APPENDIX C

Basis of Design Report

The following report can be found on the District’s Construction Website at:
http://www.valleywater.org/construction
Uvas-Carnadero Creek
Fish Passage Improvement Project

Basis of Design Report

Prepared by Santa Clara Valley Water District
May 2019
Project Number 26044002
# Table of Contents

1 Introduction
   1.1 Existing Site Conditions
   1.2 Existing Fish Passage Conditions
   1.3 Geologic Setting and Subsurface Conditions

2 Summary of Conceptual Design
   2.1 Alternatives Considered
      2.1.1 Raise Downstream Channel Invert to Meet Slab Elevation
      2.1.2 Overview of Rock Ramp Fishway
      2.1.3 Retrofit Existing Concrete Slab to Accommodate Low Flow Channel
      2.1.4 Recommended Alternative

3 Project Hydrology
   3.1 Peak Design Flow
      3.1.1 Fish Passage Design Flows

4 Fish Passage Design Criteria
   4.1 Depth, Velocity, and Surface Drop
   4.2 Turbulence
   4.3 Fish Attraction

5 Proposed Riffle-Pool Design
   5.1 Overall Project Profile
   5.2 Configuration
   5.3 Flood Assessment

6 Stability Analysis (Sizing of Boulders)
   6.1 Bank Protection

7 Fish Passage Analysis
   7.1 Depth Performance (Riffles)
   7.2 Velocity Performance (Pools and Riffles)

8 SOURCE OF STREAM BED MATERIA
   8.1 Quantity of Imported Material
   8.2 Source of Boulders
   8.3 Stream Bed Gravel
9 Construction Considerations ...........................................................................................................24

10 Conclusion .........................................................................................................................................26

List of Figures

FIGURE 1 LONGITUDINAL SURVEY DATA SHOWING THALWEG ELEVATIONS AND PEBBLE COUNT SAMPLE LOCATIONS. ...........................................................................................................2

FIGURE 2 VERTICAL EROSION ALONG SOUTH BANK OF UVAS-CARNADERO CREEK LOCATED APPROXIMATELY 400 FEET DOWNSTREAM FROM UPRR CROSSING (2011). .................................................................2

FIGURE 3 BANK FAILURE UNDERMINING AN AGRICULTURAL BUILDING LOCATED APPROXIMATELY 1,000 FEET DOWNSTREAM FROM THE UPRR CROSSING ON THE SOUTH BANK (2011) .........................................................................................................3

FIGURE 4 BANK FAILURE THREATENING TO UNDERMINE A LARGE OAK TREE LOCATED APPROXIMATELY 500 FEET UPSTREAM FROM THE UPRR CROSSING ON THE SOUTH BANK (2011) ..................................................................................................................................................3

FIGURE 5 CONCRETE RUBBLE HELD IN PLACE WITH RAILROAD RAILS DRIVEN INTO THE CREEK BANK LOCATED APPROXIMATELY 1,500 FEET DOWNSTREAM FROM THE UPRR CROSSING ON THE SOUTH BANK (2011) ........................................................................................................................................4

FIGURE 6 DEFUNCT AUTOMOBILES HELD IN PLACE BY RAILROAD RAILS DRIVEN INTO THE CREEK BANK LOCATED APPROXIMATELY 1,500 FEET DOWNSTREAM FROM THE UPRR CROSSING ON THE SOUTH BANK (2011) ........................................................................................................................................4

FIGURE 7 EXISTING DENIL TYPE FISH LADDER AT UPRR CROSSING ON UVAS-CARNADERO CREEK (DATE). THE FISH LADDERS IS CONSTRUCTED WITH CONCRETE AND INCLUDES STEEL VANES ........................................................................................................................................6

FIGURE 8 LONGITUDINAL PROFILE (SCALE OF 1 HORIZONTAL TO 40 VERTICAL) .................14

FIGURE 9 LONGITUDINAL PROFILE ......................................................................................................15

FIGURE 10 PLAN VIEW OF PROPOSED TOP OF BANK SUPERIMPOSED ON OLD THALWAG ..16

FIGURE 11 PLAN VIEW AT RIFFLE TOPS AND ALONG POOL ................................................................17

FIGURE 12 CROSS-SECTION AT TOP OF RIFFLE AND POOL ..................................................18

FIGURE 13 LOW FLOW CHANNEL WITH BOULDERS TO ACCOMMODATE FISH PASSAGE ......21

List of Tables

TABLE 1 RECOMMENDED DESIGN FLOWS FOR FISH PASSAGE .........................................................9

TABLE 2 PROPOSED DESIGN FLOWS FOR FISH PASSAGE ...............................................................10

TABLE 3 RECOMMENDED DEPTH, VELOCITY, AND SURFACE DROP CRITERIA .................................11

TABLE 4 CHANNEL DEPTHS AT TOPS OF RIFFLES ...........................................................................20

TABLE 5 VELOCITIES IN POOLS AND RIFFLES ..................................................................................22
## List of Appendices

<table>
<thead>
<tr>
<th>Appendix</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appendix A</td>
<td>Design Plans of Uvas-Carnadero Fish Passage Improvements</td>
</tr>
<tr>
<td>Appendix B</td>
<td>Hydraulic Analysis and Steady-State HEC-RAS Results</td>
</tr>
<tr>
<td>Appendix C</td>
<td>Boulder Size and Rock Slope Protection Evaluation</td>
</tr>
<tr>
<td>Appendix D</td>
<td>Geotechnical Investigation</td>
</tr>
<tr>
<td>Appendix E</td>
<td>Agencies’ Review Comments and Responses</td>
</tr>
</tbody>
</table>
1 INTRODUCTION

Uvas-Carnadero Creek is a tributary to the Pajaro River which drains into the Monterey Bay in Santa Cruz County, California. Uvas-Carnadero Creek supports a self-sustaining population of steelhead that is part of the Southern Central California Coast Distinct population segment (DPS), which is listed as “threatened” under the Endangered Species Act. The Uvas-Carnadero Creek Fish Passage Improvement project involves developing and implementing a design to improve steelhead passage at the Union Pacific Railroad (UPRR) crossing within the City of Gilroy.

1.1 Existing Site Conditions

Uvas-Carnadero Creek alignment parallels Bolsa Road from Monterey Highway south to Bloomfield Avenue in the City of Gilroy. UPRR tracks cross Bolsa Road and Uvas-Carnadero Creek approximately 1 mile south of the Uvas-Carnadero crossing at U.S. Highway 101. The crossing was originally constructed with one set of tracks by the Southern Pacific Railroad (SPRR) in the early 1900s. As-built drawings prepared in 1918 depict the crossing with two spans and a natural channel bottom. Today, the 2 span bridge remains; however, the channel bottom now includes a concrete slab that appears to connect the middle pier with both abutments. The bridge is 80 feet long by 20 feet wide and includes a roughly 20-foot tall retaining wall which extends 100 feet in the upstream direction from the north abutment (See as-built drawings).

The slab was likely constructed to address channel incision and protect the structural integrity of the bridge footings. However, UPRR has stated no knowledge of any records of the slab and has indicated that it was constructed by others. The slab extends 80 feet between each abutment, encompasses the center pier, and continues for 17 feet and 20 feet upstream and downstream from the pier, respectively.

The upstream edge of the slab is currently less than 1 foot above creek’s thalweg elevation (though this elevation varies year to year) and includes a cutoff wall of unknown thickness and depth. A similar cutoff wall faces the downstream edge of slab which is situated approximately 7 feet above the downstream thalweg elevation. The downstream cutoff wall face is lined with large rip rap (approximately 3 feet in diameter) which extends across the channel.

In 1982, a group of concerned citizens organized the installation of a Denil fish ladder situated at the downstream edge of the slab between the center pier and north abutment. In 2006, a similar group organized the installation of a system of 1-foot tall concrete curbs on top of the slab to direct low stream flows toward the fish ladder. These improvements are all located on UPRR property.

In 2011, a longitudinal profile survey was performed by SCVWD staff. The survey extended for 2,000 feet and 1,500 feet downstream and upstream from the UPRR bridge crossing, respectively. The survey included thalweg elevations at significant grade breaks (approximately every 20 feet), bankfull elevations where identifiable, and pebble count bed measurements at stable riffle sections (Figure 1).
The channel in the vicinity of the UPRR crossing has been extensively modified from the original condition and is highly incised and characterized by steep banks that are armored with riprap, and concrete rubble. Field inspections identified vertical banks, some greater than 6 feet in height (Figure 2) at locations downstream from the crossing. Bank erosion upstream and downstream from the crossing threatens Bolsa Road, private property, and numerous large trees (Figures 3 and 4).

Figure 1   Longitudinal survey data showing thalweg elevations and pebble count sample locations.

Figure 2   Vertical erosion along south bank of Uvas-Carnadero Creek located approximately 400 feet downstream from UPRR crossing (2011).
Figure 3  Bank failure undermining an agricultural building located approximately 1,000 feet downstream from the UPRR crossing on the south bank (2011).

Figure 4  Bank failure threatening to undermine a large oak tree located approximately 500 feet upstream from the UPRR crossing on the south bank (2011).

Local efforts to arrest bank erosion include placement of various materials including railroad rails, concrete rubble, and defunct automobiles (Figures 5 and 6).
Figure 5  Concrete rubble held in place with railroad rails driven into the creek bank located approximately 1,500 feet downstream from the UPRR crossing on the south bank (2011).

Figure 6  Defunct automobiles held in place by railroad rails driven into the creek bank located approximately 1,500 feet downstream from the UPRR crossing on the south bank (2011).

Channel incision or base lowering of Uvas-Carnadero Creek is likely a response to changes in watershed characteristics initiated decades ago. Increased agricultural and urban land use and flood control and water supply facilities have reduced Uvas-Carnadero Creek’s channel length,
increased the volume of surface water delivered to the creek, decreased surface water time of concentration at the creek, and arrested sediment delivery from the upper watershed. The incision or base lowering noted at Uvas-Carnadero Creek’s vertical banks is part of a geomorphic process to lower the overall channel slope and thereby reduce hydraulic energy within the system.

1.2 Existing Fish Passage Conditions

Uvas-Carnadero Creek supports a self-sustaining population of steelhead that is part of the Southern Central California Coast Distinct population segment (DPS), which is listed as “threatened” under the Endangered Species Act.

Other native fish species in the Uvas Creek watershed include Sacramento sucker (Catostomus occidentalis), Sacramento pikeminnow (Ptychocheilus grandis), California roach (Lavinia symmetricus), Riffle sculpin (Cottus gulosus), Pacific lamprey (Entosphenus tridentatus), and Threespine stickleback (Gasterosteus aculeatus). Prickly sculpin (Cottus asper) and Hitch (Lavinia exilicauda) are also present, but are relatively scarce. Non-native fish are uncommon in Uvas Creek.

The reach of Uvas-Carnadero Creek in the vicinity of the UPRR crossing exhibits intermittent flows where pools and undercut banks provide shelter for fish en route to perennial portions of the creek found upstream. However, hydraulic conditions at the UPRR crossing pose a barrier to upstream migration.

Fish passage conditions at the UPRR crossing were assessed by Santa Clara Valley Water District (SCVWD) fisheries biologists in 2006. SCVWD staff identified poor attractive flows, insufficient entrance depth, and excessive flow velocities for medium and high flows as the limiting factors hindering upstream passage through the existing Denil fish ladder for adult steelhead, and juvenile salmonids (Figure 7).
1.3 Geologic Setting and Subsurface Conditions

This reach of Uvas Creek is located at the southern end of the northwest/southwest-trending Santa Clara Valley, bounded by the Santa Cruz Mountains to the southwest and the Diablo Range to the northeast. The site is mapped as being underlain by natural levee deposit alluvium. The site geology and subsurface conditions were investigated for the slope failure occurred in 2017 along the south channel banks of the Christopher Ranch facility on 305 Bloomfield Avenue, Gilroy. The explorations conducted for this investigation revealed about 16 to 20 feet of silty sand and sandy silt overlying 15 to 20 feet of clay and silt; the underlying gravels, sands, clays and some silts are of varying thicknesses and generally higher relative density and stiffer consistency with depth. The findings of this investigation are presented in the following report:

Cotton, Shires and Associates, Inc. “Geotechnical Investigation, Creek Bank Stabilization, Christopher Ranch, Uvas/Carnadero Creek, Gilroy, California,” dated July 2018.

2 SUMMARY OF CONCEPTUAL DESIGN

The proposed fish passage design involves rehabilitating the channel bed with a series of constructed riffles and pools and rehabilitating the banks adjoining the riffles and pools to arrive at a stable channel configuration. The engineering decisions, design parameters, and predicted hydraulic performance of the proposed fish passage retrofit are described in detail in Sections 3 through 8.

2.1 Alternatives Considered

The UPRR crossing is heavily utilized for agricultural and transportation purposes. As such, temporary disruption to transportation services and high construction costs lead the design team to determine bridge replacement to be infeasible.

Removing the concrete slab beneath the bridge crossing and allowing the channel to naturally re-grade would likely result in severe head-cutting and undermining of the bridge abutments. To ensure stability of the existing bridge and public safety, the design team focused on solutions for fish passage that included grade control.

The design team investigated a number of alternatives to replace the existing Denil fish ladder. Alternatives included providing fish passage either over or through the concrete slab and included three basic approaches:

1. Raise the downstream channel invert gradually to match the existing slab elevation – Riffle and Pool Fishway;
2. Construct a rock ramp downstream of the slab – Rock Ramp Fishway; and
3. Retrofit the existing slab to accommodate a low flow channel.
2.1.1 Raise Downstream Channel Invert to Meet Slab Elevation

**Overview of Riffle and Pool Fishway**

To minimize structural modification of the concrete slab, the downstream channel bed elevation could be raised gradually to the slab elevation using constructed riffles and pools. Riffle and pool fishway channels are a series of pools at consecutively higher elevations, interspersed with runs and riffles. Water flows from pool to pool over a run and riffle built with rock and embedded with stream bed gravel. During the journey upstream, adult Salmonids rest in the downstream pool and then travel over the riffle and the run to the next pool upstream, gaining approximately 1 foot in elevation. There is a distribution of velocities in the flow at the top of the riffle. The juveniles can move through the space between the rocks forming the top of the riffle, where the velocities are lower. The energy in the flow entering each pool is dissipated in each pool before it flows to the next riffle.

The design will be similar to those implemented at Blackberry Farm on Stevens Creek and Alamitos Creek, both of which accommodate fish passage. The use of runs and riffles built with rock overcome the limitation of pool and weir system; the pool – weir system can have greater challenges maintaining velocities within the range for fish passage (CDFG, 2009). The use of riffle and run that is 40 feet in length, and is anchored with 3 ton boulders on the upstream and downstream ends and at the top of the rock riffle can provide additional stability along the channel bed.

The elevation drop from the downstream edge of the slab to the channel invert is approximately 7 feet. Additionally, the channel has a relatively mild slope of 0.002. This drop requires 7 riffles for the drop at the slab, and an additional 2 riffles to accommodate the drop in channel bed elevation downstream of the slab. In general, riffles and runs are along straight sections of the channel with additional pools at the bends. This extends the project over 1,500 feet.

Based on stable rock size calculations, a channel that would withstand a flow 7,000 cubic feet per second (cfs) and at a channel gradient equal to 0.007 requires a combination of 2-ton rock and 3-ton rock to anchor the constructed riffle.

2.1.2 Overview of Rock Ramp Fishway

An alternative to the riffle and pool fishway is to gradually raise the downstream bed elevation to the slab elevation using rock ramps. Rock ramps are continuous roughened channels constructed at a constant slope with random large rocks (up to 2 ton) placed in Engineered Streambed Material (ESM, Section 6) to create hydraulic roughness and diversity. Rock ramps are limited to slopes less than 0.04 (4 percent) and are best for overcoming elevation differences of 5 feet or less.

The 7-foot elevation drop at the downstream edge of the slab would require construction of two rock ramps that would be separated by a pool. At a slope of 0.04 the project would extend a minimum of 170 feet downstream from the slab.

The rock ramp alternative would substitute the 9 riffles and pools described previously with two rock ramps and a pool. Advantages to using rock ramps instead of pools and weirs include: simplified construction, a smaller project footprint (roughly 90 feet less length), and ease of maintenance in the event of project adjustment.
The disadvantage of rock ramps is the high velocities downstream of the rock ramps that are 4 percent slope, as opposed to riffles and runs that have only 1 percent slope. The steeper slope will likely create velocities that can erode the banks.

2.1.3 Retrofit Existing Concrete Slab to Accommodate Low Flow Channel

The overall project footprint can be greatly reduced by retrofitting the existing slab with a low flow channel. A portion of the slab and cut-off walls situated between the center pier and north abutment would be removed to accommodate a 24-foot wide, triangular low flow channel set approximately 3-feet beneath the existing slab elevation. The new low flow channel would reduce the existing elevation drop at the downstream edge of the slab from 7 feet to zero. The challenge in retrofitting the existing slab is potential damage to the foundation of existing UPRR bridge and the protection necessary to provide during construction. In addition, the banks downstream of the slab will continue to be stressed from higher velocities due to the steeper gradients of the rock ramp and roughened channel options. The banks upstream of the slab may be subject to additional erosion.

2.1.4 Recommended Alternative

The report discusses the first alternative, which is the Riffle and Pool Fishway.

3 PROJECT HYDROLOGY

Uvas-Carnadero Creek is a 29.5 mile long mainly southward flowing stream originating on Loma Prieta peak of the Santa Cruz Mountains, in Santa Clara County, California. The channel in the vicinity of the UPRR bridge crossing is intermittent and flows become subterranean during the dry season (May through October). Uvas Creek descends through Uvas Canyon County Park into Uvas Reservoir, and upon passing U.S. Highway 101 is known as Carnadero Creek, shortly before the confluence with the Pajaro River at the Santa Clara County and San Benito County boundary.

The Uvas-Carnadero Creek watershed drains the eastern slope of the Santa Cruz Mountains in southern Santa Clara County. Uvas Reservoir, built in 1957, drains 32 square miles and is 7.5 miles upstream of the City of Gilroy and 10.5 miles upstream of the Pajaro River confluence. Significant tributaries include Croy Creek, Little Uvas Creek, Little Arthur Creek, Bodfish Creek, and Gavilan Creek. Below Uvas Reservoir the creek is very low gradient. After Uvas Creek crosses Highway 101 and becomes Uvas-Carnadero Creek it is joined by Gavilan Creek, Tick Creek and then Tar Creek. Uvas-Carnadero Creek is the only stream in the Pajaro River watershed, and in Santa Clara County, whose water right specifies minimum winter and summer releases for maintaining fish resources.

Based on data on geomorphic attributes of Uvas Creek downstream of Santa Teresa Boulevard collected by the District since early 2000, the bankfull width was around 30 to 40 feet, with bankfull depths around 4 to 7 feet in relatively stable sections. The dimensions of channel cross-sections were primarily based on observations of tree trunk locations, bankfull benches, top of point bar, etc. Assessing the precise measurements was unfeasible because the original bankfull would have to be based on conditions prior to the construction of Uvas Dam in 1957.

The section of creek channel between Bloomfield Avenue and Highway 25 (starting approximately 0.4 mile downstream of the project area) can be used as a reference reach. For
this, the project needs to achieve a bankfull width of 35 +/- 5 feet, bankfull depth of 4 to 5 feet, top of bank width of 120 feet, and access to the floodplain at a height no greater than 15 feet. The project achieves these width and depth characteristics between the UPRR crossing and the first bend downstream of UPRR (along 700 feet of length). In the following 1000 feet, it achieves a stable bed for fish passage through the construction of the riffle-pool geometry. The channel remains partially incised because the top of bank height where the creek accesses the floodplain is around 20 feet and top of bank width is limited to 100 feet. The top of bank height and width are determined by the proximity of Bolsa Road on the right bank (looking upstream) and the private property and structures on the opposite bank.

3.1 Peak Design Flow

The estimated peak flow having a 100-year return period was estimated by SCVWD at the Uvas-Carnadero Creek and Gavilan Creek confluence to be 18,400 cfs (SCVWD, 2003). The top of bank flow through the section of Uvas Creek from the slab to 1,500 feet downstream is estimated to be 7,000 cfs. The flow conveyed to this section in 2017 was estimated to be slightly lower than 7,000 cfs because there was a breakout in a field upstream of Christopher Ranch. This breakout is at a private property. Should the property owner raise the level of the bank where the breakout occurred, the flow conveyed to this section would increase. Therefore, the riffle and pool bed should be constructed to be stable up to the flows that can be conveyed when the water level reaches the top of bank elevation.

3.1.1 Fish Passage Design Flows

The low and high fish passage design flows define the flow range within which the crossing should be suitable for upstream passage for a specific species and life stage. These high and low flows are used to determine the maximum water velocity and minimum depth of water at the structure, respectively. Both NOAA Fisheries (2001) and California Department of Fish and Game (CDFG, 2002) have recommended fish passage design flow criteria for juvenile salmonids, resident rainbow trout, and adult steelhead. These are defined in terms of exceedance flows which are derived from an annual flow duration curve based on mean daily flows. For ungauged creeks, NOAA Fisheries and CDFG also provide high and low flow values as a percentage of the 2-year recurrence interval flow, and as recommended (Table 1). There are no reliable gage records for the project site.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Recommended Design Flows for Fish Passage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Species and Life Stage</td>
<td>Minimum Flow (cfs)</td>
</tr>
<tr>
<td>Adult Anadromous Salmonids</td>
<td>3</td>
</tr>
<tr>
<td>Juvenile Salmonids</td>
<td>1</td>
</tr>
</tbody>
</table>

The minimum flow recommended by Table 1 is 1 cfs. HEC-RAS simulation of the current condition of the project reach upstream and downstream from the concrete slab indicates that the depth of flow at 1 cfs is insufficient for juvenile fish passage. The minimum flow predicted by the model to maintain a 6-inch depth in the existing channel is 10 cfs. The creek is expected to have flows at 10 cfs or higher during the season when the salmonids are moving through the system.
The estimated 2-year return interval flow estimated at the Uvas-Carnadero Creek and Gavilan Creek confluence is 640 cfs (SCVWD, 2003). Fish passage design flows for the project were determined as follows (Table 2).

**Table 2  Proposed Design Flows for Fish Passage**

<table>
<thead>
<tr>
<th>Species and Life Stage</th>
<th>Proposed Minimum Flow (cfs)</th>
<th>Proposed High Flow (% of 2-Yr Recurrence Interval Flow)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult Anadromous Salmonids</td>
<td>10</td>
<td>320</td>
</tr>
<tr>
<td>Juvenile Salmonids</td>
<td>10</td>
<td>64</td>
</tr>
</tbody>
</table>
4 FISH PASSAGE DESIGN CRITERIA

4.1 Depth, Velocity, and Surface Drop

Fish passage design criteria used to design project features followed the CDFG and NOAA Fisheries guidelines. This establishes the desired minimum water depth (feet, ft), maximum water velocity (feet per second, fps), and maximum water surface drop (feet, ft) for natural channel passage designs. These numbers are considered targets, unlike fish ladders and culverts, which have established criteria. (Table 3). To assess passage, a set of CDFW passage criteria (Table 4) were used that are more meaningful for fish. The depths used for passage assessment are designed around having enough depth to submerge and adult steelhead, while the velocity criteria are associated with the different swimming modes of fish.

Table 3 Recommended Depth, Velocity, and Surface Drop Design Criteria

<table>
<thead>
<tr>
<th>Fish Passage Criteria</th>
<th>Juvenile Salmonids</th>
<th>Adult Salmonids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Water Depth</td>
<td>0.5 ft</td>
<td>1.0 ft</td>
</tr>
<tr>
<td>Maximum Water Velocity</td>
<td>1.0 fps</td>
<td>6.0 fps</td>
</tr>
<tr>
<td>Maximum Water Surface Drop</td>
<td>0.5 ft</td>
<td>1.0 ft</td>
</tr>
</tbody>
</table>

Table 4 CDFW Fish Passage Prescribed Water Depth and Swimming Criteria (CDFG 2004)

<table>
<thead>
<tr>
<th>Fish Passage Criteria</th>
<th>Juvenile Salmonids</th>
<th>Adult Salmonids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Water Depth</td>
<td>0.3 ft</td>
<td>0.8 ft</td>
</tr>
<tr>
<td>Sustained Velocity Threshold</td>
<td>N/A</td>
<td>3.0 fps</td>
</tr>
<tr>
<td>Prolonged Swim Speed/Time to Exhaustion</td>
<td>1.5 fps/ 30 min</td>
<td>6.0 fps/ 30 min</td>
</tr>
<tr>
<td>Burst Swim Speed/Time to Exhaustion</td>
<td>3.0 fps/ 5.0 Sec</td>
<td>10.0 fps/ 5.0 sec</td>
</tr>
<tr>
<td>Maximum Water Surface Drop</td>
<td>0.5 ft</td>
<td>1.0 ft</td>
</tr>
</tbody>
</table>

4.2 Turbulence

Turbulence is due to the rapid fluctuations in water velocity associated with energy dissipation and typically includes entrainment of air within the water column. Large amounts of turbulence can disorient and exhaust a fish, resulting in a passage barrier (CDFG, 2009). The Energy Dissipation Factor (EDF) defines the hydraulic capacity of a fishway. EDF is essentially the maximum amount of turbulence allowed in a fishway for fish to successfully move through it.
The maximum recommended EDF for adult steelhead is 4 ft-lbs/s/ft$^3$. There is no current guidance for EDF thresholds for juvenile salmonids (WDFW, 2000).
5 PROPOSED RIFFLE-POOL DESIGN

The proposed design consists of pool and riffle channel using a mixture of materials. Appendix A presents profiles and cross-sections illustrating this riffle and pool design.

5.1 Overall Project Profile

The riffle-pool channel profile is shown on Figure 8 (scale of 1 horizontal to 40 vertical); Figure 9 presents an excerpt of the profile between Riffle 4 and Riffle 5 in 1 horizontal to 1 vertical scale. A plan view of the proposed channel improvement is shown on Figure 10. Figures 11a through 11d present plans of the riffle tops located along a straight section of the creek, approaching a creek bend, within an unconstrained section, and a constrained section of the creek.

5.2 Configuration

The proposed riffle-pool alternative consists of a series of roughened riffles with pools and glides in between. Its overall length is 1,700 feet at an overall slope of 0.5 percent to overcome 7½ vertical feet. The riffles are 40 feet long and drop 1 foot at approximately 4 percent slope. Downstream of each riffle is a pool and glide that has a length of 52 to 54 feet. The pool bottoms are 2 feet below the next downstream riffle crest. In total there are ten riffles and ten pools. One riffle and a buried boulder line downstream of the tenth pool are intended to provide additional stability of the channel bed.

The riffles are constructed of engineered streambed material (ESM), comprised of 3-ton boulders anchoring the top of riffle, its upstream and downstream ends, interspersed with 1-ton boulders and stream bed gravel. The bottom of the pool (about 20 feet from the edge of riffle) will be also lined with ESM comprised of ½ and 1-ton boulders and stream bed gravel. Bank lining will be rock with vegetation planted between crevices in the rock in those sections where the channel is expected to experience shear forces that exceed that of earth lined banks. Generally, the lining is with 1-ton and 2-ton rock along the edges.

Figures 12a shows a cross-section at a top of riffle in the less constrained section from UPRR slab to the first bend 400 feet downstream. The bankfull width is 32 to 36 feet. There is a bench on either side that is 8 to 12 feet in width. Figure 12b shows a pool between the tops of riffles.

Additional details for the riffles, pools, and bank protection are shown in Appendix A.

5.3 Flood Assessment

The 1,500-foot geometry of Uvas Creek, downstream of the UPRR Bridge, is modeled in the HEC-RAS (version 5) with the proposed riffle-pool configuration to evaluate impact to hydraulic conveyance of the modified channel. A Manning’s roughness coefficient of 0.045 was used for the roughened riffles and pools. Figure 10 presents the water surface profile from the existing channel geometry in comparison with the riffle-pool design surface. Appendix B presents additional model results.
Figure 8  Longitudinal Profile (Scale of 1 Horizontal to 40 Vertical)

Note: The difference in scales of the X and Y axes exaggerate the drop 40 fold. A profile using the same scales horizontally and vertically from Riffle 4 to Riffle 5 is shown in Figure 9.
Figure 9  Longitudinal Profile
Bioengineered Bank Protection generally to be constructed at channel bends that show significant distress.

Low Flow Bank

Riffle

Figure 10  Plan View of Proposed Top of Bank superimposed on Old Thalwag

Figure 10  Plan View of Proposed Top of Bank superimposed on Old Thalwag
Figure 11a. Plan View at Top of a Riffle along Straight Section of Creek

Figure 11b. Plan View at Top of a Riffle approaching a Bend (Creek turns left)

Figure 11c. Plan View Along Pool (glide portion) in Unconstrained Section

Figure 11d. Plan View Along Pool (glide portion) in Constrained Section

Figure 11  Plan View at Riffle Tops and along Pool
Riffle 2 Cross-Section at the Top of Riffle
Approximate Station here is 23+90
Preferred Location for construction is 23+75

3+ ton, A axis is 5', B axis is 4', C axis is 3'
2 ton
1 ton

Thalwag 159
Centered

Low flow channel
Top width at El 163: 36-42', Bottom width at El 159: 27-30'

Stability Analysis
Minimum Width at 163 = 36'
Width at 167 = 78'
This exceeds 72 feet for stability

Opening for Salmonids
4-6' width at Thalwag is 9 to 12' below rest of bed

Low flow channel.

Current X-Section

Figure 12a  Cross-Section at Top of Riffle 2 (Station 23+90)

Pool 1 Cross-Section at Deepest Point
Approximate Station Shown Here is 24+20

3+ ton, A axis is 5', B axis is 4', C axis is 3'
2 ton
1 ton

Thalwag in pool 156
Centered

Low flow channel (pool)
Top width at El 163: 44-48', Bottom width at El 156: 32-36'

Stability Analysis
Minimum Width at 163 = 36'
Width at 167 = 84'
This exceeds 72 feet for stability

Low Flow Bank Slope 2H:1V

Contractor to shape the bottom surface in Pools 1 to 3 with 1 ton rock
The lowest 2 ton rock at the toe of the bank should be mostly buried

Figure 12b  Cross-Section at Pool 1 (Station 24+20)

Figure 12  Cross-Section at Top of Riffle and Pool
6 STABILITY ANALYSIS (SIZING OF BOULDERS)

The project is using constructed riffles to raise and stabilize the bed. The boulders anchoring the tops of riffles need to be stable (not be impacted by velocities and scour) at the flood flows at which the channel overtops. The design flow is estimated to be 7,000 cfs.

