Wind River – Stabler Bend

Side-Channel Habitat Enhancement Project

Preliminary Design Report

SUBMITTED TO

Lower Columbia Fish Recovery Board

February 7, 2017

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1. Introduction

1.1 OVERVIEW

This report summarizes preliminary designs for aquatic habitat restoration on the mainstem Wind River near Stabler, Washington. The purpose of this project is to enhance habitat for ESA-listed steelhead trout. The habitat objectives are to increase high quality spawning and rearing habitat by increasing channel complexity and improving off-channel connectivity. This project builds on past habitat restoration work in this reach dating back to the mid-1990s coordinated by the Underwood Conservation District. The past work included placement of log structures along the eroding river-right (south) margin of the mainstem. This current effort focusses on activating a side-channel alignment within the north floodplain area, with an inlet on river-left upstream of the previous project and the outlet downstream of the previous project.

This report summarizes:

- Goals and objectives
- Site assessment
- Description of proposed project
- Conceptual designs
- Opinion of probable cost

1.2 BACKGROUND

This project was one of the top rated project opportunities identified in the Wind River Habitat Restoration Strategy (Strategy), which is currently in draft form (LCFRB 2017). This effort has been guided by the Wind River Work Group (WRWG), comprised of watershed stakeholders. As part of the Strategy, this project and another one on the Little Wind River have been taken forward to the Preliminary Design stage. Inter-Fluve, in cooperation with the Underwood Conservation District (UCD), has led the technical component of this design project, with guidance and support from the LCFRB and WRWG. Conceptual design alternatives were developed and presented to the WRWG to develop a preferred alternative for preliminary designs. The preliminary design process and products have been coordinated to meet the requirements outlined in SRFB Manual 18, Appendix D.

1.3 PROJECT AREA

The project area is located on private property and US Forest Service property just north of Stabler, Washington. The project is approximately 1.25 miles north of the Hemlock Road Bridge across the Wind River (Figure 1).

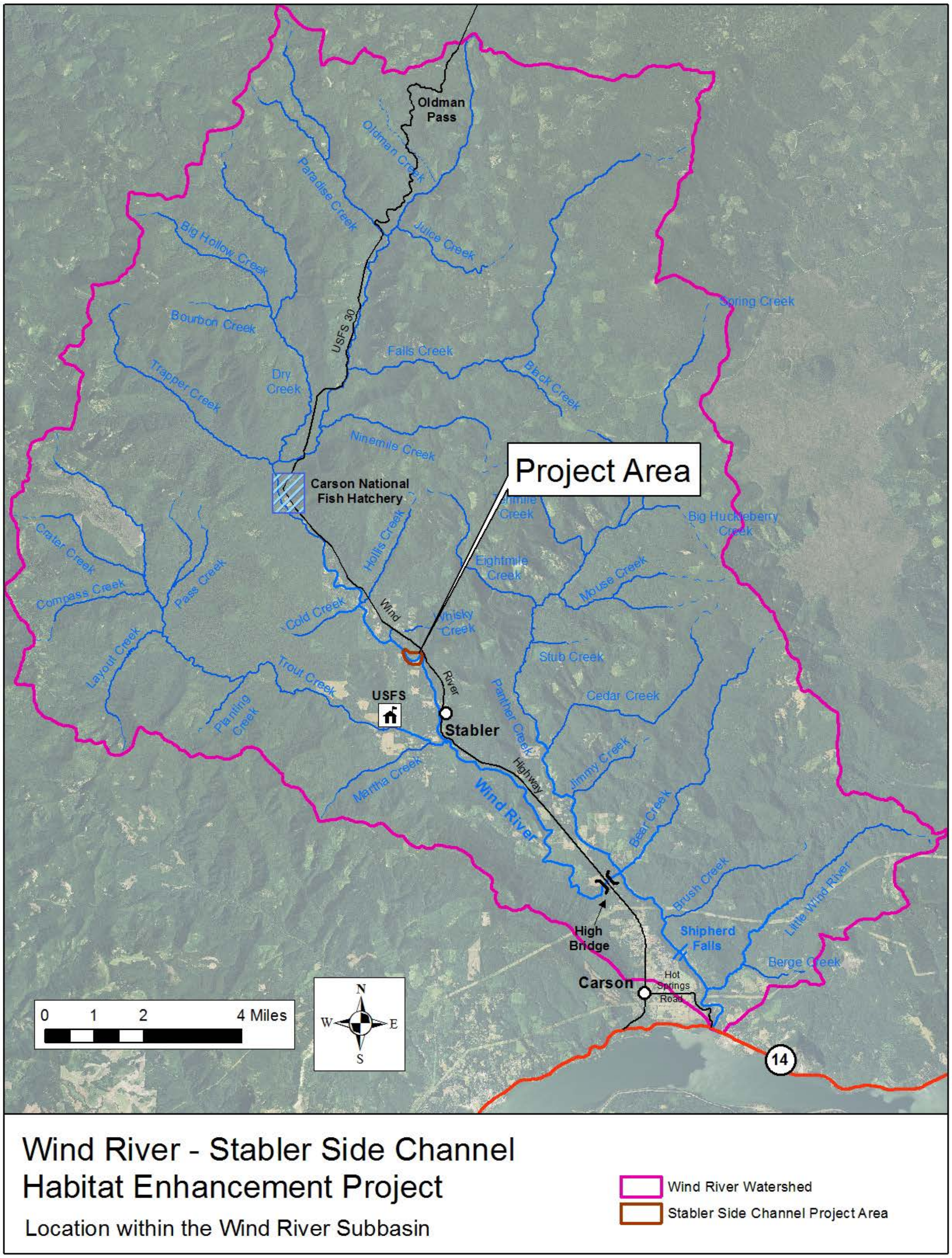

Figure 1. Wind River Stabler Bend Side-channel Habitat Enhancement Project Location within Wind River Watershed.

