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Technical Memorandum

Date: June 5, 2021

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Subject: **Summary of Final Design for Replacement of Rawson Creek Culvert Crossing No. 3 on a Tributary to Morrison Creek**

1 PURPOSE OF MEMORANDUM

The purpose of this technical memorandum (TM) is to summarize the proposed design for a culvert crossing replacement on the South Fork of Rawson Creek, a tributary to Morrison Creek, near Smith River, Del Norte County, California. The crossing replacement is intended to improve passage of fish and flood flows.

2 BACKGROUND

The tributary (Rawson Creek) flows into Morrison Creek approximately 4,500 linear feet upstream of the Morrison Creek and Smith River confluence. Several smaller tributaries flow into Rawson Creek from the steep coastal foothills east of Highway 101. This project is on the South Fork of Rawson Creek, and is intended to improve upstream fish passage for adult and juvenile Coho Salmon, Steelhead Trout, Coastal Cutthroat Trout, and potentially Chinook Salmon.

The Smith River Alliance (SRA) is dedicated to restoring habitat for salmonids in the Smith River watershed. Through a grant from the California Coastal Conservancy, SRA identified stream crossings that restrict fish movement in tributaries to the lower Smith River. This crossing was identified by SRA as Crossing No. 3 on the Unnamed Tributary (Rawson Creek) to Morrison Creek as part of the lower Smith River fish passage assessments and prioritization effort. The effort identified it as a medium priority in the lower Smith River for replacement due to the existing 3.5-foot diameter culvert being undersized, a partial barrier to salmonids, and negatively affecting the channel's natural morphology.

There are two road-stream crossings downstream of this project. Crossing No. 1 on Rawson Creek is on adjacent property and found to be passable to adult and juvenile salmonids. Crossing No. 2 is a partial barrier. SRA received a grant from the California Department of Fish and Wildlife (CDFW) Fisheries Restoration Grants Program (FRGP) for replacement of this downstream partial barrier. This crossing replacement was designed by Michael Love & Associates, Inc. (MLA) and is slated for replacement with a bridge in 2021.

The SRA has received a grant from US Fish and Wildlife Service (USFWS) Fish Passage Program for design and replacement of Crossing No. 3, thus opening up unrestricted access for salmonids to additional high-quality habitat within Rawson Creek watershed. SRA retained the services of MLA to develop a crossing replacement design, with the intent of constructing the project during the summer of 2021 in conjunction with implementation of Crossing No. 2.

3 EXISTING CONDITIONS

A private road crosses Rawson Creek approximately 3,000 feet upstream of the confluence with Morrison Creek, on property owned by the Rawson family (Figure 3-1). It is located on the USGS quadrangle map; Township 17N, Range 1W, Section 35. The crossing is the third crossing upstream of the confluence with Morrison Creek. It has light use by ATVs and private land owner vehicles. The crossing, referred to herein as Crossing No. 3, consists of a 36-inch diameter corrugated metal pipe (CMP), 20 feet in length and set at an inverse slope of 1.1 percent (Figure 3-2). The culvert bottom has a thin veneer of sand and gravel approximately 0.4 feet thick along its length. It does not show wear and is in good condition. Channel banks are armored with concrete rubble and RSP at both the inlet and outlet.

The culvert is located on a slight meander within the stream and is poorly aligned with the downstream channel (Figure 3-2a), and concrete rubble has been placed along the toe to protect the bank from scour. Some local aggradation immediately upstream of the culvert indicates it is undersized and creates a backwater during frequent high-flow events when bedload is in transport. Field and anecdotal evidence indicate the stream overtops the road crossing during moderate flow events. The landowner confirmed that the crossing overtops frequently.

The left bank of the channel along the entire project reach is heavily forested with eucalyptus trees that provide a wind block and are regularly harvested for firewood. The right bank from the upstream reach to the confluence is vegetated with dense stands of invasive Himalayan blackberries and occasional alders. Beyond the top of bank is a large grassy field/meadow with occasional redwoods in small clusters. The landowner reports that the meadow is a popular foraging area for Roosevelt elk.

The existing crossing was evaluated for fish passage by SRA following protocols described in Part IX of the California Department of Fish and Wildlife's (CDFW's) California Salmonid Stream Habitat Restoration Manual (CDFG, 2003). The crossing was classified as "Grey" and further evaluated with the FishXing program. With respect to passage for juvenile and adult resident and anadromous salmonids it was classified as a "partial barrier." The crossing was also identified as undersized and should be replaced with a properly sized crossing that meets fish passage criteria.

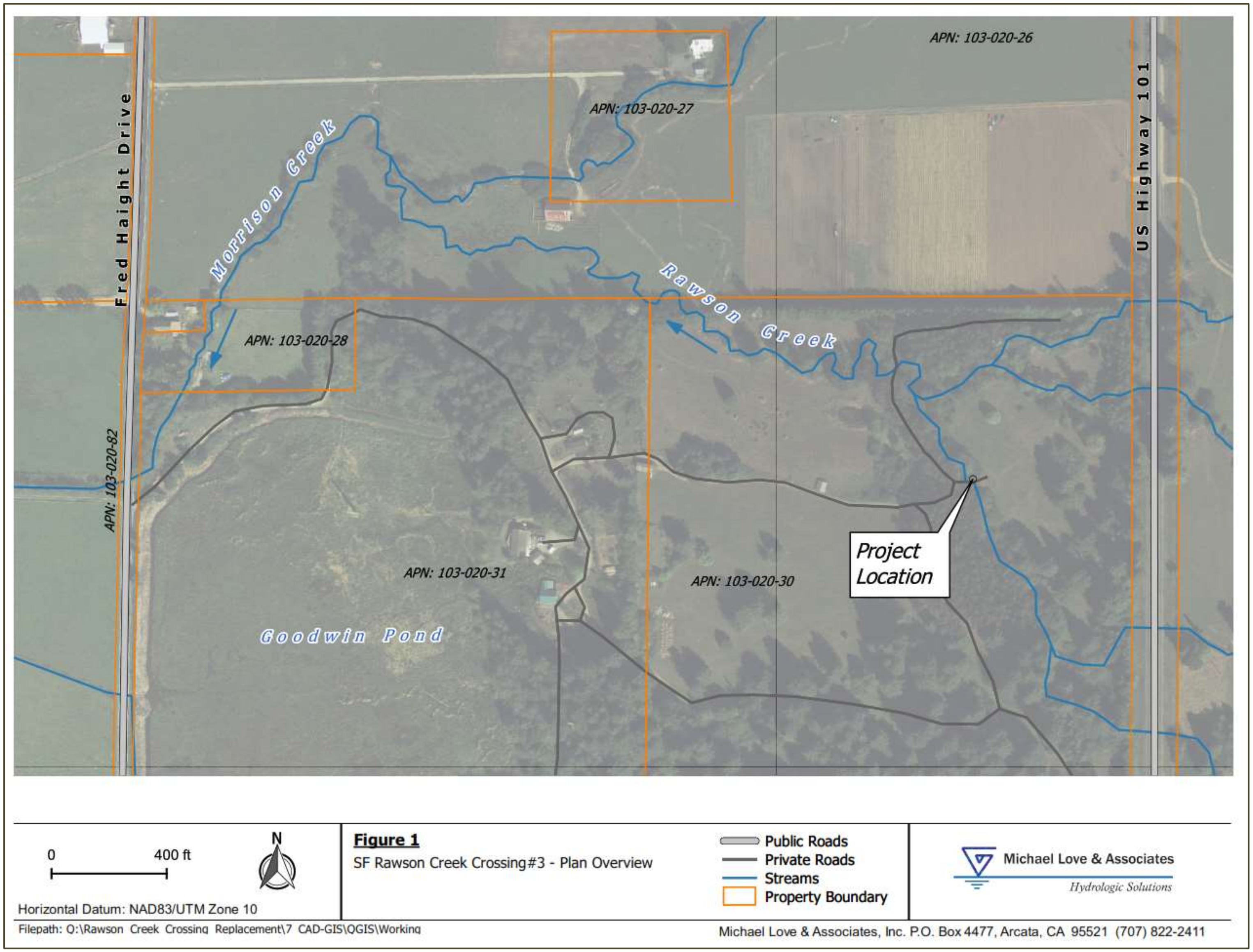

Figure 3-1: Project location and land ownership for Crossing No. 3 on South Fork Rawson Creek, a tributary to Morrison Ck.


(a)


(b)

Figure 3-2: Existing CMP stream crossing set at a reverse grade with RSP along both banks, (a) outlet slightly embedded and poorly aligned, and (b) poor inlet alignment and aggradation upstream of culvert. Photo courtesy of SRA.

4 STREAM CROSSING DESIGN APPROACH AND SITE CHARACTERIZATION

The proposed replacement stream crossing was designed using the stream simulation approach outlined in Part XII of the California Salmonid Stream Habitat Restoration Manual (CDFG, 2009) and in NMFS (2001) and USFS (2008). The stream simulation approach utilizes a crossing structure that spans the bankfull channel, provides a seamless transition between the upstream and downstream channel profiles, and maintains a natural streambed within the crossing throughout the service life of the crossing. The approach relies on using the adjacent stream channel as a geomorphic reference for design of the crossing structure.

4.1 Site Hydrology

The contributing watershed area at the road crossing is approximately 0.31 square miles and is characterized by second growth forests in the steeper headwaters that drain onto an agricultural terrace of the Smith River coastal plain. The estimated mean annual precipitation for the watershed is 76.8 inches per year (USGS, 2017). The peak flows were estimated using both USGS regional regression equations (Gotvald et al. 2012) and using probabilistic analysis of annual peak flow records from three nearby streams with similar drainage areas and land cover scaled to the project drainage area. The three streams used in the probabilistic analysis were Little Lost Man Creek near Orick California, Lopez Creek in Smith River California, and Harris Creek in Brookings Oregon. A comparison of flow estimates for various return periods is provided in Table 1. A probabilistic analysis of three regional streams was used in design of the new crossing structure. Hydrologic calculations are provided in **Attachment 2**.

Table 1: Estimated peak flows for various return periods in SF Rawson Creek using (1) probabilistic analysis of gage records from three nearby streams scaled to the Rawson Creek drainage area and (2) using the North Coast Regional Regression Equations.

Return Period of Peak Flow	Peak Flow at Rawson Creek Crossing	
	Average from Probabilistic Analysis of 3 Regional Streams	North Coast Regional Regression Equations
2-Year	43 cfs	45 cfs
5-Year	75 cfs	82 cfs
10-Year	100 cfs	108 cfs
25-Year	134 cfs	143 cfs
50-Year	161 cfs	169 cfs
100-Year	190 cfs	197 cfs

4.2 Field Surveys

On February 17, 2020 Antonio Llanos of MLA conducted topographic and geomorphic surveys of the crossing and adjacent stream channel, on March 17, 2020 Antonio Llanos and Jolyon Walkley from SRA completed the survey and data collection. The topographic survey was conducted using a total station and referenced control points established during the survey of the downstream crossing (Crossing No. 2), which are in assumed horizontal and vertical datums. The survey included the roadway and culvert, channel thalweg and toes and tops of banks, wetted edge of channel, and trees greater than 6" DBH within the project's anticipated limits of disturbance. The survey points were used to construct a basemap with 1-foot contours in AutoCAD Civil 3D. The existing conditions plan map is provided in the design drawings in **Attachment 1**.

The geomorphic field assessment included extending the thalweg profile survey further upstream and downstream. The profile survey extended 400 feet downstream to the confluence of North Fork Rawson Creek, and was appended to the previously surveyed profile associated with design of Crossing No. 2 (Figure 4-1). The survey extended 400 feet upstream of the crossing, through a reference reach beyond the influence of the current crossing. While surveying the channel profile, the active channel, bankfull, and top of bank widths were measured at numerous locations. A discrete channel cross section was surveyed in the upstream reach and geomorphic channel controlling features were noted. Two pebble counts were conducted to characterize the gradation of the streambed material. Pebble count locations, upstream and downstream of the crossing, are shown on the profile.

4.3 Stream Planform

In the project reach South Fork Rawson Creek generally flows to the northwest, where it meets the mainstem Rawson Creek. The crossing is located within a series of small meanders. The meander bends in this reach of Rawson Creek have very low sinuosity when compared to the rest of the channel. This reach has an access road on one side and a large meadow on the other. The channel condition, low sinuosity and historic land use practices suggest that the channel may have been straightened in this reach. The channel is moderately incised downstream of the crossing and substantially incised upstream. Water appears to flow out of bank at locations upstream of the project study area and across the low portions of the meadow to the east of the channel, not returning to the channel until downstream of the study area.

4.4 Stream Profile Evaluation

The longitudinal profile of the channel was used to estimate the overall stable channel profile as well as the potential variability in the channel bed elevation through the project site (Figure 4-1). Downstream of the culvert there is a small outlet pool and the channel bed is comprised of sands and gravel. The 300-foot reach downstream of the crossing, before the confluence with the North Fork, has a much lower slope than the rest of the channel. The slope of this reach is approximately 0.6% and contains visibly finer bed material than the steeper upstream reach. Scour from high velocities discharging from the culvert and from flows overtopping the existing crossing do not appear to be causing significant scour in this reach.

Marisa Parrish of SRA, visited the site to identify the cause of the aggradation and habitat quality. She found that the aggradation is caused by a few 3- to 4-foot-long logs spanning the channel in the form of an "X," which appear to be conifer (possibly redwood). The wood jam was noted during the thalweg survey and is annotated in the profile near Station 7+00 (Figure 4-1). It appears the material deposited upstream is primarily small gravels with minimal fines and suitable for spawning, which is valuable in this system given its overall lack of suitable spawning habitat. Additionally, she noted that the gravel should be readily mobilized as the debris jam slowly fails. This wood jam was categorized as only partially stable and anticipated to break apart within the next several years. The channel appears geomorphically stable upstream and downstream of the wood jam and additional aggradation is not anticipated.

Immediately upstream of the culvert for approximately 100 feet there is some evidence of deposition and lateral channel adjustment where the banks have widened through erosion and an overflow channel short circuits the upstream meander. This is likely caused by the undersized culvert constricting higher flows and creating an upstream backwater.

The upstream channel is notably different than downstream as it is characterized as incised with abundant wood in the channel. The channel profile upstream of the crossing has a slope at 2.05% and is controlled by large and small wood as well as roots spanning the channel. The channel bed in the upstream reach is frequently scoured to a clay bottom. Much of the wood appears to be cut and is aligned with the flow indicating that it may have been pushed into the channel during previous land use practices. This creates a complex channel profile with larger drops and profile controls. The banks are a sandy-clay with embedded gravel

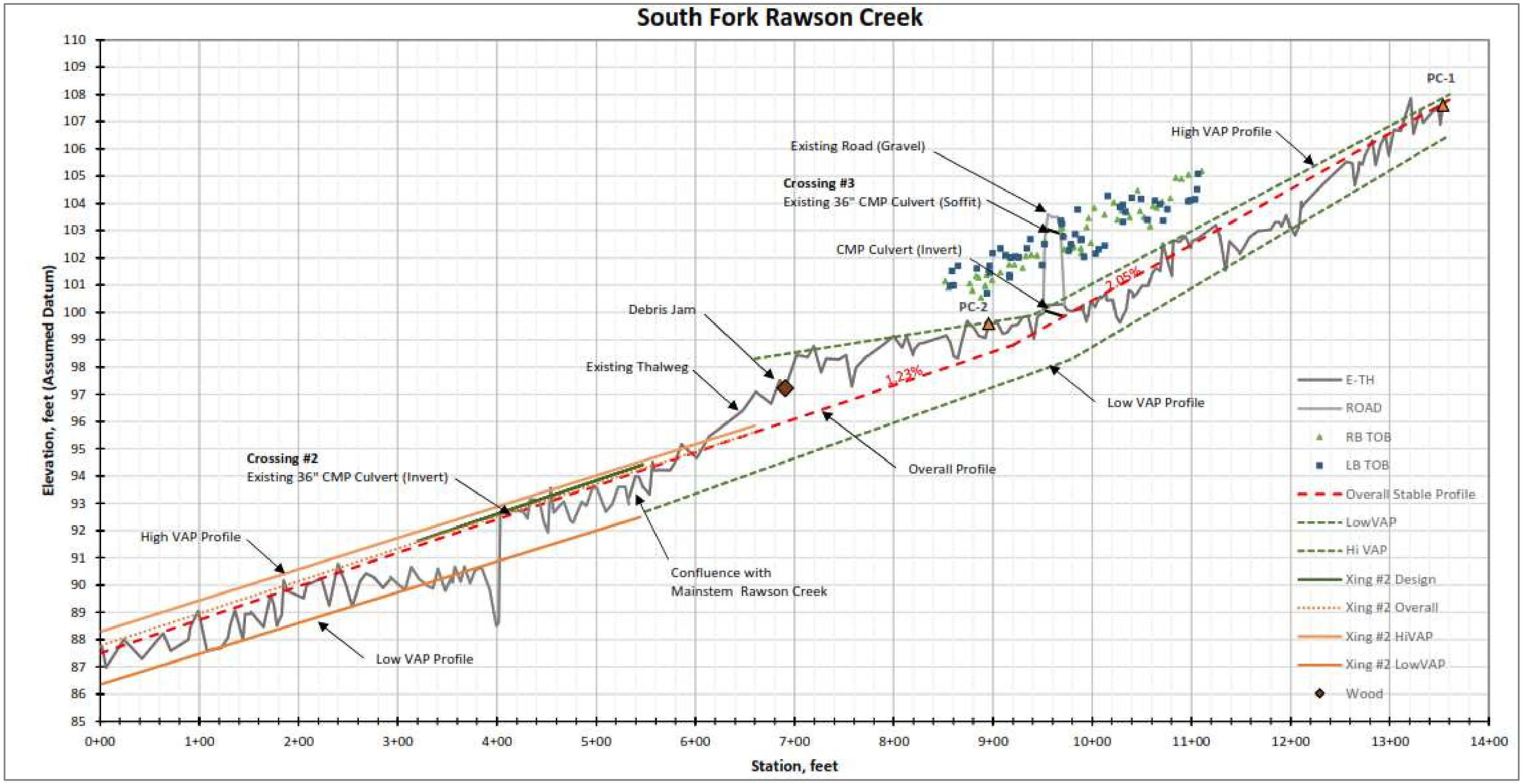

Figure 4-1: Channel thalweg profile upstream and downstream of the existing culvert Crossing No. 3, surveyed on March 17, 2020 appended with profile and analysis conducted for Crossing No. 2 replacement. Vertical adjustment potential profiles, existing culverts and pebble count locations are also shown. Right and left top of bank (RB TOB and LB TOB) shown for reference.

An overall stable profile was projected through the up and downstream channel and referenced to the stable profile developed for Crossing No. 2. Crossing No. 3 appears to be at a natural slope break in the channel. This profile has a slope of 2.05% upstream and 1.23% downstream of the crossing (Figure 4-1). The stable channel profile assumes the aggraded section of channel between the log jam (near Station 7+00) and the crossing will degrade as the jam fails.

Developing stream crossing designs requires considering the degree that the channel bed may aggrade or degrade (rise or fall). The low and high vertical adjustment potential (VAP) profiles in Figure 4-1 represent the estimated range in elevations that the channel bed may occupy during the service life of the crossing structure. The VAP profiles were estimated based on field interpretation and evaluation of the channel profile. In the reach upstream of the crossing, the low VAP profile was based on the pool bottom elevations, which are within the sandy clay soils. For the downstream reach, consideration was given when setting the low VAP to the likelihood that the aggraded channel section will degrade during the crossing service life, resulting in channel adjustments that could propagate through Crossing No. 3.

The high VAP profile is based on the top of the wood controls and riffles in the profile upstream of the crossing, and the riffle crests in the depositional reach downstream. The crossing should be designed to maintain a natural streambed, be structurally sound, and maintain adequate hydraulic capacity with the channel bed occurring anywhere between the low and high VAP profiles.

4.5 Streambed Material Gradation

Two pebble counts were conducted, with their locations shown on the thalweg profile in Figure 4-1. The downstream pebble count (PC-2) occurred within the aggraded reach while the upstream pebble count (PC-1) occurred in a much steeper reach. The resulting gradations provided in Figure 4-2 reflect the differences in channel slope, with the steeper upstream reach having a coarser bed. The streambed material downstream of the crossing has more fines representative of the depositional nature, whereas upstream is characterized as coarser gravel apparently originating from lag deposits embedded in the sandy-clay parent material seen in the bed and banks of the channel. PC-1 had a D84 of approximately 20 mm, or coarse gravel. PC-2 had a D84 of approximately 8 mm, or fine gravel.

4.6 Geomorphic Site Conditions

As part of the overall stream simulation crossing design, channel dimensions were measured for eight sections along the project reach, three downstream and five upstream. All measured sections were outside the influence of the crossing. Averages of active channel width and bankfull width and depth were computed and are provided in Table 2. These values were used to determine the appropriate dimensions for the channel within the new stream simulation crossing.

One channel cross section was surveyed upstream of the culvert as part of the geomorphic assessment and used to develop channel dimensions. Additionally, the topographic survey captured distinct breaklines in the thalweg, channel toe, and tops of bank extending approximately 100 feet downstream of the crossing and 140 feet upstream of the crossing, which aided in verifying typical channel dimensions within the project reach. The bankfull width ranged from 6.5 to 12.0 feet with an average 9.0 feet, and bankfull depth ranged between 1.4 and 2.2 feet. The active channel width, defined as the actively scoured bottom width of the channel, was relatively consistent at approximately 5.5 feet.

