To: Pete Cruickshank and Mike Kaputa; Chelan County Natural Resource Department

From: Mike (Rocky) Hrachovec, PE; Tim Abbe, PhD, PG; Susan Dickerson-Lange, PhD; and John Soden, MS, PWS; Natural Systems Design

Date: 6/30/2017

Re: Basis of Design for Mission Creek Phase II: Poison Canyon Pilot Project

BACKGROUND

Introduction

The design team at Natural Systems Design (NSD) has worked collaboratively with Chelan County Natural Resource Department (CCNRD) to develop a restoration design for the Phase II Poison Canyon Pilot Project. The purpose of this memorandum is to summarize the basis of design for the design drawing plan set ("Plan Set") for the project. The Plan Set and this basis of design memorandum are intended to support the permitting process (see Permit Conditions, below), and therefore include:

- Map with locations of the proposed structures
- Typical structure drawings with cross-section and profile
- Typical channel dimensions with ordinary high water mark (OHWM) and 100-year flood height shown, and
- Quantities of materials.

The project design was developed from field assessments conducted on 9 November 2016 and 9 May 2017, a site visit with representatives of WA Department of Natural Resources (WDNR) and WA Department of Fish and Wildlife (WDFW) conducted on 18 April 2017, 1-dimensional hydraulic modeling, spatial analysis of lidar data, and several discussions between the design team and CCNRD.

Poison Creek flows through Poison Canyon, and is a tributary to Sand Creek, which is a tributary to Mission Creek, which joins the Wenatchee River near Cashmere, Washington. The CCNRD is planning for a stream restoration project in the portion of Poison Creek that crosses WDNR land ownership, from approximately River Mile (RM) 0.4 to 1.0, starting at the confluence of Poison Creek with Sand Creek ("Project Area").

The project is considered the Phase II pilot project for a broader effort to pursue water storage and sediment retention through stream restoration in Mission Creek, where dry season water quantity and quality are key issues of concern. A Phase I assessment identified appropriate conditions in the Project Area for implementing restoration actions intended to locally store alluvial sediment and water, reduce local stream gradient, and re-aggrade the channel bed elevation in target locations. The assessment found that extensive stream restoration has the potential to store water and augment low flows by 0.8 to 1.5 cubic feet per second (cfs) during the dry season in Mission Creek, while simultaneously providing aquatic ecosystem benefits. The motivation for and scientific basis of this approach is described in detail in the final report to CCNRD: "Mission Creek, Phase I Assessment: Water Conservation Through Stream Restoration", dated 12 May 2017.

Project Goals and Expected Benefits

The primary goal of this project is to re-introduce large wood structures to the stream channel in order to increase hydraulic roughness and slow flow velocities. These structures are therefore expected to raise local in-channel and subsurface water elevations, and trigger sediment deposition and bed aggradation.

Since a substantial portion of the Project Area is moderately to severely incised, raising water surface elevation and re-aggrading the bed will substantially improve lateral hydrologic connectivity and geomorphic function. Importantly, these structures are expected to act as porous, natural dams that impound water, increasing the overall in-situ surface water storage along the Project Area. In addition, re-aggradation of the bed will raise the in-channel surface water elevation and increase the volume of subsurface water storage and decrease the groundwater inflow rate. Together, these changes are expected to increase riparian water availability and baseflow amounts, and improve water quality (temperature and sediment loads). Furthermore, the thinning of small diameter trees outside of the riparian zone, for implementation in the in-channel structures, is likely to improve upland soil moisture availability and therefore improve forest resilience to fire and drought.

BASIS OF DESIGN

Permit Conditions

A site visit to the Project Area was conducted on 18 April 2017 to discuss the conceptual design and permitting conditions. The visit included Danielle Munzing (Biologist) and Marty Mauney (Forester) from WDNR, Amanda Barg (Area Habitat Biologist) from WDFW, Pete Cruickshank and Mike Kane from CCNRD, and John Soden from NSD. The conceptual approach for the Poison Canyon pilot project as well as the broader context for water conservation through restoration were discussed.

