Basis of Design

Asotin Creek Project Area 3.2
Habitat Restoration Design
Asotin County, Washington

for
Asotin County Conservation District

October 3, 2024

GeoEngineers
Earth Science + Technology

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File No. 22281-009-00

October 3, 2024

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1.0 INTRODUCTION

GeoEngineers Inc. (GeoEngineers) has prepared this Basis of Design report (report) for the Asotin County Conservation District (ACCD). This report provides a summary of our findings pertaining to the existing conditions of the Project Area 3.2 located on Asotin Creek, near Asotin, Washington, and an explanation of the design process, analyses, and outcomes for the proposed enhancement design.

GeoEngineers organized the following sections of this report to describe the General Project and Data Summary Requirements required by the Bonneville Power Administration (BPA) for regulatory compliance coverage under the Habitat Improvement Program (HIP IV). This report is submitted to satisfy the design review for technical comment as part of the BPA Restoration Review Team (RRT) review process. BPA developed the requirements to effectively communicate that appropriate planning, analysis, design and resulting construction documentation are met. The conditions of the project reach are described in terms of processes that shaped the stream and associated ecosystem within the context of various ecological disciplines. This includes discussions on hydrology, hydraulics, habitat, and geomorphology. The evaluation and consideration of the site conditions provide the basis for the project design.

1.1. Project Overview

In 2018, an Asotin County Watershed Assessment (Bennett, et al 2018a) and Conceptual Restoration Plan (Bennett, et al 2018b) were published with the intent of describing watershed conditions and restoration treatments that would improve habitat conditions and watershed function. The Asotin Creek PA 3.2 was included in Bennett et al. (2018a and 2018b), and pertinent results shaped the overall goals, objectives, and strategies that are guiding this project. Collectively those reports set the stage for this project by detailing the following:

- Geomorphic, riparian, and floodplain conditions
- Current limiting factors
- Restoration strategies
- Conceptual restoration plan

Owing to Asotin Creek watershed's assumed historical ability to support more than 500 spawning Snake River steelhead, it is listed as a Major Spawning Aggregation (MSA). Hatchery stocking was discontinued in Asotin Creek in 1997 and it is currently designated as a natural steelhead reserve (Bennett, et al., Asotin County Conceptual Restoration Plan: Technical Document and Appendices 2018b). Steelhead are known to occupy most of the Asotin Creek mainstem throughout the year; however, degraded habitat conditions in PA 3.2 limit distribution because there is very little low-velocity habitat available. These apparent population bottlenecks include rearing conditions and migration patterns, particularly for juvenile fish.

Bennett et al. (2018b) identified restoration opportunities throughout the Asotin Creek watershed. Restoration opportunities were organized into four implementation tiers. Tier 1 opportunities were considered the highest priority for implementation because benefits to habitat and fish population response are generally expected to be realized in the short-term (5 to 10 years). Tier 2 opportunities (which PA 3.2 was identified in) are expected to have benefits similar benefits to Tier 1 projects but expected to take longer to realize or require more restoration actions. In the case of PA 3.2, restoring natural processes or some natural processes would be a substantial investment in time and resources. However, through this project reach, restoring natural processes and associated habitats is not reasonably possible due to infrastructure and adjacent land uses. Still, habitat is degraded sufficiently that without enhancement, very little juvenile rearing habitat is available, and the degraded conditions are likely to limit access to higher-quality habitat conditions upstream. By approaching this project as a relatively simple habitat enhancement project (as opposed to a project that restores natural processes), the full extent of possible habitat benefits can be achieved almost immediately following construction.

1.2. Project Goals and Objectives

The overall intent of this project will address the management objectives that were identified in the Asotin Conceptual Restoration Plan (Bennett, et al 2018b). The project will increase instream habitat complexity by placing complex structures such as large woody material (LWM) and boulders within the channel. Increasing channel complexity will primarily be focused on all freshwater life stages of Snake River steelhead, which will also benefit other native salmonids such as Chinook Salmon and Bull Trout. Additionally, this project will take advantage of the Conservation Reserve Enhancement Program (CREP) enrollment by increasing riparian width, function, and non-native species expansion.

Specific project objectives include:

- Installing LWM structures and boulder clusters throughout the project area to provide instream channel complexity.
- Installing a livestock bridge to keep cattle out of the stream and allow for movement of livestock to the south side of Asotin Creek.
- Enhancing side channel and other similar high flow paths where practical.
- Controlling invasive vegetation (to be completed by ACCD).
- Improving riparian function and condition through planting and reseeding (to be completed by ACCD).

1.3. Project Responsible Parties

- The project sponsor is the Asotin County Conservation District, and the project manager is Kodie Wight, 509.552.8119.
- The prime design consultant is GeoEngineers, Inc., and the engineer of record is Becca H. Miller, PE, 208.258.8320.