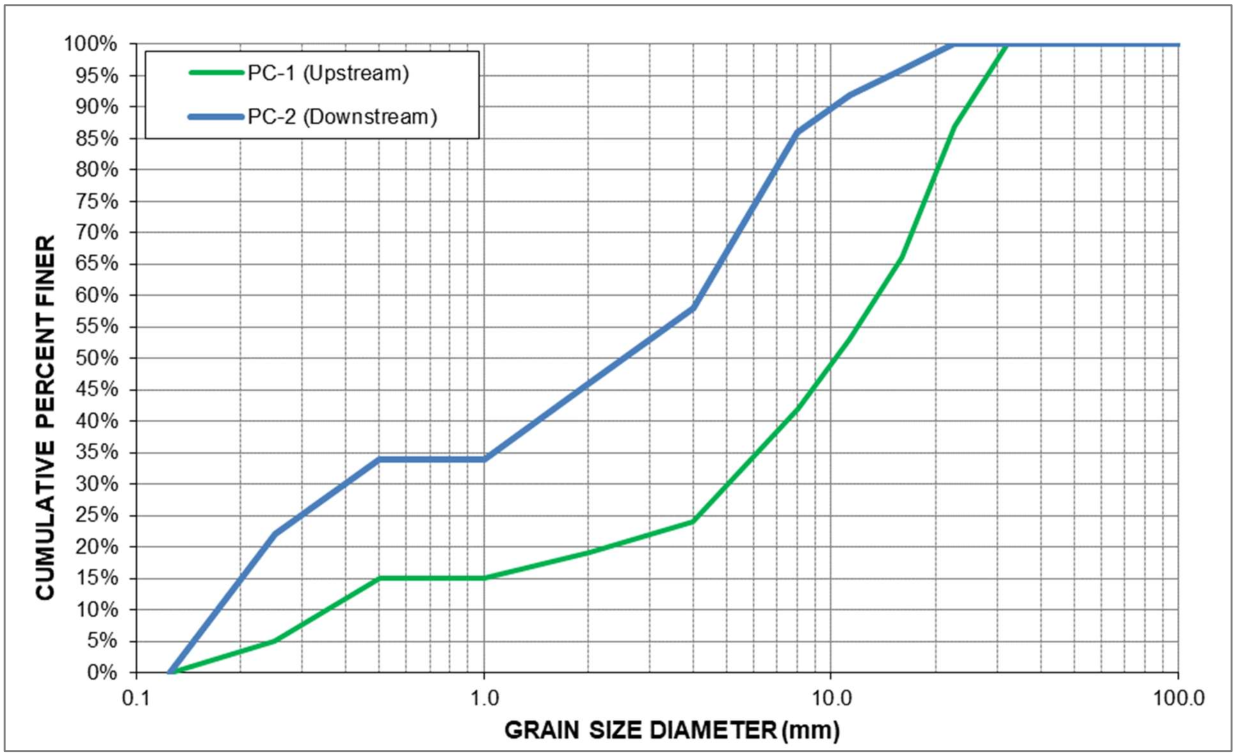

Figure 4-2. Gradation of streambed material from pebble counts occurring upstream and downstream of Crossing No. 3.

Table 2: Measured channel widths upstream and downstream of the Rawson Creek culvert No. 3 crossing.

Location	Active Channel Width (feet)	Bankfull Width (feet)	Bankfull Depth (feet)
Downstream of Crossing	5.0	8.5	1.5
	5.0	9.0	1.5
	6.5	12.0	1.4
Upstream of Crossing	7.5	11.5	1.5
	5.5	6.5	1.6
	5.5	7.5	2.0
	5.5	8.0	2.2
	5.5	9.0	2.0
Mean	**5.8**	**9.0**	**1.7**
Median	**5.5**	**8.8**	**1.6**
Min	**5.0**	**6.5**	**1.4**
Max	**7.5**	**12.0**	**2.2**

5 DESIGN DEVELOPMENT

The crossing design begins with developing the appropriate channel profile and dimensions and then determining the appropriate crossing structure. The design drawings are provided in **Attachment 1**.

5.1 Crossing Location

The current crossing is within a small bend in the channel. Although this is typically not an ideal location for a stream crossing, the location seems suitable for the replacement crossing given the small size of the stream and relative stability of the channel (i.e., no significant lateral migration occurring) The crossing will be realigned slightly to improve the approach angle and reduce potential scour to the downstream banks.

5.2 Design Profile

Figure 5-1 shows the proposed channel profile ("(N) Stream Channel") and potential future profile (Stable Channel), which matches the projected overall profile of the channel shown in Figure 4-1. The overall length of regraded channel is approximately 70 feet. The design channel is placed to match the upstream and downstream channel bed elevations. Upstream of the crossing the channel will tie into an existing shallow pool and downstream will match the existing grade. The design channel slope is 0.9%, matching the slope of the aggraded downstream reach, but slightly less than the downstream 1.23% overall slope that neglects the aggraded reach.

Over time, the downstream aggraded reach is anticipated to degrade towards the overall slope line shown in Figure 4-1 as the debris jam near Station 7+00 fails. In the adjacent channel, wood is a major feature controlling the channel profile. While wood is not proposed to be placed in the channel bed for profile control, it is possible that buried wood will become exposed as the channel adjusts or during construction.

5.3 Design Channel Alignment and Dimensions

The crossing is on a slight meaner bend and the channel alignment appears to have been affected by land use on the current-day meadow. The proposed channel alignment both upstream and downstream of the crossing was developed to improve the approach angle with the channel and reduce stress on the banks by straightening the flow line.

The channel dimensions for the project were based on the measured dimensions in Table 2. An active channel width of 6 feet and bankfull width and depth of 9 feet and 2 feet were applied. This yields a trapezoidal channel with side slopes of 1.3:1 (H:V). Above bankfull (2 feet above the channel bed) the channel banks will be laid back at 2:1 side slope and at a variable slope where transitioning to meet the existing banks.

On the outside of the meander, upstream and downstream of the crossing, rootwads at least 6 feet in diameter, are proposed to provide bank protection. They will be tipped up and placed against the bank with the stem buried into the bank. They will help deflect high flows and protect the bank from scour. RSP will be placed on the face of the backfill over the rootwad stems to protect from scour. Additional RSP will be placed at the inlet and outlet transitions to protect the road fill material and banks from flow contraction and expansion during large flood events.

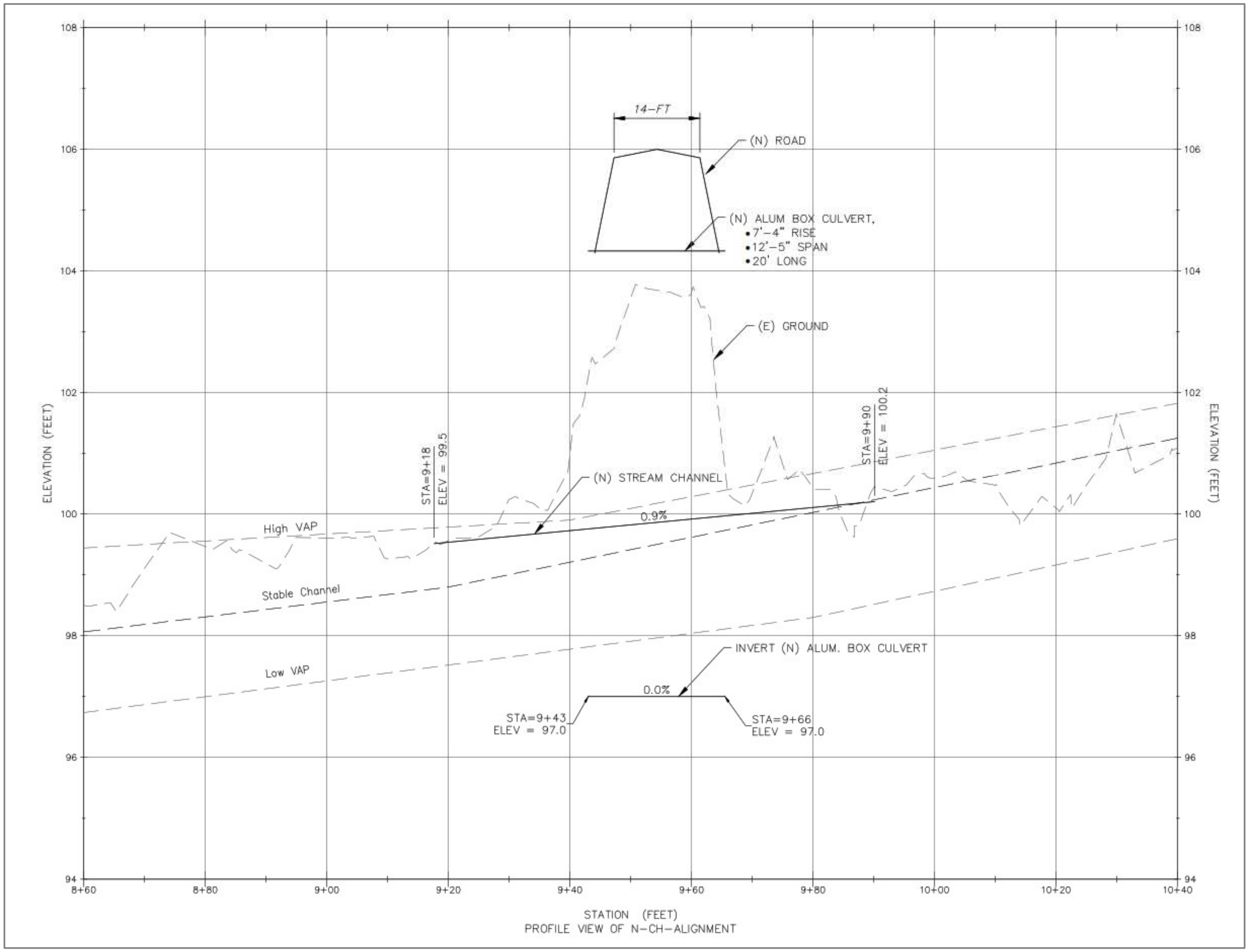

Figure 5-1: Longitudinal profile of new channel and crossing design, showing the predicted low and high VAP profiles based on existing features upstream and downstream the crossing, and the overall stable channel profile representing future conditions.

5.4 Streambed Material

Streambed material will be imported and placed into the graded channel bed to simulate the gradation of the natural channel. Given that the crossing is at the transition between the aggraded downstream reach and the steeper upstream reach, there is evidence of a continued supply of material. Similar to the plan for the Crossing No. 2 replacement, the streambed material will consist of 2-inch minus, rounded river run material. This material will be slightly coarser than the native material that will be delivered from upstream. This slight upsizing in the material is intended to compensate for the placed streambed material being less interlocking and more mobile than the material deposited by streamflows. The intent is to place material within the culvert that becomes mobilized at a similar flow as the upstream native material, thus providing continuity in sediment transport to maintain a natural streambed within the culvert.

5.5 Crossing Structure Type Selection

The proposed crossing must span the bankfull channel width and accommodate a streambed through the crossing at all elevations between the low and high VAP profiles. The bankfull width is approximately 9 feet. The site is constrained by the low roadway, providing minimal height above the stream channel. The current layout places the road surface over the crossing at the low point, such that flows overtopping the road return directly to the downstream channel.

5.5.1 Options Considered but not Developed

Initial examination of crossing options included metal circular and pipe arch culverts as potential structure types. However, these culvert shapes and materials would require raising the road substantially to convey the 100-year flow and provide the required cover over the top of the culvert. To provide a bankfull channel width, much of a round or arch culvert would be buried below the streambed. This proved impractical, especially when the potential for vertical adjustment was taken into consideration.

A modular, channel spanning bridge, similar to the one planned for the downstream crossing replacement, was considered. However, these bridges and their precast footings, are not designed for overtopping by high flows, and the thickness of the bridge deck and H-beams would require raising the road as much as 4 feet.

Open bottom culverts, such as arch culverts set on footings were not considered desirable due to the poor soil conditions and potential for scour and settlement. Also, the amount of cover required requires raising the road substantially.

5.5.2 Precast Concrete Box Preliminary Design

A precast concrete box culvert was developed at the 35% design phase. The design intent was to allow infrequent high flows to overtop the culvert and reenter the channel immediately downstream. The top of the concrete would be the driving surface, avoiding the need for road fill on top of the crossing and minimizing the obstruction during high flows. Evaluation of a concrete box culvert found a 12-foot wide by 6-foot-tall box culvert 16 feet long and embedded 3 feet below the design channel bed would provide continuity for the channel without creating a significant constriction in channel width. The concrete box would need to be segmented to allow for transport and installation.

However, further investigation revealed that a segmented concrete box culvert does not follow a standard Caltrans design, which requires a minimum of 2 feet of cover. There is an acceptable AASHTO (American Association of State Highway and Transportation Officials) standard for concrete boxes with no fill on top that requires a monolithic top rather than segmented construction. Inquires with multiple West Coast suppliers indicated that the non-standard design was not readily available and could not be delivered within the timeframe of this project. Additional cost associated with fabricating this culvert could also increase project costs beyond the available budget.

5.5.3 Preferred Crossing Structure Type

Given the low clearance for the road and need to maintain the channel width through the crossing, an aluminum box culvert designed to convey the design 100-year flow event through the crossing was subsequently identified as the preferred structure type. Aluminum box culverts provide a wide span with a relatively short rise, thus providing the channel spanning width and flow conveyance area needed at this site.

The culvert size was selected to span the bankfull channel width, provide an embedment depth to accommodate the low VAP, and convey the 100-year return period flow with the headwater below the culvert soffit. A standard size was selected from Contech. The selected corrugated aluminum box culvert has a span of 12'-5", a rise of 7'-4" and length of 22'-5" and is provided with a full invert (bottom). This type of structure is delivered in plates and ribs that require bolting together in the field to erect. A photo of a similar structure is provided in Figure 5-2 for illustration.

The proposed design embeds the culvert 3 feet below the design streambed, placing it approximately 1 foot below the low VAP profile. The culvert requires a minimum of 1'-4" of cover and an additional 6" of fill is recommended for non-paved applications to account for rutting. The road surface would be raised approximately 2 feet at its existing lowest spot.

The box culvert can be assembled in the channel or assembled and lifted into placed with an excavator. Streambed material and banklines would then be loaded into the culvert.

5.6 Road Profile

The road alignment will remain the same as current conditions, but the profile will be raised to accommodate the new crossing. The current western approach to the crossing slopes downward at about a 4% slope, reaching the sag in the road over the current culvert before sloping up at about 2% to meet the level of the meadow to the east. The new road profile will flatten the approach over the crossing and then slope down at 3.5 % to the existing road at the edge of the meadow. The regraded road will extend approximately 50 feet east of the crossing locations and will extend westward into the roadway intersection.

Figure 5-2: Example aluminum box culvert with invert and a plate and rib combination. Photo: Contech

5.7 Hydraulic Capacity

A one-dimensional steady-state hydraulic model was developed for the proposed crossing using the HEC-RAS software (USACE, 2010). The model was used to evaluate hydraulic conveyance associated with the 5-, 10-, 25-, 50 -and 100-year flow. HEC-RAS results are provided in **Attachment 3**.

5.7.1 Model Development

The model domain extends 210 feet through the project area. A total of 21 cross sections were used to model the project reach. The cross sections were sampled from the proposed conditions surface as defined by 90% design plans (**Attachment 1**). Based on observed conditions and referenced to Chow (1959), the Manning's roughness coefficient (n) was set at 0.050 for the main channel between the specified bank markers. For overbank areas, the Manning's roughness coefficient of 0.100 was assigned to simulate the hydraulic obstructions created by brush and dense vegetation along the eucalyptus grove and 0.040 for the meadow adjacent to the channel. The crossing was modeled as a 22.5-foot-long box culvert with a span and rise of 12'-5" and 7'-4" respectively. The culvert was embedded 3 feet with a Manning's n of 0.070 applied to the bottom to account for the streambed material and rock banklines. Ineffective flow areas were defined at the channel approaches to the crossing as 2:1 for the upstream contraction and 3:1 for the downstream expansion. Expansion and contraction coefficients were assigned for each cross section as 0.1 and 0.3 respectively, with the exception of the crossing approach sections where they were 0.3 and 0.5.

The proposed aluminum box culvert is not a true box, but has radiused corners and slightly sloped sides. HEC RAS does not offer this specific shape, so a true box was modeled instead. To assess capacity, the available cross-sectional conveyance area at the inlet of the aluminum box culvert was comparted to that of the true box culvert used in the model.

Flow profiles were developed for the 2-, 5-, 10-, 25-, 50- and 100-year return period flows as defined in Table 1. Upstream boundary conditions were defined as critical depth and downstream boundary conditions as normal depth with a channel slope of 0.6% representing the existing channel downstream of the crossing.

5.7.2 Model Results

The HEC-RAS results and water surface profiles for proposed conditions are provided in **Attachment 3**. Culvert capacity is measured at the inlet face of the new crossing. Water surface at the inlet during the 100-year flow (190 cfs) is at elevation 103.7 ft with the soffit of the proposed box culvert at 104.3 ft providing 0.6 feet of freeboard, (Figure 5-3). However, because the culvert was modeled as a true box the flow areas was used to assess capacity. The total cross-sectional area of the proposed aluminum box is 76 sq-ft. When accounting for the 3 feet of embedment, the actual available flow area is 42 sq-ft. The HEC-RAS model results for flow area at the culvert inlet during the 100-year return flow is 42.3 sq-ft, indicating that the proposed embedded aluminum box culvert will provide sufficient open area to convey the 100-year design flow with the headwater below the inlet soffit.

During the 100-year return flow water velocities in the channel are generally around 4.4 ft/s at the culvert approach, and remain between to between 4.0 and 5.2 ft/s downstream of the crossing. Shear stress in the channel is between 1.06 and 1.11 lb/sq ft at the up and downstream extents of the culvert, respectively. In the adjacent channel shear stress is typically around 1 to 2 lb/sq ft. However, in some sections the shear is as high as 3.4 lb/sq ft due to the incised nature of the channel.

5.8 Discussion of Shear Stress Results and Scour Potential

Based on the shear stress results reported in the HEC RAS analysis and reported mobility for ranges of particle diameters (USGS, 2008) the D84 of 22 mm from the upstream pebble count would be mobilized in the proposed crossing and adjacent channel reaches at the 2-year flow 43 cfs. Therefore, it is assumed that some material would be mobilized and scoured during flows greater than the 2-year return event and would be replenished during the receding limb of the flow event.

In areas where high shear stress has the potential to scour the banks rootwads and rock will be placed along the streambank to provide stabilization.

5.8.1 RSP Sizing

Rock slope protection (RSP) will be placed along the banks at the inlet and outlet of the culvert to protect the banks and fill prism in the areas of flow contractions and expansions. The RSP will also be placed around the backfill associated with the rootwads installed along the banks for bank protection. RSP was sized for stability during the 100-year flow event using equation 3-3 in USACE (1994) and HEC-RAS hydraulic results. The analyses indicated that a median (D_{50}) rock diameter of 1.0 foot will remain stable during a 100-year flow event. This size corresponds to facing class rock. However due to the steeper slopes of the channel banks below bankfull, it can be difficult to stack facing class RSP. Therefore, ¼ ton RSP, with a median diameter of 1.8 feet was specified.

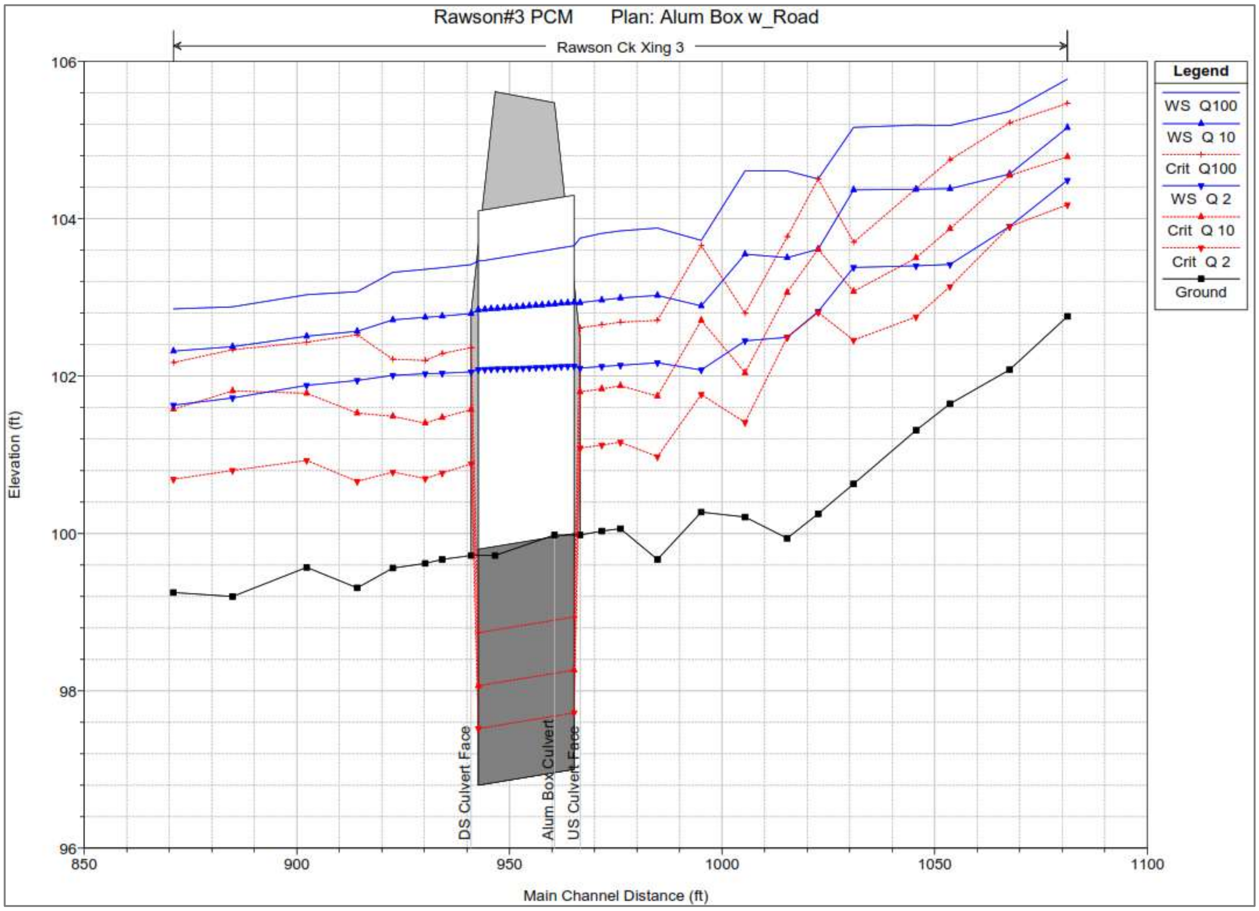

Figure 5-3. HEC RAS 1-D model results for the proposed aluminum box culvert, embedded 3 feet at Q100 (190 cfs), Q10 (100 cfs) and Q2 (43 cfs).

The thickness of the placed RSP will be 2.0 feet. The toe of the RSP will be placed to a minimum depth of 1.5 feet below the channel invert corresponding to the Low VAP profile.

Computations for RSP sizing are presented in **Attachment 4**.

5.9 Opinion of Probable Construction Cost

An Opinion of Probable Construction Cost (OPCC) was developed for this 90% design. It was developed with a 10% contingency to account for changes and refinements in the final phase of design. The cost is for materials and construction only, and does not include permitting, construction oversite or biological services. The cost is estimated to be $153,000 (**Attachment 5**).

