UPPER TWISP RIVER RESTORATION DESIGN

PROJECT AREAS 2, 3, AND 4

CONCEPT LEVEL DESIGN

Prepared for

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1. PREFACE

This report for the Upper Twisp River Restoration Design – Projects Areas 2, 3, and 4 (Project) is based on the General Project Data Summary Requirements (GPDSR) Basis of Design Report template for Bonneville Power Administration (BPA) Habitat Improvement Program (HIP III) projects (BPA 2017). Some formatting changes have been made to the template but the sections and requested information follow the template structure.

The design process for the Project as established by the Yakama Nation Fisheries includes the following steps and review junctures:

- Development of Conceptual Report and Drawings (this submittal)
- Development of Permit-level Report and Drawings
- Development of Final Construction Plans

1.1 Name and titles of sponsor, firms and individuals responsible for design

Project Name: Upper Twisp River Restoration Design – Project Areas 2, 3, and 4 (Project)

Project Location: Twisp River, River Mile 20.1 to 22.2, approximately 15 miles east of the town of Twisp in Okanogan County, Washington (See Figure 1-1)

Sponsor: Yakama Nation Fisheries, 2 Johnson Lane, Winthrop, WA 98862

Yakama Habitat Biologist: Jarred Johnson

Engineering firm: Tetra Tech, Inc. (Tetra Tech), 19803 North Creek Parkway, Bothell, WA 98011

Project Manager: Jonathan Thompson

Lead Design Engineer: Jeremy Andrews, PE

Water Resources Engineer: Chad Bailey, PE, CFM

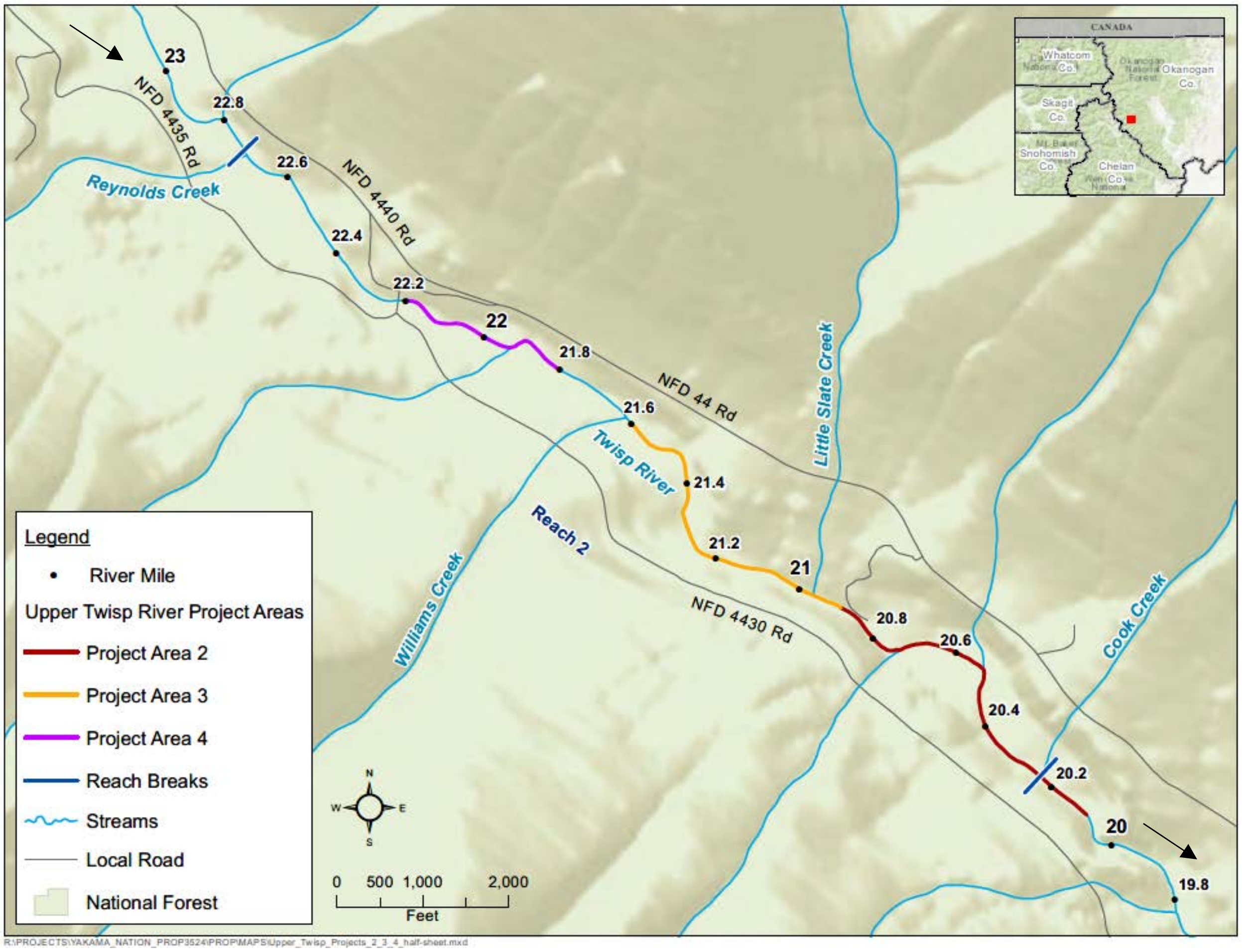

Figure 1-1. Project Vicinity Map

1.2 List of project elements that have been designed by a licensed professional engineer

Project Plan Sheets (see Appendix A).

1.3 Identification and description of risk to infrastructure or existing resources

The Project is located on the Twisp River between river miles (RMs) 20.1 to 22.2 (Figure 1-1). It includes Project Area 2 from RMs 20.1 to 20.9; Project Area 3 from RMs 20.9 to 21.6; and Project Area 4 from RMs 21.8 to 22.2. Also included is the reach between Project Areas 3 and 4 (RMs 21.6 to 21.8).

All the property surrounding the Project is publicly owned forests managed by the U.S. Department of Agriculture - Forest Service (USFS). As a result, the vast majority of the Project lies within undeveloped and remote lands. Specific locations within the Project that were identified as areas of concern to infrastructure include a single unimproved campground (Mystery Campground) on river left just upstream of the Project, and a nearby bridge crossing on National Forest Development (NFD) Road-44, just upstream of RM 22.2. The campground is likely well outside the influence of proposed Project actions. The landings of the NFD-44 bridge constrain the river to some degree, but there is likely to be low risk resulting from Project actions in this area since the bridge is relatively new and currently passes all flow conditions with sufficient freeboard. The possibility of including the removal and replacement of this bridge as a part of this project has been discussed, but is considered unlikely to occur at this time. The NFD-4430 bridge is located on RM 17.8, about 2.3 miles downstream of the NFD-44 bridge, and the nearest private residences are located near RM 15.4.

Other risks associate with the proposed Project elements include mobilization of LWD and potential boater safety concerns. The risk of mobilization of LWD will be addressed through Project design criteria and construction methods that will result in stability through anchoring, ballasting, excavation, and entwining with existing vegetation. There is no known recreational boating use in this area of the river, but potential boater safety concerns including those associated with potential collisions with installed LWD structures will be evaluated at a later design stage to determine public boat use, and any necessary safety measures will be included in the design.

1.4 Explanation and background on fisheries use (by life stage - period) and limiting factors addressed by project

The Yakama Nation Fisheries Upper Columbia Habitat Restoration Program is focused on implementing science-based restoration projects in the Upper Columbia River Basin that benefit Endangered Species Act (ESA)-listed fish species. Habitat restoration priorities, objectives, and treatments are guided by the Upper Columbia Spring Chinook Salmon, Steelhead Recovery Plan (UCSRB 2007), that also covers bull trout, and A Biological Strategy to Protect and Restore Salmonid Habitat in the Upper Columbia Region (Biological Strategy) (UCRTT 2014). While there are many fish species, both native and introduced, that reside in the Twisp River, the Project is primarily concerned with future enhancement actions that will benefit ESA-listed spring Chinook salmon (*Oncorhynchus tshawytscha*), steelhead (*O. mykis*s), and bull trout (*Salvelinus confluentus*). Other species may also benefit from these action, including summer Chinook salmon, coho salmon (*O. kisutch*), sockeye salmon (*O. nerka*), resident rainbow/redband (*O. mykiss gairdneri*), westslope cutthroat trout (*O. clarki lewisi*), mountain whitefish (*Prosopium williamsoni),* pacific lamprey (*Entosphenus tridentatus*), *and* the introduced eastern brook trout (*Salvelinus fontinalis*) (Andonaegui 2000; NPCC 2005).

