



Photo: Kachess River, Oct 2019

Kachess River Bull Trout Habitat Design Project

Final Basis of Design Report

SUBMITTED TO



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Kittitas Conservation Trust
120 W. Pennsylvania Ave, #202
Roslyn, WA 98941



PREPARED BY

Inter-Fluve
501 Portway Ave., Suite 101
Hood River, OR 97031

September 2021

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- B. Bid / Pay Item Table
- C. Construction Specifications
- D. Opinion of Probable Construction Costs
- E. Large Wood Ballasting Design and Scour Analysis Memorandum
- F. Hydraulic Modeling and Results Memo

1. Introduction

1.1 OVERVIEW

The Kittitas Conservation Trust contracted Inter-Fluve to complete restoration design plans in a section of the Kachess River, upstream of Little Kachess Lake, to improve the quality and quantity of available habitat for ESA listed Kachess River bull trout. This report provides supporting materials and summary descriptions for the habitat restoration treatments designed along 1.2 river miles of the channel and its floodplain (RM 0.55 to 1.75). Project area designation and design criteria have been developed collaboratively with the Kachess Technical Team (KTT)—a working group of stakeholders that includes staff from the Kittitas Conservation Trust (KCT—project manager), US Forest Service (USFS), US Fish & Wildlife Service (USFWS), WA Dept of Fish and Wildlife (WDFW), WA Dept of Ecology (WADOE), Yakama Nation Fisheries, Yakima Basin Fish & Wildlife Recovery Board, NOAA, Mid-Columbia Fisheries Enhancement Group, US Geological Survey (USGS), Yakima County, North Yakima Conservation District, US Bureau of Reclamation (USBR), and Central Washington University.

The Kachess River is home to an isolated native bull trout population. Today, the Endangered Species Act (ESA) listed Kachess bull trout population is low in numbers and their survival is compromised by impaired habitat and human-induced isolation via dam construction. The project area is a significant proportion of the available habitat identified as critical for the Kachess River bull trout (2.2 total river miles) for spawning and rearing of yearlings/juveniles. Year-one has been identified as the most at-risk life stage for bull trout survival in the Kachess. Activities that are suspected of impairing aquatic habitat include the construction of the Kachess Dam (1912) which isolated the watershed from other bull trout populations and seasonal water surface elevation changes of the lake related to dam management for irrigation. Additional direct impacts on the habitat area include historical logging, road building, and mining. These combined impacts over the last 150 years have resulted in increased duration and most likely increased extent of channel dewatering during summer and autumn. Dewatering dangerously limits the quantity and quality of available aquatic habitat for rearing, increases the chance of stranding or death, and constricts up-stream migration timing of bull trout for spawning. Modern and future climate change impacts are also expected to influence precipitation and discharge timing, duration, and intensity in the watershed in the future (Mastin, 2008), which will inevitably further affect the bull trout's seasonal habitat conditions.

A more comprehensive assessment of the Kachess River watershed and the project area is provided in the *Upper Kachess River Watershed and Project Area Assessment* (Inter-Fluve, 2019). Based on defined project goals and the existing conditions of the site, a suite of appropriate concept-level habitat treatment alternatives was developed by Inter-Fluve in April 2019, with estimated relative costs and habitat benefits. KCT and KTT members considered the alternatives, initiated NEPA scoping, and then selected treatment options to be moved forward to engineered designs. In 2020, Inter-Fluve undertook a floodplain groundwater study under the direction of KCT. The objectives of the study were to gain an understanding of floodplain groundwater, east floodplain tributaries, and mainstem surface water relationships to determine if seasonal or perennial connectivity was possible and to

determine how best and where to reconnect the tributaries that were disconnected following logging activities in the areas decades ago. These data then guided the design process of east-side tributary reconnection and floodplain activation that was reviewed and approved by the KTT and USFS. This design set integrates refinements and finalization of the combined design efforts.

This document serves as the Basis of Design Report for the Bull Trout Habitat Design Documents.

This report includes:

- Project area overview and objectives
- Description of supporting surveys
- Summary of existing site conditions
- Project design criteria
- Construction elements
- Kachess River Bull Trout Habitat Design Plan Set – Appendix A
- Bid / Pay Item Table—Appendix B
- Construction Specifications—Appendix C
- Opinion of Probable Construction Costs—Appendix D
- Large Wood Ballasting Design and Scour Analysis Memorandum—Appendix E
- Hydraulic Modeling and Results Memo—Appendix F

1.2 PROJECT AREA DESCRIPTION

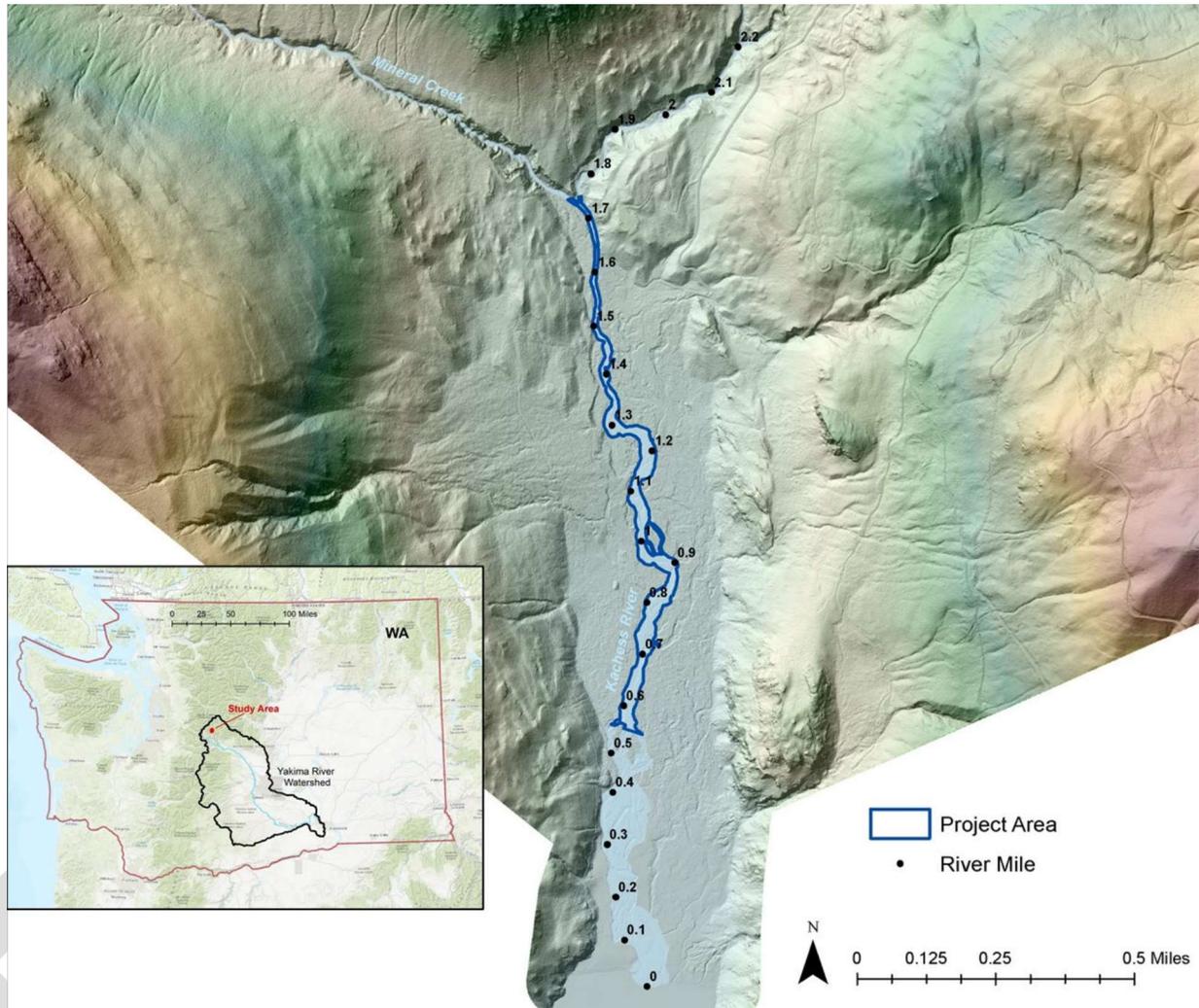


Figure 1. Project Area.

The Kachess River is located on the east side of the Cascade Mountains in Kittitas County, WA within the Okanogan-Wenatchee National Forest. It is a headwater stream within the Yakima River Watershed. The Upper Kachess River flows into Little Kachess Lake, which transitions into Kachess Lake/Reservoir. Kachess Lake was originally a natural lake with an outlet channel that formed behind a terminal glacial moraine deposit. The construction of the Kachess Dam (115 feet tall) in 1912 atop the moraine isolated the Kachess bull trout, notably increased the seasonal elevation of the lake, and increased the area of inundation behind the dam at high-pool. The Upper Kachess River flows into Little Kachess Lake and its 2.2 river miles have been defined by local conservation and regulatory agencies as the critical area for improving bull trout habitat conditions. The Upper Kachess watershed rests entirely on public lands managed by the US Forest Service. The project area includes the mainstem channel and its floodplain from river mile 0.55 to 1.75, at the confluence with Mineral Creek (Figure 1). Contributing watershed measured at the downstream end of the project area is 10.4 square miles.

1.3 PROJECT OBJECTIVES

The primary goal of this project is to improve spawning, rearing, and migratory conditions for the ESA listed Kachess River bull trout in the designated project area (RM 0.55–1.75). The designs for habitat treatment focus on meeting these goals within the constraints and guidelines of existing infrastructure and regulations. In lieu of not being able to remove the dam or alter irrigation management practices, the habitat treatments address identified limiting factors, while being appropriate and relatively sustainable within the geomorphic/hydrologic context of the contemporary river system. All design efforts are guided by the objective of doing no additional harm to the species of interest. Although restoration goals within the project area are focused on improving and increasing available Kachess River bull trout habitat, other species and environments are also considered, including ESA listed spotted owl.

1.4 SITE SURVEYS

Field surveys that support this effort were conducted by Inter-Fluve staff on July 23, August 30 – 31, and October 8 – 10 in 2018 and, after alternative treatment selection was finalized, design survey was completed by Inter-Fluve October 9–12, 2019. Seven floodplain groundwater monitoring wells were installed Sept 10–11 and 16, 2020 and the final design survey was completed October 27–30, 2020. KCT staff and WDFW biologists periodically collected discharge and water stage data, mapped the extent of dewatering, and organized fish rescues during July through October in 2018 and in 2019. Five piezometers were installed by Inter-Fluve and KCT with pressure transducer/water level data loggers that have collected water depth stage in the mainstem channel since August 30, 2018. Data has been collected and processed for loggers through July 29, 2021. Unfortunately, the barometric data logger deployed for pressure corrections required to process this data was damaged by winter conditions ice, resulting in the loss of data from Dec 2, 2018 to March 3, 2019. The usable water level data recorded at 15-minute intervals has supported the hydrology analysis and modeling efforts. Collection of high-resolution LiDAR for a 0.5-meter (cell size) Digital Elevation Model of the bare earth topography and first return landcover was collected between October 4–13, 2018 and processed by Quantum Spatial (2018) for the entire Upper Kachess watershed (8,341 acres). Topographic and bathymetric survey data collected by Inter-Fluve was integrated into the LiDAR to create the detailed surface model used for modeling and design efforts.

2. Site Conditions Summary

This section of the report summarizes highlights from the detailed assessment of the treatment area provided in the *Upper Kachess River Watershed and Project Area Assessment* (Inter-Fluve, 2019). The reader is referred to the Assessment for additional detail.

2.1 LAND USE IMPACTS

Anthropogenic disturbance in the area is primarily associated with post Euro-immigration to the region. In addition to fur trapping, early settlers engaged in ore and placer mining in the Kachess watershed (Becker, 2005). Dam construction, mining, and timber harvesting over the past 150 years have negatively impacted geomorphic and ecologic function. Reports indicate that mining began in the Mineral Creek watershed in 1917 (Kugel 2018). Mining was focused primarily on ore load mining of copper, but reports indicate that silver, molybdenum, and perhaps gold mining occurred in Mineral Creek, most productively in the early 1920s (Hudson Institute of Minerology, 2018). The Kachess Dam was constructed by the USBR in 1910–1912 at 115 feet high (de Miranda et al., 2003; Baldwin, 1913). Completion of the dam and its impoundment and downstream irrigation schedule have imposed significant changes on the river-lake hydrology, geomorphology, and aquatic habitat connectivity. Since the dam was constructed, seasonal lake elevations fluctuate by up to 60 feet (USBR and WADOE, 2018).

Logging activities in the Kachess River watershed have significantly impacted the hillslopes, valley floor, and channel. In conjunction with the construction of the Kachess Dam (1910–1912), 54 acres of mature forests that covered the downstream-most 0.45 miles of the Upper Kachess River Valley floor were logged and cleared to accommodate reservoir impoundment. Commercial logging on the valley floor began in 1968 (Swan and Lind, 2020). Aerial photographs from 1942 compared to 1975 and 1986 reveal extensive clear-cut logging on the floor of the valley, including removal of riparian forests that bordered the channel and road crossings through the channel. Aerial photos from 1999 show additional extensive hillslope logging and road construction throughout the eastern portion of the watershed. It is presumed that the large wood that existed in the channel and across the floodplain prior to logging was removed to facilitate unencumbered transport of equipment and floodwaters—further simplifying and degrading bull trout habitat. Immediately after logging, the lack of large wood in the channel and lack of standing mature forests on the floodplain resulted in channel widening and simplification. Although forests are gradually growing back on the historically logged areas of the valley floor, the channel’s capacity to recover from these impacts may take longer than the remaining bull trout population can sustain.

