead. The structures will be designed in the field, following the specifications on Sheet 13, Appendix C). Anchor bolts will be drilled into the existing rock at the site, and then a wood form will be constructed and filled with reinforced concrete. The work area will be dry during construction due to an upstream diversion and flow by-pass system." Photograph simulations show the potential weir locations downstream of the concrete curb.

This proposed modification would likely improve steelhead passage by increasing jump pool depth across the apron. The main potential problem with this design is that the four jumps will exceed NOAA Fisheries maximum hydraulic drop or jump height criteria of 12 inches. The average hydraulic drop for the design would average over 12 inches per jump with the 58-inch vertical height to be overcome from the estuary surface to the top of the concrete curb.

Proposed Curb Notching and Step Pool Fish Passage Design:

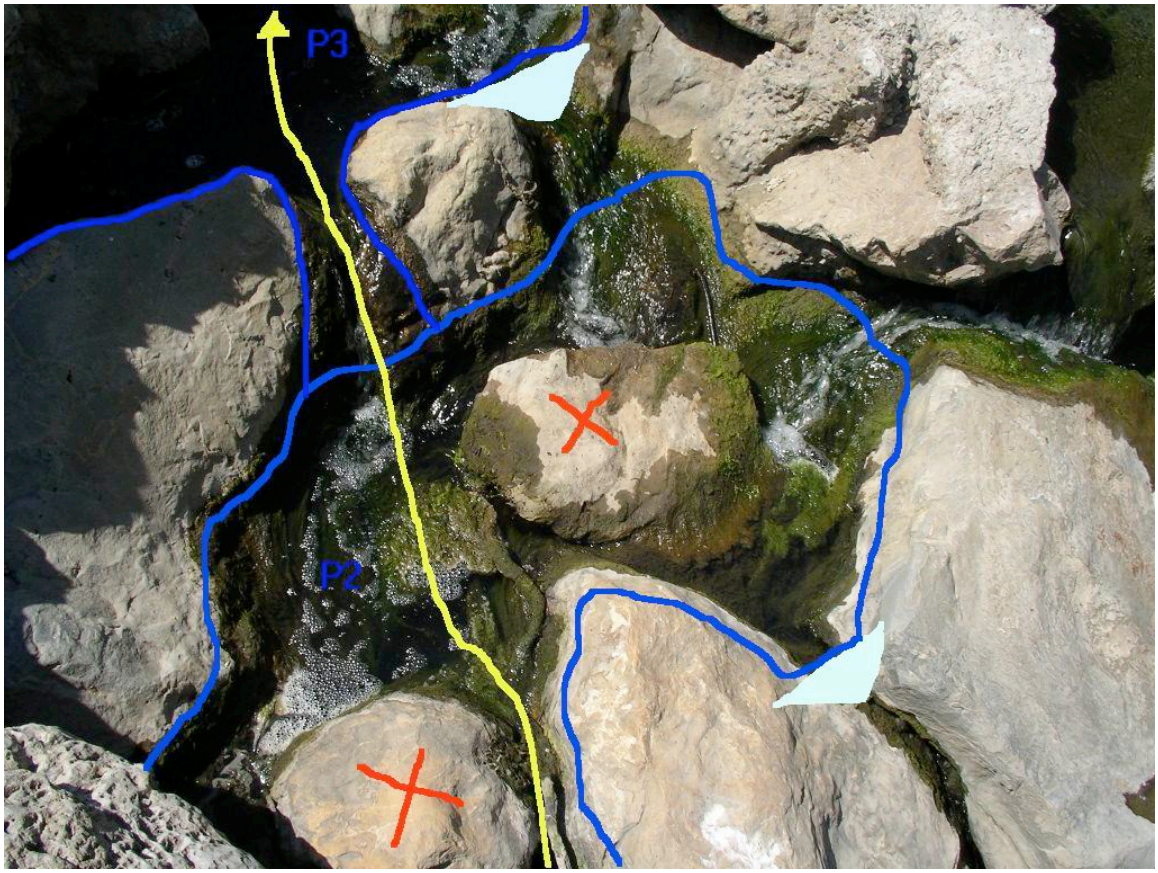
NOAA Fisheries minimum adult steelhead design criteria calls for hydraulic drops (also referred to in this report as "jump heights") not to exceed 12 inches and downstream jump pool depth to be at least 24 inches. In order to meet these adult steelhead design criteria, within the limitations of the project parameters listed above, a 10-inch deep notch can be cut in the concrete curb to change the curb's elevation above the estuary from 58 inches to 48 inches. This reduction in curb elevation will allow for the creation of three step pools with four 12-inch jump heights allowing adult steelhead to overcome the concrete curb. Juvenile steelhead passage would be improved and provide limited upstream migration. The removal or cutting of seven existing boulders will increase the step pool depths and provide sufficient jump depths for adult steelhead to gain effective jumping velocities. Removal of key boulders will also eliminate obstacles currently blocking migration routes and jump landing areas. Juvenile steelhead passage would be greatly improved with this design, but would not meet the conservative 6-inch jump height criteria set by NOAA Fisheries for juvenile steelhead passage design.

