30 PERCENT DESIGN REPORT
PROJECT AREA 14
TUCANNON RIVER PHASE II

Prepared for
Columbia Conservation District
202 South 2nd Street, U.S. Post Office Building
Dayton, Washington 99328

Prepared by
Anchor QEA, LLC
1605 Cornwall Avenue
Bellingham, Washington 98225

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<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>percent</td>
</tr>
<tr>
<td>CCD</td>
<td>Columbia Conservation District</td>
</tr>
<tr>
<td>ELJ</td>
<td>engineered log jam</td>
</tr>
<tr>
<td>ESA</td>
<td>Endangered Species Act</td>
</tr>
<tr>
<td>GPS</td>
<td>global positioning system</td>
</tr>
<tr>
<td>LWD</td>
<td>large woody debris</td>
</tr>
<tr>
<td>PA</td>
<td>project area</td>
</tr>
<tr>
<td>RM</td>
<td>river mile</td>
</tr>
<tr>
<td>WDFW</td>
<td>Washington Department of Fish and Wildlife</td>
</tr>
</tbody>
</table>
1 INTRODUCTION

Anchor QEA, LLC, was retained by the Columbia Conservation District (CCD) to develop 30 percent (%) designs for restoration within Project Area (PA) 14 of the Tucannon River as delineated in the Conceptual Restoration Plan (Anchor QEA 2011) from approximately river mile (RM) 39.2 to 37.15. The Tucannon River basin is located in Southeast Washington State in Columbia and Garfield counties (Figure 1). Enhancing and restoring instream habitat in this project area will be accomplished through a variety of treatment actions in the main channel, along the banks, and within the floodplain. This report describes the project areas as well as the function, design, and construction of restoration treatments that are proposed for implementation. These treatments include construction of instream habitat features such as engineered log jams (ELJs), removal of infrastructure such as dredge spoils, and riparian plantings. In addition a gravel augmentation program is proposed to place former dredge spoils back into the river to help treat incision and arrest an existing headcut moving through the reach near the upstream extent of PA-14. A description of the project area with respect to existing natural processes and habitat conditions is provided, along with the specific physical and biological objectives that the proposed restoration features are expected to achieve. In addition, the project’s contribution to the overall watershed-scale restoration plan is described. Construction considerations and best management practices are included for the proposed treatment actions.
2 PROJECT PURPOSE AND OBJECTIVES

The system-wide restoration objective for the Tucannon River is to improve habitat conditions for Endangered Species Act- (ESA-) listed species for all life history stages. Improving habitat conditions will lead to an increase in the abundance of listed species returning to the river. Increasing abundance will lead to delisting of the species, which is the overall recovery goal for the system. Previous efforts (CCD 2004; SRSRB 2006) have identified the habitat-limiting factors associated with the decline of ESA-listed populations. A geomorphic assessment synthesized and updated this information and identified 10 geomorphic reaches between the river mouth and Panjab Creek (RM 50). Reach-scale restoration actions based on this basin-scale assessment were provided at a preliminary level in the Conceptual Restoration Plan described below.

2.1 Conceptual Restoration Plan, Reaches 6 to 10

In 2011, a Conceptual Restoration Plan was created for Reaches 6 through 10 (RM 20 to 50), which were identified as critical for spring Chinook and steelhead populations in the system (Anchor QEA 2011). This assessment included the development of 28 site-specific restoration projects throughout the 30 miles of the study area. As part of this effort, meetings and discussions with local stakeholders and scientific experts in the Tucannon basin were held to identify the critical life history stages to target in prioritizing the implementation of the 28 projects. Four criteria were identified:

1. **Expected biologic response:** How well the project is expected to benefit listed fish populations, particularly spring Chinook. For Reaches 6 through 10, projects expected to benefit the juvenile life history stage, or contribute to habitat complexity and pool quantity, typically received the highest rank.

2. **Consistency with natural geomorphic processes:** How well the project is expected to contribute to rehabilitation of natural processes on a project and reach scale.

3. **Benefit-to-cost ratio:** The ratio of the magnitude of expected physical and biologic benefit versus the relative cost.

4. **Reach priority:** A relative ranking between Priority 1 (highest) and Priority 3 (lowest) based on existing biologic and physical data that describes the restoration potential of the geomorphic reach.
   - Priority 1: Reaches 8 and 9 (RM 32.1 to 44.0)
• Priority 2: Reaches 6 and 7 (RM 20.0 to 32.1)
• Priority 3: Reach 10 (RM 44.0 to 50.0)

The conceptual project areas were qualitatively ranked based on the four criteria and placed into three relative tier levels. The tier levels are representative of the implementation priority for projects. Tier 1 projects should be considered for early implementation within basin restoration planning, Tier 2 projects are moderate to high priority to be considered for strategic implementation, and Tier 3 projects have a lower priority due to considerations such as less certainty of benefit, high cost of implementation, or contingencies of benefit on the construction of other projects.

2.2 Project Selection

Nine Tier 1 projects were identified in the Conceptual Restoration Plan for early implementation. Six of these projects are located within Reaches 8 and 9, which were identified as the highest priority reaches based on the criteria used in the evaluation. These two reaches have the greatest existing use by adult and juvenile fish, and a high/moderate level of restoration potential based on physical characteristics and impaired geomorphic process. PA-14 was selected for early implementation by the CCD, leading to the development of this 30% design package. The project addresses existing incision and ongoing headcut with the placement of ELJs and other large woody debris (LWD) structures. Project elements target retention of mobile wood and sediment, promotion of side channel development, and overall increased connectivity between the river and its adjacent floodplain. A summary of PA-14 in regards to the four evaluation criteria from the Conceptual Restoration Plan is provided in Table 1; additional details of the project prioritization and discussion of the evaluation criteria are available in the Conceptual Restoration Plan (Anchor QEA 2011).
Table 1
PA-14 Evaluation Criteria Rationale

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected biologic response</td>
<td>In the short term, the LWD placements will provide high-flow refuge, low-flow cover, and additional pools in the project area. In the long term, the project actions are expected to initiate the formation of more complex and diverse habitats for juvenile and adult fish. Increased floodplain connectivity will contribute to the recovery of ecological riparian processes.</td>
</tr>
<tr>
<td>Consistency with natural geomorphic processes</td>
<td>The proposed restoration actions will promote the retention of LWD and sediment, which will contribute to the recovery of natural processes in the project area. In the long term, the project actions are expected to initiate increased floodplain connectivity and the development of a more complex channel network with diverse hydraulic conditions.</td>
</tr>
<tr>
<td>Benefit-to-cost ratio</td>
<td>The project is expected to have a moderate benefit and a moderate relative cost. The restoration treatments should provide some immediate benefit from the placement of LWD structures in the channel; however, the desired geomorphic response will likely take place on a longer time line.</td>
</tr>
<tr>
<td>Reach priority</td>
<td>The project area is located in Reach 8, which is a priority 1 reach.</td>
</tr>
</tbody>
</table>

Source: Anchor QEA 2011

The Conceptual Restoration Plan was intended to provide an objective look at which conceptual projects would be most beneficial to target species based on the above criteria. The assessment did not consider feasibility in terms of landowner willingness to participate or other potential challenges such as site access. PA-14 covers just over 2 RMs, which are located on property owned by the Washington Department of Fish and Wildlife (WDFW). Therefore, the potential challenges associated with landowner permission are low. While several access routes will be required to access the length of the project area, disturbance to existing vegetation will be minimized by observing best management practices during construction. Any trees disturbed may be incorporated into the project design to add additional complexity to the proposed LWD structures.
3 REACH DESCRIPTION

For purposes of discussion, the project area was divided into four discrete subareas with similar existing conditions, restoration objectives, and suites of treatment actions (Table 2). An overview of the project area is shown in Figure 2.

<table>
<thead>
<tr>
<th>Subarea</th>
<th>River Miles</th>
<th>Project Stationing</th>
<th>Length (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>39.2 to 38.8</td>
<td>108+00 to 86+50</td>
<td>2,150 ft</td>
</tr>
<tr>
<td>2</td>
<td>38.8 to 38.45</td>
<td>86+50 to 60+00</td>
<td>2,650 ft</td>
</tr>
<tr>
<td>3</td>
<td>38.45 to 37.75</td>
<td>60+00 to 30+00</td>
<td>3,000 ft</td>
</tr>
<tr>
<td>4</td>
<td>37.75 to 37.15</td>
<td>30+00 to 0+00</td>
<td>3,000 ft</td>
</tr>
</tbody>
</table>

RM rounded to nearest 0.05 mile

3.1 Subarea 1, Stations 108+00 to 86+50

Key observations: An active headcut adjacent to the hatchery levee near Station 103+00 creates an approximately 6-foot drop in channel bottom elevation through a distance of approximately 50 linear feet. This headcut currently has the potential to undermine the hatchery levee and is traveling upstream towards the bridge crossing and could undermine bridge abutments if allowed to proceed to and past the bridge location. Connectivity to the low-lying left floodplain is poor in this subarea, and the headcut process exacerbates this condition. In general, instream habitat conditions are characterized by a lack of complexity and cover.

The channel in Subarea 1 is a relatively straight, single-thread channel with short braided sections. The channel has likely been straightened and deepened historically, as indicated by its lack of sinuosity and the presence of spoil piles in the floodplain near Station 102+00. Between the bridge at Station 108+00 and approximately Station 100+00, the channel is relatively straight and plane-bed, until the bed elevation drops abruptly at an active headcut that was located near Station 103+00 during field observation by Anchor QEA staff in mid-October 2011 (Photograph 1). The headcut is located directly adjacent to the levee that
isolates the hatchery operations from the river, which includes an access road along its length. The levee is armored with riprap and vegetated with willows.

Near Stations 100+00 to 98+00, the channel contains several large trees that have been recruited, likely due to undercutting caused by the travelling headcut. The trees force deep pools at this location and will likely retain some mobile LWD moving through the system. Between approximately Stations 98+00 and 87+00, the channel contains several short secondary channels but overall lacks pools and cover (Photograph 2). The right bank between Stations 97+00 and 95+50 was actively eroding in the direction of the hatchery. LWD is minimal and limited to singular logs and small mobile debris. An outfall channel originating at the hatchery is located through the right floodplain and enters the main channel near Station 87+00.
The floodplain in Subarea 1 contains a relatively large amount of low-lying area, but connectivity to these areas is limited by incised channel conditions and the presence of infrastructure. The bridge crossing at the upstream end of the project area constrains the channel and available floodplain, although there is a built-in overbank flow path where floodwaters can overtop and cross the hatchery road in the event of a large flood. A significant low-lying former channel path in the floodplain beginning at approximately Station 103+00 is cut off at the top by an accumulation of spoiled materials that can be observed easily in the aerial images and topography. The low-lying flow path was un-wetted at the time of field observation in July 2011 and October 2011.
3.2 Subarea 2, Stations 86+50 to 60+00

Key observations: This subarea is primarily a plane-bed channel lacking hydraulic complexity and preferred juvenile habitat. Incision has resulted in low floodplain connectivity.

In Subarea 2, the river is typically a straight, plane-bed channel with a few local pools forced at LWD. Between Stations 86+50 and 80+00, the channel is relatively wide and shallow where it flows along the bedrock valley wall. Between Stations 80+00 and 71+00, there is a greater quantity of downed trees in the channel and along the outer bank, which create a few pools as well as two small backwater areas between Stations 75+00 and 72+00 (Photograph 3). At Station 70+00, a log jam and a downed pine tree have initiated split flow and gravel bar development for an approximately 300-foot portion of the channel. Evidence of channel migration and expansion in the vicinity of the log jam is apparent in the raw banks lining the channel. Between the log jam and Station 60+00, the channel transitions back to a single-thread, plane-bed channel that becomes progressively more incised and disconnected from the floodplain moving towards the downstream end of the subarea. Two mature Ponderosa pines have recently fallen across the channel near Station 62+00. Other than the split flow near Station 70+00, no significant side channels were observed in the subarea. Near Station 77+00, a small channel enters the river, presumably seepage flow from Blue Lake. In addition, the outfall channel from Blue Lake enters the river near Station 63+00. Each of these channels likely provide off-channel rearing habitat for juvenile salmonids during some life history stages.
Although much of the floodplain through Subarea 2 is at a relatively low-lying elevation, floodplain connectivity appears to be poor. For example, the high right bank between approximately Stations 77+00 and 80+00 likely prevents bank overtopping and distribution of floodwaters across the low floodplain area during high-frequency events (occurring every 5 years or less). No significant infrastructure was observed in the floodplain that prevents floodplain connectivity.