As mentioned above, there are three fish populations within the Twisp River that are protected under the ESA: spring Chinook salmon, summer steelhead, and bull trout. The Upper Columbia River (UCR) spring Chinook salmon evolutionary significant unit (ESU) was listed as endangered in 1999, and reaffirmed in 2005 (Federal Registry 2005). The UCR steelhead distinct population segment (DPS) was originally listed as endangered in 1997, but was relisted as threatened in 2007, and confirmed in 2009 (Federal Registry 2005). The National Oceanic and Atmospheric Administration National Marine Fisheries Service (NOAA Fisheries) designated the Twisp River and certain tributaries as critical habitat for spring Chinook salmon and steelhead in 2005. In 1999, the U.S. Fish and Wildlife Service (USFWS) listed bull trout as threatened (Federal Registry 2005), and 2010 designed the Twisp River as critical habitat. The Twisp River in this reach is an important migration corridor for spring Chinook salmon, steelhead, and bull trout, and contains spawning and rearing habitat for Chinook salmon and steelhead (Figure 1-2).

Table 1-1 Fish Periodicity Chart for the Focal Fish Species

Species	Lifestage	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sept	Oct	Nov	Dec
Spring Chinook Salmon	Adult Immigration & Holding												
	Adult Spawning												
	Incubation/ Emergence												
	Juvenile Rearing												
	Juvenile Emigration												
Summer Steelhead	Adult Immigration & Holding												
	Adult Spawning												
	Incubation/ Emergence												
	Juvenile Rearing												
	Juvenile Emigration												
Bull Trout	Adult Immigration, Emigration												
	Adult Spawning												
	Incubation/Emergence												
	Juvenile Rearing												
	Juvenile Emigration												

Indicates periods of most common or peak use and high certainty that the species and life stage are present.
Indicates periods of less frequent use or less certainty that the species and life stage are present.
Indicates periods of rare or no use.
Source: Andonaegui (2000), USFS (2014)

Ecological concerns (also commonly known as limiting factors) are defined as the physical, biological or chemical features experienced by fish that result in reductions in viable salmonid population parameters (abundance, productivity, spatial structure, and diversity). Several documents discuss ecological concerns/limiting factors within the Methow River Subbasin (Hydrologic Unit Code [HUC] 17020008), of which the Twisp River (HUC 1702000805) is a part, including the following:

- Salmon, Steelhead, and Bull Trout Habitat Limiting Factors Report – Water Resources Inventory Area 48 (Andonaegui 2000)
- Methow Subbasin Plan (NPCC 2005)
- Columbia Basin Fish Accords (Three Treaty Tribes-Action Agencies 2008)
- Methow Subbasin Geomorphic Assessment (USBR 2008)
- Federal Columbia River Power System Biological Opinion Tributary Habitat Program (FCRPS 2012)
- A Biological Strategy to Protect and Restore Salmonid Habitat in the Upper Columbia Region. ([Biological Strategy] UCRTT 2014)
- Upper Twisp River and Tributaries Habitat Assessment (Tetra Tech 2017)

While all these documents include useful indicators of known ecological concerns/limiting factors that are listed and described under various names and definitions, for brevity this document will only describe the determinations from four of these documents. The four documents used to describe the ecological concerns/limiting factors are the Methow Subbasin Plan (NPCC 2005), Columbia Basin Fish Accords (Three Treaty Tribes-Action Agencies 2008), Biological Strategy (UCRTT 2014), and Upper Twisp River and Tributaries Habitat Assessment (Tetra Tech 2017).

The Methow River Subbasin plan (NPCC 2005) conducted an Ecosystem Diagnosis and Treatment (EDT) analysis of the Subbasin and utilized 16 limiting factors as part of the analysis. The results of this analysis for the Upper Twisp geographic area determined that habitat diversity (floodplain connection, off-channel habitat, LWD, riparian vegetation), key habitat quantity (few quality pools for rearing and holding, and fewer pool tailouts for spawning), and obstructions were the primary limiting factors to anadromous fish (Table 1-2). Secondary limiting factors included flow (reduced base flow, increased peak flow), and food (reduced salmon carcasses and benthic productivity). The eleven remaining limiting factors were minor or not considered to be limiting to survival (Table 1-2).

Table 1-2. EDT Assessed Limiting Factors for Anadromous Species in the Methow River Subbasin

Limiting Factors and Ratings	
Habitat Diversity (Primary)	Key Habitat Quantity (Primary)
Sediment Load (Minor or Not Present)	Obstructions (Primary)
Channel Stability (Minor or Not Present)	Flow (Secondary)
Food (Secondary)	Temperature (Minor or Not Present)
Predation (Minor or Not Present)	Chemicals (Minor or Not Present)
Competition (Hatchery fish), (Minor or Not Present)	Competition (other species), (Minor or Not Present)
Harassment/Poaching (Minor or Not Present)	Oxygen (Minor or Not Present)
Pathogens (Minor or Not Present)	Withdrawals (Minor or Not Present)

Source: NPCC 2005

The Columbia River Basin Fish Accords (Three Treaty Tribes-Action Agencies 2008) listed five Primary Limiting Factors for the Twisp River. Those limiting factors were Ecological-Community, In-Channel Characteristics, Riparian/Floodplain, Sediment, and Water Quantity - Flow. Each of these limiting factors applied to both spring Chinook salmon and steelhead.

The revised Biological Strategy document for the Upper Columbia River (UCRTT 2014) contains the most recent information on ecological concerns. This document indicates that within the Upper Twisp Assessment Unit (Twisp River RM 14.0 to 31.0), the ecological concerns, in descending order of importance, area as follows:

1. Peripheral and Transitional Habitats (Side Channel and Wetland Habitat Conditions);
2. Channel Structure and Form (Instream Structural Complexity);
3. Channel Structure and Form (Bed and Channel Form);
4. Riparian Conditions (Riparian Conditions and Large Wood Recruitment);
5. Food (Altered Primary Production or Prey Species Competition and Diversity);
6. Sediment (Increased Sediment Quantity); and
7. Species Interactions (Introduced Competitors and Predators).

Although not listed as an ecological concern, Water Quantity – Decreased Water Quantity could be added for the upper portion of the reach since portions of the river near the Poplar Flats Campground near RM 24.2 frequently go subsurface in late summer and fall (USFWS 2004).

The fourth and most recent document is the Upper Twisp River and Tributaries Habitat Assessment (Tetra Tech 2017). It reviewed the ecological concerns presented by others, refined them down to the geomorphic reach scale, identified the restoration actions needed to address them, and ranked project areas. Project Areas 2, 3, and 4 were ranked 1, 5, and 6, respectively, out of the thirteen project areas in the Upper Twisp River. That assessment also discussed Reach-based Ecosystem Indicators (REI). The REI analysis provides a standardized method to summarize habitat impairments and compare geomorphic and ecosystem functionality. Each metric was evaluated against specific REI criteria and rated as adequate, at risk, or unacceptable condition. The results for the Upper Twisp River as a whole are presented in Table 1-3. A small portion of Project Area 2 lies within Reach 1, while the remainder of Project Area 2, and all of Project Area 3 and Project Area -4 occur within Reach 2 (Figure 1-1). The results indicate that within Reach 2 the habitat quality indicators for LWD and pools were both "Unacceptable." Five REI categories were identified as "At Risk," and the remaining four indicators were considered to be "Acceptable."