The following design recommendations and supporting photograph simulations are limited in detail and are intended to provide conceptual recommendations to URS Corporation for further design development. Recommendations are based on a limited review of existing documents and site survey and should not be incorporated into a final project design without thorough consideration, analysis, and acceptance of proposed recommendations by qualified professionals. Of particular importance is ensuring the structural stability of the concrete curb and apron structure with the proposed modifications. The following photographs show simulations of the proposed design with supporting written summaries of the modifications. The yellow line shows the proposed upstream migration route of steelhead through the modified design. Other components are described within the supporting text.



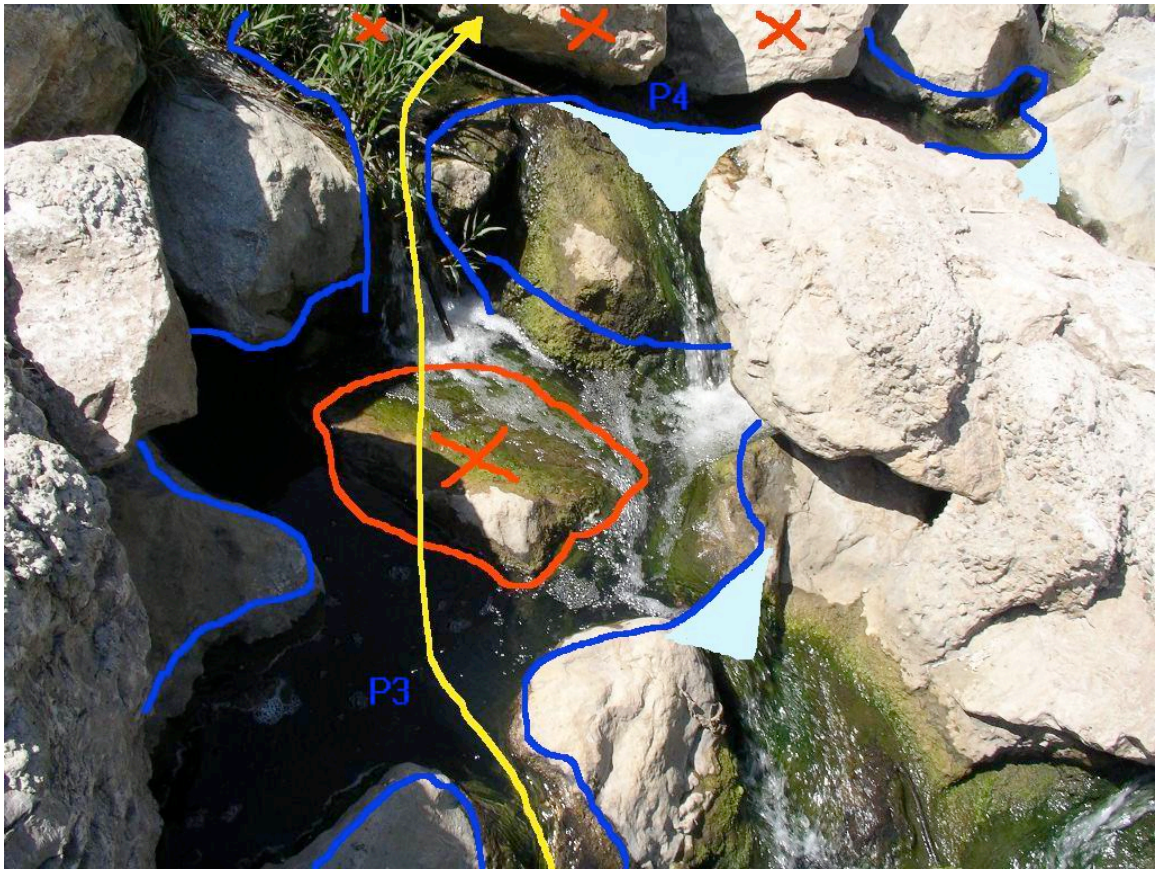
Estuary (Pool #1), Jump #1, Pool #2

The Arroyo Burro estuary P1 provides sufficient jump depth to allow steelhead to jump into P2 during the encountered base stream flows. During moderate and high stream flow conditions or with elevated sandbar development, the estuary water surface elevation can rise several feet and submerge the lower portion of the apron. Two boulders limit the size and depth of P2. Removal of these boulders (marked with red X's) would increase the pool depth to a maximum depth of at least 27 inches. Removal of these boulders may provide additional depth depending on extent of the lower buried portion. Both boulders appear to be resting on top of other boulders. The modified pool would measure approximately 50 inches longitudinally and 72 inches wide. The potential addition of reinforced concrete sills, as shown, should be determined following the completion of curb notching and upstream modifications described below. Once upstream modifications are made and 12 inch hydraulic drops are determined then the water surface elevation of P2 should be determined and sills developed to direct outflows at the yellow fish migration location. It is likely that these sills would be developed mainly to focus flows the outlet location shown and to seal off subsurface flows between boulders, but not to raise the pool surface elevation of P2. With these modifications and redirected flows, the new jump height for Jump #1 should be 12 inches or less (depending on estuary water elevation) to the new P2 outflow location.