### 3.3 Subarea 3, Stations 60+00 to 30+00

*Key observations: Subarea 3 is highly incised and disconnected from the floodplain; the simplified condition of the channel likely exacerbates this condition. The channel contains very little hydraulic complexity or suitable juvenile habitat.*
Throughout Subarea 3, the river is a single-thread, plane-bed channel. The channel is highly incised; a headcut at the top of the subarea appears to be migrating upstream around the bend at Station 58+00. The channel has likely been straightened historically, as indicated by its lack of sinuosity, particularly between Stations 55+00 and 30+00 (near Cummings Creek). Hydraulic complexity is limited to the location of downed trees (many of them fallen or felled due to fire), where local pools have scoured. Relatively large trees are present near Stations 58+00, and 55+50; other LWD in the channel was relatively small and likely easily mobilized during regular high-flow events. The channel bed is typically well armored with larger cobbles in much of the subarea. Several large boulders were observed in the bed adjacent to the Cummings Creek fan. At the downstream end of the subarea, bedrock is located along the right bank between Stations 34+00 and 32+00. The channel passes beneath the Tucannon Road Bridge at Station 32+00 and beneath the former roadway (currently a pedestrian access bridge) at Station 31+00. While Tucannon Road did not appear to significantly confine the channel, the pedestrian bridge has a smaller opening and lower bridge deck that may cause constriction of floodwaters during high flows. No significant side channels were identified in the subarea.

The river channel is highly incised and disconnected from the surrounding floodplain (Photograph 4). A small amount of low-lying floodplain is present on the inside of the bend between Stations 60+00 and 55+00. Downstream of Station 55+00, the floodplain corridor is extremely narrow. The floodplain surface is typically dry with a poor hyporheic connection to the river that supports dry, grassy vegetation. Many trees have been damaged by the School Fire, which severely affected the Cummings Creek subbasin.
3.4 Subarea 4, Stations 30+00 to 0+00

Key observations: Although this subarea contains sections with active channel migration and recruitment of LWD, the lack of hydraulic complexity limits the quality of juvenile habitat.

The river is primarily a single-thread channel through Subarea 4. Between approximately Stations 30+00 and Station 17+00, the channel is actively migrating and recruiting mature trees from the floodplain, creating a forced pool-riffle sequence ( Photograph 5). Just downstream of the diversion intake for the WDFW Headquarters site, a deep pool is located along the toe of the right bank where multiple mature trees have been undercut and fallen in the channel. This portion of the channel contains a few short secondary channels between Station 26+00 and 18+00. The downstream end of the outfall channel from Spring Lake provides an alcove-type of environment that may be used by juvenile fish.
Photograph 5
The Main Channel Near Station 20+00, Looking Downstream at an Actively Migrating Bend where Wood is being Recruited to the Channel

Downstream of Station 17+00, the channel is relatively wide and plane-bed with little hydraulic complexity. Some singular logs with rootwads or exposed tree roots force local scour pools near Stations 16+00 and 9+00. One side channel is present between approximately Stations 9+00 and 4+00. During field observation in July 2011, the upstream end of the channel was disconnected and some relatively cold water had a good downstream connection to the main channel; this may have been outflow from the irrigation ditch. Dozens of juvenile fish were observed using the side channel during the July site reconnaissance.
Floodplain connectivity in this portion of the channel is moderate. Lower-lying point bars on the insides of meander bends are likely inundated during frequent flood events. Between approximately Stations 27+00 and 9+00, little evidence indicating frequent inundation of the floodplain was observed. However, these areas likely receive overbank flow at less frequent flood events (greater than 5-year recurrence interval).
4 DESIGN DEVELOPMENT

The proposed restoration actions are described within each subarea, including the physical description and construction details, as well the expected biological and physical benefits. The proposed restoration design is shown in Figures 3a through 8b. Design details for LWD and ELJs are shown in Figures 9 through 16. For the purposes of describing the specific benefits of the design elements, the subareas have been further subdivided into groups of one or more features. However, the proposed design is intended to function collectively throughout the overall project area in order to achieve a reach-scale geomorphic response and optimum biological benefit in the long term. Therefore, the subareas and feature groups are not independent from one another.

4.1 Subarea 1, Stations 108+00 to 86+50

Subarea 1 is located between the hatchery bridge near Station 108+00 to the outlet of the hatchery outfall channel at approximately Station 86+50. The proposed restoration features within this subarea are summarized in Table 3 and shown in Figures 3a through 4b.

Table 3
Summary of Proposed Restoration Actions and Expected Benefits, Subarea 1

<table>
<thead>
<tr>
<th>Feature Group</th>
<th>Approx. Station</th>
<th>Action(s)</th>
<th>Expected Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>107+50 to 102+00</td>
<td>Spoil pile removal and gravel bedload augmentation</td>
<td>Works collectively with downstream LWD placements to raise the bed elevation of incised portions of the project area, contributing to channel complexity and floodplain connectivity.</td>
</tr>
<tr>
<td>B</td>
<td>130+50 to 98+50</td>
<td>Construction of two ELJs, approximately 5 LWD assemblies in the left split channel, and intensive riparian planting on the right bank.</td>
<td>Address the active headcut by directing the majority of flow into the left-hand split flow channel and add LWD to the left bank to promote disturbance and roughen the channel; roughen the floodplain adjacent to the hatchery levee to minimize avulsion risk. Promote retention of wood and sediment to smooth out the headcut and steepened elevation in the subarea.</td>
</tr>
<tr>
<td>C</td>
<td>97+00 to 96+00</td>
<td>Construction of three ELJs on the right bank</td>
<td>Provide hydraulic complexity and cover and reduce instream velocities along the eroding bank.</td>
</tr>
<tr>
<td>D</td>
<td>94+00 to 92+00</td>
<td>Construction of two ELJs at the heads of existing</td>
<td>Maintain the existing split flow/island configuration and promote the development of additional channel</td>
</tr>
<tr>
<td>Feature Group</td>
<td>Approx. Station</td>
<td>Action(s)</td>
<td>Expected Benefit</td>
</tr>
<tr>
<td>---------------</td>
<td>----------------</td>
<td>-----------</td>
<td>------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>islands</td>
<td>complexity through the adjacent floodplain.</td>
</tr>
<tr>
<td>E</td>
<td>90+50 to 89+50</td>
<td>Four LWD placements along the left bank</td>
<td>Create hydraulic diversity, initiate meander bend development, and promote floodplain connectivity.</td>
</tr>
<tr>
<td>F</td>
<td>90+50 to 86+50</td>
<td>Spoil pile removal; construction of one LWD assembly and multiple single-log placements</td>
<td>Promote increased floodplain connectivity and evolution of a channel network, and provide cover and complexity in the hatchery outfall channel.</td>
</tr>
</tbody>
</table>

### 4.1.1 Group A

Group A is a gravel augmentation program. Spoil piles in the floodplain located between Stations 103+00 and 101+00 and 94+00 and 92+00 will be used as the source of gravel. The left bank bridge abutment of the WDFW hatchery access road bridge will provide a viable and effective location for returning the gravel to the river. The gravel augmentation program should be carried out over a number of years until the spoil pile is depleted or the desired results are achieved. Before each winter, gravel should be dumped off the downstream side of the left bank bridge abutment near Station 107+00. A secondary gravel augmentation location is also located near Station 55+00, where gravel can be distributed from the left bank. Gravel quantity should be approximately 500 cubic yards the first year. In the following years, the volume of the gravel pile in the river should not exceed 500 cubic yards. At this rate, the smaller (upstream) spoil pile may be depleted in approximately 3 years by placing gravel at the bridge location only. The larger spoil pile downstream may be used to continue the gravel augmentation program at the bridge or it may be used for a gravel augmentation program at the second location. This pile is expected to be depleted in approximately 7 years if 500 yards of material is distributed in two locations each year.

The primary objective of the gravel augmentation program is to increase bedload sediment supply throughout the incised sections of the channel and to slow or halt the headcut that is occurring adjacent to the hatchery levee and at the site of the second gravel augmentation location near Station 55+00. The upstream end of the project area is located less than 1 mile downstream of the Hatchery Dam, which may limit the amount of sediment that would otherwise be contributed to the project area from upstream. Because of the highly modified conditions of the channel adjacent to the hatchery (e.g., restricted channel migration due to
levees, bank armoring, and low floodplain connectivity), the amount of bedload sediment recruited to the channel in the upstream project area is likely very low. Therefore, augmenting the channel with bedload at the top of the project area is critical to the intended functionality of the proposed structures downstream.

In addition to slowing the headcut, the eventual raising up of the channel bed will increase floodplain connectivity and promote the development of a network of channels throughout the floodplain. Removal of the spoil piles will dually contribute to this process, as the piles currently create an obstruction in the floodplain between the channel and the low-lying pathway on the downstream side. In the main channel, increased bedload will also provide spawning gravels and contribute to the development of multiple flow paths that will provide diverse hydraulic conditions in the channel.

4.1.2 Group B

Group B consists of the construction of two ELJs at the location of a headcut near Station 103+50, multiple Type L LWD along the left bank between approximately Stations 103+00 and 101+00, and planting in the right bank floodplain from approximately Stations 101+00 to 98+50. One bar apex (Type A) ELJ will be constructed against the right bank and a second Type A ELJ will be constructed slightly downstream at approximately the apex of the forested island.

The two ELJs constructed at the headcut will limit the proportion of water flowing down the existing thalweg and will increase the proportion of water flowing down the left side of the forested island at Station 102+00. This change in flow proportion, along with the gravel augmentation program in Subarea 1-A, will reduce the abrupt bed elevation drop at the headcut and promote a more uniform thalweg slope through this location. Construction of the LWD structures along the left bank will create hydraulic complexity to promote disturbance and channel migration towards the left bank.

The planting on the right bank floodplain will reduce the risk of an avulsion along the toe of the hatchery road/levee. At the time of field observation in October 2011, a large natural log jam was located at approximately Station 100+00. The left bank at this location was higher
than the right bank floodplain area adjacent to the hatchery levee. As the log jam continues to accumulate additional debris, the river may look to avulse through the relatively low and open right bank floodplain, following the lower-lying pathway along the toe of the hatchery road/levee. Planting of this floodplain area, especially in the low area along the base of the road/levee, is expected to reduce the likelihood of a successful avulsion along this path by roughening the floodplain surface and strengthening the floodplain sediment. In addition to intensive plantings, placement of LWD atop the floodplain surface is recommended to increase floodplain roughness and protect against avulsion while vegetation becomes established. Ideally, these actions combined with the ELJ placements and gravel augmentation upstream will eventually promote better floodplain connectivity and channel development through the flood flow path on the left bank near Station 100+00, which currently is located approximately 5 feet above the channel. The low area along the toe of the levee is currently approximately 2 feet above the channel.

In addition to the expected benefits to natural processes, construction of the two ELJs at the headcut will provide immediate biological benefits to both juvenile and adult salmonids, as discussed in Appendix A of this report. Planting of the right bank floodplain will improve the health of the riparian area and provide a long-term source of additional LWD and nutrients to the stream.

4.1.3 Group C

Group C consists of the construction of three bank configuration (Type B) ELJs along the right bank of the channel. These log jams will work to protect existing hatchery infrastructure while providing habitat benefits. The ELJs will be constructed along the existing bank and will protrude into the flow, directing the highest hydraulic forces away from the bank and providing velocity shadows in the lee of each structure where sediment may be deposited over time. The construction of these structures should eliminate the need for maintenance of the existing riprap bank at this location.