Key points that form the permit conditions for this project include:

- The use of live standing trees > 8" diameter at breast height (DBH) would likely require a Forest Practice Application (FPA) from WDNR and a Hydraulic Project Approval (HPA) from WDFW, a spotted owl habitat assessment, and payment for harvest of live standing trees >8"DBH.
- The project may use any dead and downed material. Many of the potential project sites have existing dead and down material that is larger than 8" DBH and will work as key pieces.
- Harvest of trees currently providing shade to creek will be avoided. If it is determined that a specific tree that is near to the creek is desired, the construction manager will need to have a densitometer to check available shading and make a judgement call on whether tree in question will reduce overall shading.
- Harvest of standing snags will be avoided.
- WDFW fish passage criteria are NOT applicable to the project.
- Construction methods will avoid dragging logs or causing soil erosion.

Thus, to fit this project within desired construction window and current secured funding the project will harvest standing live trees that are <8" DBH only, which will not require a FPA but will require an HPA.

Due to the remote nature of the site and the goal of minimizing construction disturbance to vegetation and soils, construction methods will rely on hand tools and forestry methods to cut and move wood into place. No tracked or wheeled equipment will be used.

For future projects, two possibly viable routes to use larger wood are:

1. Work through processes for FPA, spotted owl habitat assessment, and agreement with WDNR for a payment schedule, and/or
2. Import large wood and place via machinery or helicopter, where access and budget allow.

Field Assessment

Observations from field assessments conducted on 9 November 2016 and 9 May 2017 are incorporated in the restoration design for Poison Creek. The sole infrastructure consideration related to the potential mobilization of placed wood is a wooden culvert under Forest Service (FS) Road 7104, just upstream of the confluence of Poison Creek and Sand Creek (Figure 1). However, this culvert is protected from possible damage from a log jam failure by large boulders in Poison Creek near RM 0.2. (Figure 2). There is an unmaintained trail that follows Poison Creek up the valley. Valley width ranges from 20 to 100 feet, and the elevation of the channel bed relative to the floodplain ranges from 6 inches in a wetland complex to over 6 feet in severely incised reaches (see Phase 1 Report for additional geomorphic assessment). Floodplain sediments consist primarily of sand, with redox coloring present and depth to groundwater of 2.7 feet (9 May 2017, Figure 3). Channel sediments consist dominantly of sand and gravels, with exposed bedrock observed in two locations.

Riparian vegetation consists of coniferous and deciduous trees, shrubs and grasses. Dense stands of relatively young conifers are interspersed with exposed sandstone bedrock on hillslopes. Landslide deposits and scarps were observed.

Figure 1. Poison Creek flowing through wooden culvert under FS Road 7104, just upstream of the confluence with Sand Creek (i.e., near RM 0.0). Photograph taken on 9 November 2016.

Figure 2. Large boulders in Poison Creek at RM 0.2. Note that the creek is visible flowing through the boulders, and is approximately 4 feet wide, for scale. Photograph taken on 9 November 2016.

Figure 3. Test pit showing floodplain sediments on the left bank near RM 0.6. Photograph taken on 9 May 2017.

Geomorphology

In addition to the field observations noted above, geomorphic considerations that were incorporated in the design include longitudinal and vertical extent of incision, cross-sectional morphology, longitudinal slope and morphology, and potential for erosion through floodplain sediments. A Relative Elevation Model (REM) was constructed from a lidar digital elevation model in order to detect the vertical extent of incision and to characterize current hydrologic connectivity. The topo-bathymetric lidar data were acquired by Quantum Spatial in August 2015 and include average ground return point density of 12.8 points per square meter for a vertical accuracy of 0.054 m in non-submerged locations (TetraTech and QuantumSpatial, 2015). To construct a REM, the digital elevation model is processed to de-trend the channel gradient and express the ground surface elevation of the valley bottom topography relative to the adjacent river channel using a Kernel Density method (Olsen *et al.*, 2014). The resultant surface is a REM, which highlights local variations in the floodplain surface. The REM map and elevation profiles across the channel and floodplain were then used to identify the longitudinal extent of incision. Three geomorphic conditions were identified from the REM analysis and field observations: (1) Wetland complexes, (2) moderately incised reaches, and (3) severely incised reaches (Figure 4).

The lidar data were also used to construct a longitudinal profile along the Project Area, with particular focus on the difference in local average channel slope between the wetland complex and incised reaches. The wetland complex serves as a local analog of sediment storage and water storage resulting from large wood maintaining the hydraulic grade, and the slope in the wetland complex is an indication of how much the channel slope could change from re-aggradation of the channel bed through restoration. For example, the average slope through the wetland complex is 3.6%, and is as low as 2.8% in a portion of the wetland complex (Figure 5). In contrast, the average slope through the moderately incised reach immediately below the wetland complex is 3.3%, suggesting that re-aggradation is feasible with the addition of in-channel wood.