6 NEXT STEPS

This TM provides a summary of the basis of design for the stream crossing, the design drawings are provided in **Attachment 1** and an estimate of Probable Construction Cost in **Attachment 5**. These materials are provided for review by the project stakeholders, including staff from the fisheries resource agencies and for permit agencies. Upon receipt of comments and questions, these project construction documents will be finalized.

7 REFERENCES

CDFG. 2009. Parts IX-XII: Fish passage design and implementation. In the California Salmonid Stream Habitat Restoration Manual. California Department of Fish and Game.

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Attachments:

Attachment 1: Design Plans

Attachment 2: Hydrologic Calculations

Attachment 3: HEC-RAS Results

Attachment 4: RSP Sizing

Attachment 5: Opinion of Probable Construction Cost

Attachment 1: Design Plans

SMITH RIVER ALLIANCE

PLANS FOR CONSTRUCTION OF

RAWSON CREEK CULVERT No. 3 REPLACEMENT

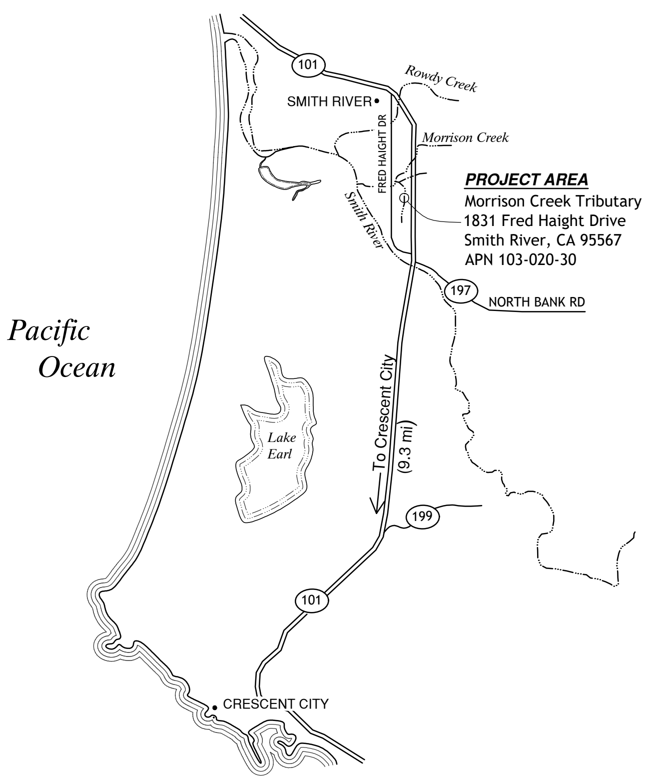
JUNE, 2021
90% DESIGN

Prepared For:

- **SMITH RIVER ALLIANCE**
- **US FISH AND WILDLIFE SERVCE**

Prepared By:

Michael Love & Associates, Inc.
PO Box 4477 ● Arcata, CA 95518 ● (707) 822-2411



LOCATION MAP
NOT TO SCALE

SHEET INDEX	
NUMBER	**SHEET TITLE**
1	TITLE SHEET
2	LEGEND AND ABBEVIATIONS
3	GENERAL SPECIFICATIONS
4	WATER MANAGEMENT
5	EXISTING CONDITIONS
6	NEW CROSSING LAYOUT
7	CROSING PROFILE
8	CROSSING DETAILS
9	CHANNEL DETAILS

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SMITH RIVER ALLIANCE
RAWSON CREEK
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1 - TITLE SHEET

DATE	JUNE 2021
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DRAWN	LLANOS
SHEET	1 of 9

LEGEND AND SYMBOLS

EXISTING

- FENCE LINE
- EDGE OF GRAVEL ROAD
- PROPERTY LINE
- 16 — CONTOUR AND ELEVATION
- CHANNEL THALWEG OR DRAINAGE
- 1+00 — ALIGNMENT STATIONING (FEET)
- CONTROL POINT/TEMPORARY BENCH MARK
- FLOW DIRECTION
- 4.5' RD — TREE OF DBH 6" AND GREATER, SIZE, AND TYPE
- STUMP
- LARGE WOOD IN CHANNEL

NEW

- LIMIT OF DISTURBANCE (LOD)
- EDGE OF GRAVEL ROAD
- 16 — CONTOUR AND ELEVATION
- 1+00 — STATIONING (FEET)
- CHANNEL THALWEG
- TEMPORARY FISH EXCLUSION FENCING
- TEMPORARY EARTH DIKE
- TEMPORARY FILTER BAG
- FLOW DIRECTION
- ROOT WAD
- TREE TO BE REMOVED

A / C-1

SECTION, DETAIL OR TYPICAL NAME OR NUMBER

PAGE NO. OR DIVISION ON WHICH SECTION, DETAIL OR TYPICAL IS APPLIED, OR APPEARS

ABBREVIATIONS

ABUT	ABUTMENT
AC	ASPHALT CONCRETE
AGG	AGGREGATE
ALD	ALDER
ALUM	ALUMINUM
APPROX	APPROXIMATELY
BVC	BEGIN VERTICAL CURVE
CH	CHANNEL
CL	CENTERLINE
CMP	CORRUGATED METAL PIPE
CONC	CONCRETE
CO	CONTRACT OWNER
COR	CONTRACT OWNER REPRESENTATIVE
CP	SURVEY CONTROL POINT
DBL	DOUBLE
DIAM	DIAMETER
EG	EXISTING GROUND
EL, ELEV	ELEVATION
EUC	EUCALYPTUS
EVG	END VERTICAL CURVE
EXCAV	EXCAVATION
FG	FINISHED GROUND
FT	FOOT OR FEET
IN	INCHES
INV	INVERT
LBS	POUNDS
LOD	LIMIT OF DISTURBANCE
LOG	LIMIT OF GRADING
LT	LEFT
MAX	MAXIMUM
MIN	MINIMUM
MP	MID POINT
NTS	NOT TO SCALE
O.C.	ON CENTER
OG	ORIGINAL GROUND
OGRD	OLD GROWTH REDWOOD
Q_{100}	PROJECT 100-YEAR RETURN PERIOD FLOW
R.C.	RELATIVE COMPACTION
R.D.	RELATIVE DENSITY
RD	ROAD
RDWD	REDWOOD
RSP	ROCK SLOPE PROTECTION
RT	RIGHT
SPA	SPACING
STA	STATION
TBD	TO BE DETERMINED
TBM	TEMPORARY BENCHMARK
TYP	TYPICAL
UNO	UNLESS NOTED OTHERWISE
VC	VERTICAL CURVE
W/	WITH
WSE	WATER SURFACE ELEVATION
#	NUMBER
%	PERCENT
(A)	EXISTING
(N)	NEW
ø	DIAMETER
1.5:1	HORIZONTAL: VERTICAL SLOPE

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2 - LEGEND AND ABBEVIATIONS

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SHEET	2 of 9

GENERAL

1. SMITH RIVER ALLIANCE (SRA) IS THE CONTRACT OWNER (CO). THE TERM CONTRACT OWNER REPRESENTATIVE (COR) IS DEFINED AS ANY AUTHORIZED PROFESSIONAL DESIGNATED BY SRA. ALL IMPROVEMENTS SHALL BE ACCOMPLISHED UNDER THE APPROVAL, INSPECTION AND TO THE SATISFACTION OF THE CO OR COR.
2. CONTRACTOR AGREES TO ASSUME SOLE AND COMPLETE RESPONSIBILITY FOR THE WORK AREA DURING THE COURSE OF CONSTRUCTION, INCLUDING SAFETY OF ALL PERSONS AND PROPERTY. THIS REQUIREMENT SHALL APPLY CONTINUOUSLY AND SHALL NOT BE LIMITED TO NORMAL WORKING HOURS. THE CONTRACTOR SHALL DEFEND, INDEMNIFY AND HOLD THE LANDOWNER, CO, AND ITS REPRESENTATIVES HARMLESS FROM ANY LIABILITY, REAL AND OR ALLEGED, IN CONJUNCTION WITH THE PERFORMANCE OF THIS PROJECT.
3. A SET OF SIGNED WORKING DRAWINGS SHALL BE KEPT ON SITE AT ALL TIMES ON WHICH CONTRACTOR SHALL RECORD VARIATIONS IN THE WORK, INCLUDING ALL EXISTING UTILITIES. THESE DRAWINGS SHALL BE SUBMITTED TO THE COR UPON COMPLETION OF WORK.
4. THE CONTRACTOR SHALL IMMEDIATELY NOTIFY THE COR UPON DISCOVERING SIGNIFICANT DISCREPANCIES, ERRORS OR OMISSIONS IN THE PLANS. PRIOR TO PROCEEDING, THE COR SHALL HAVE THE PLANS REVISED TO CLARIFY IDENTIFIED DISCREPANCIES, ERRORS OR OMISSIONS.
5. PLACED MATERIALS NOT CONFORMING TO SPECIFICATIONS SHALL BE REMOVED AND REPLACED AS DIRECTED BY THE COR AT NO ADDITIONAL COST TO THE CO.
6. IN THE EVENT CULTURAL RESOURCES (I.E., HISTORICAL, ARCHAEOLOGICAL, AND PALEONTOLOGICAL RESOURCES, OR HUMAN REMAINS) ARE DISCOVERED DURING EXCAVATION, GRADING OR OTHER CONSTRUCTION ACTIVITIES, WORK SHALL BE HALTED WITHIN A 100 FOOT RADIUS OF THE FIND. A QUALIFIED ARCHEOLOGIST RETAINED BY THE COR SHALL BE CONSULTED FOR AN ON-SITE EVALUATION. ADDITIONAL MITIGATION MAY BE REQUIRED, AT CO'S EXPENSE PER THE ARCHEOLOGIST'S RECOMMENDATIONS. IF HUMAN BURIALS OR HUMAN REMAINS ARE ENCOUNTERED, THE CONTRACTOR SHALL IMMEDIATELY NOTIFY THE COUNTY CORONER.
7. IF HAZARDOUS MATERIALS OR WHAT APPEAR TO BE HAZARDOUS MATERIALS ARE ENCOUNTERED, STOP WORK IN THE AFFECTED AREA IMMEDIATELY AND CONTACT 911 OR THE APPROPRIATE AGENCY FOR FURTHER INSTRUCTION.
8. CONTRACTOR SHALL BE RESPONSIBLE FOR PROVIDING THEIR OWN WATER AND POWER FOR OPERATIONS, IRRIGATION AND DUST CONTROL. WATER SHALL NOT BE PUMPED FROM THE CREEK FOR THESE USES.
9. NOTED DIMENSIONS TAKE PRECEDENCE OVER SCALE.
10. COR WILL PROVIDE CONSTRUCTION STAKING. RESPONSIBILITY OF CONTRACTOR TO MAINTAIN OR REPLACE CONSTRUCTION STAKES.

SEQUENCE OF CONSTRUCTION

WORK PHASING SHALL OCCUR AS FOLLOWS, UNLESS OTHERWISE APPROVED BY COR:

1. SUBMIT NECESSARY SUBMITTALS FOR APPROVAL. ONCE APPROVED, THE CONTRACTOR MAY COMMENCE THE WORK UNLESS OTHERWISE DIRECTED.
2. MOBILIZATION
3. INSTALLATION OF FISH EXCLUSION DEVICES AND REMOVAL OF FISH FROM WORK AREA.
4. INSTALLATION OF TEMPORARY COFFERDAMS, CLEAR WATER DIVERSIONS, DE-WATERING, AND SEDIMENT CONTROL WITHIN WORK AREA AS NEEDED.
5. CLEARING AND GRUBBING OF WORK AREA, INCLUDING TREE REMOVAL AND SALVAGE.
8. REMOVAL OF EXISTING CULVERT, IN STREAM CONSTRUCTION, AND INSTALLATION OF NEW CROSSING.
9. RECONSTRUCTION OF ROAD AND RE-OPENING FOR PRIVATE ACCESS.
10. REMOVAL OF WATER MANAGEMENT DEVICES.
11. REMOVAL OF FISH EXCLUSION DEVICES.
12. STABILIZATION OF THE WORK AREA.
13. DEMOBILIZATION.
14. REMEDIATION AND REPAIR OF PRIVATE ROADWAY.

CONTRACTOR SHALL SUBMIT A DETAILED SCHEDULE PRIOR TO COMMENCING CONSTRUCTION.

CLEARING AND GRUBBING

1. CLEARING AND GRUBBING SHALL BE IN ACCORDANCE WITH SECTION EC-2 OF CASQA AND THE EROSION AND SEDIMENT CONTROL NOTES IN THE CONTRACT DOCUMENTS.
2. THE LIMIT OF DISTURBANCE DOES NOT DENOTE THE LIMIT OF CLEARING AND GRUBBING. THE EXTENT OF CLEARING SHALL BE MINIMIZED TO THE EXTENT POSSIBLE WITHIN THE LIMIT OF DISTURBANCE TO ALLOW MANEUVERABILITY OF EQUIPMENT.
3. EUCALYPTUS TREES DESIGNATED FOR REMOVAL SHALL BE SALVAGED WITH ROOTWAD, EXCAVATED AND CUT TO 20-FT LENGTHS. ROOT WADS SHALL REMAIN INTACT WITH STEM MIN 20-FT IN LENGTH. CUT LOGS AND ROOT WADS SHALL BE STOCKPILED AT A DESIGNATED LOCATION NEAR PROJECT SITE.
4. ALDER TREES, LIMBS AND SLASH SHALL BE CHIPPED AND USED FOR SITE STABILIZATION.
5. EXISTING TREE ROOTS OF TREES TO REMAIN WITHIN LIMITS OF EXCAVATION SHALL BE PRESERVED TO THE EXTENT POSSIBLE.
6. REMAINING ORGANIC MATERIAL FROM TREE REMOAL CLEARING AND GRUBBING SHALL BE CHIPPED AND USED FOR SITE STABILIZATION.
7. TREES NOT DESIGNATED FOR REMOVAL SHALL REMAIN AND BE PROTECTED.

EROSION & SEDIMENT CONTROL

GENERAL NOTES

1. AT MINIMUM THE CONTRACTOR SHALL EMPLOY THE FOLLOWING BEST MANAGEMENT PRACTICES (BMPS) AS APPLICABLE, AS DESCRIBED IN THE CURRENT CALIFORNIA STORMWATER BMP HANDBOOK FOR CONSTRUCTION (CASQA HANDBOOK) (WWW.CASQA.ORG):

EC-1	SCHEDULING
EC-2	PRESERVATION OF EXISTING VEGETATION
EC-8	WOOD MULCHING
SE-1	SILT FENCE
SE-5	FIBER ROLLS
WE-1	WIND EROSION CONTROL
NS-1	WATER CONSERVATION PRACTICES
NS-2	DEWATERING OPERATION
NS-5	CLEARWATER DIVERSION
NS-8	VEHICLE AND EQUIPMENT CLEANING
NS-9	VEHICLE AND EQUIPMENT FUELING
NS-10	VEHICLE AND EQUIPMENT MAINTENANCE
SS-10	VELOCITY DISSIPATION DEVICES
WM-1	MATERIALS DELIVERY AND STORAGE
WM-2	MATERIAL USE
WM-3	STOCKPILE MANAGEMENT
WM-4	SPILL PREVENTION AND CONTROL
WM-5	SOLID WASTE MANAGEMENT
WM-9	SANITARY/SEPTIC WASTE MANAGEMENT

2. CONTRACTOR MUST ENSURE THAT THE CONSTRUCTION SITE IS STABILIZED PRIOR TO THE ONSET OF ANY RAIN EVENT TO PREVENT SEDIMENT DELIVERY TO WATERWAYS.
3. IT IS THE RESPONSIBILITY OF THE CONTRACTOR TO MINIMIZE EROSION AND PREVENT THE TRANSPORT OF SEDIMENT TO THE ADJACENT STREAM AND SENSITIVE AREAS. CONTRACTOR WILL BE RESPONSIBLE FOR ALL FINES AND CLEANUP OF ANY VIOLATIONS.
4. SUFFICIENT EROSION CONTROL SUPPLIES SHALL BE AVAILABLE ON-SITE AT ALL TIMES TO ADDRESS AREAS SUSCEPTIBLE TO EROSION DURING RAIN EVENTS.
5. MINIMIZE DISTURBANCE OF EXISTING VEGETATION TO THAT NECESSARY TO COMPLETE WORK.
6. ALL HEAVY EQUIPMENT SHALL BE STEAM CLEANED PRIOR TO ENTRY TO THE PROJECT SITE TO INHIBIT THE SPREAD OF EXOTIC SEED. ALL HEAVY EQUIPMENT SHALL BE LEAK FREE UPON ENTRY TO THE PROJECT SITE AND ANY LEAKS SHALL BE REPAIRED IMMEDIATELY.
7. ACTIVITIES SUCH AS VEHICLE WASHING ARE TO BE CARRIED OUT AT AN OFF-SITE FACILITY WHENEVER PRACTICAL.
8. THE CONTRACTOR, AS NECESSARY, SHALL IMPLEMENT OTHER BMPS SPECIFIED IN THE CASQA HANDBOOK DICTATED BY SITE CONDITIONS AND AS DIRECTED BY THE COR. THIS PLAN MAY NOT COVER ALL THE SITUATIONS THAT ARISE DURING CONSTRUCTION DUE TO UNANTICIPATED FIELD CONDITIONS. VARIATIONS MAY BE MADE TO THE PLAN IN THE FIELD SUBJECT TO THE APPROVAL OF OR AT THE DIRECTION OF THE COR.
9. THE CONTRACTOR SHALL MAKE ADEQUATE PREPARATIONS, INCLUDING TRAINING AND EQUIPMENT, TO CONTAIN SPILLS OF OIL AND OTHER HAZARDOUS MATERIALS. SPILL KITS SHALL BE PRESENT AT EACH WORK SITE TO INHIBIT THE SPREAD OF FLUID LEAKS ONTO THE GROUND OR SURROUNDING AREAS.
10. THE CONTRACTOR SHALL PROVIDE COVERED WASTE RECEPTACLE FOR COMMON SOLID WASTE AT CONVENIENT LOCATIONS ON THE JOB SITE AND PROVIDE REGULAR COLLECTION OF WASTES.
11. BOTH ACTIVE AND NON-ACTIVE SOIL AND MATERIAL STOCKPILES SHALL BE PROPERLY PROTECTED TO MINIMIZE SEDIMENT AND POLLUTANT TRANSPORT FROM THE CONSTRUCTION SITE (WM-3).
12. THE CONTRACTOR SHALL PROVIDE SANITARY FACILITIES OF SUFFICIENT NUMBER AND SIZE TO ACCOMMODATE CONSTRUCTION CREWS AND ENSURE ADEQUATE ANCHORAGE OF SUCH FACILITIES TO PREVENT TIPPING BY WEATHER OR VANDALISM.
13. PRIOR TO FINAL ACCEPTANCE, ALL DISTURBED AREAS SHALL BE PERMANENTLY STABILIZED WITH WOOD CHIPS BY CONTRACTOR AND TEMPORARY SEDIMENT CONTROL MEASURES SHALL BE INSTALLED AS SPECIFIED.

EXCAVATION AND FILL

1. EXCAVATION SHALL INCLUDE EXCAVATION AND HANDLING OF SATURATED SOILS. CONTRACTOR SHALL BE PREPARED TO DEWATER AND /OR TRANSPORT SATURATED SOIL IN A MANNER THAT PREVENTS EXCESS DISCHARGE OR SPILLAGE OF SOILS OR WATER WITHIN THE CONSTRUCTION ACCESS AREA OR ON ADJACENT PROPERTIES OR ROADWAYS. SHOULD ANY DISCHARGE OCCUR, THE CONTRACTOR SHALL BE RESPONSIBLE FOR IMMEDIATE AND COMPLETE CLEAN UP. MULTIPLE HANDLING OF MATERIAL MAY BE NECESSARY.
2. DURING EXCAVATION SUITABLE MATERIAL SHALL BE SEPARATED AND STOCKPILED FOR RE-USE AS EMBANKMENT BACKFILL AND STREAMBED MATERIAL.
3. EXCAVATED MATERIAL SHALL BE MOISTURE CONDITIONED TO ACHIEVE THE SPECIFIED COMPACTION FOR BACKFILL.
4. UNSUITABLE MATERIAL SHALL BECOME THE PROPERTY OF THE CONTRACTOR AND SHALL BE REMOVED FROM THE SITE BY THE CONTRACTOR FOR DISPOSAL IN AN APPROVED LOCATION. UNSUITABLE MATERIAL INCLUDES ORGANIC MATERIAL, CONCRETE, GROUTED RIPRAP, PIPES ALL AND OTHER MANMADE MATERIALS WITHIN THE LIMIT OF DISTURBANCE (LOD).
5. UNLESS OTHERWISE SPECIFIED, TOLERANCE FOR FINISHED GRADING SHALL BE ±0.2 FEET VERTICALLY AND ±0.5 FEET HORIZONTALLY.
6. SUITABLE EXCAVATED MATERIAL SHALL BE STOCKPILED IN THE DESIGNATED CONTRACTOR USE AREA.
7. GRADING MAY BE ADJUSTED AT DIRECTION OF COR TO AVOID TREES AND OTHER FEATURES.
8. THE GROUND SURFACE SHALL BE PREPARED TO RECEIVE FILL BY REMOVING VEGETATION, NON-COMPLYING FILL, TOPSOIL AND OTHER UNSUITABLE MATERIALS, SCARIFYING TO PROVIDE A BOND WITH THE NEW FILL.

UTILITY

1. ALL UTILITIES SHOWN (IF ANY) WERE LOCATED FROM ABOVE GROUND VISUAL STRUCTURES. NO UTILITY RESEARCH WAS CONDUCTED FOR THE SITE. NOTIFY UNDERGROUND SERVICE ALERT (DIGALERT) AT LEAST TWO DAYS PRIOR TO ANY GRADING OR EXCAVATION WITHIN THE SITE BY CALLING 811 OR 1-800-227-2600.
2. CONTRACTOR IS RESPONSIBLE FOR ANY DAMAGE TO UTILITIES, FEATURES AND STRUCTURES LOCATED IN THE PROJECT AREA AND CONSTRUCTION ACCESS ROUTES. CONTRACTOR SHALL AVOID DISRUPTION OF ANY UTILITIES UNLESS PREVIOUSLY ARRANGED WITH COR.
3. CONSTRUCTION MAY TAKE PLACE IN THE VICINITY OF OVERHEAD UTILITY LINES. IT IS THE CONTRACTOR'S RESPONSIBILITY TO BE AWARE OF AND OBSERVE THE MINIMUM CLEARANCES FOR WORKERS AND EQUIPMENT OPERATING NEAR HIGH VOLTAGE, AND COMPLY WITH THE SAFETY ORDERS OF THE CALIFORNIA DIVISION OF INDUSTRIAL SAFETY AS WELL AS OTHER APPLICABLE SAFETY REGULATIONS.
4. TELEPHONE, ELECTRIC, WATER AND OTHER UTILITY LINES SHALL BE PROTECTED DURING CONSTRUCTION TO PREVENT INTERRUPTION OF SERVICE.