Placement of the three ELJs along the right bank will provide immediate benefits to juvenile and adult salmonids by creating instream habitat complexity as discussed in Appendix A.
Additionally, the ELJs will reduce high velocities that currently exist along the face of the existing riprap that armors the toe of the bank adjacent to the hatchery.

### 4.1.4 Group D

Group D consists of the construction of two bar apex (Type A) ELJs at the head of exiting mid-channel gravel bars. One located at Station 94+00 and the other at Station 92+50. The construction of these ELJs will further promote the development and maintenance of multiple flow paths through this area.

Construction of the two apex-style ELJs will provide immediate benefits to juvenile and adult salmonids by creating instream habitat complexity at the feature, as discussed in Appendix A. The ELJs will promote additional retention of bedload sediment and development of forested islands behind the structures. These channel responses will promote better floodplain connectivity and development of a more accessible and diverse channel network through the floodplain.

### 4.1.5 Group E

Group E consists of the installation of four bank roughness (Type L) LWD assemblies along the left bank of the main channel. The Type L LWD assemblies will be installed along an open and straight portion of the steep gravel bank between Stations 90+40 and 98+40.

Construction of the four LWD assemblies along the left bank will provide immediate benefits to juvenile and adult salmonids as discussed in Appendix A. Roughening the bank with LWD will promote disturbance along the face of the steep cutbank that will manipulate the thalweg and create hydraulic complexity in this plane bed portion of the channel. This LWD will promote disturbance and re-shaping of the steep bank that will promote migration of the bend and contribute to increased connectivity to the adjacent floodplain.

### 4.1.6 Group F

Group F consists of the removal of spoil piles in the floodplain, the construction of one bar apex (Type A) ELJ and the installation of seven single rootwad log (Type S) LWD. The spoil pile removal extends along the right bank from approximately Stations 90+20 to 87+20.
Material removed from this spoil pile may be distributed in the channel during construction near Station 87+20, where it would be easily transported downstream by the locally high stream gradient. Up to 100 cubic yards of gravel is recommended to be added to the main channel during construction and the remaining material incorporated into construction of other ELJs throughout the project. The bar apex (Type A) ELJ is located at approximately Station 87+20 and would be placed against the existing left bank.

Removal of the spoil piles will open up the available floodplain area along the right bank for future channel evolution. Placing the LWD structure on the gravel bar adjacent to the spoil piles will provide high-flow refuge upon its construction and will act as a hard point to encourage split flow and hydraulic complexity as the channel evolves in this area. Placement of the ELJ near Station 87+20 will split flow and encourage development of the channel path to the left of the ELJ placement. This will encourage the main thalweg to move away from its current position along the bedrock valley wall, where instream velocities are relatively high throughout the year. The LWD placed in the downstream portion of the hatchery outfall channel will increase the roughness and hydraulic complexity of the channel, thereby improving access to this off-channel area and providing cover for juveniles.

4.2 Subarea 2, Stations 86+50 to 60+00

Subarea 2 is located between the outlet of the hatchery outfall channel at approximately Station 86+50 to Station 60+00. The proposed restoration features within this subarea are summarized in Table 4 and shown in Figures 4a through 5b.

<table>
<thead>
<tr>
<th>Feature Group</th>
<th>Approx. Station</th>
<th>Action(s)</th>
<th>Expected Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>85+00 to 80+50</td>
<td>Construction of two LWD assemblies and two ELJs</td>
<td>Add instream complexity and promote floodplain connectivity and evolution of a channel network through the adjacent floodplain.</td>
</tr>
<tr>
<td>B</td>
<td>79+00 to 77+00</td>
<td>Construction of approximately six LWD assemblies</td>
<td>Initiate development of the meander bend and promote floodplain connectivity.</td>
</tr>
<tr>
<td>C</td>
<td>74+00 to</td>
<td>Construction of one apex-</td>
<td>Split flow to enhance flow into the existing side</td>
</tr>
</tbody>
</table>
4.2.1  **Group A**

Group A consists of the construction of one Type C ELJ, one bar apex (Type A) ELJ, and the installation of two bar roughness (Type Z) LWD assemblies. The Type C ELJ is located at approximately Station 85+00 within the right split channel between the existing island and the valley wall. The Type A ELJ is located at approximately Station 81+50 and would be constructed at the head of an existing mid-channel gravel bar. One Type Z LWD assembly would be installed on the margins of an existing right bank gravel bar at approximately Station 82+50 and the second would be installed on the margins of an existing left bank gravel bar at approximately Station 80+40.

The ELJs and the two LWD assemblies will work to increase the hydraulic complexity in this section of the channel, which is currently wide, plane-bed, and lacking sufficient pools and cover. The roughness provided by these structures will promote the development of split flow, a more sinuous and complex main channel alignment, and eventually a more complex network of different channels as the river gains better connectivity with the left floodplain. The Type A ELJ is positioned to promote the activation of an existing flow path through the floodplain between Stations 81+50 and 76+50. Activation of this feature will provide high-flow refuge through this section of the river where little refuge currently exists, particularly for juvenile salmonids.

4.2.2  **Group B**

Group B consists of the installation of four bank roughness (Type L) LWD assemblies and two bar roughness (Type Z) LWD assemblies. The four Type L LWD assemblies will be installed along the right bank between Stations 79+00 and 77+40. The two Type Z LWD assemblies will be installed on the margins of an existing left bank gravel bar at approximately Stations 78+00 and 77+00.
Construction of the LWD assemblies in the channel will provide immediate benefits to juvenile and adult salmonids as discussed in Appendix A. The LWD will increase the roughness and hydraulic variability along the bank, creating hydraulic complexity during a range of flow conditions. This LWD will promote disturbance and re-shaping of the steep bank that will promote migration of the bend and contribute to increased connectivity to the adjacent floodplain, including the existing flow paths originating near Stations 79+00 and 78+00. These flow paths are expected to be activated during frequent high-flow events, which will increase channel complexity and create refuge areas for juvenile and adult salmonids. The Z-type assemblies will accelerate the development of the existing left bank gravel bar by promoting sediment deposition and riparian vegetation regeneration. These assemblies will work in conjunction with the right bank placements to encourage evolution of the outer meander bend and increased connectivity to the right floodplain area.

### 4.2.3 Group C

Group C consists of the construction of one bar apex (Type A) ELJ against the existing left bank at approximately Station 73+80 and placement of multiple Type L LWD assemblies in the side channel between Stations 74+00 and 71+00. This ELJ will function to promote the development of an existing flow path through the left bank floodplain between approximately Stations 74+00 and 70+50. The ELJ will be oriented such that it will promote increased flow through this pathway over time, pulling the thalweg away from the bedrock valley wall and encouraging development of a channel network through the floodplain. The ELJ will provide immediate benefits to juvenile and adult salmonids by creating instream habitat complexity, as discussed in Appendix A. The LWD placed in the side channel will provide hydraulic complexity and cover in the side channel.

### 4.2.4 Group D

Group D consists of the installation of three bank roughness (Type L) LWD assemblies and three bar roughness (Type Z) LWD assemblies. The three Type L LWD assemblies will be installed along the right bank between Stations 65+20 and 64+00. The three Type Z LWD assemblies will be installed on the margins of existing gravel bars at approximately Stations 65+70, 64+30, and 62+90.
Construction of the LWD assemblies in the channel will provide immediate benefits to juvenile and adult salmonids as discussed in Appendix A. The LWD assemblies will increase the roughness and hydraulic variability along the bank, creating hydraulic complexity during a range of flow conditions. The L-type LWD will promote disturbance and re-shaping of the steep bank that will promote migration of the bend and contribute to increased connectivity to the adjacent floodplain, including the existing flow paths originating near Station 64+50. These flow paths are expected to be activated during frequent high-flow events, which will increase channel complexity and create refuge areas for juvenile and adult salmonids. The Z-type assemblies will accelerate the development of the existing left bank and right bank gravel bars by promoting sediment deposition and riparian vegetation regeneration. These assemblies will work in conjunction with the right bank placements to encourage evolution of the outer meander bends and create increased connectivity to the right floodplain area.

4.3 Subarea 3, Stations 60+00 to 30+00

Subarea 3 is located at Station 60+00 and just downstream of the pedestrian bridge adjacent to Spring Lake at Station 30+00. The proposed restoration features within this subarea are summarized in Table 5 and shown in Figures 5a through 7a.

Table 5
Summary of Proposed Restoration Actions and Expected Benefits, Subarea 3

<table>
<thead>
<tr>
<th>Feature Group</th>
<th>Approx. Station</th>
<th>Action(s)</th>
<th>Expected Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 57+00 to 55+50</td>
<td>Construction of two barb ELJs and four single logs that will be incorporated into a natural log jam; gravel augmentation program</td>
<td>Create cover and refuge in the main channel short term, retain wood and sediment to increase floodplain connectivity and reverse the incised channel condition over time. Jump start this process by augmenting with spoil piles removed from the floodplain upstream.</td>
<td></td>
</tr>
<tr>
<td>B 54+00 to 48+00</td>
<td>Construction of two barb ELJs and approximately four L-type LWD assemblies</td>
<td>Add instream complexity, promote development of more complex channel configuration, and raise the bed elevation over time.</td>
<td></td>
</tr>
<tr>
<td>C 47+00 to 41+00</td>
<td>Construction of two channel-spanning ELJs</td>
<td>Provide diverse hydraulic conditions in the short term. Retain mobile LWD and bedload to raise the bed elevation of the incised channel over time.</td>
<td></td>
</tr>
<tr>
<td>D 36+50 to</td>
<td>Construction of three</td>
<td>Provide cover and complexity in the short term.</td>
<td></td>
</tr>
<tr>
<td>34+50 crate ELJs</td>
<td>Retain mobile LWD and bedload over time to promote floodplain connectivity.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 4.3.1 Group A

Group A consists of the construction of two bank configuration (Type B) ELJs, the installation of four or more single rootwad log (Type S) LWD, and a second gravel augmentation location to distribute spoil piles removed from upstream (see Section 4.1.1). The two Type B ELJs will be constructed along the right bank at approximately Stations 57+30 and 56+70. Their location along the bank coincides with existing floodplain flow paths that have been disconnected by channel incision. The Type S LWD will be installed under an existing large fallen tree on the outside of the bend at approximately Station 55+50. Gravel may be placed in the channel at this location by using the turnout on the east side of the road as shown in the figures.

The existing headcut located near Station 57+00 will be slowed and moderated by the construction of these ELJs. The bank roughness provided by the ELJs will promote the retention of additional woody debris and sediment to raise the bed elevation and the local water surface elevation, increasing floodplain connectivity to the surrounding floodplain over time. Activation of the existing overbank flow paths on the downstream side of the ELJs will be increased in the long term to provide high-flow refuge area. However, because the bank is relatively high, this is expected to be a long-term process that will occur as the headcut is mitigated and the bed elevation is able to rise.

The woody debris placed along the outside of this bend near Station 55+50 will direct flow away from the steep eroding bank near the road and back across the gravel point bar along the right bank. The LWD will also contribute to maintaining and improving the existing large pool formed under the fallen tree. The high left bank near Station 55+00 is also an opportune location for additional gravel augmentation. Gravel from the spoil piles in Subarea 1 Group A could be added to the river at this location to the same effect described for that subarea.
4.3.2 Group B

Group B consists of the construction of two bank configuration (Type B) ELJs and four bank roughness (Type L) LWD assemblies. The two Type B ELJs will be constructed along the left bank at approximately Stations 50+90 and 49+40. The four Type L LWD assemblies will be installed along the right bank between Stations 50+50 and 48+10.