The final geomorphic consideration of the design is the erodibility of the fine-grained channel and floodplain sediments. As the structures begin to slow water velocities and trigger upstream localized aggradation, a hydraulic head differential will develop between the upstream and downstream end of each structure. This water will flow along the exposed banks and may begin to erode into the bank margin. If vegetation or wood falls into this pocket it may result in minor lateral scour, especially if the erosion occurs gradually. A large storm event may trigger more significant erosion, particularly in the first 2-3 years. Increased bank erosion could ultimately result in the stream bypassing the channel-spanning structure by meandering around the structure, particularly where the riparian forest is immature or absent. Since well-sorted sand is more erodible than larger sediment sizes or a more diverse range of sediment sizes, lateral channel migration is a key consideration at this Project Area. Thus, we considered two possible approaches to compensate: (1) place wood on the floodplain which will be recruited into the channel by the bank erosion, (2) install redundant structures in key locations to minimize hydraulic head differential, and (3) plan for some amount of maintenance in these structure locations. Placing additional wood on the floodplain is expensive and not guaranteed to become functional wood when recruited, and the budget for this project is limited to installation of a small number of structures. Thus, we recommend planning for capacity to revisit and reinforce a portion of the proposed structure locations during the first 3 years following implementation.

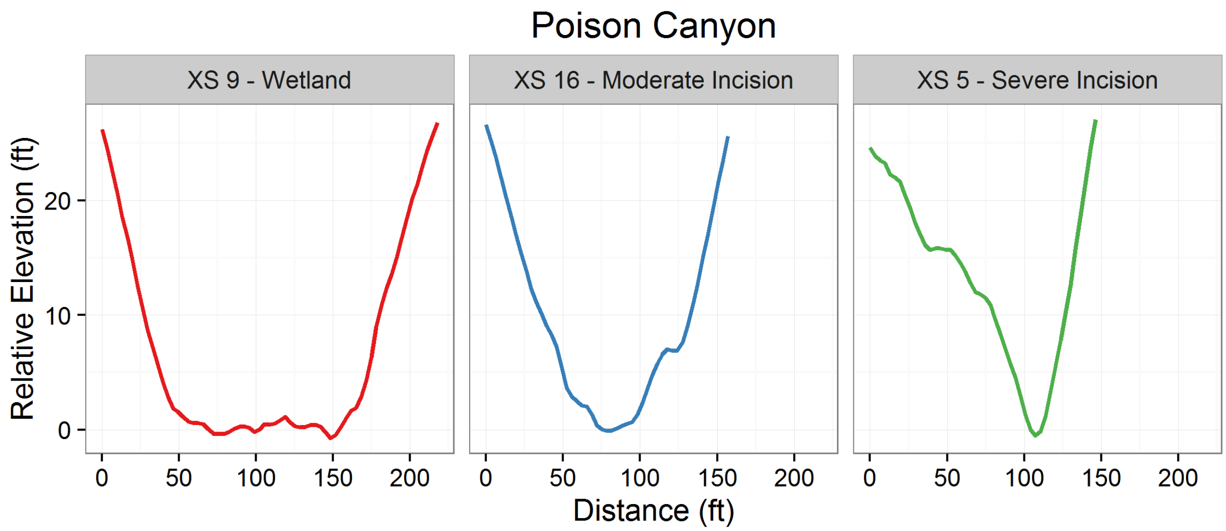

Figure 4. Topographic profiles from Poison Canyon showing elevation relative to local water surface (feet) from left bank to right bank (i.e., looking downstream) across three representative cross sections in a wetland reach, a moderately incised reach and a severely incised reach.