CONSTRUCTION ACCESS:

1. CONTRACTOR WILL USE THE PRIMARY PRIVATE ROAD FOR CONSTRUCTION ACCESS.
2. CONTRACTOR USE AREAS ARE INDICATED IN THE DRAWINGS.
3. ANY ADDITIONAL AREAS TO BE USED MUST BE APPROVED BY THE COR.

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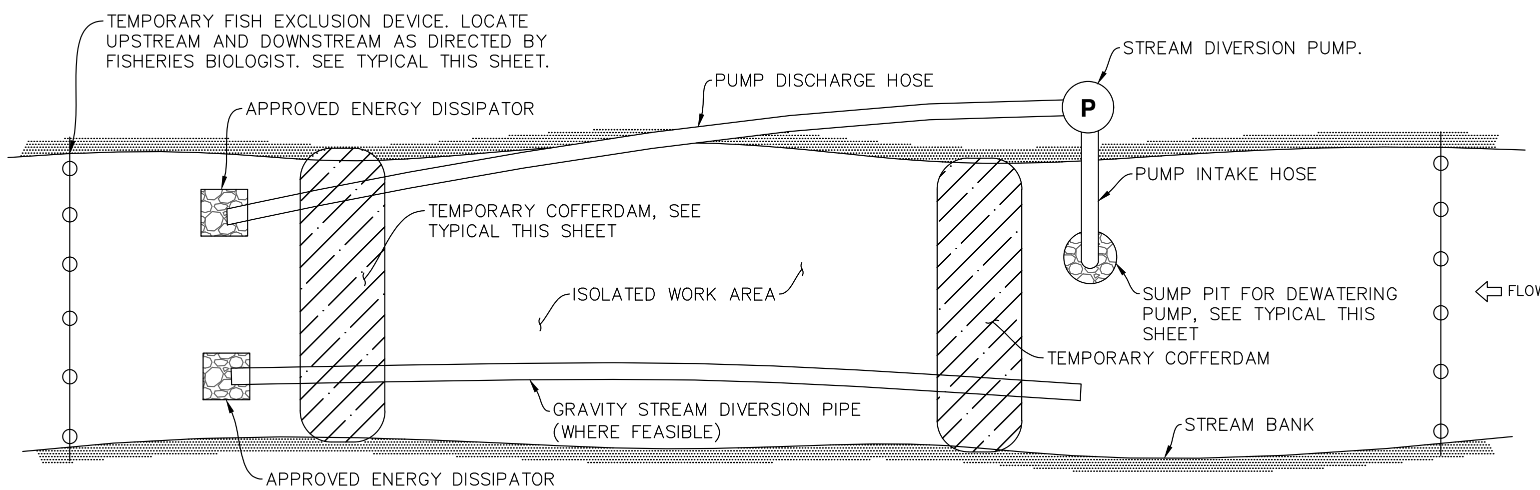
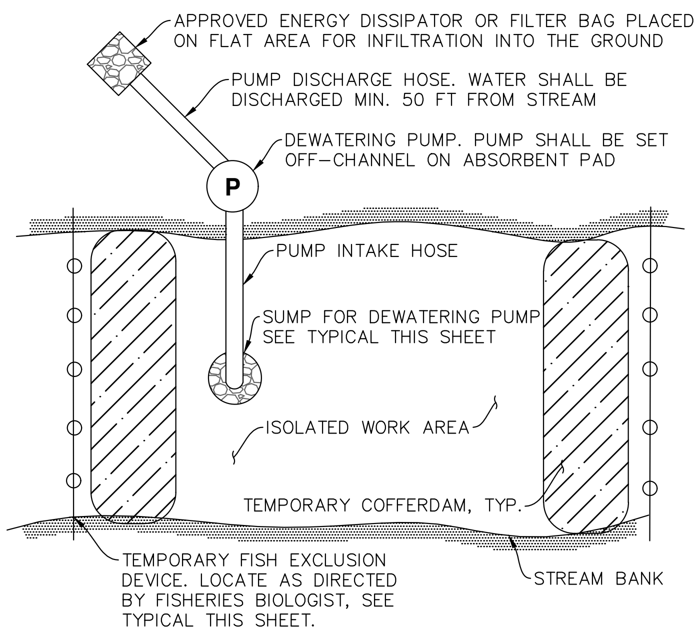
3 - GENERAL SPECIFICATIONS

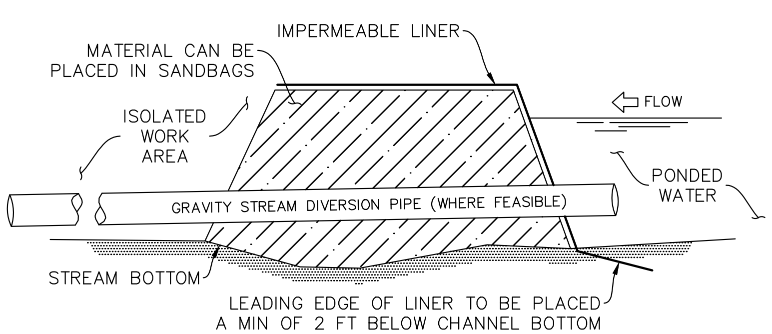
DATE	JUNE 2021
SUBMITTAL	90% DESIGN
DESIGN	LLANOS / LOVE
DRAWN	LLANOS
SHEET	3 of 9



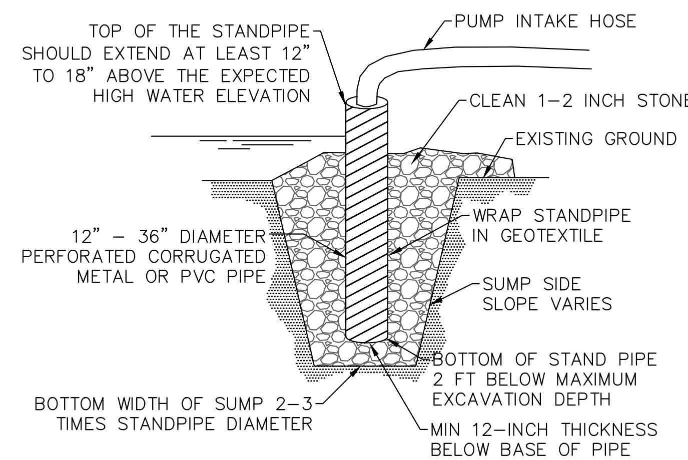
TEMPORARY CLEAR WATER BYPASS
TYPICAL PLAN (NTS)



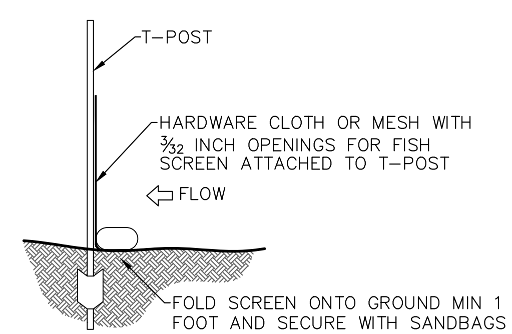
TEMPORARY NUISANCE AND POND DEWATERING MEASURES
TYPICAL PLAN (NTS)



TEMPORARY COFFERDAM
TYPICAL PROFILE (NTS)



SUMP PIT
TYPICAL SECTION (NTS)



TEMPORARY FISH EXCLUSION DEVICE
TYPICAL PROFILE (NTS)

1 / TYP **WATER MANAGEMENT**
TYPICAL

WATER MANAGEMENT

GENERAL

1. THE WATER MANAGEMENT FEATURES (E.G. COFFERDAMS) SHOWN IN THE CONTRACT DRAWINGS ARE APPROXIMATE. THE CONTRACTOR IS TO DESIGN A WATER MANAGEMENT PLAN THAT MEETS THE CONTRACTORS APPROACH TO THE PROJECT WHILE MEETING PERMIT AND OTHER CONSTRAINTS.
2. THE OBJECTIVE OF WATER MANAGEMENT IS TO ISOLATE THE CHANNEL WORK SO THAT WORK IS COMPLETED IN DRY CONDITIONS. TO ACCOMPLISH THIS, THE CONTRACTOR MUST EMPLOY A CLEAR WATER DIVERSION SYSTEM AND A DEWATERING SYSTEM. THE CLEAR WATER DIVERSION SYSTEM BYPASSES CREEK WATER AROUND THE WORK AREA. THE DEWATERING SYSTEM REMOVES "NUISANCE" WATER (E.G. SEEPAGE) FROM WITHIN THE ISOLATED WORK AREA.
3. THE CONTRACTOR MUST SUBMIT A WATER MANAGEMENT PLAN FOR APPROVAL.
4. NO CONSTRUCTION ACTIVITIES ARE PERMITTED UNTIL THE WATER MANAGEMENT PLAN HAS BEEN APPROVED.

SUBMITTALS

THE WATER MANAGEMENT PLAN MUST INCLUDE THE FOLLOWING:

1. SUMMARY OF THE CONTRACTOR'S WATER MANAGEMENT APPROACH.
2. DESCRIBE THE APPROACH TO COORDINATE THE REMOVAL OF FISH AND OTHER SPECIES FROM THE ISOLATED WORK AREA.
3. DESCRIBE IN DETAIL, INCLUDING FIGURES, THE CLEAR WATER DIVERSION SYSTEM. THIS INCLUDES, BUT IS NOT LIMITED TO, LOCATION AND TYPE OF INFRASTRUCTURE, DESIGN FLOW, PIPE SIZE, PIPE MATERIAL, PIPE LENGTH, PIPE ROUTING, ETC., AND PUMP DETAILS, IF UTILIZED.
4. DESCRIBE IN DETAIL, INCLUDING FIGURES, THE DEWATERING SYSTEM. THIS INCLUDES, BUT IS NOT LIMITED TO, THE LOCATION OF INFRASTRUCTURE, TYPES OF EQUIPMENT, SIZE OF EQUIPMENT, DISCHARGE LOCATIONS, ETC.
5. DESCRIBE IN DETAIL THE PROCEDURES TO BE EXECUTED SHOULD THE CHANNEL FLOW INCREASE (I.E. BECAUSE OF STORM EVENT).

PRODUCTS

COFFERDAM

1. MAY BE CONSTRUCTED USING NATIVE OR IMPORTED MATERIAL PLACED IN BAGS (E.G. SAND BAGS, SUPERSACKS). NO COFFERDAM MATERIAL MAY BE RELEASED TO THE CHANNEL AT THE COMPLETION OF THE CONSTRUCTION WITHOUT APPROVAL. MATERIAL AND APPROACH TO BE DESCRIBED IN THE WATER MANAGEMENT PLAN.
2. THE IMPERMEABLE LINER MATERIAL TO BE USED SHALL BE IDENTIFIED IN THE WATER MANAGEMENT PLAN.
3. COFFERDAM SHALL NOT BE OVERTOPPED

CLEAR WATER BYPASS SYSTEM

1. GRAVITY SYSTEM IS PREFERRED. SYSTEM SHALL BE CAPABLE OF CONVEYING ALL OF THE STREAM'S FLOW.
2. ANY PUMP AND PUMPING APPARATUS USED FOR THE CLEAR WATER DIVERSION SHALL BE OF THE SUBMERSIBLE TYPE WITH SUFFICIENT CAPACITY TO PUMP ALL THE STREAM'S FLOW.
3. THE CONTRACTOR SHALL PROVIDE BACKUP POWER AND PUMPING EQUIPMENT TO ASSURE THAT THE CLEAR WATER DIVERSION REMAINS FUNCTIONAL THROUGHOUT THE TIME PERIOD THAT THE CHANNEL IS ISOLATED.

DEWATERING SYSTEM

1. THE CONTRACTOR SHALL FURNISH ALL MATERIALS, TOOLS, EQUIPMENT, FACILITIES AND SERVICES AS REQUIRED FOR PROVIDING THE NECESSARY DEWATERING WORK AND FACILITIES, AND PROVIDE BACKUP EQUIPMENT AS NECESSARY FOR REPLACEMENT AND FOR UNANTICIPATED EMERGENCIES.
2. REMOVED NUISANCE WATER SHALL NOT BE RETURNED DIRECTLY TO SURFACE WATER AND SHALL BE TREATED ACCORDANCE WITH PROJECT PERMITS

EXECUTION

1. NO WORK MAY BEGIN UNTIL THE CONTRACTOR'S WATER MANAGEMENT PLAN HAS BEEN APPROVED.
2. PRIOR TO ANY INSTALLATION OF WATER MANAGEMENT FACILITIES, THE FISH REMOVAL WORK MUST BE COMPLETED.
3. INSTALL WATER MANAGEMENT SYSTEMS PER THE APPROVED WATER MANAGEMENT PLAN.
4. REFER TO CONTRACT DRAWING DETAILS FOR ADDITIONAL INFORMATION.
5. CLEAR WATER BYPASS SYSTEM MUST OPERATE CONTINUOUSLY UNTIL ALL IN CHANNEL WORK HAS BEEN COMPLETED AND REMOVAL HAS BEEN APPROVED.
6. ONCE THE IN-CHANNEL WORK IS COMPLETED AND ACCEPTED, REMOVE WATER MANAGEMENT SYSTEMS PER THE APPROVED WATER MANAGEMENT PLAN AS AS DIRECTED.

AQUATIC SPECIES MANAGEMENT

GENERAL

- THE PROJECT AREA WILL LIKELY INCLUDE FISH AND OTHER SPECIES THAT NEED TO BE REMOVED PRIOR TO ANY IN-CHANNEL WORK, INCLUDING THE INSTALLATION OF WATER MANAGEMENT SYSTEMS. THE CONTRACTOR SHALL WORK WITH THE COR TO COORDINATE THE REMOVAL OF FISH AND OTHER SPECIES.
- NO WORK MAY BE COMPLETED UNTIL THE WATER MANAGEMENT PLAN HAS BEEN APPROVED.
- CONTRACTOR SHALL INCLUDE DETAILS IN WATER MANAGEMENT PLAN ON HO FISHERIES BIOLOGIST WILL BE COORDINATED.

PRODUCTS

- REFER TO DRAWING DETAILS FOR PRODUCT INFORMATION.

EXECUTION

- THE CONTRACTOR MUST COORDINATE WITH THE CONTRACT OWNER AND THEIR BIOLOGIST. IT IS THE CONTRACTOR'S RESPONSIBILITY TO NOTIFY THE CONTRACT OWNER AT LEAST ONE WEEK PRIOR TO NEEDING THE BIOLOGIST'S SERVICES.

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4 - WATER MANAGEMENT

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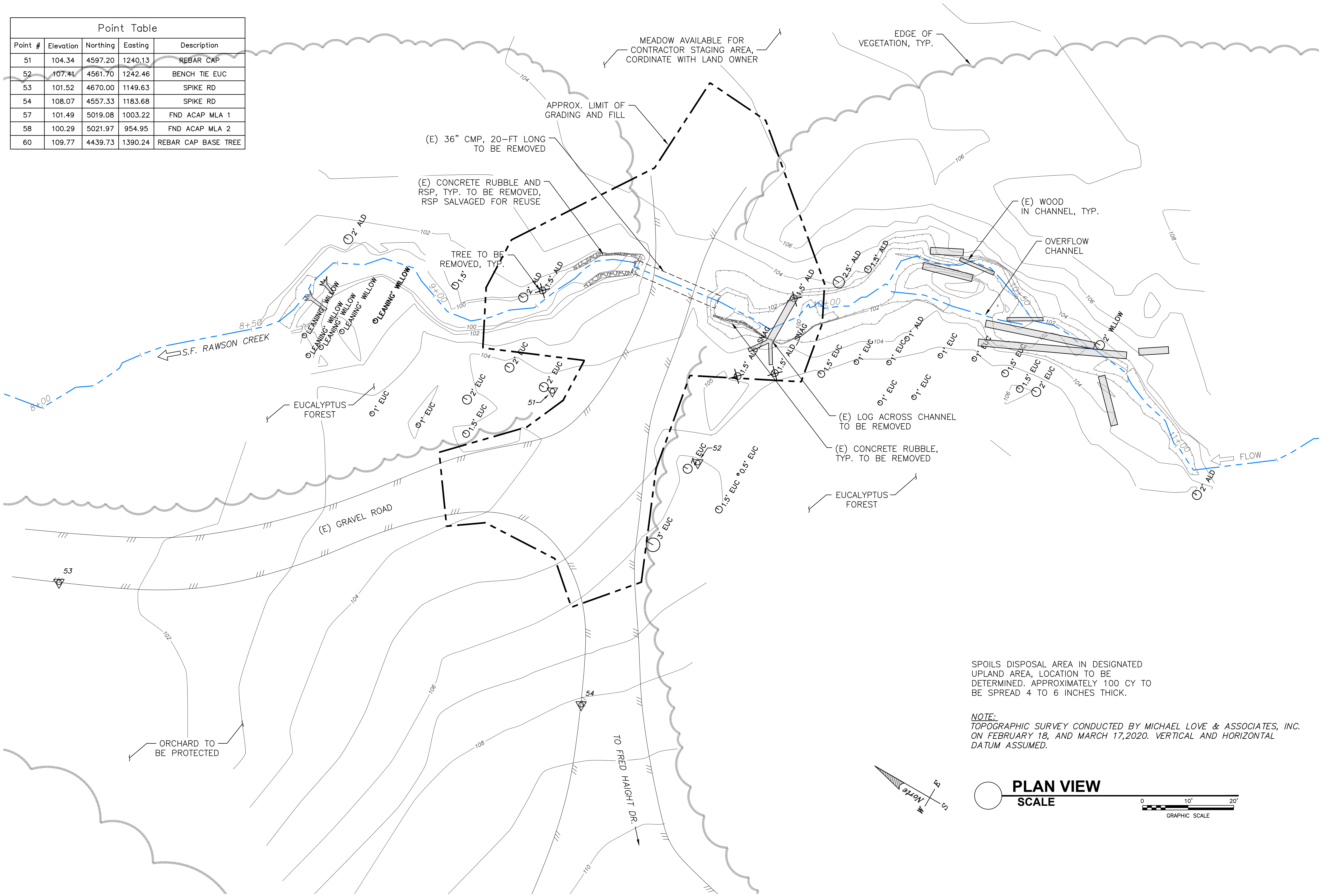
DESIGN	LLANOS / LOVE
DRAWN	LLANOS
SHEET	4 of 9

Point #	Elevation	Northing	Easting	Description
51	104.34	4597.20	1240.13	REBAR CAP
52	107.41	4561.70	1242.46	BENCH TIE EUC
53	101.52	4670.00	1149.63	SPIKE RD
54	108.07	4557.33	1183.68	SPIKE RD
57	101.49	5019.08	1003.22	FND ACAP MLA 1
58	100.29	5021.97	954.95	FND ACAP MLA 2
60	109.77	4439.73	1390.24	REBAR CAP BASE TREE

Point Table



SPOILS DISPOSAL AREA IN DESIGNATED UPLAND AREA, LOCATION TO BE DETERMINED. APPROXIMATELY 100 CY TO BE SPREAD 4 TO 6 INCHES THICK.

NOTE:
TOPOGRAPHIC SURVEY CONDUCTED BY MICHAEL LOVE & ASSOCIATES, INC. ON FEBRUARY 18, AND MARCH 17,2020. VERTICAL AND HORIZONTAL DATUM ASSUMED.