1.4 GOALS AND OBJECTIVES

The Strategy identified a vision and suite of goals for restoration planning and implementation work throughout the Wind River subbasin. For the Stabler Bend Side-channel Enhancement project, a subset of those goals applies. The goal for the project is to enhance fish habitat and habitat-forming processes for summer steelhead. A suite of preliminary design objectives has been developed that fit within this goal. Preliminary design objectives have been categorized into geomorphic and habitat objectives, recognizing that they are interdependent and interrelated.

Habitat Objectives

- Increase the quantity and accessibility of juvenile rearing habitat for salmonids, with an emphasis on ESA-listed summer steelhead.
- Increase the amount of potential spawning habitat for summer steelhead.
- Off-channel habitat complexity – Increase the wetted area of off-channel habitat at a range of flows (including low flows) through construction of a flow-through side-channel with interconnected alcoves and floodplain wetlands.
- Pool frequency – Provide abundant pool habitat in the side-channel and in the mainstem associated with mainstem log structures. Design log jams and other project elements to encourage and maintain scour conditions and pool formation.
- Cover – Provide increased aerial extent of cover per unit stream length, primarily through the placement of large wood and log jams.
- Increase wood quantities to meet or exceed the NMFS standard for Western Cascades streams, which is 80 pieces per mile (>12 inches diameter; >35 feet long). This target meets or exceeds the reference quantities measured by Fox and Bolton (2007). Increase the frequency of log jams to emulate historical patterns and processes.
- Hydraulic refuge – Increase the area available for hydraulic refuge during high flow events. Accomplish this through increased off-channel habitat availability and increased stream channel structure (i.e. large wood).
- Temperature – Provide access to off-channel habitats that are fed by groundwater and hyphoreic flow to provide suitable refuge from summer and winter temperature extremes.
- Riparian conditions – Work closely with property owners to control invasive species and restore healthy native riparian and floodplain forests where vegetation conditions have been impaired.
- Select construction methods that minimize negative impacts to target species, existing habitat, and vegetation.

Geomorphic Objectives

- Design project elements that will be geomorphically sustainable given the current and future sediment load, land use, and large wood regime.
- Increase the length and availability of side-channels and planform complexity.
- Place large wood within the side-channel to maintain pool depths.

- Mainstem avulsion downstream could result in channel incision that moves up through the site. This project should minimize habitat impacts that could result from mainstem channel avulsion.
- Increase flood flow volume in the left bank floodplain via side-channel excavation and connection.

2. Site Surveys

As part of the Restoration Strategy development, initial surveys were performed through this reach in the summer of 2016. These surveys documented habitat conditions and identified potential project opportunities. Once the project was selected for design, further surveys were performed to serve as the basis to develop a suite of conceptual restoration alternatives, identify key feasibility constraints, consult with landowners, and identify access routes to implement designs. The current condition of past restoration work at the site was also observed in order to understand stream channel response to inform the designs.

Topographic surveys were performed of the site over numerous field visits from October to December 2016. Surveys were performed using RTK GPS and total station survey equipment to support design and hydraulic analysis. The area surveyed included approximately 5,000 feet of the Wind River through the project reach. Surveys focused on collecting cross-sections of the channel to be combined with LiDAR data in overbank areas for hydraulic analyses.

3. Site Conditions

3.1 OVERVIEW OF WATERSHED AND STREAM HABITAT CONDITIONS

The Wind River is located in the Washington cascades range and discharges to the Columbia River upstream of Bonneville Dam. Forestry (logging and road building) is the dominant land use in the Wind River subbasin, with agriculture, transportation corridors, and residential land uses also influencing river processes. Past forestry practices have impacted streams in the watershed through timber harvest, splash damming, wood removal, boulder removal, and the building of roads and bridges. The mainstem Wind River through this area was subjected to splash dam logging and associated stream cleanouts in the early 1900s, which had a profound effect on channel complexity and function. Since that time, the project site has been impacted by agricultural and residential uses, resulting in clearing of riparian and floodplain vegetation. Most of the riparian zone impacts are located on the river-right bank although in some areas there are small stands of 10-20 year old conifer trees from past successful plantings. The riparian zone on the relatively low lying left bank is in good condition other than a stand of scotch broom at the downstream end of the project site near the outlet of the proposed side-channel.

Beginning in 1997, a series of phases of large wood restoration work occurred at the site. These efforts were coordinated by the Underwood Conservation District and involved placing partially buried and anchored large wood structures along the river-left (south) bank along the long eroding meander bend. The downstream portion of the site is highly dynamic and is characterized by a tight meander bend that has resulted from the continual river-right scrolling of the main upstream meander bend. Several of the older large wood structures in this area have failed and the meander bend has continued to scroll and further tighten the downstream meander bend. A large log jam is currently located at this bend. Other than this jam, the stream channel is lacking large wood necessary to provide habitat conditions to support critical salmonid life stages.

In the habitat assessment performed as part of the Wind River Restoration Strategy, the reach that encompasses the project area (Reach Wind 5a) was rated as either fair or poor for numerous attributes including Riparian Condition, Floodplain Connectivity, Bank Condition/Channel Migration, Pools, Large Wood, Mainstem Habitat Complexity, Off-Channel Habitat, and Fine Sediment.

3.2 GEOMORPHIC CONDITIONS

3.2.1 Historical geomorphic conditions

The geomorphic and habitat characteristics of the Wind River have changed dramatically since European settlement. Historically, a complex matrix of floodplain vegetation communities would have existed within the riparian zone and floodplain of the mainstem Wind River in this area. This would have included mature conifers that would provide abundant shade and a source of large wood that would fall in the river and create channel complexity, sort gravels and sediment, create side-channel features, and provide high quality fish habitat. Floodplain and side-channel connectivity, for floods and fish, would have been high, with numerous instances of split flow and an abundance of floodplain wetlands and off-channel features created by the dynamic lateral movement of the river over time.