The hard points created by the ELJs along the outer bank will promote local scour and bank erosion that will add velocity refuge to this area of the channel. Placement of the LWD assemblies on the inside bend will work collectively with the ELJs to diversify the thalweg in the plane-bed channel and lead to the development of a more complex channel planform over time. The roughness provided by the ELJs will promote the retention of additional woody debris and sediment to raise the bed elevation and the local water surface elevation, increasing floodplain connectivity to the surrounding floodplain. Because the existing bank is relatively high, this is expected to be a long-term process that will occur as the proposed woody debris features function collectively to raise the channel bed throughout the project area over time.

4.3.3 Group C

Group C consists of the construction of two channel-spanning (Type C) ELJs. The Type C ELJs are located at approximately Stations 47+10 and 41+00. The location of the channel-spanning log jams was selected to provide the most potential for raising the channel grade through this incised area while minimizing the required width of the ELJs. Both of the log jams extend from the left bank to the bedrock valley wall to prevent the main channel from flanking the structures on the right side. The structures will also be built snugly against the left bank to help prevent immediate flanking of the structure on that side. The largest key pieces may be obtained from the adjacent floodplain, where several very large pine trees are present.

The primary objective of the channel-spanning structures is to retain mobile wood and sediment and raise the channel grade through the highly incised area of the channel while maintaining fish passage under and over the structures. The channel-spanning structures will initiate deep pools and a high amount of instream complexity within the plane-bed
The ELJs will create diverse hydraulic conditions throughout the channel cross-section and upstream and downstream of the structures.

### 4.3.4 Group D

Group D consists of the construction of three channel grade (Type M) ELJs. The three structures will be located at approximately Stations 36+50, 35+50, and 34+50. Taking advantage of the local coarse bed material at the toe of the Cummings Creek fan, the Type M ELJs will be constructed on the existing channel grade to minimize construction costs and in-water disturbance.

The ELJs will create immediate biologic benefits as described in Appendix A. The primary purpose of the three structures will be to promote retention of mobile debris and sediment to add additional roughness and raise the channel grade. Over time, these effects will work to reverse the incised condition of the channel, increasing floodplain connectivity and channel migration to eventually lead to more complex habitat over time.

### 4.3.5 Bridge Removal

Removal of the pedestrian bridge at Station 31+00 is proposed as part of this project (the bridge is located across the former Tucannon Road crossing). This process will involve demolition and removal of two concrete abutments, four cast-in-place piers, and the bridge deck and railings. The bridge opening currently represents a significant channel constriction that likely causes a backwater effect and accelerated velocities during flood flows that may affect fish passage, particularly juveniles. In addition to creating better instream conditions, removal of this constriction will allow the presently straight channel to evolve to a more natural configuration over time.

### 4.4 Subarea 4, Stations 30+00 to 0+00

Subarea 4 is from the pedestrian bridge near Station 30+00 to the downstream end of the project subarea at Station 0+00. The proposed restoration features within this subarea are summarized in Table 6 and shown in Figures 7a through 8b.
### Table 6
Summary of Proposed Restoration Actions and Expected Benefits, Subarea 4

<table>
<thead>
<tr>
<th>Feature Group</th>
<th>Approx. Station</th>
<th>Action(s)</th>
<th>Expected Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>35+30 to 10+20</td>
<td>Construction of multiple LWD assemblies</td>
<td>Diversify hydraulics and add cover in the plane-bed channel; promote floodplain connectivity and side channel development over time.</td>
</tr>
<tr>
<td>B</td>
<td>8+50 to 1+50</td>
<td>Construction of multiple LWD assemblies in the main channels and in the active side channel</td>
<td>Increase hydraulic complexity in the main channel; maintain the existing side channel outlet and provide additional cover, complexity, and high-flow refuge in the side channel.</td>
</tr>
<tr>
<td>C</td>
<td>1+00</td>
<td>Construction of one channel-spanning ELJ</td>
<td>Provide diverse hydraulic conditions in the short term. Retain mobile LWD and bedload to raise the bed elevation of the incised channel over time and prevent mobile wood from being distributed in privately owned portions of the river downstream.</td>
</tr>
</tbody>
</table>

#### 4.4.1 Group A

Group A consists of the installation of six bank roughness (Type L) LWD assemblies and two bar roughness (Type Z) LWD assemblies. The Type L LWD assemblies will be placed along both banks between Stations 13+30 and 11+20. The two Type Z LWD assemblies will be placed at approximately Station 14+50 on the outside of the meander along the bedrock valley wall and at Station 10+20 on the margin of an existing gravel bar along the right bank.

This area of the main channel presently is lacking hydraulic complexity and LWD. Although the thalweg is deep along the left bank near Station 12+00, the channel lacks cover and hydraulic refuge for juvenile salmonids. The LWD assemblies through this portion of the channel will manipulate the thalweg to create hydraulic complexity and cover that will provide more diverse conditions to support both adult and juvenile fish (Appendix A).

Placement of the LWD assemblies along the inside (right) bank will create disturbance along this bank and promote local bank erosion, leading to increased floodplain connectivity and development of flow paths through the gravel bar. The overall channel roughness provided by the group of LWD assemblies through the channel will promote additional retention of wood and sediment, raising the local water surface elevation and leading to increased floodplain connectivity over time.
### 4.4.2 Group B

Group B consists of the installation of five bank roughness (Type L) LWD assemblies and four bar roughness (Type Z) LWD assemblies in the main channel. The Type L LWD assemblies will be placed along both banks between Stations 7+50 and 4+50. The Type Z LWD assemblies will be placed at approximately Station 8+50 on the margins of an existing left gravel bar and between Stations 4+20 and 1+50 along the margins of an existing right bank gravel bar. Several Type L assemblies will also be placed in the active side channel between approximately Stations 8+50 and 4+00.

This area of the main channel presently is lacking hydraulic complexity and LWD. There is little cover for juveniles other than the wood and overhanging vegetation in the side channel near Station 5+00. The LWD assemblies through this portion of the channel will manipulate the thalweg in the main channel to create hydraulic complexity and cover that will provide more diverse conditions to support both adult and juvenile fish, as discussed in Appendix A. Placement of the Z-type LWD assembly near Station 4+00 will also act to maintain the outlet of the existing side channel that is currently the only side channel habitat in this portion of the river. The channel roughness provided by the group of LWD assemblies through the channel will promote additional retention of wood and sediment, raising the local water surface elevation and leading to increased floodplain connectivity over time. Placement of the LWD assemblies in the side channel will enhance the existing habitat by providing additional cover and complexity and increasing the quality of high-flow refuge habitat in this portion of the river.

### 4.4.3 Group C

Group C consists of the construction of one channel-spanning (Type C) ELJ. The Type C ELJ is located at approximately Station 1+00. The location of the ELJ was selected to retain mobile wood that may be carried down the channel from upstream at the downstream end of the property owned by WDFW. This feature will minimize risk to the privately owned lands downstream, as well as provide instream complexity and contribute to raising the channel grade through this locally incised area over time. The log jam extends from the high right bank to the bedrock valley wall to prevent the main channel from flanking the structure on the right side. The structure will also be built snugly against the left bank to
help prevent immediate flanking of the structure on that side. The large key pieces in the structures may be obtained from mature trees in the floodplain if practicable.

Fish passage will be maintained under and over the structures. The channel-spanning structures will initiate deep pools and a high amount of instream complexity within the plane-bed channel during low to high flows. The ELJs will create diverse hydraulic conditions throughout the channel cross-section, and upstream and downstream of the structures.
5 CONSTRUCTION ACTIONS

5.1 Mobilization and Project Area Preparation

Mobilization and project area preparation includes transporting equipment to the area, clearing for construction access and staging, and installing silt fencing and other project-specific best management practices. Any trees and brush cleared for access and staging will be side cast and used during decommissioning of the project area or integrated into other project components. Construction fencing will be placed along the perimeter of the staging areas and access roads to protect adjacent areas from disturbance.

5.1.1 Temporary Access

Temporary access roads may be constructed to access the project area from both sides of the river. Proposed access routes and staging areas are displayed in Figures 3a through 8b. In addition, temporary channel crossings may be installed to access bar/island components of the project. This may require some clearing of immature deciduous trees and shrubs. Any trees and brush cleared during this process will be stockpiled in the project area and used to decommission the access routes or integrated into other project components. Unvegetated gravel bars that are exposed during the construction window will be used as access routes between project area locations to minimize riparian impacts. For this reason, these areas may also be used as staging areas.

5.1.2 Weed Control/Prevention

To minimize the establishment and colonization of weeds and invasive plant species in the project area, several preventative measures can be implemented:

Pre-construction

- A survey for invasive/weed species should be conducted in the entire project area and upstream of all contributing waters prior to construction, planting, or soil-disturbing activities
- Invasive/weed species that are found should be documented on a map or noted by global positioning system (GPS) coordinates for annual inspection
During Construction

- The root systems of woody invasive/weed species should be removed if in the footprint of the designed soil-disturbance area
- Disturbed soils should be stabilized and covered with a seed-free mulch or anti-erosion material once final grade is established
- Established corridors of travel by construction and support vehicles should be minimized to prevent disturbance of soil and carrying invasive species/weeds into the project area
- All staged or delivered materials (rock, soil, mulch, plants, and LWD) should be inspected upon arrival to minimize the introduction of invasive seed sources and plant material

Post-construction

- All disturbed soils, including soil at planting areas should be protected with seed-free mulch or compost to suppress invasive/weed species and to retain moisture
- Revisit pre-construction invasive/weed species survey areas to look for regeneration and suppression (document findings)
- If plantings require irrigation, use a localized drip system instead of a broadcast system to minimize benefit to invasive/weed seed sources
- Establish an annual or biannual monitoring plan to identify and address the problem of invasive/weed species

5.2 General Earthwork

Earthwork involves excavation, hauling, and backfilling of native materials. Earthwork associated with a majority of the LWD and ELJ placements will likely be in coarse
gravel/cobble material with a variable sand and organic fraction. Earthwork associated with spoil pile removal and gravel augmentation will likely be in gravel/cobble material with an unknown quantity of small- to medium-sized boulders. Boulders excavated from spoil piles should not be used for gravel augmentation and will be stockpiled for reuse in other components of this project or other projects in the basin.

Generally, a majority of the excavation may be efficiently accomplished using a tracked excavator with an appropriately sized bucket. A bucket with a clamp would be advantageous for working with larger sized material, including boulders. Large areas of spoil pile excavation may be efficiently accomplished using a front-end loader (if the material is loose and unconsolidated). Material hauling within the project area may be accomplished with a dump truck (standard or articulating depending on the condition of the haul route) or a front-end loader. Generally, a majority of backfill could be efficiently accomplished using a tracked excavator.

5.3 **Large Woody Debris**

This activity involves placing LWD of various types throughout the project area. Once the placement locations have been surveyed and, if required, field adjusted by the engineer, placement would begin at the location farthest from the staging area and progressively work toward the staging area. Installation of LWD could be accomplished by using an excavator with a bucket equipped with a clamp (or a grapple) for log placement and a skidder (or similar machine) to ferry materials to the placement site. Before construction begins, all necessary material would be staged in an area on the floodplain or gravel bar adjacent to each LWD location so that the materials are within reach of the excavator once it is in a position to build the LWD. Some LWD types will require excavation for installation. If excavation extends below the water table, turbid water will be generated. Any dewatering required for installation of the LWD will be carried out in accordance with the best management practices for water control (Section 5.8.2). Some LWD may require the installation of mechanical soil anchors. Mechanical soil anchors may be driven into the ground using a hand-operated or machine-mounted jackhammer. Load locking and testing of the mechanical soil anchors will require the use of a calibrated strain gauge capable of measuring force at least 1.5 times the specified anchor capacity. Each LWD placement will be
completed before the start of construction of another unless enough equipment is present to work concurrently.