2.0 EXISTING CONDITIONS

2.1. Physical Setting

The PA 3.2 reach is located on the mainstem of Asotin Creek generally between River mile (RM) 4.0 and 5.2. Most of the left bank floodplain is used for ranching operations and includes barns, outbuildings, feed storage, equipment storage, and winter feeding/calving area for approximately 400 mother cows. In addition to the unlikely ability to relocate ranching operations, decades of relatively intense cattle presence in the floodplain has resulted in substantial nutrient entrainment potential if floodplain habitats were to be reestablished. Therefore, restoring natural processes through this area could be counterproductive as water quality impacts are certain.

GeoEngineers completed a site reconnaissance on January 12, 2023, to observe existing conditions and map locations where additional structures would be most effective and beneficial for native salmonids. Site photographs are included in Figures 1 through 5. LWM was rare throughout the project reach; however, in the few locations where LWM is present, the stream response is creating good habitat conditions for native salmonids (Figures 1 through 3). Boulder clusters (Figures 3 and 4) were observed more frequently and are creating low-velocity refugia and habitat diversity.

Our field observations were consistent with the Bennett et al. (2018a) report findings for the PA 3.2 site and included:

- **Geomorphic conditions**: The channel has been straightened and confined by levees to protect private property from high-flow events and is mostly confined against the right bank valley wall. The channel is a single thread throughout the site, and hydraulic diversity is low, having very little LWM and other structural elements such as boulders, root masses, and undercut banks.
- **Riparian conditions**: Through most of this project reach, riparian function is moderate. In most areas, mature trees in the riparian area provide some shade to the channel. However, the riparian community, where present, is a relatively thin strip of trees so even small avulsions could result in complete loss of mature riparian tree canopy. Additionally, the riparian area is composed mostly of late seral stages of alder (*Alnus sp.*) and black cottonwood (*Populus balsamifera*), so recruitment appears to be limited.
- **Floodplain conditions**: Owing to the construction of levees, channel straightening, and adjacent land use, the floodplain is completely disconnected from the main channel through this reach. Anecdotally, the project area landowner mentioned that the stream rarely gets out of the channel even during high flow events. Although the stream is disconnected from the floodplain, it is important to note that—given the long history of the adjacent floodplain being used as a wintering and calving area for approximately 400 mother cows—floodplain reconnection is not practical or desired through this project area.
- **Habitat limiting factors**: As it applies to fish habitat, the most significant limiting factor is the lack of holding and rearing habitat. Over 90 percent of the channel through this project reach is a riffle. An estimated 10 percent of the riffle habitat has boulders that provide pocket-water, but the pocket-water capacity is low and is not suitable for young of the year through 1+ age classes due to high velocities and lack of contiguity with low-velocity habitats. The lack of holding and rearing habitat can largely be attributed to a lack of complex structure such as LWM, boulders, and root masses in the channel margins. Floodplain isolation is also a limiting factor because it prevents natural processes from shaping and maintaining complex habitats.

3.0 DESIGN DEVELOPMENT

3.1. HIP 4 Biological Opinion Considerations

The proposed design is subject to the HIP IV Biological Opinion process and design elements follow conservation measures defined by the BPA HIP Guidelines (Bonneville Power Administration 2023). The following subsections describe the project elements designed under the responsible charge of an engineer licensed in the state of Washington. Project elements are shown in the Preliminary Design Drawings (Appendix A).

3.1.1. Form Requirements

- Project Title: Asotin Creek Project Area 3.2-Fish Habitat Restoration
- Hydrologic Unit Code (HUC) 12: 170601030205
- Endangered Species Act – Listed and State-Listed Species
  - National Marine Fisheries Service (NMFS)—Snake River Spring/Summer run Chinook Salmon (*Oncorhynchus tshawytscha*)
  - NMFS—Snake River Basin steelhead (*O. mykiss*)
  - United States Fish and Wildlife Service (USFWS)—Bull Trout (*Salvelinus confluentus*)
- Category of Action (2): River, Stream, Floodplain, and Wetland Restoration (Bonneville Power Administration 2023)
  - HIP 4 Category 2a—River, Stream, Floodplain, and Wetland Restoration—Improve Secondary Channel and Floodplain Interactions
  - HIP 4 Category 2d—Install Habitat-Forming Natural Material Instream Structures (Large Wood, Boulders, and Spawning Gravel)
  - HIP 4 Category 2e—Riparian Vegetation Planting