Table 1-3. Upper Twisp River Reach-Based Ecosystem Indicator Ratings

General Characteristics	General Indicators	Specific Indicators	Reach					
			1	2	3	4	5	6
Habitat Assessment	Physical Barriers	Main Channel Barriers	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate
Habitat Quality	Substrate	Dominant substrate/Fine sediment	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate
	LWD	Pieces/mile at bankfull	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Adequate	Unacceptable
	Pools	Pool frequency and quality	Adequate	Unacceptable	At risk	Adequate	Adequate	Adequate
	Off-Channel Habitat	Connectivity with main channel	Adequate	At risk	Adequate	At risk	Adequate	Adequate
Channel	Dynamics	Floodplain connectivity	Adequate	At risk	Adequate	Adequate	Adequate	Adequate
		Bank stability/Channel migration	Adequate	At risk	Adequate	Adequate	Adequate	Adequate
		Vertical channel stability	Adequate	At risk	Adequate	Adequate	Adequate	Adequate
Riparian Vegetation	Condition	Structure	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate
		Disturbance (human)	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate
		Canopy cover	Unacceptable	At risk	Unacceptable	At risk	At risk	At risk

Adequate   At risk   Unacceptable

Collectively, these analyses of ecological concerns and REIs, combined with field survey results were used to guide selection of Project features as discussed in the following section.

1.5 List of primary project features including constructed or natural elements

The primary Project features were selected based on regional and Project goals and objectives as described in Section 1.5.1. Based on those goals and objectives, a variety of constructed or natural design elements were then considered at the Conceptual Level Design stage (Section 1.5.2).

1.5.1 Project Goal and Objectives

Key recovery planning efforts that have addressed conditions in the Methow Subbasin include the Methow Subbasin Plan (NPCC 2005), the Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan (Recovery Plan; UCSRB 2007), the Recovery Plan for the Coterminous United States Population of Bull Trout (USFWS 2015a) and an update to that, the Mid-Columbia Recovery Unit Implementation Plan for Bull Trout (*Salvelinus confluentus*) (USFWS 2015b), and the revised Biological Strategy (UCRTT 2014). Additionally, in 2012, tribes and state and federal agencies signed the Conservation Agreement for Pacific Lamprey, which was developed "to promote implementation of conservation measures for Pacific Lamprey in Alaska, Washington, Oregon, Idaho, and California" (USFWS 2012).

Based on the above, the goal of the Project is to design restoration actions that benefit ESA-listed Chinook salmon, steelhead and bull trout, and address the priority ecological concerns for the Twisp River. To address the Project goal, the Recovery Plan (UCSRB 2007) established regional objectives for habitat restoration along streams that currently support or may support ESA-listed salmonids. The following regional objectives and general recovery actions identified in the Recovery Plan support the development of the Project restoration strategy.

Regional Objectives

- Protect existing areas where high ecological integrity and natural ecosystem processes persist.
- Restore or maintain connectivity (access) throughout the historical range where feasible and practical for each listed species.
- Protect and restore water quality where feasible and practical within natural constraints.
- Increase habitat diversity by adding instream structures (e.g., LWD, boulders, etc.) where appropriate.
- Protect and restore riparian habitat along spawning and rearing streams and identify long-term opportunities for riparian habitat enhancement.
- Protect and restore floodplain function and reconnection, off-channel habitat, and channel migration processes where appropriate and identify long-term opportunities for enhancing these conditions.
- Restore natural sediment delivery processes by improving road networks, restoring natural floodplain connectivity, riparian health, natural bank erosion, and wood recruitment.
- Reduce the abundance and distribution of non-native species that compete and interbreed with or prey on listed species in spawning, rearing, and migration areas.

The revised Biological Strategy (UCRTT 2014) provides specific support and guidance on implementing the 2007 Recovery Plan described above. In the revised Biological Strategy, the Upper Twisp is designated as a Priority 1 area (on scale of 1 to 4, with 1 being highest priority) within the Methow River Subbasin. Restoration priority action types include restoring natural geomorphic processes such as channel structure and form and migration, floodplain interaction, and sediment transport (UCRTT 2014). Ecological concerns and restoration actions recommended for improving these functions are listed in the revised Biological Strategy. These include (in order of priority):

1) Peripheral and Transitional Habitats (Side Channel and Wetland Habitat) – Reconnect disconnected side channels or where low wood loading has changed the inundation frequency, improve hydraulic connection of side channels and wood complexity within side channels.

2) Channel Structure and Form (Instream Structural Complexity – Install large wood and engineered log jams (ELJs) in strategic locations to provide short-term habitat benefits and intermediate-term channel form and function benefits. The scale and locations should be consistent with the biological objectives and geomorphic potential for the reach and site.

3) Channel Structure and Form (Bed and Channel Form) – Remove levees; replace undersized bridges; remove bank armoring; and resolve other human impacts.

4) Riparian Condition (Riparian Condition) – Restore condition in degraded areas associated with residential development or where there are legacy effects from past riparian logging practices; improve LWD recruitment and allow regeneration; fence riparian areas and wetlands and maintain existing fences; implement the respect for river program in listed areas and other dispersed sites.

5) Food (Altered Primary Productivity) – place carcasses or analogs in streams to supplement marine derived nutrients where known shortages exist, within current and historic range of anadromy, and tie to existing monitoring programs where feasible.

6) Sediment (Increased Sediment Quantity) – implement road management, reduction and maintenance to restore sediment and LWD recruitment rates within riparian and upland areas.

7) Species Interactions (Introduced Competitors and Predators) – Reduce or eliminate brook trout in high density areas.

1.5.2 Concept Level Design

Restoration opportunities were identified during the field surveys conducted for the Upper Twisp River and Tributaries Habitat Assessment (Tetra Tech 2017). The topographic and geomorphic site surveys were performed between October 24 and November 8, 2016, and between October 9 and 11, 2017. Concept level design alternatives were developed based on the topographic and geomorphic site surveys described above; evaluation of existing light detection and ranging (LiDAR) data; evaluation of available background documents; and discussion with Yakama Nation Fisheries staff. Upon gathering all of the available information, Tetra Tech moved forward in developing alternative drawings, while taking into consideration the risks identified in Section 1.3, the surveys previously described, and the analyses in the habitat assessment (Tetra Tech 2017), with a focus on the “At Risk” or “Unacceptable” REI ratings as shown previously in Table 1-3.

The selection of proposed restoration actions in the 15 Percent Concept Design Alternatives was mostly based on the strategy of Alternative 1, except where infrastructure was involved. Specific restoration actions included:

- Adding stable LWD structures of various configurations to increase pool frequency and quality, retain mobile sediment and wood to aggrade the streambed and reduce channel incision, and facilitate reconnection of side channels and adjacent floodplains to increase habitat quantity, create hydraulic diversity and dissipate energy;
- Enhance existing backwater alcoves and pools with additional LWD instream cover;
- Improve connectivity of existing side channels and increase high flow relief by reopening relic inlets;
- Decommission old roads where feasible; and
- Plant all disturbed or deficient areas with native vegetation.

The three general alternative strategies that were considered included:

Alternative 1 - Full Floodplain, Fish Passage, and Habitat Restoration

This alternative included restoring stream and watershed processes that create and maintain habitats and biota in an effort to return habitats to their historic and normative state as described by Beechie et al. (2010). Restoration actions under this alternative should address the root causes of degradation.

Alternative 2 - Partial Floodplain, Fish Passage, and Habitat Restoration

This alternative considered an intermediate approach to restore or improve selected processes to partially return the Project areas to their historic and normative state.

Alternative 3 - Habitat Enhancement

This alternative considers a more site-specific approach to improve the quality of habitat by treating specific symptoms such as the lack of pools or LWD through the creation of locally appropriate habitat structures within the Project areas. Restoration actions under this alternative provide some local habitat improvements when more holistic process-based options are not available, or may not occur in the short term.

1.6 Description of performance / sustainability criteria for project elements and assessment of risk of failure to perform, potential consequences and compensating analysis to reduce uncertainty

Performance/sustainability criteria for Project elements, including associated risks to infrastructure or risk of failure to perform, and compensating analyses will be fully developed at later design stages. These criteria are intended to ensure that the engineering design meets Project objectives and maintains compliance with applicable codes, standards, and established criteria. General performance/sustainability criteria at this design stage include:

- Activation of existing or relic side channels and high flow channels (includes increasing perennial flows in existing channels);
- Floodplain restoration and reconnection (e.g., reduce main channel incision to increase floodplain connectivity and frequency of inundation, decompaction of artificially hardened surfaces).
- Channel enhancement and restoration (e.g., increase main channel complexity and habitat diversity, and cover and velocity refugia).
- LWD structure stability and performance criteria where necessary (e.g., ballast, bank protection, deposition, pool scour).
- Protection of existing infrastructure (roads and bridges).