### 5.4 Engineered Log Jams

This activity involves construction of various types of ELJs throughout the project area. Final locations for the ELJs will be determined by the engineer in the field following the objectives described previously in this document. All necessary material will be staged in an area on the floodplain or gravel bar adjacent to each ELJ location before construction of each structure such that the materials are in reach of the excavator once it is in a position to build the ELJ. ELJs will be founded at the specified elevation to minimize undermining from scour after completion. Construction will involve excavation of the footprint of the structure and subsequently backfilling the structure with the material excavated for the footprint. All materials excavated for the placement of the ELJ will be used for backfill. No off-site disposal or redistribution of excavated materials is expected. Once the initial logs are placed at the necessary elevation, the structure can be constructed rapidly. Each ELJ will be completed before construction begins for another ELJ, unless enough equipment is present to work concurrently. Construction of ELJs could be accomplished by using an excavator with a bucket equipped with a clamp (or a grapple) for the log placement and a skidder (or similar machine) to ferry materials to the placement site. Because the ELJs will be constructed below the water table, turbid water will be generated. Any dewatering required for installation of the ELJs will be carried out in accordance with the best management practices for water control (Section 5.8.2). The contractor shall be responsible for dewatering the excavations and pumping water to a location suitable for natural infiltration and approved by the engineer and in compliance with any permits and regulations.

### 5.5 Riparian Vegetation Enhancement

Riparian vegetation enhancement will involve planting in the floodplain. The delineated area will only require minimal selective undesirable vegetation removal and native riparian vegetation plantings to re-establish a diverse native plant community. Wire fencing should be used to protect the plantings from deer and beaver. Riparian seeding may also be conducted in areas disturbed by construction. The areas disturbed by construction include construction access routes, spoil pile removals, LWD assemblies, and ELJ structures.
The planting areas should be monitored and maintained for at least 3 years following restoration. Maintenance includes maintaining fencing and irrigation and removing invasive species. Monitoring and maintenance of plantings will greatly contribute to the success of the restoration effort and may be required for permitting approval. Eradication of invasive species, such as reed canarygrass, will likely require a longer and more involved maintenance and monitoring effort.

5.5.1 Irrigation and Watering

To minimize stressors, decrease mortality, minimize irrigation, and prevent competition from invasive/weed species, all planting and live staking should be conducted between October 15 and March 15. Newly planted tree and shrub species in exposed and more xeric areas should be watered in the mid- to late-spring once the native soils begin to dry out, and watering should continue every week or every other week based on daily temperatures and precipitation monitoring. Ideally, a watering plan should extend through the first three growing seasons post-planting. Broadcast irrigation should be avoided to minimize colonization and competition from invasive/weed species. If on-site water resources (well, stream, or river) are available, a series of semi-permanent irrigation lines/hoses could be established and connected to a portable pump during irrigation visits. Each planting should receive targeted watering until the surrounding soil is saturated. During irrigation visits, the plantings should be monitored for mortality, stress, invasive/weed species, and mulch around the planting should be replaced, if missing, to help with moisture retention. If mortality and evidence of stress (yellow leaves, wilting, or leaf loss) becomes evident, then irrigation frequency should be increased and the stressed plants should be documented and monitored. Live staking areas should be monitored for mortality and stress but should not require irrigation if placed within saturated soils. If live staking areas are implemented in more xeric areas, then these areas should be irrigated on the same schedule. Irrigation water should not contain additives such as fertilizer, but can contain natural sediments from adjacent water sources. The use of reclaimed water should be assessed prior to use to minimize nutrient sinks and, if used, should be avoided in the spring and fall to minimize mixing with adjacent water sources during flood or storm events.
5.6 Bridge Removal

This activity involves the removal of an abandoned road bridge and its abutments. Removal will require the demolition of reinforced concrete and bituminous road surface. All debris generated during bridge removal should be hauled off site.

5.7 Project Area Decommissioning

The contractor will break down any equipment and clean any remaining areas that need decommissioning. Water and sediment control structures will be left in place until all construction activities within the river have been completed and any temporary surface erosion control measures are in place. Once construction is complete, these components will be broken down and removed by hand, and the rest of the project area will be decommissioned before leaving the project area. Any temporary access routes and staging areas will be regraded to blend into the adjacent topography and revegetated with a native seed mix to minimize erosion of materials disturbed during construction.

5.8 Best Management Practices

5.8.1 Surface Erosion Control

Surface erosion control during construction is an important turbidity control measure for the project. Removal of vegetation may temporarily leave areas exposed and vulnerable to erosion before re-establishment of vegetation. Silt fencing around the perimeter of areas where vegetation is removed is recommended to capture sediment and delineate the construction disturbance limits. During project area decommissioning, straw mulch should be placed to minimize erosion of materials as vegetation is established. Silt fencing should be removed by hand once temporary surface erosion control measures are in place or vegetation is established in the disturbed areas.

5.8.2 Water Control

Water control during construction is the most critical turbidity control measure for the project. Installation of many project components will require excavation below the water table, and turbid water will be generated. The following section provides a brief description of the recommended water control procedures for project features requiring significant water
control. However, the contractor will be responsible for developing the final water control plan. Additionally, the contractor will be responsible for dewatering the excavations as required for constructability and pumping water to a location suitable for natural infiltration as approved by the engineer. The contractor will provide sufficient equipment to accommodate changes to the water control plan required by project area conditions during construction as directed by the engineer.

5.8.2.1 Large Woody Debris and Engineered Log Jam Construction

Many of the LWD assemblies and ELJs will be placed in the active channel (or in areas with a surface water connection to the active channel during construction). For these locations, any required excavation will be conducted within temporary gravel berms, silt curtains, or other temporary flow separation method to minimize the dispersion of turbid water into the active channel. For structures in or near the main channel, water entering the excavation will be of a significant volume. We recommend pumps (of sufficient size and quantity) to partially dewater the excavation. Water would be pumped from the excavation area into an infiltration area. The infiltration area should be located on the floodplain to minimize the potential for overland flow back into the river and to prevent damage to sensitive habitat (wetlands and alcoves). Infiltration rates into the floodplain will be significant and we expect that only a minimum amount of turbid water pumped onto the floodplain will not be infiltrated. If the infiltration capacity is exceeded, overland flow will be routed over existing vegetation to encourage suspended sediment deposition before flowing back to the river.

For LWD assemblies and ELJs placed in the active channel that do not require a significant quantity of excavation, turbidity control is not expected to be a significant issue. For structures not requiring excavation dewatering of the feature, location is also not anticipated to be required.

5.8.3 Refueling Practices and Spill Prevention and Countermeasures

The following best management practices will be implemented for spill prevention during refueling:

- Each piece of machinery will be checked daily for leaks and any repairs will be done before work in or near water
• All vehicle staging, cleaning, maintenance, refueling, and fuel storage will take place above the ordinary high water line in an approved staging area that is 150 feet or more from any waterbody in accordance with local, state, and federal regulations and permit conditions
• A driver/operator must be present and maintain constant observation/monitoring of the fuel transfer at all times
• A driver/operator must be trained in spill prevention, cleanup measures, and emergency procedures
• All employees must be made aware of the significant liability associated with fuel spills
• Spill containment and countermeasures must be maintained at all locations where refueling occurs; materials include non-water absorbents capable of absorbing 15 gallons of diesel fuel and drip pans
• All machinery and equipment working in or near waterbodies will maintain non-water absorbents capable of absorbing 15 gallons of diesel fuel and drip pans
• If a power generator is used during construction, the generator should be placed out of the river channel within a spill containment unit
6 LIMITATIONS

We have prepared this report for use by CCD for use in securing permits for the project. Further development of the conceptual designs described in this document will require additional evaluation and design. The figures included in this report were not developed for use in construction or contract bidding. Conditions within the project reach may change both spatially and with time, and additional scientific data may become available. Significant changes in reach conditions or the available information may require re-evaluation. Within the limitations of scope, schedule, and budget, our services have been executed in accordance with generally accepted scientific and engineering practices in this area at the time this report was prepared.
7 REFERENCES


NOTES:
1. Horizontal Datum: WA State Plane South Zone, NAD 83, Feet.
2. Public lands data provided by WA State Dept. of Natural Resources.
BASE DATA NOTES:
1. Aerial photo collected in 2010 provided by CCD.
2. Relative elevation created by Anchor QEA, LLC from 2010 LiDAR.
3. Roads from WA DNR.
4. Tributary alignments digitized from the 2010 aerial photo by Anchor QEA, LLC.
5. Locations of other mapped existing features are approximate.
Figure 3a
Project Features, 108+00 to 91+00
30 Percent Design Report - Project Area 14 - Tucannon River
Columbia Conservation District

Base Data Notes:
1. Aerial photo and LiDAR collected in 2010 provided by CCD.
2. Roads, from WA DNRL.
3. Tributary alignments digitized from the 2010 aerial photo.
4. Locations of features shown are approximate.
5. Project stationing in feet from river mile 37.15.
6. Contour interval is one foot. Contours extracted from 2010 LiDAR.

LEGEND

Project Station
Tributary
Outfall
Groundwater

Proposed Features

Type L LWD
Type S LWD
Type Z LWD

Type A ELJ
Type B ELJ
Type C ELJ
Type M ELJ

Flow Path Promotion

- Side Channel
- Bankfull
- Flood/Short Term
- Flood/Long Term

Planting
Spoil Pile Removal
Staging Area
Gravel Haul Route
Access Route

Figure 3a
Figure 3b

Project Features, 108+00 to 91+00
30 Percent Design Report - Project Area 14 - Tucannon River
Columbia Conservation District

**Base Data Notes:**
1. Aerial photo and LiDAR collected in 2010 provided by CCD.
2. Roads from WA DNR.
3. Tributary alignments digitized from the 2010 aerial photo.
4. Locations of features shown are approximate.
5. Project stationing in feet from river mile 37.15.
6. Contour interval is one foot. Contours extracted from 2010 LiDAR.

**LEGEND**
- Project Station
- Tributary
- Outfall
- Groundwater

**Proposed Features**
- Type A ELJ
- Type B ELJ
- Type C ELJ
- Type M ELJ
- Type L LWD
- Type S LWD
- Type Z LWD
- Planting
- Spoil Pile Removal
- Staging Area
- Gravel Haul Route
- Access Route

**Flow Path Promotion**
- Side Channel
- Bankfull
- Flood/Short Term
- Flood/Long Term

**Tributary Augmentation Location**
- Hatchery Outfall
- Tucannon Road
- Existing Headcut

**Gravel Augmentation Location**

**Relative Elevation (ft)**
- High: 11
- Low: -1
Base Data Notes:
1. Aerial photo and LiDAR collected in 2010 provided by CCD.
2. Roads from WA DNR.
3. Tributary alignments digitized from the 2010 aerial photo.
4. Locations of features shown are approximate.
5. Project stationing in feet from river mile 37.15.
6. Contour interval is one foot. Contours extracted from 2010 LiDAR.

Figure 4a
Project Features, 91+00 to 73+00
30 Percent Design Report - Project Area 14 - Tucannon River
Columbia Conservation District
BLUE LAKE HATCHERY OUTFALL

Spoil pile material distribution during construction

LEGEND
- Project Station
- Tributary
- Outfall
- Groundwater

Proposed Features
- Type L LWD
- Type B LWD
- Type S LWD
- Type Z LWD

Flow Path Promotion
- Planting
- Spoil Pile Removal
- Staging Area
- Gravel Haul Route
- Access Route

Base Data Notes:
1. Aerial photo and LiDAR collected in 2010 provided by CCD.
2. Roads from WA DNR.
3. Tributary alignments digitized from the 2010 aerial photo.
4. Locations of features shown are approximate.
5. Project stationing in feet from river mile 37.15.
6. Contour interval is one foot. Contours extracted from 2010 LiDAR.