In the early 1900s, and possibly earlier, the Wind River was impacted by splash dam logging, which included the construction of temporary wooden crib dams that were intentionally breached to facilitate log transport downstream. Although the specific activities related to log drives in the reach are unknown to the investigators, it was typical of the time to cut off side-channels, remove natural wood accumulations, and blast out boulders to increase the efficiency of log drives. These practices, along with later impacts related to agriculture and residential development, have resulted in the lack of habitat and geomorphic complexity that exists today.

3.2.2 Current geomorphic conditions

An overview of conditions can be seen in the aerial photo (Figure 2) and LiDAR (Figure 3) site maps provided at the end of this section. A long glide is located at the upstream end of the project reach. There is a 700 foot long side-channel on the right bank adjacent to the glide. A downstream riffle and mid-channel bar provide a hydraulic control for the glide. The existing glide and hydraulic control provide very good conditions for splitting flow into the proposed left bank side-channel. Downstream of the mid-channel bar begins a broad sweeping left-hand bend. There are several private residences on the relatively high right (southerly) bank at the outside of the bend. This is the location of the dozen or more large wood structures that were installed along the outside of the bend beginning in 1997. The inside of the bend is comprised of a forested floodplain, which has a maximum width of over 800 feet. The river-right bank is mostly cleared of woody vegetation except for a few patches of conifers, some of them planted as part of past restoration efforts or by landowners 15-20 years ago.

The river flows north out of the broad sweeping bend and turns abruptly south through a tight radius bend. On the left bank, at the apex of the tight radius bend, is the location of the proposed side-channel outlet. Upstream of the tight bend on river-right, there has been recent (winter 2015/16) erosion and meander scrolling. This can be seen in the aerial photo (Figure 2) but had not yet occurred as of the 2015 LiDAR flight (Figure 3). Due to the tight radius of curvature of the bend, the increased channel length, the reduced channel gradient, log jams, and active gravel deposition at the bend, it appears to be primed for an avulsion via a neck cutoff. This is evident from channels that have already avulsed across the tip of the narrow peninsula separating the northerly and southerly flows. There is a large log jam at this location. This is a highly dynamic area, with channel change likely during future floods.

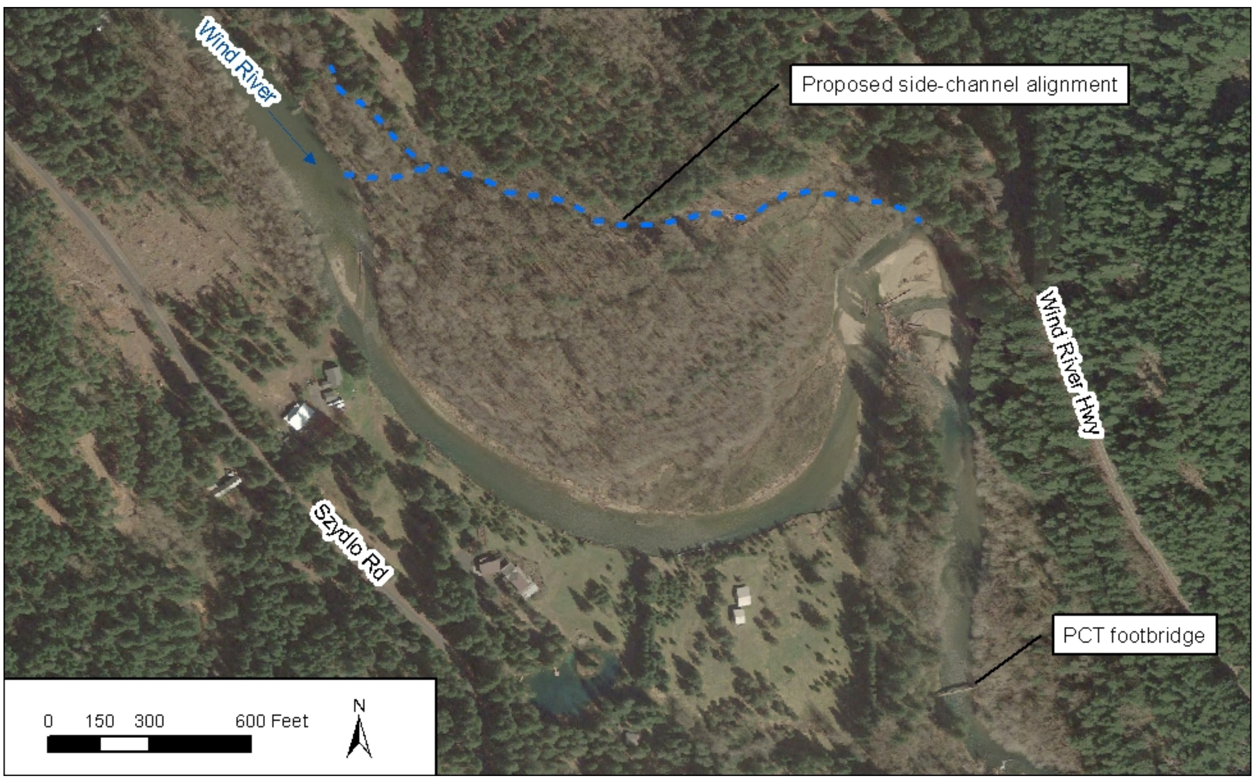

Figure 2. Stabler project site. March 31, 2016 aerial photo courtesy of Google Earth.