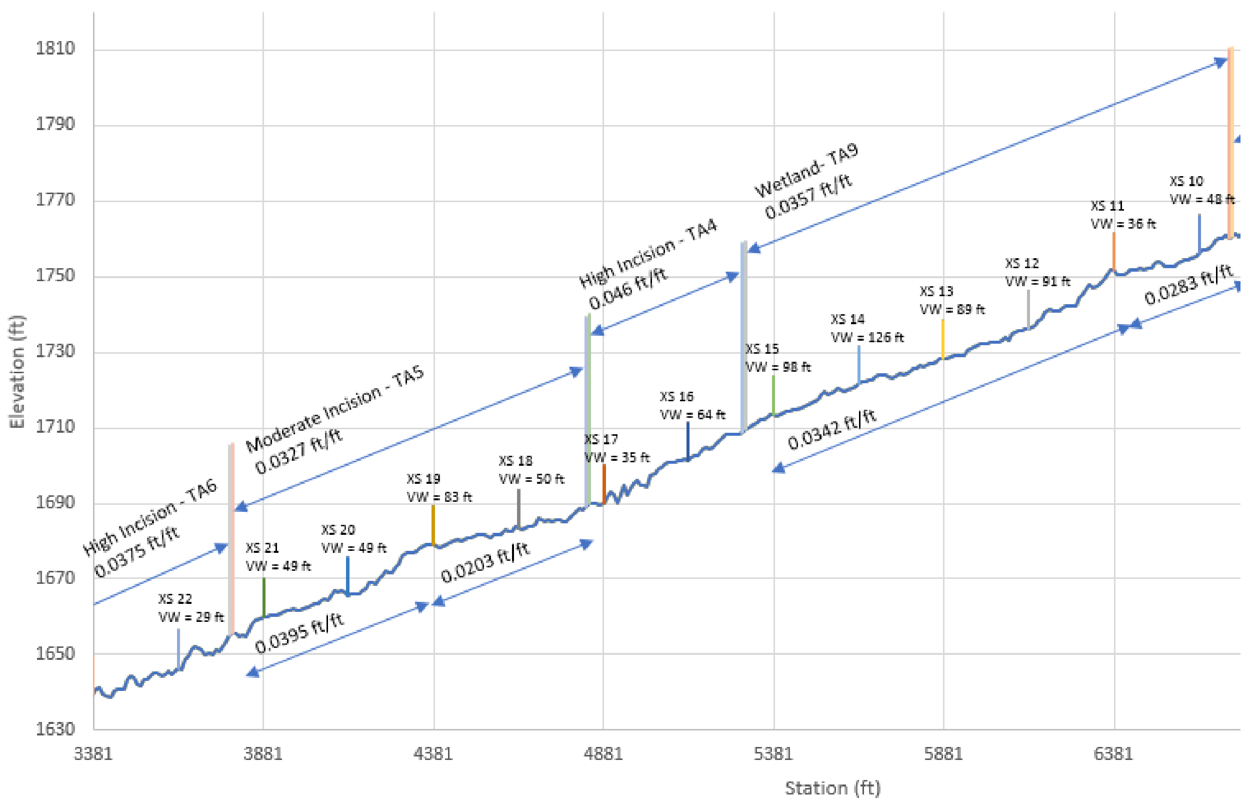

Figure 5. A portion of the longitudinal profile showing the local average slope by reaches that were field delineated on 10 November 2016, and by natural slope breaks.

Hydrology and Hydraulics

The hydrology and hydraulics of Poison Creek were assessed in order to inform the project design. Design-relevant streamflows, including the 2-, 10-, and 100-year floods, were derived using regression relationships implemented in USGS StreamStats Version 3.0 (Table 1). The equations implemented in StreamStats are based on drainage area (3.3 square miles), mean annual precipitation (19.1 inches) and region (Region 4). There are no validation data since there are no stream gages on Poison Creek, so the discharge values are considered estimates.

We implemented representative values for channel morphology based on field measurements, relevant design flows (described above), and roughness parameters (i.e., Manning's n) into 1-dimensional hydraulic equations to model the hydraulics of both existing and proposed conditions in the Project Area (Table 2, Figure 6). Values used for existing conditions channel morphology include channel width of 5 feet, channel depth of 3 feet, and valley width of 80 feet. Since the proposed wood structures are intended to serve as porous natural dams that impound water, we modeled proposed conditions with a completely obstructed, roughened channel in order to bracket the largest expected effect on hydraulics. To represent existing conditions in the wood-poor channel, we used typical Manning's n values of 0.035 in the channel and 0.07 on the floodplain. To represent a dramatic increase in hydraulic roughness from the implementation of large wood structures filling the channel, we adjusted the channel cross-sectional profile to be filled by wood and applied a Manning's n value of 0.15 to the channel and floodplain.

Table 1. Design-relevant streamflows at Poison Creek near the WDNR property boundary, derived using regression relationships implemented in USGS StreamStats Version 3.0.