2.2 GEOMORPHIC SETTING

The bull trout habitat treatment area associated with these designs is located within the mainstem river and adjacent valley floor surfaces of the Kachess River upstream of Little Kachess Lake. The Kachess River Valley is a broad glacial valley filled with unconsolidated glacial till and outwash as well as alluvium. The substrate material (sand, gravel, cobble, and boulder) is considered to have high groundwater conductivity (Mastin, 2008). Field observation as well as water temperature and water quality in isolated scour holes and water elevations in the scour holes in the mainstem channel bed indicate that hyporheic processes and groundwater transfer is efficiently occurring through the valley alluvium.

The treatment area of the *Kachess River Bull Trout Habitat Design Project* (Appendix C) includes the mainstem channel and adjacent flood plain surfaces upstream of high-pool stage (clear cut and seasonally inundated delta area—Reach 1). The area generally includes Reaches 2–4, as defined in the *Upper Kachess River Watershed and Project Area Assessment* (Inter-Fluve, 2019). After assessment and review, no treatment actions are currently designed for the downstream delta, Reach 1 (RM 0–0.55), upstream of RM 1.75, or in Mineral Creek. Concept level treatment options were provided for Reach 1 and could be moved forward to design in future phases—accessed via barge or boat across the lakes.

2.2.1 Geology

The glacially carved U-shaped valleys of the Upper Kachess River and Mineral Creek are filled with unconsolidated glacial outwash, till, or alluvium and colluvium sourced from the steep glacially carved hillslope walls. The glacial till deposits on the west side of Kachess Valley have produced notable landslide and debris flow contributions. The complex geologic assemblage of the basin's geology produces a mixed lithology of sediment that has accumulated in the valleys including basalt, rhyolite, granodiorite, schists and other mixed metamorphics. The Kachess watershed is located at the border of the North Cascades and South Cascades Geologic Provinces. The Cascade Provinces of Washington are a complex assemblage of lithologic types shaped by millions of years of accretion, sedimentation, tectonics, and volcanic activity. The formation of the Cascade Range is powered by subduction along the western margin of the North American Plate that fuels volcanism throughout the Cascades, an area that extends from California to southern Canada (DNR, 2019; Reiners et al., 2002). The North and South Cascades Geologic Province boundary is aligned with the

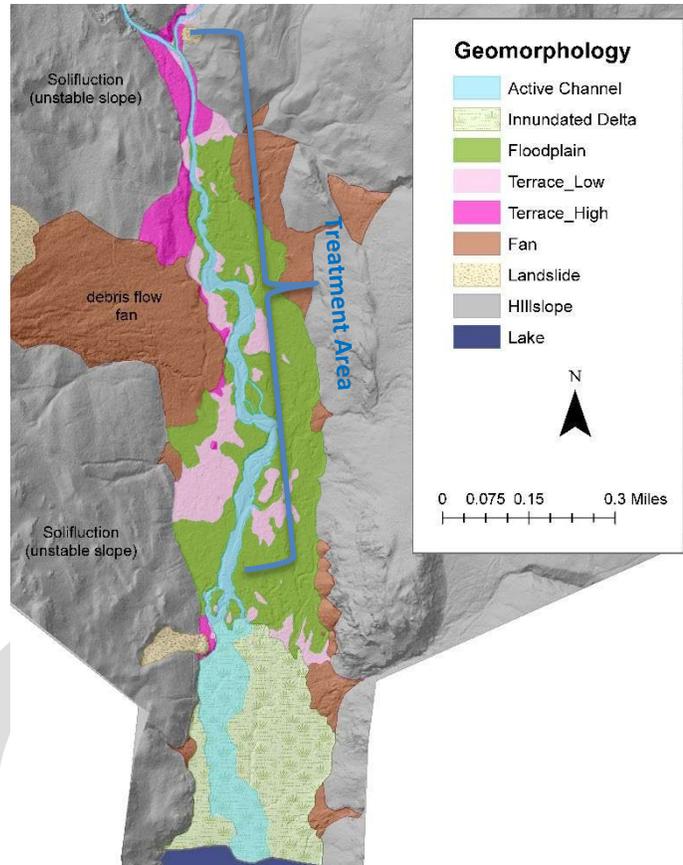


Figure 2. Geomorphic surface map of the project area.

Straight Creek Fault, which trends south-southeast and runs along the eastern edge of the Kachess Valley and Lakes. East of the dividing fault, surficial geology includes continental sedimentary, metamorphic, and volcanics. West of the Straight Creek Fault, the surficial geology is comprised of continental sedimentary, volcanics, intrusive granodiorites, and volcanics (Czajkowski 2016).

2.2.2 Soils

The soils of the Upper Kachess are derived from weathering and erosion of the local geology, aerial contributions of volcanic ash, and decomposition of plant material. The primary bedrock erosion mechanisms include glacial, fluvial, frost/ice fracture, and gravity (landslides and colluvium). In general, the soils of the Kachess are relatively immature, forming only since the recession of glacial ice from the valley approximately 13,000–11,000 years ago. Where it exists, topsoil is a relatively shallow (0–4 inches) layer of moderately decomposed plant material. Volcanic ash sourced from Cascade volcanos is included in most of these loamy or sandy soil types and all soils are well to moderately-well drained. Hillslope soils are derived from glacial till mixed with volcanic ash or composed generally of residuum, fragments, and/or colluvium of eroded bedrock, often mixed with ash. The alluvial soil of the Kachess River Valley and small sections of Mineral Creek is an ashy sandy loam or very cobbly ashy sandy loam topped with a few inches of organic soil derived from decomposing plant material. Below the sandy loam layer(s) is usually a stratified, extremely cobbly sand to gravel layer. The substrata below the upper soil layer in the Kachess River Valley is described as coarse glacial outwash of varied depths.

2.2.3 Sediment

The bedload sediment of the Upper Kachess River project area is relatively mobile within the modern active channel boundaries. Material ranges from coarse sand to boulders that are rounded to subangular. Varied angularity suggests sediment sources are from different distances upstream (duration in channel), mixed lithology of source material (resistance), and likely proximity to both colluvial and alluvial

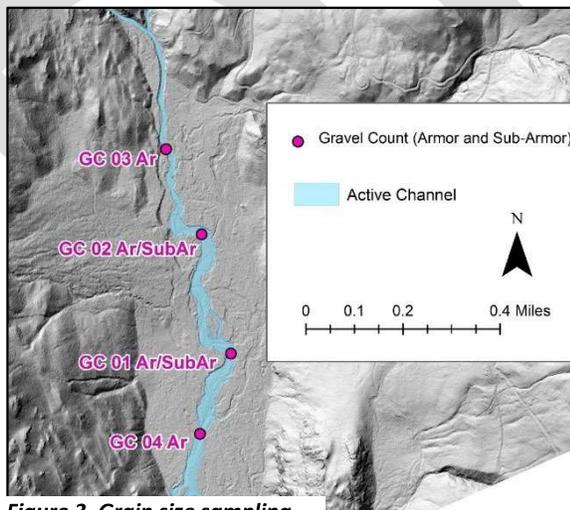


Figure 3. Grain size sampling locations and percent distribution of sand, gravel, cobble, and boulder in the surface and sub-surface samples.

Material	GC 01 Armor % Composition	GC 01 Sub-Armor % Composition	GC 02 Armor % Composition	GC 02 Sub-Armor % Composition	GC 03 Armor % Composition	GC 04 Armor % Composition
Sand	0%	8%	0%	9%	0%	1%
Gravel	35%	42%	45%	58%	39%	43%
Cobble	64%	50%	55%	23%	49%	55%
Boulder	2%	0%	0%	0%	13%	1%

contributions. Grain-size sorting on bedforms reveals varied flow-path hydraulics at the falling limb of a storm hydrograph. Field observations and the grain-size analysis results at four representative sites (Figure 3) of the surface sediment (armored channel bed) is predominantly composed of cobble-sized material (64–256 mm B-axis diameter) with sand (<2 mm diameter) being basically absent. The sub-armor bulk samples collected from below the armor layer were observed and sieved to have a much higher sand and more gravel (2–64 mm B-axis diameter) composition than the surface material. For example, GC 02 sub-armor

sample had a greater composition of gravel than cobble. Sand and gravel in the sub-armor layer and lack of it on the surface indicates that plucking and armoring occurs on the channel bed at subsequent flows. The composition of grain size during mobilization of the channel bed is likely a mix of sand to cobble-sized material, similar to that in the sub-armor samples.

The surface/armor grain-size distribution analysis are used to calculate the critical shear (force needed to mobilize grains. When the shear stress exerted on the bed is greater than the critical shear needed to mobilize a grain of a particular size, bed mobility is predicted. The critical shear stress (τ_c) in pounds per square foot has been calculated for the D_{50} (50% of the bed equal or smaller than this diameter) and the D_{84} (Table 1).

Table 1. Calculated critical shear stress (τ_c) for the D_{50} and D_{84} grain size at the four surface/armor gravel count surveys (2018)

Sample ID	Sample Type	D_{50} (mm)	D_{50} (ft)	θ°	τ_{c50} (psf)	D_{84} (mm)	D_{84} (ft)	θ°	τ_{c84} (psf)
GC01 surface	Pebble count	66	0.22	0.03	0.67	202	0.66	0.03	2.05
GC02 surface	Pebble count	69	0.23	0.03	0.70	123	0.40	0.03	1.25
GC03 surface	Pebble count	70	0.23	0.03	0.71	169	0.55	0.03	1.71
GC04 surface	Pebble count	69	0.23	0.03	0.70	132	0.43	0.03	1.34

The shear stress results generated by the 2D hydraulic model (Appendix A) were used to evaluate bed mobility and identify the potential for the 1.5-year estimated flood event to mobilize existing bedload. The critical grain diameter (grain diameter of sediment predicted to be mobilized) was determined by solving the critical shear stress equation assuming that modeled shear stress represents the critical shear stress variable and using a dimensionless shear stress of 0.03. These results were verified against the results of the gravel counts, which suggested that the 1.5-year flood provides a reasonable approximation of the threshold discharge throughout the project area. The critical grain diameter mapping (Figure 4) represents the grain sizes expected to be mobilized at the modeled 1.5-year discharge with existing conditions, based on the modeled shear stress results. When the critical grain diameter is reached, grains that diameter size or smaller have the potential to be mobilized while anything larger in diameter is expected to be stable or deposited.

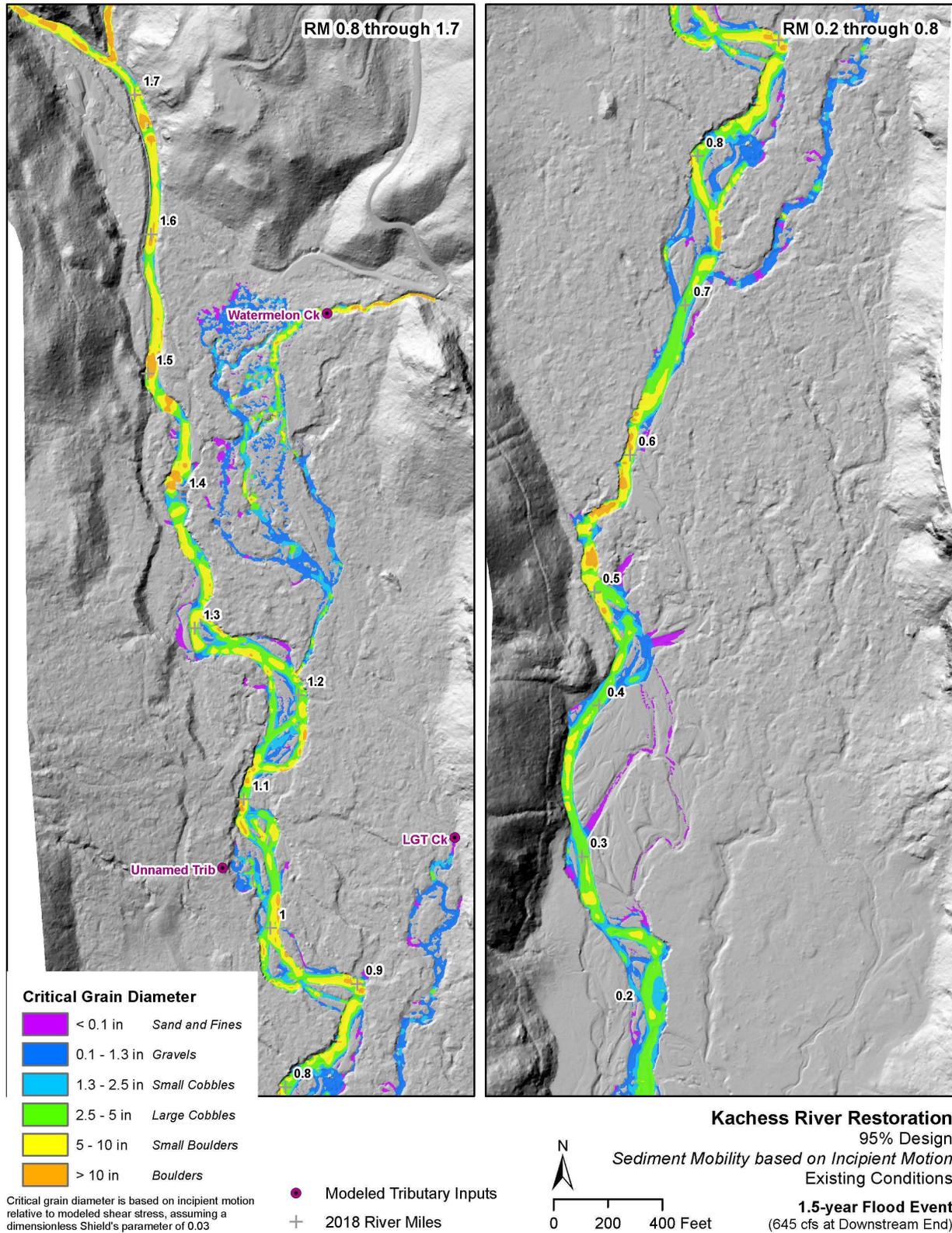


Figure 4. Critical grain diameter derived from modeled shear stress at the 1.5-year event for existing conditions