Based on empirical analyses, the footer rocks at the top of riffle are estimated to be from 900 lbs to 5,500 lbs. The larger size accounts for the scour depth.

The largest boulders recommend for this project are 3 ton (6,000 lb). They should be angular, with an A axis length of 5 feet, a B axis of 4 feet and a C axis of 3 feet. Multiple rows of 2-ton boulders are to be used at the riffle to provide stability to the riffle.

6.1 Bank Protection

In addition to the channel riffle sizing, stability analysis was conducted to evaluate the minimum rock sizing necessary to maintain a stable bank during the design flow event (7,000 cfs). Based on Caltrans’ “California Bank and Shore Rock Slope Protection Design,” October 2000 version, the rock slope protection (RSP) Class ¼ Ton should meet the estimated minimum rock mass of 460 pounds (Appendix C). Therefore, RSP-Class ½ Ton is recommended for the bank stabilization along the south bank between approximate Stations 9+00 and 12+50, as well as an approximate 100 feet reach of the north bank adjacent to UPRR Bridge.
7 FISH PASSAGE ANALYSIS

Manning’s equation and HEC-RAS (Version 5.0.0) hydraulic model were used to assess fish passage performance for the proposed design. This model was particularly useful to determine low flow depths and velocities within the proposed roughened channel.

7.1 Depth Performance (Riffles)

The average slope extending over 1,500 feet of riffle-run-pool downstream of the slab is 0.006 (0.6%). The hydraulic gradient line varies from 2.5% at the riffle to less than 0.1% along the pool. The depth criteria for both juvenile and adult salmonids are generally met with depths exceeding 1 foot at flow of 10 cfs. At the tops of the riffles, the thalweg depth is estimated to be about ¾ to 1¼ feet (Figure 13).

Table 4 Channel Depths at Tops of Riffles

<table>
<thead>
<tr>
<th>Species and Life Stage</th>
<th>Low Passage Design Flow</th>
<th>Minimum Depth For Passage</th>
<th>Predicted Depths Ranging</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>From</td>
</tr>
<tr>
<td>Juvenile Salmonids</td>
<td>10 cfs</td>
<td>0.4 ft</td>
<td>0.5 ft</td>
</tr>
<tr>
<td>Adult Salmonids</td>
<td>10 cfs</td>
<td>0.8 ft</td>
<td>0.5 ft</td>
</tr>
</tbody>
</table>

The depths in the pools are greater than 1 foot and are presented in Table 5.
7.2 Velocity Performance (Pools and Riffles)

In general, the hydraulic computations indicate velocities to be lower than the design criteria of 4 fps at 320 cfs and are lower than 1 fps at 64 cfs in the pools. Table 5 presents a summary of the velocity calculations indicating between 0.5 and 0.9 fps at 64 cfs, and between 1.8 and 2.1 fps at 320 cfs. These values are also less than the 3 fps sustained velocity threshold for adults indicating the pools are providing velocity refuge between riffles.

The velocities in the riffles are generally less than 6 fps allowing for fish to navigate most of the riffle using a prolong swim speed. At the tops of the riffles, velocities increase over that threshold, up to 7.6 fps, which would require adult steelhead to use burst swimming mode. This velocity is still well under the max burst swim speed of 10 fps and given the short distance fish would be exposed to these velocities, riffles would still be passable. Additionally, at higher flows much more of the riffles would meet the depth criteria allowing fish to navigate the riffles outside of the thalweg where velocities would be lower. The high velocities (Table 5) estimated at the tops of riffles are isolated and occur over a relatively short segment. In addition, the velocities in the crevices between the riffle boulders are estimated to be lower than the average velocity (Figure 12).
### Velocities in Pools and Riffles

#### Velocities in Pools

<table>
<thead>
<tr>
<th>Species and Life Stage</th>
<th>High Passage Design Flow</th>
<th>Velocity Target</th>
<th>Predicted Velocity Ranging</th>
<th>Water Depth in Pool Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Juvenile Salmonids</td>
<td>64 cfs</td>
<td>1.0 fps</td>
<td>0.5 fps, 0.9 fps</td>
<td>3½ ft</td>
</tr>
<tr>
<td>Adult Salmonids</td>
<td>320 cfs</td>
<td>4.0 fps</td>
<td>1.8 fps, 2.1 fps</td>
<td>4½ ft</td>
</tr>
</tbody>
</table>

#### Velocities at Riffles

<table>
<thead>
<tr>
<th>Species and Life Stage</th>
<th>High Passage Design Flow</th>
<th>Velocity Target</th>
<th>Predicted Velocity Ranging</th>
<th>Predicted Lower Velocity Through Boulder Gaps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Juvenile Salmonids</td>
<td>64 cfs</td>
<td>1.0 fps</td>
<td>0.9, 4.7 fps</td>
<td>1.1 fps</td>
</tr>
<tr>
<td>Adult Salmonids</td>
<td>320 cfs</td>
<td>4.0 fps</td>
<td>2.4, 7.6 fps</td>
<td>1.8 fps</td>
</tr>
</tbody>
</table>
8 SOURCE OF STREAM BED MATERIAL

8.1 Quantity of Imported Material

It is estimated that 2,000 cy of stream bed gravel import will be required for use as interstitial fill material in the riffles and to form the pools. If the quantity available is limited to 1,000 cy, pools 1 and 2 can be left a little deeper; the pools are anticipated to be filled in with a soil and gravel mixture conveyed with flows in the first two winters.

An estimate of the amount of boulders / rocks is as follows:

- Rock to construct the riffles, pools and benches is 5,000 cy
- Rock for bank protection along three bends is 1,600 cy

The distribution is of this rock is as follows:

<table>
<thead>
<tr>
<th>Rock Size / Dimension</th>
<th>Quantity (cubic yards)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3+ foot B axis, 3 ton+</td>
<td>1,000</td>
</tr>
<tr>
<td>2.5 foot B Axis, 1 ton</td>
<td>3,000</td>
</tr>
<tr>
<td>2 foot B axis, ½ ton</td>
<td>2,000</td>
</tr>
<tr>
<td>1.5 foot B axis, ¼ ton</td>
<td>750</td>
</tr>
</tbody>
</table>

8.2 Source of Boulders and Streambed Gravel

The boulders and streambed gravels could be sourced from a quarry. The 2-ton boulders should be angular with larger A axis and smaller C axis. The streambed gravel should be river washed gravels that are clean, hard and durable.
9 CONSTRUCTION CONSIDERATIONS

Uvas Creek runs dry during summer months. As a result, construction activities such as sediment trapping or fish handling are not expected over the duration of the construction from June 15th through October 15th. Localized dewatering may be required.

Access may be required after the first and second and fifth winters to install additional boulders if there is excessive settling at the riffles and movement along the toe of the bank.

Proper implementation of the design will require considerable amount of field-fitting. A design engineer familiar with the concepts and methods used to design fish passage features, bank protection and geomorphology should be available to review the riffles, pools and weirs.

All workers will be required to complete railroad safety training prior to commencing work in the vicinity of the rail road tracks.

Upon completion of the construction, an as-built survey should be performed to document any modifications to the original design and establish a basis for post-construction monitoring. The scope of the as-built survey should include, at least, cross sections and longitudinal profile surveys and photo documentation. Specifically, the post-construction monitoring should consist of the following:

- A longitudinal profile extending along the thalweg of the creek from approximately 25 feet upstream of the UPRR crossing (Station 26+50) to approximately 1,700 feet downstream (Station 9+00) of the crossing will be collected as part of the post-project as-built surveys, and in years 5 and 10. Additional surveys may be taken should qualitative assessments indicate a more frequent need.
- Cross-section profiles will be taken at a total of 9 permanent transects between Riffles 1 and 2, 5 and 6, and 8 and 9 with transects at the top of riffle, mid-riffle, and pool in each of the three riffles surveyed. Cross-sections will be collected as part of the post-project as-built surveys, and in years 5 and 10. Additional surveys may be taken should qualitative assessments indicate a more frequent need.
- Photo-documentation of the site will be conducted from at least 10 fixed locations in the project reach with representative photos of the riffles, pools, reconstructed banks, and riparian habitat. Photographic documentation will be captured prior to the start of construction and during monitoring years 1 through 3, 5 and 10.

Construction of the fish passage modifications is conceived to proceed as follows:

- Establish traffic control along Bolsa Road, as necessary.
- Grade access roads and install erosion and sediment control measures
- Bring in the boulders
- Bring in some stream bed gravel
- Demolish the current fish ladder
- Rough grade the proposed cross-section inclusive of bank protection and cut at each riffle and pool
- Begin placing the boulders to form riffles and pools
  - Insure that the correct layout of 2 ton, 1 ton and ½ ton rock are implemented.
  - Where necessary, excavate to place the rock.
  - Excavate the pool(s) where necessary.
• Use stream bed gravel as infill between the boulders in the low flow channel
• Use a mix of ½ ton rock and stream bed gravel to grade in the bottom of pools.
• Construct the bank protection with rocks
• Cover the rocks on the bench and bank with dirt, tamp down and hydro-seed.
• Plant blackberry above top of bank protection and willows on channel benches, as appropriate.

The following precautions should be taken:

• All large rocks used in the riffles should be individually placed and secured in desired position by machine tamping
• Bank line rocks should be placed on native subgrade material and against excavated banks. Smaller rocks and fines should be vibrated into voids between rock and jetted with water if necessary. Constructed bank line faces should be left with a roughened appearance; i.e smooth shaping the edges is not required.
• Rocks structure surface should be left uncovered along the creek bed; however, those along the low flow bank and bench should be exposed no more than 30% above finished grade upstream or downstream.
10 CONCLUSION

The proposed riffle-pool alternative that restores the channel grade downstream of the UPRR slab using a sequence of riffles and pools is feasible and is estimated to extend over 1,500 feet downstream of the UPRR slab in order to be effective and stable.

A stable riffle pool sequence of 10 riffles and pools can be constructed along this portion of Uvas Creek bed to improve the fish passage. The improvements to the bed also should be connected to a stable bank. Therefore, limited bank stabilization along two creek bends (around 300 and 1300 feet downstream of UPRR) is recommended along with the bed stabilization. The proposed channel configuration should help minimize the risk that a constructed riffle from being undermined by the restored channel flows.

The proposed project should improve passage conditions for migrating steelhead and other aquatic organisms. The proposed system of channel fill with riffles and pools meets the fish passage flow rate and depth performance criteria.
APPENDIX A

DESIGN PLANS FOR UVAS-CANADERO CREEK FISH PASSAGE IMPROVEMENTS
Replace Bolsa Fish Ladder with Rehabilitated Channel

Riffle Pool Layout
Bank Protection Where Required
PROJECT LOCATION
Bolsa Fish Ladder (Uvas)
Location of Project

Hwy 101 in Gilroy

UPRR

Existing Denil Fish Ladder

Christopher Ranch Farm

Bloomfield Road
Approximate Locations of Tops of Riffles to Replace 7 foot Drop at Denil Fish Ladder

Eliminate Current Drop of 7 feet At Denil Fish Ladder

Image of Typical Rock Riffle And Pool

Lay back bank bank

Approximately 1 foot drop from top of riffle to next top of riffle

Bank Protection

Approximately 1 foot drop from top of riffle to next top of riffle
Approximate Locations of Tops of Riffles

- Boulder Weir (end of Project)
- Lay back bank
- Bank Protection

Locations:
- R5
- R6
- R7
- R8
- R9
- R10
Plan View at **Bend** (Typical)

Extend Rock between Tops of Riffle up to 2 feet above bench. Cover with 4 to 6 inches of soil and plant.

**Right Bank**

**Right Bench (3 to 4’)**

Low flow channel Right Bank

Low flow channel left bank

Low flow channel bed

Shape pool bed with 1 ton & 0.5 ton boulders. Cover with 12 inch layer of Stream Bed Gravel.

C/L Thalwag

No bench

Left bank on Farm Side – Add Bank Protection to 2 BF Height on downstream half of Bend
### Plan View (Typical)

#### Placement of Rock

<table>
<thead>
<tr>
<th>Number of Rows of Rock</th>
<th>Direction relative to Flow</th>
<th>Perpendicular</th>
<th>Parallel</th>
<th>Both</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Exposed</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Exposed</td>
<td>4</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Buried</td>
<td>3</td>
<td>3</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>Buried</td>
<td>3</td>
<td>2.5</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Buried</td>
<td>3</td>
<td>2.5</td>
<td>2</td>
</tr>
</tbody>
</table>

#### Rock Exposed / Buried?

<table>
<thead>
<tr>
<th>Rock Exposed / Buried?</th>
<th>ft</th>
<th>ft</th>
<th>ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposed</td>
<td>5</td>
<td>4</td>
<td>3.5</td>
</tr>
<tr>
<td>Exposed</td>
<td>4</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Buried</td>
<td>3</td>
<td>3</td>
<td>3.5</td>
</tr>
<tr>
<td>Buried</td>
<td>3</td>
<td>3</td>
<td>2.5</td>
</tr>
<tr>
<td>Buried</td>
<td>3.5</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

**Low flow channel left bank**

- Shape pool bed with 1 ton & 0.5 ton boulders.
- Cover with 12 inch layer of Stream Bed Gravel C/L.
- Thalwag.
Extend Rock between
Riffle Anchor | Riffle between Anchors | Bank | Bench Anchor | Bench, Bank of Pool | Edge | Pool Center
--- | --- | --- | --- | --- | --- | ---

<table>
<thead>
<tr>
<th>Placement of Rock</th>
<th>Number of Rows of Rock</th>
<th>Direction relative to Flow</th>
<th>Exposed ft</th>
<th>Exposed ft</th>
<th>Buried ft</th>
<th>Buried ft</th>
<th>Buried ft</th>
<th>Buried ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anchors</td>
<td>Riffle</td>
<td>Perpendicular</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Parallel</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Both</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

Top of Riffle to Top of Riffle
Plan View at Bend (Typical)

Low flow channel bed
Shape pool bed with 1 ton & 0.5 ton boulders
Cover with 12 inch layer of Stream Bed Gravel

C/L Thalwag

Left bank on Farm Side – Add Bank Protection to 2 BF Height on downstream half of Bend

No bench
ELEVATION VIEW OF RIFFLES TO BE CONSTRUCTED ALONG THE THALWAG OF THE CHANNEL
Riffle 1  
El 160  
Shown here at Station 24+92

Riffle 2  
El 159  
Shown here at Station 23+90

Pool 1  
El 156  
Preferred Location Station 23+60  
Most D/S Station 23+60

Stream Bed Gravel as Cover and in Interstitial Space

Current Thalwag Level (~153)

Approximate volume of fill in pool = (60)(4)(33) / 27 = 300 cy

Adjust the spacing between Riffles to preserve mature trees on the

Flat section of pool can be 15 to 55 feet in length for riffle to riffle spacing of 85 to 125 feet

1.5, 1 and 0.5 ton rock shaping underlying layer of pool Covered with 1 to 2’ existing stream bed gravel

1:25 for 25 feet  
1:10 for 30 feet  
1:5 for 15 feet

1 ton or A axis is 3’, B axis is 3’, C axis is 2.5’

1.5 ton or A axis is 4’, B axis is 3’, C axis is 3’

3 ton, or A axis is 5’, B axis is 4’, C axis is 3.5’

0.5 ton or A axis is 2.5’, B axis is 2.5’, C axis is 2’

1.5 ton or A axis is 4’, B axis is 3’, C axis is 3’

0.5 ton or A axis is 2.5’, B axis is 2.5’, C axis is 2’

0.5 ton or A axis is 2.5’, B axis is 2.5’, C axis is 2’
Riffle 2
El 159
Preferred location Station 23+75
Most D/S Station 23+60

Riffle 3
El 158
Preferred Location Station 22+90
Locate Before start of bend

Pool 2
El 155
Approximate volume of fill in pool = (60)(3)(33) / 27 = 220 cy

Use 1 ton rock to fill
Hole in bed where necessary

Current Thalwag Level (~153)
1.5 ton or A axis is 5’, B axis is 4’, C axis is 3.5’

1.5 ton or A axis is 4’, B axis is 3’, C axis is 3’

1 ton or A axis is 3’, B axis is 3’, C axis is 2.5’

0.5 ton or A axis is 2.5’, B axis is 2.5’, C axis is 2’

Stream Bed Gravel Cover and in Interstitial Space

Stream Bed Gravel Cover and in Interstitial Space

Use 1 ton rock to fill Hole in bed where necessary

Adjust the spacing between Riffles to preserve mature trees on th...
Approximate volume of fill in pool = \( \frac{(60)(3)(33)}{27} = 220 \text{ cy} \)

Excavate and place aside 12 inches of stream bed gravel
Install boulders to lock in bowl
Cover with the stream bed gravel

Adjust the spacing between Riffles to preserve mature trees on

Stream Bed Gravel Cover and in Interstitial Space

1.5, 1 and 0.5 ton rock shaping underlying layer of pool
Covered with 1 to 2' existing stream bed gravel

Current Thalwag Level (~152)
Riffle 5
El 156
Preferred Location Station 16+60

Shown here Station 16+60

1.5 ton or A axis is 4’, B axis is 3’, C axis is 3’

1 ton or A axis is 3’, B axis is 3’, C axis is 2.5’

0.5 ton or A axis is 2.5’, B axis is 2.5’, C axis is 2’

Riffle 6
El 155
Shown here Station 15+
Preferred Location Station 16+60

Pool 5
El 152

1.5, 1 and 0.5 ton rock shaping underlying layer of pool
Covered with 1 to 2’ existing stream bed gravel

Stream Bed Gravel Cover
and in Interstitial Space

Current Thalwag Level (~151)

Approximate volume of fill in pool = (60)(3)(33) / 27 = 220 cy
Excavate and place aside 18 inches of stream bed gravel
Install boulders in pool to lock in bowl
Cover with the stream bed gravel
Riffle 6
El 155
Shown here Station 15+60

Riffle 7
El 154
Shown here Station 14+60

Pool 6
El 151

Stream Bed Gravel Cover and in Interstitial Space

1.5, 1 and 0.5 ton rock shaping underlying layer of pool
Covered with 1 to 2’ existing stream bed gravel

Current Thalwag Level (~152)

Excavate and place aside 24 inches of stream bed gravel
Install boulders in pool to lock in bowl
Cover with the stream bed gravel

Adjust spacing along X Axis as necessary to accommodate
3 ton, or A axis is 5', B axis is 4', C axis is 3.5'
1.5 ton or A axis is 4', B axis is 3', C axis is 3'
1 ton or A axis is 3', B axis is 3', C axis is 2.5'
0.5 ton or A axis is 2.5', B axis is 2.5', C axis is 2'

Shown here Station 12+20 moving downstream to 12+00, downstream of bend

Riffle 9
El 152
Shown here Station 11+

Current Thalwag Level (~151)

Excavate and place aside 24 inches of stream bed gravel
Install boulders to lock in bowl
Cover with the stream bed gravel

Pool 8 after Bend Pool 7

2 ton rock shaping underlying layer of pool
Covered with existing stream bed gravel
Excavated to install rock
Mini Riffle 10
El 151
Shown here at Station 9+00

Buried Boulder
El 150
Shown here at Station 8+00

Stream Bed Gravel Cover and in Interstitial Space

3 ton, or A axis is 5', B axis is 4', C axis is 3.5'
1.5 ton or A axis is 4', B axis is 3', C axis is 3'
1 ton or A axis is 3', B axis is 3', C axis is 2.5'
0.5 ton or A axis is 2.5', B axis is 2.5', C axis is 2'

The purpose of the buried weir is to prevent a future headcut, should one form, from migrating upstream.

Pool 10 after bend pool 9
No scour protection layer in Pool 10

Current Thalwag Level (~150)
Riffle 1
El 160
Shown here at Station 24+92
3 ton, or A axis is 5', B axis is 4', C axis is 3.5'
1.5 ton or A axis is 4', B axis is 3', C axis is 3'
1 ton or A axis is 3', B axis is 3', C axis is 2.5'
0.5 ton or A axis is 2.5', B axis is 2.5', C axis is 2'

Pool 1
El 156
1.5, 1 and 0.5 ton rock shaping underlying layer of pool
Covered with 1 to 2' existing stream bed gravel

Riffle 2
El 159
Shown here at Station 23+90
Preferred Location Station 23+75
Most D/S Station 23+60
Stream Bed Gravel as Cover and in Interstitial Space
1:5 for 15 feet

UPRR Slab
160
148

Current Thalwag Level (~153)

Flat section of pool can be 15 to 55 feet in length for riffle to riffle spacing of 85 to 125 feet
Adjust the spacing between Riffles to preserve mature trees on the bank

Bottom elevation of slab is approximate

Approximate volume of fill in pool = (60)(4)(33) / 27 = 300 cy

Typical Distance along Thalwag
Riffle 2
El 159
Shown here Station 23+90
Preferred location Station 23+75
Most D/S Station 23+60

- 3 ton, or A axis is 5', B axis is 4', C axis is 3.5'
- 1.5 ton or A axis is 4', B axis is 3', C axis is 3'
- 1 ton or A axis is 3', B axis is 3', C axis is 2.5'
- 0.5 ton or A axis is 2.5', B axis is 2.5', C axis is 2'

Riffle 3
El 158
Shown here Station 22+90
Preferred Location Station 22+60
Locate Before start of bend

Pool 2
El 155

- 1.5, 1 and 0.5 ton rock shaping underlying layer of pool
- Covered with 1 to 2' existing stream bed gravel

Stream Bed Gravel Cover and in Interstitial Space

Current Thalweg Level (~155)

Use 1 ton rock to fill Hole in bed where necessary

- Adjust the spacing between Riffles to preserve mature trees on the bank

Approximate volume of fill in pool = (60)(3)(33) / 27 = 220 cy
3 ton, or A axis is 5', B axis is 4', C axis is 3.5'
1.5 ton or A axis is 4', B axis is 3', C axis is 3'
1 ton or A axis is 3', B axis is 3', C axis is 2.5'
0.5 ton or A axis is 2.5', B axis is 2.5', C axis is 2'

Riffle 4
El 157

Riffle 5
El 156

Pool 4 after Bend Pool 3
El 154

Shown here Station 17+60

Stream Bed Gravel Cover and in Interstitial Space

1.5, 1 and 0.5 ton rock shaping underlying layer of pool
Covered with 1 to 2' existing stream bed gravel

Stream Bed Gravel Cover and in Interstitial Space

Current Thalweg Level (~152)

Adjust the spacing between Riffles to preserve mature trees on the bank

Approximate volume of fill in pool = (60)(3)(33) / 27 = 220 cy
Excavate and place aside 12 inches of stream bed gravel
Install boulders to lock in bowl
Cover with the stream bed gravel
Riffle 6
El 155
Shown here Station 15+60

- 3 ton, or A axis is 5’, B axis is 4’, C axis is 3.5’
- 1.5 ton or A axis is 4’, B axis is 3’, C axis is 3’
- 1 ton or A axis is 3’, B axis is 3’, C axis is 2.5’
- 0.5 ton or A axis is 2.5’, B axis is 2.5’, C axis is 2’

Pool 6
El 151

- Stream Bed Gravel Cover and in Interstitial Space
- 1.5, 1 and 0.5 ton rock shaping underlying layer of pool Covered with 1 to 2’ existing stream bed gravel

Riffle 7
El 154
Shown here Station 14+60

- Stream Bed Gravel Cover and in Interstitial Space

Current Thalweg Level (~152)

- Excavate and place aside 24 inches of stream bed gravel
- Install boulders in pool to lock in bowl
- Cover with the stream bed gravel

Adjust spacing along X Axis as necessary to accommodate trees
3 ton, or A axis is 5’, B axis is 4’, C axis is 3.5’
1.5 ton or A axis is 4’, B axis is 3’, C axis is 3’
1 ton or A axis is 3’, B axis is 3’, C axis is 2.5’
0.5 ton or A axis is 2.5’, B axis is 2.5’, C axis is 2’

Shown here Station 12+20
Recommend moving downstream to 12+00, downstream of bend

172
Stream Bed Gravel Cover
and in Interstitial Space

160

148

Current Thalweg Level (~151)

Excavate and place aside 24 inches of stream bed gravel
Install boulders to lock in bowl
Cover with the stream bed gravel

Pool 8 after Bend Pool 7
2 ton rock shaping underlying layer of pool
Covered with existing stream bed gravel
Excavated to install rock

Stream Bed Gravel Cover
and in Interstitial Space
CROSS-SECTION
Riffle 1 Cross-Section at the Top of Riffle
Approximate Station 24+92

3 ton, or A axis is 5’, B axis is 4’, C axis is 3.5’
1.5 ton or A axis is 4’, B axis is 3’, C axis is 3’
1 ton or A axis is 3’, B axis is 3’, C axis is 2.5’
0.5 ton or A axis is 2.5’, B axis is 2.5’, C axis is 2’

Low flow channel at Riffle 1 which is in a wide X-Section downstream of the slab
Top width at El 164 corresponding to bench: 38-48’
Bottom width at El 160: 27-30’

Stability Analysis:
Minimum Width at Bankfull El of 164 = 36’
Width at 2 Bankfull El of 168 = 84+’
This exceeds 72 feet width at 2 x Bankfull height, recommended for stability of banks

Current X-Section

Opening for Salmonids
Is 4-6’ width at Thalwag and 9-12” below rest of bed

Thalwag moved slightly to left (looking u/s)

Low Flow Bank Slope 1.5H:1V
Can be between 2H:1V and 1H:1V

Length of blue line represents width required for stability
2 x Bankfull Height
Pool 1 Cross-Section at Deepest Point
Approximate Station Shown Here is 24+20

3 ton, or A axis is 5’, B axis is 4’, C axis is 3.5’
1.5 ton or A axis is 4’, B axis is 3’, C axis is 3’
1 ton or A axis is 3’, B axis is 3’, C axis is 2.5’
0.5 ton or A axis is 2.5’, B axis is 2.5’, C axis is 2’

Low Flow Bank Slope 2H:1V

A root wad can be partially buried in the channel bed near the downstream end of pool

Contractor to shape the bottom surface in Pools 1 to 3 with 1 ton rock
The lowest 2 ton rock at the toe of the bank should be mostly buried

Water Surface EL 159
Bench 6-8’ wide
Bench 4’ above WSEL (163)

Stability Analysis
Minimum Width at 163 = 36’
Width at 167 = 84’
This exceeds 72 feet for stability

Low flow channel (pool)
Top width at 163 El: 44-48’, Bottom width at 156 El: 32-36’

Centered

Rock d/s of top of riffle to 2 feet above bench
Do not remove Trees on bank, rock around them with 1 ton rock
May use 1 ton above bench
Pool 1
Plan View
at Bottom of Pool

Right bank

Right bench
(width varies 3 to 8', see riffle to riffle plan view)

Low flow channel right bank

C/L
Thalwag

Low flow channel bed

Left bench
(width varies, see riffle to riffle plan view)

Left bank

Christopher Ranch Side

Extend Rock between Top of Riffle to 2 feet above bench

Except where bank protection is to be constructed
Riffle 2 Cross-Section at the Top of Riffle
Approximate Station here is 23+90
Preferred Location for construction is 23+75

3 ton, or A axis is 5’, B axis is 4’, C axis is 3.5’
1.5 ton or A axis is 4’, B axis is 3’, C axis is 3’
1 ton or A axis is 3’, B axis is 3’, C axis is 2.5’
0.5 ton or A axis is 2.5’, B axis is 2.5’, C axis is 2’

Current X-Section
Length of blue line represents width required for stability
2 x Bankfull Height

Low flow channel
Top width at El 163: 36-42’,
Bottom width at El 159: 27-30’

Stability Analysis
Minimum Width at 163 = 36’
This exceeds 72 feet for stability
Riffle 2
Plan View
at Top of Riffle

Offset 3 to 4 feet
Back from C/L

Right bank

C/L
Thalwag

Low flow channel right bank

Low flow channel left bank

Left bench

Left bank

Bolsa Road Side

Extend Rock at
Top of Riffle
To 7000 cfs
Water Line

Extend Rock at
Top of Riffle
To 7000 cfs
Water Line

Farm Side
Riffle 3 Cross-Section at the Top of Riffle

Approximate Station 22+60

- 3 ton, or A axis is 5', B axis is 4', C axis is 3.5'
- 1.5 ton or A axis is 4', B axis is 3', C axis is 3'
- 1 ton or A axis is 3', B axis is 3', C axis is 2.5'
- 0.5 ton or A axis is 2.5', B axis is 2.5', C axis is 2'

Merge rock on left bank with the bank protection on left bank at bend downstream. At bend, creek thalwag is moved right 5 feet from existing to give room for bank protection.

Water Surface EL 158

Bench 4' above WSEL (162)

Bench 8' wide

Rock at Top of Bank

Bench 6-8' wide

Opening for Salmonids
4-6' width at Thalwag is 9 - 12" below rest of bed

Low flow channel
Top width at El 162: 36-42', Bottom width at El 158: 27-30'

Stability Analysis
Minimum Width at 162 = 36'
Width at 168 = 78'
This exceeds 72 feet for stability

Thalwag 158 Moved 4' towards Right

Bench 4' above WSEL (162)

Bank Protection with 1 ton rock at 2 foot above bench up to Top of Bank on Left Side Between Riffle 3 to Riffle 4

Feed rock on left bank with the bank protection on left bank at bend downstream.