PLAN VIEW
SCALE

0 10' 20'
GRAPHIC SCALE

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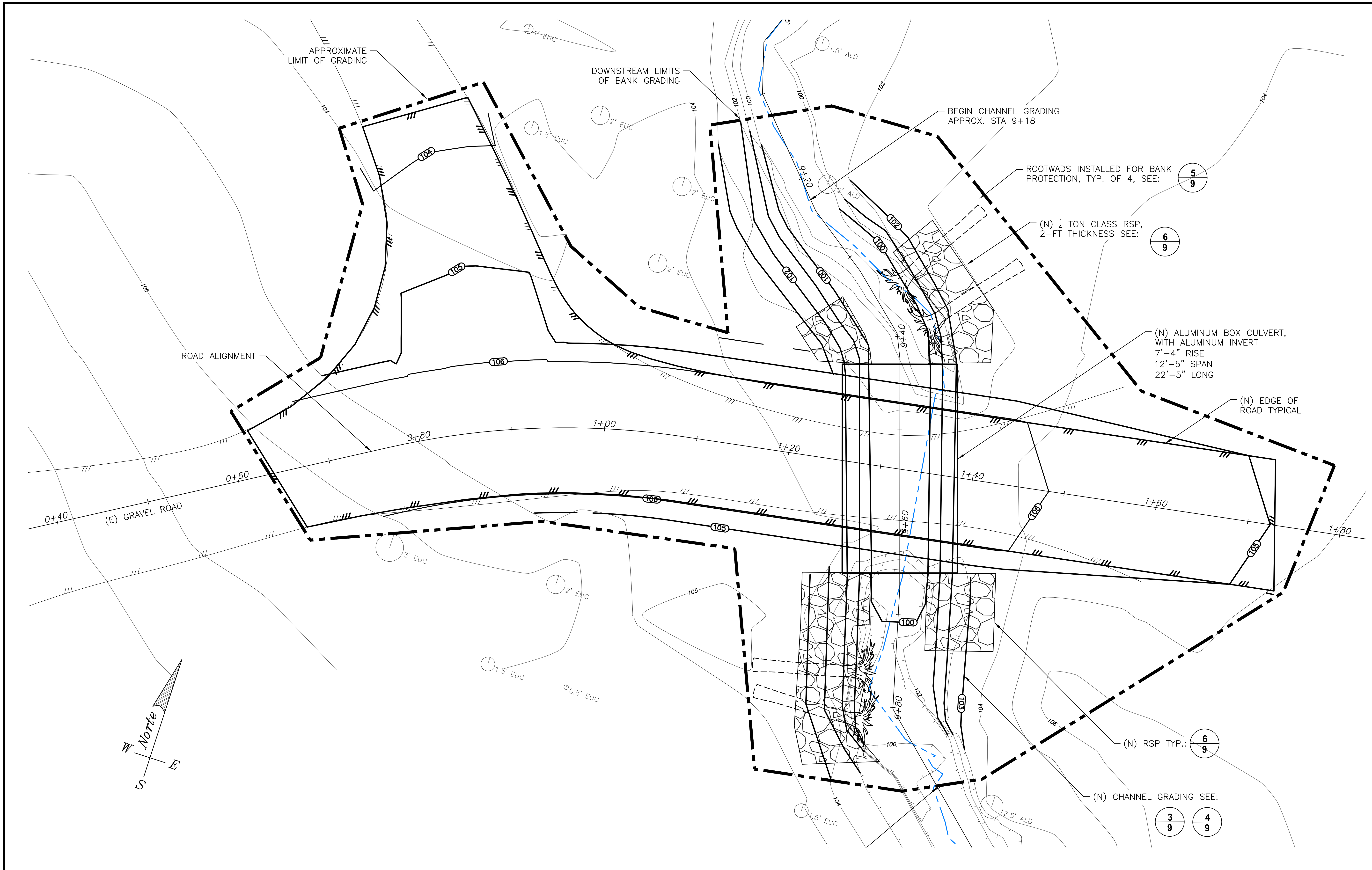
RAWSON CREEK
CULVERT No. 3 REPLACEMENT

5 - EXISTING CONDITIONS

DATE JUNE 2021
SUBMITTAL 90% DESIGN
DESIGN LLANOS / LOVE
DRAWN LLANOS
SHEET 5 of 9



PLAN VIEW

SCALE

0 10' 20'
GRAPHIC SCALE

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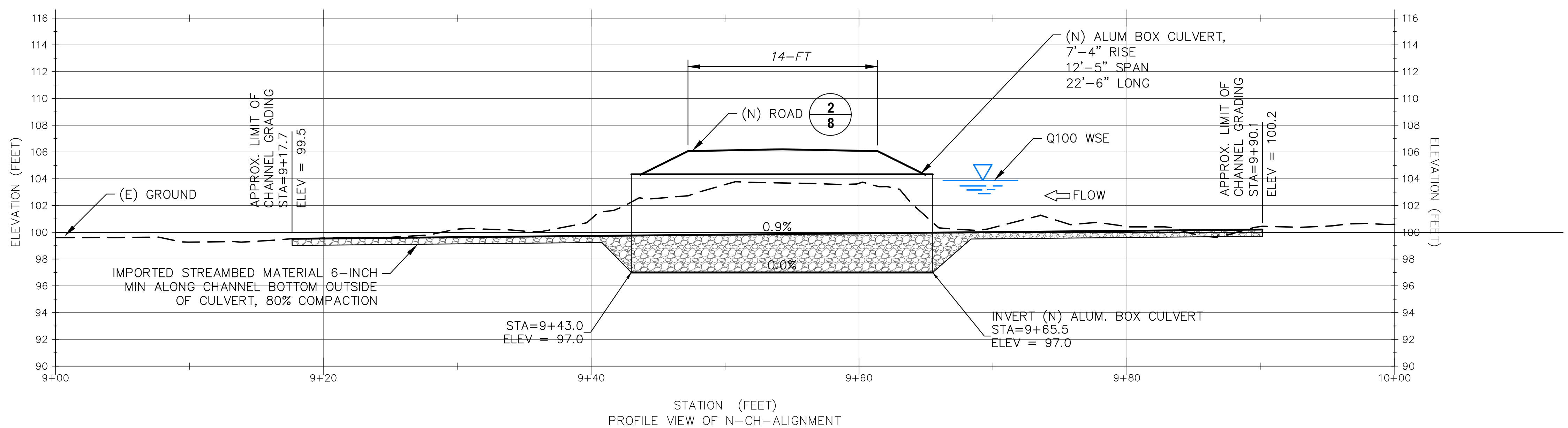
RAWSON CREEK
CULVERT No. 3 REPLACEMENT

6 - NEW CROSSING LAYOUT

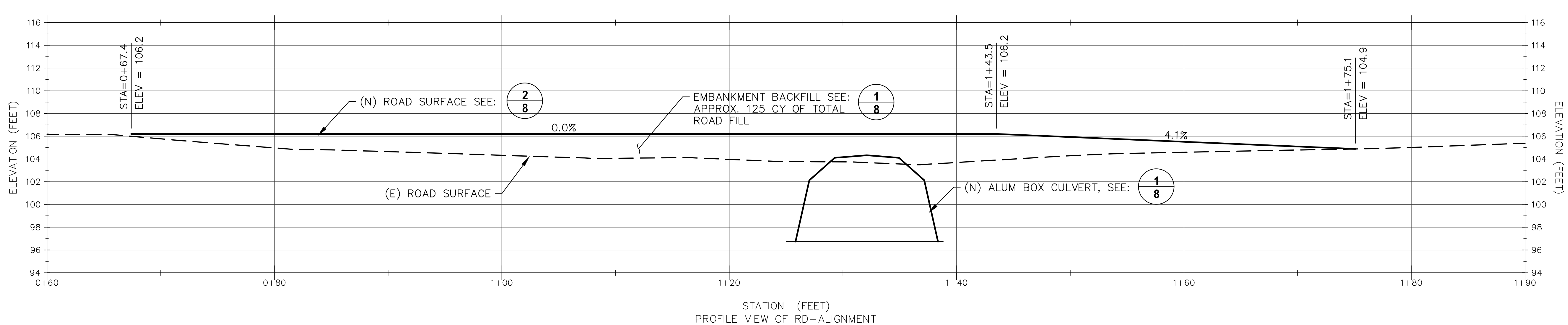
DATE	JUNE 2021
SUBMITTAL	90% DESIGN
DESIGN	LLANOS / LOVE
DRAWN	LLANOS
SHEET	6 of 9



CHANNEL PROFILE

SCALE: 0 5' 10' GRAPHIC SCALE

(VERTICAL EXAGGERATION 1:1)



ROAD PROFILE

SCALE: 0 5' 10' GRAPHIC SCALE

(VERTICAL EXAGGERATION 1:1)

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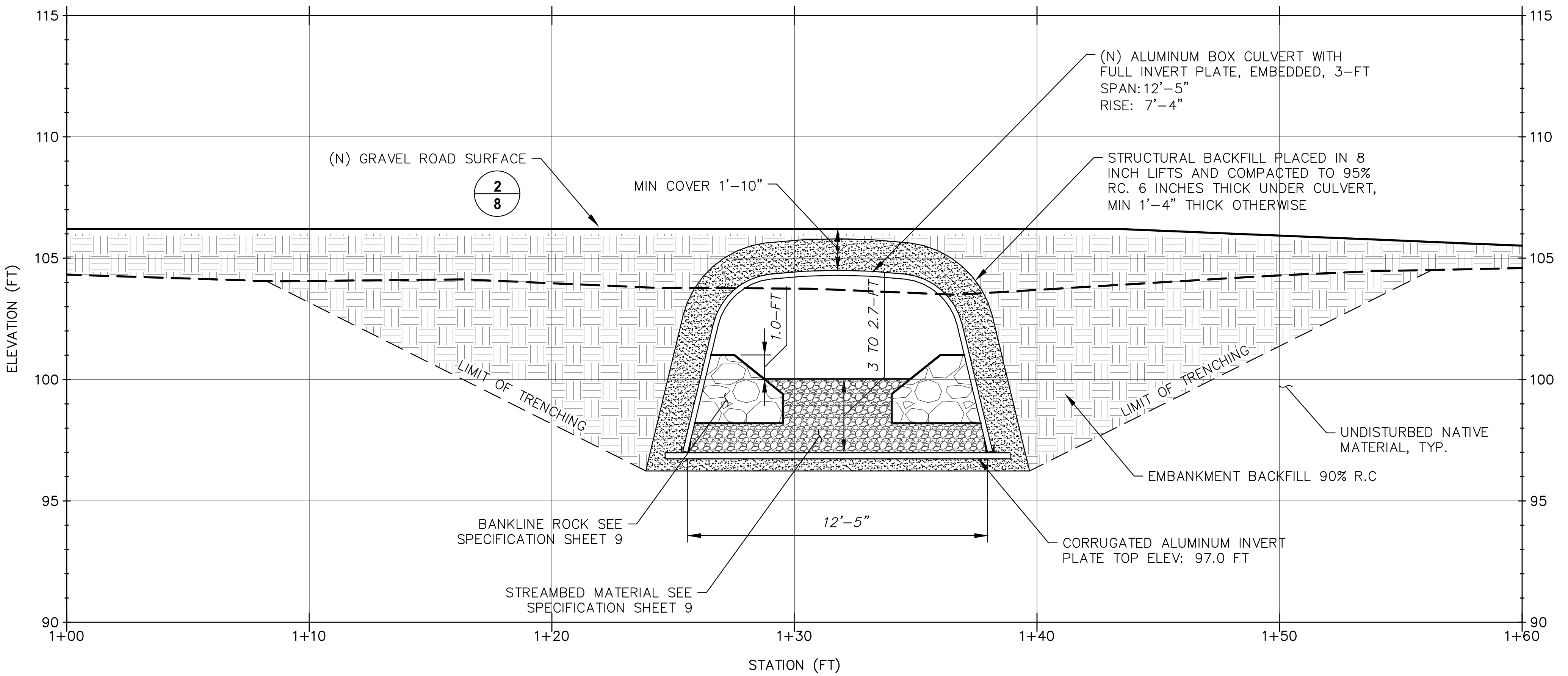
RAWSON CREEK
CULVERT No. 3 REPLACEMENT

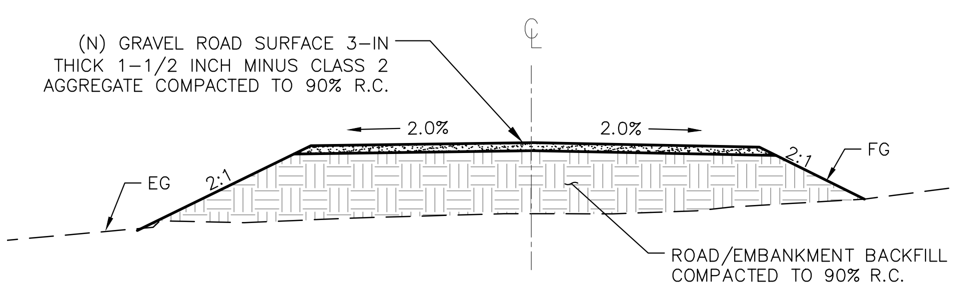
CROSSING PROFILE

DATE	JUNE 2021
SUBMITTAL	90% DESIGN
DESIGN	LLANOS / LOVE
DRAWN	LLANOS
SHEET	7 of 9



1 CULVERT SECTION ALONG ROAD PROFILE
TYPICAL

0 3' 6'
GRAPHIC SCALE



2 ROAD SECTION
NTS

ROAD IMPROVEMENT SPECIFICATIONS

GENERAL

1. EMBANKMENT CONSTRUCTION SHALL BE IN ACCORDANCE WITH CALTRANS STANDARD SPECIFICATIONS (2015) SECTION19-6, UNLESS OTHERWISE SPECIFIED.
2. ALL MATERIAL (IMPORTED OR NATIVE FOR REUSE) MUST BE APPROVED BY THE COR PRIOR TO INSTALLATION.

SUBMITTALS

3. CERTIFICATIONS FOR ALL IMPORTED MATERIALS PRIOR TO DELIVERY.
4. COMPACTION TESTING REQUIRED FOR ALL BACKFILL AROUND CULVERT CROSSING.

PRODUCTS

5. ROAD ROCK SHALL BE 1-1/2 INCH MINUS CLASS 2 AGGREGATE BASE
6. EMBANKMENT FILL, SEE CULVERT SPECIFICATIONS THIS SHEET

EXECUTION

7. ALL COMPACTION SHALL BE COMPLETED BY MECHANICAL MEANS UNLESS THE CONTRACTOR CAN DEMONSTRATE OTHER MEANS THAT WILL ACCOMPLISH THE REQUIRED COMPACTION TO THE SATISFACTION OF THE ENGINEER. COMPACTION EQUIPMENT SHALL BE OF SUITABLE TYPE AND ADEQUATE TO OBTAIN THE DENSITIES SPECIFIED AND APPROVED. COMPACTION EQUIPMENT SHALL BE OPERATED IN STRICT ACCORDANCE WITH THE MANUFACTURER'S INSTRUCTIONS AND RECOMMENDATIONS. EQUIPMENT SHALL BE MAINTAINED IN SUCH CONDITION THAT IT WILL DELIVER THE MANUFACTURER'S RATED COMPACTIVE EFFORT.
8. ROAD ROCK SHALL BE PLACED AS INDICATED IN THE DRAWINGS AND AS DIRECTED BY THE COR.
6. EMBANKMENT FILL, SEE CULVERT SPECIFICATIONS THIS SHEET

CULVERT AND BACKFILL SPECIFICATIONS

GENERAL

1. THE CONTRACTOR SHALL ENGAGE A QUALIFIED COMPACTION TESTING FIRM TO PERFORM NECESSARY TESTS AND INSPECTIONS DURING THE INSTALLATION OF STRUCTURAL AND EMBANKMENT BACKFILL.
2. EMBANKMENT CONSTRUCTION SHALL BE IN ACCORDANCE WITH CALTRANS STANDARD SPECIFICATIONS (2015) SECTION 19-6, UNLESS OTHERWISE SPECIFIED.
3. WHEN COMPACTION TESTS INDICATE THAT THE SPECIFIED COMPACTION HAS NOT BEEN ACHIEVED, THAT PORTION OF THE WORK SHALL BE REWORKED UNTIL THE REQUIRED DENSITY HAS BEEN ATTAINED; ALL COSTS BORNE BY THE CONTRACTOR.
4. ALL MATERIAL (IMPORTED OR NATIVE FOR REUSE) MUST BE APPROVED BY THE COR PRIOR TO INSTALLATION.

SUBMITTALS

5. SHOP DRAWINGS AND CALCULATIONS FOR THE CULVERT SHALL BE PROVIDED TO THE COR FOR REVIEW PRIOR TO BEING INSTALLED .
6. CERTIFICATIONS FOR ALL IMPORTED MATERIALS PRIOR TO DELIVERY. RESULTS OF COMPACTION TESTING.
7. COMPACTION TESTING WILL BE REQUIRED FOR ALL FILL RELATED TO THE CULVERT INSTALLATION.
8. RELATIVE COMPACTION TESTING METHODS: CURRENT VERSIONS OF CALTRANS CALIFORNIA TEST 216 OR 231, OR OTHER METHODS APPROVED BY THE ENGINEER.

PRODUCTS

9. CULVERT SHALL BE ALUMINUM BOX CULVERT 50E6 (HS-25 LOAD RATING) BY CONTECH WITH A FULL INVERT OR APPROVED EQUAL.
10. STRUCTURAL BACKFILL SHALL BE IMPORTED CALTRANS CLASS 2 AGGREGATE BASE WITH 3/4 INCH MAXIMUM AS PRESENTED IN CALTRANS STANDARD SPECIFICATIONS (2015) SECTION 26-1.02B.
11. CONTROLLED LOW STRENGTH MATERIAL (CLSM) CAN BE USED IN PLACE OF BASE AGGREGATE MATERIAL. CLSM SHALL BE SELF-LEVELING AND SELF-COMPACTING, CEMENTITIOUS MATERIAL WITH A MINIMUM COMPRESSIVE STRENGTH OF 300 PSI PER ACI 229R
12. ROAD/EMBANKMENT BACKFILL SHALL BE NATIVE OR IMPORTED MATERIAL, NO LARGER THAN 6-INCHES IN DIAMETER AND FREE OF ORGANICS. MATERIAL SHALL BE PLACED IN 6-INCH LIFTS AND COMPACTED AS SPECIFIED.

EXECUTION

13. ALL COMPACTION SHALL BE COMPLETED BY MECHANICAL MEANS UNLESS THE CONTRACTOR CAN DEMONSTRATE OTHER MEANS THAT WILL ACCOMPLISH THE REQUIRED COMPACTION TO THE SATISFACTION OF THE ENGINEER. COMPACTION EQUIPMENT SHALL BE OF SUITABLE TYPE AND ADEQUATE TO OBTAIN THE DENSITIES SPECIFIED AND APPROVED. COMPACTION EQUIPMENT SHALL BE OPERATED IN STRICT ACCORDANCE WITH THE MANUFACTURER'S INSTRUCTIONS AND RECOMMENDATIONS. EQUIPMENT SHALL BE MAINTAINED IN SUCH CONDITION THAT IT WILL DELIVER THE MANUFACTURER'S RATED COMPACTIVE EFFORT.
14. EXPOSED SOILS SHALL BE SCARIFIED TO A DEPTH OF 8 INCHES, MOISTURE CONDITIONED AS NECESSARY TO PROVIDE ABOVE OPTIMUM MOISTURE CONTENT.
15. STRUCTURAL BACKFILL SHALL BE INSTALLED IN UNCOMPACTED 8 INCH LIFTS, MAXIMUM, AND COMPACTED TO 95% RELATIVE COMPACTION.
16. EMBANKMENT FILL SHALL BE INSTALLED IN UNCOMPACTED 8 INCH LIFTS MAXIMUM, AND COMPACTED TO 90% RELATIVE COMPACTION.

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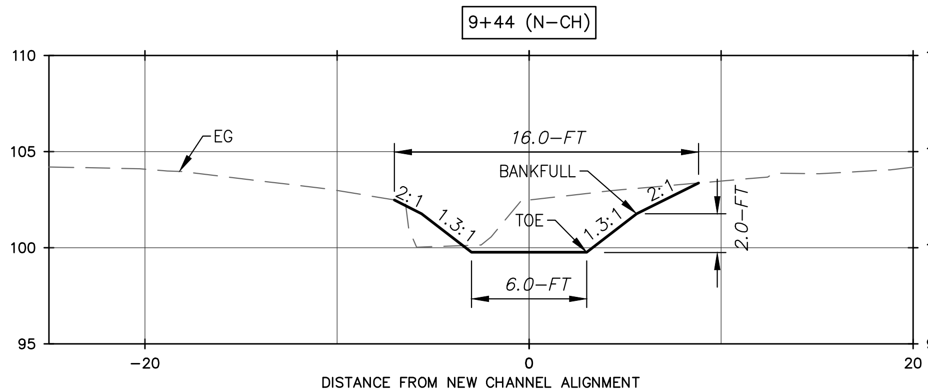
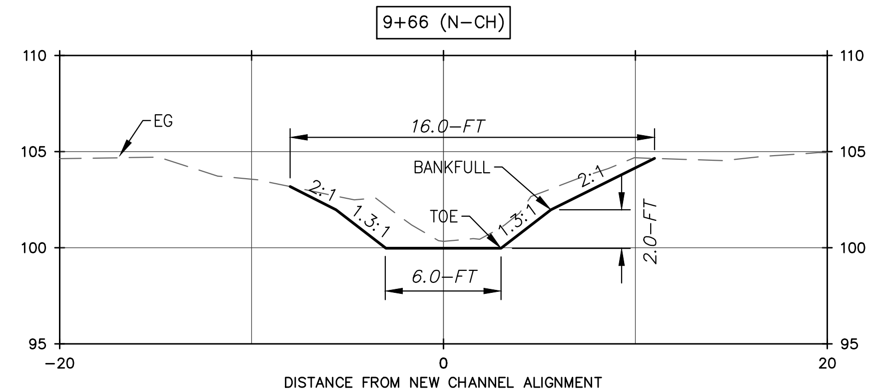
RAWSON CREEK
CULVERT No. 3 REPLACEMENT

8 - CROSSING DETAILS

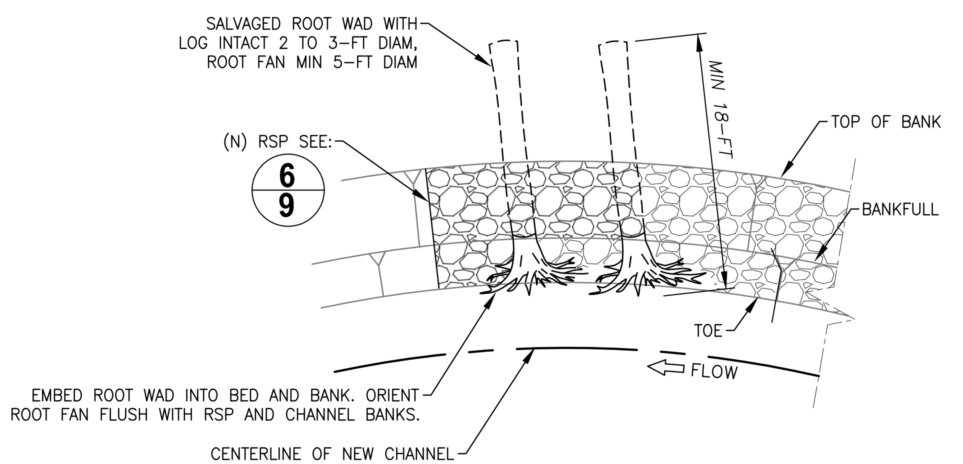
DATE	JUNE 2021
SUBMITTAL	90% DESIGN
DESIGN	LLANOS / LOVE
DRAWN	LLANOS
SHEET	8 of 9



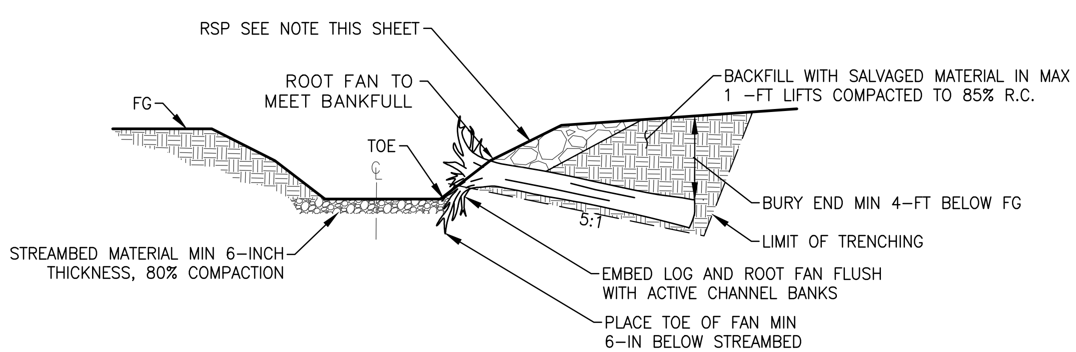
3 **CHANNEL SECTION DOWNSTREAM**
1H:1V
GRAPHIC SCALE 0 5' 10'



4 **CHANNEL SECTION AT CULVERT FACE**
1H:1V
GRAPHIC SCALE 0 5' 10'

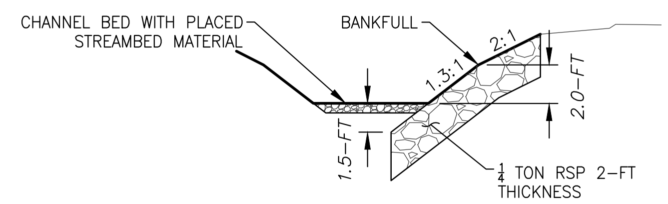


PLAN



SECTION

5 **ROOTWAD DETAIL**
TYPICAL (NTS)



6 **ROCK SLOPE PROTECTION (RSP)**
TYPICAL (NTS)

ROCK SLOPE PROTECTION (RSP)

MATERIAL SPECIFICATIONS

1. ROCK SHALL MEET MATERIAL PROPERTIES IN ACCORDANCE WITH CALTRANS, 2015 SECTION 72-2.
2. RSP SHALL BE ¼ TON CLASS ROCK.

INSTALLATION SPECIFICATIONS

3. ROCK SHALL BE PLACED IN ACCORDANCE WITH CALTRANS, 2015 SECTION 72 AND USING "METHOD A" PLACEMENT, INDIVIDUALLY PLACED .
4. ROCK SHALL HAVE A MINIMUM OF THREE CONTACT POINTS.
5. PLACE ROCK IN ROWS BEGINNING IN THE CHANNEL AND WORKINGUP THE BANK.
6. BACKFILL ALL VOIDS WITH STREAMBED MATERIAL AND COMPACT AFTER THE EACH ROW IS PLACED.