2.2.4 Large Wood

A survey of large wood within the project area was completed by USFS during June and July of 2017 along with a WDFW survey of wetted width, bank full width, and presence of pools (USFS and WDFW 2017). The 2017 survey found and measured several hundred individual pieces of wood (769). However, only 58 pieces were measured to be the minimum size considered capable of influencing channel process in east-side rivers (≥ 12 -inches diameter and at least 35 feet long) (USFS, 2015). Inter-Fluve noted during 2018 surveys that only very large pieces of wood (> 24 -inch diameter) were influencing channel geomorphology and habitat complexity in a substantive manner. At least 1–3 pieces of very large wood that created a log jam are capable of influencing geomorphic process for more than one year in this system. As a result of the commercial logging that started in 1968, a large portion of the valley forest was clear-cut logged and all very large trees removed. These activities reduced the quantity and quality of available large wood in the channel and the potential for recruitment from the floodplain for several decades. The areas that were logged 50 years ago are gradually revegetating, but the average diameter of trees in these sections is not large enough to act as lone key-members for creating log jams, maintaining scour holes, or securing bars for floodplain development.

2.2.5 Channel

Channel geomorphology varies within the three reaches included in the project area (generally Reaches 2, 3, & 4) located between RM 0.55 to RM 1.75. Table 2 provides the general channel metrics for the reaches of the Kachess River. Channel gradient increases from 1.58 percent in the downstream Reach 2 to 2.16 percent in the upstream reach 4. Sinuosity is greatest in the middle reach 3 and straightest in reach 4, with sinuosity values ranging from 1.43 to 1.07. Active channel width in reach 4 is approximately 65 ft, where gradient is higher, the channel is straight, and valley width is approximately 480 ft. Both the active channel and valley width increases downstream to approximately 212 ft and 1178 ft respectively, in reach 2. Cobble is the dominant bed material throughout the treatment area. In Reach 4, the channel is partially confined within an incised pathway at the toe of debris flow(s)/colluvium deposits that filled this section of the valley at some point in the past. Discontinuous levees, (largest on river left) exaggerate confinement in the mid portion of Reach 4. In the middle reach (Reach 3), the valley widens and the channel increases in sinuosity. Here, the channel is continuing to work through and re-adjust to a large historical landslide/debris flow from the western hillslope that pushed the channel to the east. The downstream portion of the treatment area (Reach 2) is a semi-plane bed channel that is over widened in response to logging impacts and sediment supply.

Table 2. Channel metrics by reach. Project area includes RM 5.55 to 1.75 (generally, Reaches 2, 3, and 4).

	METRIC	Kachess Reach 1 (Delta)	Kachess Reach 2	Kachess Reach 3	Kachess Reach 4	Kachess Reach 5	Mineral Creek (Lower)
Channel and Floodplain	Length (miles)	0.45	0.42	0.44	0.43	0.48	0.79
	River Mile	0.0-0.45	0.45-0.87	0.87-1.31	1.31-1.74	1.74-2.22	0.0-0.79
	Stream Gradient (%)	1.13	1.60	1.58	2.16	5.16	9.69
	Sinuosity	1.23	1.15	1.43	1.07	1.15	1.10
	Confinement	unconfined	unconfined	unconfined	partially confined	confined	very confined
	Average Active Channel Width (ft)	326	212	142	66	33	45
	Dominant Substrate (ocular)	gravel and fines	cobble	cobble	cobble	cobble/boulder	cobble/boulder
	Valley Width (ft)	1118	1178	950	483	50	45

2.3 HYDROLOGY

The project area receives hydrologic surface inputs from upstream contributing hillslopes and tributaries as well as groundwater inflow across the valley. Surface water-groundwater exchange occurs through the thick layer of coarse substrate (glacial outwash, colluvium and alluvium) that fills the valley floor. Segments of the channel dewater in the late summer when groundwater elevations decrease and the quantity of incoming surface water is less than the infiltration rate through the coarse substrate. At the end of summer, the dewatered channel bed extends from RM 0 to RM 1.3. Within the dewatered section, only a handful of disconnected scour holes maintained by large wood jams are deep enough to intercept ground water perennially, providing only a few small pockets of habitat for rearing bull trout in this section of the channel. The water in these scour pools is hyporheic-sourced groundwater throughflow that remains relatively cool even in the summer months. Spring seeps are present along the toe of the eastern hillslope at mid-valley and one seep feeds a small unnamed tributary sourced from a landslide on the west side, also at mid-valley. Cold Creek is a small perennial spring-fed floodplain tributary on the eastern floodplain that joins the Kachess River at RM 0.9. The springs on the west side of the valley are sourced on surface above the floodplain, and then when their water flows onto the relatively narrow strip of floodplain it infiltrates into the substrate.

The hydrology information included in this report is a summary of the peak flow estimates and daily exceedance flow estimates used in the hydraulic model and for design considerations (constructability and fish habitat requirements). Details on the data and analysis used to arrive at these values are discussed in the *Kachess River Hydrology Assessment* (Swan and Lind 2020).

2.3.1 Peak Flow and Daily Flow Estimates

The only working stream gage on the Kachess is located downstream of the Kachess Dam and reflects an irrigation outfall hydrograph. Given the lack of a stream gage that represents the project area, several sources of information and analysis were used and compared to estimate peak flow magnitudes and frequencies for the project area. StreamStats peak flow estimates reported a standard error of 69% for the 5-year return period event to 106% for the 100-year return period event. Therefore, a basin-area ratio analysis on nearby gaged rivers (American, Icicle, South Fork Cedar, and Snow Creek) was done and showed that Snow Creek is the most applicable in precipitation and drainage area for comparison to the Kachess River. The peak flow estimates calculated after Mastin et al. (2016) from the Snow Creek gage (USGS 12103500) were then scaled, based on watershed area, for use in the hydraulic model for the project area.

Estimates of daily flow rates were determined through the development of a regional flow duration curve and by processing water level logger data. A regional duration curve was developed for the project site using a graphical method employed by Wible et al. (2014). The resultant estimated discharge associated with each listed annual exceedance percentage for the downstream end of the project area is provided in Table 2. These discharge estimates were used to model annual hydrograph discharges and evaluate fish habitat requirements to guide treatment design.

Table 3. Annual daily flow exceedance estimates for the Upper Kachess River at the downstream end of the project area.

Daily Exceedance (%)	Days per year Q \geq	Upper Kachess River at downstream end of project area (cfs)
1	3.65	230
5	18.25	139
10	36.5	101
25	91.25	52
50	182.5	23
75	273.75	11
90	328.5	7
95	346.75	6
99	361.35	4

Daily flow rates were also assessed using water level logger data from instruments placed at Mineral Creek (P-01) and the Upper Kachess River at the Mineral Creek Trail crossing (P-02) (Figure 5). Stage-discharge relationships were developed by combining the stage data from the loggers with discrete field-

collected discharge measurement using power functions to define a line of best fit. The resulting functions were then used to generate a time series of discharges from water surface elevations measured by the water level loggers (Figure 6). Lower magnitude discharges are generally higher in Mineral Creek compared to those in the Kachess, demonstrating the loss of surface flow via infiltration into the valley alluvium (i.e., losing reach) during dry months of the year (summer–early autumn). Higher magnitude flows are higher in the Upper Kachess River than in Mineral Creek, showing that flow loss by infiltration rates is exceeded by flow gains from surface water inputs discharge rates during the wet seasons (winter–spring). Note that field measured discharges and staff gage readings were not recorded during any of the higher magnitude flow events captured by the water level loggers. Therefore, discharges greater than ~100 cfs on the Kachess River and ~50 cfs on Mineral Creek are projected and less reliable. Comparing these hydrographs back to the daily exceedance values reported in Table 2, the majority of the low flows are lower than the 95% daily exceedance value.

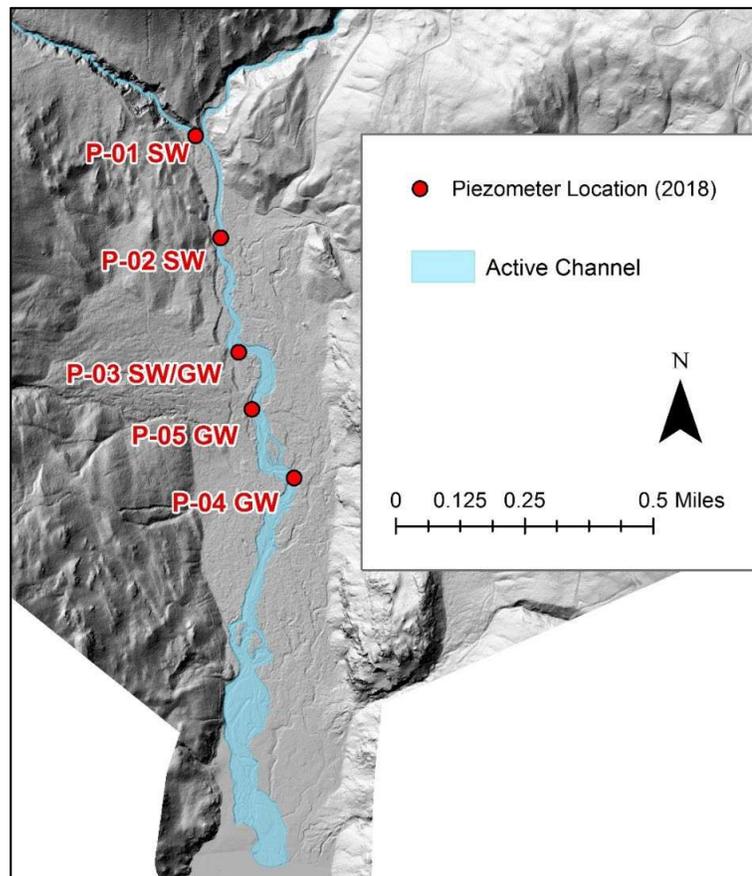
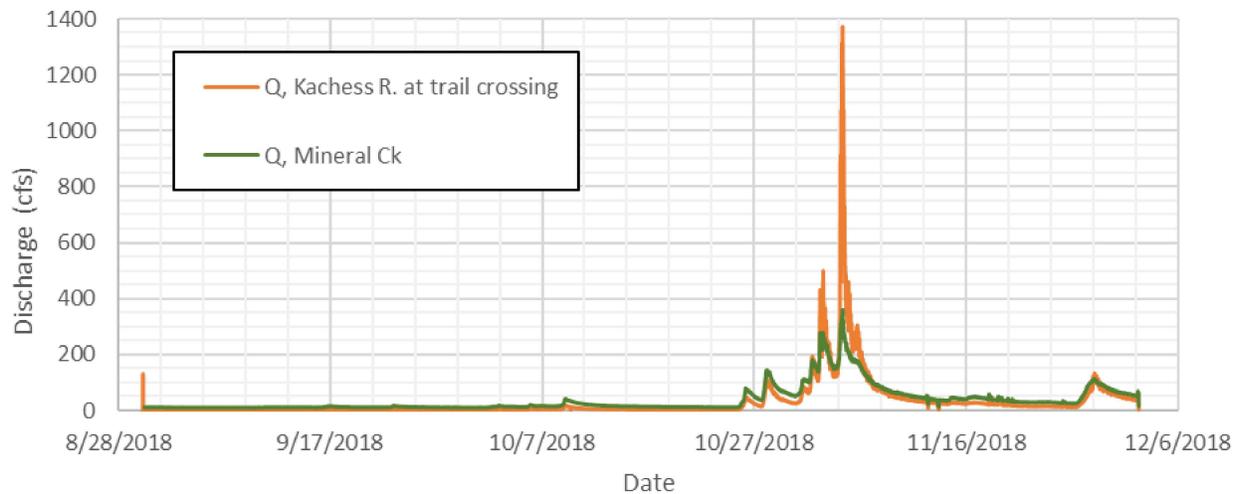


Figure 5. Locations of water level data loggers. installed in 2018.