Length of blue line represents width required for stability 2 x Bankfull Height
Offset 5 feet Back from C/L Of left bank

Offset 3 feet From left bank

Riffle 3 Plan View at Top of Riffle

Bolsa Road Side

C/L

Extend Rock at Top of Riffle To 7000 cfs Water Line

Thalwag 4’ from C/L

Low flow channel right bank

Low flow channel left bank

Right bench

Left bank

C. Ranch Side
Cross Section at Bend with Bend Pool 3 (Steeper outer bank)
Selected Location Shown is at Station 20+00

- Thalwag moved right 4' from Existing El 154'
- Current Toe
- Design Toe
- Water Surface EL 157
- Rock to TOB
- Rock to 167' EL
- Outside Of Bend
- Stability Analysis
  - Width at 162 = 36'
  - Width at 167 = 72'
  - Width provided = 70 feet

Bank Protection with 1 ton rock at 2 foot above bench up to Top of Bank on Left Side Between Riffle 3 to Riffle 4

Low flow channel (pool)
- Top width at 160 EL: 44-48'
- Bottom width at 155 EL: 32-36'

Slope 1V:1.5H
Slope 1V:2H or Conform
Slope 1V:20H
Riffle 4
Approximate Station 17+60

- 3 ton, or A axis is 5’, B axis is 4’, C axis is 3.5’
- 1.5 ton or A axis is 4’, B axis is 3’, C axis is 3’
- 1 ton or A axis is 3’, B axis is 3’, C axis is 2.5’
- 0.5 ton or A axis is 2.5’, B axis is 2.5’, C axis is 2’

Blue line represents width required for stability

Low Flow Bank Slope 1.5H:1V
Can be between 2H:1V and 1H:1V

Bank Protection with 1 ton rock at 2 foot above bench up to Top of Bank on Left Side Between Riffle 3 to Riffle 4

Stability Analysis
Width at 162 = 36’
Width at 167 = 80’
This exceeds 72 feet
Pool 4
Approximate Station 1700

Rock layout typical of Pools 5, 6, 8

Low flow channel (pool)
Top width at 160 El: 44-48',
Bottom width at 155 El: 32-36'

Stability Analysis
Width at 161 = 36'
Width at 166 = 72'

Conform to bank
Rock to 4 feet above elevation of bench at downstream riffle

Thalwag of Pool
153
Closer to Center

Bankfull 5' above WSEL (161')

Water Surface EL 156

Slope 1H:1V
For low flow bank
Pool 4
Plan View
at Bottom of Pool

Right bank

Right bench
(width varies, 0 to 2 feet at pools)

Low flow channel right bank

C/L Thalwag

Low flow channel bed

Low flow channel left bank

Left bench (width varies, 0 to 2 feet at pools)

Left bank

Extend Rock between Top of Riffle to 4 feet above bench elevation at next riffle downstream
Channel Construction
With Highly Constrained Width from Pool 4 to Riffle 10

• Low flow channel bottom – 20’ +/-
• Bankfull height – 4 to 5 feet, bankfull slope 1:1 (shaped with 1.5 ton boulders)
• Low flow channel – 28 – 30’
• Bench – 4’ each side at riffle, goes down to 2 feet on each side in pool
• Bankfull channel width = 20 + 4 + 4 = 28 feet minimum, 30 feet typical
• Bank slope above bench: 1.5H:1V (or conform to existing slope and shape on non eroding bank)
• Bank height above bench – 17.5’ (total bank height is 22.5’)
• Span of high flow bank = 17.5 x 1.5 = 25’
• Top of bank width = 25+ 4 + 5 + 20 + 5 + 4 + 25 = 92’
  – Bankfull width = 30’
  – Bankfull height = 4 feet (max 5 feet)
  – Bankfull bench = 4 feet
  – Low flow channel X-Sectional area = 25 x 5 = 125’
  – Bankfull flow = 625 to 750 cfs (slightly lower than 2 year flow without reservoir)
  – 2 Bankfull height, 10 feet above bed = 30+ 4 + 4 + 7.5 + 7.5 = 53 feet (ideally 60 feet for stability)
• Rock with 2.5-3’ dia rock (~1.0 ton) rock to 2 feet above bench where necessary from Pool 4 to Riffle 10
  – Rock to near top of bank at tops of riffles
  – Rock to near top of bank on outside of bends
  – In between riffles, rock to 2 feet above the elevation of bench at downstream riffle
• Reduce bottom width to 18 feet, reduce bench width to 3 feet if TOB width < 92 feet
Pool Construction (New)
From Riffle 5 to Riffle 10

- Excavate 2 feet of stream bed gravel and set it aside
- Add layer of 0.5 to 1 ton rock on bed of pool as lining below stream bed gravel
  - Rock is approximately 2.5 feet on B axis
  - Shape it to form bowl of pool
- Cover rock with stream bed gravel
- *This avoids developing a large scour in the pool.*
  *Without this, the water in the creek can behave like a firehose because the low flow channel is smaller than current observations* *(we are filling in part of the low flow channel to accommodate bank protection)*
Bend Construction for Bend Pool 9

- **Outside of bend: 1.5H:1V**
  - Rock to near top of bank (or 20 feet above bed)
  - Typical height of outside of bend is 25 Feet
  - Because of severity of erosion, layer the construction
    - 2 ton boulders and soil where it is very deep
    - Then add a layer of 3 ton boulders and soil

- **Span of outside of bend = 37.5’ (25 x 1.5)**

- **Low flow channel bottom = 20’**
  - Slope across width of 20’ is 10H:1V (so bottom goes up 2 feet from one side to the other)
  - Line the bottom of channel with 2 ton boulders (prevent scouring)

- **Inside of bend - Slope of bank to bankfull height of 5 feet above bed at 2H:1V**
  - 3 feet to bankfull height
  - **Span = 6’**

- **Height of high flow bank above bankfull = 25 – 2 – 3 = 20’**

- **Inside of bend: 2H: 1V or conform to existing bank if it is not eroding inside of bend.**
  - Rock inside of bend to 10 feet above thalwag

- **Span of inside of bend = 20 x 2 = 40’**

- **TOB width = 37.5+ 20 + 6 + 40 = 103.5’**
  - Available width = 98 feet (starting at current edge of erosion, which is not where the creek was before)
  - Alternative 1
    - Open inside of bend at slope of 1.5H:1V for a height of 10 feet
    - Rock it to 10 feet
  - Alternative 2
    - Ask C. Ranch for 5 feet width at top
  - Alternative 3
    - Have C. Ranch fix the top 10 feet on their side as vertical wall – this can give them back 3 to 5 feet
  - Alternative 4
    - Set back bank on inside of bend 15 feet at the extreme points and keep slope at 2H:1V
Riffle 5
Approximate Station 1660
(Constrained width)

Conform to existing bank

2H:1V from 161 to 166 EL

Conform to existing slope or 1.5H:1V

Thalwag 156
Closer to Center

Blue line represents width required for stability
2 x Bankfull Height

2H:1V from 161 to 166 EL

Water Surface EL 156

Bench 4’ wide

Bench 5’ above WSEL (161)

Opening for Salmonids is 4-6’ width at Thalwag
is 9-12’ below rest of bed

Low flow channel
Top width at El 161: 30’, Bottom width at El 156: 20’

Stability Analysis
Width at 161 = 36’
Width at 166 = 72’
Need 72’ for stability
Width as constructed = 56’
Continuous bank protection recommended up to Top of Bank along both banks, extending from Riffle 5 at Stn 1660 to Bend Pool 7 at Stn 1300. Use 1 ton rock extending from 2 foot above bench to Top of Bank in between tops of riffles.

Water Surface EL 155

Bench 5’ above WSEL (160)

Bench 4’ wide

Bench 4’ wide

May grout Rock at 1:1 Slope Above 165 EL

Slope of 1.5H:1V

160 to 165 EL or existing bank

Bench 4’ wide

Slope of 2H:1V

160 to 165 EL

Blue line represents width required for stability 2 x Bankfull Height

Conform to Existing Slope For High Flow

Conform to Existing Slope for High Flow Or 1.5H:1V

Stability Analysis

Width at 160 = 36’

Width at 165 = 72’ (if we open 12’)

Width as constructed = 56’

Very entrenched

Opening for Salmonids

4-6’ width at Thalwag is 9-12” below rest of bed

Low flow channel

Top width El 160: 30’, Bottom width El 155: 20’

Can this side be opened up?

Continuous bank protection recommended up to Top of Bank along both banks, extending from Riffle 5 at Stn 1660 to Bend Pool 7 at Stn 1300. Use 1 ton rock extending from 2 foot above bench to Top of Bank in between tops of riffles.
Riffle 7
Approximate Station 1460

Rock to Top of Bank. May grout Rock at 1:1 Slope Above 164 EL

Bench 4' wide

Bench 5' above WSEL (159)

Water Surface EL 154

Thalwag EL 154
Moved 4' to left of center

Blue line represents width required for stability 2 x Bankfull Height

Slope of 1.5H:1V 159 to 164 EL

Slope conform to Existing above 164 EL if it is eroding

Conform to Existing Slope or 1.5H:1V Above 164 EL if it is eroding

Opening for Salmonids
4-6' width at Thalwag is 9-12'' below rest of bed

Low flow channel
Top width EL 159: 30', Bottom width EL 155: 20'

Stability Analysis
Width at 159 = 36'
Width at 164 = 72'
Width at 164 provided = 56'
Riffle 7 Plan View at Top of Riffle

- Offset 5 feet Back from C/L Of left bank
- Offset 3 feet Upstream in reference to Right Bank

- Extend Rock at Top of Riffle To 7000 cfs Water Line
- Extend Rock at Top of Riffle To 7000 cfs Water Line

Bolsa Road Side
Bend Pool 7
Approximate Station 13+00

Cross-Section is approximated from Sta 12+80
Current thalwag at bend pool has Elevation of 150 or 151; it is left at that Elevation
Bend needs some protection on outside of bend.
Inside of bend left untouched above 163’

Rock to TOB
Conform To Existing Slope
1.5H:1V, 2 ton rock to 163’

Low flow channel
Bank Slope 2H:1V

Low Flow channel
Bank Slope 2H:1V

Rock to 164’ EL
At 2H:1V

Water Surface EL 153

Thalwag moved left
EL 150’

Bankfull 5’ above WSEL (158)

Design
Current

Low flow Bank Slope 1.5H:1V

Slope of bed 10H:1V

Blue line represents width required for stability
2 x Bankfull Height

Low flow channel (pool)
Top width at 158 El: 44-48’, Bottom width 152 El 30-34’

Stability Analysis
Min Width at 158 = 36’ (40’ typical at bend)
Width at 163 = 72’

Width as constructed = 56’
Riffle 8
Approximate Station at 1220

Recommend moving this riffle farther downstream to 1200 or 1180
Shape will be in between X-Section at 1220 and 1150
Need to locate it downstream of end of bend

Water Surface EL 153
Bench 5' above WSEL (158)
Bench 4' wide

Thalwag 153

Blue line represents width required for stability
2 x Bankfull Height

Low flow channel
Top width at El 158: 30’
Bottom width at El 154: 20’

Stability Analysis
Width at 158 = 36’
Width at 163 = 72’
Width provided at 163 = 66’

Slope of 1.5H:1V
158 to 163 EL

Conform to Existing Slope above 163 EL or repair to 1.5H:1V

Rock to Top of Bank. Conform to Existing Slope or 1.5H:1V max

Bolsa Road
C.Ranch Side
Riffle 9

Approximate Station Shown is 1120

Thalwag El 152 Moved 4 feet to Right of center

172 160 148

Bankfull at WSEL (157)

Bench 4’ wide

Water Surface EL 152

C.Ranch Side

Bolsa Road

Right Bank

Rock to Top of Bank

172

160

148

Conform to Existing Slope 157 to 162 EL

Bench 4’ wide

Bankfull at WSEL (157)

Water Surface EL 152

Blue line represents width required for stability 2 x Bankfull Height

2 x Bankfull Height

Rock to Top of Bank

157 to 162 EL

Bench 4’ wide

Opening for Salmonids 4-6’ width at Thalwag is 9-12” below rest of bed

Blue line represents width required for stability 2 x Bankfull Height

Low flow channel

Top width El 157: 36

Bottom width at El 153: 24’

Stability Analysis

Width at 157 = 36’

Width required at 162 = 72’

Width provided = 66’

Continuous Bank

Protection on Left Bank from Riffle 9 to Riffle 10

42 48 72 960

24 48 72 96
Riffle 9
Plan View at Top of Riffle

Offset 3 feet From left bank

Offset 5 feet Back from C/L Of left bank

Thalwag 4' from C/L

C/L Low flow channel bed

Left bench

Extend Rock at Top of Riffle To 7000 cfs Water Line

Extend Rock at Top of Riffle To 7000 cfs Water Line

Bolsa Road Side

Right bank

Right bench

Low flow channel right bank

Low flow channel left bank

Left bench

Left bank
Cross Section at Bend with Bend Pool 9 (Steeper outer bank)  
Station 1050  
No Cut option

Determine where TOB on left bank should be  
Use 1.5H:1V slope for bank protection  
This may require moving current toe to the right (looking upstream)  
Stable channel width may require laying back right bank on inside of bend

Low flow channel (pool)  
Top width at 156 El: 36’ (instead of 44’)  
Bottom width 151 El 20’ (instead of 30’)

Stability Analysis  
Width at 156’ = 36’  
Width at 161’ = 72’  
Need 72 for stability  
Providing 54’ instead of 72’

Blue line represents width required for stability  
2 x Bankfull Height

Thalwag El 148’
Current Design (2 feet right)
Cross Section at Bend with Bend Pool 9
Station 1000

Determine where TOB on left should be
Use 2:1 slope for bank protection along outside of bend
This may require moving current toe to the right (looking upstream)
Stable channel width requires laying back toe of other bank along inside of bend 12 to 15 feet

Left bank rock continuously from Riffle 9 to Riffle 10

Low flow channel (pool)
Top width at 156 El: 36', Bottom width 150 El 20'

Stability Analysis
Width at 156' = 36' (40' typical at bend)
Width at 161' = 72'
Providing 64'

Fill
Thalwag moved right 7' from Existing El 148'
Bankfull at WSEL (156)
Bench if any 8' above Thalwag At 162

Slope 2H:1V
Low Flow Bank
Bench if any 8' above Thalwag At 162

Slope 1V:10H on Bed

Blue line represents width required for stability 2 x Bankfull Height at 161'

Current Toe
Design Toe

Lay Top of Bank
If required
Riffle 10 or Buried Boulders
Approximate Station 9+00

Determine existing X-Section
The purple line shown here is at 10+00

Blue line represents width required for stability
2 x Bankfull Height at 161’

Thalwag
151
Need current ground elevation

Water Surface EL 151

Opening for Salmonids
4-6’ width at Thalwag is 9-12” below rest of bed

Low flow channel
Top width EL 156: 36’, Bottom width at EL 151: 26’

Stability Analysis
Width at 156’ = 36’
Width at 161’ = target 72’
Width provided = 70’

May need to open up Right Bank a few feet
BURIED BOULDERS in BED  8+00

Superimpose on surveyed X-Section

Elevation of Bed is approximated

Rock up along bank to 5’ above WSEL (157)

Water Surface EL 152

Match existing grade all across
APPENDIX B
STEADY STATE HEC-RAS RESULTS
PURPOSE

The Uvas-Carnadero Fish Passage Project will improve fish passage downstream of the UPRR railroad bridge. Historically, the channel degraded downstream of the concrete slab under the bridge, so that the concrete slab is now perched about 6 feet above the channel bed elevation. Based on a conceptual alternatives analysis completed in April 2018\(^1\), a riffle-pool design, which creates a series of 10 riffles and pools downstream of the bridge gradually rising to the elevation of the slab, was selected as the preferred alternative. The project team has developed a refined alternative based on the recommendations of that study and other considerations such as site conditions and geomorphic design. This memo summarizes the results of a hydraulic analysis of the refined design to: 1) determine the impacts of raising the channel bed downstream of UPRR, especially at large flows, 2) define the work required to mitigate the impacts, 3) evaluate the fish passage design, and 4) calculate the rock size required for construction of the riffles.

DEVELOPMENT OF HEC-RAS MODELS

The most up to date existing condition one-dimensional steady state Hec-Ras model for Uvas-Carnadero Creek\(^2\) was further updated with 2018 survey data collected by the Santa Clara Valley Water District (SCVWD). The SCVWD’s 2018 survey covered the reach extending about 1800 feet downstream and 550 feet upstream of UPRR. Once the existing model was updated and checked, it was used as the basis for the design model. The design model incorporates the riffle- pool sequence proposed for the project, which extends about 1800 feet downstream of the UPRR bridge. Cross sections for both the existing and design scenarios were provided by the project team.

Manning’s N values were based on suggested ranges for Excavated or Dredged Channels (Chow, 1959) as well as from input from the project team. In the design reach, Mannings N values were set to 0.04 in the bankfull channel and 0.045 in the channel overbanks. In other reaches, Mannings roughnesses were based on the existing conditions, and were varied horizontally within each section to reflect vegetated benches, dirt bottom, etc.
Minor updates were made to the model in May 2019 to improve representation of the slab under the railroad and to add one riffle/pool just downstream of the railroad bridge. In addition, the model cross section geometry was cut off at the most downstream Riffle, and the boundary condition at the riffle crest was set to critical depth there to achieve the most conservative conditions for fish passage. In the previous version of this memo, the bed elevation downstream was elevated relative to the existing condition, as the surveyed cross sections reflected sediment deposited due to a bank failure. The elevated bed level downstream of the project caused the most downstream pools to appear drowned. Setting critical depth at the most downstream riffle will provide the most conservative estimate of how the riffle/pool sequence will function for fish passage.

HYDRAULIC ANALYSIS- METHODOLOGY AND RESULTS

Impacts of Proposed Design

The main concern associated with the proposed design is that the raised bed and reduced channel cross sectional area in the design reach will result in reduced channel capacity and more frequent overtopping especially in the project reach upstream of the UPRR.

To determine the channel capacity for both existing and design conditions, the Hec-Ras models were run for a range of flows to estimate the capacity for two key project reaches: 1) the “Downstream” or project reach where the channel geometry is being changed (~1800 feet extending downstream of UPRR), and 2) the “Middle” reach extending upstream of the UPRR bridge to just downstream of Hwy 101. The flow distributions used for this purpose assumed a constant flow rate along the channel’s length. This led to conservative estimates of channel capacity because the channel capacity downstream of the CA-25 bridge crossing drops.

Table 1 provides the capacities for the two project reaches (upstream and downstream of UPRR) as well as the UPRR bridge itself, for the existing and with project conditions. The table shows that: 1) The project reach upstream of UPRR has the smallest capacity, and so would limit flows to the downstream reaches, under both existing and post-project conditions, and 2) The capacity for the upstream project reach would drop from 7000 cfs to 6000 cfs after the project’s construction. Noting that 7000 cfs has a recurrence interval of about 10 years, the project will include a component to maintain the channel capacity of the project reach upstream of UPRR to prevent more frequent flooding in this area. Maintaining the capacity of the project reach upstream should not pose a new problem for downstream reaches. As shown in Table 1, the capacity of the UPRR bridge itself as well as the project reach downstream of UPRR are larger than 7000 cfs. Reaches further downstream would function as they do under existing conditions during a 7000 cfs flow event, since they are not being modified by the project.
Table 1. Channel Capacity Estimates

<table>
<thead>
<tr>
<th>Reach or Bridge</th>
<th>Existing Conditions</th>
<th>With Project Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity of Project Reach Upstream of UPRR</td>
<td>7,000 CFS Capacity, Minimum capacity at Project STA 31+50, modeled WSE 173.8 [NAVD88]</td>
<td>6,000 CFS Capacity, Minimum capacity at Project STA 31+50, modeled WSE 173.83 [NAVD88]</td>
</tr>
<tr>
<td>Capacity of Project Reach Downstream of UPRR</td>
<td>9,500 CFS Capacity, Minimum capacity at Project STA 25+58, modeled WSE 176.93 [NAVD88]</td>
<td>8,750 CFS Capacity, Minimum capacity at Project STA 25+58, modeled WSE 176.94 [NAVD88]</td>
</tr>
<tr>
<td>UPRR Bridge Capacity</td>
<td>9,500 CFS Capacity, Upstream soffit becomes submerged first</td>
<td>8,750 CFS Capacity, US soffit becomes submerged first</td>
</tr>
</tbody>
</table>

Previous versions of this memo stated that a ~200 ft long reach along the south bank of Uvas (upstream of UPRR) would require between 0.5 and 1.2 ft of raising to maintain existing flood capacity. The project team ordered new survey for the banks, and the revised determination is that the flows would stay contained within channel. The bank elevations have been updated to match the 2019 survey data, and demonstrate that flows would remain contained within the channel after the project is complete.
Table 2. Design Flow is Contained in Channel for Post-Project Conditions

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>3345</td>
<td>22098</td>
<td>180.04</td>
<td>176.15</td>
</tr>
<tr>
<td>3245</td>
<td>21998</td>
<td>177.3</td>
<td>175.99</td>
</tr>
<tr>
<td>3200</td>
<td>21953</td>
<td>177.3</td>
<td>175.04</td>
</tr>
<tr>
<td>3150</td>
<td>21903</td>
<td>176.75</td>
<td>175.16</td>
</tr>
<tr>
<td>3100</td>
<td>21853</td>
<td>177</td>
<td>175.14</td>
</tr>
<tr>
<td>3050</td>
<td>21803</td>
<td>178</td>
<td>174.91</td>
</tr>
<tr>
<td>3000</td>
<td>21753</td>
<td>178</td>
<td>175.24</td>
</tr>
<tr>
<td>2950</td>
<td>21703</td>
<td>176.3</td>
<td>175.11</td>
</tr>
<tr>
<td>2750</td>
<td>21503</td>
<td>176.3</td>
<td>174.94</td>
</tr>
<tr>
<td>2642</td>
<td>21395</td>
<td>177.49</td>
<td>175.1</td>
</tr>
<tr>
<td>2641.99</td>
<td>21394.99</td>
<td>177.49</td>
<td>175.06</td>
</tr>
<tr>
<td>2641</td>
<td>21394</td>
<td>177.49</td>
<td>175.06</td>
</tr>
<tr>
<td>2640.99</td>
<td>21393.99</td>
<td>177.49</td>
<td>175.08</td>
</tr>
<tr>
<td>2638</td>
<td>21391</td>
<td>177.49</td>
<td>175.08</td>
</tr>
<tr>
<td>UPRR Bridge</td>
<td></td>
<td></td>
<td>UPRR</td>
</tr>
</tbody>
</table>

Note: The minor updates to the design did not substantially change the high flow results; therefore, this table has not been updated with new values.

FISH PASSAGE CRITERIA ANALYSIS

Fish Passage criteria for Juvenile and Adult Salmonids are presented below in Tables 3 and 4. These criteria are based on a previous study of a proposed roughened channel design³.

The design attempts to provide the required minimum water depth for Juveniles with a 6 ft wide by 9 inch deep low flow notch. Maximum velocities and maximum water surface drop criteria are accomplished by using 10 rock riffles to distribute hydraulic forces.

Table 3. Fish Passage Criteria - Minimum Depths

<table>
<thead>
<tr>
<th>Species and Life Stage</th>
<th>Low Passage Design Flow</th>
<th>Minimum Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Juvenile Salmonids</td>
<td>10 cfs</td>
<td>0.5 ft</td>
</tr>
<tr>
<td>Adult Salmonids</td>
<td>10 cfs</td>
<td>1 ft</td>
</tr>
</tbody>
</table>

Table 4. Fish Passage Criteria – Maximum Velocities

<table>
<thead>
<tr>
<th>Species and Life Stage</th>
<th>High Passage Design Flow</th>
<th>Maximum Velocity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Juvenile Salmonids</td>
<td>64 cfs</td>
<td>1 ft/s</td>
</tr>
</tbody>
</table>
In addition to the depth and velocity criteria, there is a turbulence criteria. Turbulence is measured by the Energy Dissipation Factor, computed as follows:

$$EDF = \frac{(\text{Gamma} \times Q \times S)}{A},$$

where

- \(\text{Gamma} = 62.4 \text{ lb/ft}^3\)
- \(Q = \text{fish passage flow}\)
- \(S = \text{Slope of the culvert (in this case, since the design does not include a culvert, the energy grade slope was used)}\)
- \(A = \text{cross sectional area at fish passage flow}\)

According to the Basis of Design report, a good fish passage design channel should have EDF values which are less than 4 ft-lbs/ft3 for adult steelhead; no criteria were provided for juveniles.

**Depth Performance**

Table 5 provides the depths at each cross section within the riffles reach for 10 cfs. The depth criteria for both juvenile and adult salmonids are generally met; i.e., depths exceed 1 ft at 10 cfs. At the tops of riffles, the flow becomes critical (or near critical), and at these locations, the depth becomes as low as 0.44 feet, violating both criteria (but almost meeting the criteria for juvenile salmonids). Given that the locations where depth criteria are violated are isolated, and represent very short reaches (namely, at the crests of riffles), the design is judged to generally meet the depth criteria.

**Table 5. Depth Performance – Cross-Section Depths**

<table>
<thead>
<tr>
<th>Cross Section Description</th>
<th>Project Stationing</th>
<th>HEC-RAS River Station</th>
<th>Cross-Section Depth @ 10 CFS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[FEET]</td>
<td>[FEET]</td>
<td>[FEET]</td>
</tr>
<tr>
<td></td>
<td>25+74</td>
<td>21340</td>
<td>4.38</td>
</tr>
<tr>
<td></td>
<td>25+40</td>
<td>21293</td>
<td>4.38</td>
</tr>
<tr>
<td>R1 - Riffle 1</td>
<td>25+18</td>
<td>21311</td>
<td>0.85</td>
</tr>
<tr>
<td>R1 - Riffle 1</td>
<td>24+92</td>
<td>21245</td>
<td>0.44</td>
</tr>
<tr>
<td></td>
<td>24+40</td>
<td>21193</td>
<td>3.79</td>
</tr>
<tr>
<td></td>
<td>24+26</td>
<td>21179</td>
<td>3.79</td>
</tr>
<tr>
<td></td>
<td>23+90</td>
<td>21143</td>
<td>3.79</td>
</tr>
<tr>
<td>R2 - Riffle 2</td>
<td>23+75</td>
<td>21128</td>
<td>0.44</td>
</tr>
<tr>
<td></td>
<td>23+20</td>
<td>21073</td>
<td>3.69</td>
</tr>
<tr>
<td></td>
<td>22+91</td>
<td>21044</td>
<td>3.69</td>
</tr>
<tr>
<td></td>
<td>22+75</td>
<td>21028</td>
<td>3.69</td>
</tr>
</tbody>
</table>
Table 5. Depth Performance – Cross-Section Depths

<table>
<thead>
<tr>
<th>Cross Section Description</th>
<th>Project Stationing</th>
<th>HEC-RAS River Station</th>
<th>Cross-Section Depth @ 10 CFS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[FEET]</td>
<td>[FEET]</td>
<td>[FEET]</td>
</tr>
<tr>
<td>R3 - Riffle 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22+60</td>
<td>21013</td>
<td>0.44</td>
<td></td>
</tr>
<tr>
<td>21+65</td>
<td>20918</td>
<td>2.94</td>
<td></td>
</tr>
<tr>
<td>21+10</td>
<td>20863</td>
<td>2.44</td>
<td></td>
</tr>
<tr>
<td>20+55</td>
<td>20808</td>
<td>2.94</td>
<td></td>
</tr>
<tr>
<td>20+00</td>
<td>20753</td>
<td>2.44</td>
<td></td>
</tr>
<tr>
<td>19+45</td>
<td>20698</td>
<td>2.94</td>
<td></td>
</tr>
<tr>
<td>18+90</td>
<td>20643</td>
<td>2.54</td>
<td></td>
</tr>
<tr>
<td>18+35</td>
<td>20588</td>
<td>2.94</td>
<td></td>
</tr>
<tr>
<td>R4 - Riffle 4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17+60</td>
<td>20513</td>
<td>0.44</td>
<td></td>
</tr>
<tr>
<td>17+50</td>
<td>20503</td>
<td>1.28</td>
<td></td>
</tr>
<tr>
<td>17+40</td>
<td>20493</td>
<td>2.89</td>
<td></td>
</tr>
<tr>
<td>17+20</td>
<td>20473</td>
<td>2.99</td>
<td></td>
</tr>
<tr>
<td>17+00</td>
<td>20453</td>
<td>3.69</td>
<td></td>
</tr>
<tr>
<td>16+80</td>
<td>20433</td>
<td>3.69</td>
<td></td>
</tr>
<tr>
<td>R5 - Riffle 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16+60</td>
<td>20413</td>
<td>0.44</td>
<td></td>
</tr>
<tr>
<td>16+40</td>
<td>20393</td>
<td>3.07</td>
<td></td>
</tr>
<tr>
<td>16+20</td>
<td>20373</td>
<td>3.87</td>
<td></td>
</tr>
<tr>
<td>16+10</td>
<td>20363</td>
<td>3.47</td>
<td></td>
</tr>
<tr>
<td>16+00</td>
<td>20353</td>
<td>3.87</td>
<td></td>
</tr>
<tr>
<td>15+80</td>
<td>20333</td>
<td>3.87</td>
<td></td>
</tr>
<tr>
<td>R6 - Riffle 6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15+60</td>
<td>20313</td>
<td>0.61</td>
<td></td>
</tr>
<tr>
<td>15+40</td>
<td>20293</td>
<td>2.89</td>
<td></td>
</tr>
<tr>
<td>15+20</td>
<td>20273</td>
<td>3.69</td>
<td></td>
</tr>
<tr>
<td>15+10</td>
<td>20263</td>
<td>2.68</td>
<td></td>
</tr>
<tr>
<td>15+00</td>
<td>20253</td>
<td>3.69</td>
<td></td>
</tr>
<tr>
<td>14+80</td>
<td>20233</td>
<td>3.69</td>
<td></td>
</tr>
<tr>
<td>R7 - Riffle 7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14+60</td>
<td>20213</td>
<td>0.44</td>
<td></td>
</tr>
<tr>
<td>14+00</td>
<td>20153</td>
<td>2.94</td>
<td></td>
</tr>
<tr>
<td>13+40</td>
<td>20093</td>
<td>2.94</td>
<td></td>
</tr>
<tr>
<td>12+80</td>
<td>20033</td>
<td>2.94</td>
<td></td>
</tr>
<tr>
<td>R8 - Riffle 8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12+00</td>
<td>19953</td>
<td>0.44</td>
<td></td>
</tr>
<tr>
<td>11+50</td>
<td>19903</td>
<td>2.34</td>
<td></td>
</tr>
<tr>
<td>R9 - Riffle 9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11+00</td>
<td>19853</td>
<td>0.44</td>
<td></td>
</tr>
<tr>
<td>10+50</td>
<td>19803</td>
<td>2.54</td>
<td></td>
</tr>
<tr>
<td>10+00</td>
<td>19753</td>
<td>3.24</td>
<td></td>
</tr>
<tr>
<td>R10 - Riffle 10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9+50</td>
<td>19703</td>
<td>3.24</td>
<td></td>
</tr>
<tr>
<td>9+00</td>
<td>19653</td>
<td>0.44</td>
<td></td>
</tr>
</tbody>
</table>
Velocity Performance in Project Reach

Table 6 provides the velocities at 64 cfs (juvenile salmonids) and 320 cfs (adult salmonids) at each cross section within the project reach downstream of UPRR. Velocities are quiescent upstream of the UPRR because of the riffle and pool design causes a backwater (pool) conditions through the UPRR bridge. Figure 1 below labels the 10 riffles and shows the backwater profile for design conditions for the 10 cfs case.