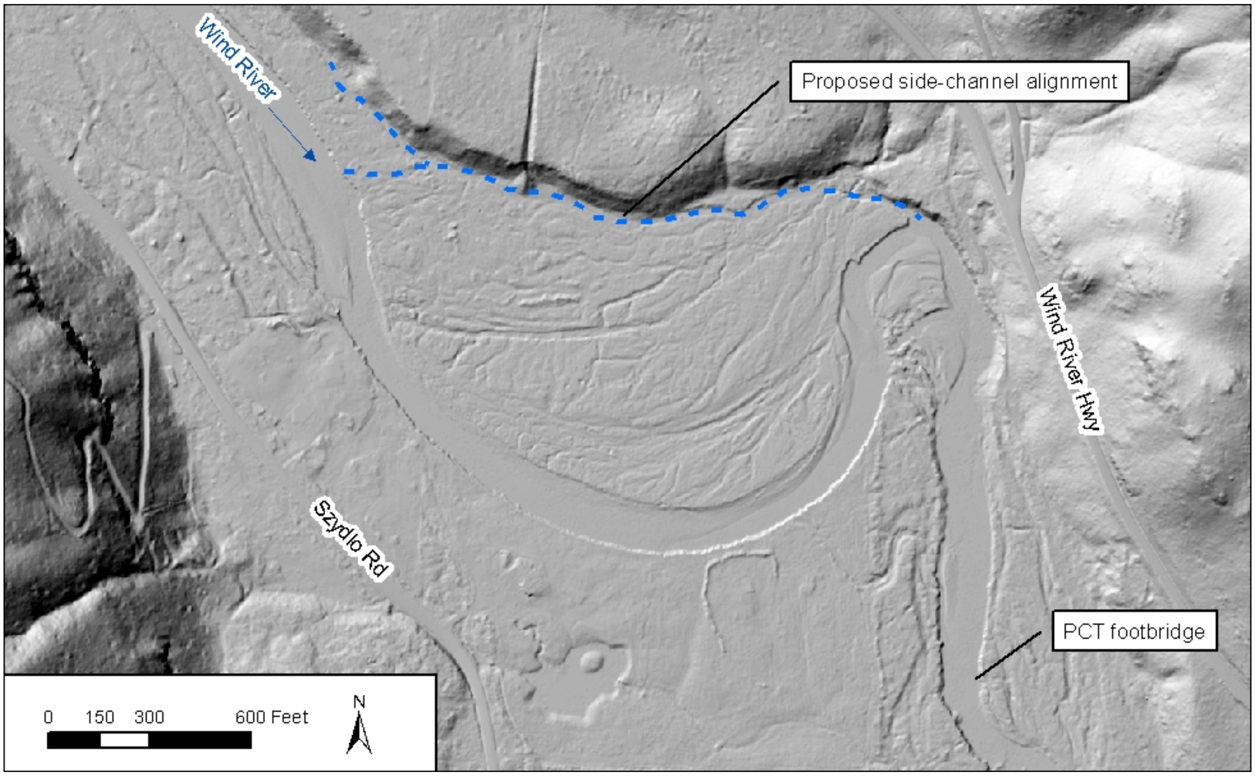

Figure 3. Stabler project site. 2015 LiDAR (DOGAMI 2016).

4. Hydrology and Hydraulics

4.1 HYDROLOGY

4.1.1 Hydrologic Setting

The Wind River is a 5th order stream emptying into the Columbia River at RM 154.5 near Carson, WA. The river is approximately 31 miles long, and the basin drains approximately 225 square miles. The project site is located at river mile 13 and has a drainage area of approximately 105 square miles. The project site is located at approximately 950 feet elevation. The basin contributing to the project site has a mean annual precipitation of 104 inches, with the highest precipitation occurring between November and April, and summer months having very little precipitation. The maritime climate produces cool, wet winters and hot, dry summers. Snowfall is light due to mild winters and the relatively low elevation of this watershed, and rain on snow events do occasionally occur.

The historical USGS gage near Stabler provides some information on streamflow patterns. The month with the greatest discharge is December, with a mean of 955 cfs and the month with the lowest discharge is September, with a mean of 101 cfs. According to the Ecology gage, flows get down to as low as 53 cfs on a low water year (2015 and 2016).