3.2. Main Channel Complexity Enhancement – HIP IV Category 2d

Increasing and improving mainstem channel complexity is one of the primary objectives of this project. Owing to the straightened and confined channel conditions along with the lack of floodplain accessibility, our design approach focused on increasing complex structure in the channel that will create and maintain habitat conditions for steelhead and other native salmonids. Although structure was limited, where it was present, habitat forming channel response in the form of scour, sediment sorting, and velocity diversity was evident. Therefore, we used those observations, past experiences in similar conditions, and professional judgment to strategically locate and design structures that will improve habitat conditions. Because Asotin Creek through PA 3.2 is primarily a homogeneous riffle, it is important to add structure throughout the entire project reach to provide complexity and contiguity. Additionally, the riparian area width is narrow and appears to be at risk, so, to the extent practical, we located structures where riparian disturbance would be least. Our Preliminary Design drawings (Appendix A) include the following habitat enhancing structure types:

Habitat Boulders and Boulder Clusters: Single boulders and boulder clusters will be placed throughout the mainstem channel to increase hydraulic diversity, cover, promote sediment sorting, and help direct water into the proposed side channels. Boulder clusters will also selectively help stabilize large wood placed within the channel. Boulder placement is a key feature throughout the design because, although limited, they are the structure type currently providing the most channel complexity and habitat diversity. We recognize that pre-disturbance habitat complexity was likely created by LWM and side channels; however, current conditions dictate the prominent use of boulders as habitat forming structures.

Habitat boulder placement targeted areas identified during the site reconnaissance and focused on locations such as shallow runs and riffles where boulders would be partially exposed during a range of flows. The number and density of boulders within these areas targeted approximately 30 to 40 percent of the channel width, and approximately 2 to 3 percent of the channel volume during a 2-year event. This targeted density is based on research by Shinbein and Holste (2020) that suggests this range of obstruction is most effective at reducing localized water velocities (Shinbein and Holste 2020).

Large Woody Material: Large wood will be incorporated in the main channel and side channels in the form of buried rootwads, sweeper logs, and whole trees/treetops. Currently there is very little structure in the mainstem, and secure cover is sparse. Proposed wood structures, located in the bank of the mainstem, are intended to function as fish habitat cover for both juvenile and adults during both high- and low-flow conditions. Stabilizing large wood will incorporate a combination of methods including bank trenching and securing with embedded boulders and piles at the streambank. Material used for these structures will be imported from offsite sources. Five types of LWM structures are proposed, including:

- Flow Deflection Jam—This large, engineered log jam will be buried in the channel bank with four large rootwads protruding into the main channel along with 13 smaller logs that are stabilized with piles. These structures are designed to interact with all ranges of flow events and redirect flow to the opposite bank, with the purpose of increasing hydraulic roughness, increasing habitat complexity, and accumulating additional woody material through time.
- Bank Rootwad Jam —This LWM structure is composed of two medium logs with rootwads plus two large treetops and small racking logs. It will be buried in the bank for stability with rootwads partially embedded in the channel to increase hydraulic roughness, redirect flow, create diverse fish habitat, and accumulate additional woody material through time.
- Sweeper Logs—This LWM structure consists of two treetops of large trees extended into the channel to redirect flow, create scour, and encourage gravel deposition. The base of the logs are buried in the bank for ballast and stability.
- Single Rootwads—Large wood will be partially buried as single logs and in clusters in the main channel to provide roughness, stability, and habitat diversity. Some single rootwads will be buried in the channel bank while others will be buried in the bed of the main channel, with rootwads sticking out into flow in both cases. Both types of single rootwad structures will be stabilized with boulders and overburden ballast.
- Side Channel Logs—Side channel habitat throughout this project area and the adjacent reaches of the stream are limited and, where present, provide very little secure cover and refugia from high-velocity mainstem flows. The wood structures proposed within the side channels are primarily intended to promote scour and provide secure cover. The wood structures, combined with riparian restoration, will create a highly complex nursery/juvenile rearing habitat that allows fish to escape high-velocity mainstem flows and avoid predation. Floodplain woody material serves to increase roughness, which attenuates flow velocities and creates unique niche habitat for vegetation and wildlife.

Placement and configuration of LWM can vary and be field fit to maximize benefits, provided it is approved by the contracting officer and burial depth is adequate. Proposed locations of LWM target areas identified during the site reconnaissance that lacked instream structure and could be accessed from the bank with minimal disturbance to established riparian canopy. LWM placement also targets areas where other restoration actions would occur, including boulder placement, side channel grading, and bank terracing. The number of large wood pieces is based on studies by Fox and Bolton (2007) that identify the median number of pieces per linear length of stream in eastern Washington forests and for channels with bankfull width between 30 and 100 feet (Fox and Bolton 2007). We multiplied this target density (0.052 pieces per linear foot of channel) by an adjusted reach length equal to 4,800 feet. The adjusted reach length is the project reach length reduced to remove areas with limited suitability for placement of wood, including bedrock outcrops along the steep valley right bank, and to avoid disturbance to areas with mature native riparian canopy along the left bank. The resulting target number of large wood pieces is 249 and the number of large wood pieces included in the design is 266.