Calculated Discharge (8/2018 - 12/2018)



Calculated Discharge (cfs) 11/2019 - 3/2020

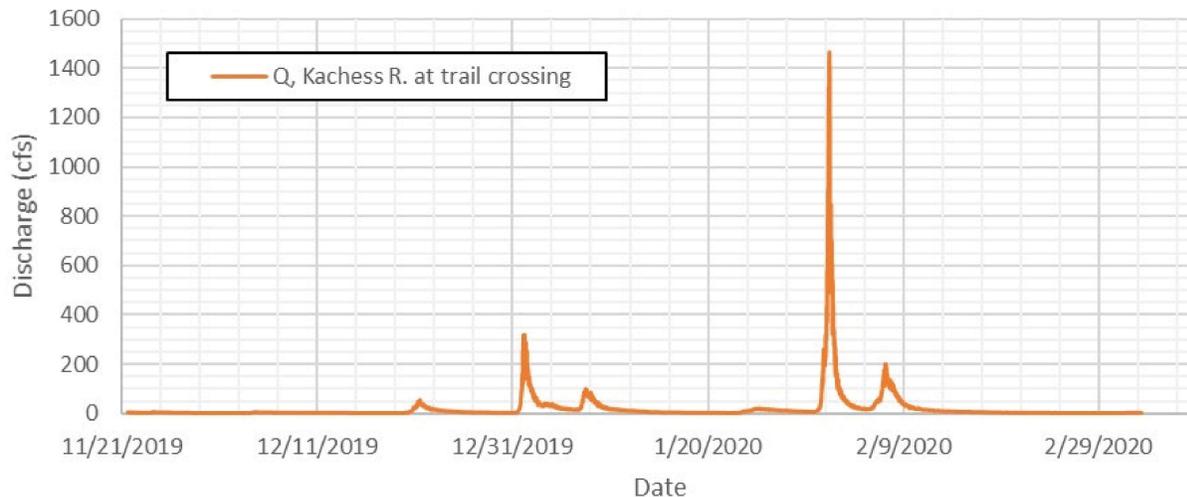


Figure 6. Calculated daily discharge at Mineral Creek and Upper Kachess River (8/30/2018-12/2/2019) and for Upper Kachess River (11/21/2019 – 3/4/2020)

The estimated peak flow discharges as well as selected annual discharges from the projected hydrograph were used in the hydraulic model (see Appendix B) to evaluate stream processes and fish habitat conditions for both existing conditions and proposed design conditions. The flow hydrograph used in the hydraulic model, including its primary contributing tributaries, is provided below in Table 3.

Table 4. Peak Flow estimated discharge for the project area - Upper Kachess River and primary tributaries within the project area.

Summary of Flows used in Hydraulic Modeling (all flows in cfs)								
Flow Recurrence Interval	Upper Kachess	Mineral Creek	Watermelon Creek	Cold Creek	Magic Creek	Cedar Creek	Unnamed Tributary	Total Combined Flow at Little Kachess Lake
95% Daily Exceedance	1.6	2.7	0.5	0.1	<0.1	0.1	0.4	5.4
50% Daily Exceedance	6.7	11.2	1.9	0.6	0.2	0.3	1.9	23
5% Daily Exceedance	29.6	49.7	8.5	3.6	1.0	1.8	44.8	139
1.5-year Flood ¹	193.4	325	55.6	4.5	3.4	6.8	53.8	643
2-year Flood	226	381	65	5	5	10	63	755
5-year Flood	363	610	104	8	9	16	101	1211
10-year Flood	456	766	131	10	11	20	126	1520
25-year Flood	579	973	167	13	14	25	159	1930
50-year Flood	672	1129	193	15	16	29	186	2240
100-year Flood	768	1291	221	17	18	33	211	2559

¹1.5-year flood (66.67%) was extrapolated from the 1% to 50% Annual Exceedance Probability curve

2.4 VEGETATION

The floodplain of the Kachess River within the project area is vegetated primarily with varied age stands of conifer forests that house varied densities of mix stage undergrowth. The right side (west) floodplain from RM 0.7 to 1.8 and the left side from RM 0.9 to 1.6 was clear cut and the surfaced graded approximately fifty years ago. This area is currently slowly regenerating a second-growth fir-dominant forest. Second growth forests are a mix of height classes and maturity, depending on their state and age of regeneration. The primary vegetation of the second growth forests on the valley floor is fir and alder trees with a dense understory of maple, ferns, forbs, and grasses. Downstream of RM 0.7 to approximately RM 0.55 (high-pool lake elevation) is vegetated with old growth forest dominated by mature cedar and fir trees with a moderately dense understory of native plants such as maple, alder, snowberry, nine-bark, forbs, and ferns.

3. Project Design

The design criteria and descriptions of the project elements are provided below. Project elements were collaboratively selected by KCT and the Kachess Technical Team (KTT) working group members through review of shared watershed knowledge and project area assessment materials (Inter-Fluve, 2019), concept alternative analysis review (April–October 2019), preliminary design and analysis review (November 2019–January 2020), draft design and analysis (January 2020–May 2020), and related internal review and decision making associated with regulatory and permitting requirements. Floodplain and tributary reconnection elements are now included after field observations, pit tests, survey, modeling, and preliminary groundwater data analysis (Sept–Dec 2020). The project element descriptions below include benefits relative to the project design criteria, design considerations, specific evaluations completed to support the designs, and construction considerations. The Kachess River Bull Trout Habitat Design—95% and Floodplain-Tributary Concept Design Plans are provided as an appendix.

3.1 DESIGN CRITERIA

The design criteria listed below were developed in collaboration with KCT and members of the KTT. The list of design criteria incorporates site conditions, project area objectives, construction impacts, regulatory constraints, USFS public lands recreation usage planning, and feasibility. Design criteria serve three primary purposes: 1) to clearly document and communicate specific project objectives and constraints, 2) to help inform and guide the design process so that objectives are met, and 3) to provide a basis for future performance monitoring.

The following criteria are not presented in order of priority:

- Improve the quantity and quality of available habitat for rearing (year one), migrating, and spawning of ESA listed Kachess River bull trout.
- Extend the duration and area of seasonally available habitat, where possible.
- Increase proximity of available habitat in the dewatered sections.
- Design treatments that are consistent with current and climate change projected hydrologic and geomorphic conditions and trends.
- Minimize impact during construction to existing mature and old growth forests and riparian vegetation.
- Protect identified wetland areas and cultural resources.
- Increase floodplain connectivity where possible.
- Reconnect ephemeral tributaries disconnected by logging activities on the east side of the valley.
- Consider USFS trail re-route and recreation access (hiking or snowshoeing).

- Increase natural gravel retention in the upstream portion of the project area (Reach 4).
- Design features to manage flow energy and erosion potential.
- Design treatments that consider potential risk to ESA species during and after construction.
- Sequence treatments to optimize system recovery.
- Use existing natural features to support treatments.
- Minimize impacts to intact habitat (aquatic, terrestrial, and avian).
- Locate and configure construction access to use existing access routes wherever practical (USFS roads). Where existing access routes do not exist, temporary access routes will be developed to limit impacts to existing plants and sensitive surfaces—e.g., access routes along dry channel beds, inside-out construction, strict limits of disturbance and access route widths. All access routes used during project installation will be decompacted and remediated.
- Use biodegradable erosion-control materials for temporary erosion control until vegetation becomes established.
- Coordinate efforts with planting treatments to emphasize native species and minimize establishment of non-native species.
- All treatments will be permissible within the current Aquatic Restoration Biological Opinion (ARBO II) regional guidelines.
- All work will be confined within the boundary of the approved Area of Potential Effect (APE) and in compliance with any cultural resource survey limitations.

The project can be installed in sequence or phases that provide time for completion to occur over years or months to facilitate seasonal conditions, permitting requirements, and funding. Phasing and sequencing of treatments is recommended such that once restoration equipment leaves an area it does not need to reenter the area again—keeping disturbance as limited as possible.

Several of the elements include hydraulic modeling design considerations. The Hydraulic Modeling and Results Memo (Appendix B) provides information on model development, refinement, and results. The results include model outputs for flow depth and velocities for estimated annual low, median, and high-flow discharges as well as a suite of estimated peak flood events ranging from the 1.5-yr to the 100-yr flood discharge.

As the permitting agency, the US Forest Service (USFS) developed a set of criteria and guidelines that are provided in Appendix C, Construction Specifications.

3.2 PROJECT ELEMENTS

In addition to the above listed design criteria, restoration treatments are designed with the understanding that channels and the landscape of the Kachess River Valley are highly dynamic and evolving. All parties engaged in this effort recognize that the Kachess River is a hydrologically,

geomorphically, and hydraulically dynamic system. Treatments are not expected to keep the channel in a single location or remain in a static state. Project elements are designed to support and enhance conditions within the project area to increase the quantity, quality, and maintenance of available habitat for Kachess bull trout. Project elements are designed to impose no additional risk to Kachess bull trout upon installation. Project elements are designed to support channel and floodplain evolution that improves and ideally sustains geomorphic and ecologic function immediately and over time.

3.2.1 Large Wood

Large wood structures are important components of this restoration project. Large wood (LW) in a channel contributes nutrients, shade, cover, and promotes habitat complexity suitable for many riverine species (Langford et al., 2012). Quality large woody material (QLW) in a channel is expected to influence local geomorphic processes and increase channel complexity by promoting scour and/or sediment retention related to locally induced flow hydraulics, influencing flow pathways, and adding hydraulic roughness that can increase floodplain connectivity and improve groundwater recharge in disturbed systems (Abbe et al., 2019; Abbe & Montgomery, 1996; Brummer et al., 2006; Grabowski & Gurnell, 2016; Langford et al., 2012; Montgomery & Piégay, 2003).

The quantity of QLW within a riverine system depends on the presence of mature or maturing forests upstream and locally, as well as the processes of recruitment (lateral channel migration, infall from banks, debris flows or landslides off hillslopes, in-channel transport, etc.) occurring within the watershed. Tree size (length and diameter) compared to active channel width, channel form, and flow regimes also controls retention and accumulation patterns of the LWM in the channel. Similar to other channels with old-growth vegetated valley floors, it is expected that LW played a critical role in flow hydraulics, sediment retention, system complexity, hydrologic processes, and floodplain development of the Kachess throughout the last several thousand years. Although no records or estimates have been provided, it is assumed that historical LW loading in the channel was much greater than what is observed today. It is expected that loading was most probably increased periodically following events such as the massive landslide evidenced on the west side of the valley or one of the debris flows that filled the upper valley at the mouth of Mineral Creek.

Surveys completed by others (WDFW 2017; USFS and WDFW 2017) found that the mainstem Kachess River is lacking in large wood, such that LW-related habitat metrics for bull trout and other salmonids in east-side channels are not met (Fox and Bolton 2007). Inter-Fluve noted during 2018-2020 surveys that only very large pieces of wood (>24-inch diameter) were capable of influencing channel geomorphology and maintaining habitat complexity in a substantive manner in the Kachess. Currently, only a few QLW-sized large wood pieces or jams are supplying sufficient enough influence on the channel to provide perennial habitat benefits. After restoration treatments are completed, LW loading in the mainstem channel will better reflect recommended minimum habitat metrics for large wood distribution, as described by Fox and Bolton (2007).

The current lack of QLW in the Kachess project area is related to commercial logging that started in 1968, resulting in a large portion of the valley forest being clear-cut logged and its surfaces graded and channel banks disturbed. Old growth forests were removed from large portions of the

floodplain, riparian zone, and the channel. The channel and floodplain are still responding and recovering from the impacts associated with this large-scale disturbance. See Assessment Report for more details [Inter-Fluve 2019]. In addition to landscape disturbance and channel response, logging activities reduced the quantity and quality of available large wood for potential recruitment into the channel for several decades, if not a century. The areas that were logged are gradually revegetating, but the trees in these sections are generally not large enough yet to act as a key-log (QLW) for creating a substantive log jam for a long enough period of time to provide persistent scour holes, or securing bars for floodplain development. The lack of QLW in a recovering system with dynamic hydraulics has made reestablishment of riparian forests and floodplain challenging in the Kachess. A lack of QLW in the channel also reduces hydraulic roughness such that surface water velocities and stream power are higher and the benefits of slowing down surface water, such as an increased timeline for groundwater recharge/retention and sediment retention, are diminished.

The designed installations of large wood in the Kachess will notably increase the quantity of LW in the channel and are expected to provide a range of geomorphic and ecologic functions summarized above. The size of the LW structures (number and orientation of large wood pieces) and burial requirements are designed so that they function as QLW jams in relation to modeled flow hydraulics and local processes. The design elements of the different LW structures developed for the Kachess are described below.