Performance criteria for Project elements, including associated risks to infrastructure or failure to perform, and compensating analyses are summarized in Table 1-4. Performance criteria and habitat benefits for LWD structures are provided in Table 1-5.

Table 1-4. Project Actions and Performance Criteria

Project Actions	Performance Criteria	Risk Assessment	Compensating Analyses or Measures
Side Channel Creation or Reactivation	• Increase floodplain inundation at perennial flows to old floodplains and side channels. • Convey ~10-20 percent of the main channel bankfull flow. • Side channels are to be self-sustaining and allowed to evolve over time. • Increase hydraulic connectivity to existing wetlands.	• The proposed side channels inlets will be excavated into floodplain deposits of native alluvium. The native alluvium may or may not be suitable for side channel substrate and able to maintain sediment transport conveyance of gravel and small cobble materials transported through the mainstem. • Potential for channel dewatering and fish stranding. • A substantial portion of all proposed side channels are not proposed to be excavated and constructed. Several natural depressions exist in the floodplain and the side channel flows will naturally select a path to reconnect with the mainstem.	• Quantify bed material sizing following excavation to determine if bed material meets minimum size criteria based on vertical stability analyses. • If substrate encountered during construction does not meet criteria, the channel bed will be over-excavated and suitable material placed and compacted to specifications. • Hydrologic and hydraulic analyses to ensure delivery of perennial design flows. • Velocity and shear stress calculations for lateral stability.
Bridge and Bridge Approach Removal	• Increase side channel and off-channel habitat through the removal of artificial fill associated with the NFD-44 bridge.	• Potential risk to loss of access to NFD-4430.	• Hydrologic and hydraulic analyses. • Velocity and shear calculations.
Alcove Enhancement	• Stable up to the proposed 25-year flood hydraulic conditions.	• Adding LWD and roughness, alcoves may fill in with fines over time, but overall low risk.	• None, some deposition is expected to occur over time.
Revegetation	• Revegetation of all disturbed areas • 12-month plant survival of >75%	• Potential for low survival and ungulate browsing • Noxious weed infestations.	• Use site appropriate native vegetation, and preserve and replant existing native vegetation here feasible • Technical specifications for plant handling, care, installation, and survival. • Installation of fencing or caging to protect vegetation from wildlife browsing. • Noxious weeds shall be monitored and removed.

Table 1-5. Large Wood Structure Performance Criteria and Habitat Benefits

LWD Structure	Primary Purpose	Performance Criteria	Risk Assessment	Compensating Analyses or Measures	Habitat Benefits
Log Jam Structure	Promote lateral migration of main channel; Encourage flow splitting to facilitate side channel and floodplain reconnection	• Maintain side channel inlet dimensions to withstand up to the proposed 100-year flood hydraulic conditions.	• The proposed side channels inlets require lateral stability to control side channel entry flow and maintain consistent inlet cross sectional area.	• Stability calculations to be performed at a future design stage.	• Provide complex pool habitat for adults and margin habitat for juveniles. • Encourage lateral migration in straight sections when placed to act as deflectors. • Local scour pools at edges of structure. • Aggrade sediment downstream of structure.
2- Log Cross Structure Type 1	Side channel and alcove instream habitat diversity	• Increase pool frequency and complexity. • Surface placed and expected to adjust to higher flow buoyancy forces.	• No infrastructure immediately downstream.	• Stability calculations to be performed at a future design stage. • Some structures will be stabilized using vertical pilings. • Any single logs that are conveyed below the Project reach are expected to deposit or rack on existing structures and simulate natural LWD transport and accumulation.	• Provide complex instream and overhanging cover in pools for adults and juveniles. • Promote downward flow forces at lower flows to develop hydraulic complexity and small scour pool habitat.
Bank Jam Structure	Instream habitat diversity	• Surface placed and expected to adjust to higher flow buoyancy forces.	• No infrastructure immediately downstream. • Increased roughness can elevate flood stage.	• Stability calculations to be performed at a future design stage • Placed in main channel and interlocked with existing bank vegetation to provide additional roughness.	• Provide complex instream and overhanging cover in scour pools for adults and juveniles. • Provide bank stability in some locations. • Aggrade sediment downstream of structure.
Helicopter Bank Jam Structure	Instream habitat diversity	• Surface placed with helicopter and expected to adjust to higher flow buoyancy forces.	• No infrastructure immediately downstream. • Increased roughness can elevate flood stage.	• Stability calculations to be performed at a future design stage • Placed in main channel and interlocked with existing bank vegetation or channel boulders to provide additional roughness.	• Provide complex instream and overhanging cover in scour pools and outside bends for adults and juveniles. • Provide bank stability in some locations. • Aggrade sediment downstream of structure.

1.7 Description of disturbance including timing and areal extent and potential impacts associated with implementation of each element

Construction is not yet scheduled but would occur during the Washington Department of Fish and Wildlife (WDFW) in-water work window. According to WDFW guidelines, the in-water work window for the Upper Twisp River is July 1 to August 15. A detailed construction schedule will be developed at later design stages, and will include an implementation plan that describes the areal extent and potential impacts such as temporary turbidity releases to the stream, wetland impacts, minor impacts to resident fish populations from de-fishing activities, possible spills from construction equipment, colonization of disturbed ground by invasive vegetation, damage to existing vegetation along designated access routes, and short term disturbance issues for landowners. Overall impacts will be minimized through incorporation of BPA HIP III Best Management Practices (BMP's) and conservation measures.

2. RESOURCE INVENTORY AND EVALUATION

2.1 Description of past and present impacts on channel, riparian and floodplain conditions

Substantial anthropogenic impacts to the Twisp River began with beaver trappers in the early 1800s (NPCC 2005), which started affecting riparian conditions and off-channel water storage. Gold and silver mining occurred in the watershed between 1870s to 1890s, resulting in the establishment of several mines on the Twisp River, which included an encampment upstream near North Creek (near RM 28), which involved placer and hydraulic mining (PWI 2003). These mines resulted in a large influx of settlers and merchants, with orchards and livestock production starting the late 1800s. Water diversions for the mining and for supporting lower watershed agriculture in the Twisp River were completed in 1919, with the East Side and West Side Canals by the Methow Valley Irrigation District (USFS 2006). The Survey of the Columbia River and Its Tributaries (Bryant and Parkhurst 1950) that was completed in 1935 identified 18 diversions, which reduced streamflow and impacted anadromous fisheries. Timber harvest in the Methow River Subbasin started in the 1920s, peaking in the 1980s (NPCC 2005). Additionally, while wildfires are an integral part of the subbasin ecology, recent fires such as the Carlton Complex (2014) and Twisp (2015) fires were especially devastating, removing ground and canopy cover from large areas, resulting in decreased stream shading and increased sediment and turbidity inputs (NPCC 2005; Cardno 2017).

Current impacts to existing channel, riparian and floodplain conditions stem from many of the above mentioned sources. While timber harvest has been reduced in scale from previous harvest levels, it still occurs in limited levels at higher elevations in the Twisp River watershed (HUC 1702000805). Riparian corridors along the Twisp River are mostly intact, exceptions being a few meadows and where the Twisp River flows adjacent to the valley wall.

2.2 Instream flow management and constraints in the project reach

As discussed above (Section 1.4), flows are a known limiting factor in the Twisp River. While the water diversions mentioned previously occur downstream of the Project, there are known locations of seasonal dewatering that occur in the Upper Twisp River due to the flow going subsurface. Dewatering has been documented approximately 1.8 miles above the Poplar Flats Campground (RM 24.2) where the flows usually go subsurface, except in years where precipitation is higher than average (USFWS 2004). Radio telemetry studies have shown this dewatering has resulted in observed stranding mortality of adult bull trout during fall spawning, and prevents post-spawning downstream migration into the Methow River where over-winter survival rates are higher (USFWS 2004). These seasonal losses of surface flow are a natural process that can be found in many drainages of the Methow River Subbasin, typically due to the hydrogeology of deep, unconsolidated sediment deposits (Konrad et al. 2005). There has also been evidence of aggradation in this portion of the Twisp River (PWI 2003) which could be increasing the amount of water going subsurface. Additionally, a segment of the Twisp River has been 303(d) listed as Category 4C for instream flow, which means that the impairment is due to non-pollutant, and cannot be corrected by a Total Maximum Daily Load (TMDL) plan (WADOE 2017).