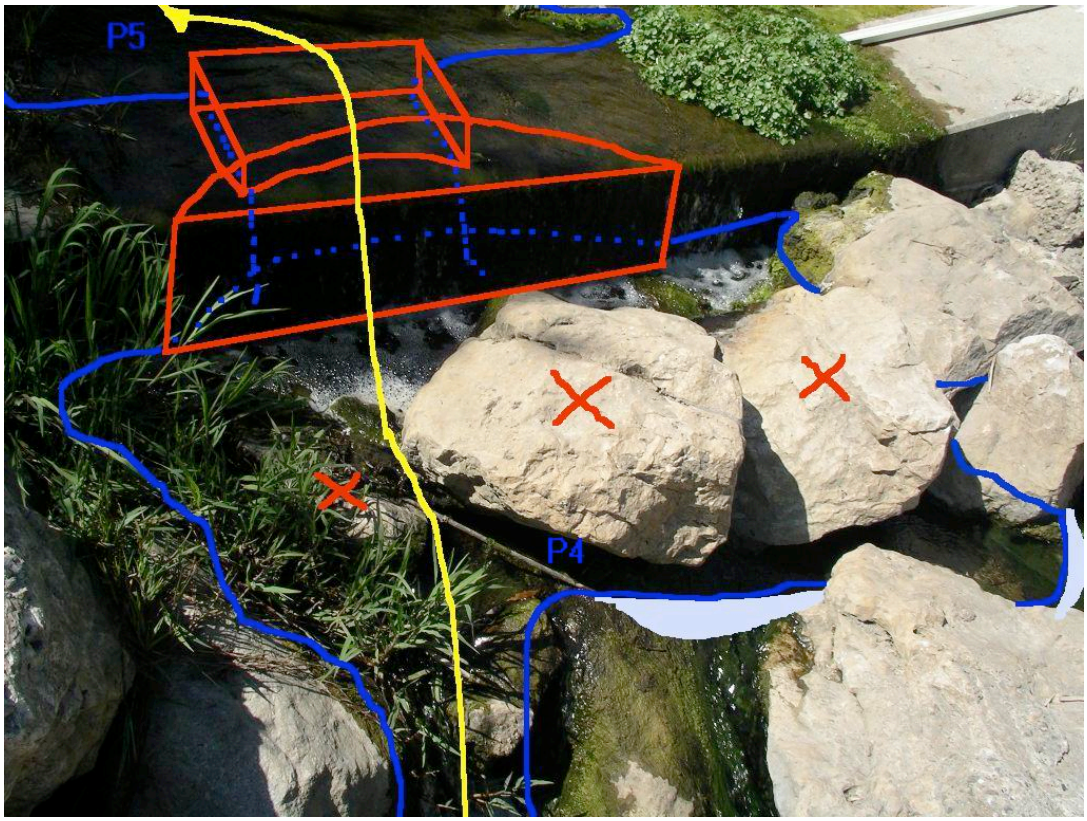
Pool #2 and Jump #2

See previous summary for Estuary (Pool #1), Jump #1, Pool #2. Note: Flows entering the photograph from the right side would be refocused into the upstream end of the step pools with a concrete sill described in the summary for Pool #4 and Jump # 4 (Notched Concrete Curb).



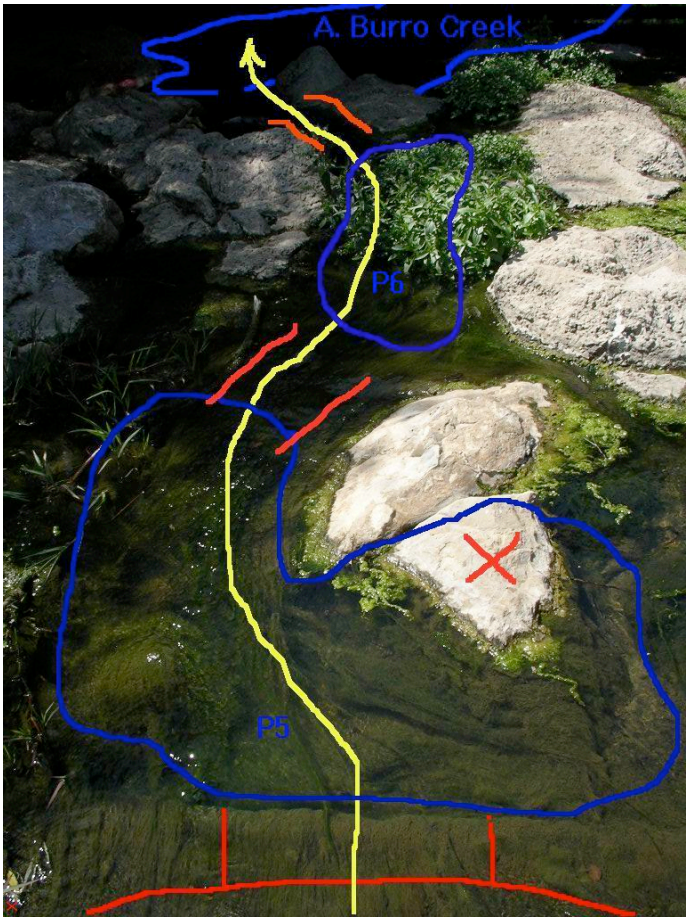
Pool #3 and Jump #3

Remove a significant downstream portion of the boulder marked with a red X by cutting out the approximate circle shown to increase pool depth in P3 and remove this jump obstacle. This large boulder provides structural support for upstream and adjacent boulders and the extent to which portions can be removed will need to be determined by a qualified structural professional. The addition of concrete and/or other reinforcement to the pool bottom may be needed following boulder cutting. Identify the elevation for the tailwater control for P3 at 12 inches below the elevation of the top of the Jump #3 upstream following curb notching and upstream modifications. The outlet elevation for P3 should be close to the existing elevation control where the yellow steelhead migration line occurs. Construct one concrete sill near shown location to ensure that flows are focused down the yellow fish migration line outlet location. The concrete sills should be approximately 4 inches higher in elevation than the outlet elevation at the yellow line location.