Bank Buried Large Wood Structures (BBLW)

Description and Benefits

Bank Buried Large Wood (BBLW) are engineered log structures constructed along and buried into the bank of the channel. Each BBLW is designed with: fifteen 40-ft logs with rootwads with an 18" minimum diameter at breast height (dbh) and slash for log spacing infill. The jams include a dug scour pool beneath the exposed root wads that is 4-ft deep and extends in front of the root wads 6-ft and laterally 4-ft on each side. The trunks of the logs are ballasted by burial in the bank and backfill with salvaged gravel, cobble, and boulders to a minimum burial depth of 2 ft. Typical drawing and installation parameters are provided on Sheet 22 of the Design Plans with Large Wood Quantities and location tables provided on Sheet 30. The trunks of the logs are buried into the bank for stability and the rootwads extend into the channel to provide hydraulic, geomorphic, and habitat function. Design intentions of bank buried jams are to:

- Promote/maintain high-quality habitat for bull trout within the mainstem channel that provides complex overhanging cover at a maintained scour pool.
- Direct flow hydraulics to support and define a narrower single-thread channel form at low-flow to increase duration of wetting and complexity of channel bed.
- Increase hydraulic roughness such that hydrologic function (surface water retention duration, floodplain connectivity, groundwater recharge) is increased.
- Influence flow direction along the bank in appropriate locations to support channel form and/or bank stability.
- Capture and retain rafted woody material to rejuvenate jam structure over time.

- Act as a substantive structure in the channel and floodplain that is capable of promoting and potentially speeding up channel adjustment/recovery.

Design Considerations

- Location along the bank relative to existing channel form and/or restoration treatments.
- Avoid installation at locations with existing desirable mature trees for conservation.
- Distribution and location to provide desired proximal habitat with other features.
- Hydraulic processes and the feature's influence on channel processes and floodplain connectivity.
- Likelihood and longevity of the jam to maintain and provide habitat.
- Installation is expected to NOT increase risk of survival to target species and is expected to be usable as habitat upon construction completion.
- Constructability of the jams – including, but not limited to access, seasonal hydrology, availability of materials.

Design Evaluations and Rational

- 2-D hydraulic modeling was done to estimate flow properties (i.e., velocity, depth) for both low and high-flow discharge events.
- Flow hydraulics combined with wood stability calculations for burial and ballasting requirements to determine log quantities, diameters and lengths.
- Estimated pool scour maintenance, inundation frequency, and placement in proximity to low-flows to increase bull trout survivability.
- Local scour conditions and scour pool maintenance potential.
- Size and number of logs required to meet design intentions.
- Inundation frequency.

Construction Considerations

- Timing: dry-season access and construction to minimize risk of impacting aquatic species and water quality
- Adequate access routes and available nearby staging for materials, temporary stockpiling, delivery, and needed equipment
- Revegetation potential and stability of disturbed bank.
- Potential for dewatering or erosion control requirements during installation in wetted section.
- Installation techniques and regional availability of equipment to construct.

Mid-Channel Large Wood Structures (MCLW)

Description and Benefits

Mid channel large wood structures (MCLW) are engineered log jams constructed within or at the margin of the mainstem channel. Each MCLW is designed with: five 50-ft logs with rootwads with a 24" minimum diameter at breast height (dbh); 22 40-ft logs with rootwads with an 18" minimum dbh; ten 30-ft log piles with a 16-18" dbh; and slash for log spacing infill. Each MCLW includes a dug scour pool at the exposed root wads that is at least six feet deep and extends in front of the rootwads six feet and laterally on both sides by four feet. The trunks of the lattice logs are ballasted by burial with salvaged gravel, cobble and boulder to a minimum depth of three feet. Typical drawing and installation parameters are provided on Sheets 22, 22, and 24 of the Design Plans with Large Wood Quantities and location tables provided on Sheet 30.

MCLW structures are designed to function as key features within the active channel boundary that are capable of persisting and influencing channel and floodplain processes over time. The engineered log-jams are expected to sustain and develop complex channel morphology, improve hydrologic function of the channel, and support the growth of mature patches of floodplain forest on their downstream side that will provide LW benefits in the future to the system (Montgomery and Abbe 2006). MCLW structure design intentions are to:

- Increase density of maintained scour pools that are sufficiently deep to both intercept groundwater (rearing habitat) and support flow path routes (up-migration)
- Increase hydraulic roughness such that hydrologic function (surface water retention duration, floodplain connectivity, groundwater recharge) is increased.
- Define a more-narrow single-thread channel form at low-flow to increase duration of wetting and complexity of channel bed.
- Capture and retain rafted woody material to rejuvenate jam structure over time.
- Create hydraulics that promote vegetated bar and floodplain development immediately downstream of the jam.
- Sustain narrowed low-flow channel form and increase floodplain connection and future contributions (shade, nutrients, etc.).
- Increase floodplain activation frequency by increasing hydraulic roughness and occupying space within the existing active channel boundary and hydraulically directing high-flow surface water into secondary flow paths and/or on to the floodplain.
- Increase hydraulic roughness to increase floodplain activation.

Design Considerations

- Construction timing needs to be low-flow season within the permitted in-water-work window for Kachess River bull trout.
- Flow hydraulic interactions with the jam at varied peak flow events. Required ballasting to meet structures requirements (depth of burial, horizontal piles, log length, boulders) without using cable or chain.

- Distribution of the MCLW and their relative location to each other to maximize proximal scour hole and low-flow habitat for target species—within hydraulic and geomorphic parameters of watershed processes.
- Resultant hydraulic influence on channel processes, including supporting downstream vegetated bar/floodplain development and supporting channel gradient adjustment processes.
- Likelihood and longevity of jam to maintain scour pools and provide habitat cover.
- Installation is expected to NOT increase risk of survival to target species and is expected to be usable as habitat upon construction completion.
- Constructability of the LW jams—including, but not limited to access, seasonal hydrology, availability of materials.
- Depth and location of scour pool excavation to maximize seasonal pool wetting by groundwater.

Design Evaluations and Rational

Mid channel structure shape, size, and orientations are designed to address the goal of increasing the quantity and quality of available bull trout habitat with a treatment that has potential for reasonable persistence within the hydraulic and sediment loading conditions of the site, while also promoting beneficial geomorphic channel response. 2-D hydraulic modeling of proposed conditions was done to estimate flow properties (i.e., velocity, depth) at a jam for a suite of estimated discharges (expected annual discharges and peak floods). Flow hydraulics combined with wood stability calculations provided information on burial and ballasting requirements for desired log quantities, diameters and lengths. Other considerations include estimated pool scour maintenance, inundation frequency, and placement in proximity to low-flows to increase bull trout survivability. The intent is to create scour holes at all mid channel structures that provide covered habitat for rearing bull trout that is supported by groundwater through-flow, for all or a portion of the dry season.

Construction Considerations

- Timing: dry-season access and construction to minimize risk of impact to aquatic species and water quality.
- Adequate access routes and nearby staging for materials temporary stockpiling, delivery and needed equipment.
- Installation techniques and regional availability of equipment to construct.
- Constructing in conjunction with downstream floodplain bar stability roughness feature.

Bar Roughness Areas (BRA) – Large Wood and Live Planting

Description and Benefits

Bar Roughness Areas (BRA) are constructed within or at the margin of the mainstem channel. Several of the BRAs are designed downstream of MCLW structures and some are located downstream of existing large wood accumulations or on margin surfaces in need of revegetation.

BRAs include log pilings that are 30 ft long with a 16–18" dbh. The logs are vibratory pile driven into the bar surface to a depth 8 ft below existing thalweg of adjacent channel. Logs pilings are to be installed in a row-like pattern that is perpendicular to flow with ~30-ft row separation and 15-ft off-center density spacing (approximately 3 piles per 1,000 sq ft). Placement will be randomized during construction. Pile driving may prove difficult, and in that case excavation and burial of the horizontal log piles may become necessary. Salvaged trees and small wood material are woven between the piles and slash is placed along the rows. Live stakes and plants are planted behind and between the rows. Typical drawing and installation parameters are provided on Sheet 21 of the Design Plans with Live State planting detail on Sheet 33 and Large Wood Quantities and location tables provided on Sheet 30.

Design intentions are to:

- Promote vegetated bar and floodplain development within over-widened existing active channel boundary.
- Increase hydraulic roughness such that hydrologic function (surface water retention duration, floodplain connectivity, and groundwater recharge) is increased.
- Reduce active channel width and support narrow single-thread channel form at low-flow, which may potentially increase duration of wetting to improve survivability of rearing bull trout in sections of the channel that currently dewater.
- Provide high-flow/flood refugia within active channel boundary.
- Promote increased inundation frequency of the floodplain.

Design Considerations

- Potential channel flow hydraulic at the feature and required form and roughness to fulfil design intentions.
- Seasonal wetting and groundwater availability to support vegetation establishment on the bar.
- Proximity to upstream mid-channel structure or existing large wood jams.
- Size and positioning of the feature to achieve desired influences on channel form/processes and floodplain development, including flow distribution and floodplain activation.
- Installation is expected to NOT increase risk of survival to target species.
- Constructability of the BRA features—including, but not limited to access, seasonal hydrology, available materials, and ability to vibratory drive piles in to the existing substrate (excavation pits may be necessary alternatives).

Design Evaluations and Rational

- 2-D hydraulic model results (flow depth, velocity, inundation limits, etc.) for suite of annual and estimated flood events (annual flow elevations as well as 1.5- to 100-year discharge events) to evaluate:
 - Size, location, and relative position to the channel.

- Surface roughness requirements to facilitate design that promotes vegetation establishment, including density and depth of piles, placement of tree tops and slash and vegetation.
- Inundation frequency and seasonal depth to groundwater.
- Influence on channel form and effective flows.

Construction Considerations

- Timing: dry-season access and construction to minimize risk of impacting aquatic species and water quality.
- Adequate access routes and nearby staging for materials temporary stockpiling, delivery and needed equipment.
- Installation techniques and regional availability of equipment to construct.
- Construction in conjunction with upstream apex jam.
- Existing substrate and the ability to drive piles into the existing material—excavation may be required.

Gravel Retention and Habitat Large Wood Structures (GRHLW)

Description and Benefits

Gravel Retention and Habitat Structures (GRHLW) are engineered log structures constructed of 2-4 40ft long large wood pieces with rootwads with an 18" dbh. Partial burial of the log stems with salvaged gravel, cobble, boulders range from 4-ft deep for 20-ft stem burial to 3-ft deep for 30-ft of stem burial. The GRHLW are constructed into the bank of the existing mainstem channel and extend into low-flow wetted boundary. GRHLW are designed for installation along the upper mainstem channel where perennial flow occurs. These wood structures are designed to function similarly to natural large wood inputs sourced from nearby bank tops that have been caught/wedged into the channel bank. These features provide geomorphic complexity that promote localized areas of reduced hydraulic energy, gravel retention, and/or covered scour pools. Structures are designed and placed to enhance and/or create spawning and rearing habitat for bull trout. The tops of the logs are partially buried into the bank and the exposed portion of the log extends into the channel to provide hydraulic, geomorphic, and habitat function. In correlation with installation of the GRHLW, sections of the existing constructed levee along the river-left side of the mainstem channel will be excavated. Recommend sorting out cobble and boulder material from excavated material for use as required backfill material. Locations and details for the GRHLW are provided on Sheets 15, 23, and 30 of the Design Plans.

Design intentions are to:

- Increase complexity by providing localized variations in flow hydraulics and thus available habitat in perennial mainstem.
- Enhance and/or create desirable habitat (channel margin refugia and cover).
- Retain gravels and incoming woody material in the mainstem channel.

Design Considerations

- Within the permitted in-water-work window for Kachess River bull trout.
- Modeled estimates of depth, frequency of inundation, and flow velocity.
- Distribution and location of features to influence hydraulics, promote geomorphic process, and increase quantity and type of habitat in otherwise high-energy section of the channel.
- Preferred large wood density requirements for bull trout.
- Location along the bank relative to channel form and/or other restoration treatments.
- Distribution and location to provide desired proximal habitat with other features.
- Installation is expected to NOT increase risk of survival to target species and is expected to be usable as habitat upon construction completion.
- Size and number of logs required.
- Constructability of the structures – including, but not limited to access, seasonal hydrology, materials.

Design Evaluations and Rational

- 2-D hydraulic model results (flow depth, velocity, inundation limits, etc.) for suite of annual and estimated flood events (1.5- to 100-year discharge events) to evaluate:
 - Flow pathways and hydraulics at and resulting from the features (inundation frequency, velocity, and depth).
 - Probable sediment mobility and deposition at the features.
 - Stability and ballasting requirements.
- Large wood loading density and habitat requirements for bull trout.
- Allowable risk associated with wood mobilization and accumulations.

Construction Considerations

- Adequate access routes and nearby staging for materials temporary stockpiling, delivery and needed equipment.
- Construct to minimize risk of impacting aquatic species and water quality.
- Revegetation and stability of disturbed bank.
- Potential for dewatering, fish salvage, and/or erosion control requirements during installation.
- Installation techniques and regional availability of equipment to construct.
- ESA requirements for target and other species at the site.