SPECIFICATIONS FOR ROOTWAD STRUCTURES

MATERIAL AQUISITION

1. CONTRACTOR SHALL BE RESPONSIBLE FOR CUTTING EUCALYPTUS TREES AND EXCAVATING ROOTWAD AT DIRECTION OF COR.
2. EXCESS SOIL SHALL BE REMOVED FROM THE ROOTWAD AND THE VOID BACKFILLED
3. ROOTWAD SHALL HAVE A MINIMUM OF 18 FEET TRUNK ATTACHED TO ROOT FAN.

MATERIAL SPECIFICATIONS

4. ALL ROOTWADS SHALL BE SOUND, NON-ROTTED AND UNBROKEN EUCALYPTUS OBTAINED ON SITE AT THE DIRECTION OF THE COR.
5. LOGS SHALL MEET THE DIMENSIONS SPECIFIED. LOG LENGTH SHALL NOT BE ACCOMPLISHED WITH JOINING OF MULTIPLE LOGS. LOG DIAMETER SHALL BE MEASURED AT THE MIDPOINT OF THE LOG.
6. LOG LENGTH INCLUDES THE ROOTWAD.
7. LOGS EXCEEDING THE MAXIMUM DIAMETER WILL NEED ADDITIONAL BURIAL AS DIRECTED BY THE COR.

INSTALLATION SPECIFICATIONS

8. ROOTWAD STRUCTURES SHALL BE INSTALLED AS SPECIFIED AND DIRECTED BY THE COR. LOGS PLACED NOT MEETING COR'S APPROVAL SHALL BE REMOVED AND RESET.
9. EXCAVATE TRENCH AS NECESSARY.
10. INSTALL LOGS WITH ROOTWADS ORIENTED UPSTREAM WITH FAN AT TOE OF CHANNEL.
11. BACKFILL TRENCH WITH COMPACTED SALVAGE BACKFILL OR COMPACTED EMBANKMENT FILL IN 1-FT LIFTS TO SPECIFIED COMPACTION. MOUND BACKFILL UP TO 1-FT ABOVE EXISTING GROUND FOR DRAINAGE.

STREAMBED MATERIAL

MATERIAL SPECIFICATIONS

1. EXCEPT AS DIRECTED BY COR, NO ROCK OR SIMILAR IRREDUCIBLE MATIERAL WITH A MAXIMUM DIMENSION GREATER THAN 12-INCHES SHALL BE BURIED OR PLACED IN STREAM BANK FILLS. DETRIMENTAL AMOUNTS OF ORGANIC MATERIAL SHALL NOT BE PERMITTED IN STREAM BANK FILLS.
2. STREAMBED MATERIAL SHALL CONSIST OF 2-INCH MINUS ROUNDED RIVER RUN MATERIAL.
3. NATIVE MATERIAL MAY BE REUSED, IF APPROVED BY THE COR.

INSTALLATION SPECIFICATIONS

4. STREAMBED MIX MUST BE THOROUGHLY MIXED PRIOR TO INSTALLATION. IF THE MATERIAL IS MIXED AND THEN TRANSPORTED TO THE INSTALLATION LOCATION, THE MATERIAL MUST BE REMIXED AS IT WILL NATURALLY SORT DURING TRANSPORT.
5. INSTALLED MATERIAL SHALL BE COMPACTED AS SPECIFIED.
6. STREAM BED MATERIAL AND BANKLINE ROCK SHALL BE SEALED SO THAT WATER DOES NOT FLOW INTO THE VOIDS, AND REMAINS BETWEEN THE BANKLINE ROCK TOES. SEAL UNTIL WATER FLOWS ON THE SURFACE AND DOES NOT GO SUBSURFACE.
7. THE CONTRACTOR CAN SEAL THE VOIDS USING A METHOD THEY PREFER. IT IS RECOMMENDED THAT JETTING OR FLOODING AS WELL AS MECHANICAL MEANS BE USED, WITHOUT DAMAGING THE CULVERT.
8. WATER MAY BE USED MULTIPLE TIMES FOR SEALING PURPOSES (E.G. PUMPED FROM COLLECTION POOL). WATER FOR SEALING PURPOSES SHALL BE TREATED AS NUISANCE WATER AND FOLLOW THE DEWATERING SYSTEM GUIDELINES AS PRESENTED IN THE APPROVED WATER MANAGEMENT PLAN.

BANKLINE ROCK

MATERIAL SPECIFICATIONS

1. BANKLINE ROCK SHALL CONSIST OF FACING CLASS ROCK WITH VOIDS FILLED WITH STREAMBED MATERIAL.
2. NATIVE MATERIAL MAY BE REUSED IF APPROVED BY THE ENGINEER.

INSTALLATION SPECIFICATIONS

3. ROCK PLACEMENT SHALL BE AT THE DISCRETION OF THE ENGINEER, BUT IS GENERALLY SHOWN.
4. ROCK SHALL BE PLACED IN ACCORDANCE WITH CALTRANS, 2015 SECTION 72 AND USING "METHOD A" PLACEMENT, INDIVIDUALLY PLACED, FOR ROCK DIAMETERS GREATER THAN 10 INCHES. SMALLER MATERIAL CAN PLACED USING CALTRANS "METHOD B".
5. ROCK SHALL HAVE A MINIMUM OF THREE CONTACT POINTS.
6. FINISHED GRADE IS MEASURED AT THE HIGHEST CONTACT POINT OF TWO ADJACENT ROCKS.
7. THE BANKLINE ROCK SHALL BE SEALED AS DESCRIBED IN THE STREAMBED MATERIAL INSTALLATION NOTE 5 THROUGH 8

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CULVERT No. 3 REPLACEMENT

9 - CHANNEL DETAILS

DATE	JUNE 2021
SUBMITTAL	90% DESIGN
DESIGN	LLANOS / LOVE
DRAWN	LLANOS
SHEET	9 of 9

Attachment 2: Hydrologic Calculations

Peak Flow Calculation Summary
Rawson Creek at Crossing #3

Method	Q-1yr (cfs)	Q-1.5yr (cfs)	Q-2yr (cfs)	Q-5yr (cfs)	Q-10yr (cfs)	Q-25yr (cfs)	Q-50yr (cfs)	Q-100yr (cfs)
LPIII Analysis of Stream Gages (Average of 3)		32	43	75	100	134	161	190
North Coast Regional Regression Equations	36	63	45	82	108	143	169	197

[1]Peak Flow Calculation Summary - Rawson Creek
Rawson Creek Near Smith River, CA (41.904220°N, -124.139361°W)

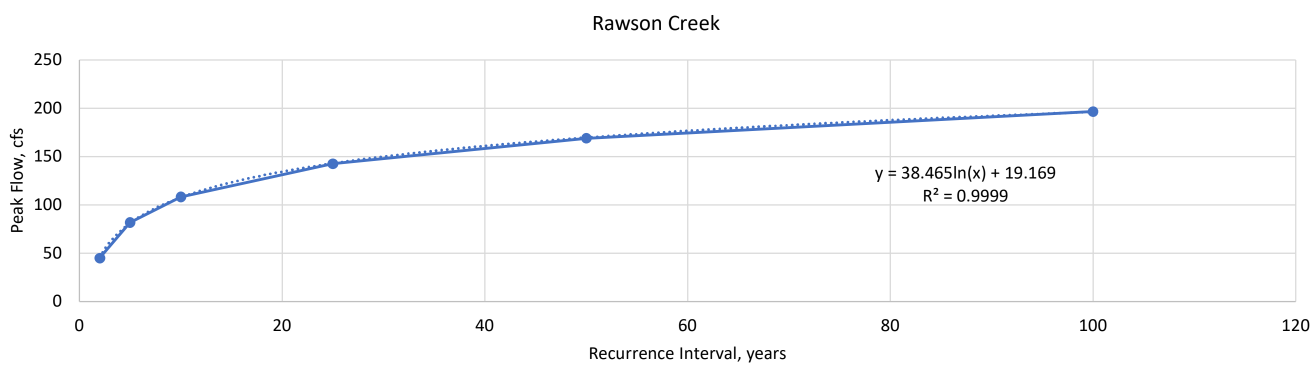
Reach	Q-1yr (cfs)	Q-1.5yr (cfs)	Q-2yr (cfs)	Q-5yr (cfs)	Q-10yr (cfs)	Q-25yr (cfs)	Q-50yr (cfs)	Q-100yr (cfs)	A Drainage Area (mi^2)	P Mean Annual Precipitation (in)
Rawson Creek	36	63	45	82	108	143	169	197	0.31	76.8

[1] Estimates using regional regression equations developed for the North Coast Region of California by the USGS (Gotvald, Barth, Veilleux, and Parrett, 2012).

$Q2\text{-}yr = 1.82\ A^{0.904}\ P^{0.983}$ $Q5\text{-}yr = 8.11\ A^{0.887}\ P^{0.772}$

$Q10\text{-}yr = 14.8\ A^{0.88}\ P^{0.696}$ $Q25\text{-}yr = 26.0\ A^{0.874}\ P^{0.628}$

$Q50\text{-}yr = 36.3\ A^{0.87}\ P^{0.589}$ $Q100\text{-}yr = 48.5\ A^{0.866}\ P^{0.556}$



Log Pearson Type III Probabilistic Analysis

Rawson Creek at Crossing #3

Peak flows were estimated using a Log-Pearson type III distribution as described in Bulletin 17B (Guidelines for Determining Flood Flow Frequency, 1982).

Stream Name	Location	Drainage Area (mi^2)	Recurrence Interval of Peak Flows 1.5-yr (cfs/mi^2)	2-yr (cfs/mi^2)	5-yr (cfs/mi^2)	10-yr (cfs/mi^2)	25-yr (cfs/mi^2)	50-yr (cfs/mi^2)	100-yr (cfs) (cfs/mi^2)
Little Lost Man Creek	Orick, CA	3.46	58.89	81.47	147.47	197.56	266.30	320.67	377.04
Lopez Creek	Smith River, CA	0.92	117.50	165.35	311.36	427.04	591.51	725.71	868.71
Harris Creek	Brookings, OR	1.05	137.37	172.92	270.36	341.61	438.52	515.36	595.97
		Average	104.59	139.91	243.06	322.07	432.11	520.58	613.91

Rawson Creek at Crossing #3

Drainage Area (mi^2)	Q 1.5-yr (cfs)	Q 2-yr (cfs)	Q 5-yr (cfs)	Q 10-yr (cfs)	Q 25-yr (cfs)	Q 50-yr (cfs)	Q 100-yr (cfs)
0.31	32.42	43.37	75.35	99.84	133.95	161.38	190.31

Flood Frequency based on Annual Maximum Series

USGS 11482468 Little Lost Man C A Site No 2 Nr Orick Ca

Station #: 11482468

Drainage Area (sq. miles) 3.46

Maximum Daily Average Discharge

Water Year	Date of Peak	Discharge (cfs)
1975	03/18/75	808.0
1976	02/16/76	165.0
1977	09/28/77	88.0
1978	12/14/77	391.0
1979	01/11/79	177.0
1980	03/14/80	230.0
1981	12/02/80	240.0
1982	12/19/81	486.0
1985	11/12/84	252.0
1986	02/17/86	787.0
1987	01/03/87	76.0
1988	12/10/87	301.0
1989	11/22/88	471.0

RANK	Recurrence Interval (years)	Annual Exceedance Probability	Discharge (cfs)	Discharge (cms)	Log-Discharge (cfs)
1	14.00	0.07	808.0	22.88	2.91
2	7.00	0.14	787.0	22.29	2.90
3	4.67	0.21	486.0	13.76	2.69
4	3.50	0.29	471.0	13.34	2.67
5	2.80	0.36	391.0	11.07	2.59
6	2.33	0.43	301.0	8.52	2.48
7	2.00	0.50	252.0	7.14	2.40
8	1.75	0.57	240.0	6.80	2.38
9	1.56	0.64	230.0	6.51	2.36
10	1.40	0.71	177.0	5.01	2.25
11	1.27	0.79	165.0	4.67	2.22
12	1.17	0.86	88.0	2.49	1.94
13	1.08	0.93	76.0	2.15	1.88

Sample Size, n =	13		
Skewness =	1.03	1.03	-0.22
Mean=	344.00	9.74	2.44
Median=	252.00	7.14	2.40
Std Dev=	238.30	6.75	0.32
Outliers			
Kn=	2.335		
Q_{LOW}	49.08 cfs		
Q_{HIGH}	1517.21 cfs		

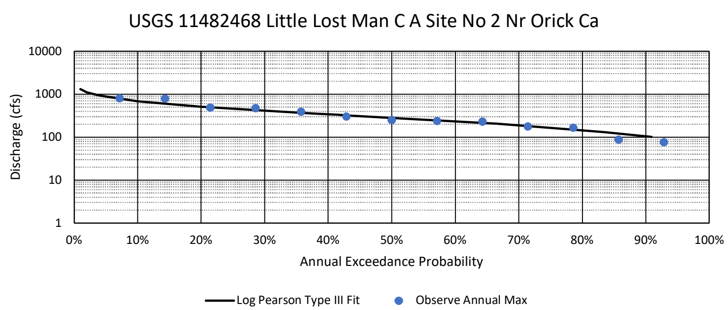
Generalized Skew=	-0.3	A=	-0.312413121
Station Skewness (log Q)=	-0.22	B=	0.882842643
Station Mean (log Q)=	2.44	MSE (station skew) =	0.38636
Station Median (log Q)=	2.40		
Station Std Dev (log Q)=	0.32		
Weighted Skewness (G_W)=	-0.26		

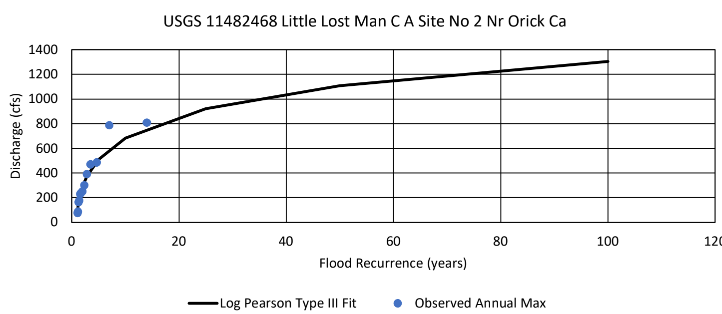
Log Pearson Type III Distribution

Return Period (years)	Exceedence Probability	Log-Pearson K	Est. Discharge [mean] (cfs)	Est. Discharge [median] (cfs)
1.1	0.909	-1.35010	101.2040	93.4561
1.2	0.833	-0.98622	132.2224	122.0998
1.5	0.667	-0.39751	203.7754	188.1749
2.0	0.500	0.04406	281.8712	260.2918
2.33	0.429	0.21941	320.6270	296.0805
2.4	0.417	0.25395	328.8678	303.6905
2.6	0.385	0.34239	350.9463	324.0787
2.8	0.357	0.41819	371.0468	342.6403
5.0	0.200	0.85180	510.2510	471.1874
10	0.100	1.24976	683.5435	631.2130
25	0.040	1.65620	921.4096	850.8687
50	0.020	1.90907	1109.5351	1024.5917
100	0.010	2.12948	1304.5725	1204.6976

Values From K-Table for Linear interpolation

Weighted Skewness =	-0.30	-0.20	-0.26
P	K	K	K
0.9	-1.30936	-1.30105	-1.30644
0.8	-0.82377	-0.83044	-0.82612
0.7	-0.48600	-0.49927	-0.49067
0.6	-0.20552	-0.22168	-0.21120
0.500	0.04993	0.03325	0.04406
0.429	0.22492	0.20925	0.21941
0.200	0.85285	0.84986	0.85180
0.100	1.24516	1.25824	1.24976
0.040	1.64329	1.67999	1.65620
0.020	1.88959	1.94499	1.90907
0.010	2.10294	2.17840	2.12948





Flood Frequency based on Annual Maximum Series

USGS 11533000 Lopez Creek Near Smith River, CA

Station #: 11533000

Drainage Area (sq. miles) 0.92

Maximum Daily Average Discharge

Water Year	Date of Peak	Discharge (cfs)
1962	11/23/61	305.0
1963	05/06/63	330.0
1964	01/19/64	65.0
1965	12/22/64	84.0
1966	01/06/66	149.0
1967	11/15/66	95.0
1968	02/23/68	239.0
1969	01/12/69	123.0
1970	01/22/70	195.0
1971	01/16/71	125.0
1972	03/02/72	570.0
1973	01/16/73	35.0

RANK	Recurrence Interval (years)	Annual Exceedance Probability	Discharge (cfs)	Discharge (cms)	Log-Discharge (cfs)
1	13.00	0.08	570.0	16.14	2.76
2	6.50	0.15	330.0	9.34	2.52
3	4.33	0.23	305.0	8.64	2.48
4	3.25	0.31	239.0	6.77	2.38
5	2.60	0.38	195.0	5.52	2.29
6	2.17	0.46	149.0	4.22	2.17
7	1.86	0.54	125.0	3.54	2.10
8	1.63	0.62	123.0	3.48	2.09
9	1.44	0.69	95.0	2.69	1.98
10	1.30	0.77	84.0	2.38	1.92
11	1.18	0.85	65.0	1.84	1.81
12	1.08	0.92	35.0	0.99	1.54

Sample Size, n =	12		
Skewness =	1.55	1.55	-0.09
Mean=	192.92	5.46	2.17
Median=	137.00	3.88	2.14
Std Dev=	150.71	4.27	0.34
Outliers			
Kn=		2.335	
Q_{LOW}		24.18 cfs	
Q_{HIGH}		906.90 cfs	

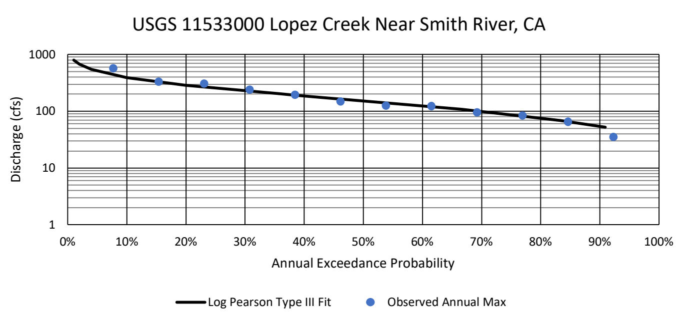
Generalized Skew=	-0.3	A=	-0.323103133
Station Skewness (log Q)=	-0.09	B=	0.917585181
Station Mean (log Q)=	2.17	MSE	
Station Median (log Q)=	2.14	(station skew) =	0.40201
Station Std Dev (log Q)=	0.34		
Weighted Skewness (G_W)=	-0.21		

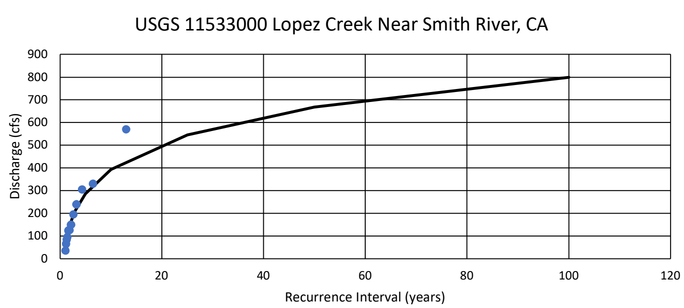
Log Pearson Type III Distribution

Return Period (years)	Exceedence Probability	Log-Pearson K	Est. Discharge [mean] (cfs)	Est. Discharge [median] (cfs)
1.1	0.909	-1.34463	52.1529	48.0637
1.2	0.833	-0.98717	68.8283	63.4317
1.5	0.667	-0.40556	108.0957	99.6203
2.0	0.500	0.03463	152.1187	140.1915
2.33	0.429	0.21055	174.3725	160.7005
2.4	0.417	0.24548	179.1647	165.1169
2.6	0.385	0.33492	192.0437	176.9862
2.8	0.357	0.41159	203.8173	187.8367
5.0	0.200	0.85011	286.4517	263.9919
10	0.100	1.25716	392.8740	362.0700
25	0.040	1.67695	544.1903	501.5221
50	0.020	1.94040	667.6529	615.3043
100	0.010	2.17214	799.2170	736.5529

Values From K-Table for Linear interpolation

Weighted Skewness =	-0.30	-0.20	-0.21
P	K	K	K
0.9	-1.30936	-1.30105	-1.30174
0.8	-0.82377	-0.83044	-0.82989
0.7	-0.48600	-0.49927	-0.49817
0.6	-0.20552	-0.22168	-0.22034
0.500	0.04993	0.03325	0.03463
0.429	0.22492	0.20925	0.21055
0.200	0.85285	0.84986	0.85011
0.100	1.24516	1.25824	1.25716
0.040	1.64329	1.67999	1.67695
0.020	1.88959	1.94499	1.94040
0.010	2.10294	2.17840	2.17214