2.3 Description of existing geomorphic conditions and constraints on physical processes

Previous geomorphic work that has been performed for the Twisp River includes the Draft Twisp River Stream Survey Report – 2013 (USFS 2014). It includes a summary of geomorphic conditions for a 20 mile segment of the Twisp River from RM 9.5 to RM 29.7. The summary includes reach-level data such as pool frequency and depths, LWD, percentage of habitat units, bank erosion, channel characteristics, and substrate. More recently, the Upper Twisp and Tributaries Habitat Assessment (Tetra Tech 2017) also describes the existing geomorphic conditions of the Upper Twisp River and associated tributaries.

Based on these two documents, the Twisp River within the Project lies within a U-shaped valley and primarily consists of a single thread channel with extended riffles, punctuated by infrequent pools and short glides. The channel is confined by varying degrees by steep valley walls, landslide deposits, terraces, bedrock out crops, and alluvial fans. At numerous locations bank tops are several feet from the bankfull indicators, with out of bank flows likely only cresting into the floodplain during larger flood events. With the exception of the NFD-44 road and bridge crossing, the river is not artificially constrained by roads or other infrastructure in this reach.

2.4 Description of existing riparian condition and historical riparian impacts

Historical impacts to the riparian community are consistent with other smaller higher elevation drainages in the region. Past timber harvest occurred in the Twisp River watershed; however, recent impacts to the riparian corridor within the Project reach are minimal. Stream surveys conducted by the USFS (USFS 2014) indicated that the riparian habitat and future LWD recruitment potential in Reach 4 (RM 20.3 to RM 22.8) was generally in good condition. The Upper Twisp River and Tributaries Habitat Assessment (Tetra Tech 2017) describes the REI for existing riparian condition as “Adequate”.

Existing riparian vegetation was documented during the 2017 field surveys conducted for the Project. Overstory consists primarily of mature black cottonwoods (*Populus balsamifera* ssp*. trichocarpa)* and large conifers including Engelmann spruce (*Picea engelmannii*), Doulas fir (*Pseudotsuga menziesii*), and to a lesser degree ponderosa pine (*pinus ponderosa*), interspersed with alders (*Alnus* sp.) along the bank margins. Toward the downstream end of the Project Western red cedar (*Thuja plicata*) were also noted in greater frequency. Understory coverage consists of young alders, willows (*Salix* spp.), vine maple (*Acer circinatum*), red-osier dogwood (*Cornus sericea*), and snowberry (*Symphoricarpos* sp.) on the drier terraces. The ground cover is patchy weeds and duff (decaying leaves and conifer needles). The recolonizing vegetation in unconstrained segments along the river bars consists of young cottonwoods and willows. Overall vegetation and canopy density is high, with minor gaps spread across the Project Area. The single largest gap is a terraced meadow on river left, approximately in the middle of the Project Area (near RM 20.7). Figure 2-1 illustrates the riparian vegetation community typical within the Project.

Figure 2-1. Riparian Vegetation Typical of the Upper Twisp River Project Area

2.5 Description of lateral connectivity to floodplain and historical floodplain impacts

Floodplain connectivity was analyzed using Relative Elevation Maps (REM), as illustrated in Appendix B – Relative Elevation Map series, and varies throughout the Project. In Project Area 2 (RM 20.1 to 20.9), confinement is moderate and incision relatively low. Numerous existing or relic side channels are evident. In Project 3 (RM 20.9 to 21.6), the downstream portion is highly confined while the upper portion is moderately confined. The lower portion of Project Area 4 (RM 21.8 to 22.2) is naturally moderately confined: however, lateral connectivity is highly restricted at the upstream end by the NFD-44 road bridge crossing footings where local incision persists. Potential lateral connectivity on river right (south side) is restricted by both the bridge and road prisms. With that exception, there are no other anthropogenic structures or development within the Project (see Appendix B).

3. TECHNICAL DATA

3.1 Incorporation of HIP III specific Activity Conservation Measures for all included project elements

The BPA HIP III Handbook Version 4.1 (BPA 2016) identifies General Aquatic Conservation Measures Applicable to all restoration actions that include:

- Project Design and Site Preparation;
- Work Area Isolation & Fish Salvage;
- Construction and Post-Construction Conservation Measures;
- Staged Rewatering Plan;
- HIP III Turbidity Monitoring Protocol;
- Stormwater Management Guidance; and
- Terrestrial Plants, Wildlife, and Aquatic Invertebrates.

Restoration action categories and risk levels applicable to the Project will be identified by the BPA RRT (Restoration Review Team) and included in future design stages.

3.2 Summary of site information and measurements (survey, bed material, etc.) used to support assessment and design

The following sections describe site information that was collected to support the assessment and design alternatives.

3.2.1 Topographic Surveys and Surface Development

Consistent with the direction provided by the Washington Board of Registration for Professional Engineers and Land Surveyors for incidental survey work, site surveys were conducted under the direction of a licensed professional engineer and are intended for his or her own use toward the development of an engineered design.

The field collected topographic survey data for the Project were acquired between October 9 and 11, 2017. Field data included topographic and bathymetric northing, easting, and elevation Global Positioning System (GPS) coordinates, as well as geomorphic and habitat data collection. Additional GPS locations and descriptions of key features including road crossings, bridges, levees, edges of pavement, and other points of interest were collected during field surveys. Data were acquired using a Trimble R10 real time kinetic (RTK) GPS with Global Navigation Satellite System (GLONASS) receivers operating from established control points. In areas of dense canopy in the upper portion of the Project a conventional Nikon Total Station was used. Two survey control points were established by collecting raw static GPS data for a minimum of 2 hours. Tetra Tech staff sent the data in to the Online Positioning User Service (OPUS) for post-processing and conversion to the preferred coordinate system: North American Datum (NAD) 83, Washington State Plane, North Zone, horizontal projection, and to the North American Vertical Datum (NAVD) 88, using U.S. survey feet as the vertical projection.

The topographic survey included a longitudinal profile of the thalweg, with data collected at approximately 20-foot intervals, and capturing all major breaks in slope necessary for hydraulic analyses. The profile covered 11,581 feet of river (Figure 3-1). The slope at the upper end in Project Area 4 averaged 1.99 percent, 1.63 percent in Project Area 3, and 1.46 percent at the downstream end in Project Area 2.