Whole Tree Large Wood Placement (WTLW)

Description and Benefits

Whole Tree Large Wood Placements (WTLW) includes placing whole trees salvaged from the floodplain or otherwise into the mainstem channel. The design recommends clusters of 2–5 whole trees placed in locations that are both accessible via equipment or cabling from the bank and provide additional live standing trees on the bank to wedge the placed trees between. WTLW are designed to function similarly to natural large wood inputs or accumulations sourced from nearby bank tops or upstream. These features provide geomorphic complexity that promote small areas of reduced hydraulic energy, localized gravel retention, and/or covered scour pools. Exact locations of the whole tree clusters and orientation of the placements will be directed in the field by the engineer. Number of trees per cluster will be dependent on tree availability and in-field evaluation of conditions. Whole trees should include the rootwad and branches and be 60–70+ feet long. If unable to salvage tree with rootwad, half of the WTLW cluster trees could be felled tree of 70–65+ feet long with branches. Suitable locations for WTLW are depicted on Sheet 15 and 30 with whole-tree cluster graphic. Typical drawing and installation parameters are provided on Sheet 23 of the Design Plans. Design intentions of WTLW are to:

- Increase quality of aquatic habitat conditions in perennially wetted mainstem channel.
- Increase localized geomorphic and hydraulic complexity.
- Increase hydraulic roughness such that hydrologic function (surface water retention duration, floodplain connectivity, groundwater recharge) is increased locally.
- Provide local nutrient input.

Design Considerations

- Within the permitted in-water-work for Kachess River bull trout.
- Probable ESCP requirements to minimize impacts to aquatic habitat.
- Width of channel relative to whole tree length.
- Modeled estimates of depth, frequency of inundation and flow velocity.
- Location relative to channel form and/or other restoration treatments.
- Acceptable risk locally and downstream if LW is moved.
- Size and number of logs required.
- Constructability of the structures – large equipment access from left bank only.

Design Evaluations and Rational

- Large wood loading density and habitat requirements for bull trout.
- Approved risk associated with wood mobilization.
- Installation of all, some, or none of the WTLW

Construction Considerations

- The mechanism in which the tree is harvested and identification of the tree(s) for salvage will be defined by USFS silviculture plan and KCT forest thinning project guidelines.

- Mechanisms for tree placement may include one or a mix of equipment placement of tree salvaged elsewhere, toppling of tree from bank, or cable dragging tree from nearby salvage location or opposite (river-right) bank.
- Large equipment access from left bank of mainstem channel only.
- The channel is perennially wetted in the area designated for whole-tree placement. Strictly comply with ESA permitted actions and BMP's.
- Access routes will be defined by USFS silviculture plan and KCT forest thinning project.
- Installation techniques and regional availability of equipment to construct.

Helicopter Placed Large Wood (Heli)

Description and Benefits

Helicopter Placed Large Wood (HeliLW) includes placing whole trees in the channel via helicopter cable drops. The design recommends clusters of 2–5 whole trees or logs with rootwads be placed in locations where large boulders occur in the channel for natural ballasting and wedging and/or live standing trees on the bank occur to wedge the top of the placed trees between. HeliLW are designed to function similarly to natural large wood inputs or accumulations sourced from nearby bank tops or upstream. These features provide geomorphic complexity that promote small areas of reduced hydraulic energy, localized gravel retention, and/or covered scour pools. Because placement does not include partial burial or cable/bolt ballasting, it is understood that these pieces of LW will adjust and move during flood events. Exact locations of the HeliLW clusters and orientation of the placements will be directed in the field by the engineer. Materials should include the rootwad and branches of whole trees or logs with rootwads that are at least 40-ft long with a dbh of at least 18 inches. The generally suitable locations for HeliLW are depicted on Sheet 15 and 30 with whole-tree cluster graphic. on the Design Plans.

Design intentions of HeliLW are to:

- Increase quality of aquatic habitat conditions in perennially wetted mainstem channel.
- Increase localized geomorphic and hydraulic complexity.
- Increase hydraulic roughness such that hydrologic function (surface water retention duration, floodplain connectivity, groundwater recharge) is increased locally.
- Provide local nutrient input.

Design Considerations

- Within the permitted in-water-work for Kachess River bull trout.
- Probable ESCP requirements to minimize impacts to aquatic habitat.
- Width of channel relative to whole tree length.
- Location and orientation of existing large boulders in the channel.
- Modeled estimates of depth, frequency of inundation and flow velocity.

- Location relative to channel form and/or other restoration treatments.
- Acceptable risk locally and downstream if LW is moved.
- Size and number of logs required.
- Constructability of the structures – helicopter cable access and risk.

Design Evaluations and Rational

- Large wood loading density and habitat requirements for bull trout.
- Allowable and expected risk associated with wood mobilization.

Construction Considerations

- Proximity to staging area.
- Helicopter cable access and risk
- Air clearance approval – this is an Air Force jet usage area.
- The channel is perennially wetted in the area designated for HeliLW placement. Strictly comply with ESA permitted actions and BMP's.
- No large equipment access to the area.
- Installation techniques and regional availability of equipment to construct.

Inlet Apex Large Wood Structure (IALW)

The Inlet Apex Large Wood Structure (IALW) is an engineered log jam constructed designed at the inlet of the high-flow side channel. The structure is designed with: five 50-ft logs with rootwads with a 24" minimum diameter at breast height (dbh); ten 40-ft long logs with rootwads with an 18" min dbh; ten 30-ft long tree tops (with branches) with a 5-8in dbh; twelve 16-18" dbh x 20-ft long log pilings that will be embedded 10ft below subgrade; and, slash for log spacing infill. The jam includes a dug scour pool beneath the exposed root wads that is 6-ft deep, 6-ft wide (perpendicular to flow) and 6-ft long (parallel to flow). Log stems are backfill buried with salvaged gravelly cobble and boulders that are bucket compacted in lifts to a minimum depth of 3 ft. The trunks of the LW lattice logs are ballasted by burial and vertical piles. Location of the IALW is shown on Sheet 15 and defined on Sheet 30 of the Design Plans. The typical drawing and installation parameters for the jam are provided on Sheets 24.

The design intention of the IALW is to:

- Maintain the inlet of the high-flow side channel.
- Provide channel complexity and quality habitat in the mainstem channel.
- Increase hydraulic roughness and reduce localized flow velocities during high-flow or flood events in an otherwise high velocity section of the channel.
- Capture and retain rafted woody material to rejuvenate jam structure over time.
- Act as a substantive hard structure capable of promoting and supporting channel adjustment/recovery.

Design Considerations

- Flow hydraulic interactions with the jam at varied peak flow events. Needed ballasting to meet structures requirements (depth of burial, horizontal piles, log length, boulders) without using cable or chain.
- Resultant hydraulic influence on channel processes including support high-flow side channel connectivity and wetting, provide quality habitat at low-flows, maintain scour pool with estimated annual flows.
- Likelihood and longevity of jam to maintain function.
- Installation is expected to NOT increase risk of survival to target species and is expected to be usable as habitat upon construction completion
- Constructability—including, but not limited to access, seasonal hydrology, availability of materials.

Design Evaluations and Rational

- 2-D hydraulic modeling of proposed conditions was done to estimate flow properties (i.e., velocity, depth) for both low and high-flow discharge events as well as predicted sediment mobility.
- Flow hydraulics combined with wood stability calculations provided information on burial and ballasting requirements for desired log quantities, diameters and lengths.
- Estimated pool scour maintenance, inundation frequency, and placement in proximity to existing channel thalweg.
- Local scour conditions and scour pool maintenance potential.
- Size and number of logs required to meet design intentions.

Construction Considerations

- Timing: within the permitted in-water-work for Kachess River bull trout.
- Probable ESCP requirements to minimize impacts to aquatic habitat.
- Access and construction via the high-flow side channel flow-rout to minimize impact from equipment and available nearby staging for materials, temporary stockpiling, delivery, and needed equipment.
- Revegetation potential.
- The channel is perennially wetted near the IALW location. Strictly comply with ESA permitted actions and BMP's Installation techniques and regional availability of equipment to construct.

Habitat Large Wood Structures (HLW)

Description and Benefits

Three instream habitat structures and one floodplain roughness structure are included in the design to provide instream and floodplain habitat in the designed High Flow Side Channel (see Section 3.2.3). These wood structures are designed to function similarly to natural large wood inputs or accumulations sourced from nearby bank tops or upstream. These features provide overhead cover for bull trout, low velocity holding areas, promote pool scour and localized gravel sorting, and also improve bank and floodplain stability before vegetation re-establishes along the constructed High Flow Side Channel. The design also includes the option for single log placements throughout the side channel and groundwater tributaries, which include rootwad logs and whole trees. All of the LW habitat elements will be braced against existing vegetation where possible, or will be self-ballasted by burying the ends partially into the bank. The single logs may be combined to form small structures where appropriate, and will be placed at the direction of the engineer or owner during construction. Details on HLWS are provided on Sheets 26, and 28 of the Design Plans with Large Wood Quantities and location tables provided on Sheet 30. Design intentions are to:

- Increase complexity in the High Flow Side Channel by providing localized variations in flow hydraulics and thus available habitat.
- Enhance and/or create desirable habitat (high flow refugia, cover, spawning gravel accumulation).
- Promote pool scour.
- Provide floodplain and bank soil stability.
- Increase hydraulic roughness such that hydrologic function (surface water retention duration, floodplain connectivity, groundwater recharge) is increased.

Design Considerations

- Modeled estimates of depth, frequency of inundation and flow velocity.
- Distribution and location of features to influence hydraulics, promote geomorphic process, and increase proximal habitat frequency.
- Expected hydraulic influence of the structures on channel processes.
- Preferred large wood density requirements and varied habitat needs for bull trout during period of activation.
- Location along the bank relative to channel form and/or other restoration treatments.
- Distribution and location to provide desired proximal habitat with other features.
- Size and number of logs required.
- Constructability of the structures – including, but not limited to access, seasonal hydrology, materials.

Design Evaluations and Rational

- 2-D hydraulic model results (flow depth, velocity, inundation limits, etc.) for suite of annual and estimated flood events (1.5- to 100-year discharge events) to evaluate:

- Flow pathways and hydraulics at and resulting from the features (inundation frequency, velocity, and depth).
- Stability and ballasting requirements.
- Large wood loading density and habitat requirements for bull trout.
- Allowable risk associated with wood mobilization.

Construction Considerations

- Adequate access routes and nearby staging for materials temporary stockpiling, delivery and needed equipment.
- Revegetation and stability of disturbed areas.
- Can be installed in the dry. Sequencing.
- ESA requirements for target and other species at the site.

Snag Forest – Floodplain Roughness

Description and Benefits

Where high-flow floodplain inundation is being reactivated (see Floodplain and Tributary Connection 3.2.2) across an abandoned logging road that is currently gullied, floodplain roughness is being added to support vegetation and soil establishment in the remediated area (Gully Fill). The Snag Forest is constructed of vertical log pilings that are 12–15 ft long and embedded into the gully fill and nearby floodplain in an overlapping V-shaped configuration such that 3–8 feet of the log extends above finish grade. Two 10–15-inch diameter racking logs with floodplain embedded slash are braced within the pilings horizontally such that they are generally perpendicular to floodplain routing flow. The Snag Forest is designed to function similarly to the base of a standing forest with natural undergrowth that provides roughness and irregularly diverts/spreads surface floodplain flow such that erosivity is reduced and soil and vegetation establishment is supported. The tops of the vertical pilings are snapped off such that they appear more like broken trees, for aesthetic purposes. Details on the Snag Forest are provided on Sheets 12 and 29 of the Design Plans with Large Wood Quantities and location tables provided on Sheet 30. Design intentions are to:

- Increase localized floodplain roughness in an area that is currently an eroded road gully, but will be filled and then regularly inundated with surface overland flow after construction of the High-Flow Side Channel.
- Provide floodplain and bank soil stability.
- Promote soil accumulation and vegetation establishment.
- Provide floodplain and bank soil stability.

Design Considerations

- Modeled estimates of depth, frequency of inundation and flow velocity.
- Distribution and location of features to influence hydraulic and promote geomorphic process and vegetation establishment.

- Overlap and orientation of structures to each other and routed flow to maximize function.
- Size and number of logs required.
- Constructability of the structures – including, but not limited to access, seasonal hydrology, materials.
- Snag Forest is expected to decay over time after providing sufficient protection and roughness for revegetation of the area.

Design Evaluations and Rational

- 2-D hydraulic model results (flow depth, velocity, inundation limits, etc.) for suite of annual and estimated flood events (1.5- to 100-year discharge events) to evaluate:
 - Flow pathways and hydraulics at and resulting from the features (velocity and depth).
 - Stability and ballasting requirements.

Construction Considerations

- Adequate access routes and nearby staging for materials temporary stockpiling, delivery and needed equipment.
- Constructed in conjunction with Gully Fill.
- Important to sequence prior to or with installation of High Flow Side Channel.
- Once installed, access route through this area is no longer recommend. Consider in sequence planning.
- Install when floodplain is not inundated or at risk of inundation.
- ESA requirements for species at the site.