Flood Frequency based on Annual Maximum Series

USGS 14378800 Harris Creek near Brookings, OR

Station #: 14378800

Drainage Area (sq. miles) 1.05

Maximum Daily Average Discharge

Water Year	Date of Peak	Discharge (cfs)
1953	1/17/1953	436.0
1954	11/22/1953	297.0
1955	12/30/1954	439.0
1957	12/11/1956	251.0
1959	1/12/1959	109.0
1960	5/26/1960	136.0
1961	2/10/1961	118.0
1962	11/22/1961	205.0
1963	5/6/1963	186.0
1964	11/8/1963	84.0
1965	4/19/1965	104.0
1966	12/28/1965	128.0
1967	11/19/1966	149.0
1968	2/20/1968	269.0

RANK	Recurrence Interval (years)	Annual Exceedance Probability	Discharge (cfs)	Discharge (cms)	Log-Discharge (cfs)
1	15.00	0.07	436.0	12.35	2.64
2	7.50	0.13	439	12.43	2.64
3	5.00	0.20	297	8.41	2.47
4	3.75	0.27	269	7.62	2.43
5	3.00	0.33	251	7.11	2.40
6	2.50	0.40	205	5.80	2.31
7	2.14	0.47	186	5.27	2.27
8	1.88	0.53	149	4.22	2.17
9	1.67	0.60	136	3.85	2.13
10	1.50	0.67	128	3.62	2.11
11	1.36	0.73	118	3.34	2.07
12	1.25	0.80	109	3.09	2.04
13	1.15	0.87	104	2.94	2.02
14	1.07	0.93	84	2.38	1.92

Sample Size, n =	14		
Skewness =	1.08	1.08	0.39
Mean=	207.93	5.89	2.26
Median=	167.50	4.74	2.22
Std Dev=	117.17	3.32	0.23
Outliers			
Kn=	2.335		
Q_{LOW}	52.63 cfs		
Q_{HIGH}	627.05 cfs		

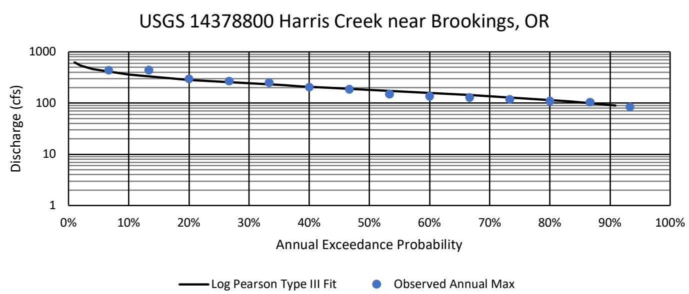
Generalized Skew=	-0.3	A=	-0.298683262
Station Skewness (log Q)=	0.39	B=	0.838220601
Station Mean (log Q)=	2.26	MSE	
Station Median (log Q)=	2.22	(station skew) =	0.37917
Station Std Dev (log Q)=	0.23		
Weighted Skewness (G_W)=	0.01		

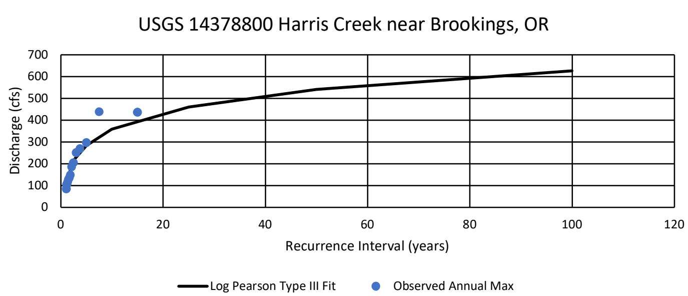
Log Pearson Type III Distribution

Return Period (years)	Exceedence Probability	Log-Pearson K	Est. Discharge [mean] (cfs)	Est. Discharge [median] (cfs)
1.1	0.909	-1.32072	90.1509	82.6108
1.2	0.833	-0.98822	107.5432	98.5485
1.5	0.667	-0.43491	144.2360	132.1724
2.0	0.500	-0.00109	181.5646	166.3789
2.33	0.429	0.17627	199.4788	182.7948
2.4	0.417	0.21259	203.3602	186.3515
2.6	0.385	0.30559	213.6461	195.7771
2.8	0.357	0.38530	222.8756	204.2347
5.0	0.200	0.84128	283.8738	260.1311
10	0.100	1.28222	358.6951	328.6945
25	0.040	1.75292	460.4482	421.9371
50	0.020	2.05724	541.1305	495.8713
100	0.010	2.33116	625.7721	573.4337

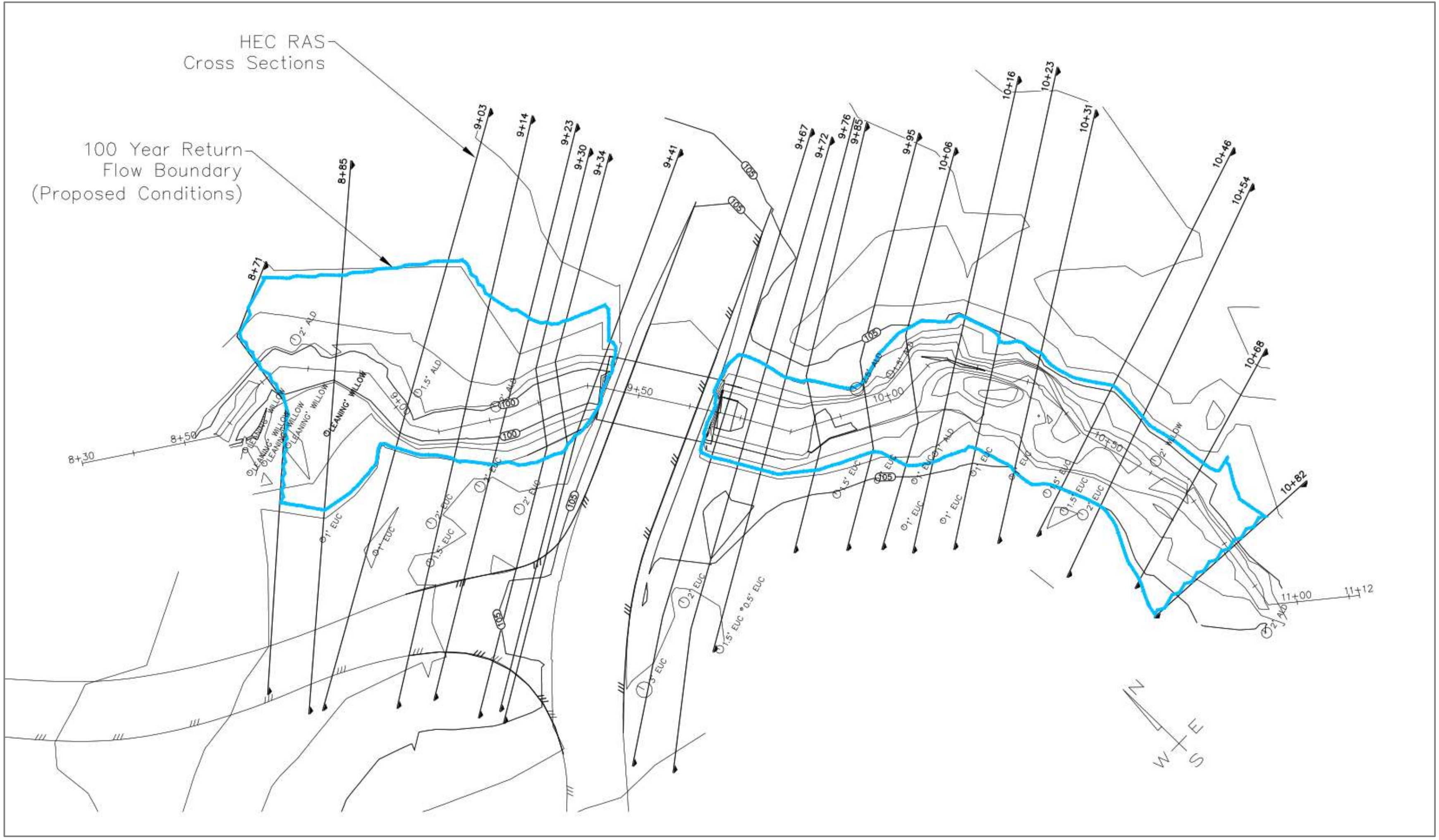
Values From K-Table for Linear interpolation

Weighted Skewness =	0.00	0.10	0.01
P	K	K	K
0.9	-1.28155	-1.27037	-1.28082
0.8	-0.84162	-0.84611	-0.84191
0.7	-0.52440	-0.53624	-0.52518
0.6	-0.25335	-0.26882	-0.25437
0.500	0.00000	-0.01662	-0.00109
0.429	0.17733	0.16111	0.17627
0.200	0.84162	0.83639	0.84128
0.100	1.28155	1.29178	1.28222
0.040	1.75069	1.78462	1.75292
0.020	2.05375	2.10697	2.05724
0.010	2.32635	2.39961	2.33116

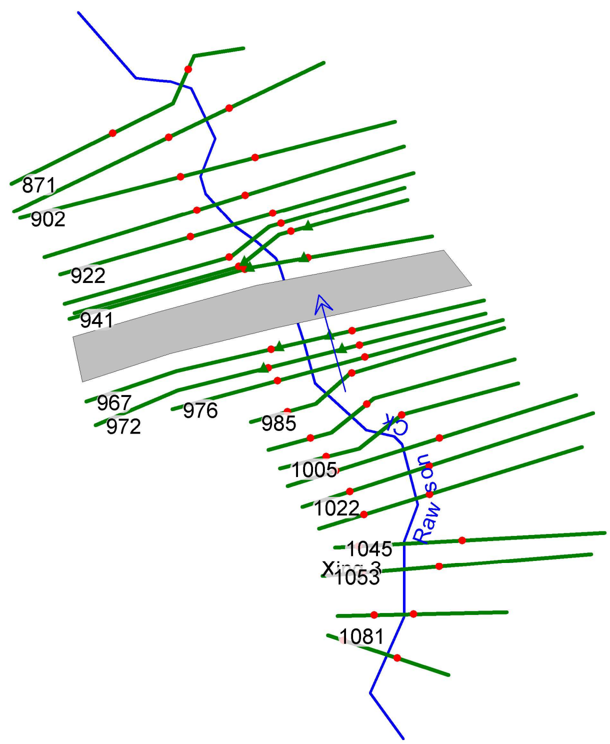




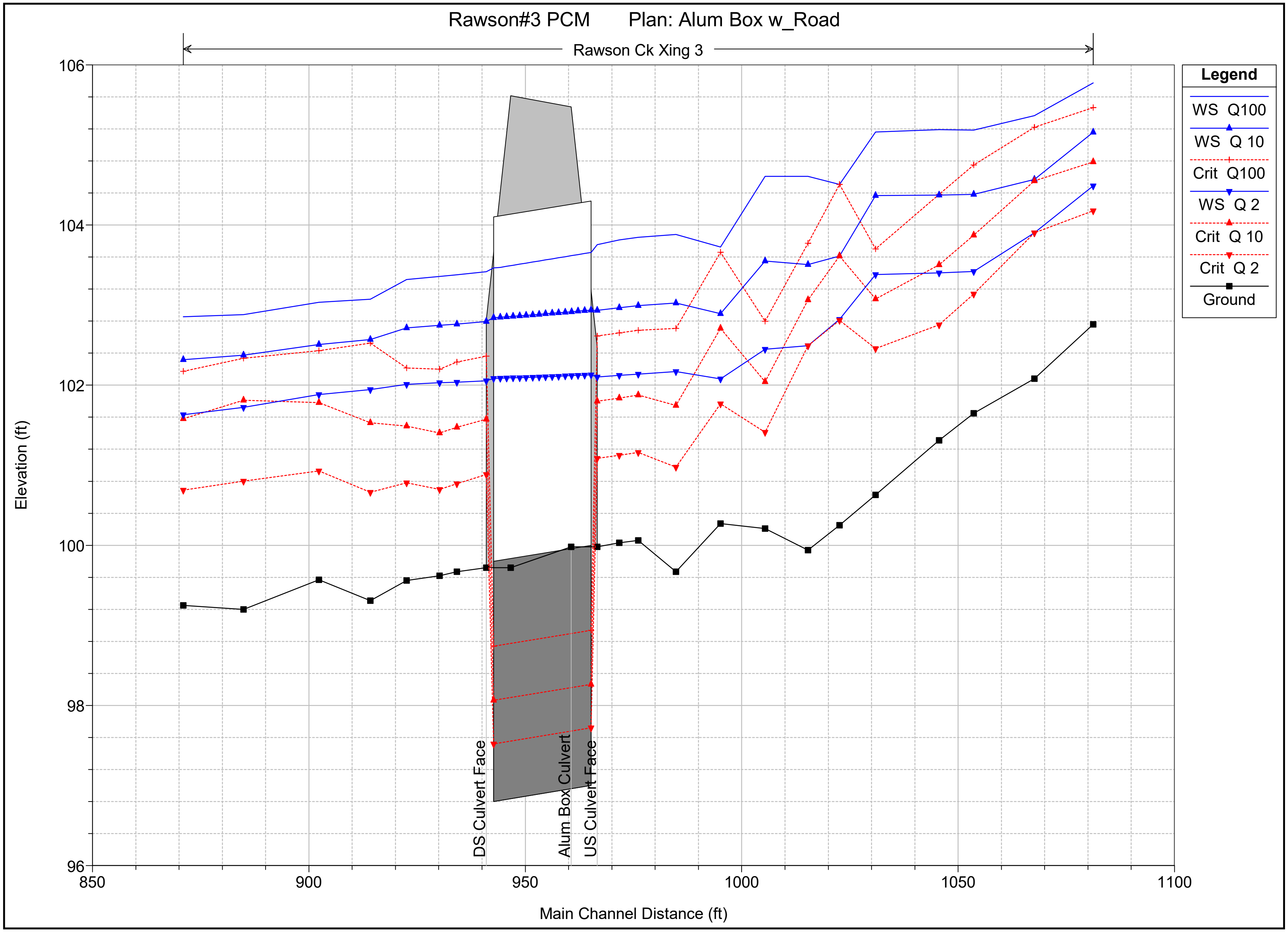
Attachment 3: HEC-RAS Results



HEC RAS Model domain for South Fork Rawson Creek, Crossing No. 3. Aluminum Box Culvert embedded 3 feet.



871
902
922
941
967
972
976
985
1005
1022
1045
Xing 3
1053
1081
Raw son C



Rawson#3 PCM Plan: Alum Box w_Road
Rawson Ck Xing 3
Legend
WS Q100
WS Q 10
Crit Q100
WS Q 2
Crit Q 10
Crit Q 2
Ground
Elevation (ft)
106
104
102
100
98
96
850
900
950
1000
1050
1100
Main Channel Distance (ft)
DS Culvert Face
Alum Box Culvert
US Culvert Face

Plan: AlumBoxRd Rawson Ck Xing 3 RS: 954 Culv Group: Culvert #1 Profile: Q100

Q Culv Group (cfs)	190.00	Culv Full Len (ft)	
# Barrels	1	Culv Vel US (ft/s)	4.19
Q Barrel (cfs)	190.00	Culv Vel DS (ft/s)	4.18
E.G. US. (ft)	104.07	Culv Inv El Up (ft)	97.00
W.S. US. (ft)	103.75	Culv Inv El Dn (ft)	96.80
E.G. DS (ft)	103.74	Culv Frctn Ls (ft)	0.19
W.S. DS (ft)	103.42	Culv Exit Loss (ft)	0.00
Delta EG (ft)	0.33	Culv Entr Loss (ft)	0.14
Delta WS (ft)	0.34	Q Weir (cfs)	
E.G. IC (ft)	103.00	Weir Sta Lft (ft)	
E.G. OC (ft)	104.07	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	103.66	Weir Max Depth (ft)	
Culv WS Outlet (ft)	103.46	Weir Avg Depth (ft)	
Culv Nml Depth (ft)	3.66	Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	1.94	Min El Weir Flow (ft)	106.20

HEC-RAS Plan: AlumBoxRd River: Rawson Ck Reach: Xing 3 Profile: Q 2

Reach	River Sta	Profile	Q Total	Max Chl Dpth	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)
Xing 3	1081	Q 2	43.00	1.73	102.76	104.49	104.18	104.68	0.016173	3.49	12.33	12.85	0.63	0.90
Xing 3	1067	Q 2	43.00	1.82	102.08	103.90	103.90	104.31	0.046472	5.11	8.42	10.68	1.01	2.07
Xing 3	1053	Q 2	43.00	1.77	101.65	103.42	103.14	103.69	0.019308	4.19	10.27	9.12	0.70	1.23
Xing 3	1045	Q 2	43.00	2.09	101.31	103.40	102.75	103.56	0.008762	3.14	13.68	9.91	0.47	0.66
Xing 3	1030	Q 2	43.00	2.75	100.63	103.38	102.46	103.45	0.003823	2.03	21.16	15.61	0.31	0.28
Xing 3	1022	Q 2	43.00	2.57	100.25	102.82	102.81	103.32	0.059702	5.68	7.58	7.64	1.00	2.58
Xing 3	1015	Q 2	43.00	2.55	99.94	102.49	102.49	102.87	0.051667	4.93	8.72	11.54	1.00	2.01
Xing 3	1005	Q 2	43.00	2.24	100.21	102.45	101.41	102.52	0.003129	2.12	20.29	12.63	0.29	0.28
Xing 3	995	Q 2	43.00	1.81	100.27	102.08	101.77	102.42	0.022739	4.70	9.14	6.81	0.72	1.53
Xing 3	985	Q 2	43.00	2.50	99.67	102.17	100.98	102.27	0.003886	2.45	17.52	9.04	0.31	0.37
Xing 3	976	Q 2	43.00	2.08	100.06	102.14	101.16	102.23	0.004279	2.41	17.84	11.65	0.34	0.37
Xing 3	972	Q 2	43.00	2.09	100.03	102.12	101.12	102.21	0.004088	2.37	18.11	11.64	0.34	0.36
Xing 3	967	Q 2	43.00	2.12	99.98	102.10	101.09	102.19	0.003928	2.34	18.37	11.73	0.33	0.35
Xing 3	954		Culvert											
Xing 3	941	Q 2	43.00	2.33	99.72	102.05	100.88	102.12	0.002949	2.06	20.87	13.09	0.29	0.27
Xing 3	934	Q 2	43.00	2.37	99.67	102.04	100.77	102.10	0.002589	1.99	21.64	13.01	0.27	0.24
Xing 3	930	Q 2	43.00	2.41	99.62	102.03	100.70	102.09	0.002311	1.90	22.67	13.45	0.26	0.22
Xing 3	922	Q 2	43.00	2.45	99.56	102.01	100.78	102.07	0.002493	1.89	22.70	14.55	0.27	0.22
Xing 3	914	Q 2	43.00	2.64	99.31	101.95	100.66	102.03	0.005175	2.40	17.92	12.87	0.36	0.38
Xing 3	902	Q 2	43.00	2.31	99.57	101.88	100.93	101.97	0.006110	2.34	18.40	16.68	0.39	0.38
Xing 3	885	Q 2	43.00	2.52	99.20	101.72	100.80	101.82	0.011021	2.55	16.84	20.99	0.50	0.51
Xing 3	871	Q 2	43.00	2.38	99.25	101.63	100.69	101.71	0.006003	2.25	19.47	21.23	0.39	0.36

HEC-RAS Plan: AlumBoxRd River: Rawson Ck Reach: Xing 3 Profile: Q 5

Reach	River Sta	Profile	Q Total	Max Chl Dpth	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)
Xing 3	1081	Q 5	75.00	2.16	102.76	104.92	104.55	105.18	0.016507	4.08	18.38	15.38	0.66	1.14
Xing 3	1067	Q 5	75.00	2.21	102.08	104.29	104.29	104.82	0.040701	5.83	12.98	13.63	0.99	2.43
Xing 3	1053	Q 5	75.00	2.36	101.65	104.01	103.58	104.35	0.016733	4.63	16.19	10.95	0.67	1.38
Xing 3	1045	Q 5	75.00	2.69	101.31	104.00	103.19	104.20	0.010648	3.64	20.60	14.06	0.53	0.86
Xing 3	1030	Q 5	75.00	3.36	100.63	103.99	102.87	104.08	0.003705	2.42	30.94	16.70	0.31	0.36
Xing 3	1022	Q 5	75.00	3.06	100.25	103.31	103.31	103.95	0.055874	6.39	11.73	9.25	1.00	3.03
Xing 3	1015	Q 5	75.00	2.71	99.94	102.65	102.85	103.41	0.093015	6.99	10.73	13.27	1.37	3.93
Xing 3	1005	Q 5	75.00	2.92	100.21	103.13	101.79	103.23	0.003494	2.51	29.83	15.56	0.32	0.37
Xing 3	995	Q 5	75.00	2.30	100.27	102.57	102.31	103.10	0.029357	5.85	12.81	8.35	0.83	2.26
Xing 3	985	Q 5	75.00	3.03	99.67	102.70	101.44	102.87	0.006185	3.31	22.63	10.56	0.40	0.65
Xing 3	976	Q 5	75.00	2.61	100.06	102.67	101.59	102.81	0.005561	3.05	24.55	13.62	0.40	0.56
Xing 3	972	Q 5	75.00	2.62	100.03	102.65	101.56	102.79	0.005465	3.04	24.71	13.63	0.40	0.55
Xing 3	967	Q 5	75.00	2.64	99.98	102.62	101.51	102.76	0.005330	3.00	24.96	13.76	0.39	0.54
Xing 3	954		Culvert											
Xing 3	941	Q 5	75.00	2.81	99.72	102.53	101.30	102.65	0.004218	2.73	27.52	14.77	0.35	0.44
Xing 3	934	Q 5	75.00	2.84	99.67	102.51	101.20	102.62	0.003988	2.66	28.24	15.22	0.34	0.42
Xing 3	930	Q 5	75.00	2.87	99.62	102.49	101.12	102.60	0.003616	2.55	29.41	15.69	0.33	0.38
Xing 3	922	Q 5	75.00	2.91	99.56	102.47	101.22	102.57	0.003761	2.51	29.86	17.11	0.34	0.38
Xing 3	914	Q 5	75.00	3.05	99.31	102.36	101.18	102.52	0.007015	3.18	23.81	15.95	0.43	0.63
Xing 3	902	Q 5	75.00	2.73	99.57	102.30	101.36	102.42	0.007519	2.86	26.25	21.92	0.45	0.55
Xing 3	885	Q 5	75.00	2.97	99.20	102.17	101.63	102.29	0.007647	2.83	27.95	29.51	0.45	0.54
Xing 3	871	Q 5	75.00	2.85	99.25	102.10	101.15	102.19	0.006006	2.43	32.15	34.04	0.40	0.41