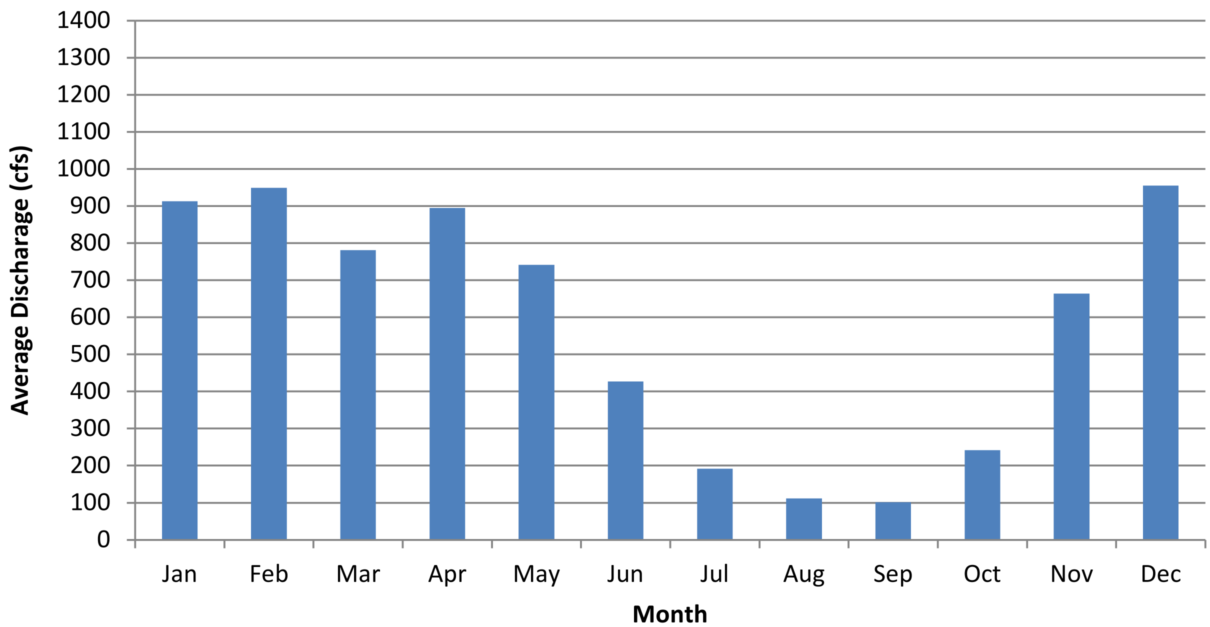

Figure 4. Average monthly discharges from USGS Gage 14127000 Wind River above Trout Creek near Carson, WA. The gage location is in Stabler, WA. Values are from the limited period of record at the gage and extend from 1944 to 1969.

4.1.2 Peak Flow Analysis

A hydrologic analysis of the site was conducted in order to estimate the magnitude of peak flow events for several standard recurrence intervals (2-, 5-, 10-, 25-, 50-, and 100-year). There are past and current stream gaging data available for the Wind River at Stabler, just downstream of the project area. The USGS operated a gaging station from 1944 to 1969 (USGS 14127000 Wind River above Trout Creek near Carson, WA) and the Washington State Department of Ecology (Ecology) has operated a gaging station since 2008 (Wind R. @ Stabler #29C100). For peak flow analysis, the Ecology gage is not suitable because a rating curve has not yet been established for flows over 2,680 cfs. Therefore, peak flow estimates from the 2- to 500-year events were obtained from Mastin et al. (2016), which uses a combination of the historical USGS gage data and regional regression equations (Table 1). In addition, we used 2,750 cfs as an estimate of the annual (1-year) recurrence interval flood based on observing the lowest annual peaks from the USGS gage and Ecology gage (in years when rating curve not exceeded).

Table 1. Recurrence Interval Flows used for hydraulic modeling at the Stabler project.

	Recurrence Interval								
	1-year	**2-year**	**5-year**	**10-year**	**25-year**	**50-year**	**100-year**	**200-year**	**500-year**
Flow (cfs)	2,750	5,240	6,810	7,780	8,950	9,790	10,600	11,400	12,400

4.2 HYDRAULICS

Although flow pathways, wetted widths, and flow velocity can be observed on the landscape and recorded by collecting survey data or imagery, the information is only relevant to existing conditions during a particular time and flowrate. Furthermore, parameters such as velocity and depth can be difficult to measure in the field, particularly during flooding. Hydraulic modeling is useful for predicting the effects of various flow conditions including extreme low flow and various floods upon the existing landscape. It also allows for comparing proposed conditions to existing conditions to inform design. Hydraulic modeling provides an important industry-standard for evaluating the effects of possible enhancement actions.

For the Stabler Bend project, two-dimensional (2D) hydraulic models were developed for existing conditions and the proposed design conditions in order to better understand existing site hydraulics and to help optimize project designs and predict their impacts within the project reach. The 2D hydraulic models for the site were developed in the U.S. Army Corps of Engineers HEC-RAS 5.0 software (USACE 2016) for modeling the hydraulics of water flow through natural rivers and other channels. The following sections describe the capabilities and limitations of HEC-RAS 5.0 and document the development and output processing of the existing and proposed conditions models.

4.2.1 Model Capabilities and Limitations

HEC-RAS 5.0 was used in its two-dimensional (2D) unsteady flow simulation mode with the capacity to model the complex flow patterns, on-site water storage, and temporally variable boundary conditions. The 2D hydraulic model calculates depth averaged water velocities (including magnitude and direction), water surface elevation, and mesh cell face conveyance throughout the simulation. Other hydraulic parameters, such as; depth, shear stress, and stream power can be calculated after the simulation. The model does not simulate vertical variations in velocities or complex three-dimensional (3D) flow eddies.

4.2.2 Model Extent

The project reach is a little over one half mile along the main stem of the Wind River between the inlet and outlet of the proposed side-channel. The hydraulic model extends considerable distances upstream and downstream from the proposed side-channel connections to avoid computational errors that can result if model boundaries are located too close to the project site. The downstream boundary of the model is located at Hemlock Road, approximately 1.2 miles downstream of the proposed side-channel outlet. The upstream boundary of the model is located at a small bridge approximately 1.3 miles upstream of the proposed side-channel inlet, see Figure 5.