In general, velocities are lower than 4 ft/s at 320 cfs, and are lower than 1 ft/s for at 64 cfs, except at riffle crests, where the flow becomes critical (or close to critical). The high velocities are isolated and occur over short reaches. Therefore, the proposed design of natural quarried boulder riffle and pool design generally satisfies the velocity criteria for juvenile and adult salmonids, and is deemed reasonable as salmonids have the ability to fight larger velocities over such short distances.

<table>
<thead>
<tr>
<th>Cross Section Description</th>
<th>Project Stationing</th>
<th>HEC-RAS River Station</th>
<th>Cross-Section Velocity @ 64 CFS</th>
<th>Cross-Section Velocity @ 320 CFS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[FEET]</td>
<td>[FEET]</td>
<td>[FT/S]</td>
<td>[FT/S]</td>
</tr>
<tr>
<td>25+74</td>
<td>21340</td>
<td>0.18</td>
<td>0.66</td>
<td></td>
</tr>
<tr>
<td>25+40</td>
<td>21293</td>
<td>0.23</td>
<td>0.87</td>
<td></td>
</tr>
<tr>
<td>R1 - Riffle 1</td>
<td>25+18</td>
<td>21271</td>
<td>2.51</td>
<td>4.87</td>
</tr>
<tr>
<td>R1 - Riffle 1</td>
<td>24+92</td>
<td>21245</td>
<td>4.17</td>
<td>6.84</td>
</tr>
<tr>
<td></td>
<td>24+40</td>
<td>21193</td>
<td>0.56</td>
<td>1.82</td>
</tr>
<tr>
<td></td>
<td>24+26</td>
<td>21179</td>
<td>0.56</td>
<td>1.82</td>
</tr>
<tr>
<td></td>
<td>23+90</td>
<td>21143</td>
<td>0.56</td>
<td>1.83</td>
</tr>
<tr>
<td>R2 - Riffle 2</td>
<td>23+75</td>
<td>21128</td>
<td>4.39</td>
<td>7.16</td>
</tr>
<tr>
<td></td>
<td>23+20</td>
<td>21073</td>
<td>0.62</td>
<td>2.11</td>
</tr>
<tr>
<td></td>
<td>22+91</td>
<td>21044</td>
<td>0.62</td>
<td>2.12</td>
</tr>
<tr>
<td></td>
<td>22+75</td>
<td>21028</td>
<td>0.62</td>
<td>2.12</td>
</tr>
<tr>
<td>R3 - Riffle 3</td>
<td>22+60</td>
<td>21013</td>
<td>4.27</td>
<td>6.27</td>
</tr>
<tr>
<td></td>
<td>21+65</td>
<td>20918</td>
<td>0.74</td>
<td>2.04</td>
</tr>
<tr>
<td></td>
<td>21+10</td>
<td>20863</td>
<td>0.9</td>
<td>2.35</td>
</tr>
<tr>
<td></td>
<td>20+55</td>
<td>20808</td>
<td>0.74</td>
<td>2.08</td>
</tr>
<tr>
<td></td>
<td>20+00</td>
<td>20753</td>
<td>0.91</td>
<td>2.41</td>
</tr>
<tr>
<td></td>
<td>19+45</td>
<td>20698</td>
<td>0.75</td>
<td>2.12</td>
</tr>
<tr>
<td></td>
<td>18+90</td>
<td>20643</td>
<td>0.73</td>
<td>2.07</td>
</tr>
<tr>
<td></td>
<td>18+35</td>
<td>20588</td>
<td>0.75</td>
<td>2.14</td>
</tr>
<tr>
<td>R4 - Riffle 4</td>
<td>17+60</td>
<td>20513</td>
<td>4.57</td>
<td>7.37</td>
</tr>
<tr>
<td></td>
<td>17+50</td>
<td>20503</td>
<td>1.91</td>
<td>4.04</td>
</tr>
</tbody>
</table>
### Table 6. Velocity Performance – Maximum Cross-Section Velocities

<table>
<thead>
<tr>
<th>Cross Section Description</th>
<th>Project Stationing</th>
<th>HEC-RAS River Station</th>
<th>Cross-Section Velocity @ 64 CFS</th>
<th>Cross-Section Velocity @ 320 CFS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[FEET]</td>
<td>[FEET]</td>
<td>[FT/S]</td>
<td>[FT/S]</td>
</tr>
<tr>
<td>17+40</td>
<td>20493</td>
<td>0.61</td>
<td>1.81</td>
<td></td>
</tr>
<tr>
<td>17+20</td>
<td>20473</td>
<td>0.76</td>
<td>2.23</td>
<td></td>
</tr>
<tr>
<td>17+00</td>
<td>20453</td>
<td>0.55</td>
<td>1.76</td>
<td></td>
</tr>
<tr>
<td>16+80</td>
<td>20433</td>
<td>0.55</td>
<td>1.77</td>
<td></td>
</tr>
<tr>
<td>R5 - Riffle 5</td>
<td>16+60</td>
<td>20413</td>
<td>4.61</td>
<td>7.55</td>
</tr>
<tr>
<td>16+40</td>
<td>20393</td>
<td>0.85</td>
<td>2.6</td>
<td></td>
</tr>
<tr>
<td>16+20</td>
<td>20373</td>
<td>0.69</td>
<td>2.25</td>
<td></td>
</tr>
<tr>
<td>16+10</td>
<td>20363</td>
<td>0.81</td>
<td>2.49</td>
<td></td>
</tr>
<tr>
<td>16+00</td>
<td>20353</td>
<td>0.59</td>
<td>1.89</td>
<td></td>
</tr>
<tr>
<td>R6 - Riffle 6</td>
<td>15+60</td>
<td>20313</td>
<td>4.67</td>
<td>7.64</td>
</tr>
<tr>
<td>15+40</td>
<td>20293</td>
<td>0.71</td>
<td>2.13</td>
<td></td>
</tr>
<tr>
<td>15+20</td>
<td>20273</td>
<td>0.6</td>
<td>1.95</td>
<td></td>
</tr>
<tr>
<td>15+10</td>
<td>20263</td>
<td>1.24</td>
<td>3.55</td>
<td></td>
</tr>
<tr>
<td>15+00</td>
<td>20253</td>
<td>0.69</td>
<td>2.19</td>
<td></td>
</tr>
<tr>
<td>R7 - Riffle 7</td>
<td>14+60</td>
<td>20213</td>
<td>4.67</td>
<td>7.63</td>
</tr>
<tr>
<td>14+00</td>
<td>20153</td>
<td>0.94</td>
<td>2.69</td>
<td></td>
</tr>
<tr>
<td>13+40</td>
<td>20093</td>
<td>0.89</td>
<td>2.35</td>
<td></td>
</tr>
<tr>
<td>12+80</td>
<td>20033</td>
<td>0.9</td>
<td>2.45</td>
<td></td>
</tr>
<tr>
<td>R8 - Riffle 8</td>
<td>12+00</td>
<td>19953</td>
<td>4.65</td>
<td>7.53</td>
</tr>
<tr>
<td>11+50</td>
<td>19903</td>
<td>0.86</td>
<td>2.59</td>
<td></td>
</tr>
<tr>
<td>R9 - Riffle 9</td>
<td>11+00</td>
<td>19853</td>
<td>4.42</td>
<td>7.15</td>
</tr>
<tr>
<td>10+50</td>
<td>19803</td>
<td>0.8</td>
<td>2.31</td>
<td></td>
</tr>
<tr>
<td>10+00</td>
<td>19753</td>
<td>0.82</td>
<td>2.34</td>
<td></td>
</tr>
<tr>
<td>9+50</td>
<td>19703</td>
<td>0.82</td>
<td>2.4</td>
<td></td>
</tr>
<tr>
<td>R10 - Riffle 10</td>
<td>9+00</td>
<td>19653</td>
<td>4.58</td>
<td>7.37</td>
</tr>
</tbody>
</table>
Hydraulic Drop Analysis

The hydraulic drop analysis entails computing the drop in water levels between adjacent pools for all relevant fish passage flows, (320 cfs for adults and 64 cfs for juveniles, and 10 cfs for low flow analysis). This analysis was performed to establish that the design contains drops that meet the fish passage criteria; i.e., which are not too large for fish to navigate. The criteria used in the previous fish passage analysis³ are based on CDFG and NOAA criteria, which state that drops should not exceed 0.5 ft for Juvenile salmonids or 1 ft for adults. The pools are numbered consecutively from upstream to downstream, with Pool 0 located immediately downstream of the UPRR slab.

Figure 2 shows labels the 10 pools in the design, and Table 7, provides the computed hydraulic drop heights for 10 cfs, 64 cfs and 320 cfs. Hydraulic drops are calculated by taking the difference between modeled water surface elevations in the middle of each pool. The results show that:

- The riffle pool design should perform very well for adult salmonids.
- Most drops are near 1 ft and do not exceed 1.3 ft.
- The 3 deep pools (P8, P4, and P1) are placed correctly to give rest to salmonids between the overall hydraulic water surface elevation changes of 5 feet. These deep pools will give additional rest to salmonids and will improve fish passage.
Table 7. Hydraulic Drop Heights

<table>
<thead>
<tr>
<th>Riffle Number</th>
<th>10 cfs</th>
<th>64 cfs</th>
<th>320 cfs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Upstream to Downstream Drop Height (ft)</td>
<td>Upstream to Downstream Drop Height (ft)</td>
<td>Upstream to Downstream Drop Height (ft)</td>
</tr>
<tr>
<td>0</td>
<td>1.34</td>
<td>1.21</td>
<td>1.07</td>
</tr>
<tr>
<td>1</td>
<td>1.1</td>
<td>1.15</td>
<td>1.23</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>0.85</td>
<td>0.52</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>1.04</td>
<td>1.12</td>
</tr>
<tr>
<td>4</td>
<td>0.82</td>
<td>0.93</td>
<td>0.9</td>
</tr>
<tr>
<td>5</td>
<td>1.19</td>
<td>1.06</td>
<td>1.11</td>
</tr>
<tr>
<td>6</td>
<td>0.99</td>
<td>0.94</td>
<td>0.79</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>1.11</td>
<td>1.35</td>
</tr>
<tr>
<td>8</td>
<td>0.7</td>
<td>0.64</td>
<td>0.53</td>
</tr>
<tr>
<td>9</td>
<td>1.34</td>
<td>1.21</td>
<td>1.07</td>
</tr>
</tbody>
</table>

**Turbulence Performance**

The EDF was computed for 10 cfs, 64 cfs and 320 cfs. Values in pools were universally less than 4 ft-lb/(ft3/s). However, values at riffle crests were as high as 12. Given that the only exceedance of the criteria occurs at the riffle crest where velocities reach critical depth, the design is deemed to be reasonable. The EDF values are summarized here.

Table 8. Hydraulic Drop Performance – 64 CFS

<table>
<thead>
<tr>
<th>Flow</th>
<th>10 cfs</th>
<th>64 cfs</th>
<th>320 cfs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Pool EDF (ft-lb/ft3/s)</td>
<td>0.69</td>
<td>1.03</td>
<td>2.5</td>
</tr>
<tr>
<td>Maximum Riffle Crest EDF (ft-lb/ft3/s)</td>
<td>8.79</td>
<td>9.08</td>
<td>10.81</td>
</tr>
</tbody>
</table>

**Rock Sizing**

The rock sizing calculations have not been updated to reflect the proposed minor design changes since the results for the 7000 cfs flow profile have not changed significantly.

In the project design, riffles will be created with the strategic placement of in-channel rock. This analysis outlines the work done to size rocks so that the design will not wash out due to hydraulic forces, calculated rock sizes are shown in Table 10 and Table 11. The US Army Corps Steep Slope riprap
equation [USACE 1994] is used to calculate the rock diameter needed to resist hydraulic forces as specified in SCVWD’s Design Manual.

\[
D_{30} = \frac{1.95 \times S^{0.555} q^{2/3}}{g^{1/3}}, \text{ where}
\]

\(D_{30}\) = Rock size of which 30% is finer by weight [FEET]
\(q\) = flow per unit width [FT²/S]
\(g\) = gravitational acceleration [FT/S²] = 32.2 [FT/S²]
\(S\) = channel bed slope [FT/FT]. The channel bed slope, \(S\), is calculated from the invert of UPRR to the downstream end of the project dy/dx = 0.00693

The \(D_{30}\) is then converted to \(D_{50}\) with the following approximation Equation 5-2 given in SCVWD’s Design Manual.

\[D_{50} = 1.22D_{30},\text{ where}\]

\(D_{30}\) is defined above, and
\(D_{50}\) = Rock size of which 50% is finer by weight

The existing capacity flow rate of 7000 CFS produces the largest velocities of the velocities analyzed. Table 9 provides the hydraulic rock sizing calculations for the project. The maximum calculated size is selected at Project Stationing 15+80 and is used to calculate \(D_{100}\) in feet with a safety factor of 1.5 in Table 10 below. This maximum \(D_{50}\) value is converted to a maximum \(D_{100}\) value using Table 5-1 from SCVWD’s Design Manual.

Table 9. Hydraulic Rock Sizing Calculations

<table>
<thead>
<tr>
<th>Cross Section Description</th>
<th>Project Stationing</th>
<th>HEC-RAS Model River Stationing</th>
<th>Top Width</th>
<th>Froude #</th>
<th>Flow Rate Per Width</th>
<th>(D_{30}) [USACE 1994]</th>
<th>(D_{50}) [SCVWD eq. 5-2]</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1 - Riffle 1</td>
<td>25+58</td>
<td>21311</td>
<td>85.1</td>
<td>0.36</td>
<td>82.26</td>
<td>0.75</td>
<td>0.92</td>
</tr>
<tr>
<td>R1 - Riffle 1</td>
<td>24+92</td>
<td>21245</td>
<td>87.71</td>
<td>0.4</td>
<td>79.81</td>
<td>0.74</td>
<td>0.90</td>
</tr>
<tr>
<td></td>
<td>24+40</td>
<td>21193</td>
<td>127.35</td>
<td>0.32</td>
<td>54.97</td>
<td>0.57</td>
<td>0.70</td>
</tr>
<tr>
<td></td>
<td>24+26</td>
<td>21179</td>
<td>127.28</td>
<td>0.32</td>
<td>55</td>
<td>0.57</td>
<td>0.70</td>
</tr>
<tr>
<td></td>
<td>23+90</td>
<td>21143</td>
<td>127.1</td>
<td>0.32</td>
<td>55.07</td>
<td>0.58</td>
<td>0.70</td>
</tr>
<tr>
<td>R2 - Riffle 2</td>
<td>23+75</td>
<td>21128</td>
<td>94.69</td>
<td>0.46</td>
<td>73.93</td>
<td>0.70</td>
<td>0.85</td>
</tr>
<tr>
<td></td>
<td>23+20</td>
<td>21073</td>
<td>94.24</td>
<td>0.35</td>
<td>74.28</td>
<td>0.70</td>
<td>0.86</td>
</tr>
<tr>
<td></td>
<td>22+91</td>
<td>21044</td>
<td>94.14</td>
<td>0.36</td>
<td>74.36</td>
<td>0.70</td>
<td>0.86</td>
</tr>
<tr>
<td></td>
<td>22+75</td>
<td>21028</td>
<td>94.08</td>
<td>0.36</td>
<td>74.40</td>
<td>0.70</td>
<td>0.86</td>
</tr>
<tr>
<td>R3 - Riffle 3</td>
<td>22+60</td>
<td>21013</td>
<td>85.57</td>
<td>0.41</td>
<td>81.80</td>
<td>0.75</td>
<td>0.91</td>
</tr>
<tr>
<td></td>
<td>21+65</td>
<td>20918</td>
<td>81.49</td>
<td>0.34</td>
<td>85.90</td>
<td>0.77</td>
<td>0.94</td>
</tr>
<tr>
<td></td>
<td>21+10</td>
<td>20863</td>
<td>78.43</td>
<td>0.37</td>
<td>89.25</td>
<td>0.79</td>
<td>0.97</td>
</tr>
</tbody>
</table>
Table 9. Hydraulic Rock Sizing Calculations

<table>
<thead>
<tr>
<th>Cross Section Description</th>
<th>Project Stationing</th>
<th>HEC-RAS Model River Stationing</th>
<th>Top Width [FEET]</th>
<th>Froude #</th>
<th>Flow Rate Per Width [CFS/Foot]</th>
<th>D30 [USACE 1994] [FEET]</th>
<th>D50 [SCVWD eq. 5-2] [FEET]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>20+55</td>
<td>20808</td>
<td>86.31</td>
<td>0.33</td>
<td>81.10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>20+00</td>
<td>20753</td>
<td>80.6</td>
<td>0.37</td>
<td>86.85</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>19+45</td>
<td>20698</td>
<td>84.58</td>
<td>0.34</td>
<td>82.76</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>18+90</td>
<td>20643</td>
<td>87.46</td>
<td>0.33</td>
<td>80.04</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>18+35</td>
<td>20588</td>
<td>85.9</td>
<td>0.35</td>
<td>81.49</td>
</tr>
<tr>
<td>R4 - Riffle 4</td>
<td>17+60</td>
<td>20513</td>
<td>83.09</td>
<td>0.43</td>
<td>84.25</td>
<td>0.76</td>
<td>0.93</td>
</tr>
<tr>
<td></td>
<td>17+50</td>
<td>20503</td>
<td>84.32</td>
<td>0.39</td>
<td>83.02</td>
<td>0.76</td>
<td>0.92</td>
</tr>
<tr>
<td></td>
<td>17+40</td>
<td>20493</td>
<td>84.43</td>
<td>0.29</td>
<td>82.91</td>
<td>0.76</td>
<td>0.92</td>
</tr>
<tr>
<td></td>
<td>17+20</td>
<td>20473</td>
<td>85.71</td>
<td>0.33</td>
<td>81.67</td>
<td>0.75</td>
<td>0.91</td>
</tr>
<tr>
<td></td>
<td>17+00</td>
<td>20453</td>
<td>78.73</td>
<td>0.31</td>
<td>88.91</td>
<td>0.79</td>
<td>0.97</td>
</tr>
<tr>
<td></td>
<td>16+80</td>
<td>20433</td>
<td>76.65</td>
<td>0.32</td>
<td>91.32</td>
<td>0.81</td>
<td>0.98</td>
</tr>
<tr>
<td>R5 - Riffle 5</td>
<td>16+60</td>
<td>20413</td>
<td>76.04</td>
<td>0.5</td>
<td>92.06</td>
<td>0.81</td>
<td>0.99</td>
</tr>
<tr>
<td></td>
<td>16+40</td>
<td>20393</td>
<td>76.4</td>
<td>0.4</td>
<td>91.62</td>
<td>0.81</td>
<td>0.99</td>
</tr>
<tr>
<td></td>
<td>16+20</td>
<td>20373</td>
<td>65.27</td>
<td>0.4</td>
<td>107.25</td>
<td>0.90</td>
<td>1.09</td>
</tr>
<tr>
<td></td>
<td>16+10</td>
<td>20363</td>
<td>74.28</td>
<td>0.38</td>
<td>94.24</td>
<td>0.82</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>16+00</td>
<td>20353</td>
<td>69.35</td>
<td>0.33</td>
<td>100.94</td>
<td>0.86</td>
<td>1.05</td>
</tr>
<tr>
<td></td>
<td>15+80</td>
<td>20333</td>
<td>60.69</td>
<td>0.36</td>
<td>115.34</td>
<td>0.94</td>
<td>1.15</td>
</tr>
<tr>
<td>R6 - Riffle 6</td>
<td>15+60</td>
<td>20313</td>
<td>72.39</td>
<td>0.5</td>
<td>96.70</td>
<td>0.84</td>
<td>1.02</td>
</tr>
<tr>
<td></td>
<td>15+40</td>
<td>20293</td>
<td>70.98</td>
<td>0.33</td>
<td>98.62</td>
<td>0.85</td>
<td>1.03</td>
</tr>
<tr>
<td></td>
<td>15+20</td>
<td>20273</td>
<td>77.07</td>
<td>0.32</td>
<td>90.83</td>
<td>0.80</td>
<td>0.98</td>
</tr>
<tr>
<td></td>
<td>15+10</td>
<td>20263</td>
<td>76.22</td>
<td>0.41</td>
<td>91.84</td>
<td>0.81</td>
<td>0.99</td>
</tr>
<tr>
<td></td>
<td>15+00</td>
<td>20253</td>
<td>72.67</td>
<td>0.34</td>
<td>96.33</td>
<td>0.83</td>
<td>1.02</td>
</tr>
<tr>
<td></td>
<td>14+80</td>
<td>20233</td>
<td>71.58</td>
<td>0.33</td>
<td>97.79</td>
<td>0.84</td>
<td>1.03</td>
</tr>
<tr>
<td>R7 - Riffle 7</td>
<td>14+60</td>
<td>20213</td>
<td>77.08</td>
<td>0.46</td>
<td>90.81</td>
<td>0.80</td>
<td>0.98</td>
</tr>
<tr>
<td></td>
<td>14+00</td>
<td>20153</td>
<td>76.2</td>
<td>0.36</td>
<td>91.86</td>
<td>0.81</td>
<td>0.99</td>
</tr>
<tr>
<td></td>
<td>13+40</td>
<td>20093</td>
<td>82.18</td>
<td>0.3</td>
<td>85.18</td>
<td>0.77</td>
<td>0.94</td>
</tr>
<tr>
<td></td>
<td>12+80</td>
<td>20033</td>
<td>80.21</td>
<td>0.32</td>
<td>87.27</td>
<td>0.78</td>
<td>0.95</td>
</tr>
<tr>
<td>R8 - Riffle 8</td>
<td>12+00</td>
<td>19953</td>
<td>70.5</td>
<td>0.41</td>
<td>99.29</td>
<td>0.85</td>
<td>1.04</td>
</tr>
<tr>
<td></td>
<td>11+50</td>
<td>19903</td>
<td>78.63</td>
<td>0.31</td>
<td>89.02</td>
<td>0.79</td>
<td>0.97</td>
</tr>
<tr>
<td>R9 - Riffle 9</td>
<td>11+00</td>
<td>19853</td>
<td>80.93</td>
<td>0.37</td>
<td>86.49</td>
<td>0.78</td>
<td>0.95</td>
</tr>
<tr>
<td></td>
<td>10+50</td>
<td>19803</td>
<td>80.45</td>
<td>0.28</td>
<td>87.01</td>
<td>0.78</td>
<td>0.95</td>
</tr>
<tr>
<td></td>
<td>10+00</td>
<td>19753</td>
<td>85.5</td>
<td>0.27</td>
<td>81.87</td>
<td>0.75</td>
<td>0.91</td>
</tr>
<tr>
<td></td>
<td>9+50</td>
<td>19703</td>
<td>82.41</td>
<td>0.29</td>
<td>84.94</td>
<td>0.77</td>
<td>0.94</td>
</tr>
<tr>
<td>R10 - Riffle 10</td>
<td>9+00</td>
<td>19653</td>
<td>81.39</td>
<td>0.29</td>
<td>86.01</td>
<td>0.77</td>
<td>0.94</td>
</tr>
<tr>
<td></td>
<td>8+50</td>
<td>19603</td>
<td>81.93</td>
<td>0.32</td>
<td>85.44</td>
<td>0.77</td>
<td>0.94</td>
</tr>
</tbody>
</table>
CONCLUSIONS AND RECOMMENDATIONS

Based on the above analyses, the following recommendations are made:

- The proposed riffle design reduces the existing channel capacity from 7000 cfs to 6000 cfs in the project reach upstream of UPRR, due to the riffle design which raises the bed for an 1800 ft long reach downstream of UPRR. The post project capacity downstream of UPRR is also reduced but its capacity larger than 7000 cfs.

- Fish passage criteria are generally met for both adult and juvenile salmonids. More specifically:
  - The criteria for drops meets that for juveniles for the downstream 3-4 riffles.
  - The drop criteria for adult salmonids is met in general, with drops exceeding the 1 ft depth criteria at a couple of the riffles.
  - Depth and velocity criteria are met, except at the locations of the crests of some riffles, where depths are small and velocities are large, but isolated and for very short reaches (right near the riffle crests).
  - Based on these results, the project will definitely improve fish criteria when compared with existing conditions, and meets them for the most part.

- Recommended rock sizes for the riffles have been calculated, as documented herein.

<table>
<thead>
<tr>
<th>From Table 5-1</th>
<th>D100 Values with Safety Factor of 1.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>D100 MAX [FEET]</td>
<td>D100 MIN [FEET]</td>
</tr>
<tr>
<td>FEET 2</td>
<td>1.47</td>
</tr>
<tr>
<td>LBS 691</td>
<td>276</td>
</tr>
<tr>
<td>TONS 0.3455</td>
<td>0.138</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>D100 MAX [FEET]</th>
<th>D100 MIN [FEET]</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEET 3</td>
<td>2.205</td>
</tr>
<tr>
<td>LBS 1036.5</td>
<td>414</td>
</tr>
<tr>
<td>TONS 0.51825</td>
<td>0.207</td>
</tr>
</tbody>
</table>
REFERENCES

Zedler, Emily. Hydraulic Analysis – Design Recommendations for Fish Passage Alternatives dated April 24, 2018. [BolsaFishPassageAlt_HydraulicAnalysisOnly.docx, Request folder 173]

Zedler, Emily. Development of Hec-Ras Models for a Hydraulic Analysis of Fish Passage Alternatives dated April 23, 2018. [BolsaFishPassageAlt_RasModelDoc.docx, Request folder 173]

Santa Clara Valley Water District, March 2018 Uvas Carnadero Creek Fish Passage Improvement Project: Basis of Design Report.

Newbury, Robert. Designing Pool and Riffle Streams 2008

APPENDIX C

RIFFLE ROCK AND ROCK SLOPE PROTECTION EVALUATION
Summary: Design Procedures for Scour pool Design 5-42 page and 5-43 of design manual

| Needed Values: | 
|------------------|-------------------|
| Symbol          | Description       | Value       |
| Q25             | 25-year discharge | 7,000 CF    |
| W               | bankfull width    | 30 Feet     |
| H               | drop or weir height | 1 Feet    |
| So              | Channel Slope     | 0.00709     |
| g               | gravitational acceleration | 32.2 ft/sec² |

Equations

1. Determine design flow

   The design flow for sizing the rocks of the scour hole is determined using Eq. (3-1). The rocks are sized using Eq. (5-8). In addition to this design flow, the design calls for the unit 25-year discharge, \( q_{25} \), determined by

   \[
   q_{25} = \frac{Q_{25}}{W}
   \]

   where \( W \) = bankfull width, and

   \( Q_{25} \) = discharge of 25-year return interval

2. Determine scour depth

   \[
   \frac{\text{Scour Depth}}{W} = 0.0118 + 1.394 \left( \frac{H}{W} \right) + 5.314 \left( \frac{S_o G_{25}}{g \sqrt{W}} \right)^{0.75}
   \]

   where

   - \( H \) = drop or weir height
   - \( S_o \) = channel slope
   - \( g \) = gravitational acceleration, 32.2 ft/sec²

3. Determine pool length (\( L_2 \))

   \[
   L_2 = 0.409 + 4.211 \left( \frac{H}{W} \right) + 8.741 \left( \frac{S_o G_{25}}{g \sqrt{W}} \right)^{0.75}
   \]

4. Determine maximum pool width (\( B_3 \))

   \[
   B_3 = 1.27T
   \]

   Note that in the natural setting where this relationship was developed, \( W \) is the weir width which is less than the bankfull width, or the full bottom width, in most cases, as depicted in Figure 5-16.

5. Lay out the scour pool design using weir width, maximum pool width, pool length and scour depth. Provide rock and filter layer design as described in Sections 5.2.1.3 and 5.2.2.
### Uvas Creek

**Rock size for Cross-Vanes and Riffles-Pools**

*Instructions: If you have limited data, fill in values in Cells C8 to C23.*

<table>
<thead>
<tr>
<th>Column</th>
<th>34x40</th>
<th>51x40</th>
<th>78x40</th>
<th>69x393</th>
<th>78x303</th>
<th>69x415</th>
<th>78x425</th>
<th>69x539</th>
<th>78x548</th>
</tr>
</thead>
<tbody>
<tr>
<td>Column</td>
<td>34x40</td>
<td>51x40</td>
<td>78x40</td>
<td>69x423</td>
<td>78x433</td>
<td>69x515</td>
<td>78x525</td>
<td>69x548</td>
<td>78x548</td>
</tr>
<tr>
<td>Column</td>
<td>34x40</td>
<td>51x40</td>
<td>78x40</td>
<td>69x539</td>
<td>78x539</td>
<td>69x548</td>
<td>78x548</td>
<td>69x548</td>
<td>78x548</td>
</tr>
</tbody>
</table>

#### Rock on invert at top of riffle

- Bankfull height: 4
- Bankfull width: 4
- Velocity at top of riffle: 4
- Bankfull flood plain: 4
- Velocity at bankfull flood plain: 4
- Rock on bankfull flood plain before construction: 4
- Rock on bankfull flood plain after construction: 4
- Rock on bankfull flood plain at edge: 4
- Rock on invert at top of riffle: 4
- Velocity at top of riffle: 4
- Rock at edge of pool: 4
- Velocity at edge of pool: 4
- Pool Rock: 4
- Velocity at edge of pool: 4

#### Rock size to be used for Footer and Weir?

- Specific gravity of rock: 1
- Maximum rock size to be used for Footer and Weir: 1

#### Specific gravity of rock

- Specific gravity of rock: 2.85

#### Velocity over rock at TOB flow

- Velocity over rock at TOB flow (based on HEC RAS or other model): 9
- Velocity is for the location of rock, thalweg, riffle, BF flood plain, etc.