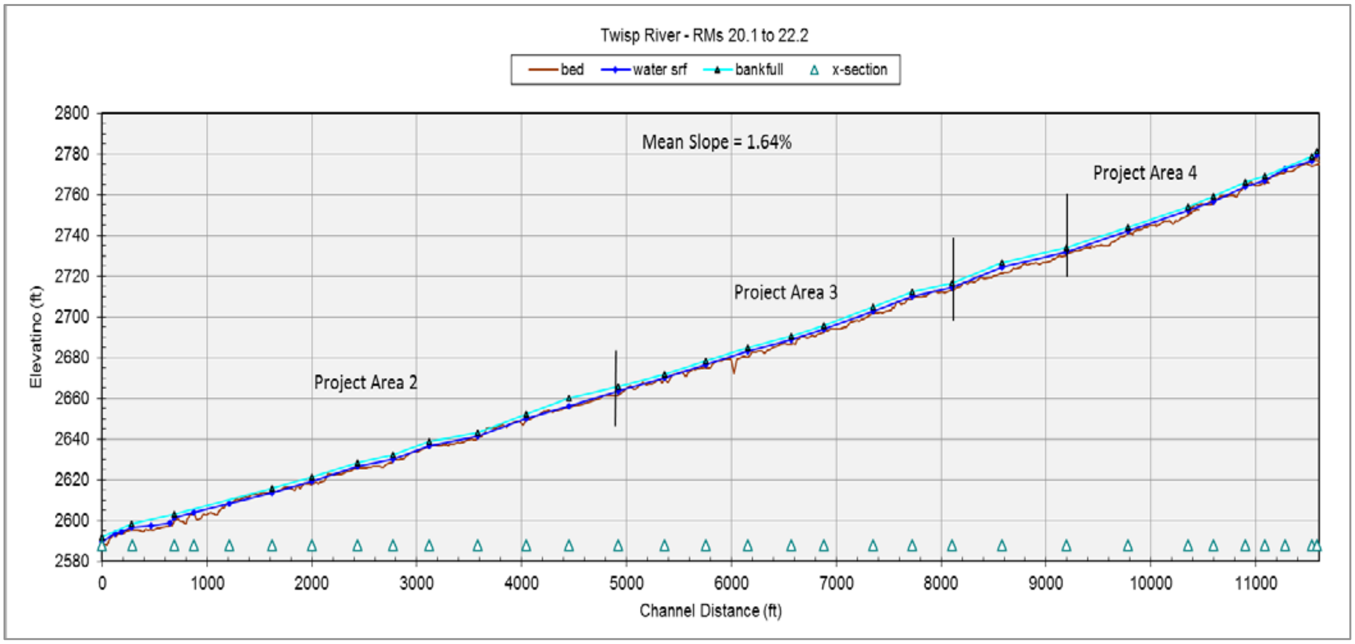

Figure 3-1. Longitudinal Profile of the Twisp River, Project Areas 2, 3, and 4

A total of 32 cross sections were surveyed, spaced at approximately 300-foot intervals. Additional data such as intermediate channel bottom and gravel bar data was collected throughout the reach to improve the surface resolution for suitability for hydraulic modeling and account for any changes in bed or banks since the LiDAR flight.

Traditional LiDAR data were acquired in 2006 (Watershed Sciences 2007). More recently, 1-meter resolution LIDAR data were collected in 2015 for the Oregon LiDAR Consortium Okanogan Federal Emergency Management Agency (FEMA) Study (QSI 2016). Canopy height was calculated using the 2015 LiDAR dataset to determine the height of vegetation in the LiDAR survey area. The calculation used both the bare earth and highest hit digital elevation model (DEM). The highest hit DEM comprises the LiDAR first returns that include the tree tops and are removed from the bare earth model by classification.

Traditional LiDAR laser pulses do not penetrate water surfaces, but rather reflect off the surface. Therefore, to produce an accurate surface for hydraulic modeling and designs, the water surface data was removed and replaced with field collected GPS bathymetric data. In addition, while the 2015 lidar dataset is the more recent, a review of both datasets based on field survey information concluded that the 2006 dataset represented the floodplain more accurately and was selected to be merged with the bathymetric data. LiDAR data were compared against field collected GPS points to determine if any adjustments of the data were required. These comparisons indicated that no horizontal or vertical adjustments to LiDAR northing, easting, or elevation data were needed. The survey data was merged with the 2006 LiDAR data to provide a final surface for hydraulic modeling and design development.

3.2.2 Geomorphic and Habitat Data Collection and Observations

Geomorphic and habitat data were collected during the field survey. In addition, detailed potential restoration actions, site photographs, and related notes were recorded on iPads using GISPro software. These data were gathered to characterize current in-channel and riparian habitat, establish baseline conditions in the Methow River, and identify potential restoration opportunities. Specific attention was given during field surveys to making observations related to sediment transport and response conditions, channel incision and channel stability trends (erosion or aggradation), substrate characteristics (e.g., size, distribution, supply), the abundance and influence of instream wood, floodplain connectivity, the influence of human alterations, and the interaction of the stream with riparian ecological processes.

Table 3-1 shows geomorphic and habitat data from surveys conducted in 2013 (USFS 2014), compared with field survey data collected in 2017. Most of the data were very similar, but some differences would be expected since the USFS data from Reach 4 extended upstream of the Project reach by 0.6 miles, where the channel becomes steeper, narrower and more confined. The lower portion of the Project survey in Project Area 2 was less confined, contained 5 of the 11 total pools observed, and likely explains the difference in LWD counts since a large portion of the wood counted occurred in large log jams in that reach.

Table 3-1. Geomorphic and Habitat Characteristics

Metric	2013[1/]	2017[2/]
River Miles (mapped)	20.3 to 22.8	20.1 to 22.2
Valley Setting	U-shaped	U-shaped
Channel Morphology	Riffle-rapid	Riffle-rapid
Rosgen Type	B3	B3, C4
Gradient (percent)	1.8	1.59
Sinuosity	1.05	1.16
Wetted Width (feet)	38	35.9
Bankfull Width (feet)	57	63.7
Width-to-Depth Ratio	37	41.8
Entrenchment Ratio	1.85	--
Substrate (dominant (percent), subdominant (percent))	Sand (6%), Gravel (15%), Cobble (51%), boulder (28%)	See Table 3-2
Unstable Banks (percent)	5.3	Not fully measured
LWD (pieces/mile)	15.7	32.4
Pools (pools/mile)	5.4	4.9
Habitat Units (percent)	Pool (5.8%), Run (4.5%), Riffle (90.5%), Side Channel (0.2%)	Pool (4.2%), Run (5.7%), Riffle (85.9%), Glide (4.2%)

1/ USFS (2014)
2/ Tetra Tech 2017 field survey data

Additional geomorphic data collected during field surveys included pebble counts using sampling methods similar to those described in Bunte and Abt (2001). The pebble count substrate samples were collected near the upstream and downstream extents of each of the three project areas. Table 3-2 contains the sediment characteristic metrics such as characteristic grain sizes (e.g., D_{50}, D_{84}), and the percentages based on size categories (percent fines, gravels, cobbles, boulders, and bedrock) of the bed material. Sediment sizes generally increase from downstream to upstream, as might be expected with the corresponding increases in channel slope. Plots of the sediment grain size distributions are shown in Figure 3-2.

Table 3-2. Substrate Characteristics from Pebble Counts Taken on the Upper Twisp River

	Project Area 2 RMs 20.1 to 20.9		Project Area 3 RMs 20.9 to 21.6		Project Area 4 RMs 21.8 to 22.2	
Substrate Size Characteristics	Downstream Sample Site	Upstream Sample Site	Downstream Sample Site	Upstream Sample Site	Downstream Sample Site	Upstream Sample Site
Percent Silt/Clay	0	0	0	0	0	0
Percent Sand	4	0	0	0	0	4
Percent Gravel	48	44	45	33	25	26
Percent Cobble	44	52	52	60	38	44
Percent Boulder	4	4	3	7	36	27
D_{16} (mm)	29	45	37	45	39	37
D_{35} (mm)	46	57	54	65	92	78
D_{50} (mm)	62	70	68	78	150	130
D_{65} (mm)	90	87	81	96	370	210
D_{84} (mm)	150	150	120	200	780	380
D_{95} (mm)	240	230	230	340	1500	670