HEC-RAS Plan: AlumBoxRd River: Rawson Ck Reach: Xing 3 Profile: Q 10

Reach	River Sta	Profile	Q Total	Max Chl Dpth	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)
Xing 3	1081	Q 10	100.00	2.40	102.76	105.16	104.79	105.47	0.017527	4.49	22.27	17.31	0.69	1.33
Xing 3	1067	Q 10	100.00	2.49	102.08	104.57	104.55	105.13	0.032428	6.05	17.62	18.13	0.92	2.44
Xing 3	1053	Q 10	100.00	2.73	101.65	104.38	103.87	104.75	0.017275	4.84	20.67	13.60	0.69	1.49
Xing 3	1045	Q 10	100.00	3.06	101.31	104.37	103.50	104.60	0.010111	3.80	26.33	16.35	0.53	0.90
Xing 3	1030	Q 10	100.00	3.74	100.63	104.37	103.08	104.48	0.003814	2.67	37.44	17.72	0.32	0.42
Xing 3	1022	Q 10	100.00	3.36	100.25	103.61	103.61	104.34	0.054709	6.82	14.66	10.25	1.01	3.32
Xing 3	1015	Q 10	100.00	3.57	99.94	103.51	103.07	103.79	0.018195	4.27	23.40	18.00	0.66	1.25
Xing 3	1005	Q 10	100.00	3.34	100.21	103.55	102.04	103.66	0.004021	2.69	37.14	19.70	0.35	0.43
Xing 3	995	Q 10	100.00	2.62	100.27	102.89	102.71	103.52	0.031913	6.37	15.71	9.74	0.88	2.62
Xing 3	985	Q 10	100.00	3.36	99.67	103.03	101.75	103.25	0.008047	3.80	26.32	12.49	0.46	0.85
Xing 3	976	Q 10	100.00	2.93	100.06	102.99	101.88	103.18	0.006270	3.43	29.14	14.84	0.43	0.69
Xing 3	972	Q 10	100.00	2.94	100.03	102.97	101.84	103.15	0.006240	3.42	29.28	14.94	0.43	0.68
Xing 3	967	Q 10	100.00	2.95	99.98	102.93	101.80	103.11	0.006090	3.39	29.50	14.98	0.43	0.67
Xing 3	954		Culvert											
Xing 3	941	Q 10	100.00	3.07	99.72	102.79	101.57	102.95	0.005218	3.17	31.55	15.83	0.40	0.58
Xing 3	934	Q 10	100.00	3.09	99.67	102.76	101.48	102.91	0.005216	3.09	32.38	17.10	0.40	0.56
Xing 3	930	Q 10	100.00	3.13	99.62	102.75	101.40	102.89	0.004721	2.98	33.60	17.44	0.38	0.52
Xing 3	922	Q 10	100.00	3.15	99.56	102.71	101.49	102.85	0.004873	2.91	34.33	19.21	0.38	0.51
Xing 3	914	Q 10	100.00	3.26	99.31	102.57	101.53	102.78	0.008701	3.73	27.38	18.26	0.49	0.85
Xing 3	902	Q 10	100.00	2.94	99.57	102.51	101.78	102.67	0.008145	3.25	31.33	26.82	0.48	0.68
Xing 3	885	Q 10	100.00	3.18	99.20	102.38	101.81	102.53	0.007817	3.17	34.64	34.44	0.46	0.65
Xing 3	871	Q 10	100.00	3.07	99.25	102.32	101.58	102.42	0.006007	2.60	40.48	40.16	0.41	0.45

HEC-RAS Plan: AlumBoxRd River: Rawson Ck Reach: Xing 3 Profile: Q 25

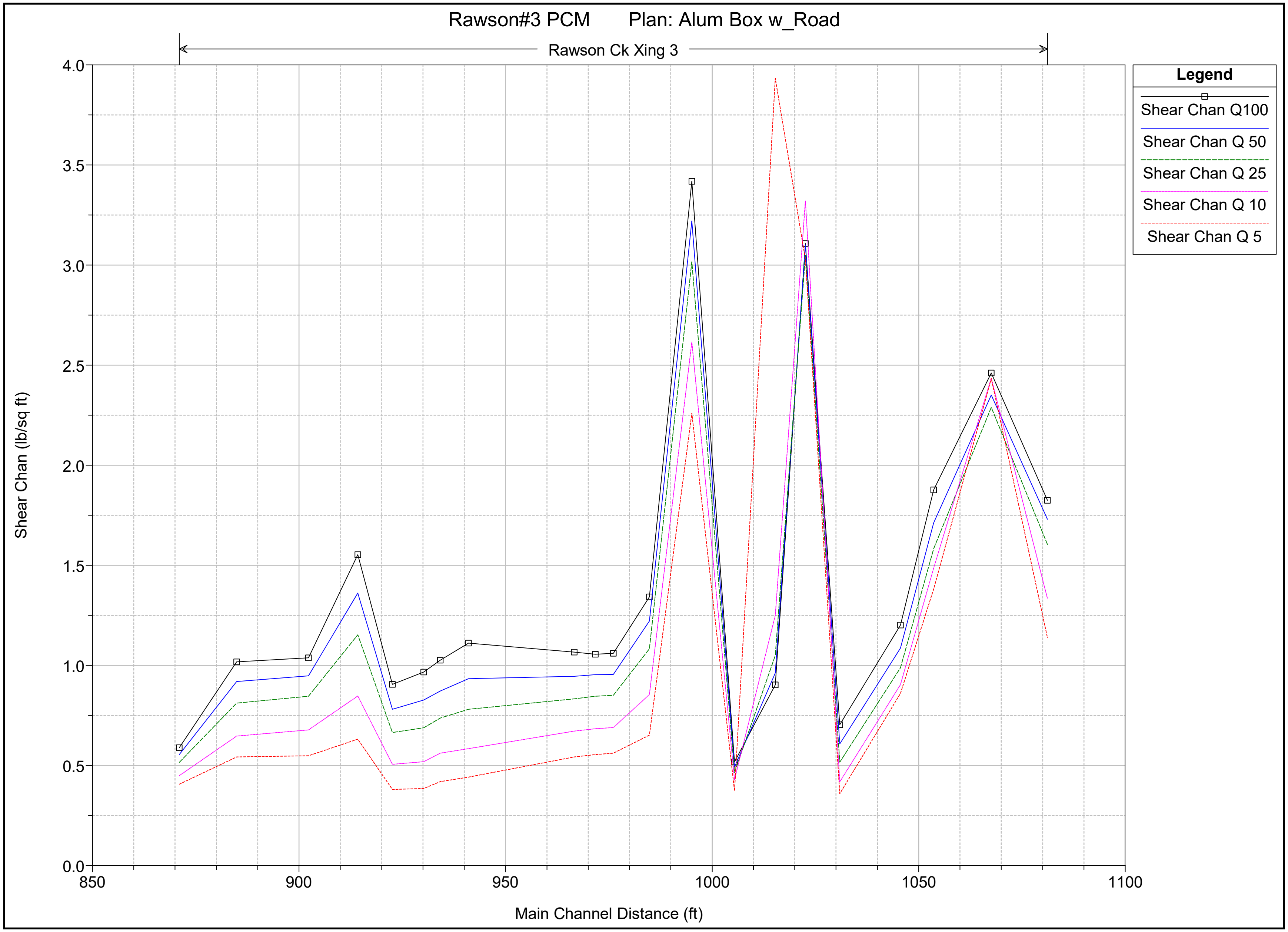
Reach	River Sta	Profile	Q Total	Max Chl Dpth	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)
Xing 3	1081	Q 25	134.00	2.64	102.76	105.40	105.07	105.80	0.018290	5.04	26.90	21.67	0.72	1.60
Xing 3	1067	Q 25	134.00	2.86	102.08	104.94	104.83	105.50	0.023876	6.11	24.92	21.51	0.82	2.29
Xing 3	1053	Q 25	134.00	3.12	101.65	104.77	104.26	105.17	0.017183	5.05	26.54	16.47	0.70	1.58
Xing 3	1045	Q 25	134.00	3.45	101.31	104.76	103.92	105.02	0.010138	4.03	33.26	19.16	0.54	0.99
Xing 3	1030	Q 25	134.00	4.12	100.63	104.75	103.34	104.89	0.004371	3.01	44.57	19.61	0.35	0.52
Xing 3	1022	Q 25	134.00	3.83	100.25	104.08	104.08	104.75	0.049246	6.56	20.43	15.32	1.00	3.05
Xing 3	1015	Q 25	134.00	4.05	99.94	103.99	103.33	104.24	0.013383	4.00	33.49	23.21	0.59	1.05
Xing 3	1005	Q 25	134.00	3.80	100.21	104.01	102.35	104.14	0.003986	2.85	46.99	22.83	0.35	0.47
Xing 3	995	Q 25	134.00	2.97	100.27	103.24	103.13	103.98	0.034209	6.92	19.36	11.29	0.93	3.02
Xing 3	985	Q 25	134.00	3.71	99.67	103.38	102.12	103.67	0.009873	4.30	31.16	14.63	0.52	1.08
Xing 3	976	Q 25	134.00	3.29	100.06	103.35	102.22	103.58	0.007125	3.86	34.67	16.26	0.47	0.85
Xing 3	972	Q 25	134.00	3.29	100.03	103.32	102.17	103.55	0.007121	3.85	34.79	16.38	0.47	0.85
Xing 3	967	Q 25	134.00	3.30	99.98	103.28	102.14	103.51	0.006698	3.85	34.82	17.14	0.46	0.83
Xing 3	954		Culvert											
Xing 3	941	Q 25	134.00	3.35	99.72	103.07	101.91	103.29	0.006440	3.71	36.10	17.19	0.45	0.78
Xing 3	934	Q 25	134.00	3.37	99.67	103.04	101.81	103.24	0.006129	3.60	37.42	19.81	0.44	0.74
Xing 3	930	Q 25	134.00	3.40	99.62	103.02	101.73	103.21	0.005739	3.48	38.68	20.07	0.42	0.69
Xing 3	922	Q 25	134.00	3.42	99.56	102.98	101.79	103.16	0.006013	3.37	39.78	21.65	0.43	0.66
Xing 3	914	Q 25	134.00	3.47	99.31	102.78	102.06	103.08	0.010946	4.41	31.79	23.92	0.56	1.15
Xing 3	902	Q 25	134.00	3.16	99.57	102.73	102.06	102.93	0.009139	3.69	37.81	31.75	0.51	0.85
Xing 3	885	Q 25	134.00	3.38	99.20	102.58	102.03	102.78	0.008581	3.63	42.18	38.58	0.49	0.81
Xing 3	871	Q 25	134.00	3.29	99.25	102.54	101.83	102.65	0.006002	2.85	49.52	42.57	0.42	0.52

HEC-RAS Plan: AlumBoxRd River: Rawson Ck Reach: Xing 3 Profile: Q 50

Reach	River Sta	Profile	Q Total	Max Chl Dpth	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)
Xing 3	1081	Q 50	161.00	2.83	102.76	105.59	105.28	106.03	0.017550	5.34	31.41	26.07	0.72	1.73
Xing 3	1067	Q 50	161.00	3.09	102.08	105.17	105.03	105.74	0.021692	6.32	29.99	23.76	0.80	2.35
Xing 3	1053	Q 50	161.00	3.34	101.65	104.99	104.53	105.43	0.017539	5.30	30.37	17.84	0.72	1.71
Xing 3	1045	Q 50	161.00	3.68	101.31	104.99	104.14	105.27	0.010593	4.26	37.81	20.81	0.56	1.09
Xing 3	1030	Q 50	161.00	4.34	100.63	104.97	103.52	105.14	0.004915	3.28	49.07	21.46	0.38	0.61
Xing 3	1022	Q 50	161.00	4.06	100.25	104.31	104.31	104.99	0.049172	6.63	24.27	18.62	1.02	3.10
Xing 3	1015	Q 50	161.00	4.37	99.94	104.31	103.58	104.54	0.011067	3.90	41.30	26.11	0.55	0.96
Xing 3	1005	Q 50	161.00	4.11	100.21	104.32	102.56	104.45	0.003845	2.97	54.26	24.74	0.35	0.49
Xing 3	995	Q 50	161.00	3.22	100.27	103.49	103.40	104.30	0.034609	7.21	22.32	12.42	0.95	3.22
Xing 3	985	Q 50	161.00	3.97	99.67	103.64	102.39	103.97	0.010828	4.59	35.10	16.24	0.55	1.22
Xing 3	976	Q 50	161.00	3.54	100.06	103.60	102.46	103.87	0.007569	4.13	38.95	17.27	0.49	0.96
Xing 3	972	Q 50	161.00	3.54	100.03	103.57	102.41	103.83	0.007740	4.12	39.12	17.81	0.49	0.95
Xing 3	967	Q 50	161.00	3.54	99.98	103.52	102.38	103.79	0.006980	4.16	38.69	18.84	0.47	0.95
Xing 3	954		Culvert											
Xing 3	941	Q 50	161.00	3.54	99.72	103.26	102.14	103.52	0.007191	4.11	39.19	18.12	0.48	0.93
Xing 3	934	Q 50	161.00	3.55	99.67	103.22	102.05	103.46	0.006680	3.97	41.07	22.03	0.46	0.87
Xing 3	930	Q 50	161.00	3.58	99.62	103.20	101.97	103.43	0.006687	3.83	42.47	22.47	0.46	0.83
Xing 3	922	Q 50	161.00	3.60	99.56	103.16	102.00	103.37	0.006614	3.70	43.87	25.13	0.46	0.78
Xing 3	914	Q 50	161.00	3.62	99.31	102.93	102.29	103.28	0.012295	4.83	35.59	27.84	0.59	1.36
Xing 3	902	Q 50	161.00	3.31	99.57	102.88	102.25	103.12	0.009521	3.96	42.97	34.50	0.53	0.95
Xing 3	885	Q 50	161.00	3.53	99.20	102.73	102.18	102.95	0.008933	3.92	48.14	41.65	0.51	0.92
Xing 3	871	Q 50	161.00	3.44	99.25	102.69	102.02	102.82	0.006001	2.99	56.41	44.46	0.42	0.55

HEC-RAS Plan: AlumBoxRd River: Rawson Ck Reach: Xing 3 Profile: Q100

Reach	River Sta	Profile	Q Total	Max Chl Dpth	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)
Xing 3	1081	Q100	190.00	3.02	102.76	105.78	105.47	106.25	0.016670	5.58	36.61	28.94	0.72	1.82
Xing 3	1067	Q100	190.00	3.29	102.08	105.37	105.22	105.98	0.020578	6.58	34.95	25.48	0.79	2.46
Xing 3	1053	Q100	190.00	3.54	101.65	105.19	104.75	105.67	0.018286	5.60	33.94	19.00	0.74	1.88
Xing 3	1045	Q100	190.00	3.88	101.31	105.19	104.38	105.51	0.011173	4.51	42.09	22.17	0.58	1.20
Xing 3	1030	Q100	190.00	4.53	100.63	105.16	103.70	105.36	0.005348	3.57	53.43	23.24	0.40	0.70
Xing 3	1022	Q100	190.00	4.26	100.25	104.51	104.51	105.21	0.045714	6.73	28.25	20.90	1.01	3.11
Xing 3	1015	Q100	190.00	4.67	99.94	104.61	103.77	104.84	0.009406	3.84	49.47	28.49	0.51	0.90
Xing 3	1005	Q100	190.00	4.40	100.21	104.61	102.80	104.76	0.003740	3.09	61.76	26.90	0.35	0.52
Xing 3	995	Q100	190.00	3.45	100.27	103.72	103.66	104.60	0.035053	7.49	25.37	13.57	0.97	3.42
Xing 3	985	Q100	190.00	4.21	99.67	103.88	102.71	104.25	0.011447	4.84	39.25	17.62	0.57	1.34
Xing 3	976	Q100	190.00	3.79	100.06	103.85	102.69	104.15	0.007991	4.39	43.26	18.23	0.50	1.06
Xing 3	972	Q100	190.00	3.78	100.03	103.81	102.65	104.11	0.008277	4.35	43.64	19.54	0.51	1.06
Xing 3	967	Q100	190.00	3.77	99.98	103.75	102.61	104.07	0.007191	4.49	42.35	20.22	0.49	1.07
Xing 3	954		Culvert											
Xing 3	941	Q100	190.00	3.70	99.72	103.42	102.36	103.74	0.007995	4.53	41.93	19.01	0.51	1.11
Xing 3	934	Q100	190.00	3.71	99.67	103.38	102.29	103.67	0.007351	4.36	44.50	24.53	0.49	1.03
Xing 3	930	Q100	190.00	3.74	99.62	103.36	102.20	103.63	0.007281	4.19	46.36	26.73	0.49	0.97
Xing 3	922	Q100	190.00	3.76	99.56	103.32	102.22	103.57	0.007250	4.02	48.26	29.11	0.48	0.91
Xing 3	914	Q100	190.00	3.76	99.31	103.07	102.52	103.47	0.013216	5.21	39.78	31.86	0.62	1.55
Xing 3	902	Q100	190.00	3.47	99.57	103.04	102.43	103.30	0.009755	4.19	48.46	37.19	0.54	1.04
Xing 3	885	Q100	190.00	3.68	99.20	102.88	102.34	103.13	0.009151	4.18	54.55	45.03	0.53	1.02
Xing 3	871	Q100	190.00	3.60	99.25	102.85	102.17	103.00	0.005996	3.11	63.69	46.82	0.43	0.59



Rawson#3 PCM Plan: Alum Box w_Road
Rawson Ck Xing 3
Legend
Shear Chan Q100
Shear Chan Q 50
Shear Chan Q 25
Shear Chan Q 10
Shear Chan Q 5
Shear Chan (lb/sq ft)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
850
900
950
1000
1050
1100
Main Channel Distance (ft)

Attachment 4: RSP Sizing

Rawson Crossing #3 RSP Sizing	AL	6/4/2021

Stone Stability Calculation

USACE 1110-2-1601 , 1994. Hydraulic Design of Flood Control Channels, ***Equation 3-3***

Equation for sizing riprap for channel bottom and side slopes

$$D_{30} = S_f C_s C_V C_T d \left[\left(\frac{\gamma_w}{\gamma_s - \gamma_w} \right)^{1/2} \frac{V}{\sqrt{K_1 g d}} \right]^{2.5} \qquad (3\text{-}3) \qquad K_1 = \sqrt{1 - \frac{\sin^2 \theta}{\sin^2 \phi}}$$

and

D 50 = D 30 (D 85 /D 15)^(1/3)

CONSTANTS		
Stability Coef. for Incipient Failure (D85/D15 = 1.7 to 5.2) *0.30 = Angular Rock; 0.375 = Rounded Rock*	Cs	0.3
Vertical Velocity Distribution Coefficient for a Channel Bend *1.283-.2log(R/W) = Outside of Bends*	Cv	1.24
1.0 for thickness of 1D100 or 1.5 for thickness of 1.5D50 (whichever greater)	Ct	1.00
Gravitational Constant (ft/s^2)	g	32.2
Unit Weight of Water (lb/cf)	γw	62.4
Unit Weight of Sediment or Rock (lb/cf)	γs	165.0

HEC-RAS RIVER STATION:			
ROCK PLACEMENT LOCATION:		Upstream Face of Culvert	Downstream Face of Culvert
INPUT VARIABLES			
Side Slope Correction Factor			
Angle of Repose of Riprap (deg) *Normally 40 deg*	ϕ	40	40
Angle of Side Slope with Horizontal (deg) (Steepest)	Θ	37.6	37.6
Side Slope Correction Factor	K1	0.31	0.31
Design Variables			
Depth-Averaged Local Velocity (ft/s)	**V**	4.49	4.53
Local Depth of Flow* (ft)	**d**	3.75	3.42
Radius of Curvature - Bend (ft)	**R**	35.00	35.00
Channel Width at Water Surface (ft)	**W**	20.22	19.01
Radius Curvature/Width	**R/W**	**1.73**	**1.84**
Safety Factor	**Sf**	2.00	2.00
Rock Gradation			
Gradation Ratio (for Calculating D50)	**D84/D15**	2.0	2.0
RESULTS			
D30 Rock			
Rock Diameter (ft)	**D30**	**0.7**	**0.7**
Weight (lb) [dia. rounded to tenths]	**W30**	**30**	**30**
D50 Rock			
Rock Diameter (ft)	**D50**	**0.9**	**0.9**
Weight (lb) [dia. rounded to tenths]	**W50**	**63**	**63**

Attachment 5: Opinion of Probable Construction Cost

Opinion of Probable Construction Cost for 90% Design Submittal

Michael Love & Associates
Hydrologic Solutions
PO Box 4477 • Arcata, CA 95518 • (707) 822 -2411

Rawson Crossing No.3 Replacement

6/3/2021

Item Description	Unit	Quantity	Unit Cost	Total Cost
Mobilization/Demonization (8%)	LS	1	$10,291	$10,300
Clearing and Grubbing	DAY	1	$5,014	$5,100
Tree Removal	EA	4	$1,500	$6,000
Water Management	DAY	15	$500	$7,500
General Excavation	CY	200	$25	$5,000
Furnish and Install Aluminum Box Culvert 12.5x7.4x22.5-ft (Span x Rise x length)	LS	1	$44,900	$44,900
Furnish and install Structural backfill with compaction	TON	60	$193	$11,580
Embankment and Road Backfill (Salvaged)	CY	160	$92	$14,742
Road Surfacing	TON	34	$92	$3,099
Root Wad Bank Protection (includes excavating rootwad)	EA	4	$3,500	$14,000
Channel grading and finsh grading	CY	40	$25	$1,000
Furnish and Install Bankline Rock	TON	20	$150	$3,000
Furnish and Install RSP	TON	49	$150	$7,420
Furnish and Install Streambed Material	TON	60	$65	$3,900
Site Stabilization (Seed, Placement of Chip)	LS	1	$1,000	$1,000
Riparian Replanting (1 gal trees/shrubs)	EA	10	$40	$400
			Subtotal Construction	**$138,941**
			10% Contingency	**$13,894**
			TOTAL	**$152,835**