#### Computed Slope from Manning's equation

- Computed slope from Manning's equation (should be close to hydraulic gradient): 0.786%

#### Depth from TOB to Thalweg

- Depth from TOB to Thalweg: 18
- Depth from TOB to bankfull flood plain: 14

#### Is Max Rock Size to be used for Footer and Weir?

- Is Max Rock Size to be used for Footer and Weir: 1

#### Hyd R Depth

- Hyd R Depth: 3.0

#### Computations (Unhide Row 28 to 115 to see computations)

- Program selects Max - max of slope from Manning's eqn, riffle, hydraulic gradient, elf = 0.79%

#### Entrenchment ratio before construction

- Entrenchment ratio before construction: 1.33

#### Entrenchment ratio after construction

- Entrenchment ratio after construction: 1.50

#### Depth from Bankfull to Thalweg

- Depth from Bankfull to Thalweg: 45

#### Specific weight of Water

- Specific weight of Water: 62.4

#### Specific weight of Rock

- Specific weight of Rock: 178

#### Tb is applied bed shear - based on 1/4D depth

- Tb is applied bed shear: 8.8

#### Tb - based on bankfull depth

- Tb - based on bankfull depth: 2.0

#### Tb - based on critical shear (riffle to D<0.03)

- Tb - based on critical shear: 0.06

#### Tc* Andrews, 1984: 0.0834*(di/d50)^(-0.834)

- Tc* Andrews, 1984: 0.0834

#### Di bed feet

- Di bed feet: 1.27

#### D50 Riffle Rock

- D50 Riffle Rock, first guess: 2.55

#### D50 Rock

- D50 Rock, first guess: 4.0

#### Tc* from Andrews, 1984: 0.0834*(di/d50)^(-0.834)

- Tc* from Andrews, 1984: 0.0834

#### D100 weir (max rock size) / D 50 weir

- D100 weir - max rock size (or top of riffle): 3.8

#### D100 rock weight

- D100 rock weight: 6103

#### Method 1: Maximum Rock weight D100

- Method 1: Maximum Rock weight D100: 6103

### Notes

- At bankfull flow - channels that open up to wide flood plain at bankfull flow
- At Top of Bank (TOB) Flow - Design for Entrenched Channels (Typical for us)
- At bankfull flow - channels that open up at bankfull flow
- Velocity is for the location of rock, thalweg, riffle, BF flood plain, etc.
- Velocity is for the location of rock, thalweg, riffle, BF flood plain, etc.
**Uvas Creek**

**Rock size for Cross-Vanes and Riffles-Pools**

Instructions: If you have limited data, fill in values in Cells C8 to C23

<table>
<thead>
<tr>
<th>Column</th>
<th>b</th>
<th>c</th>
<th>d</th>
<th>e</th>
<th>f</th>
<th>g</th>
<th>h</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Rock on invert at top of riffle</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Rock on bankfull flood plain</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Rock on bottom of pool</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Column</th>
<th>b</th>
<th>c</th>
<th>d</th>
<th>e</th>
<th>f</th>
<th>g</th>
<th>h</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Riffle rock</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Pool Rock</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Column</th>
<th>b</th>
<th>c</th>
<th>d</th>
<th>e</th>
<th>f</th>
<th>g</th>
<th>h</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Column c = Column b</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Column d = Column c</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Column e = Column d</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Column f = Column e</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Column g = Column f</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Column h = Column g</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
</tbody>
</table>

**Cross-Vanes & Use Safety Factor of 1.5**

**Method 1: Rock weight**

<table>
<thead>
<tr>
<th>Column</th>
<th>b</th>
<th>c</th>
<th>d</th>
<th>e</th>
<th>f</th>
<th>g</th>
<th>h</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>With existing</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>With new</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Column</th>
<th>b</th>
<th>c</th>
<th>d</th>
<th>e</th>
<th>f</th>
<th>g</th>
<th>h</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Column b</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Column c</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Column d</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Column e</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Column f</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Column g</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Column h</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Column</th>
<th>b</th>
<th>c</th>
<th>d</th>
<th>e</th>
<th>f</th>
<th>g</th>
<th>h</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Column b</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Column c</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Column d</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Column e</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Column f</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Column g</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Column h</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Column</th>
<th>b</th>
<th>c</th>
<th>d</th>
<th>e</th>
<th>f</th>
<th>g</th>
<th>h</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Column b</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Column c</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Column d</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Column e</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Column f</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Column g</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Column h</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
</tbody>
</table>

**Velocity Method (Isbach, 1936)**

<table>
<thead>
<tr>
<th>Column</th>
<th>b</th>
<th>c</th>
<th>d</th>
<th>e</th>
<th>f</th>
<th>g</th>
<th>h</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>From Stream Habitat Restoration Guidelines, Final Draft, Washington Dept of Fish and Wildlife, June 2004</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Column</th>
<th>b</th>
<th>c</th>
<th>d</th>
<th>e</th>
<th>f</th>
<th>g</th>
<th>h</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>D70 / Dmin 2 2 2 2</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>D100/D50 1.5 1.5 1.5 1.5</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Column</th>
<th>b</th>
<th>c</th>
<th>d</th>
<th>e</th>
<th>f</th>
<th>g</th>
<th>h</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Method Alt 1</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Dmin = (Vavg/9.571)(^{2.05}) feet</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>D50 1.76 1.21 0.37 1.05 from Stream Habitat Restoration Guidelines OK</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>D100 2.64 1.82 1.55 1.92 OK</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Column</th>
<th>b</th>
<th>c</th>
<th>d</th>
<th>e</th>
<th>f</th>
<th>g</th>
<th>h</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Method Alt 2</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Dmin 0.1724 Ln (x) + 0.6349</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>D50 0.88 0.61 0.61 0.53 Costa 1983, Paleo-hydraulic reconstruction of flash flood peak</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>D100 1.28 1.11 0.83 0.83</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Column</th>
<th>b</th>
<th>c</th>
<th>d</th>
<th>e</th>
<th>f</th>
<th>g</th>
<th>h</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Diameter B axis Elliptical/Cuboidal</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Dimensions of C axis for cubical rock</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Diameter B axis Elliptical/Cuboidal</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Dimensions of C axis for cubical rock</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Diameter B axis Elliptical/Cuboidal</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Dimensions of C axis for cubical rock</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Diameter B axis Elliptical/Cuboidal</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Column</th>
<th>b</th>
<th>c</th>
<th>d</th>
<th>e</th>
<th>f</th>
<th>g</th>
<th>h</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Results</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Summary of Most Sizes of D100 Rock</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Based on ratios from Rip-rap sizing and bed critical shear</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Riffle Max sizing factor 2.2</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Riffle Min sizing factor 1.6</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Pool at edge of water</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Bottom of pool, D50 Based on ratio of D50/Dmax at edge of water</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Bottom of pool, Dmin Based on ratio of D50/Dmin</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Column</th>
<th>b</th>
<th>c</th>
<th>d</th>
<th>e</th>
<th>f</th>
<th>g</th>
<th>h</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dimensions of C axis for cubical rock</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Dimensions of C axis for cubical rock</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Dimensions of C axis for cubical rock</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Dimensions of C axis for cubical rock</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Dimensions of C axis for cubical rock</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Column</th>
<th>b</th>
<th>c</th>
<th>d</th>
<th>e</th>
<th>f</th>
<th>g</th>
<th>h</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Summary of Most Sizes of D100 Rock</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Based on ratios from Rip-rap sizing and bed critical shear</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Riffle Max sizing factor 2.2</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Riffle Min sizing factor 1.6</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Pool at edge of water</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Bottom of pool, D50 Based on ratio of D50/Dmax at edge of water</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Bottom of pool, Dmin Based on ratio of D50/Dmin</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Column</th>
<th>b</th>
<th>c</th>
<th>d</th>
<th>e</th>
<th>f</th>
<th>g</th>
<th>h</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Expected Volume ft(^3)</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td><strong>Expected Weight lbs</strong></td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
</tbody>
</table>

**Notes**

- If selected size at edge < D100, cover pool with layer of 0.8 \( \times \) D100 rock.
### Notes:

**Revisions**

1. 2018-12-18: hydraulic model files:

<table>
<thead>
<tr>
<th>Factor</th>
<th>Variable</th>
<th>Value</th>
<th>Units</th>
<th>Formula</th>
<th>Description of Variable / Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Velocity to which bank is exposed</td>
<td>V</td>
<td>11.97</td>
<td>ft/s</td>
<td>$\text{multiply average channel velocity by 0.67 (2/3)}$</td>
<td>for parallel flow and multiply average channel velocity by 1.33 (4/3) for impinging flow.</td>
</tr>
<tr>
<td>Specific gravity of rock</td>
<td>SG</td>
<td>2.65</td>
<td>-</td>
<td></td>
<td>typical for this area</td>
</tr>
<tr>
<td>70 degrees (for random placement)</td>
<td>r</td>
<td>70.00</td>
<td>degrees</td>
<td></td>
<td>suggested</td>
</tr>
<tr>
<td>outside slope face angle with horizontal</td>
<td>a</td>
<td>45.00</td>
<td>degrees</td>
<td></td>
<td>1.5:1 slope</td>
</tr>
<tr>
<td>Weight or size</td>
<td>W</td>
<td>549.77</td>
<td>pounds</td>
<td></td>
<td>Theoretical minimum rock mass (size or weight) which resists forces of flowing water and remains stable on the slope of the stream or river bank.</td>
</tr>
</tbody>
</table>

From Table 5-1: "1 TON, Method A Placement"

From Table 5-2: Inner Layers RSP-Class "LIGHT", Backing Class No. "NONE", RSP-Fabric Type B.

From Table 5-3: Minimum Layer Thickness for 1 TON Method A is 4.3 feet, Backing Class "Light" Method B is 2.5 feet.

From Table A-1: Base Width = 4.3/(sin(atan(1/1))) = 6.0 feet

### Table 5-1: Guide for Determining RSP-Class of Outside Layer

<table>
<thead>
<tr>
<th>RSP-Class (US customary)</th>
<th>Method A Placement</th>
<th>Minimum Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 T (8 ton)</td>
<td>Method A Placement</td>
<td>2.60 meters (8.5 feet)</td>
</tr>
<tr>
<td>4 T (4 ton)</td>
<td></td>
<td>2.07 meters (6.8 feet)</td>
</tr>
<tr>
<td>2 T (2 ton)</td>
<td></td>
<td>1.65 meters (5.4 feet)</td>
</tr>
<tr>
<td>1 T (1 ton)</td>
<td></td>
<td>1.31 meters (4.3 feet)</td>
</tr>
<tr>
<td>1/2 T (1/2 ton)</td>
<td></td>
<td>1.04 meters (3.4 feet)</td>
</tr>
<tr>
<td>1/4 T (1/4 ton)</td>
<td></td>
<td>0.80 meters (2.6 feet)</td>
</tr>
<tr>
<td>Light</td>
<td></td>
<td>760 millimeters (2.5 feet)</td>
</tr>
<tr>
<td>Facing</td>
<td></td>
<td>550 millimeters (1.8 feet)</td>
</tr>
<tr>
<td>Backing No. 1</td>
<td></td>
<td>550 millimeters (1.8 feet)</td>
</tr>
<tr>
<td>Backing No. 2</td>
<td></td>
<td>380 millimeters (1.25 feet)</td>
</tr>
<tr>
<td>Backing No. 3</td>
<td></td>
<td>230 millimeters (0.75 feet)</td>
</tr>
</tbody>
</table>

### Table 5-2: California Layered RSP

<table>
<thead>
<tr>
<th>OUTSIDE LAYER</th>
<th>INNER LAYERS</th>
<th>BACKING CLASS No.</th>
<th>RSP-FABRIC TYPE **</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 T (8 ton)</td>
<td>Method A</td>
<td>1 T over 1/2 T</td>
<td>B</td>
</tr>
<tr>
<td>4 T (4 ton)</td>
<td>Method A</td>
<td>1 T over 1/4 T</td>
<td>1 or 2 B</td>
</tr>
<tr>
<td>2 T (2 ton)</td>
<td>Method A</td>
<td>1/2 T</td>
<td>1</td>
</tr>
<tr>
<td>1 T (1 ton)</td>
<td>Method A</td>
<td>1/4 T</td>
<td>1 or 2 B</td>
</tr>
<tr>
<td>1/2 T (1/2 ton)</td>
<td>Method A</td>
<td>LIGHT</td>
<td>NONE</td>
</tr>
<tr>
<td>1/4 T (1/4 ton)</td>
<td>Method A</td>
<td>LIGHT</td>
<td>NONE</td>
</tr>
<tr>
<td>8 T (8 ton)</td>
<td>Method A</td>
<td>LIGHT</td>
<td>NONE</td>
</tr>
<tr>
<td>4 T (4 ton)</td>
<td>Method A</td>
<td>LIGHT</td>
<td>NONE</td>
</tr>
<tr>
<td>2 T (2 ton)</td>
<td>Method A</td>
<td>LIGHT</td>
<td>NONE</td>
</tr>
<tr>
<td>1 T (1 ton)</td>
<td>Method A</td>
<td>LIGHT</td>
<td>NONE</td>
</tr>
<tr>
<td>1/2 T (1/2 ton)</td>
<td>Method A</td>
<td>LIGHT</td>
<td>NONE</td>
</tr>
<tr>
<td>1/4 T (1/4 ton)</td>
<td>Method A</td>
<td>LIGHT</td>
<td>NONE</td>
</tr>
</tbody>
</table>

### Table 5-3: Minimum Layer Thickness

<table>
<thead>
<tr>
<th>RSP-Class Layer</th>
<th>Method of Placement</th>
<th>Minimum Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 T (8 ton)</td>
<td>Method A Placement</td>
<td>2.60 meters (8.5 feet)</td>
</tr>
<tr>
<td>4 T (4 ton)</td>
<td></td>
<td>2.07 meters (6.8 feet)</td>
</tr>
<tr>
<td>2 T (2 ton)</td>
<td></td>
<td>1.65 meters (5.4 feet)</td>
</tr>
<tr>
<td>1 T (1 ton)</td>
<td></td>
<td>1.31 meters (4.3 feet)</td>
</tr>
<tr>
<td>1/2 T (1/2 ton)</td>
<td></td>
<td>1.04 meters (3.4 feet)</td>
</tr>
<tr>
<td>1/4 T (1/4 ton)</td>
<td></td>
<td>0.80 meters (2.6 feet)</td>
</tr>
<tr>
<td>Light</td>
<td></td>
<td>760 millimeters (2.5 feet)</td>
</tr>
</tbody>
</table>

**Weights:**

- **W** theoretical minimum rock mass (size or weight) which resists forces of flowing water and remains stable on the slope of the stream or river bank.

**Slope Protection:**

- US customary values shown for OUTSIDE LAYER only.

---

**Factor Variable Value Units Formula Description of Variable / Notes**

- Velocity to which bank is exposed V 11.97 ft/s for parallel flow and multiply average channel velocity by 0.67 (2/3) for impinging flow and multiply average channel velocity by 1.33 (4/3)
- Specific gravity of rock SG 2.65 - typical for this area
- 70 degrees (for random placement) r 70.00 degrees suggested
- outside slope face angle with horizontal a 45.00 degrees 1.5:1 slope
- Weight or size W 549.77 pounds 208.55 kg

---

**Table 5-1:** Guide for Determining RSP-Class of Outside Layer

- **US customary values shown for OUTSIDE LAYER only.**
- **RSP-Fabric Type:**

  - Type A RSP-fabric has lighter mass per unit area and it also has lower toughness (tensile x elongation, both at break) than Type B RSP-fabric. Both types require minimum permeability of 0.5 per second.

---

**Facing RSP-Class**: Has same gradation as Backing No. 1.

---

**Backings No. 1**:

- 550 millimeters (1.8 feet)

---

**Backings No. 2**:

- 550 millimeters (1.8 feet)

---

**Backings No. 3**:

- 380 millimeters (1.25 feet)

---

**Backings No. 4**:

- 230 millimeters (0.75 feet)
Figure 5-1. Key Variables in Equation 1

Note: Calculates approx. rock diameter for given weight class

Assumes: Specific Weight = 2.5
LBS/FT^3 = 156.0

<table>
<thead>
<tr>
<th>TONS</th>
<th>VOLUME (FT^3)</th>
<th>SPHERICAL DIAMETER (FT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
<td>3.21</td>
<td>1.83</td>
</tr>
<tr>
<td>0.5</td>
<td>6.41</td>
<td>2.30</td>
</tr>
<tr>
<td>1</td>
<td>12.82</td>
<td>2.89</td>
</tr>
<tr>
<td>2</td>
<td>25.64</td>
<td>3.64</td>
</tr>
<tr>
<td>4</td>
<td>51.28</td>
<td>4.57</td>
</tr>
<tr>
<td>5</td>
<td>64.10</td>
<td>4.92</td>
</tr>
</tbody>
</table>
GEOTECHNICAL INVESTIGATION
CREEK BANK STABILIZATION
CHRISTOPHER RANCH, UVAS/CARNADERO CREEK
GILROY, CALIFORNIA

Prepared for:
SCHAAF & WHEELER
1171 Homestead Road, Suite 255
Santa Clara Road, California 95050
July 2018
Mr. Chuck Anderson  
President  
SCHAAF AND WHEELER  
1171 Homestead Road, Suite 255  
Santa Clara, CA 95050

SUBJECT: Geotechnical Investigation  
RE: Creek Bank Stabilization – Christopher Ranch, Uvas/Carnadero Creek  
Gilroy, California

Dear Mr. Anderson:

COTTON, SHIRES AND ASSOCIATES, INC. (CSA) is pleased to provide Schaaf and Wheeler with the following report in which we describe the findings, conclusions and recommendations of our geotechnical investigation for addressing a failing creek bank at Christopher Ranch, in Gilroy, California. In this report, we describe our scope of work, provide a description of the project, describe the surface and subsurface conditions as well as the seismic setting, and provide conclusions, recommendations and the limitations of our investigation.

We appreciate the opportunity to have been of service to you on this project. If you have any questions regarding this report, please feel free to contact us.

Sincerely,

COTTON, SHIRES AND ASSOCIATES, INC.

David T. Schrier  
Principal Geotechnical Engineer  
GE 2334

Andrew T. Mead  
Senior Engineering Geologist  
CEG 2560
# Table of Contents

**EXECUTIVE SUMMARY**
- Conclusions
- Recommendations

**1.0 INTRODUCTION**
- 1.1 Project Description
- 1.2 Purpose and Scope of Work

**2.0 PHYSICAL AND GEOLOGIC SETTING**
- 2.1 Terrain
- 2.2 Geologic Setting
- 2.3 Seismic Setting
  - 2.3.1 Peak Ground Acceleration

**3.0 SITE CONDITIONS**
- 3.1 Surface Conditions
  - 3.1.1 Creek Bank Stability
- 3.2 Subsurface Conditions
  - 3.2.1 Laboratory Testing
- 3.3 Groundwater Conditions

**4.0 POTENTIAL GEOLOGIC AND GEOTECHNICAL HAZARDS**
- 4.1 Creek Bank Failure (Landslide, Erosion and Scour)
- 4.2 Seismic Ground Shaking

**5.0 RECOMMENDATIONS**
- 5.1 Selected Alternative to Arrest Future Creek Bank Failures
- 5.2 General Recommendations
- 5.3 Grading
  - 5.3.1 Site Preparation
  - 5.3.2 Compaction
  - 5.3.3 Utilities

---

COTTON, SHIRES AND ASSOCIATES, INC.
**Table of Contents (cont.)**

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.4 Erosion Control</td>
<td>15</td>
</tr>
<tr>
<td>5.5 Seismic Design</td>
<td>15</td>
</tr>
<tr>
<td>5.6 Technical Review</td>
<td>15</td>
</tr>
<tr>
<td>5.7 Earthwork Construction Observation and Testing</td>
<td>16</td>
</tr>
<tr>
<td>6.0 INVESTIGATION LIMITATIONS</td>
<td>16</td>
</tr>
<tr>
<td>7.0 REFERENCES</td>
<td>18</td>
</tr>
<tr>
<td>7.1 Maps and Reports</td>
<td>18</td>
</tr>
</tbody>
</table>

**APPENDIX A - Field Investigation and Logs of Exploratory Borings**

- Field Investigation ........................................................................ A-1
- Logs of Exploratory Borings ...................................................... Follows A-1

**APPENDIX B - Laboratory Testing** ....................................................... B-1

**FIGURES**

<table>
<thead>
<tr>
<th>FIGURE</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Site Location Map</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Regional Geologic Map</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>San Francisco Bay Area Fault Map</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>Full Site Engineering Geologic and Site Identification Map</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>Engineering Geologic Map Site 1</td>
<td>6</td>
</tr>
<tr>
<td>6</td>
<td>Engineering Geologic Map Site 2</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>Engineering Geologic Cross Section 1-1’</td>
<td>6</td>
</tr>
<tr>
<td>8</td>
<td>Engineering Geologic Cross Section 2-2’</td>
<td>6</td>
</tr>
<tr>
<td>9</td>
<td>Engineering Geologic Cross Section 3-3’</td>
<td>6</td>
</tr>
<tr>
<td>10</td>
<td>Engineering Geologic Cross Section 4-4’</td>
<td>6</td>
</tr>
</tbody>
</table>
EXECUTIVE SUMMARY

In this Executive Summary, Cotton, Shires and Associates, Inc. (CSA) is providing a summary of the pertinent conclusions and recommendations resulting from our Geotechnical Investigation, of the over-steepened, and failing creek bank on Uvas/Carnadero Creek at Christopher Ranch in Gilroy, California. In this report, we characterize the geologic and geotechnical conditions in the vicinity of creek bank, provide a discussion regarding geologic and geotechnical hazards along the creek, discuss alternative measures to address the failing creek bank and possibly reclaim failed property, and provide recommendations for the selected alternative to arrest future creek bank stability. A more detailed discussion of our findings, conclusions and recommendations is presented in the main body of this report.

Conclusions

• The northern side of Christopher Ranch is bounded by Uvas/Carnadero Creek. The channel is roughly 90 feet wide at the top, 30 to 40 feet wide at the bottom, and about 24 feet deep.

• During the winter of 2016-2017, a roughly 12- to 13-foot wide by 85-foot long section of creek bank failed into the channel and dropped about 12 to 13 feet. The failure mechanism appears to consist of the creek scouring and undermining the base of the bank, which then resulted in a portion of the creek slumping into the channel.

• In our subsurface exploration we encountered alluvium consisting of gravels, sands, silts and clays which extended to the bottoms of our borings. We also encountered a 14 to 20-foot thick layer of very loose to medium dense silty sand and medium stiff sandy silt beginning at the ground surface. We didn’t encounter moderate to high blow count material until a depth of about 40 feet in all four borings.

• Groundwater was encountered in borings between depth of 23 to 31 feet, at the time of drilling.

• We observed that old vehicles, a vending machine and concrete slabs had been placed on the slope downstream of the recent failure, likely placed to shore-up the creek bank and mitigate previous failures.
The very loose to medium dense silty sand and medium stiff sand silt layer encountered down to 14 to 20 feet, and several other layers of sands and silts located between 30 and 40 feet are susceptible to seismically induced creek bank failures (landsliding), liquefaction (below the groundwater) and dry densification (above the groundwater), with a total settlement of up to 6-3/4 inches.

**Recommendations**

- Several alternatives were considered and evaluated to address the high potential for future creek bank failures to further erode and encroach on the Christopher Ranch property, including rip rap, shotcrete and soil nail facing, cement mixed soil columns, Ultrablock wall, and a shear pin and tieback wall. Ultimately, Christopher Ranch Management selected an alternative that consists of placing rock slope protection (rip rap) across the failing and incipient failure slopes.

- The rip rap for the rock slope protection should be sized based on calculated flow velocities. The rock slope protection should be placed no steeper than 1.5:1 (H:V) and equipped with a toe keyway. The rip rap should be placed on horizontal benches and vertical steps excavated into the slope.

- The final drawings and specifications should be reviewed and approved by a representative of our firm to confirm that the recommendations of this report have been incorporated into the design of the project.

- Earthwork construction activities should be observed and tested by a representative of our firm to confirm that the recommendations of this report are incorporated into the construction of the project and to address potential unanticipated soil conditions not encountered during site investigation.

COTTON, SHIRES AND ASSOCIATES, INC.
1.0 INTRODUCTION

1.1 Project Description

In this report, Cotton, Shires and Associates, Inc. (CSA) presents the results of our geotechnical investigation for stabilizing a creek bank along Uvas/Carnadero Creek at Christopher Ranch in Gilroy, California. Christopher Ranch is located in southern Gilroy, and bordered by Uvas/Carnadero Creek to the north, Bloomfield Avenue to the east, Highway 25 to south, and train tracks to the west (See Figure 1).

We understand that the subject section of creek bank has been failing for some time, and that during the 2016/2017 winter a significant section of the bank failed in the vicinity of Building N (Figure 4). It appears that the failure is encroaching towards existing buildings, and we further understand that Christopher Ranch would like to stabilize the creek bank to mitigate the potential for future failures that could undermine their buildings and other improvements, and if possible, reclaim lost land.

1.2 Purpose and Scope of Work

The purpose of our investigation was to develop geotechnical data and recommendations for stabilizing the subject section(s) of creek. Our objectives were to: 1) evaluate surface and subsurface conditions; and 2) develop conclusions and recommendations regarding geotechnical hazards, creek bank stabilization alternatives, and corresponding design criteria. The specific scope of work performed for our investigation included the following tasks:

1) Reviewed available geologic data;
2) Performed a geotechnical reconnaissance of the creek bank area;
3) Performed a topographic survey of the creek bank area;
4) Prepared a topographic base map of the creek bank area;
5) Performed engineering geologic mapping of the creek bank area;
6) Explored the subsurface conditions along the creek bank with four borings;
7) Performed laboratory testing;
8) Performed geotechnical engineering and geologic analyses;
9) Formulated conclusions, identified alternative mitigation measures and corresponding relative costs; and
10) Prepared this report.

2.0 PHYSICAL AND GEOLOGIC SETTING

2.1 Terrain

Christopher Ranch is relatively level and located at roughly elevation 175 feet. Natural grades in the area slope gently down toward Uvas/Carnadero Creek.

2.2 Geologic Setting

Christopher Ranch is located at the southern end of the northwest/southeast-trending Santa Clara Valley, bounded by the Santa Cruz Mountains to the southwest and the Diablo Range to the northeast. The site is mapped as being underlain by natural levee deposit alluvium (Geology of Southernmost Santa Clara County, California; see attached Figure 2, Regional Geologic Map).

The site is located within the Coast Range Geomorphic Province, not far from the transform fault boundary (the San Andreas Fault) between the Pacific and North American tectonic plates.

2.3 Seismic Setting

Christopher Ranch is situated in an area of high seismicity. The nearest and controlling active faults, with respect to site seismicity, are the Sargent Fault located approximately 2.1 miles (3.4 km) to the southwest, the Calaveras Fault located approximately 3.7 miles (6.0 km) to the northeast, and the San Andreas Fault located approximately 6.1 miles (9.8 km) to the southwest (see attached San Francisco Bay Area Fault Map, Figure 3).

2.3.1 Peak Ground Acceleration - We performed a peak ground acceleration analysis of the site employing the USGS Seismic Design Tool, with the 2010 ASCE 7 (with March 2013
EXPLANATION

Earth Materials

Alluvium
Qhl Natural levee deposits (Holocene)
Qhfp Floodplain deposits (Holocene)
Qhaf Alluvial fan and fluvial deposits (Holocene)
Qpaf Alluvial fan and fluvial deposits (Pleistocene)

Franciscan Complex and associated rocks
Kfpg Greenstone agglomerate

Type A Fault (with segmentation boundaries)

Type B Fault

San Andreas Fault Zone Segments
SAFZ-1 North Coast Segment
SAFZ-2 Peninsula Segment
SAFZ-3 Santa Cruz Mountains Segment
SAFZ-4 Creeping Segment

Abbreviated Faults
M Maacama Fault
MB Monterey Bay - Tularcitos Fault
MDT Mount Diablo Thrust Fault
MV Monta Vista - Shannon Fault
O Ortigalita Fault
PR Point Reyes Fault
QS Quien Sabe Fault
R Rinconada Fault
S Sargent - Berrocal Fault
WN West Napa Fault
Z Zayante - Vergeles Fault

Christopher Ranch

CONSULTING ENGINEERS AND GEOLOGISTS
APPROVED BY
GEO/ENG BY SCALE DATE FIGURE NO.
COTTON, SHIRES AND ASSOCIATES, INC.
E5617 JULY 2018 3
CONSULTING ENGINEERS AND GEOLOGISTS

SAN FRANCISCO BAY AREA FAULT MAP
Christopher Ranch Creek Bank Stabilization
Gilroy, California

GEO/ENG BY SCALE PROJECT NO.
RR 1"=25 mi E5617
APPROVED BY DATE FIGURE NO.
DTS JULY 2018 3
errata) Design Code. The results of our analysis indicate an appropriate Maximum Considered Earthquake Geometric Mean (MCEG) Peak Ground Acceleration (PGA) of 0.59g.

Taking into account the faults described above, the 2016 California Building Code (CBC), the ASCE 7-10 code coefficients presented in Section 5.5 of this report, and the results of the peak ground acceleration analysis, it is our opinion that Christopher Ranch could experience a peak horizontal ground acceleration (PGA) as high as 0.59g.