Magic Creek Connector Routing Large Wood

Description and Benefits

Where Magic Creek is being reconnected to the mainstem channel (see Floodplain and Tributary Connection 3.2.2), floodplain roughness is added at two existing alternate flow pathways to support primary routing of Magic Creek into the mainstem via Cold Creek. The Magic Creek Connector Routing Large Wood is added to the routing fill to provide roughness on freshly constructed low, frequently inundated floodplain surfaces that are currently seasonally activated tributary routes. The MCCR LW is constructed of vertical log pilings inset into the routing fill in a pattern to brace support V-shaped crossing horizontal logs and packed slash under and on top of the routing fill material. The locally salvaged logs should be at least 6 inches in diameter and at least 4–8 ft long. The MCCR LW is designed to function similarly to a vegetated low floodplain surface that provides roughness and diverts/spreads surface floodplain flow in irregularly multiple pathways such that erosivity is reduced and soil and vegetation establishment is supported. The tops of vertical pilings are snapped off such that they appear more like broken trees, for aesthetic purposes. One end of the horizontal logs is embedded into the channel bank at the base of the fill and placed on top of existing bank at the top of the fill. Details on the Magic Creek Connector Routing Large Wood are provided on Sheets 12 and 29 of the Design Plans with Large Wood Quantities and location tables provided on Sheet 30. Number of logs and their size will be

finalized in the field based on locally salvaged materials generated while accessing and constructing the Magic Creek Connector.

Design intentions are to:

- Maintain high and low-flow connectivity of Magic Creek to the mainstem channel via Cold Creek.
- Increase localized floodplain roughness and support vegetation establishment on fill material.
- Provide floodplain and bank soil stability.
- Promote soil accumulation and vegetation establishment.
- Provide floodplain and bank soil stability.

Design Considerations

- Modeled estimates of depth, frequency of inundation and flow velocity.
- Maintains Magic Creek connection to the mainstem channel via Cold Creek.
- Distribution and location of features to influence hydraulic and promote geomorphic process and vegetation establishment.
- Constructability of the structures—including, but not limited to access, seasonal hydrology, materials.
- The Magic Creek Connector Routing LW is expected to decay over time after providing sufficient protection and roughness for revegetation of the routing fill.

Design Evaluations and Rational

- 2-D hydraulic model results (flow depth, velocity, inundation limits, etc.) for suite of annual and estimated flood events (1.5- to 100-year discharge events) to evaluate:
 - Flow pathways and hydraulics at and resulting from the features (velocity and depth).
 - Stability and ballasting requirements.

Construction Considerations

- Adequate access routes and nearby staging for materials temporary stockpiling, delivery and needed equipment.
- Constructed in conjunction with Gully Fill.
- Important to sequence prior to or with installation of High Flow Side Channel.
- Once installed, access route through this area is no longer recommend. Consider in sequence planning.
- Install when floodplain is not inundated or at risk of inundation.
- ESA requirements for species at the site.

3.2.2 Floodplain and Tributary Connection

Channel and floodplain evolution in response to land management and resource extraction has resulted in the disconnection of east-valley tributaries and reduced overall floodplain connectivity. Road building and surface grading associated with logging efforts, including levees and berms, further simplify system function. The seasonal discharge from Watermelon Creek is currently routed into a disconnected channel scar where it ponds or is routed along an unmaintained logging road (NF 4600) where it has eroded a 375-ft-long gully that captures floodplain surface flow. The gully efficiently captures and routes floodplain surface water back to the mainstem, instead of utilizing it to recharge the floodplain and valley groundwater.

Logging and surface grading played a role in disconnecting Magic Creek, a perennial spring-fed tributary on the east side of the valley. Based on remnant scars, historical photos, and wetting patterns, it is assumed that the old-growth forest and its downed wood that Magic Creek once flowed through likely created a complex set of cold-water ponds and channels that supplied high-quality off-channel habitat, including summer-time rearing. The surface disturbance and grading that resulted from the logging disturbed connectivity such that Magic Creek is disconnected via surface flow from the mainstem channel.

Cedar Creek, another perennial spring-fed tributary, remains intact within the old-growth forest it is located in. However, the mouth of its channel has been partially plugged by sediment loading generated by the upstream logging impacts. See assessment report for more details [Inter-Fluve, 2019]. Today, Magic Creek, Cedar Creek and a few small spring seeps sourced on the east-side of the valley gradually infiltrate into the coarse valley floor alluvium, supplying groundwater source contributions. During the dry season the creeks go completely sub-surface. In the winter and spring, when the tributaries should be connected to the mainstem channel via surface flow, the current configuration of surface grading and plugs reduce connectivity.

The design elements to address improving access to off-channel habitat, floodplain connectivity, and tributary reconnection are described below. In addition to levee removal at the upstream end of the project area floodplain and tributary Connection design elements include construction of a high-flow side channel to provide off-channel habitat, reconnect Watermelon Creek, and increase floodplain flow routing; gully fill and road obliteration; reconnection of Magic Creek via flow routing to Cold Creek, and sediment plug removal at the outlet of Cedar Creek.

Levee Removal

Description and Benefits

The existing levee along the top of the mainstem channel bank on river left between stationing 82+00 and 86+00 will be removed. The levee was constructed during historical logging and surface grading activities. Removal of the levee increases the potential for future floodplain connectivity and system complexity (lateral processes) in the future. Appropriately sized material generated during levee excavation (gravel, cobble, and boulders) can be sorted and utilized in the construction (backfill) of large wood structures or gully filling. Other materials will be stockpiled in designated staging areas.

High-Flow Side Channel (HFSC)

Description and Benefits

The High-Flow Side Channel (HFSC) is a constructed side channel on the east, river left, side of the historical floodplain. This surface was graded and logged in the past and now hosts a regenerating second-growth forest. The HFSC is designed to be a 5-6ft wide gravel, cobble, and boulder bed inset 1-2ft below its adjacent constructed floodplain. The inset floodplain provides regularly inundated surfaces to support riparian vegetation establishment, high-flow refugia, and flood event flow capacity. The HFSC's pathway is excavated into the floodplain and occupies remnant channel scars. Planform, stationing and typical cross sections are provided on sheets 26 and 27 of the Design Plans.

The HFSC is designed to activate at the 5% exceedance discharge to provide annual seasonal high-flow refugia in the spring, when bull trout fry emerge and young juveniles are beginning to rear. At this flow or greater, flow velocities in the mainstem channel are high enough to prematurely flush rearing fish downstream. The HFSC will provide lower velocities (off-channel) quality habitat conditions and refugia to support bull trout survival. The HFSC meets what will be the primary flow path of the currently disconnected Watermelon Creek tributary prior to re-entering the mainstem. Watermelon Creek contributions are expected to provide ephemeral surface water flow in the winter and spring. The HFSC is designed to wet and dry from the downstream end, reducing stranding risks. A scour pool at the downstream end of the HFSC with a BBLW structure will provide perennial off-channel rearing habitat. Hydraulic model results indicate that construction of the HFSC will result in more frequent and increased inundation of the east-valley floodplain. Thus, it is necessary that the down-valley Gully Fill be constructed prior or in conjunction with the HFSC. Design intentions for the HFSC are to:

- Increase type, quantity, and quality of available bull trout habitat.
- Create an annually activated side channel that provides seasonal high-flow refugia and rearing habitat.
- Provide inset floodplain for riparian vegetation establishment.
- Include channel and inset floodplain large wood for habitat and hydraulic roughness.
- Increase floodplain connectivity and inundation at the side channel and down-valley across eastern floodplain.
- Reconnect Watermelon Creek with the mainstem channel.
- Reduce high-flow velocities in mainstem channel (to support mainstem sediment retention and habitat) by conveying a portion of high-flow discharge through the HFSC.
- At flows ranging from the 1.5- to 5-year flood events, create sufficient flow-through velocity to provide flushing maintenance flows in the HFSC. This will promote longevity of the HFSC.

Design Considerations

- Activate side channel annually at the 5% exceedance discharge so the mainstem channel contains all flow during low-flow periods

- Channel geometry, gradient, and planform that is appropriate for site conditions (geomorphology and hydrology) and supports bull trout habitat needs.
- Elevation of inset floodplain to support riparian forest establishment and high-flow hydraulics.
- Bank slope gradient to support vegetation establishment.
- Floodplain slope grade to minimize potential for fish stranding.
- Side-channel inlet location and elevation for desired seasonal average high-flow activation (5% annual exceedance discharge) and convey less than 20% of total flow for the 2-year and lower flow discharges.
- Side-channel alignment and gradient to facilitate inlet apex jam (IALW).
- Boulder salvage for use and placement in the channel bed for habitat complexity.
- Channel gradient, form, and wetting sequence to minimize risk of fish stranding during seasonal dewatering.
- Confluence connection with Watermelon Creek to reconnect tributary to mainstem seasonally.
- HFSC outlet hydraulics and associated habitat requirements.
- HFSC bed is equal to or higher in elevation than the mainstem channel to reduce risk of surface flow or groundwater capture from mainstem.

Design Evaluations and Rational

- 2-D hydraulic model results (flow depth, velocity, etc.) for suite of annual and estimated flood events (1.5- to 100-year discharge events) to evaluate:
 - Activation discharge and water surface elevation.
 - Suitability of hydraulics for bull trout habitat.
 - Channel geometry that provides appropriate habitat.
 - Probable sediment mobility and potential for infilling.
 - Probable bed stability and lateral migration
 - Frequency of flushing flows.
 - Seasonal wetting and drying sequence/timing.
 - Increase floodplain inundation frequency at and downstream of the feature.

Construction Considerations

- Utilize channel excavation limits as access route to minimize impact to existing vegetation and soil.
- Construct from within the channel excavation limits to minimize equipment footprint on the floodplain.

- Sediment/erosion control options during construction (i.e., cofferdams at inlet and outlet, dewatering, turbidity BMPs).
- Salvage and reuse of excavated spoils in other features (i.e., gully fill) or stockpile quantities.
- Selective salvage and reuse of boulders for installation in bed for bull trout habitat diversity.
- ESA requirements at the site for target and other species (spotted owl).
- Timing: dry season installation.
- Potential to leave plugs at up and downstream end if not constructing during dry season. Remove plugs when ready to activate.
- Activation will occur during next high-flow season.
- Adequate access routes and nearby staging for temporary stockpiling, delivery, and needed equipment.
- Revegetation and stability of disturbed bank.
- Installation techniques and regional availability of equipment to construct

Gully Fill

Description and Benefits

Gully Fill will occur where no abandoned logging road (NF 4600) created preferential surface water routing that evolved into extensive gully erosion that now captures and rapidly re-routes surface flow off the floodplain. Currently, the gully continues to actively incise and, via head cut migration, extend along the pathway of the old road. Filling the gully will be done with the material excavated during construction of the High-Flow Side Channel and/or Levee Removal. A BBLW structure will be placed and buried at the mouth of the existing gully during filling. Gully Fill is designed to restore annual floodplain surface flow routing down valley across the east-side valley floor. Gully Fill should be constructed in conjunction with the HFSC because of the increased frequency and duration of floodplain inundation it will result in – otherwise increased gully erosion is expected to occur. Planform, profiles and details on the Gully Fill and related Snag Forest Large Wood are provided on Sheets 12, 14 and 29 of the Design Plans.

Design intentions for the Gully Fill are to:

- Create annual down valley floodplain area inundation.
- Halt ongoing road/gully erosion process.
- Restore floodplain connectivity of east side valley floor to mainstem.
- Increase potential for floodplain groundwater recharge.
- Support forest regeneration.

Design Considerations

- Timing: dry season installation and prior to or in conjunction with activation of the High Flow Side Channel.

- Installation of BBLW at mouth of existing gully.
- Floodplain and fill gradient to support shallow dispersed overland flow.
- Fill topography to facilitate dispersed overland flow of east side valley and minimize risk that decommissioned/filled road/gully will be reactivated as preferential route.
- Composition of HFSC excavated material is as adequate gully fill material. May require sorting of excavated material for reuse.
- Installation is expected to NOT increase risk of survival to target species and is expected to function as designed upon construction completion.
- Constructability of the structures – including, but not limited to access, seasonal hydrology, materials.

Design Evaluations and Rational

- 2-D hydraulic model results (flow depth, velocity, inundation limits, etc.) for suite of annual and estimated flood events (1.5- to 100-year discharge events) to evaluate:
 - Flow pathways and hydraulics at and resulting from the features (inundation frequency, velocity, and depth).
 - Probable floodplain sediment mobility and deposition at the features.

Construction Considerations

- Adequate access routes and nearby staging for materials temporary stockpiling, delivery and needed equipment.
- Fill quantities and composition generated from on-site excavations.
- Sediment/erosion control options during construction (i.e., cofferdams at inlet and outlet, dewatering, turbidity BMPs).
- Revegetation and stability of fill material.
- Potential for erosion control requirements during installation.
- Installation techniques and regional availability of equipment to construct.
- ESA requirements for target and other species at the site.

Magic Creek Tributary Reconnection and Floodplain Routing

Description and Benefits

The proposed Tributary Connector (TC) is a small excavated flow path that reconnects Magic Creek to the mainstem channel through a narrow section of historically logged and graded floodplain. The TC will reestablish surface flow routing from Magic Creek to what is now referred to as Cold Creek. Cold Creek is located in an abandoned channel scar created shortly after logging destabilized the system. It is currently sourced from groundwater generated by the east valley tributaries and hyporheic flow from the mainstem. Surface water retention (ponding) in Cold Creek behind downed logs and an abandoned beaver dam suggests that accumulation of fines into the underlying coarse

alluvium can retard infiltration and increase the quantity of water retained on the surface for available habitat. Reconnecting Magic Creek to Cold Creek as per design is expected to increase cold-water off-channel high quality bull trout habitat by seasonally reconnecting 0.25 miles of available habitat without impacting upstream groundwater contributions made by Magic Creek. As the forests along Magic and Cold Creek mature and provide more nutrients, organic matter, and wood directly into the channel, it is expected that habitat conditions, connectivity, and groundwater contributions will continue to improve.