Relative Elevation (ft)
- High : 11
- Low : -1

Figure 4b
Project Features, 91+00 to 73+00
30 Percent Design Report - Project Area 14 - Tucannon River
Columbia Conservation District

R:\Jobs\100687-01.02_TucannonRiver_Phase2\Maps\Project_Area_Maps\PA_14_DDP.mxd  lhudson  12/14/2011  1:08:21 PM
Figure 5a

Project Features, 74+00 to 53+00

30 Percent Design Report - Project Area 14 - Tucannon River
Columbia Conservation District

Base Data Notes:
1. Aerial photo and LiDAR collected in 2010 provided by CCD.
2. Roads from WA DNR.
3. Tributary alignments digitized from the 2010 aerial photo.
4. Locations of features shown are approximate.
5. Project stationing in feet from river mile 37.15.
6. Contour interval is one foot. Contours extracted from 2010 LiDAR.
Legends:

- Project Station
- Tributary
- Outfall
- Groundwater

Proposed Features:
- Type L LWD
- Type B ELJ
- Type S LWD
- Type C ELJ
- Type M LWD
- Type A ELJ

Flow Path Promotion:
- Planting
- Spoil Pile Removal
- Staging Area
- Gravel Haul Route
- Access Route

Base Data Notes:
1. Aerial photo and LiDAR collected in 2010 provided by CCD.
2. Roads from WA DNR.
3. Tributary alignments digitized from the 2010 aerial photo.
4. Locations of features shown are approximate.
5. Project stationing in feet from river mile 37.15.
6. Contour interval is one foot. Contours extracted from 2010 LiDAR.
Base Data Notes:
1. Aerial photo and LiDAR collected in 2010 provided by CCD.
2. Roads from WA DNR.
3. Tributary alignments digitized from the 2010 aerial photo.
4. Locations of features shown are approximate.
5. Project stationing in feet from river mile 37.15.
6. Contour interval is one foot. Contours extracted from 2010 LiDAR.

Figure 6a
Project Features, 53+00 to 36+00
30 Percent Design Report - Project Area 14 - Tucannon River
Columbia Conservation District
LEGEND

+ Project Station

Tributary

Outfall

Groundwater

Proposed Features

Type L LWD

Type B ELJ

Type S LWD

Type C ELJ

Type M ELJ

Planting

Spoil Pile Removal

Staging Area

Gravel Haul Route

Access Route

Flow Path Promotion

Side Channel

Bankfull

Flood/Short Term

Flood/Long Term

Relative Elevation (ft)

High : 11

Low : -1

Base Data Notes:

1. Aerial photo and LiDAR collected in 2010 provided by CCD.
2. Roads from WA DNR.
3. Tributary alignments digitized from the 2010 aerial photo.
4. Locations of features shown are approximate.
5. Project stationing in feet from river mile 37.15.
6. Contour interval is one foot. Contours extracted from 2010 LiDAR.

Figure 6b

Project Features, 53+00 to 36+00

30 Percent Design Report - Project Area 14 - Tucannon River
Columbia Conservation District
Figure 7a
Project Features, 37+00 to 20+00
30 Percent Design Report - Project Area 14 - Tucannon River
Columbia Conservation District

Base Data Notes:
1. Aerial photo and LiDAR collected in 2010 provided by CCD.
2. Roads from WA DNR.
3. Tributary alignments digitized from the 2010 aerial photo.
4. Locations of features shown are approximate.
5. Project stationing in feet from river mile 37.15.
6. Contour interval is one foot. Contours extracted from 2010 LiDAR.
Spring Lake
Cummings Creek
Spring Lake Outfall
Tucannon Road
Abandoned Tucannon Road
Remove bridge and abutments

LEGEND

Project Station
Tributary
Outfall
Groundwater

Proposed Features

Type L LWD
Type S LWD
Type Z LWD
Type A ELJ
Type B ELJ
Type C ELJ
Type M ELJ

Planting
Spoil Pile Removal
Side Channel
Staging Area
Gravel Haul Route
Access Route

Flow Path Promotion

Side Channel
Bankfull
Flood/Short Term
Flood/Long Term

Base Data Notes:
1. Aerial photo and LiDAR collected in 2010 provided by CCD.
2. Roads from WA DNR.
3. Tributary alignments digitized from the 2010 aerial photo.
4. Locations of features shown are approximate.
5. Project stationing in feet from river mile 37.15.
6. Contour interval is one foot. Contours extracted from 2010 LiDAR.
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1. Aerial photo and LiDAR collected in 2010 provided by CCD.
2. Roads from WA DNR.
3. Tributary alignments digitized from the 2010 aerial photo.
4. Locations of features shown are approximate.
5. Project stationing in feet from river mile 37.15.
6. Contour interval is one foot. Contours extracted from 2010 LiDAR.

Figure 8b
Project Features, 19+00 to 0+00
30 Percent Design Report - Project Area 14 - Tucannon River
Columbia Conservation District
HABITAT GOALS AND OBJECTIVES:

1. VOID SPACES IN LWD TO PROVIDE HYDRAULIC REFUGE, COVER AND STRUCTURE FOR JUVENILE SLAMONIDS AND OTHER FISH SPECIES.

2. SORTED SEDIMENT DEPOSITS IN LEE OF LWD TO PROVIDE CHANNEL SUBSTRATE FOR SELECTIVE SPAWNING BY SALMON AND OTHER FISH SPECIES.

CONSTRUCTION NOTES:

1. ANCHORING TECHNIQUE MAY VARY ACCORDING TO SITE CONDITIONS. BURIED LOG ANCHORS MAY BE USED IN PLACE OF MECHANICAL SOIL ANCHORS. ASSEMBLY CAN BE SECURED TOGETHER USING A LIMITED AMOUNT OF SYNTHETIC FIBER OR STEEL WIRE ROPE STRATEGICALLY DESIGNED INTO THE STRUCTURE TO LIMIT VISIBILITY.

2. SCOUR POOL EXTENTS ARE TYPICAL AND MAY BE EXCAVATED AS PART OF CONSTRUCTION.

3. ROOTWAD TOP ELEVATION IS RELATED TO THE ANTICIPATED TYPICAL ORDINARY HIGH WATER LEVEL.

MATERIAL SPECIFICATIONS

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>SIZE</th>
<th>CONSTRUCTION / MATERIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>MECH. SOIL ANCHORS</td>
<td>MR-3</td>
<td>FOR LIFTING / FOR LIFTING PRODUCTS MATCH MR-3 OR EQUAL</td>
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<tr>
<td>EYE BOLTS</td>
<td>5/8” - 11 UNS THREAD</td>
<td>FOR LIFTING / GALVANIZED STEEL</td>
</tr>
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<td>ROPE THIMBLES</td>
<td>1/8 IN. CAP</td>
<td>OPEN CONSTRUCTION / GALVANIZED</td>
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<tr>
<td>UHMWPE ROPE</td>
<td>3/8 IN. DIA</td>
<td>12-STRAND SINGLE BRAID / DYNEEMA Π SK-57 OR EQUAL</td>
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<tr>
<td>WIRE ROPE</td>
<td>3/8 IN. DIA</td>
<td>7X19 STANDARD CORE / GALVANIZED</td>
</tr>
<tr>
<td>WIRE ROPE CLIPS</td>
<td>3/8 IN. CAP</td>
<td>GALVANIZED STEEL</td>
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LOG SPECIFICATIONS

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<tr>
<th>DESCRIPTION</th>
<th>DBH (IN.)</th>
<th>MIN. LENGTH (FT.)</th>
<th>ROOTWAD (3x DBH)</th>
<th>SPECIES</th>
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<tr>
<td>ROOTWAD LOG</td>
<td>24</td>
<td>25</td>
<td>72</td>
<td>PONDEROSA PINE / DOUGLAS FIR</td>
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NOTES:

1. VOID SPACES IN LWD TO PROVIDE HYDRAULIC REFUGE, COVER AND STRUCTURE FOR JUVENILE SLAMONIDS AND OTHER FISH SPECIES.

2. SORTED SEDIMENT DEPOSITS IN LEE OF LWD TO PROVIDE CHANNEL SUBSTRATE FOR SELECTIVE SPAWNING BY SALMON AND OTHER FISH SPECIES.

CONSTRUCTION NOTES:

1. ANCHORING TECHNIQUE MAY VARY ACCORDING TO SITE CONDITIONS. BURIED LOG ANCHORS MAY BE USED IN PLACE OF MECHANICAL SOIL ANCHORS. ASSEMBLY CAN BE SECURED TOGETHER USING A LIMITED AMOUNT OF SYNTHETIC FIBER OR STEEL WIRE ROPE STRATEGICALLY DESIGNED INTO THE STRUCTURE TO LIMIT VISIBILITY.

2. SCOUR POOL EXTENTS ARE TYPICAL AND MAY BE EXCAVATED AS PART OF CONSTRUCTION.

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<td>FOR LIFTING / GALVANIZED STEEL</td>
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<td>ROPE THIMBLES</td>
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<td>12-STRAND SINGLE BRAID / DYNEEMA Π SK-57 OR EQUAL</td>
</tr>
<tr>
<td>WIRE ROPE</td>
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<th>SPECIES</th>
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<tr>
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<td>24</td>
<td>25</td>
<td>72</td>
<td>PONDEROSA PINE / DOUGLAS FIR</td>
</tr>
</tbody>
</table>
HABITAT GOALS AND OBJECTIVES:
1. VOID SPACES IN LWD TO PROVIDE HYDRAULIC REFUGE, COVER AND STRUCTURE FOR JUVENILE SLAMONIDS AND OTHER FISH SPECIES.
2. SORTED SEDIMENT DEPOSITS IN LEE OF LWD TO PROVIDE CHANNEL SUBSTRATE FOR SELECTIVE SPAWNING BY SALMON AND OTHER FISH SPECIES.

CONSTRUCTION NOTES:
1. ANCHORING TECHNIQUE MAY VARY ACCORDING TO SITE CONDITIONS. PERPENDICULAR LWD MAY BE PLACED BETWEEN EXISTING TREES OR BURIED INTO THE BANK. ASSEMBLY CAN BE SECURED TOGETHER USING A LIMITED AMOUNT OF SYNTHETIC FIBER OR STEEL WIRE ROPE STRATEGICALLY DESIGNED INTO THE STRUCTURE TO LIMIT VISIBILITY.
2. SCOUR POOL EXTENTS ARE TYPICAL AND MAY BE EXCAVATED AS PART OF CONSTRUCTION.
3. ROOTWAD TOP ELEVATION IS RELATED TO THE ANTICIPATED TYPICAL ORDINARY HIGH WATER LEVEL.

LOG SPECIFICATIONS
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<td>SK-57 OR EQUAL</td>
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MATERIAL SPECIFICATIONS
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<tr>
<td>WIRE ROPE</td>
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<td>7/16 STANDARD LWC / GALVANIZED</td>
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</tbody>
</table>

NOTES:
FOR CONCEPTUAL PURPOSES ONLY, NOT FOR CONSTRUCTION.
HYDRAULIC FLOW FEATURES ARE CONCEPTUAL.
HABITAT GOALS AND OBJECTIVES:
1. VOID SPACES IN LWD TO PROVIDE HYDRAULIC REFUGE, COVER AND STRUCTURE FOR JUVENILE SLAMONIDS AND OTHER FISH SPECIES.
2. SORTED SEDIMENT DEPOSITS IN LEE OF LWD TO PROVIDE CHANNEL SUBSTRATE FOR SELECTIVE SPAWNING BY SALMON AND OTHER FISH SPECIES.

CONSTRUCTION NOTES:
1. ANCHORING TECHNIQUE MAY VARY ACCORDING TO SITE CONDITIONS. PERPENDICULAR LWD MAY BE PLACED BETWEEN EXISTING TREES OR BURIED INTO THE BANK. ASSEMBLY CAN BE SECURED TOGETHER USING A LIMITED AMOUNT OF SYNTHETIC FIBER OR STEEL WIRE ROPE STRATEGICALLY DESIGNED INTO THE STRUCTURE TO LIMIT VISIBILITY.
2. SCOUR POOL EXTENTS ARE TYPICAL AND MAY BE EXCAVATED AS PART OF CONSTRUCTION.
3. ROOTWAD TOP ELEVATION IS RELATED TO THE ANTICIPATED TYPICAL ORDINARY HIGH WATER LEVEL.