3.0 SITE CONDITIONS

3.1 Surface Conditions

From west to east, the structures located adjacent to the Uvas/Carnadero Creek Bank at Christopher Ranch include Scales, Buildings I, J, C3, AL, a Propane Tank, Buildings S3, AM, N, another Propane Tank, Boiler, Seed Tanks, and Building V. The adjacent ground between Building N and Building V is paved with asphalitic concrete (AC), and there is a fence extending along the top of the creek bank.

The creek channel is approximately 80 to 90 feet wide across the top of the bank and about 20 to 30 feet wide at the bottom of the channel. The bottom of the channel is approximately, 24 feet below the top of the channel. The creek flows west to east at Christopher Ranch.

Mature trees and brush line the sides and center of the channel, and a couple of trees had recently fallen across the channel.

3.1.1 Creek Bank Instability - During our initial site reconnaissance, we observed a roughly 12- to 13-foot wide by 85-foot long section of creek bank that had failed and dropped about 12 to 13 feet. For future reference, we’ve designated this failure as the Seed Tank Failure. The Seed Tank Failure area was protected with a temporary fence. Toward the eastern end of the Seed Tank Failure, we observed a bowl-shaped depression that extended approximately 9 feet toward the seed tanks, and extended for about 20 feet along the recently formed scarp (See Figure 4).
Silty Fine Sand with little to no binder, poorly consolidated, with varying amounts of pebble/gravel near approximately elevation 162', medium yellow/orange brown, dry, loose (isolated) to medium dense, moderately friable, erosive

Clayey Silt Fine Sand (Paleosol Ele 160'), 6"-10" medium to dark brown soil horizon, dry, dessication cracks, dense/hard, little to no pebbles, resistant

Clayey Silt Fine Sand (Paleosol Ele 155'), 6"-10" dark/dusky brown, soil horizon, dry, dessication cracks, dense/hard, little to no pebbles, resistant

Tension Crack
Limit of Recent Creek Bank Failure
Location of Small-Diameter Exploratory Boring
Geologic Contact, dashed where approximate, queried where uncertain
Contours Derived from CSA Topographic Survey
Contours Derived from Santa Clara Valley Water District LiDAR
Location of Engineering Geologic Cross Section
During our engineering geologic mapping of the creek bank, we also observed areas of soil creep, bank slough, insipient failure and landslide scarps including behind Buildings I, J and C3, Building C3 and N, and east of Building N.

We also observed that old cars, a vending machine, concrete blocks, and railroad tracks, had been cabled to the creek bank adjacent to the downstream (eastern) end of the Seed Tank Failure.

3.2 Subsurface Conditions

We explored subsurface conditions adjacent to the Seed Tank Failure between December 6 and 7, 2018 by means of three exploratory boring drilled to depths of 51.5 feet to 73 feet at the locations shown on Figure 4, 5 and 6. We also explored the subsurface conditions adjacent to sloughing creek bank behind Building J on April 10, 2018. In our borings we generally encountered alluvial sands, silts and clays. In the borings drilled adjacent to the Seed Tank Failure (CSA/SD-1, CSA/SD-2 and CSA/SD-3), we generally encountered 16 to 20 feet of very loose to medium dense silty sand and medium stiff sand silty, overlying a 15- to 20-foot thick medium stiff to stiff layer of clay and silt. Below the clay, we encountered varying thicknesses of gravels, sands, clays and some silts to the bottom of the borings (Figures 7, 8 and 9). In general, the blow counts increased significantly below depths of about 40 feet in these three borings.

In the boring drilled behind Building J, we encountered a 14-foot thick layer of very loose to medium dense silty sand overlying a 16-foot thick layer of stiff to very stiff clay. Below the clay, we encountered medium dense to very dense silty sand and dense silty gravel which extended to the bottom of the boring at 42.5 feet (Figure 10). The blow counts increased significantly below 31.5 feet.

3.2.1 Laboratory Testing - We performed laboratory tests on disturbed and relatively undisturbed soil samples obtained from our borings. Those tests included Atterberg limits, in-situ unit weight, natural moisture content, sieve analysis, #200 sieve wash analysis, and consolidated undrained triaxial compression test. Based on the results of these tests, it appears that the sandy/silty soils in the upper 16 to 20 feet adjacent to the Seed Tank Failure (Borings CSA/SD-1, CSA/SD-2 and CSA/SD-3) have low to high fines content (25% to 52%), low to moderate dry unit weights (93pcf to 100 pcf), moderate to high moisture content (13.0% to 20.9%), and low plasticity (Liquid Limits = 28 to 31, Plasticity Indices = 8 to 11). The laboratory test results on the underlying 15- to 20-foot thick clay and silty layer indicates that these soils
Loose debris: concrete slabs, railroad ties, trees, vegetation snags
Mass of trees, garbage, concrete blocks, cars, and vertical railroad ties

Circular cracks
Bowl-shaped depression

Slough Depression

Slope rolling

Dessication cracks ~ 1' 8" snags ~12' above creek bed ~ 164'

Cutbank ~8'-10' high

Gravel bar covered in vegetation

Paleosol 155' covered

High water mark

EARTH MATERIALS

SURFICIAL DEPOSITS:

Landslide Deposits: recent slough off of over-steepened creek bank
Active Channel Deposits; Sand and Gravel

ALLUVIUM:

Silty Fine Sand with little to no binder, poorly consolidated, with varying amounts of pebble/gravel near approximately elevation 162', medium yellow/orange brown, dry, loose (isolated) to medium dense, moderately friable, erosive

Clayey Silt Fine Sand (Paleosol Ele 160'), 6"-10" medium to dark brown soil horizon, dry, dessication cracks, dense to hard, semi consolidated, sparse rounded pebbles, resistant

Clayey Silty Fine Sand (paleosol Ele 155'), 6"-10" dark/dusky brown, soil horizon, dry, dessication cracks, dense/hard, little to no pebbles, resistant

EXPLANATION

MAP SYMBOLS

Location of Engineering Geologic Cross Section
Contours Derived from CSA Topographic Survey
Contours Derived from Santa Clara Valley Water District LIDAR
Geologic Contact, dashed where approximate, queried where uncertain
Location of Small Diameter Exploratory Boring
Tension Crack
Limit of Recent Creek Bank Failure

Christopher Ranch
GILROY, CALIFORNIA

COTTON, SHIRES AND ASSOCIATES, INC
CONSULTING ENGINEERS AND GEOLOGISTS

ENGGEOL MAP SITE 1

GEOENG BY AM
APPROVED BY DT9
PROJECT NO. E5617
SCALE 1"=30'
DATE JULY 2018
FIGURE NO. 5

60
30
15
0
0 15 30 60 (feet)
CARNADERO CREEK

Slope rollover

Leaf litter

Bench

Rollover minor dessication cracks

Bench

Sloughing

Undermining fence footing

Drainage-related soft ground cracks (dessication)

Creeping soil

Voids under foundation slab

Soil dropping ~4"-6" from concrete slab foundation

Hydrophyllic Grasses

Cutbank ~8'-10' high

CSA/SD-4

Paleosol 155'

Paleosol 160'

Paleosol 160' covered

High water mark

S3

AM

I

J

C3

EARTH MATERIALS

ALLUVIUM:

1 Silty Fine Sand with little to no binder, poorly consolidated, with varying amounts of pebble/gravel near approximately elevation 162', medium yellow/orange brown, dry, loose (isolated) to medium dense, moderately friable, erosive

2 Clayey Silt Fine Sand (Paleosol Ele 160'), 6"-10" medium to dark brown soil horizon, dry, dessication cracks, dense to hard, semi consolidated, sparse rounded pebbles, resistant

3 Clayey Silt Fine Sand (Paleosol Ele 155'), 6"-10" dark/dusky brown, soil horizon, dry, dessication cracks, dense/hard, little to no pebbles, resistant

EXPLANATION

MAP SYMBOLS

- Tension Crack
- Limit of Creek Bank Sloughing
- Location of Engineering Geologic Cross Section
- Contours Derived from CSA Topographic Survey
- Contours Derived from Santa Clara Valley Water District LiDAR
- Geologic Contact, dashed where approximate, queried where uncertain

COTTON, SHIRES AND ASSOCIATES, INC.
CONSULTING ENGINEERS AND GEOLOGISTS
GILROY, CALIFORNIA

GEOENG BY
AM
Christopher Ranch
GILROY, CALIFORNIA

SCALE
1"=30'

PROJECT NO.
E5617

APPROVED BY
DTS
JULY 2018

FIGURE NO.
6
Silty Fine Sand with little to no binder, poorly consolidated, with varying amounts of pebble/gravel near approximately elevation 162', medium yellow/orange brown, dry, loose (isolated) to medium dense, moderately friable, erosive

Clayey Silt Fine Sand (Paleosol Ele 160'), 6"-10" medium to dark brown soil horizon, dry, dessication cracks, dense to hard, semi consolidated, sparse rounded pebbles, resistant

Clayey Silty Fine Sand (paleosol Ele 155'), 6"-10" dark/dusky brown, soil horizon, dry, dessication cracks, dense/hard, little to no pebbles near surface, increased gravels with depth, resistant
Silty Fine Sand with little to no binder, poorly consolidated, with varying amounts of pebble/gravel near approximately elevation 162', medium yellow/orange brown, dry, loose (isolated) to medium dense, moderately friable, erosive

Clayey Silt Fine Sand (Paleosol Ele 160'), 6"-10" medium to dark brown soil horizon, dry, dessication cracks, dense to hard, semi consolidated, sparse rounded pebbles, resistant

Sandy Clay grading to Clayey Silty Fine Sand with depth (Paleosol Ele 155'), 6"-10" dark/dusky brown, soil horizon, dry, dessication cracks, dense/hard, little to no pebbles, resistant

EXPLANATION

EARTH MATERIALS

SURFICIAL DEPOSITS:
- **Als**: Landslide Deposits: recent slough off of over-steepened creek bank
- **Qac**: Active Channel Deposits: Sand and Gravel

ALLUVIUM:
1. Silty Fine Sand with little to no binder, poorly consolidated, with varying amounts of pebble/gravel near approximately elevation 162', medium yellow/orange brown, dry, loose (isolated) to medium dense, moderately friable, erosive
2. Clayey Silt Fine Sand (Paleosol Ele 160'), 6"-10" medium to dark brown soil horizon, dry, dessication cracks, dense to hard, semi consolidated, sparse rounded pebbles, resistant
3. Sandy Clay grading to Clayey Silty Fine Sand with depth (Paleosol Ele 155'), 6"-10" dark/dusky brown, soil horizon, dry, dessication cracks, dense/hard, little to no pebbles, resistant

MAP SYMBOLS
- **Assumed Geologic Contact**
- **Groundwater**
- **Paleosol**
- **Location of Small-Diameter Exploratory Boring**
- **CSA/SD-2**
Silty Fine Sand with little to no binder, poorly consolidated, with varying amounts of pebble/gravel near approximately elevation 162’, medium yellow/orange brown, dry, loose (isolated) to medium dense, moderately friable, erosive

Silty Sandy Clay (Paleosol Ele 160’), 6”-10” medium to dark brown soil horizon, dry, dessication cracks, dense to hard, semi consolidated, sparse rounded pebbles, resistant

Sandy Clay grading to Clayey Silty Fine Sand at depth (paleosol Ele 155’), 6”-10” dark/dusky brown, soil horizon, dry, dessication cracks, dense/hard, little to no pebbles, resistant

**EXPLANATION**

**MAP SYMBOLS**

- Qac: Active Channel Deposits; Sand and Gravel

**ALLUVIUM:**

- 1: Silty Fine Sand with little to no binder, poorly consolidated, with varying amounts of pebble/gravel near approximately elevation 162’, medium yellow/orange brown, dry, loose (isolated) to medium dense, moderately friable, erosive

- 2: Silty Sandy Clay (Paleosol Ele 160’), 6”-10” medium to dark brown soil horizon, dry, dessication cracks, dense to hard, semi consolidated, sparse rounded pebbles, resistant

- 3: Sandy Clay grading to Clayey Silty Fine Sand at depth (paleosol Ele 155’), 6”-10” dark/dusky brown, soil horizon, dry, dessication cracks, dense/hard, little to no pebbles, resistant

- CSA/SD-3: Location of Small-Diameter Exploratory Boring

- TD = 51.5': Assumed Geologic Contact

- Groundwater

- Paleosol

**Christopher Ranch**
Silty Fine Sand with little to no binder, poorly consolidated, with varying amounts of pebble/gravel near approximately elevation 162', medium yellow/orange brown, dry, loose (isolated) to medium dense, moderately friable, erosive

Sandy Silt Clay (Paleosol Ele 160'), 6'-10' medium to dark brown soil horizon, dry, dessication cracks, dense to hard, semi consolidated, sparse rounded pebbles, resistant

Clayey Silt Clay (Paleosol Ele 155'), 6'-10' dark/dusky brown, soil horizon, dry, dessication cracks, dense/hard, little to no pebbles near surface, increasing gravels at depth, resistant

Assumed Geologic Contact

Groundwater

Paleosol

Location of Small-Diameter Exploratory Boring

UNDERMINED FENCE

APPROXIMATE PRE-FAILURE TOPOGRAPHY

RECENT FAILURE EVACUATION SCAR

CSA/SD-4 (proj. 46.5')

Building J

Approximate Pre-Failure Topography

Recent Failure Evacuation Scar

Bolsa Road

Undermined Fence

Building J

1. Silty Fine Sand with little to no binder, poorly consolidated, with varying amounts of pebble/gravel near approximately elevation 162', medium yellow/orange brown, dry, loose (isolated) to medium dense, moderately friable, erosive

2. Sandy Silt Clay (Paleosol Ele 160'), 6'-10' medium to dark brown soil horizon, dry, dessication cracks, dense to hard, semi consolidated, sparse rounded pebbles, resistant

3. Clayey Silt Clay (Paleosol Ele 155'), 6'-10' dark/dusky brown, soil horizon, dry, dessication cracks, dense/hard, little to no pebbles near surface, increasing gravels at depth, resistant
have low to moderate plasticity (Liquid Limits = 26 to 48, Plasticity Indices = 8 to 22), low to moderate dry unit weights (94 pcf to 108 pcf), moderate to high moisture content (21.2% to 28.1%), high fines content (68%), and moderate shear strength (C' = 100 psf \( \phi' = 33.9^\circ \)).

Based on the results of laboratory test results on samples taken from Boring CSA/SD-4 (behind Building J), the 14-foot thick layer of silty sand has low to moderate dry unit weights (90 to 100 pcf) and moderate to high moisture content (18.4% to 23.4%). The laboratory test results also indicate that the underlying clayey soil has low to moderate plasticity (Liquid Limits = 33 to 41, Plasticity Indices = 8 to 22), low dry unit weights (99 pcf), high moisture content (26.5%), and moderate shear strength (C' = 0 psf \( \phi' = 34^\circ \)). Laboratory test results on the soil below 30 feet indicate that the sands have low dry unit weight (105 pcf), moderate moisture content (20.6%), and low fines content (9.7%).

The results of the laboratory tests performed on representative samples are presented on the boring logs in Appendix A (Field Investigation) and in Appendix B (Laboratory Testing).

A detailed description of the exploration program and our logs of the exploratory borings are presented in Appendix A.

3.3  **Groundwater Conditions**

We encountered groundwater in the following borings at the corresponding depths at the time of drilling:

- Boring CSA/SD-1: 31 feet
- Boring CSA/SD-2: 29 feet
- Boring CSA/SD-3: 28 feet
- Boring CSA/SD-4: 23 feet

It should be understood that Borings CSA/SD-1, CSA/SD-2 and CSA/SD-3 were drilled at the beginning of December, when groundwater levels are typically lower, while CSA/SD-4 was drilled in April when groundwater levels are generally at their highest level. Furthermore, fluctuations in groundwater levels could occur from variations in rainfall, flooding and other factors. Groundwater levels may be different at different times, climatic conditions and locations.
4.0 POTENTIAL GEOLOGIC AND GEOTECHNICAL HAZARDS

Geologic and geotechnical hazards along Uvas/Carnadero Creek at Christopher Ranch include the following: 1) creek bank failures (landslides, erosion and scour); and 2) seismic shaking, liquefaction/lateral spreading. In the following sections, we describe these hazards along with corresponding degrees of determined potential risk, and provide design recommendations.

4.1 Creek Bank Failure (Landslide, Erosion and Scour)

Based on our investigation and mapping, we judge that the potential for future creek bank failures along the Uvas/Carnadero Creek Bank, including landslide, erosion and scour to be high, in part due to the very loose to medium dense silty sandy and medium stiff sandy silt materials encountered in our borings down to depths of 14 to 20 feet. Based on the multitude of large debris (cars, a vending machine, concrete blocks, etc.) that has been cabled to the slope, it appears that the Seed Tank Failure area has been experiencing erosion and scour for many years.

We hypothesize that the typical sequence of failure consists of scouring and eroding the lower third of the creek bank, resulting in an oversteepened slope condition, which then collapses into the creek channel.

In order to address the high potential for future creek bank failures to further erode and encroach on the Christopher Ranch property, we considered several alternatives including the following:

1) A row of shear pins, with a tiebeam connecting the tops and a post-tensioned tieback to add additional support;
2) A row of overlapping cement mixed columns;
3) A sculpted shotcrete facing with soil rail anchor support; and
4) Rock slope protection (rip rap revetment).

We also considered two alternatives to reclaim the lost land including the following:

1) A row of shear pins, with a tiebeam connecting the tops and a post-tensioned tieback to add additional support; and
2) An Ultrablock modular block wall with geogrid reinforced backfill.
After discussions with the Project Team, the consensus was that an Ultrablock modular block wall had a high risk of being undermined by creek scour and was therefore eliminated from consideration.

We understand that the Christopher Ranch management selected the rock slope protection alternative to protect the creek bank from future erosion/failures including all areas identified as recently failed and incipient failures.

4.2 **Seismic Ground Shaking**

Seismic ground shaking associated with a large earthquake on either the Sargent, Calaveras, San Andreas or Faults, is considered to be a high potential hazard at Christopher Ranch. Peak ground accelerations of up to 0.59g should be anticipated at the site. Seismically-induced ground failure mechanisms include fault rupture, lurching, landslides, liquefaction, dry densification, and lateral spreading. No active faults have been recognized on, or mapped through the subject property; consequently, the potential for surface faulting and ground rupturing on the property is considered to be low.

The potential for lurching due to earthquake shaking is considered to be moderate, and could result in minor differential settlements, while the potential for seismically induced landsliding of the creek bank is considered to be high. However, the selected rock slope protection should provide some buttressing to reduce the adverse impacts of earthquake-induced creek bank failures along the creek bank. The potential for deep landsliding, which could impact (undermine) the selected rock slope protection, is considered to be low.

Soil liquefaction is a phenomenon in which a saturated, cohesionless or non-plastic, near-surface soil layer loses strength during cyclic loading (such as that typically generated by earthquakes). During the loss of strength, the soil develops mobility sufficient to permit both horizontal and vertical movements. Soils that are most susceptible to liquefaction are loose, saturated, fine-grained sands and non-plastic silts and clays that are generally located within 50 feet of the ground surface. Due to the depth of groundwater (measured as high as 23 feet), the very loose to medium dense sands, a site peak ground acceleration of 0.59g, and the procedure outlined in the Soil Liquefaction During Earthquakes monograph (Idriss, Boulanger), the potential for liquefaction is considered to be high for soils below a depth of 23 feet.
We calculated a high potential for dry densification of the very loose to medium dense sands encountered in our boings above the highest groundwater depth (23 feet) and based on the procedure outlined in the Soil Liquefaction During Earthquakes monograph (Idriss, Boulanger). We calculated these potentials using a site peak ground acceleration of 0.59g, as well as the site boring and laboratory test data.

For both liquefaction and densification analysis, we determined the factors of safety against triggering liquefaction (FS) (dry densification) by calculating the ratio of: 1) the horizontal cyclic shear stress necessary to trigger liquefaction (dry densification), to 2) the average horizontal cyclic shear stress induced by the design earthquake. When this ratio is 1.3 or less (i.e., FS≤1.3), liquefaction (dry densification) is predicted to occur or could potentially be a problem (the State of California considers a FS=1.3 as the threshold for identifying the site as having a liquefaction hazard).

We calculated that there is a high potential for liquefaction dry densification and associated settlement of the very loose to medium dense and medium stiff alluvial soils encountered in all four borings.

In the following table we present a summary of the results of our liquefaction, dry densification and associated settlement analysis by boring:

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>N60</th>
<th>N160</th>
<th>CRR</th>
<th>CSR_eq</th>
<th>N160cs</th>
<th>Volumetric Strain (%)</th>
<th>Settlement (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.75-4.25</td>
<td>7</td>
<td>14</td>
<td>0.21</td>
<td>0.37</td>
<td>22</td>
<td>2.1</td>
<td>0.38</td>
</tr>
<tr>
<td>4.25-5.75</td>
<td>5</td>
<td>10</td>
<td>0.16</td>
<td>0.37</td>
<td>17</td>
<td>2.7</td>
<td>0.49</td>
</tr>
<tr>
<td>7.25-8.75</td>
<td>9</td>
<td>18</td>
<td>0.30</td>
<td>0.36</td>
<td>27</td>
<td>0.9</td>
<td>0.16</td>
</tr>
<tr>
<td>8.75-12.75</td>
<td>9</td>
<td>17</td>
<td>0.27</td>
<td>0.35</td>
<td>26</td>
<td>1.0</td>
<td>0.48</td>
</tr>
<tr>
<td>32-34.25</td>
<td>8</td>
<td>10</td>
<td>0.18</td>
<td>0.19</td>
<td>17</td>
<td>2</td>
<td>0.60</td>
</tr>
<tr>
<td>34.25-36.75</td>
<td>11</td>
<td>15</td>
<td>0.14</td>
<td>0.19</td>
<td>18</td>
<td>1.2</td>
<td>0.36</td>
</tr>
<tr>
<td>36.75-40</td>
<td>4</td>
<td>5</td>
<td>0.07</td>
<td>0.20</td>
<td>8</td>
<td>4.5</td>
<td>1.35</td>
</tr>
</tbody>
</table>

Total Settlement 3.82”
Total Dry Densification Settlement 1.51”
Total Liquefaction Settlement 2.31”
### Boring CSA/SD-2

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>N_{60}</th>
<th>N_{160}</th>
<th>CRR_1</th>
<th>CSR_{eq}</th>
<th>N_{160cs}</th>
<th>Volumetric Strain (%)</th>
<th>Settlement (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-2.75</td>
<td>7</td>
<td>14</td>
<td>0.21</td>
<td>0.38</td>
<td>22</td>
<td>2.1</td>
<td>0.44</td>
</tr>
<tr>
<td>2.75-4.25</td>
<td>2</td>
<td>4</td>
<td>0.10</td>
<td>0.37</td>
<td>10</td>
<td>4.1</td>
<td>0.74</td>
</tr>
<tr>
<td>4.25-5.75</td>
<td>3</td>
<td>6</td>
<td>0.12</td>
<td>0.37</td>
<td>12</td>
<td>3.6</td>
<td>0.65</td>
</tr>
<tr>
<td>5.75-7.25</td>
<td>3</td>
<td>6</td>
<td>0.12</td>
<td>0.37</td>
<td>13</td>
<td>3.5</td>
<td>0.63</td>
</tr>
<tr>
<td>7.25-8.75</td>
<td>7</td>
<td>14</td>
<td>0.21</td>
<td>0.36</td>
<td>22</td>
<td>2.2</td>
<td>0.40</td>
</tr>
<tr>
<td>8.75-12.75</td>
<td>5</td>
<td>9</td>
<td>0.15</td>
<td>0.35</td>
<td>16</td>
<td>2.9</td>
<td>1.40</td>
</tr>
<tr>
<td>12.75-16.75</td>
<td>10</td>
<td>17</td>
<td>0.25</td>
<td>0.28</td>
<td>25</td>
<td>0.8</td>
<td>0.38</td>
</tr>
<tr>
<td>16.75-20</td>
<td>8</td>
<td>12</td>
<td>0.17</td>
<td>0.26</td>
<td>18</td>
<td>2.5</td>
<td>0.75</td>
</tr>
<tr>
<td>35-36.75</td>
<td>11</td>
<td>15</td>
<td>0.16</td>
<td>0.20</td>
<td>21</td>
<td>0.7</td>
<td>0.21</td>
</tr>
<tr>
<td>36.75-40</td>
<td>3</td>
<td>4</td>
<td>0.07</td>
<td>0.20</td>
<td>8</td>
<td>4.2</td>
<td>1.26</td>
</tr>
</tbody>
</table>

**Total Settlement** 6.86”
**Total Dry Densification Settlement** 5.39”
**Total Liquefaction Settlement** 1.47”

### Boring CSA/SD-3

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>N_{60}</th>
<th>N_{160}</th>
<th>CRR_1</th>
<th>CSR_{eq}</th>
<th>N_{160cs}</th>
<th>Volumetric Strain (%)</th>
<th>Settlement (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-2.75</td>
<td>7</td>
<td>14</td>
<td>0.21</td>
<td>0.38</td>
<td>22</td>
<td>2.1</td>
<td>0.44</td>
</tr>
<tr>
<td>2.75-4.25</td>
<td>5</td>
<td>10</td>
<td>0.16</td>
<td>0.37</td>
<td>17</td>
<td>2.7</td>
<td>0.49</td>
</tr>
<tr>
<td>4.25-5.75</td>
<td>5</td>
<td>10</td>
<td>0.16</td>
<td>0.37</td>
<td>17</td>
<td>2.7</td>
<td>0.49</td>
</tr>
<tr>
<td>7.25-8.75</td>
<td>9</td>
<td>18</td>
<td>0.29</td>
<td>0.36</td>
<td>27</td>
<td>0.7</td>
<td>0.13</td>
</tr>
<tr>
<td>8.75-11.25</td>
<td>10</td>
<td>19</td>
<td>0.33</td>
<td>0.35</td>
<td>28</td>
<td>0.6</td>
<td>0.18</td>
</tr>
<tr>
<td>11.25-14.5</td>
<td>12</td>
<td>22</td>
<td>0.35</td>
<td>0.32</td>
<td>29</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>14.5-16</td>
<td>10</td>
<td>17</td>
<td>0.22</td>
<td>0.28</td>
<td>23</td>
<td>1.7</td>
<td>0.82</td>
</tr>
<tr>
<td>30-33.25</td>
<td>8</td>
<td>10</td>
<td>0.14</td>
<td>0.20</td>
<td>17</td>
<td>1.9</td>
<td>1.14</td>
</tr>
<tr>
<td>33.25-40</td>
<td>5</td>
<td>6</td>
<td>0.10</td>
<td>0.20</td>
<td>12</td>
<td>3.5</td>
<td>2.10</td>
</tr>
</tbody>
</table>

**Total Settlement** 5.79”
**Total Dry Densification Settlement** 2.55”
**Total Liquefaction Settlement** 3.24”
**Boring CSA/SD-4**

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>N60</th>
<th>N160</th>
<th>CRR</th>
<th>CSR&lt;sub&gt;eq&lt;/sub&gt;</th>
<th>N160&lt;sub&gt;cs&lt;/sub&gt;</th>
<th>Volumetric Strain (%)</th>
<th>Settlement (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-6.76</td>
<td>3</td>
<td>5</td>
<td>0.11</td>
<td>0.37</td>
<td>11</td>
<td>3.8</td>
<td>1.94</td>
</tr>
<tr>
<td>6.75-10.75</td>
<td>12</td>
<td>20</td>
<td>0.37</td>
<td>0.36</td>
<td>29</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10.75-14.0</td>
<td>10</td>
<td>14</td>
<td>0.21</td>
<td>0.32</td>
<td>22</td>
<td>2.1</td>
<td>0.76</td>
</tr>
<tr>
<td>30-31.5</td>
<td>13</td>
<td>16</td>
<td>0.15</td>
<td>0.22</td>
<td>17</td>
<td>2.1</td>
<td>0.82</td>
</tr>
<tr>
<td>31.5-34</td>
<td>18</td>
<td>25</td>
<td>0.25</td>
<td>0.22</td>
<td>26</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Total Settlement 3.52”
Total Dry Densification Settlement 2.70”
Total Liquefaction Settlement 0.82”

Based on our liquefaction and dry densification induced settlement calculations summarized in the above tables, we anticipate total settlements of between to 3-1/2 and 6-3/4 inches and differential settlements of up to 3-1/2 inches over 30 feet during or immediately following the design seismic event. Structures bearing on deep foundations bearing below a depth of about 40 feet would not be susceptible to the above calculated total and differential seismically induced settlements.

The potential for lateral spreading due to earthquake shaking is considered to be low, due to the highest groundwater depths being at the bottom of the creek channel.

Due to the depth of groundwater (23 feet), there is a low potential for sand boils and ejecta to occur along the creek bank at Christopher Ranch.

In summary, the soils underlying the creek bank are very loose to medium dense and medium stiff and are highly susceptible to liquefaction/densification. Shallow supported wall and barrier alternatives such as Ultrablock, rock slope protection (rip rap) and shotcrete facing will likely experience differential movement during a strong earthquake. However, the selected rock slope protection alternative will likely accommodate localized differential settlement without compromising the overall integrity or the overall structure.

**COTTON, SHIRES AND ASSOCIATES, INC.**
5.0 RECOMMENDATIONS

5.1 Selected Alternative to Arrest Future Creek Bank Failures

We considered various alternative measures to address the over-steepened creek bank, and arrest the on-going and future creek bank scour, including the following: 1) constructing a row of drilled, shear pin piers with tiebacks inboard of the creek bank; 2) constructing a row of drilled, intersecting cement mixed columns inboard of the creek bank; 3) constructing a soil nail and shotcrete wall across the face of the creek bank; and 4) placing rock slope protection (rip rap buttress). We also considered two alternatives to reclaim land that failed during the winter of 2016/2017 in a graben type failure, including the following: 1) a row of drilled shear pin piers with tiebacks; and 2) an Ultrablock modular block wall with geogrid reinforced backfill.