Flow	Recurrence Interval (years)	Probability (%) of Occurrence in Any Given Year	Discharge (cfs)	Notes
Q2	2	50	10.8	Used as the discharge to estimate height of OHWM
Q10	10	10	28.4	
Q100	100	1	57.4	

Table 2. Water depth and flow velocity in channel and on floodplain, estimated from hydraulic equations for existing conditions and proposed conditions.

Flow	Existing Conditions: Depth in Channel	Existing Conditions: Channel Flow Velocity (fps)	Existing Conditions: Depth on Floodplain	Existing Conditions: Floodplain Flow Velocity (fps)	Proposed Conditions: Depth in Channel	Proposed Conditions: Channel Flow Velocity (fps)	Proposed Conditions: Depth on Floodplain	Proposed Conditions: Floodplain Flow Velocity (fps)
Q2	1.5	5.2	0	0	FULL[1]	1.1	0.6	0.7
Q10	2.1	6.7	0	0	FULL[1]	1.4	0.8	1.0
Q100	2.7	7.9	0	0	FULL[1]	1.6	1.1	1.3

[1] Channel modeled as totally obstructed by large wood structure, but designed to accommodate throughflow.

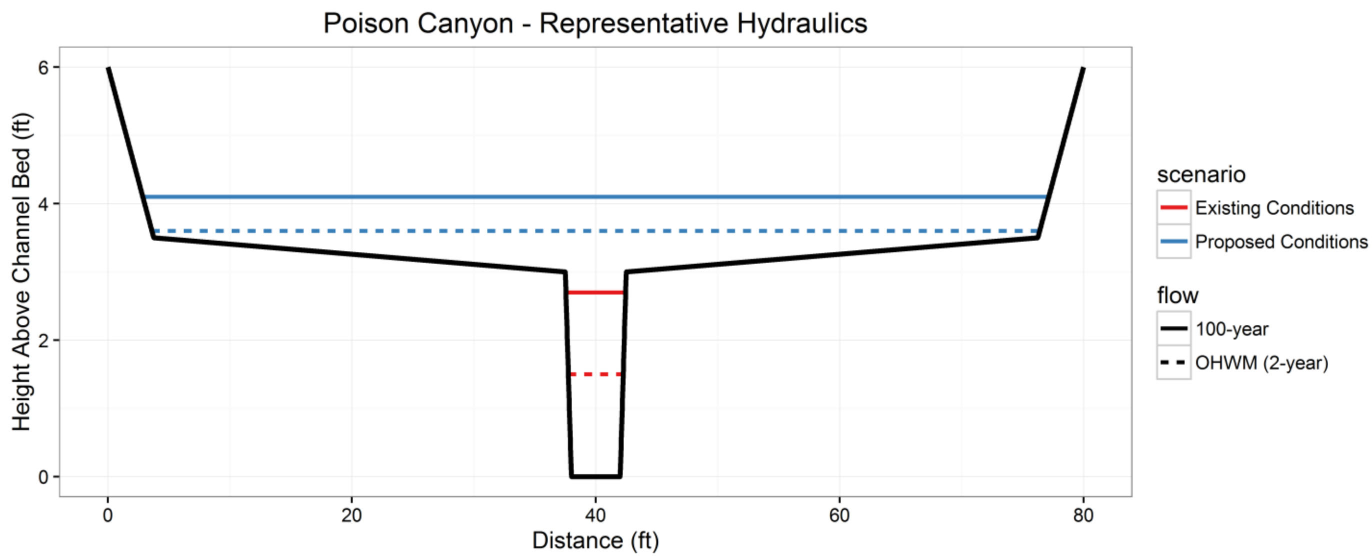

Figure 6. Representative cross-section showing OHWM (based on a recurrence interval of 2 years) and 100-year flow under existing conditions (red) and proposed conditions (blue). Note that the graph is vertically exaggerated to emphasize differences.

DESIGN COMPONENTS

Project Locations

Project locations were identified in the field based on geomorphic characteristics and the availability of sufficient wood to build a structure. In particular, projects were located in reaches that were identified as moderately to severely incised through analysis of the REM, longitudinal profile, and field observations. The availability of wood was noted in the field, and included downed large logs and standing live stems < 8" DBH outside of the riparian corridor.