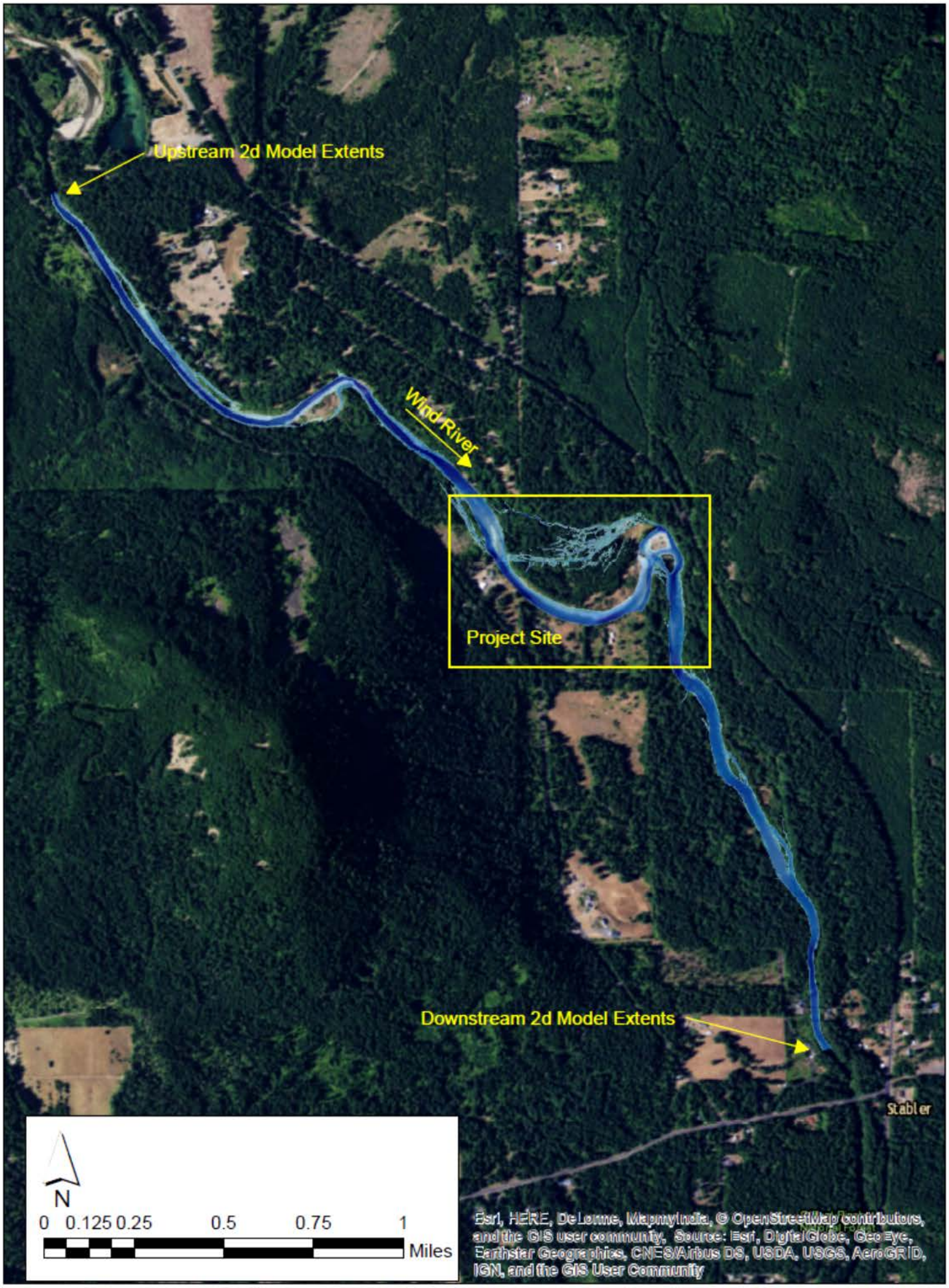

Figure 5, Wind River, Stabler Bend, Side-channel Habitat Enhancement Project Area and 2D Hydraulic Model Extent.

4.2.3 Model Terrain

The exiting conditions model terrain was developed using both ground/bathymetric survey data collected by Inter-Fluve staff in 2016 along with aerial LiDAR acquired in 201. The LiDAR provided a 3 meter horizontal resolution bare earth digital elevation model (DEM) raster for the entire site, including floodplain areas and valley hillslopes. Since LiDAR reflects off the water surface, ground/bathymetric survey data were used for river bathymetry, and other areas of interest, including regions where potential project elements may occur. The ground and bathymetric survey data (points and break lines) were used to create a triangulated irregular network (TIN) surface for the surveyed areas. LiDAR was used to extend the hydraulic model beyond the surveyed bed of the river since flow can exit the main channel in the project reach and flow overland a significant distance downstream, and to extend model boundaries far away from project work. The depth of the streambed surface below the LiDAR surface was estimated in areas where stream bed bathymetry was not surveyed. The ground survey surface was then resampled to a 1-foot resolution DEM raster and pasted over the LiDAR DEM to create the existing conditions model terrain. The proposed condition model terrain incorporated the design grading TIN surfaces into the existing conditions terrain following a similar process. The model terrains are projected on the Washington State Plane South Zone, North American Datum 1983 (NAD83), coordinate system with US feet distance units. The terrain elevations are in US feet relative to the North American Vertical Datum of 1988 (NAVD88).

4.2.4 Model Geometry

The 2D model geometry used a multi-resolution computational mesh adjusted according to terrain complexity and areas of interest. The nominal mesh spacing in complex areas of the main channel and side-channels of interest was 10 feet. A coarser nominal spacing of 25 feet was used in more uniform portions of the main channel and on flatter regions of the floodplain as well as the model edge along the valley toe/hillslope. Break lines were also added to further refine the mesh along the tops of banks, channel alignments, and narrow ridge features (e.g. levees). Although the typical computation mesh size was greater than the terrain resolution the modeling capabilities of HEC-RAS 5.0 integrates the sub-grid terrain into the computations and projects the results accordingly.

4.2.5 Model Roughness

Roughness coefficients (Manning’s n values) are used by the 2D model to calculate flow energy losses, or frictional resistance, caused by channel bed materials, and the type and density of floodplain vegetation. Existing conditions roughness coefficients were applied across the model extent to represent the various types and densities of vegetation or surface conditions. Roughness coefficients where modified in the proposed conditions models to represent immediate post construction conditions. In general, roughness regions were delineated based on field observations, aerial photos, and proposed designs. Roughness values for each region were selected using published guidelines (Arcement and Schneider 1989) for channel types and vegetation conditions, then adjusted for calibration. Table 2 summarizes the roughness coefficients used in the models.