We understand that the Christopher Ranch management selected the rock slope protection (rip rap) alternative to arrest the high potential for future creek bank failures, further erosion and encroachment on the Christopher Ranch property. We also understand that the Christopher Ranch management would like the rock slope protection to extend across all slopes with active and incipient failures.

5.2 General Recommendations

We understand that Schaff and Wheeler will size the rip rap for the rock slope protection based on calculated flow velocities. We also understand that Schaff and Wheeler will determine scour depth also based on flow velocities for designing the toe keyway embedment depths.

We recommend that the rip rap size be equal to, or greater than, Caltrans Facing Class rock. We also recommend that the finished exposed rip rap slope should be no steeper than 1.5:1 (H:V). We further recommend that the rock slope protection should be equipped with a continuous toe keyway at least 6 feet wide and embedded at least 5 feet below the adjacent thalweg of the creek. The keyway should be continuous were the rock slope protection is placed and parallel the top of slope. The rip rap should only be placed on horizontal benches and against vertical cuts.
5.3 **Grading**

Grading excavations should be within the capabilities of heavy duty drilling equipment; however, depending on the time of year, excavations below about a depth of 23 feet (measured from the top of the creek bank) could require dewatering.

5.3.1 **Site Preparation** - All loose material, vegetation, debris, and other deleterious material should be stripped, removed and off-hauled. This material should be disposed of in a suitable, legal location off-site. Excavation for the continuous toe keyway, horizontal benches and vertical steps should proceed as depicted on the plans. Where soft and/or yielding materials is encountered in the bottom of the toe keyway or the surface of the benches, the material should be over-excavated until firm/unyielding material is encountered and replaced with engineered fill or additional rip rap. Areas to be filled should be scarified to at least an 8-inch depth, moisture conditioned to at least optimum moisture content and compacted to at least 90 percent relative compaction based on ASTM D-1557-16.

There are significant amounts about of debris including abandoned vehicles, vending machines, broken concrete, railroad ties, asphaltic concrete, cables, etc. on the bank that should be removed and off-hauled to a dump site, and replaced with the rock slope protection. The surfaces exposed in these areas after removal of the debris should further be excavated to create a continuous toe keyway and horizontal benches and vertical steps.

5.3.2 **Compaction** - Excavated on-site material is suitable for re-use as compacted fill provided it is free of organic material and other debris and rocks greater than 4 inches in maximum dimension. Imported fill should be free of organic material, should contain no material larger than 4 inches and should have a Plasticity Index of less than 16. Once the area has been prepared, including removing debris, any existing fill material, the new fill should be placed in horizontal lifts not exceeding 8 inches in loose lift thickness, moisture conditioned to at least optimum moisture content, and compacted in lifts to at least 95 percent relative compaction within 18 inches below pavements, and 90 percent relative compaction elsewhere.

5.3.3 **Utilities** - If underground utilities are exposed during construction, they should be replaced at least 3 feet below final ground surface. Bedding materials for pipes should be in accordance with the manufacturer’s recommendations. Trenches should be backfilled with either on-site or approved import fill material compacted to a minimum of 90% of maximum dry unit weight in non-structural areas and a minimum of 95% of maximum dry unit weight beneath
structures and the upper 18 inches of pavement. It is important to use equipment and methods that are suitable for work in confined areas without damaging the walls or conduits.

### 5.4 Erosion Control

All grounds disturbed by construction activities should be planted with vegetation or treated with hydroseed prior to exposure to rain. If freshly graded surfaces are exposed to rain, this plan should include properly staked straw bale barriers at the top of the creek bank.

### 5.5 Seismic Design

A Maximum Considered Earthquake (MCER) peak horizontal ground acceleration (PGA<sub>M</sub>) as high as 0.59g, and Design Earthquake peak horizontal ground acceleration of 0.39g should be anticipated for design purposes at the site. Based on our geotechnical investigation, the site location, our interpretation of the 2016 CBC documents related to Earthquake Loads and using the USGS U.S. Seismic Design Maps tool, we are providing the following parameter recommendations from the corresponding figures and tables:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site Classification</td>
<td>D</td>
</tr>
<tr>
<td>Mapped Spectral Acc. 0.2 Sec. (g)</td>
<td>S&lt;sub&gt;s&lt;/sub&gt; = 1.524</td>
</tr>
<tr>
<td>Mapped Spectral Acc. 1 Sec. (g)</td>
<td>S&lt;sub&gt;1&lt;/sub&gt; = 0.664</td>
</tr>
<tr>
<td>Fa – Site Coefficient</td>
<td>1.0</td>
</tr>
<tr>
<td>Fv – Site Coefficient</td>
<td>1.5</td>
</tr>
<tr>
<td>S&lt;sub&gt;MS&lt;/sub&gt; = FaS&lt;sub&gt;s&lt;/sub&gt;</td>
<td>1.524</td>
</tr>
<tr>
<td>S&lt;sub&gt;M1&lt;/sub&gt; = FvS&lt;sub&gt;1&lt;/sub&gt;</td>
<td>0.996</td>
</tr>
<tr>
<td>S&lt;sub&gt;DS&lt;/sub&gt; = 2/3 S&lt;sub&gt;MS&lt;/sub&gt;</td>
<td>1.016</td>
</tr>
<tr>
<td>S&lt;sub&gt;DI&lt;/sub&gt; = 2/3 S&lt;sub&gt;M1&lt;/sub&gt;</td>
<td>0.664</td>
</tr>
</tbody>
</table>

### 5.6 Technical Review

Supplemental geotechnical design recommendations should be provided by our firm based on specific design needs developed by the other project design professionals. This report, and any supplemental recommendations, should be reviewed by the contractor as part of the bid process. It is strongly recommended that no construction be started nor grading undertaken until the
final drawings, specifications, and calculations have been reviewed and approved in writing by a representative of Cotton, Shires and Associates, Inc.

5.7 Earthwork Construction Observation and Testing

All excavations and ground improvement should be observed by a representative of Cotton, Shires and Associates, Inc. prior to filling or pouring of concrete foundations. Any grading should also be observed and tested as appropriate to assure adequate stripping and compaction. Our office should be contacted with a minimum of 48 hours advance notice of construction activities requiring inspection and/or testing services and a minimum of 72 hours advance notice and provision of representative laboratory compaction curve samples for testing of fill.

6.0 INVESTIGATION LIMITATIONS

Our services consist of professional opinions and recommendations made in accordance with generally accepted engineering geology and geotechnical engineering principles and practices. No warranty, expressed or implied, or merchantability of fitness, is made or intended in connection with our work, by the proposal for consulting or other services, or by the furnishing of oral or written reports or findings. It was not within our scope to investigate the site for environmental concerns such as contaminated soils and therefore we accept no liability associated with such materials being present.

Any recommendations and/or design criteria presented in this report are contingent upon our firm being retained to review the final drawings and specifications, to be consulted when any questions arise with regard to the recommendations contained herein, and to provide testing and inspection services for earthwork and construction operations. Unanticipated soil and geologic conditions are commonly encountered during construction which cannot be fully determined from existing exposures or by limited subsurface investigation. Such conditions may require additional expenditures during construction to obtain a properly constructed project. Some contingency fund is recommended to accommodate these possible extra costs.

This report is issued with the understanding that it is the responsibility of the owner, or of his representative, to ensure that the information and recommendations contained herein are called to the attention of the project architect and/or engineer and incorporated into the plans.
Furthermore, it is also the responsibility of the owner, or of his representative, to ensure that the contractor and subcontractors carry out such recommendations in the field.
7.0 REFERENCES

7.1 Maps and Reports


California Department of Conservation, Division of Mines and Geology, Seismic Hazard Zones Map for the Mountain View Quadrangle 7.5-Minute Quadrangle, 2006.

Duncan J.M., Horz R.C., and Yang T.L., August 1989, Shear Strength Correlations for Geotechnical Engineering, Virginia Tech, Department of Civil Engineering, Geotechnical Engineering.

Idriss I.M., Boulanger R.W., Soil Liquefaction During Earthquakes monograph, Earthquake Engineering Research Institute, 2008.


APPENDIX A

Field Investigation
Logs of Exploratory Borings
APPENDIX A
FIELD INVESTIGATION

We explored subsurface conditions at along the top of the creek bank at Christopher Ranch in Gilroy, California on between December 6 and 7, 2017, and on April 10, 2018 by means of four small-diameter exploratory borings drilled to a depth of 42.5 to 73.0 feet using track-mounted hollow-stem auger drilling equipment and a portable solid-stem auger. The locations of the borings are shown on Figure 4. The engineer who logged the borings visually classified the soils in accordance with ASTM D-2487. We obtained relatively undisturbed samples of the materials encountered at selected depths. These samples were obtained in stainless steel liners that were 2.5 inches in outside diameter by 6 inches long, and placed inside a 3-inch diameter modified split-barrel California Sampler for sampling. The California Sampler was driven with an automatic 140-pound hammer that was allowed to freely fall about 30 inches or raised by a rope and cathead system and allowed to freely fall about 30 inches. We also performed Standard Penetration Tests (SPT) at selected depths. The depths of the sampling are shown on the boring logs. The number in the circle at the conclusion of the sampling interval represents the Standard Penetration Test blow count derived by multiplying the Modified California Sampler blow count by a factor of 0.68.

Descriptive logs of the borings are presented in this appendix. These logs depict our interpretation of the subsurface conditions at the dates and locations indicated, based on representative samples collected at roughly five-foot sampling intervals. It is not warranted that they are representative of subsurface conditions at other times and locations. The contacts on the logs represent the approximate boundaries between earth materials, and the transitions between these materials may be gradual.
# Log of Exploratory Drilling

**Project:** Christopher Ranch  
**Location:** 30' SE of Building "N", 15' SW of Power Pole  
**Drilling Contractor/Rig:** Britton Exploration / CME 550 Tracked Rig  
**Ground Surface Elev.:** 174.6'  
**Surface:** Asphalt Concrete  
**Boring:** CSA/SD-1  
**Project No.:** E5617  
**Date of Drilling:** 12/06/2017  
**Hole Diameter:** 8" HSA  
**Weather:** Sunny  

## Geotechnical Description

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Graphic Log</th>
<th>USCS Class.</th>
<th>Sample Type</th>
<th>Moisture Content (%)</th>
<th>SPT Blows/ft</th>
<th>Recov. (%)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0'-15.0'</td>
<td>ML/SM</td>
<td>ML/SM</td>
<td>MC-1</td>
<td>10</td>
<td>SPT-1</td>
<td>2</td>
<td>Driller added water</td>
</tr>
<tr>
<td>15.0'-16.5'</td>
<td>CL</td>
<td>CL</td>
<td>MC-4</td>
<td>3</td>
<td>SPT-2</td>
<td>10</td>
<td>Driller: Paul Britton</td>
</tr>
<tr>
<td>16.5'-20.0'</td>
<td>SC</td>
<td>SC</td>
<td>T-7</td>
<td>2</td>
<td>T-8</td>
<td>4</td>
<td>Helper: Sergio</td>
</tr>
<tr>
<td>20.0'-21.5'</td>
<td>CL/ML</td>
<td>CL/ML</td>
<td>T-10</td>
<td>2</td>
<td>T-9</td>
<td>4</td>
<td>Start Time = 08:15</td>
</tr>
<tr>
<td>21.5'-26.0'</td>
<td>ML</td>
<td>ML</td>
<td>MC-6</td>
<td>3</td>
<td>SPT-6</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>26.0'-32.0'</td>
<td>CL</td>
<td>CL</td>
<td>MC-1</td>
<td>3</td>
<td>SPT-1</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

**Geotechnical Description:**
- **0.5'-BOH ALLUVIUM:**  
  - 0.0'-15.0' Sandy Silt to Silty Sand - Light-brown, medium stiff/loose, dry
  - 15.0'-16.5' Sandy Clay - Dark-brown, very stiff, moist
  - 16.5'-20.0' Clayey Sand - Dark-brown, medium dense, moist, trace gravel
  - 20.0'-21.5' Silty Clay to Clayey Silt - Brown, stiff, moist
  - 21.5'-26.0' Clayey Silt - Black, stiff, moist, iron oxide streaks
  - 26.0'-32.0' Silty Clay - Brown, medium stiff, moist

**Remarks:**
- LL=31, PI=13
- 200 wash: 39% fines
- LL=43, PI=16
- TX/CU φ'=33.9°, C'=100 psf
<table>
<thead>
<tr>
<th>Depth (feet)</th>
<th>Graphic Log</th>
<th>USCS Class.</th>
<th>Geotechnical Description</th>
<th>Sample Design</th>
<th>Dry Unit Weight (pcf)</th>
<th>Moisture Content (%)</th>
<th>SPT Blows/ft</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>ML</td>
<td>ML</td>
<td>32.0’-35.0’ Silty Clay - Brown, medium stiff, wet</td>
<td>MC-7</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>MC</td>
</tr>
<tr>
<td>34</td>
<td></td>
<td></td>
<td></td>
<td>T-11</td>
<td></td>
<td></td>
<td>34</td>
<td>200 wash: 68% fines</td>
</tr>
<tr>
<td>36</td>
<td>GP</td>
<td>GP</td>
<td>35.0’-40.0’ Sandy Gravel - Brown, very loose to medium dense, saturated</td>
<td>T-13</td>
<td>11</td>
<td>12</td>
<td>11</td>
<td>SPT 36</td>
</tr>
<tr>
<td>38</td>
<td></td>
<td></td>
<td></td>
<td>MC-8</td>
<td></td>
<td></td>
<td>4</td>
<td>* No Recovery</td>
</tr>
<tr>
<td>40</td>
<td></td>
<td>CL</td>
<td>40.0’-45.0’ Gravely Sandy Clay - Brown, very stiff, saturated</td>
<td>T-14</td>
<td>10</td>
<td>18</td>
<td>17</td>
<td>SPT 40</td>
</tr>
<tr>
<td>42</td>
<td></td>
<td></td>
<td></td>
<td>T-15</td>
<td></td>
<td></td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>44</td>
<td></td>
<td></td>
<td></td>
<td>MC-9</td>
<td></td>
<td></td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>46</td>
<td>GW-GC</td>
<td>GW-GC</td>
<td>45.0’-51.5’ Clayey Sandy Gravel - Dark-brown, dense, saturated</td>
<td>T-16</td>
<td>31</td>
<td>33/6</td>
<td>30</td>
<td>SPT 46</td>
</tr>
<tr>
<td>48</td>
<td></td>
<td>CL</td>
<td></td>
<td>T-17</td>
<td></td>
<td></td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td>MC-10</td>
<td></td>
<td></td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>52</td>
<td></td>
<td>CL</td>
<td></td>
<td>SPT-10</td>
<td>15</td>
<td>19</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>54</td>
<td></td>
<td></td>
<td></td>
<td>SPT-11</td>
<td>4</td>
<td>6</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>56</td>
<td>SM</td>
<td>SM</td>
<td>55.0’-70.5’ Silty Sand - Light-brown, medium dense to very dense, saturated, fine to medium sand</td>
<td>T-20</td>
<td>6</td>
<td>9</td>
<td>18</td>
<td>SPT 56</td>
</tr>
<tr>
<td>58</td>
<td></td>
<td></td>
<td></td>
<td>T-21</td>
<td></td>
<td></td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>SM</td>
<td>SM</td>
<td>61’ - With silt and gravel, olive-brown, dense</td>
<td>T-22</td>
<td>14</td>
<td>30</td>
<td>17</td>
<td>* No Bag Sample</td>
</tr>
<tr>
<td>62</td>
<td></td>
<td></td>
<td></td>
<td>T-23</td>
<td></td>
<td></td>
<td>14</td>
<td></td>
</tr>
</tbody>
</table>

**Remarks:**
- LL=26, PI=8
- No Bag Sample

* Sheet 2 of 3 *
<table>
<thead>
<tr>
<th>Depth (feet)</th>
<th>Graphic Log</th>
<th>Geotechnical Description</th>
<th>Sample Type</th>
<th>Moisture Content (%)</th>
<th>SPT Blows/ft</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>66</td>
<td></td>
<td>55.0’-70.5’ Silty Gravelly Sand - Olive-brown, very dense, saturated, fine to medium sand</td>
<td>T-24, T-25</td>
<td>MC</td>
<td>34, 50/6”</td>
<td>* No Bag Sample</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>SPT-14</td>
<td></td>
<td>11, 22</td>
<td>68</td>
</tr>
<tr>
<td>68</td>
<td></td>
<td></td>
<td>T-26, T-27</td>
<td>63/9”</td>
<td>12, 45</td>
<td>* No Bag Sample</td>
</tr>
<tr>
<td>70</td>
<td></td>
<td>70.5’-BOH Sand - Dark-gray to brown, very dense, saturated, medium to coarse sand</td>
<td>T-26, T-27</td>
<td>63/9”</td>
<td>12, 45</td>
<td>12:30 SCVWD Arrived</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>SPT-15</td>
<td></td>
<td>13, 27</td>
<td>72</td>
</tr>
<tr>
<td>74</td>
<td></td>
<td>Total Depth = 73.0 feet</td>
<td></td>
<td>77/11</td>
<td></td>
<td>12:45 Completed Sampling</td>
</tr>
<tr>
<td>74</td>
<td></td>
<td>Groundwater - 31.0 feet</td>
<td></td>
<td>77/11</td>
<td></td>
<td>13:40 Completed Seal</td>
</tr>
</tbody>
</table>

* No Bag Sample
## Log of Exploratory Drilling

**Project:** Christopher Ranch  
**Location:** 10' N of Boiler Tank  
**Drilling Contractor/Rig:** Britton Exploration / CME 550 Tracked Rig  
**Ground Surface Elev.:** 174.5  
**Logged By:** TRH  
**Surface:** Asphalt Concrete  

**Boring:** CSA/SD-2  
**Project No.:** E5617  
**Date of Drilling:** 12/06/2017 - 12/07/2017  
**Hole Diameter:** 8” HSA  
**Weather:** Sunny  

### Geotechnical Description

<table>
<thead>
<tr>
<th>Depth (feet)</th>
<th>Graphic Log</th>
<th>USCS Class.</th>
<th>Sample Design</th>
<th>Dry Unit Weight (pcf)</th>
<th>Moisture Content (%)</th>
<th>SPT Blows/ft</th>
<th>Sample Type</th>
<th>Recov. (%)</th>
<th>Remarks</th>
</tr>
</thead>
</table>
| 2 | ML/SM | CL | 1 | 1 | 4 | 7 | MC | 2 | Driller: Paul Britton  
200 wash: 52% fines |
<p>| 4 | ML/SM | CL | T-1 | T-2 | MC-1 | 13 | 7 | 4 | 200 wash: 52% fines |
| 6 | ML/SM | CL | SPT-1 | 2 | 1 | 1 | SPT | 4 | |
| 8 | ML/SM | CL | T-3 | T-4 | MC-2 | 3 | 2 | 4 | LL=28, PI=8 |
| 10 | ML/SM | CL | SPT-2 | 3 | 2 | 1 | SPT | 6 | |
| 12 | ML/SM | CL | T-5 | T-6 | MC-3 | 93 | 20.9 | 7 | |
| 14 | ML/SM | CL | SPT-3 | 2 | 3 | 7 | SPT | 8 | |
| 16 | ML/SM | CL | T-7 | T-8 | MC-4 | 106 | 18.8 | 10 | 200 wash: 25% fines |
| 18 | ML/SM | CL | SPT-4 | 3 | 3 | 5 | SPT | 8 | |
| 20 | ML/SM | CL | T-9 | T-10 | MC-5 | 94 | 28.1 | 6 | LL=48, PI=22 |
| 22 | CL | SM | T-11 | T-12 | MC-6 | 108 | 21.2 | 12 | 26 | TX/CU $\phi^e=33.9$, $C=100$psf |
| 24 | CL | SM | SPT-5 | 3 | 3 | 4 | SPT | 7 | |
| 26 | CL | SM | SPT-6 | 1 | 3 | 3 | SPT | 6 | |
| 28 | CL | SM | | | | | | | GWT confirmed by overnight check |</p>
<table>
<thead>
<tr>
<th>Depth (feet)</th>
<th>Graphic Log</th>
<th>USCS Class.</th>
<th>Geotechnical Description</th>
<th>Sample Design</th>
<th>Dry Unit Weight (pcf)</th>
<th>Moisture Content (%)</th>
<th>SPT Blows/ft</th>
<th>Sample Type</th>
<th>Recover. (%)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>CL</td>
<td>CL</td>
<td>20.0'–35.0' Clay - Brown, stiff, wet</td>
<td>MC-7 T-13 T-14</td>
<td>104</td>
<td>23.7</td>
<td>7</td>
<td>2</td>
<td>5</td>
<td>TX/CU φ' = 33.9, C' = 100 psf</td>
</tr>
<tr>
<td>34</td>
<td></td>
<td>SM</td>
<td>35.0'–40.0' Silty Sand - Olive-brown, loose to medium dense, saturated</td>
<td>T-15 T-16 MC-8</td>
<td>118</td>
<td>14.0</td>
<td>11</td>
<td>6</td>
<td>7</td>
<td>15:40 Spoke w/ Peter @ SCWVD. Approved seal w/out inspection.</td>
</tr>
<tr>
<td>36</td>
<td></td>
<td>SC</td>
<td>40.0'–41.5' Clayey Sand - Olive-brown, medium dense, saturated</td>
<td>MC-9 T-17 T-18</td>
<td>6</td>
<td>13</td>
<td>19</td>
<td>6</td>
<td>13</td>
<td>200 wash: 22% fines</td>
</tr>
<tr>
<td>38</td>
<td></td>
<td></td>
<td>41.5'–BOH Gravely Sand - Olive-brown to gray, medium dense to very dense, saturated</td>
<td>SPT-9</td>
<td>9</td>
<td>12</td>
<td>20</td>
<td>9</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td></td>
<td></td>
<td></td>
<td>T-19 T-20 MC-10</td>
<td>14</td>
<td>19</td>
<td>21</td>
<td>14</td>
<td>12</td>
<td>Paused drilling @ 49' 16:15 12/06/2017</td>
</tr>
<tr>
<td>42</td>
<td></td>
<td></td>
<td></td>
<td>SPT-10</td>
<td>17</td>
<td>23</td>
<td>54</td>
<td>17</td>
<td>23</td>
<td>Resumed 07:30 12/07/2017</td>
</tr>
<tr>
<td>44</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>* T-21 Contains flow sand</td>
</tr>
<tr>
<td>46</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>48</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>52</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>54</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>56</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>58</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>08:25 12/07/2017 Completed Sampling</td>
</tr>
</tbody>
</table>

Total Depth = 58.0 feet
Groundwater - 29.0 feet at time of drilling

08:50 12/07/2017
Completed Seal

Sheet 2 of 2
**Project**: Christopher Ranch  
**Location**: 34' NE of Seed Tank Canopy, 10' S of Temporary Fence  
**Drilling Contractor/Rig**: Britton Exploration / CME 550 Tracked Rig  
**Ground Surface Elev.**: 174.0  
**Logged By**: TRH  
**Boring**: CSA/SD-3  
**Project No.**: E5617  
**Date of Drilling**: 12/07/2017  
**Hole Diameter**: 8’ HSA  
**Weather**: Sunny  

### Geotechnical Description

<table>
<thead>
<tr>
<th>Depth (feet)</th>
<th>Graphic</th>
<th>USCS Class.</th>
<th>Geotechnical Description</th>
<th>Sample</th>
<th>MC-1</th>
<th>MC-2</th>
<th>T-1</th>
<th>T-2</th>
<th>SPT-1</th>
<th>SPT-2</th>
<th>SPT-3</th>
<th>SPT-4</th>
<th>SPT-5</th>
<th>SPT-6</th>
<th>SPT-7</th>
<th>Remarks</th>
</tr>
</thead>
</table>
| 0.0'-7.0'   | SM      | CL          | Sandy Silt to Silty Sand - Light-brown, medium stiff/loose, dry | T-1    | 7    | 5    | 2   | 3   | 2     | 6     | 4     | 1     | 10    | 12    | 14    | Driller: Paul Britton Helped: Sergio  
Start Time = 09:03 |
| 7.0'-8.0'   | SM      | ML/SM       | Silty Sand - Light-brown, loose, dry | T-3    | 3    | 4    | 4   | 3   | 4     | 5     | 5     | 6     | 8     |       |       |
| 8.0'-12.0'  | SM      | ML/SM       | Sandy Silt - Light-brown, soft, dry | T-4    | 3    | 4    | 4   | 3   | 4     | 5     | 5     | 6     | 8     |       |       |
| 12.0'-16.0' | SP      | CL          | Sand - Red-brown, medium dense, dry | MC-2   | 7    | 6    | 4   | 4   | 6     | 4     | 6     | 10    |       | 12    | 14    |        |
| 16.0'-40.0' | CL      | CL          | Silty Clay - Black, stiff, dry | MC-3   | 5    | 6    | 4   | 4   | 6     | 4     | 6     | 10    |       | 12    | 14    |        |
| 20' -       | CL      | CL          | Clay, dark-brown | T-5    | 3    | 5    | 7   | 5   | 8     | 8     | 11    |       | 18    | 20    | Driller added water |
| 25' -       | CL      |            | Trace gravel | T-6    | 6    | 5    | 8   | 5   | 8     | 6     | 11    |       | 22    | 24    |        |
| 28' -       | CL      |            |                | T-7    | 6    | 5    | 8   | 5   | 8     | 6     | 11    |       | 26    | 28    |        |

**Graphic Log**

**Geotechnical Description**

- **0.5'-BOH ALLUVIUM**: 0.0'-7.0' Sandy Silt to Silty Sand - Light-brown, medium stiff/loose, dry
- **7.0'-8.0'**: Silty Sand - Light-brown, loose, dry
- **8.0'-12.0'**: Sandy Silt - Light-brown, soft, dry
- **12.0'-16.0'**: Sand - Red-brown, medium dense, dry
- **16.0'-40.0'**: Silty Clay - Black, stiff, dry
- **20'-25'**: Clay, dark-brown
- **25'-26'**: Trace gravel

**Remarks**

- Start Time = 09:03
- Driller: Paul Britton
- Helped: Sergio
- Driller added water
### Geotechnical Description

<table>
<thead>
<tr>
<th>Depth (feet)</th>
<th>Graphic Log</th>
<th>USCS Class</th>
<th>Geotechnical Description</th>
<th>Sample Design</th>
<th>SPT Blows/ft</th>
<th>moisture Content (%)</th>
<th>Dry Unit Weight(pcf)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td></td>
<td>CL</td>
<td>16.0'-40.0' Silty Clay - Olive-brown, medium stiff, moist to wet</td>
<td>SPT-8</td>
<td>4</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>34</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>36</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>38</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td></td>
<td></td>
<td>35' - Trace gravel</td>
<td>SPT-9</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>42</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>44</td>
<td></td>
<td>ML</td>
<td>40.0'-45.0' Sandy Gravelly Silt - Brown, very stiff, saturated</td>
<td>SPT-10</td>
<td>11</td>
<td>23</td>
<td>16</td>
<td>LL=21, PI=5</td>
</tr>
<tr>
<td>46</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>48</td>
<td></td>
<td>SM</td>
<td>40.0' - 45.0' Gravelly Silty Sand - Brown, medium dense to very dense, saturated</td>
<td>SPT-11</td>
<td>5</td>
<td>11</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>52</td>
<td></td>
<td></td>
<td>Total Depth = 51.5 feet</td>
<td>SPT-12</td>
<td>20</td>
<td>31</td>
<td>32</td>
<td>11:05 Completed Sampling</td>
</tr>
<tr>
<td>54</td>
<td></td>
<td></td>
<td>Groundwater - 28.0 feet at time of drilling</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>11:35 SCVWD arrived</td>
</tr>
<tr>
<td>56</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>12:20 Completed seal</td>
</tr>
<tr>
<td>58</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>62</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Remarks**
- 11:05 Completed Sampling
- 11:35 SCVWD arrived
- 12:20 Completed seal
**COTTON, SHIRES AND ASSOCIATES, INC.**  
**LOG OF EXPLORATORY DRILLING**

<table>
<thead>
<tr>
<th>Depth (feet)</th>
<th>Graphic Log</th>
<th>USCS Class.</th>
<th>Geotechnical Description</th>
<th>Sample Design</th>
<th>Dry Unit Weight (pcf)</th>
<th>Moisture Content (%)</th>
<th>SPT Blows/ft</th>
<th>Sample Type</th>
<th>Recov. (%)</th>
<th>Remarks</th>
</tr>
</thead>
</table>
| 0.0'-12.0'   | SM          | SM          | BOH ALLUVIUM:            | T-1           | 90                    | 23.0                | 2            | MC          | 4          | Driller: Michael Olmeda  
|              |             |             | 0.0'-12.0' Silty Sand - Dark-brown, very loose, wet |               |                       |                     |              |             |            | Helper: Theron  
|              |             |             |                           |               |                       |                     |              |             |            | Start Time = 08:50 |
| 12'-14.0'    | SM          | SM          | Silty Sand - Tan-brown, loose, moist, fine to medium sand | T-2           | 100                   | 18.4                | 5            | 10          | 8          | 09:06   
| 14.0'-20.0'  | CL          | CL          | Silty Clay - Gray to brown, stiff, moist, medium plasticity | T-3           | 98                    | 23.4                | 7            | 8           | 7          | 12      
| 20.0'-30.0'  | CL          | CL          | Clay - Black, very stiff, moist, high plasticity | T-4           | 12                    | 15                  | 12           | MC          | 24         | LL=33, PI=11  
| 25'          |             |             | Brown, stiff, saturated | T-5           | 7                     |                    | 7            | 10          |            | LL=41, PI=19  
|              |             |             |                           | T-6           | 7                     |                    | 9            | 10          |            |                     
|              |             |             |                           | T-7           | 99                    | 26.5                | 6            | 7           | 11         | TX/CU $\phi'=34^\circ$, C'=0 psf |
|              |             |             |                           | T-8           | 99                    | 26.5                | 6            | 7           | 11         |                     |

**Log of Exploratory Drilling**  
**Project No.** E5617  
**Date of Drilling** 04/10/2018  
**Hole Diameter** 4" Solid Stem  
**Weather** Sunny
### Geotechnical Description

<table>
<thead>
<tr>
<th>Depth (feet)</th>
<th>Sample</th>
<th>Type</th>
<th>Moisture Content (%)</th>
<th>SPT Blows/ft</th>
<th>Sample Recovery (%)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>SM - SP - 30.0'-35.0' Silty Sand</td>
<td>T-9</td>
<td>MC</td>
<td>105</td>
<td>8</td>
<td>32</td>
<td>10:45</td>
</tr>
<tr>
<td>SM - SP - 35.0'-41.0' Gravely Silty Sand</td>
<td>SPT-2</td>
<td>SPT</td>
<td>13</td>
<td>8, 9</td>
<td>34</td>
<td>32 Sieve - 9.7% fines</td>
</tr>
<tr>
<td>SM - 40' - Very dense</td>
<td>T-10</td>
<td>MC</td>
<td>15</td>
<td>50/4.5</td>
<td>40</td>
<td>12:02</td>
</tr>
<tr>
<td>GW - 41.0'-BOH Silty Sandy Gravel</td>
<td>SPT-4</td>
<td>SPT</td>
<td>13</td>
<td>12, 14</td>
<td>42</td>
<td>Finished Sampling @ 12:15</td>
</tr>
</tbody>
</table>

**Total Depth = 42.5 feet**

**Groundwater - 23.0 feet at time of drilling**

**Finished Sampling @ 12:15**

**Finished Backfill @ 13:10**
APPENDIX B

Laboratory Testing
Summary of Laboratory Testing
Triaxial Compression Test Results
Atterberg Limits Test Results
Particle Size Determination Results
APPENDIX B
LABORATORY TESTING

The laboratory analysis performed for the site consisted of limited testing of the representative soil types sampled during the field investigation to evaluate index properties of subsurface materials. The soil descriptions and the field and laboratory test results were used to assign parameters to the various materials at the site. The results of the laboratory testing program are presented in this appendix and on the boring logs.