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<td>SPECIES</td>
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</tr>
<tr>
<td>PONDEROSA PINE/DOUGLAS FIR</td>
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<td>72</td>
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MATERIAL SPECIFICATIONS

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<th>CONSTRUCTION / MATERIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>UHMWPE ROPE</td>
<td>3/8 IN. DIA.</td>
<td>12-STRAND SINGLE BRAID / DYNEEMA OR SK-57 OR EQUAL</td>
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<tr>
<td>WIRE ROPE</td>
<td>3/8 IN. DIA.</td>
<td>7x7 STANDARD STRAIN / GALVANIZED (MEETS FED SPEC RR-W-410)</td>
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<td>WIRE ROPE CAPS</td>
<td>3/8 IN. CAP.</td>
<td>FORGED / GALVANIZED STEEL</td>
</tr>
</tbody>
</table>

NOTES:
FOR CONCEPTUAL PURPOSES ONLY, NOT FOR CONSTRUCTION.
HYDRAULIC FLOW FEATURES ARE CONCEPTUAL.
Habitat Goals and Objectives:

1. Flow stagnation areas upstream and downstream of the structure to provide hydraulic refuge for juvenile salmonids and other fish species.
2. Void spaces in LWD to provide hydraulic refuge, cover and structure for juvenile salmonids and other fish species.
3. Sediment deposits in lee of LWD to provide media for vegetation growth further promoting bar development and a diverse riparian zone.

Construction Notes:

1. Anchoring technique may vary according to site conditions. Mechanical soil anchors or boulders may be used in place of rootwad piles.
2. Assembly can be secured together using a limited amount of synthetic fiber or steel wire rope strategically designed into the structure to limit visibility.
3. Rootwad top elevation is related to the anticipated typical ordinary high water surface elevation.

Log Specifications

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<th>DESCRIPTION</th>
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<th>LENGTH (FT.)</th>
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<td>Rootwad Log</td>
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<td>10</td>
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<td>Ponderosa Pine/Douglas Fir</td>
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<tr>
<td>Rootwad Log</td>
<td>24</td>
<td>25</td>
<td>72</td>
<td>Ponderosa Pine/Douglas Fir</td>
</tr>
<tr>
<td>Buried Log Pile</td>
<td>16</td>
<td>10</td>
<td>94</td>
<td>Ponderosa Pine/Douglas Fir</td>
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Material Specifications

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<th>DESCRIPTION</th>
<th>SIZE</th>
<th>CONSTRUCTION / MATERIAL</th>
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</thead>
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<tr>
<td>UHMWPE Rope</td>
<td>3/8 IN. DIA</td>
<td>12-STRAND SINGLE BRAID / DYNEEMA®</td>
</tr>
<tr>
<td>Wire Rope</td>
<td>3/8 IN. DIA</td>
<td>7X19 STANDARD CORE / GALVANIZED (MEETS FED SPEC RR-W-410)</td>
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<tr>
<td>Wire Rope Clips</td>
<td>3/8 IN. CAP</td>
<td>FORGED / GALVANIZED STEEL</td>
</tr>
<tr>
<td>Mechanical Soil Anchor Alternative</td>
<td>MR-3</td>
<td>FORGED PRODUCTS / WIRE RAY OR EQUAL</td>
</tr>
<tr>
<td>Eyebolts</td>
<td>5/8 IN. - 1/2 UNF THREAD</td>
<td>FOR LIFTING / GALVANIZED STEEL</td>
</tr>
<tr>
<td>Rope Thimbles</td>
<td>3/8 IN. CAP</td>
<td>ORN CONSTRUCTION / GALVANIZED</td>
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<tr>
<td>Boulder Ballast for Shallow Bedrock Areas</td>
<td>4' MIN. O.A.</td>
<td>NA / NATIVE ROCK TYPES</td>
</tr>
<tr>
<td>Rock Anchors</td>
<td>5/8 IN. - 1 UNF THREAD</td>
<td>INTERMEDIATE THREADED FOUR-WAY EXPANSION ANCHOR</td>
</tr>
</tbody>
</table>

Notes:

For conceptual purposes only, not for construction. Hydraulic flow features are conceptual.
Type-A ELJ - Typical Construction and Habitat Benefits

**CONSTRUCTION NOTES:**
1. Structure secured together using a limited amount of synthetic fiber or steel wire rope strategically designed into the structure.
2. Scour pool extents are typical and may be excavated as part of construction.
3. ELJ top elevation is typically determined based on the anticipated design flood water surface elevation.
4. Structure voids and area downstream backfilled during construction with native channel sediment as shown.

**HABITAT NOTES:**
1. High flow refuge for juvenile salmon and other fish species provided by flow stagnation areas upstream and downstream of structure.
2. Void spaces in ELJ provide hydraulic refuge, cover and structure for juvenile salmon and other fish species.
3. Pool areas provide holding habitat for adult salmon.
4. Sorted sediment deposits provide channel substrate variation for selective spawning by salmon and other fish species.

**LOG SPECIFICATIONS**

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**NOTES:**
For conceptual purposes only, not for construction. Hydraulic flow features are conceptual.
CONSTRUCTION NOTES:
1. Structure secured together using a limited amount of synthetic fiber or steel wire rope strategically designed into the structure.
2. Scour pool extents are typical and may be excavated as part of construction.
3. ELJ top elevation is typically determined based on the anticipated design flood water surface elevation.
4. Structure voids and area downstream backfilled during construction with native channel sediment as shown.

HABITAT NOTES:
1. High flow refuge for juvenile salmon and other fish species provided by flow stagnation areas upstream and downstream of structure.
2. Void spaces in ELJ provide hydraulic refuge, cover and structure for juvenile salmon and other fish species.
3. Pool areas provide holding habitat for adult salmon.
4. Sorted sediment deposits provide channel substrate variation for selective spawning by salmon and other fish species.

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NOTES:
For conceptual purposes only, not for construction.
Hydraulic flow features are conceptual.
HABITAT GOALS AND OBJECTIVES:

1. Flow stagnation areas upstream and downstream of the structure to provide hydraulic refuge for juvenile salmonids and other fish species.
2. Void spaces in LWD to provide hydraulic refuge for juvenile salmonids and other fish species.
3. Structure to increase local floodplain connectivity and promote over bank flow path development.

CONSTRUCTION NOTES:

1. Anchoring technique may vary according to site conditions. Rootwad piles may be used in place of boulders.
2. Jam can be secured together using a limited amount of synthetic fiber or steel wire rope strategically designed into the structure. Jam secured in place using boulders to provide stability under hydraulic forces.

LOG SPECSIFICATIONS

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NOTES:

For conceptual purposes only, not for construction. Hydraulic flow features are conceptual.

LEGEND:

- LARGE WOODY DEBRIS
- APPROXIMATE CONTOURS
- FLOW DIRECTION
- WATER SURFACE, DESIGN FLOOD
- WATER SURFACE, ORDINARY HIGH

Figure 14

Type-C ELJ - Typical Construction and Habitat Benefits
30 Percent Design Report - Project Area 14 - Tucannon River
Columbia Conservation District
CONSTRUCTION NOTES:
1. STRUCTURE SECURED TOGETHER USING A LIMITED AMOUNT OF SYNTHETIC FIBER OR STEEL WIRE ROPE STRATEGICALLY DESIGNED INTO THE STRUCTURE.
2. SCOUR POOL EXTENTS ARE TYPICAL AND MAY BE EXCAVATED AS PART OF CONSTRUCTION.
3. ELJ TOP ELEVATION IS TYPICALLY DETERMINED BASED ON THE ANTICIPATED DESIGN FLOOD WATER SURFACE ELEVATION.
4. STRUCTURE VOIDS AND AREA DOWNSTREAM BACKFILLED DURING CONSTRUCTION WITH NATIVE CHANNEL SEDIMENT AS SHOWN.

HABITAT NOTES:
1. HIGH FLOW REFUGE FOR JUVENILE SALMON AND OTHER FISH SPECIES PROVIDED BY FLOW STAGNATION AREAS UPSTREAM AND DOWNSTREAM OF STRUCTURE.
2. VOID SPACES IN ELJ PROVIDE HYDRAULIC REFUGE, COVER AND STRUCTURE FOR JUVENILE SALMON AND OTHER FISH SPECIES.
3. POOL AREAS PROVIDE HOLDING HABITAT FOR ADULT SALMON.
4. SORTED SEDIMENT DEPOSITS PROVIDE CHANNEL SUBSTRATE VARIATION FOR SELECTIVE SPAWNING BY SALMON AND OTHER FISH SPECIES.

LOG SPECIFICATIONS

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NOTES:
FOR CONCEPTUAL PURPOSES ONLY, NOT FOR CONSTRUCTION.
HYDRAULIC FLOW FEATURES ARE CONCEPTUAL.

LEGEND:
- LARGE WOODY DEBRIS
- WATER SURFACE, DESIGN FLOOD
- WATER SURFACE, ORDINARY HIGH
- APPROXIMATE CONTOURS
- FLOW DIRECTION
- FLOW SEPARATION
- FLOW STAGNATION AREA
- FLOW CONVERGENCE
- TYP. SCOUR POOL EXTENTS
- TYP. SCOUR POOL EXTENTS (SEE CONSTRUCTION NOTE 2)
- LARGE DEEP HOLDING POOL (ADULTS)
- EXISTING CHANNEL BED
- STRUCTURE BACKFILL
- LOG POLE, TYP.
- TYP. SEDIMENT BACKFILL / DEPOSIT
- HYDRAULIC REFUGE IN LEE OF STRUCTURE
- LOGS SECURED TOGETHER (TYP. 4 LOCATIONS) (SEE CONSTRUCTION NOTE 1)
- LOGS SECURED TOGETHER (TYP. 1/3 OF TOTAL LENGTH)
- CLASSIFIED WOODY DEBRIS
- APARTMENT CONTOURS
- FLOW DIRECTION
- DESIGN FLOOD RETURN FLOW
- TYP. ORDINARY HIGH WATER
- TYP. ORDINARY HIGH WATER
- TYP. ORDINARY HIGH WATER
- TYP. OR DE A
- TYP. OR D A
- TYP. ORDINARY HIGH WATER
- EXISTING CHANNEL BED
- STRUCTURE BACKFILL
- LOGS SECURED TOGETHER
- TYP. SCOUR POOL EXTENTS
- HYDRAULIC REFUGE IN ELJ VOID SPACES (JUVENILES)
- ENGINEERED LOG JAM TYPICAL PROFILE (A-A')
- ENGINEERED LOG JAM TYPICAL PLAN
- ENGINEERED LOG JAM TYPICAL SECTION (B-B')
- ENGINEERED LOG JAM TYPICAL PROFILE (A-A')
- ENGINEERED LOG JAM TYPICAL SECTION (B-B')

Figure 15
Type-M ELJ - Typical Construction and Habitat Benefits
30 Percent Design Report - Project Area 14 - Tucannon River
Columbia Conservation District
Dec 14, 2011 3:46pm dgaffney
B:\Projects\Columbia Conservation District\Tucannon River 30\Type M\Drawings\100687-01-ELJ-LWD_Details.dwg Type-M
EXISTING GRADE

EXISTING BRIDGE

EXISTING GRAVEL AUGMENTATION 1/3 OF CHANNEL WIDTH

PROPOSED GRAVEL AUGMENTATION

APPROX. 1FT

APPROX. OHWL

EXISTING GRADE

TYPICAL PROFILE SECTION A-A'

LEGEND:

- APPROXIMATE CONTOURS
- FLOW DIRECTION

NOTES:

1. FOR CONCEPTUAL PURPOSES ONLY, NOT FOR CONSTRUCTION.
2. HYDRAULIC FLOW FEATURES ARE CONCEPTUAL.
3. PLAN MAY BE MODIFIED BASED ON SITE-SPECIFIC CONDITIONS AT GRAVEL AUGMENTATION SITES.