The TC is located downstream of where the Magic Creek currently subs out (infiltrates) into the floodplain during dry-season conditions. The TC is designed to have a 3-ft channel bed that cuts through a narrow section of a logged and graded surface that currently separates Magic and Cold Creeks by ~30 feet. Seasonal disconnection of Magic and Cold Creeks is not expected to harm rearing bull trout because of the quality of habitat provided in both. Primary flow routing of Magic Creek into the connector channel will be accomplished by placing the excavated spoils into existing seasonally utilized flow routes to depths that maintain high-flow wetting (Magic Creek Connector Routing Fill). Debris and LW generated during excavation of the connector channel will be integrated into the flow routing fill. Flow routing fill is designed to route flow of Magic Creek into Cold Creek through the TC but, during flood events the fill will be activated similarly to the surrounding floodplain and routed down the fill along its old flow routes (converted to high-flow multi-thread routes). Details are provided on Sheets 12, 14 and 29 of the Design Plans.

Design intentions for the TC are to:

- Reestablish a surface water route that annually reconnects Magic Creek to the mainstem channel via Cold Creek.
- Increase availability of high-quality bull trout off-channel rearing and potentially spawning habitat.
- Do not disturb existing function of Cold Creek.
- Do not negatively impact existing groundwater contributions made upstream by Magic Creek.

Design Considerations

- All material excavated will be re-distributed in the vicinity to promote primary flow routing through the TC. This allows for use of a small excavator to complete the feature.
- Channel geometry, gradient, and planform that is appropriate for site conditions (geomorphology and hydrology) and supports bull trout habitat needs.
- Modeled estimates of depth, frequency of inundation and flow velocity.
- Access route will utilize old logging road route.
- Installation is expected to NOT increase risk of survival to target species and is expected to be usable as habitat upon construction completion.
- At flows ranging from the 2- to 5-year flood events, create sufficient flow-through velocity to provide channel maintenance.

- Constructability—including, but not limited to access, seasonal hydrology, materials.

Design Evaluations and Rational

- 2-D hydraulic model results (flow depth, velocity, inundation limits, etc.) for suite of annual and estimated flood events (1.5- to 100-year discharge events) to evaluate:
 - Flow pathways and hydraulics at and resulting from the features (inundation frequency, velocity, and depth).
 - Probable sediment mobility and deposition at the features.
- Allowable risk associated with wood mobilization in this area.

Construction Considerations

- Adequate access route for needed equipment – ideally one small excavator and one small dump truck only.
- Revegetation and stability of disturbed bank.
- Proximity of old growth trees to feature.
- Utilize channel excavation limits as access route to minimize impact to existing vegetation and soil.
- Construct from designated access routes and keep all equipment out of flow routes to minimize impacts to sensitive tributary features.
- Potential for groundwater activation of the channel during construction—prepare to manage water and sediment at downstream end.
- Sediment/erosion control options during construction (i.e., cofferdams at inlet and outlet, dewatering, turbidity BMPs).
- Salvage and reuse and/or placement of excavated spoils in designed routing fill locations.
- Potential for erosion control requirements during installation.
- Installation techniques and regional availability of equipment to construct.
- ESA requirements for target and other species at the site.

Cedar Creek Unplugged

Description and Benefits

The plug of sediment accumulated at the mouth of Cedar Creek will be removed to match existing up and downstream elevations. The plug is removed in conjunction with the installation of a MCLW at the mouth of the tributary. The excavated materials can be distributed on near by BRA 01 or 02. Removal of the plug will reconnect Cedar Creek to the mainstem channel during high-flow or flood-event conditions.

Design Considerations

- Timing: dry season construction

- Installation is expected to NOT increase risk of survival to target species and is expected to be usable as habitat upon construction completion
- At flows ranging from the 2-year flood events, create sufficient flow velocity to maintain scour at alcove mouth
- Constructability—including, but not limited to access, seasonal hydrology, materials

Design Evaluations and Rational

- Groundwater data from piezometer installation pit and groundwater dataloggers.
- 2-D hydraulic model results (flow depth, velocity, inundation limits, etc.) for suite of annual and estimated flood events (1.5- to 100-year discharge events) to evaluate:
 - Flow pathways and hydraulics at and resulting from the features (inundation frequency, velocity, and depth)

Construction Considerations

- Adequate access routes and nearby feature utilization of excavated materials.
- No expected requirements for erosion control requirements during installation—dry bed during dry season.
- Installation techniques and regional availability of equipment to construct.
- ESA requirements for target and other species at the site.

3.2.3 Revegetation

Description and Benefits

The revegetation plan is designed to support regeneration of native riparian and upland plant species following construction. Planting zones were developed in consultation with the US Forest Service, and were modeled after existing vegetation communities at the site. The planting plan is expected to provide long-term stability to graded areas, and plantings in floodplain roughness areas are intended to promote sediment deposition and channel narrowing over the long-term, consistent with project goals and objectives. Topsoil compost is specified to be intermixed during planting of potted stock, and hogfuel mulch will be installed on top of potted plants to retain moisture and reduce sedimentation and erosion. Straw mulch will be installed over all other disturbed areas that are planted. Gully Fill and floodplain benches within the HFSC will be treated with topsoil, blended into the top 6 inches of finish grade, to increase organics and nutrients in the soil, and promote rapid revegetation of these surfaces. Details on RV will be revised in the next set of plans after concept-level Floodplain and Tributary Connection design elements are selected. Existing revegetation plan sheets are 17-19 and 28 of the 95% and Floodplain-Tributary Concept Design Plans. Current design intentions are:

- Promote rapid recovery of disturbed surfaces.
- Improve riparian health and species diversity.
- Increase roughness in floodplain areas.

- Suppress weeds following construction.

Design Considerations

- Construction timing and seasonal precipitation patterns.
- Hardiness and age of available plants.
- Existing native species at the site, and their location related to inundation frequencies.
- Estimated inundation frequency under existing and proposed conditions.

Design Evaluations and Rational

- Seasonal relative elevation and proximity to surface and groundwater.
- Estimated duration and frequency of inundation. Inundation tolerances and requirements of selected species.
- Flow velocity tolerances and estimated floodplain roughness after established.
- Availability of desired native plants.

Construction Considerations

- Seed mix purity (i.e., weed seed free) and plant health.
- Proper surface preparation for the selected application method.
- Planting timing to maximize survival.
- Live stakes will be installed in floodplain roughness features using a stinger or equivalent metal driving rod.

4. Project Construction

General project construction information is discussed in the following sub-sections and related documents are provided as Appendix. Project Manager refers to KCT's managing staff, Engineer refers to Inter-Fluve staff, Construction Contractor refers to selected contractor under contract with KCT to complete the project, Agency Representative refers to staff or contractors of the federal, state, and tribal entities included in the KTT—including archeologists, biologists, foresters, etc., and Regulator refers to staff of relative state or federal permitting entities

4.1 ACCESS & STAGING

Site access is on NF 46 and 4600, a maintained gravel and then single-lane gravel road that accesses the current location of the Mineral Creek Trailhead. The Salmon la Sac Road (903) is a two-lane paved county Rd that intersects with NF 46 approximately 10 miles north of the town of Ronald, WA. Currently, NF 4600 is a dirt road closed by vegetation and fallen trees after the existing Mineral Creek Trail head and parking area, but its route continues into and across the project area to near Staging Area 1. The unmaintained section of the road will be re-opened by the contractor for use during construction. Staging Area 2 will occupy the current Mineral Creek trailhead parking area. Staging Areas 3 and 4 are old landing areas used during past logging actions that are located on a spur road from NF 4600. Access to Staging Areas 2 and 3 will require the contractor to re-open and improve the road to minimal standards to allow equipment access. Temporary access routes developed for treatment installation will be no more than 15 ft wide. The need for isolated and occasional pullouts will be determined and approved by the Owner during construction to accommodate construction traffic patterns. Where access routes are converted into channels, channel construction will occur from the farthest end and work towards the point of access to avoid travel over completed work. Sheet 32 of the Design Plans (Appendix A) provides a map and description of the Access Roads and Staging Areas, as well as identifies which road will be decommissioned.

A temporary bridge with sufficient abutments and fill for approaches will be provided, installed, and maintained by the contractor to access treatment sites. Hydraulic modeling indicates a 30-foot clear span bridge with low chord 3.0 feet above the average streambed elevation will pass anticipated flows during construction. After the treatments being accessed by the bridge are completed, the contractor will remove the bridge and all related abutments and fill. Pre-project grade or designed finish grade will be established and the surface will be decompacted and revegetated. A temporary small tributary crossing constructed of a steel plate set over logs and slash in the small tributary will be installed and maintained by the contractor for access to Staging Area 1. The steel plate will be wide enough and extend far enough past the top of the tributary banks to facilitate equipment passage. After Staging Area 1 no longer needs to be accessed, the steel plate will be removed and the logs and slash will remain in place.

After construction identified existing roads and temporary access roads (See Sheet 32 of Design Plans) will be decommissioned per the USFS Specifications for ML1 and ML 3 Roads of the U.S. Department of Transportation, Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects, FP-14. Decompaction includes re-grading the road surface to naturalize

the contour to adjacent topography, decompacting, and planting with native vegetation so as to return it to functioning conditions. Compacted soils will be decompacted by ripping or scarifying. Where needed, access barriers such as a berm, large rocks, or logs will be placed to discourage road usage. See Figure 7 for examples. Where access routes are established in a dry river-bed, all large wood temporarily moved will be replaced and equipment tracks graded to pre-project conditions.



Figure 7. USFS. 2018. Guidelines for Storing and Decommissioning Roads. US Dept of Agriculture, National Technology and Development Program. 1677-1804P-NTDP

4.2 LIMITS OF DISTURBANCE

The Design Plans show construction limits of disturbance (LOD) line and USFS-approved Area of Potential Effect (APE) boundary. The LOD, grading surfaces and structure locations will be available to the contractor in a digital spatial data format (i.e., CADD or GIS). It is expected that prior to work the Construction Contractor, Engineer, Project Manager and identified Agency Representative(s) will review the LOD and make field adjustments. These field adjustments may account for things such as; identified or potential cultural resources, specific vegetation patch preservation, equipment widths, and previous disturbances. Once established, the LOD will be enforced to limit impacts to the environment outside the footprint of each project element.

4.3 SEQUENCING AND PHASING

Treatments are designed to be completed in one window or in phases, depending on resource availability and funding. The Construction Contractor is required to develop and provide a sequencing plan and schedule for approval prior to initiation of the project. Any changes made to

the plan need to be provided to the Owner for approval. Proposed sequence and sequence recommendations are provided on Sheet 9 of the Design Plans. Sequencing and phasing considerations of importance include:

- Potential to excavate portion of High-Flow Side Channel in Phase I, leaving a sufficient length at the up and downstream ends uncut. Store excess excavated materials in designated staging areas – prioritizing disposal needs in Staging Area 1. Plant banks and inset floodplain of High-Flow Side Channel.
- Construction of completed High Flow Side Channel needs to be done in conjunction with the Road Gully Fill.
- Coordinate so that temporary bridges (at stations 65+00) and access routes are installed once.
- Sequence so that areas, once treated, are not reentered.

Mass excavation can occur on entry. Finished work will be completed from furthest limits of a project feature and work towards the access point into the feature. An exception to this may be warranted if excavation intercepts groundwater that needs to be freely drained downstream. For this condition, the Construction Contractor will provide a plan for approval to move materials and equipment in a manner that has the least disturbance and meets all permit requirements. Construction will occur during the permitted in-water work windows, prior to autumn bull trout spawning to minimize direct impact to aquatic species and habitat.

4.4 ENVIRONMENTAL CONTROLS

The Construction Contractor is responsible to provide and implement an approved erosion, sediment, and dust control plan (ESC) that meet applicable regulations and permit requirements to protect adjacent waters and lands from sediment runoff, turbidity and water quality. Suggested BMPs are included in the plans and may include: silt fence, infiltration of overland flow. The Construction Contractor is also responsible for environmental control plans that include:

- Temporary Stream Crossing Plan
- Stream Diversion, Fish Isolation, and Dewatering Plans
- Environmental Protection and SPCC Plan

4.5 DEWATERING

Dewatering for project elements may be required depending on surface and ground water levels and construction sequencing/phasing. The Construction Contractor is responsible to provide and implement an approved dewatering plan that meets applicable regulations and permit requirements. Suggested BMPs are included in the plans and include: cofferdams to isolate work areas from surface flows and reduce turbid waters entering surface waters. Surface water and groundwater encountered by excavation, may require pumping to drawdown water to a level that allows construction and intercepts turbid waters. Pumped water is discharged to upland areas to be infiltrated into the ground. The Construction Contractor will be required adjust their dewatering BMPs to prevent turbid waters from reentering surface waters or wetlands. Construction Specifications are provided in Appendix C.

4.6 SPECIFICATIONS

Project specifications are based, by reference, on the WSDOT 2020 Standard Specifications; with project specific conditions refined with special provisions as well as specific USFS project criteria and ARBO II specifications. See Appendix C.

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