The following laboratory tests were performed as part of this investigation:

1. Detailed soil description, ASTM D2487;
2. Natural moisture content of the soil, ASTM D2216;
3. In-situ unit weight of the soil (wet and dry) ASTM D7263b;
4. Atterberg limits, ASTM D4318;
5. Consolidated, undrained triaxial compression test, ASTM D2850;
6. Particle size determination, ASTM D 422; and
7. Percent minus the No. 200 sieve, ASTM D1140.
Remarks: Strengths picked at the peak effective stress ratios.
### Consolidated Undrained Triaxial Compression with Pore Pressure

**Specimen 1234**

**Boring**
- SD-4

**Sample**
- T-8

**Visual Description**
- Olive Brown CLAY

### Sample Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MC (%)</td>
<td>26.5</td>
</tr>
<tr>
<td>Dry Density (pcf)</td>
<td>98.9</td>
</tr>
<tr>
<td>Saturation (%)</td>
<td>96.8</td>
</tr>
<tr>
<td>Void Ratio</td>
<td>0.767</td>
</tr>
<tr>
<td>Diameter (in)</td>
<td>2.41</td>
</tr>
<tr>
<td>Height (in)</td>
<td>4.99</td>
</tr>
</tbody>
</table>

### Control Numbers

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTL Number</td>
<td>026-668</td>
</tr>
</tbody>
</table>

### Client Information

- **Client Name:** Cotton, Shires & Associates
- **Project Name:** Christopher Ranch
- **Project Number:** E5617
- **Date:** 4/30/2018
- **By:** MD/DC

### Excess Stress Calculations

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total C (ksf)</td>
<td>0.000</td>
</tr>
<tr>
<td>Total phi (degrees)</td>
<td>20.3</td>
</tr>
<tr>
<td>Eff. C (ksf)</td>
<td>0.000</td>
</tr>
<tr>
<td>Eff. Phi (degrees)</td>
<td>34.0</td>
</tr>
</tbody>
</table>

### Effective Stresses

- **Strain (%):** 5.0
- **Deviator (ksf):** 4.210
- **Excess PP (psi):** 16.1
- **Sigma 1 (ksf):** 5.927
- **Sigma 3 (ksf):** 1.717
- **P (ksf):** 3.822
- **Q (ksf):** 2.105
- **Stress Ratio:** 3.452
- **Rate (in/min):** 0.0004

### Diagram Details

- **Stress-Strain Response**
- **Total Tangent**
- **Effective Tangent**
Dashed line indicates the approximate upper limit boundary for natural soils.

<table>
<thead>
<tr>
<th>MATERIAL DESCRIPTION</th>
<th>LL</th>
<th>PL</th>
<th>PI</th>
<th>%&lt;#40</th>
<th>%&lt;#200</th>
<th>USCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brown Lean Clayey SAND</td>
<td>31</td>
<td>18</td>
<td>13</td>
<td>100%</td>
<td>100%</td>
<td>CL</td>
</tr>
<tr>
<td>Olive Brown SILT</td>
<td>43</td>
<td>27</td>
<td>16</td>
<td></td>
<td></td>
<td>ML</td>
</tr>
<tr>
<td>Olive Lean Clayey SAND</td>
<td>26</td>
<td>18</td>
<td>8</td>
<td></td>
<td></td>
<td>OL</td>
</tr>
<tr>
<td>Brown Lean Clayey SAND</td>
<td>28</td>
<td>20</td>
<td>8</td>
<td></td>
<td></td>
<td>CL-ML</td>
</tr>
<tr>
<td>Dark Olive Lean CLAY</td>
<td>48</td>
<td>26</td>
<td>22</td>
<td></td>
<td></td>
<td>MH</td>
</tr>
</tbody>
</table>

**Project No.** 026-660  **Client:** Cotton, Shires & Associates
**Project:** Christopher Ranch - E5617

**Remarks:**
- •
- ■
- ▲
- *
- ▼

**Source:**
- • Source: SD-1  Sample No.: T-6  Elev./Depth: 16-16.5'
- ■ Source: SD-1  Sample No.: T-8  Elev./Depth: 20.5-21'
- ▲ Source: SD-1  Sample No.: SPT-7  Elev./Depth: 31.5-33'
- * Source: SD-2  Sample No.: T-5  Elev./Depth: 7-7.5'
- ▼ Source: SD-2  Sample No.: SPT-5  Elev./Depth: 21.5-23'

**LIQUID AND PLASTIC LIMITS TEST REPORT**

**COOPER TESTING LABORATORY**
LIQUID AND PLASTIC LIMITS TEST REPORT

Dashed line indicates the approximate upper limit boundary for natural soils

MATERIAL DESCRIPTION | LL | PL | PI | %<#40 | %<#200 | USCS
--- | --- | --- | --- | --- | --- | ---
Strong Brown Silty CLAY | 21 | 16 | 5 | | | |

Project No. 026-660  Project: Christopher Ranch - E5617

Source: SD-3  Sample No.: SPT-9  Elev./Depth: 35-36.5'
LIQUID AND PLASTIC LIMITS TEST REPORT

Dashed line indicates the approximate upper limit boundary for natural soils

---

MATERIAL DESCRIPTION | LL | PL | PI | %<#40 | %<#200 | USCS
---|---|---|---|---|---|---
Light Yellowish Brown Sandy Lean CLAY | 33 | 22 | 11 | |

Dark Grayish Brown Lean CLAY w/ Sand | 41 | 22 | 19 | |

---

Project No. 026-668  
Client: Cotton, Shires & Associates  
Remarks:  

- Source: SD-4  
  Sample No.: T-4  
  Elev./Depth: 16.5-17.0'
- Source: SD-4  
  Sample No.: T-6  
  Elev./Depth: 20.5-21.0'
Particle Size Distribution Report

Source: SD-4
Sample No.: SPT-2
Elev./Depth: 31.5-33.0'

% COBBLES | % GRAVEL | % SAND | % SILT | % CLAY | USCS | AASHTO | PL | LL
--- | --- | --- | --- | --- | --- | --- | --- | ---

<table>
<thead>
<tr>
<th>SIEVE</th>
<th>PERCENT FINER</th>
<th>SIEVE</th>
<th>PERCENT FINER</th>
<th>SOIL DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8&quot;</td>
<td>100.0</td>
<td>#4</td>
<td>86.2</td>
<td>○ Yellowish Brown Well-Graded SAND w/ Silt</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#10</td>
<td>69.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>#30</td>
<td>49.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>#40</td>
<td>40.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>#50</td>
<td>28.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>#100</td>
<td>14.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>#200</td>
<td>9.7</td>
<td></td>
</tr>
</tbody>
</table>

GRAIN SIZE

D_{60} | 1.06 |
D_{30} | 0.311 |
D_{10} | 0.0801 |

COEFFICIENTS

C_{c} | 1.15 |
C_{u} | 13.20 |

Client: Cotton, Shires & Associates
Project: Christopher Ranch - E5617
Project No.: 026-668

Figure
APPENDIX E

AGENCIES' REVIEW COMMENTS AND RESPONSES
Bolsa Rd Fish Passage (1600-2019-0011)

Review comments by CDFW fisheries biologist received on 4/16/2019

<table>
<thead>
<tr>
<th>1</th>
<th>Comment</th>
<th>For fish passage design flows, please indicate minimum specific flow rate at which all constructed riffles will meet fish passage criteria for juvenile and adult anadromous salmonids. Also clearly define the maximum flow rate passage will be provided according to criteria. Additionally, the Uvas Creek watershed has stream gaging so you should be able to express criteria for low fish passage design flow using CDFW Culvert Criteria for fish passage, similar to how you calculated upper fish passage design flow (Attachment D Pages 9 &amp; Appendix B).</th>
</tr>
</thead>
</table>
|  | Response | Each riffle-pool is defined in Hec Ras as follows:  
• Riffle crests are represented by at least one cross section  
• Riffle pools are represented by at least two (and typically three) cross sections  
At low flow rates, the flow goes critical at riffle crests, and is subcritical in the pools, similar to examples of riffle/pool hydraulics in the literature (e.g., Designing Pool and Riffle Streams, Lectures and Exercises, River Restoration NW Short Course 2008, Robert Newbury- see image below). Hence, the range of safe fish passage flows was determined as follows:  
• The low flow range was determined by finding the lowest flow at which critical depths over the riffle crests was close to 0.5 ft for juvenile and 1 ft for adult salmonids  
• The high flow range was determined by finding the flow rates at which velocities reached 1 ft/s in pools for juveniles and 4 ft/s in pools for adults. |

![Diagram of riffle-pool hydraulics](image.png)

**Figure 23:** Schematic profile of the change in state of subcritical to critical flow in an open channel as it passes over a riffle crest in Chapman Creek without increasing the flood stage. In more detailed analysis small contraction and frictional losses will alter the dimensions slightly.
Bolsa Rd Fish Passage (1600-2019-0011)
Review comments by CDFW fisheries biologist received on 4/16/2019

<table>
<thead>
<tr>
<th>2</th>
<th>Comment</th>
<th>Have alternatives been considered as to how to improve hydraulic drop height on some of the riffles at lower flows? The concern is during spring flow recession, juvenile steelhead trout and other fish attempting to migrate upstream to perennial reaches are getting stranded. Best measures possible should be taken to minimize future fish stranding during spring/summer dry back in the redesign of this channel. Also, a little unclear how to interpret this, and some of my concern may be more of an interpretation issue. What might be more informative is difference in water elevation from thalweg riffle crest and pool entrance, and slope of water surface across riffle (See Appendix B).</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Response</strong></td>
<td></td>
<td>Yes, we considered alternatives, and selected the lowest slope that is feasible by extending the project to 1500 feet, greater than 750 feet that was originally envisioned. The crest of the riffle does not have a vertical drop. The Figure showing a longitudinal profile from top of riffle to next top of riffle downstream should show a 50 foot run. There is a drop of 1 foot along that run (so 2 percent slope, which is a substantial reduction from the drop of 6 feet with 50% slope over the Denil). After this, the surface of the run is below the water level controlled by the pool elevation downstream when flow is 10 cfs or higher. As the spring flows recede, our observation at the pool upstream of the UPRR slab shows that the pools begin to fill in with material. The accumulated material would be washed out under bigger flows the following season. This sequence should result in pool depths (relative to downstream riffle) decreasing gradually toward flow season end (from 3½ feet in the winter flow</td>
</tr>
</tbody>
</table>
season to about 1 foot at season end). Pool depths in the 1 foot range would not support a substantial volume of water for the stragglers to linger on.

The proposed stream modification should result in lower supercritical flow and corresponding bed scouring velocities, due to lower flow approaches the slab.

3  **Comment**  
There are noticeable inconsistencies between ESM sizing gradation specified in memorandum text and in cross-sectional views in the design memorandum versus those shown in current engineering design plan submittals. Please be clear of ESM sizing for all features in the project (Attachment D Page 21)

<table>
<thead>
<tr>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>The riffles are to be constructed of engineered streambed material (ESM), comprised of 3-ton boulders anchoring the top of riffle, its upstream and downstream ends, interspersed with 1-ton boulders and stream bed gravel. The bottom of the pool (about 20 feet from the edge of riffle) will be also lined with ESM comprised of $\frac{1}{2}$ and 1-ton boulders and stream bed gravel. The gradations for 3-ton, 2-ton, 1-ton, $\frac{1}{2}$-ton and streambed gravel are as follows:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Streambed Gravel</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Size</strong></td>
</tr>
<tr>
<td>6-in</td>
</tr>
<tr>
<td>2-in</td>
</tr>
<tr>
<td>$\frac{1}{2}$-in</td>
</tr>
<tr>
<td>3/16-in</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>$\frac{1}{2}$ ton Rock</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rock Size</strong></td>
</tr>
<tr>
<td>1 ton</td>
</tr>
<tr>
<td>$\frac{1}{2}$ ton</td>
</tr>
</tbody>
</table>
Bolsa Rd Fish Passage (1600-2019-0011)
Review comments by CDFW fisheries biologist received on 4/16/2019

<table>
<thead>
<tr>
<th>Rock Size</th>
<th>Percentage Larger than</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 ton Rock</td>
<td></td>
</tr>
<tr>
<td>Rock Size</td>
<td>Percentage Larger than</td>
</tr>
<tr>
<td>2 ton</td>
<td>0 – 5</td>
</tr>
<tr>
<td>1 ton</td>
<td>50 - 100</td>
</tr>
<tr>
<td>½ ton</td>
<td>95 – 100</td>
</tr>
<tr>
<td>2 ton Rock</td>
<td></td>
</tr>
<tr>
<td>Rock Size</td>
<td>Percentage Larger than</td>
</tr>
<tr>
<td>4 ton</td>
<td>0 – 5</td>
</tr>
<tr>
<td>2 ton</td>
<td>50 - 100</td>
</tr>
<tr>
<td>1 ton</td>
<td>95 – 100</td>
</tr>
<tr>
<td>3 ton Rock</td>
<td></td>
</tr>
<tr>
<td>Rock Size</td>
<td>Percentage Larger than</td>
</tr>
<tr>
<td>8 ton</td>
<td>0 – 5</td>
</tr>
<tr>
<td>4 ton</td>
<td>50 - 100</td>
</tr>
<tr>
<td>2 ton</td>
<td>95 – 100</td>
</tr>
</tbody>
</table>

4 Comment: Design Memorandum mentions there is a possibility rootwads will be added to project. Locations of where rootwad structures will be placed need to be specified on the final designs. Final designs should diagram and show the orientation of these structures in plan and cross-section view, specify sizing of material, type of wood used, specify anchoring methods, and engineering calculations should also be done to show these structures will be stable at the high design flow (7000+ CFS) (Attachment D Page 16).

Response: Based on discussion with NFMS, rootwads for this reach of Uvas Creek are not desired as not to encourage prolong fish resting in the local pools.

5 Comment: Stream gravels should not be sourced from Uvas Creek floodplain below Uvas reservoir. This is already a sediment starved reach. Appropriateness of sourcing gravels from upstream of the reservoir needs to be further assessed, could also purchase river washed gravel from a quarry. Please also specify a size gradation for stream gravels material used in project (Attachment D Page 21).

Response: Will delete reference to gravel source downstream. Project intends to specify the river washed gravel be purchased from a quarry.

6 Comment: Post-project monitoring should as components include periodic collection of longitudinal profile extending from above railroad tressel to below constructed riffle 10, and cross-section profile at fixed locations, plus photo documentation (Page 23).

Response: The Draft Monitoring Plan (March 2019) provided to CDFW on March 28, 2019 includes the elements described in this comment.
<table>
<thead>
<tr>
<th>Comment</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cross-section view of riffles 6 &amp; 7 in the design memorandum specify that grouted rip-rap may be placed at top of south bank. This same detail is not specified in engineering designs. In final submittals please specify if grouted rip-rap is going to be used, if so this should also be designated as a stream bank protection measure and clearly labeled as such similar to bank protection designated between riffles 3-4 &amp; 9-10. This bank protection may be necessary on steep unstable slopes, and to protect infrastructure, but please specify specific need for this type of hardscaping versus softer engineering approaches.</strong></td>
<td><strong>No grouted rip-rap is proposed; updated report.</strong></td>
</tr>
<tr>
<td><strong>For interpretation in how much fish passage is improved by project, please provide hydrologic modeling data that shows current fish passage condition similar to what is in Attachment D Appendix B</strong></td>
<td><strong>The largest fish barrier occurs at the Denil fish ladder. Although the fish ladder itself was designed well, it fails to function regularly during most storms due to becoming frequently blocked with debris. This is despite copious efforts by the District to regularly remove the debris from the ladder. When the ladder malfunctions, fish must jump up about 5 ft to move upstream of UPRR. Valley Water biologist identified insufficient pool depth at the entrance and excessive velocities at medium to high flows as limiting factors of the current Denil ladder. Modeling of the proposed design indicates passage at flows at least as high as 1,000 cfs, a big improvement over the current condition. The proposed design also eliminates the shallow entrance pool issue by converting the ladder to a pool riffle sequence, passing fish both adults and juveniles at lower flows than the current condition. A secondary issue is the 200 ft long reach (part of a pool) located downstream of the existing riffle located just downstream of the slab. In addition, depths in this pool reach about 1 ft at 3 cfs, compared with more than 3 ft of depth in the proposed design at 1 cfs.</strong></td>
</tr>
</tbody>
</table>
Bolsa Rd Fish Passage (1600-2019-0011)
Review comments by CDFW fisheries biologist received on 4/16/2019

<table>
<thead>
<tr>
<th>In other words, the design improves fish passage in several ways:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- It brings the riffle/pool sequence up to the elevation of the slab, allowing fish to migrate upstream of UPRR.</td>
</tr>
<tr>
<td>- It eliminates a shallow pool which has formed downstream of the slab.</td>
</tr>
<tr>
<td>- It is much less likely to clog with debris.</td>
</tr>
<tr>
<td>- Reduced velocities at higher flows.</td>
</tr>
<tr>
<td>- Eliminates issues with the shallow entrance pool.</td>
</tr>
<tr>
<td>- Passes fish at lower flows.</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>6</td>
</tr>
</tbody>
</table>
**Bolsa Road Fish Passage (1600-2019-0011)**  
**Response to Comments from CDFW Received on 4/24/2019**

<table>
<thead>
<tr>
<th><strong>Response</strong></th>
<th>Basis of Design (BOD) Report. The rationale for excluding this information should be provided by the applicant.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Response</strong></td>
<td>The relevant geomorphic information is provided below.</td>
</tr>
<tr>
<td></td>
<td>As part of the fieldwork for various projects on Uvas Creek, the District collected data on geomorphic attributes of the creek downstream of Santa Teresa Boulevard. In relatively flat and geomorphically stable sections along the creek, bankfull widths are approximately 30 to 40 feet and bankfull depths are around 4 to 7 feet. The estimated section dimensions were based on locations of tree trunks, bankfull benches, top of point bars, and other indicators. The original bankfull depth indicators are based on bankfull flow conditions prior to the construction of Uvas Dam in 1957. The floodplain is around 15 feet above the stream bed. These dimensions are observed in stable sections of the creek downstream of the bridge at Bloomfield Avenue, or approximately 3,000 feet downstream of the UPRR crossing in the project area, and upstream of 101.</td>
</tr>
<tr>
<td></td>
<td>For this project, the section of creek channel between Bloomfield Avenue and Highway 25 (starting approximately 0.4 mile downstream of the project area) can be used as a reference reach. For this, the project needs to achieve a bankfull width of 35 +/- 5 feet, bankfull depth of 4 to 5 feet, top of bank width of 120 feet, and access to the floodplain at a height no greater than 15 feet. The project achieves these width and depth characteristics between the UPRR crossing and the first bend downstream of UPRR (along 700 feet of length). In the following 1000 feet, it achieves a stable bed for fish passage through the construction of the riffle-pool geometry. The channel remains partially incised because the top of bank height where the creek accesses the flood plain is around 20 feet and top of bank width is limited to 100 feet. The top of bank height and width are determined by the proximity of Bolsa Road on the right bank (looking upstream) and the private property and structures on the opposite bank.</td>
</tr>
</tbody>
</table>

<p>| <strong>Comment</strong> | Post construction evaluation and monitoring plan in the BOD noted that “visual monitoring should begin the first year after a normal high flow period and be repeated after each large flood event for a minimum of five years” and that “if there is a settling of more than six inches from the original construction, it should be reviewed with the design team”. Who will be performing the visual monitoring, and how will settling of more than six inches be confirmed? Will elevation surveys be repeated for a minimum of five years after construction? |
| <strong>Response</strong> | The Draft Monitoring Plan (March 2019) provided to CDFW on March 28, 2019 includes the elements described in this comment. The description of post-construction monitoring in BOD has been updated to be consistent with the Draft Monitoring Plan. Specifically, the post-construction monitoring calls for: |
| | • A longitudinal profile extending along the thalweg of the creek from approximately 25 feet upstream of the UPRR crossing (Station 26+50) to approximately 1,700 feet downstream (Station 9+00) of the crossing will be collected as part of the post-project as-built surveys, and in years 5 and 10. Additional surveys may be taken should qualitative assessments indicate a more frequent need. |
| | • Cross-section profiles will be taken at a total of 9 permanent transects between Riffles 1 and 2, 5 and 6, and 8 and 9 with transects at the top of riffle, mid-riffle, and pool in each of the three riffles surveyed. Cross-sections |</p>
<table>
<thead>
<tr>
<th><strong>Bolsa Road Fish Passage (1600-2019-0011)</strong></th>
<th><strong>Response to Comments from CDFW Received on 4/24/2019</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>will be collected as part of the post-project as-built surveys, and in years 5 and 10. Additional surveys may be taken should qualitative assessments indicate a more frequent need. <em>Photo-documentation of the site will be conducted from at least 10 fixed locations in the project reach with representative photos of the riffles, pools, reconstructed banks, and riparian habitat. Photographic documentation will be captured prior to the start of construction and during monitoring years 1 through 3, 5 and 10.</em></td>
<td></td>
</tr>
<tr>
<td><strong>8</strong> Comment</td>
<td>Manning’s roughness values referenced in the BOD (0.06) does not agree with the values noted in Appendix B (0.04 – 0.045). Please address this discrepancy.</td>
</tr>
<tr>
<td><strong>Response</strong></td>
<td>The BOD has been updated to be consistent with the HEC-RAS model presented in Appendix B.</td>
</tr>
<tr>
<td><strong>9</strong> Comment</td>
<td>Turbulence, the Energy Dissipation Factor (EDF), and a maximum recommended EDF for adult steelhead is discussed in the body of the BOD, yet the applicant does not show that the project will not result in an EDF that prohibits fish passage. Please include the rationale for excluding these results.</td>
</tr>
<tr>
<td><strong>Response</strong></td>
<td>The EDF has been computed for 10 cfs, 64 cfs and 320 cfs. Values only exceed 4 ft-lbs/s/ft³ at riffle crests where the flow goes critical. In pools, EDF values reach maximum values of 2.5, 1 and 0.7 ft at 320 cfs, 64 cfs and 10 cfs, respectively. This is deemed to be a reasonable design because the length of the riffle crest/critical flow region is very short, and unavoidable in riffle/pool designs at low flows.</td>
</tr>
<tr>
<td><strong>10</strong> Comment</td>
<td>HEC-RAS cross sections used in the simulation should be provided, and resulting HEC-RAS water surface profiles, and an output table of results for each simulation should be included in Appendix B. Additionally, how were the proposed riffles simulated using HEC-RAS (e.g. inline weirs, manipulated cross sections, additional section losses, etc.)?</td>
</tr>
<tr>
<td><strong>Response</strong></td>
<td>The Hec-Ras model is provided with this submittal. We are also providing an excel spreadsheet which computes the drops between riffles and water surface profiles for many different flow profiles ranging from 1 cfs up to 1,000 cfs. Riffle crests are highlighted as yellow rows (for which Froude number generally exceeds 1). Riffles were simulated as cross sections. Lastly, please note the following:</td>
</tr>
<tr>
<td>Bolsa Road Fish Passage (1600-2019-0011)</td>
<td></td>
</tr>
<tr>
<td>-----------------------------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td>Response to Comments from CDFW Received on 4/24/2019</td>
<td>In the previous report, the few downstream riffles appeared to be drowned out by backwater effects from downstream. The backwater effects were occurring because the cross sections downstream of project had artificially high bed elevations which reflected sediment deposited locally due to a bank failure. This condition no longer persists. In order to obtain the most conservative evaluation of fish passage criteria, the model has been updated by cutting it off at the most downstream riffle crest and applying critical depth as the boundary condition there. Please note that the memo formerly provided to the project team has been updated to incorporate the new model results. <strong>The updated memo is being provided as part of this submission.</strong></td>
</tr>
<tr>
<td>1</td>
<td>Comment</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td></td>
<td>Response</td>
</tr>
<tr>
<td>2</td>
<td>Comment</td>
</tr>
<tr>
<td></td>
<td>Response</td>
</tr>
<tr>
<td>3</td>
<td>Comment</td>
</tr>
<tr>
<td></td>
<td>Response</td>
</tr>
<tr>
<td>4</td>
<td>Comment</td>
</tr>
<tr>
<td></td>
<td>Response</td>
</tr>
<tr>
<td>5</td>
<td>Comment</td>
</tr>
</tbody>
</table>
### Bolsa Road Fish Passage (1600-2019-0011)
#### Response to Design Concerns from CDFW Received on 5/23/2019

<table>
<thead>
<tr>
<th>Comment</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>6</strong> Who will be responsible for the field quality control of the riffle/pool structures? Have any quality control metrics been established (e.g. testing, visual observations, etc.)?</td>
<td>Valley Water’s construction manager/team will oversee the project progress based on field inspections/observations, daily/weekly construction progress meetings with contractor and subcontractors. The contractor’s required submittal of 3-week look ahead schedule will be monitored and adjusted as necessary to meet the project milestones. If no improvements in progress, then, Valley Water will direct the contract to bring in additional resources to expedite the work progress. Valley Water’s field inspectors, with support from design engineer/specialists will be responsible for the field quality assurance of the riffle/pool structures; the contractor will be responsible for the quality control (QC) of his/her work that meet project requirements. Specifically, Valley Water’s field engineer/inspector will be checking elevations of riffle crest and pool, bankful bench utilizing handheld levels and/or laser rangefinder capable of measuring horizontal, vertical and slope distance from point to point; similar type of elevation control is required from the contractor QC. Valley Water’s design engineer will make frequent site visits to oversee the placement of boulders during construction and provide responses to contractor’s inquiries both onsite and through the request for information (RFI) process.</td>
</tr>
<tr>
<td><strong>7</strong> The Geotechnical Investigation performed by Cotton, Shires and Associates, Inc. (CSA) for Schaaf and Wheeler (Cristopher Ranch) was not previously included in the basis of design (Appendix D). It appears Cristopher Ranch (not SCVWD) hired CSA to perform a geotechnical investigation for addressing the failing creek bank along the Cristopher Ranch property, which also appears to include the limits of the right bank through the project site. It also appears that the applicant is utilizing this investigation to support design decisions related to the stability of the stream bank through the project. If this assumption is correct, does Valley Water intend to address the following recommendations provided in the Geotechnical Investigation? If Valley Water does not intend on addressing these recommendations, please provide a rationale for excluding them.</td>
<td>The final drawings and specifications should be reviewed and approved by a representative of our firm to confirm that the recommendations of this report have been incorporated into the design of the project. Earthwork construction activities should be observed and tested by a representative of our firm to confirm that the recommendations of this report are incorporated into the construction of the project and to address potential unanticipated soil conditions not encountered during site investigation. It is strongly recommended that no construction be started nor grading undertaken until the final drawings, specifications, and calculations have been reviewed and approved in writing by a representative of Cotton, Shires and Associates, Inc.</td>
</tr>
</tbody>
</table>

- The final drawings and specifications should be reviewed and approved by a representative of our firm to confirm that the recommendations of this report have been incorporated into the design of the project.
- Earthwork construction activities should be observed and tested by a representative of our firm to confirm that the recommendations of this report are incorporated into the construction of the project and to address potential unanticipated soil conditions not encountered during site investigation.
- It is strongly recommended that no construction be started nor grading undertaken until the final drawings, specifications, and calculations have been reviewed and approved in writing by a representative of Cotton, Shires and Associates, Inc.
| **Response** | Valley Water developed a preliminary slope repair alternative consisting of rock slope protection at an inclination of 1.5 to 1 (horizontal to vertical). This preliminary design (based on geotechnical data from nearby Highway 25 site) is similar to one of the recommended alternatives presented in CSA report. Therefore, Valley Water utilized the geotechnical data included CSA report to finalize the design and presented CSA report as relevant and site specific geotechnical data reference. Valley Water is responsible for the design of bank repair along the Christopher Ranch facility, and will provide construction oversight on the observations and testing of the installation of rock slope protection. |
| **Comment** | In the Basis of Design Report, there are two scour calculations. Please clarify the results of the scour analysis and provide the maximum scour that is anticipated. |
| **Response** | The first set of scour calculations is for the determination of scour pool depth for the riffle-pool configurations. The second set of scour analysis is for the sizing of rock slope protection. Will add title to the calculations to clarify. |