Figure 16

Typical Gravel Augmentation Plan
30 Percent Design Report - Project Area 14 - Tucannon River
Columbia Conservation District
APPENDIX A
WOOD PLACEMENT AND STRUCTURE DESIGNS
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A.1 LARGE WOODY DEBRIS

A.1.1 Functions and Benefits

Large woody debris (LWD) create instream complexity that will provide cover, hydraulic refuge, and holding areas and will promote retention of additional woody debris, spawning gravels, and fine sediment. Installing LWD is often necessary to supplement existing conditions, recognizing that it will take decades of watershed-scale restoration to begin to provide natural replenishment rates. In the long term, the added channel and bank roughness created by wood structures will help retain additional mobile wood and sediment, thereby further diversifying hydraulic and bedform complexity, and contributing to increased floodplain connectivity and functionality of floodplain processes over time. LWD may be installed specifically to direct flow or promote flow into side channels.

Habitat benefits provided by LWD in streams include:

- Improved habitat diversity during low-flow conditions from hydraulic complexity in pools with cover
- Velocity shelters in the lee of the LWD structures and individual logs that create holding and resting areas for fish during a range of discharge conditions
- Retention and distribution of spawning-sized sediment through the channel network

A.1.2 Types

There are several types of LWD placements that may be installed in the channel bed, bank, or gravel bar to create beneficial fish habitat and desired geomorphic effects. Each type has varying levels of engineering and construction effort and a range in magnitude of physical and biological benefit. Each type is identified by its functional name and the type letter used in the design Drawings. The three types of LWD proposed for the Project area are:

- A channel log (Type S) LWD placed in small side channels (Figures 9a and 9b)
- A bank roughness (Type L) LWD placed along the banks of the main channel (Figure 10)
- A bar roughness (Type Z) LWD placed on gravel bars in the main channel or side channels (Figure 11)
A.1.2.1 Single Rootwad Logs (Type S)

The proposed Type S LWD placements are single logs with rootwads placed in small channels, with the bole placed either perpendicular or parallel to flow and the rootwad exposed in the channel (Figures 9a and 9b). For the parallel orientation, the log may be secured to mechanical soil anchors driven into the bed or log anchors buried into the bed. For the perpendicular orientation, the rootwad log may be secured to healthy standing trees or the bole of the log may be buried into the bank to provide stability. For both orientations, a limited amount of synthetic fiber or steel wire rope, strategically designed to limit visibility, can be used to secure the rootwad log to the anchors are trees.

Specific habitat benefits of Type S placements include:

- Providing low-flow cover and structure for juvenile fish
- Providing high-flow refuge locations for juvenile fish in flow stagnation areas and in void spaces

A.1.2.2 Bank Roughness Assemblies (Type L)

The Type L bank roughness assemblies consist of two logs with rootwads oriented in an L-shape and placed along the channel bank, with one log parallel to the bank and one log perpendicular to the bank placed over the parallel log (Figure 10). These assemblies add roughness along the channel banks. The rootwads protrude into the channel to interact with low flows and help create a small localized scour pool. These assemblies are sufficiently spaced along the channel bank so to not limit the natural channel migration process. Overtime if the channel migrates over the assemblies the logs will collect additional woody debris and continue to provide juvenile fish habitat benefits. The log perpendicular to the bank may be secured to mechanical soil anchors with synthetic fiber or steel wire rope to provide stability. Alternatively, the bole of the log may be keyed into the bank to provide stability. The log parallel to the bank is pinned under the perpendicular log and held in place behind the rootwad.

Specific habitat benefits of Type L placements include:

- Providing low-flow cover and structure for juvenile fish
Appendix A

- Promoting development of a small localized scour pool that provides hydraulic diversity at low flow
- Providing high-flow refuge locations for juvenile fish in flow stagnation areas and in void spaces

A.1.2.3 Bar Roughness Assemblies (Type Z)

The Type Z bar roughness assemblies consist of three logs with rootwads laid out in a Z shape (Figure 11). Typically, these assemblies are placed atop a gravel bar, with the rootwads facing toward the channel to interact with low flow. Stability is achieved by securing the four corners of the assembly to buried rootwad log piles. Alternatively, mechanical soil anchors driven into the bed may be used in place of buried rootwad log piles. In locations where bedrock may be near the surface, large boulders may be used as ballast. A limited amount of synthetic fiber or steel wire rope, strategically designed to limit visibility, is used to secure the logs together and to the piles, mechanical soil anchors, or rock ballast.

Specific habitat benefits of Type Z placements include:

- Providing low-flow cover and structure for juvenile fish
- Promoting sorting and temporary storage of sediment in the lee of the assembly to provide habitat diversity and a medium for riparian vegetation growth over the longer term
- Providing high-flow refuge locations for juvenile fish in flow stagnation areas and in void spaces
A.2 ENGINEERED LOG JAMS

A.2.1 Function

Engineered log jams (ELJs) are wood structures that can be placed in the main channel of a river. The primary function of these log jam structures is to create pools and provide cover and refuge while accumulating additional woody debris and promoting gravel sorting and retention. ELJs may also promote the development of multiple flow paths and side channels. ELJs are typically placed along the bank or mid-channel with the bottom of the structure near the anticipated scour depth and the top built to the approximate height of the design water surface elevation. A large portion of the structure is backfilled with streambed materials for stability, and a gravel bar deposit may be placed in the lee of the structure to emulate the natural sediment deposit that would occur in the lee of this type of structure.

A.2.2 Benefits

ELJs create diverse hydraulic conditions that provide resting areas in close proximity to complex cover. Fish conserve energy when holding in the flow stagnation areas up-and downstream of the structure. ELJs also contain a substantial amount of void space within the logs and root masses, providing considerable area for fish refuge. During high flows, the rootwads interact with hydraulic forces from the river and scour large, deep pools that provide holding areas for adults, while the void space within the face of the structure is used by juveniles. In addition, these structures are able to retain mobile wood debris, providing greater complexity and refuge habitat (Photograph 1). Because of the hydraulic conditions and hard points created by ELJs, they may also be used as “deflectors” to influence flow direction to promote channel expansion or activation of side channels.
Photograph 1
Natural Retention of Mobile Wood and Pool Formation at an ELJ on the Stillaguamish River, Washington

On a reach scale, ELJs can influence gravel scour and deposition, creating localized pool-riffle sequences in otherwise straight, confined plane-bed channel segments. Collectively, the addition of ELJs to a channel can result in a significant increase in hydraulic complexity and a more diverse channel profile throughout a reach. Sediment storage and deposition adjacent to the ELJs can create gravel bars in the active channel, allowing for colonization of riparian vegetation and eventually the development of forested islands. The overall roughening of the active channel and deposition on the riverbed promotes rehabilitation of natural processes by increasing floodplain connectivity and promoting channel migration.

A.2.3 Types
There are several types of ELJ placements that may be constructed in the project area to create beneficial fish habitat and desired geomorphic effects. Each type has varying levels of engineering and construction effort and a range in magnitude of physical and biological
benefit. Each type is identified by its functional name and the type letter used in the design Drawings. The four types of ELJs proposed for the Project area are:

- A bar apex (Type A) ELJ constructed at the head of an island or mid-channel bar (Figure 12)
- A bank configuration (Type B) ELJ constructed along the margins of the active channel (Figure 13)
- A channel spanning configuration (Type C) ELJ constructed across the active channel (Figure 14)
- A channel grade (Type M) ELJ constructed within the active channel and set on the existing channel bed (Figure 15)

Each structure type provides essentially the same habitat functions but creates different hydraulic conditions and varying levels of benefits.

**A.2.3.1 Bar Apex (Type A) Engineered Log Jams**

The Type A bar apex ELJs are constructed of multiple logs with rootwads configured strategically with rootwads exposed along the front and sides of the structure (Figure 12). The logs are secured together with a limited amount of synthetic fiber or steel wire rope at the corners and the structure is backfilled with streambed material, which is not exposed to the river. Typically, the logs placed parallel to flow are the largest in diameter and rootwad size, providing more exposed rootwad area to the approach flow. The logs perpendicular to flow may be smaller in diameter. When a bar apex ELJ is placed mid-channel, a scour pool is typically maintained around the structure. The scour pool provides a deep holding area at the upstream end that tails out along the sides. The scour pool may be excavated at the time of construction if desired. The hydraulic conditions created by the ELJ create low-velocity stagnation zones upstream and downstream as flow is redirected around the structure.

Because the channel adjusts to the structure by forming the scour pool and depositing sediment in the lee, this type of ELJ is often placed in rivers with ample bedload and in areas of the channel where sediment sorting is likely to occur. Bar Apex ELJs may be placed near the upstream end of existing flood flow paths to promote development of a side channel, or they may be placed mid-channel on gravel bars to promote development of split flow
thereby increasing channel complexity. An example of a Type A ELJ is shown in Photograph 2.

Photograph 2
A Type A ELJ Shortly after Construction on the Green River, Washington

A.2.3.2 Bank Configuration (Type B) Engineered Log Jams

The Type B bank configuration ELJs (Figure 13) are typically placed along channel banks and may be implemented successfully in high-energy locations such as the outside of meander bends in the main channel. The logs are secured together using synthetic fiber or steel wire rope, strategically designed to limit visibility. Behind the rootwads, the structure is backfilled with streambed materials for stability; the backfill does not interact with the river. Key pieces at the base of the structure are typically buried into the bank/channel bed where the rootwads will be exposed as a scour pool develops. The scour pool may be excavated at the time of construction if desired. The rootwads protrude into the flow along the exposed sides of the structure providing habitat complexity and cover at low flow and hydraulic refuge at high flow. The structure is typically constructed to conform to the shape of the bank in a stepped configuration where the upper portion will be inundated only during
higher flows. This configuration allows vegetation to be established within the structure, supporting riparian development. An example of a Type B ELJ is shown in Photograph 3.

Photograph 3
A Type B ELJ Constructed in 2009 on the Entiat River, Washington. A Scour Pool has Developed at the Structure and Mobile Wood has been Retained.

A.2.3.3 Channel Spanning (Type C) Engineered Log Jams

The Type C channel spanning ELJs (Figure 14) are constructed of multiple logs with rootwads laid out across the active channel and the adjacent gravel bars or low floodplain. The logs are secured together using synthetic fiber or steel wire rope, strategically designed to limit visibility. The structure is secured to large boulders to resist movement under hydraulic forces. The structure will retain mobile wood and sediment thereby helping to reverse the incision process and promote increased floodplain connectivity and overbank flow path development. It is likely that these structures will accumulate additional woody
debris that adds to the overall height and complexity of the structure, further promoting local floodplain connectivity. Low flow will pass through the voids in the structure while high flows will pass over the top and around the edges of the structure. The structure will be placed on the existing channel grade and will be flexible to conform to changes in bed or bank topography.

A.2.3.4 Channel Grade (Type M) Engineered Log Jams

The Type M channel grade ELJs (Figure 15) are constructed of multiple logs with rootwads configured very similar to a Type A bar apex EJL (Figure 12). However, the Type M ELJ has two major differences; 1) the ELJ is placed at the grade of the existing channel bed and 2) the logs parallel to the flow extend beyond the backfilled portion of the structure; creating a pocket for additional woody debris accumulation over time. As in the Type A ELJ, the logs are secured together at the corners with a limited amount of synthetic fiber or steel wire rope and the enclosed portion of the structure is backfilled with streambed material. To provide the required ratio of ballast to wood volume the logs placed perpendicular to the flow are positioned to retain the sediment backfill while the center of the enclosed portion of the structure remains open. This configuration is required to prevent the logs placed parallel to the flow from leveraging the structure out of place.

Because the Type M ELJ is placed at the grade of the existing channel bed, this type of ELJ is placed in portions of the river with larger than average bed material where a deep scour pool is not anticipated; however, when a channel grade ELJ is placed mid-channel, a small scour pool is still typically maintained around the structure. The scour pool provides a holding area at the upstream end that tails out along the sides. The scour pool may also be excavated at the time of construction if desired. The hydraulic conditions created by the ELJ create low-velocity stagnation zones upstream and downstream as flow is redirected around the structure. Channel grade ELJs may be placed close together to roughen the active channel and promote deposition on the riverbed rehabilitating natural processes and reducing channel incision.