Pool #4 and Jump # 4 (Notched Concrete Curb)

Removal of a half-oval section of the concrete curb as shown will expand the size of jump pool P4 and reduce the horizontal jump across the notch in the curb. This half-oval should measure approximately 5 feet across on the downstream side and extend 15 inches upstream into the curb to the center/apex of the half-oval. If structurally feasible, the removed half-oval will comprise the entire thickness of the curb (24 inches). Remove a notch from the remaining concrete curb at the upstream side of the removed half-oval section. The notch should be centered at the apex of the removed half-oval and measure approximately 3 feet wide, 10 inches deep, and be aligned in a perpendicular manner from the upstream edge of the curb. Removal of the three boulders marked with red X's will allow development of 24-inch pool depth in P4 and eliminate obstacles to upstream migration. If boulder removal does not add 12 inches of pool depth and create the desired 24-inch minimum pool depth then excavate slightly to develop desired pool depth. Following curb modification, boulder removal, and pool development identify the location for the tailwater control elevation for P4 at 12 inches below the downstream edge of the notch cut in the concrete curb. This outlet location and elevation should be close to the existing elevation control where the yellow steelhead migration line occurs. The tailwater elevation may need to be lowered slightly by cutting into existing rock and producing an outlet flow notch. Construct two concrete sills near shown locations to ensure that low flows are focused down the yellow fish migration line location. These concrete sills should be approximately 4 inches higher in elevation than the elevation of the outlet location at the yellow line.



Pool #5 and #6 (Upstream of Notched Curb)

Upstream from the completed concrete curb notch, the pool P5 should be enhanced to ensure adequate landing and resting depth for steelhead jumping over the curb from P4. Notching of the curb will lower the water surface elevation upstream of the curb and reduce water depth within P5 and P6. Following notching of the curb, the depth of P5 immediately upstream from the notch should be lowered to the new notch elevation and allowed to gradually gain depth to the lowest portion of the pool. Additional depth could be created in P5 if structurally feasible. Due to the low gradient of the apron upstream of the curb, a low-flow channel could be cut between P5 and P6 and upstream of P6 to the natural pool under Cliff Drive Bridge. The depth of this low-flow channel and additional development of depth in P5 and P6 will need to be determined by qualified professionals following assessment of the apron depth and impacts to structural stability. Ideally the channel and pools P5 and P6 will all have depths of at least 12 inches. The low-flow channel and pools can be cut and lined with concrete to protect undercutting of the apron. Removal of the rock marked with the red X would increase the size of P5, increase pool depth, and eliminate the likelihood of upstream migrating steelhead landing on the rock. Once upstream of the concrete curb, steelhead have several options for migration across the low gradient apron with its variable roughness, resting areas, and existing channel that offer various upstream migration options under different flow scenarios.

Long-term Recommended Action:

While steelhead passage conditions can be greatly improved in the short-term by modifying the existing apron as proposed, the proposed modifications would not preclude future, permanent modification that meet potential restoration objectives for the estuary and provide fish passage for all native fish species and life stages. Long-term objectives for Arroyo Burro estuary restoration and unimpeded fish passage at Cliff Drive might include assessing the feasibility of:

1) Reducing the size of the main parking lot at the Brown Pelican and Watershed Resource Center and establishing a native vegetation buffer along the west side of the lower estuary. This action would help to reduce the direct drainage of automotive pollution and parking lot runoff into the estuary. Currently the buffer between parking lot and lagoon is very limited in size and extent of native vegetation. Poor water quality might be a deterrent to steelhead occurrence and recolonization to the Arroyo Burro.
2) Eliminating or reducing the size of the overflow parking lot to the north along the upper lagoon and allowing for lagoon expansion and establishment of a native vegetation buffer along the lagoon.
3) Eliminating the Cliff Drive Bridge and entire downstream apron structure to allow estuary expansion and unimpeded upstream migration for all life stages of native fish species. Replace the bridge with a wider span bridge that does not impact the stream channel and provides adequate capacity for the 100-year flow event.