Table 2: Roughness coefficients used in the 2D model.

Region description	Manning's n value
Field with shrubs	0.08
Forested	0.12
Gravel bar with shrubs	0.06
Proposed Channel	0.032
Residential	0.07
Wind River	0.032

4.2.6 Model Calibration

The model was calibrated using surveyed water surface elevations and flow measurements from the Department of Ecology (DOE) gage 29C100 on the Wind River at Stabler. The surveys performed on December 1, 2016 and December 6, 2016 corresponded to daily average flows of 986 cfs and 853 cfs, respectively. Model roughness values were adjusted to approximately match surveyed water surface elevations at those flows.

4.2.7 Model Discharges

The modeled discharges of interest included low flows of 55 cfs and 77 cfs, an annual flow of 2,755 cfs, and the 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year recurrence interval event peak flows listed in Table 1. These discharges were incorporated into a synthetic hydrograph with periods of steady flow (at the discharges of interest) connected by smooth transition periods to create a stair-step like pattern. The periods of steady flow allow the model to come to a quasi-steady state condition improving the interpretation of hydraulics at discharges of interest.

4.2.8 Model Boundary Conditions

HEC-RAS 5.0 2D models require boundary conditions at the upstream and downstream ends of the model to control the flow into and out of the model extent. The synthetic hydrograph described above was applied as the upstream boundary condition. The flow was initially distributed along the boundary assuming normal flow depth at a friction slope estimated from the average channel slope upstream of the model (0.009 feet per foot). The downstream boundary condition assumed normal flow depth at a friction slope estimated from the average channel slope downstream of the model (0.01 feet per foot).

4.2.9 Model Output

To examine the inundation patterns, velocities, and other hydraulic parameters within the model extent for existing and proposed conditions, the RAS Mapper utility of HEC-RAS 5.0 was used to generate results in the form of raster data sets at the discharges of interest. These raster data sets were then loaded into an ESRI ArcMap file to prepare various figures depicting inundation extent, flow depth, and velocity magnitude for existing and proposed conditions. Plan views of model output for existing conditions are provided in Appendix A. Plan views of model output for proposed conditions are provided in Appendix B.

5. Alternatives Evaluation

At the concept stage, the alternative of placing additional main channel large wood was considered. The focus area was at the downstream portion of the project where large wood structures placed in the late 1990s are becoming undermined. Because this is a high energy and highly dynamic area, and because log structures are still providing some habitat benefit, this area was not included in these designs. It is advised to monitor this area into the future and potentially add log jams as a follow-up phase depending on how conditions develop.

6. Project Design

6.1 PRELIMINARY DESIGN CRITERIA

As set of preliminary design criteria have been developed to guide the preliminary design process and to ensure that project objectives are achieved and project constraints understood and explicitly addressed. Development of these design is based upon: 1) Wind River Work Group vision and goals for habitat work, 2) additional information obtained from site surveys, and 3) coordination and communication with stakeholders. It is anticipated that these design criteria will continue to be refined throughout the final design phase. Preliminary design criteria are provided below – by necessity and intention, there is some overlap with the geomorphic and habitat objectives stated earlier in this report:

- Design resilient project conditions that will withstand the predicted hydraulic effects of flood events.
- Provide from 10-25% of main channel flow into side-channel.
- Use a constructed apex log jam to regulate the aperture of the side-channel inlet and to maintain scour conditions to keep inlet open and functioning.
- Use a bank log jam structure on the opposite bank to constrict the main channel flow to assist with diversion of flow into side-channel and maintenance of side-channel flow over time.
- Locate side-channel inlet and configure log jam at inlet to minimize the risk of channel migration away from the inlet location.
- Provide large wood to maintain pool depths within constructed side-channel
- Utilize logs that have intact rootwads that provide stability and create complex pool habitat.
- Discourage the side-channel from capturing the main channel by using large wood placements that limit channel expansion or vertical incision, and that sufficiently increase hydraulic roughness.
- Increase wood quantities to meet or exceed the NMFS standard for Western Cascades streams, which is 80 pieces per mile (>12 inches diameter; >35 feet long).
- Design side-channel geometry to effectively transport sediment that enters it; this will help to maintain side-channel function over time.

- Locate main channel log structures so there is clear line of sight and time for river recreational floaters to avoid structures.
- Place bumper logs on the upstream face of the structures to increase the potential for deflecting river recreational floaters back into the main flow.
- Avoid any adverse impacts to the past habitat restoration project.
- Avoid any increased flood or erosion risk to adjacent private property or infrastructure.

6.2 DESCRIPTION AND BENEFITS OF PROPOSED FEATURES

The preliminary designs include side-channel and habitat complexity enhancement to benefit ESA-listed summer steelhead. The design includes the creation of a side-channel within the low lying left bank floodplain. The side-channel location is aligned with the northerly valley slope through the riparian floodplain forest at the inside of the broad sweeping bend at the site. The side-channel would be located along the hillslope toe, taking advantage of an existing relic channel in the floodplain. This location is expected to receive groundwater seeps from the hillslope toe and hyporheic flow inputs from the alluvial floodplain soils; conditions typical of wall-based channels in similar broad-valley alluvial systems. Much of the side-channel alignment would be excavated to achieve the desired width and gradient, with some portions left unexcavated where there are already deep pools within the relic floodplain channel. Pool and riffle habitats will be constructed within the side-channel. The total excavation volume for the Preliminary Designs is 3,800 cubic yards. A disposal area for the spoils has not yet been determined. Disposing the spoils in a nearby upland area, without having to use the highway, would be a significant cost benefit.