RM — River Mile
mm — millimeter

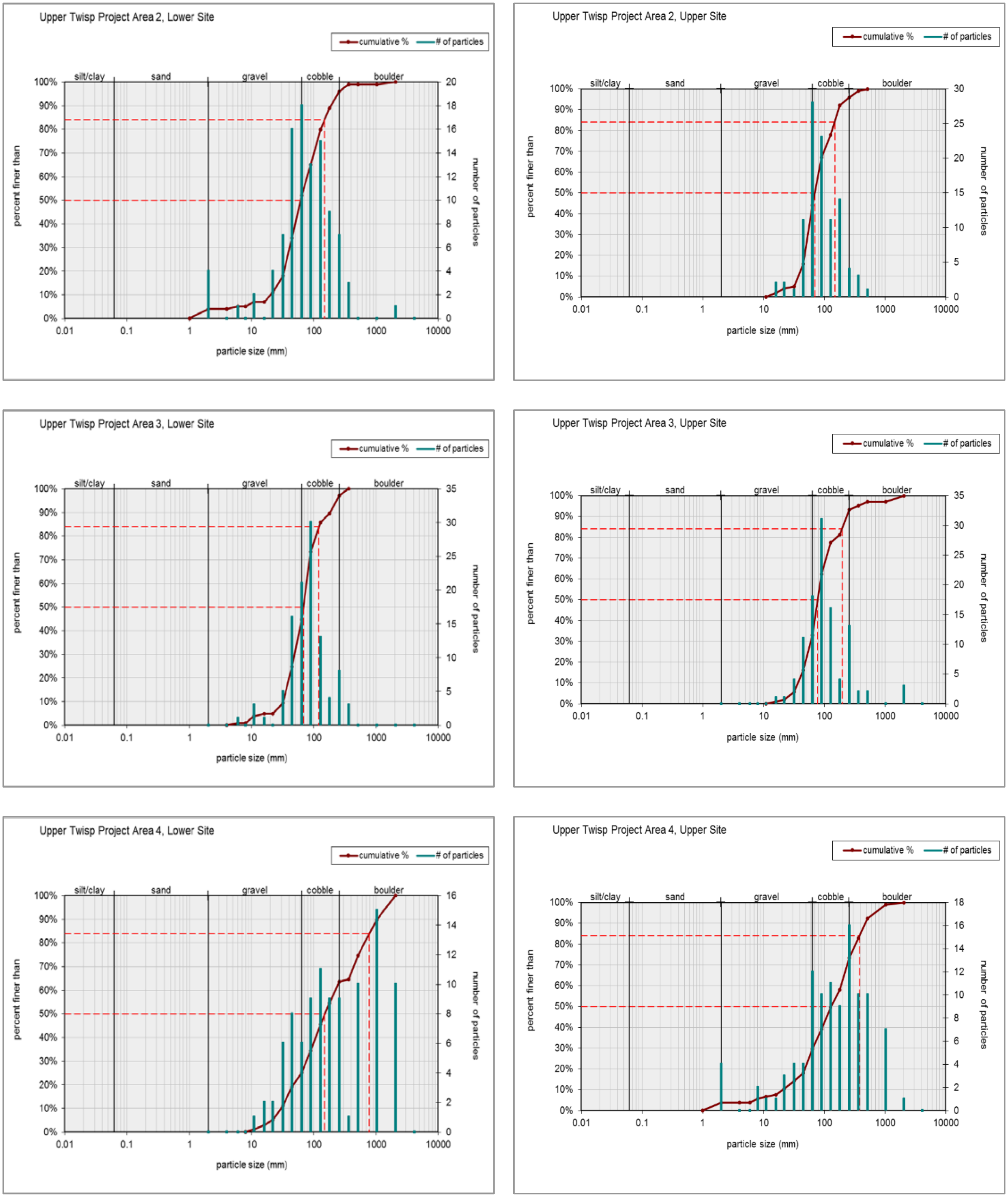

Figure 3-2. Substrate Grain Size Plots for Project Areas 2 (top row), 3 (middle row), and 4 (bottom row)

3.3 Summary of hydrologic analyses conducted, including data sources and period of record including a list of design discharge (Q) and return interval (RI) for each design element

The Project resides in the fifth field Hydrologic Unit Code (HUC) Twisp River watershed (HUC 1702000805). The U.S. Geological Survey (USGS) has operated a stream gage (#12448998) near the town of Twisp from May 1975 to Sept. 1979 and Oct. 1989 to present, for a total of approximately 33 peak flow records, and includes a historical event recorded in May 2006 corresponding to a peak discharge of 3,880 cubic feet per second (cfs). Additionally, an extreme event was recorded outside of the period of record in May 1948 by slope area measurement, approximately 1,000 feet upstream from the mouth, corresponding to a peak discharge of 9,440 cfs (USGS 2017). The gage is located at the lower crossing of the Twisp River Road (at RM 1.7). The drainage area at this site is approximately 244.0 square miles (USGS 2017). Table 3-3 shows the peak flow results from gage 12448998 utilizing the U.S. Army Corps of Engineers (USACE) Hydraulic Engineering Center Statistical Software Package (HEC-SSP) and Log-Pearson III analysis. Both the May 2006 and May 1948 historical peak discharges were included in the analysis.

Table 3-3. Log-Pearson III Gage Analysis and Gage Basin-Area Transfer Results

Return Period (years)	Gage #124498998Peak Flow (cfs)	Project at RM 20.1 Peak Flow (cfs)
2	2,185	750
5	3,135	1,104
10	3,789	1,358
25	4,647	1,703
50	5,307	1,971
100	5,984	2,253

cfs – cubic feet per second

Based on the USGS StreamStats watershed delineation tool (USGS 2017), the drainage area at the Upper Twisp River at the downstream end of Project Area 2 (at RM 20.1) is approximately 72.4 square miles. Table 3-3 shows the Project peak flow values as adjusted using a basin-area ratio and regional adjustment factor (Cooper 2006; Mastin et al. 2016). The basin-area ratio between the Upper Twisp Project reach and the gage is 0.3. The USGS accepted range to utilize this method of gage transfer for basin-area ratio is between 0.5-1.5. The estimated value is outside the USGS accepted range, therefore peak flow values were also estimated using regional regression equations for comparison. The regional regression equations utilized are provided in Magnitude, Frequency, and Trends of Floods at Gaged and Ungaged Sites in Washington, and are based on data through water year 2014 (Mastin et al. 2016). Input parameters for the regression analysis were taken from StreamStats (USGS 2017). Results of the regional regression analysis are shown in Table 3-4 below.

Table 3-4. Project Regional Regression Peak Flow Estimates

Return Period (years)	Project at RM 20.1 Peak Flow (cfs)
2	894
5	1,390
10	1,770
25	2,280
50	2,730
100	3,170

cfs – cubic feet per second

Results of the regional regressions analysis peak flow values are moderately higher than those of the Log-Pearson III gage basin-area transfer analysis. While the gage contains 31 years of record, the basin-area ratio for gage transfer is outside the USGS acceptable range. The drainage area for the Upper Twisp Project reach lies further upstream in the overall drainage area of gage 12448998, and contains steeper slopes and alpine vegetation that would suggest higher peak flows. The regional regression analysis utilizes data taken from all areas that fall within the specified drainage. After careful consideration, Tetra Tech selected the results of the regional regression analysis as shown in Table 3-4 to be utilized in the hydraulic model due to engineering judgement and conservative design.

Typically, historical gage data is the primary method used to estimate average annual flow, baseflow, and evaluate the bankfull discharge. The recurrence interval for the bankfull discharge is typically around 1.5 to 2 years but can range from 1 to 32 years (Hey 1997). Regression analysis was chosen as the primary tool for estimating discharge for this project, therefore Tetra Tech evaluated several flows in the hydraulic model for comparison against bankfull survey points collected from the topographical field data. Upon completion of the existing conditions hydraulic model, bankfull flow was estimated at slightly less than the 2-year recurrence interval.

3.4 Summary of sediment supply and transport analyses conducted, including data sources including sediment size gradation used in streambed design

This section will be developed in later design stages.

3.5 Summary of hydraulic modeling or analyses conducted and outcomes – implications relative to proposed design

Restoration design for improvements requires a fundamental model to evaluate the hydraulic behavior of the existing reach system. Tetra Tech generated a detailed one-dimensional (1D) model utilizing GeoHECRAS (version 2) coupled with AutoCAD Civil 3D (Civil 3D) 2018 as primary software applications. GeoHECRAS combines GIS and HEC-RAS software into one user interface for efficient task management, while Civil 3D was used as the main engine behind surface generation. The existing surface was generated with the LiDAR and survey topographical data described in Section 3.2.1. The two data sets were merged together in Civil 3D to represent the existing conditions surface of the reach and were inserted into GeoHECRAS to create a terrain for the hydraulic model.