Priority levels were determined qualitatively from field observations. A higher priority level was assigned to locations with wider valley morphology, and to structures that were placed to prevent head cut migration or incision into bedrock. Wider valleys are favored because of the larger available volume for subsurface and surface water storage under restored conditions. Preventing further incision is intended to retain as much natural alluvial water storage as the stream valley currently has. A secondary consideration in assigning priority levels was the spacing of structures, to avoid redundancy, and the availability of wood and riparian trees to entangle with. See the structure schedule in the Plan Set for notes on each location.

Photographs of select project locations are presented in Appendix A to provide additional context and to highlight features of select sites, but do not represent a full catalog of locations. The KMZ (Google Earth) file has been provided to CCNRD with locations of all proposed structures and georeferenced photographs of each location. In addition, all locations were flagged in the field with pink flagging tape.

Material Types

Wood Bundles

Thinned material will be bundled to a diameter of 2-4 feet using biodegradable (manila) rope. Bundles will be placed both horizontally and vertically (see typical structure sequence in Plan Set), and used to fill spaces between placed logs and the channel banks to decrease structure porosity.

Logs < 8" DBH

Logs will be harvested from standing live stems, away from riparian zone so that there is a negligible effect on riparian shade. Alternatively, downed logs < 8" DBH may also be used. No standing snags will be used.

Key pieces

Where larger diameter (≥ 8" DBH) downed logs are available, they will be cut with chain saws to allow for transport and placement in-channel without dragging or causing soil erosion. In some locations, downed logs with in-tact root wads were identified, and these represent prime candidates for key pieces for the in-channel structures.

Methods & Access

Construction will be accomplished entirely with hand tools. Standing live stems will be felled with chain saws and rigging. Logs will be hand-carried in such a way as to minimize soil erosion. Chain saws will be refueled on a spill pad at least 20' from the edge of the channel.

Crews will walk into the site from the approximately 0.4 mile access trail along Poison Creek, and will carry tools and supplies (e.g., manila rope). Parking is available at a pull-off on the south side of FS Road 7104, just to the west of the trailhead to the Project Area.

Architecture & Sequencing

Structures will be constructed from logs and wood bundles to create channel-spanning wood structures that effectively act as a porous wood dam. Structures will extend 30-40 feet along the length of the channel. Logs will be placed at an angle to the channel, and some portion will be entangled with riparian trees, where possible, for stability. Racking bundles will be used to fill holes in the structure and will be held in place by additional large wood placed on top. Sequencing of placements of logs and bundles is detailed in the plan set.

Material Quantities & Cost Estimating

The quantities of logs and bundles are provided with the structure schedule in the Plan Set.

A construction cost estimate is provided below (Table 3).

Table 3. Construction cost estimate for proposed structures.

Item #	Item Description	Quantity	Unit	Unit Price ($)	Amount ($)
1	Labor	22	DAY	$1,500	33,000
2	Manila Rope - 0.5" diameter	240	LF	$1	204

	Subtotal				*33,204*
	Taxes (as % of Construction Sub-Total)	*8.7%*			*2,889*
	TOTAL				**36,093**

LIST OF APPENDICES

Appendix A: Field Photographs of Proposed Locations

REFERENCES

Olsen, P.L., N.T. Legg, T.B. Abbe, and J.K. Radloff, 2014. A Methodology for Delineating Planning-Level Channel Migration Zones. https://fortress.wa.gov/ecy/publications/SummaryPages/1406025.html.

TetraTech and QuantumSpatial, 2015. Lower Wenatchee River Topobathymetric LiDAR. Bothell, WA.

APPENDIX A: FIELD PHOTOGRAPHS OF PROPOSED LOCATIONS

All photographs were taken on 9 May 2017.

Perched downed wood near proposed structure 2.

Perched downed wood near proposed structure 7, where the floodplain is low and wide.

Severe incision (up to 6 feet) near proposed structure 9, where there are very large cedars perched over the channel.

Bedrock in channel near proposed structure 10.

Moderately incised channel and adjacent conifers to entangle with at proposed structure 10.

Head cut downstream of proposed structure 10.

Looking downstream at Proposed structure 11.

Downed log with root wad to cut and haul as a key piece for proposed structure 12; located upslope from left bank.

Large downed log on right bank as key piece for proposed structure 15.

Large downed log perched across channel to use as a key piece for proposed structure 16.

Large downed log perched across channel to use as a key piece in proposed structure 18.

Large downed log perched across channel to use as key piece in proposed structure 19.