The side-channel inlet would be located near the downstream end of a long glide at the upstream end of the project site. This is considered to be a relatively stable location for the side-channel inlet with respect to potential channel migration. Flow into the proposed side-channel will be encouraged by placing large wood structures at strategic locations in the mainstem at the inlet and across the channel from the inlet. The apex jam at the side-channel inlet will help reduce the potential for sedimentation at the inlet and will help regulate the width and elevation of the inlet. The large wood structure placed along the bank across from the inlet will constrict the main channel flow enough to help divert and maintain flow into the inlet. These two main channel log structures are not only important to support the function of the side-channel, but they will also provide important main channel habitat, including cover, pool scour, and sorting/storage of spawning gravels. Large wood will also be placed within the side-channel to provide cover habitat, maintain pool depths, and provide hydraulic roughness to discourage excessive mainstem flow from entering the side-channel. In total, the preliminary designs include approximately 120 log placements, including the main channel structures and large wood placed within the side-channel. For the main channel large wood structures, additional coordination will be necessary with the landowners in this area in order to proceed with this work.

Numerous iterations of the hydraulic model were performed to determine the appropriate side-channel location, elevation, planform, and cross-section geometry necessary to achieve the desired flow split. The latest model iteration has flow splits ranging from approximately 10 to 30% of the main channel flow depending on total stream discharge. During the final design stage, additional modeling will need to be performed to further define the flow splits at target flows and to determine the channel and log jam configuration that optimizes conditions. Effects on habitat conditions in the mainstem during the lowest flow periods, such as to temperature and instream flow, will need to be further evaluated and incorporated into the final design.

The side-channel should reduce erosion rates on the mainstem Wind River since proposed side-channel flows will bypass the broad sweeping bend that is currently eroding. Modeling suggests that this effect may be relatively small at high flows, but it will nevertheless have some effect on limiting the degree of continued meander scrolling (and thus potential future avulsion). The side-channel outlet will discharge to the tight radius bend where river flows abruptly turn from north to south. In the event of a mainstem avulsion cutting off the tight radius bend, side-channel flows are anticipated to be extended from the apex of the tight radius bend and flow south through the current mainstem alignment to the downstream end of the avulsion pathway; thus still providing off-channel habitat benefits.

6.3 ENGINEERING AND STABILITY CONSIDERATIONS

The project is located in a highly dynamic area in close proximity to private residences and structures, some of which are located within the active floodplain and channel migration zone. Placed structures, including the log jams in the mainstem near the proposed side-channel inlet, will need to be stable during large flood events (e.g. 50- or 100-year event). This could be accomplished in a number of ways, and will likely include some combination of partial burial, attachment to vertically-driven pilings, bracing against existing trees, and alluvial or boulder ballast within the matrix of the structures. The required degree of stability, and the means of accomplishing it, will be determined during the final design stage.

The surrounding floodplain is mapped by FEMA as Flood Zone A. This means it is prone to flooding but a base flood (i.e. 100-year flood) elevation has not been determined. Nevertheless, the design will need to make sure that proposed actions do not increase the elevation of the base flood, and this will need to be properly analyzed and documented.

Although this is not a particularly popular section of river for boating, there is some boating by local residents, typically in the summer months using tubes or other small craft; and there may be occasional boating use at higher flows. For these reasons, main channel log structures will need to be designed with river users in mind. This includes placing structures in clear line of sight from upstream, with enough time for boaters to maneuver around the structures. It may also be necessary to add angled bumper logs to the front face of the structures to divert floating objects away from the structure and back out into the main flow path. Consultation with landowners and other river users should be conducted to inform final design from a river safety perspective.

6.4 OPINION OF PROBABLE COST

Costs associated with construction, permitting, and design services for the Wind River Stabler Bend Side-Channel Habitat Enhancement project have been developed. The cost opinion is provided in Table 3.

Table 3. Opinion of Probable Cost.

Stabler Bend - Opinion of Probable Cost

Preferred Alternative

Construction oversight expenses not included
Assumes revegetation stock/effort completed by Sponsor
Spoils disposal assumes on-site disposal (i.e. no highway travel)

Location	Item	Unit	Qty	Unit Cost	Total
Site-wide	Mobilization	LS	1	$30,000	$30,000
	Access	LS	1	$15,000	$15,000
	Clearing and Grubbing	LS	1	$10,000	$10,000
	Erosion Control	LS	1	$8,000	$8,000
Excavation	Cut	CY	3800	$18	$68,400
	Fill	CY	280	$12	$3,360
	Disposal of Excavation Spoils	CY	3520	$8	$28,160
Large Wood Placements	Large wood	EA	120	$900	$108,000
	Slash	CY	200	$50	$10,000
	Construction subtotal				**$225,920**
	State Sales Tax (7.7%)				**$17,3968**
	Construction cost				**$243,316**
	Permitting				**$35,000**
	Final Design				**$35,000**
	Construction Oversight				**$20,000**

Total	**$333,316**

7. References

Arcement, G.J. and V.R. Schneider. 1989. Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Flood Plains. U.S. Geological Survey Water-Supply Paper 2339.

Fox, M.J. and S.M. Bolton. 2007. A regional and geomorphic reference for quantities and volumes of instream wood in unmanaged forested basins of Washington State. North American Journal of Fisheries Management 27:342-359.

Mastin, M.C., C.P. Konrad, A.G. Veilleux, and A.E. Tecca. 2016. Magnitude, frequency, and trends of floods at gaged and ungaged sites in Washington, based on data through water year 2014 (ver 1.1, October 2016): U.S. Geological Survey Scientific Investigations Report 2016 - 5118, 70 p.

Oregon Department of Geology and Mineral Industries (DOGAMI). 2016. 2015 LiDAR dataset for the Wind River subbasin obtained from DOGAMI fall of 2016.