The hydraulic model analysis included scenarios ranging from flows at the time of survey (approximately 44 cfs) through the 100-year recurrence interval. The 2-, 5-, 10-, 25-, 50- and 100-year recurrence intervals were evaluated using the peak flow values obtained from the regression analysis described in Section 3.3 and match the values listed in Table 3-4. Model geometry includes the entire reach length alignment and multiple cross sections, flow paths, bank stations, and roughness coefficients to best represent the hydraulic behavior of the existing system. The Geolocation feature within Civil 3D was used to overlay an aerial map on the project extents. Based on the landcover presented in the aerial, a Manning's roughness value of 0.05 was selected for the channel and a value of 0.1 was used for the heavily vegetated overbanks. Boundary conditions were set for each terminus of the model, inflow at the upstream end representing the recurrence interval flow rate, and normal depth at the downstream end representing the energy slope measured at the end of the model. Initial modifications to the channel alignment were necessary based on field survey data collected for thalweg locations. Figure 3-3 below illustrates a meander section of the hydraulic model and shows the typical cross sections, flow paths, and bank stations that were used throughout the reach.

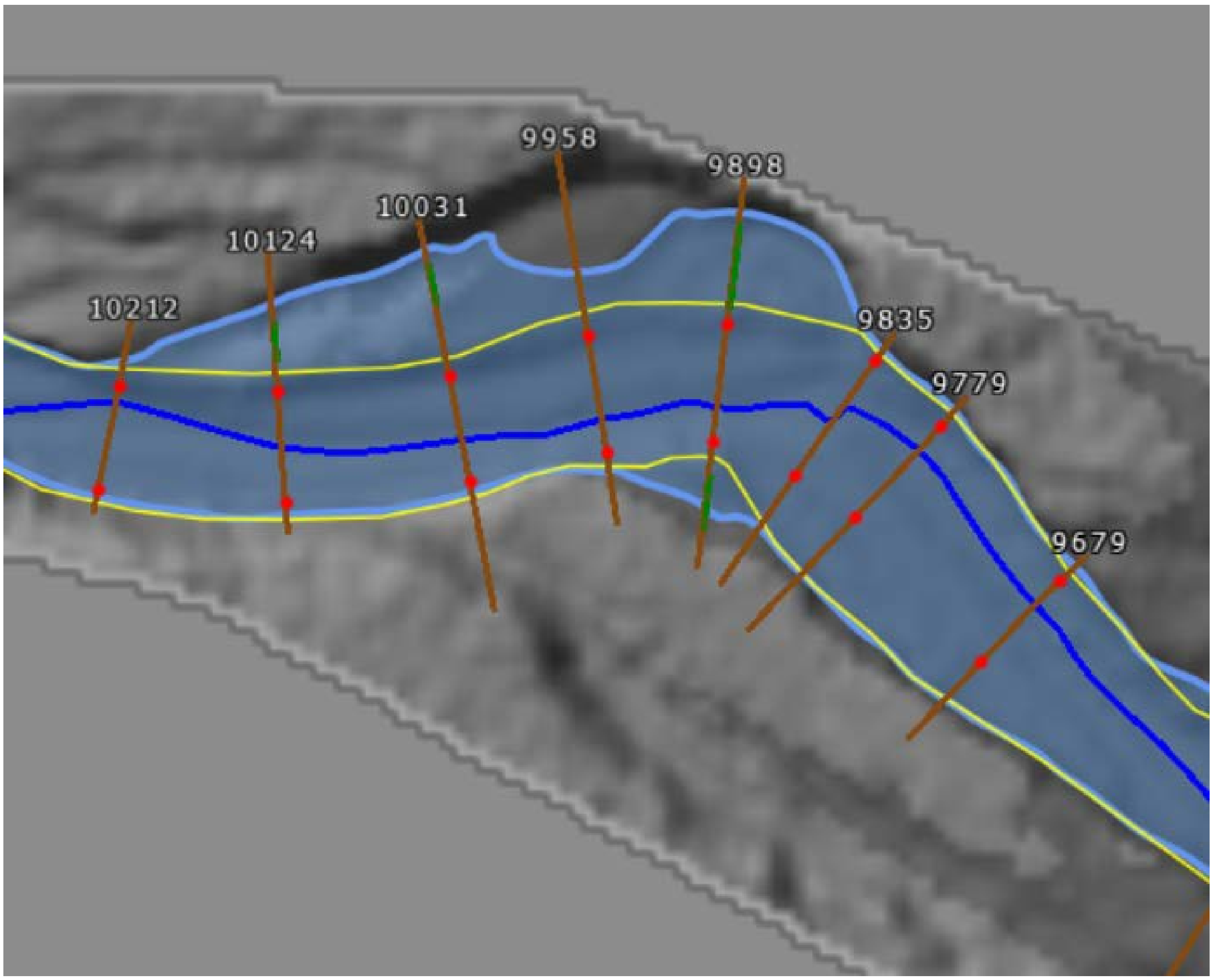

Figure 3-3. Hydraulic Model Typical Meander Section

After entering the geometry and hydraulic parameter information, steady flow analysis was computed for the time of survey flow value to review geometry input parameters and model calibration. Edge of water survey points were reviewed against inundation extents for 44 cfs (flow at time of survey). Results suggested that a slightly higher Manning's roughness value was necessary for model calibration, and the process was repeated for a channel manning's value of 0.055. Results of the second iteration indicated an accurate match between inundation extents and surveyed edge of water points. Additional revisions to cross sections, bank stations, and flow paths were made for calibration against estimated bankfull flow and bankfull surveyed points using the same process as described above. Upon the completion of model calibration, steady flow analysis computations were computed for the remainder of the scenarios.

Inundation results for the existing conditions hydraulic model analysis are provided as Appendix C. The existing NFD-44 bridge crossing at the upstream extent of the reach passes all modeled flow conditions with sufficient freeboard. Inundation extents towards the downstream end of the reach illustrate expected outcomes based on field observations and historical stream locations. Restoration design improvements for floodplain connection and activation of relic channels are anticipated.

The proposed conditions hydraulic model will be fully developed in later design stages.

3.6 Stability analyses and computations for project elements, and comprehensive project plan

This section will be developed in later design stages.

3.7 Description of how preceding technical analysis has been incorporated into and integrated with the construction – contract documentation

This section will be developed in later design stages.

3.8 For projects that address profile discontinuities (grade stabilization, small dam and structure removals): A longitudinal profile of the stream channel thalweg for 20 channel widths upstream and downstream of the structure shall be used to determine the potential for channel degradation

This Project does not address profile discontinuities.

3.9 For projects that address profile discontinuities (grade stabilization, small dam and structure removals): A minimum of three cross-sections – one downstream of the structure, one through the reservoir area upstream of the structure, and one upstream of the reservoir area outside of the influence of the structure) to characterize the channel morphology and quantify the stored sediment

This Project does not address profile discontinuities.

4. CONSTRUCTION – CONTRACT DOCUMENTATION

4.1 Incorporation of HIP III general and construction conservation measures

Conservation measures will be included in the contract documentation for construction, and relevant items will be included in the design drawings, construction specifications, and implementation plan in later design stages. The overall design will be compliant with all HIP III activity conservation measures.

4.2 Design – construction plan set including but not limited to plan, profile, section and detail sheets that identify all project elements and construction activities of sufficient detail to govern competent execution of project bidding and implementation

This section will be fully developed in later design stages.

4.3 List of all proposed project materials and quantities

This section will be fully developed in later design stages.

4.4 Description of best management practices that will be implemented and implementation resource plans including:

This section will be fully developed in later design stages.

4.4.1 Site Access Staging and Sequencing Plan

4.4.2 Work Area Isolation and Dewatering Plan

4.4.3 Erosion and Pollution Control Plan

4.4.4 Site Reclamation and Restoration Plan

4.4.5 List Proposed Equipment and Fuels Management Plan

4.5 Calendar schedule for construction/implementation procedures

This section will be fully developed in later design stages, and a detailed construction schedule provided in the implementation plan.

4.6 Site or project specific monitoring to support pollution prevention and/or abatement

No site- or Project-specific monitoring for pollution prevention and/or abatement will be required.

5. MONITORING AND ADAPTIVE MANAGEMENT PLAN

If a Monitoring and Adaptive Management Plan is deemed necessary for this Project, Yakama Nation Fisheries will develop and submit as required.

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APPENDIX A

PROJECT PLAN SHEETS

APPENDIX B

RELATIVE ELEVATION MODEL RM 19.9-RM 20.8

APPENDIX C

INUNDATION MAPS