Rope is included in the design of Flow Deflection Jams to provide additional stability in this high energy system during the first few years following structure installation when structures are the most vulnerable. We have selected a biodegradable material in place of chain so the material does not remain in the stream for years following the degradation of the original log structure.

3.3. Side Channel Grading - HIP IV Category 2a

Side channel development includes the creation of four side channels targeting areas with low topography or existing high flow side channels. The existing side channels have become disconnected from the main channel at low flows. The proposed side channels A, B, and C are intended to be active at the July/August 10 percent exceedance discharge (approximately 51 cubic feet per second [cfs]) with approximately 0.5 feet to 1.0 feet of water. These side channel enhancements are on the right bank of the creek and intended to increase habitat connectivity to existing vegetated areas along the right bank. Side channel enhancement includes excavation to expose native soils and does not include import of streambed materials or washing fines into the streambed.

A fourth side channel—Side Channel D—is proposed at the downstream project limits on the left bank. This side channel will be activated by removing a portion of an existing left bank levee and allowing moderate flow events to occupy the left bank floodplain in a wooded area between the feed lot and mainstem channel. This floodplain area is currently activated at the 5-year discharge (892 cfs) under existing conditions and is designed to be active at the 2-year discharge (approximately 431 cfs) with approximately 0.5 feet to 1.0 feet of water under proposed conditions.

Large wood, including whole trees, will be placed throughout the floodplain and side channels. We anticipate side channels will primarily be used as nursery and juvenile rearing areas, so complexity and cover are important to provide refugia from high velocities and predator avoidance. Wood structures in the side channels will promote scour, create current breaks, and add diverse and secure hiding areas.

It is important to note that side channels are naturally transient. As such, channel avulsions and sediment deposition should be expected and could significantly change the size, shape, and flow over time. While our design intent is to create active side channels, sustainability is dictated by events beyond our control.

3.4. Bank Terracing - HIP IV Category 2a

Approximately 300 feet of bank terracing is proposed on the left bank from approximately station 26+50 to 29+50, adjacent to and on the opposite bank from Side Channel B. The existing bank is steep, unvegetated, and eroding. The proposed terracing will maintain the existing left bank toe and lay the bank back at a 2:1 (horizontal to vertical) slope to allow for the installation of LWM and riparian vegetation. The proposed terrace will stabilize the bank, decrease sediment inputs to the stream, and reduce the likelihood of channel avulsion into the adjacent feed lot. Additionally, it provides cover and shade, provides a velocity break where juvenile fish can avoid high-velocity conditions, reestablishes riparian vegetation, and increases hydraulic diversity.

3.5. Riparian Planting - HIP IV Category 2e

Riparian planting will occur throughout the project reach by the ACCD in the winter and spring following construction and will further enhance an established CREP area. Up to 3.5 acres will be revegetated with approximately 1,700 trees and shrubs. Planting locations will focus on areas where there are gaps in the existing riparian canopy and areas disturbed during construction. Plantings will include the following shrubs and trees:

- Blue Elderberry *(Sambucus caerulea)*
- Choke Cherry *(Prunus virginiana)*
- Golden Currant (*Ribes aureum)*
- Smooth Sumac *(Rhus glabra)*
- Water Birch *(Betula occidentalis)*
- Coyote Willow *(Salix exigua)*
- Peachleaf Willow *(Salix amygdaloides)*

Additionally, any and all shrubs excavated during construction will be salvaged to the extent practical and either replanted or buried throughout the excavated areas of the site.

Herbaceous grass and forb species will be seeded throughout all areas disturbed during construction with native seed mixes that are readily available and appropriate for the site. Seeding will be conducted through broadcast hand seeding methods throughout both zones. Seeding may be accompanied by mulching (weed free straw) to reduce erosion, provide ground cover, and reduce the likelihood of invasive species encroachment. If seeding occurs the year after construction, it will be important to do it as early as practical, after high-flow events, and might require re-scarifying the seed bed again, as appropriate. Spot weed treatment may be required as a post-construction follow up to reduce the likelihood of invasive species encroachment.

3.6. Livestock Bridge

The project area landowner operates a ranch adjacent to and north of Asotin Creek. One of his main summer pasture areas is located south of Asotin Creek, which requires cattle to cross the stream to access it. Currently there is a location that is sometimes used as a ford crossing; however, this location is basically just a location in the stream used for opportunistic livestock crossing and has not been designed specifically as a hardened crossing. As it is, the site is not suitable for reliable and safe crossing due to high water velocities and unstable channel bed. Cattle will need to use this crossing in the spring months when water is highest and calves do not have the weight or strength to navigate the high-water conditions. The bank opposite the cattle wintering area is a talus slope, which makes it difficult and dangerous for cattle to scale the bank after leaving the water.

Construction of a ford at this location is not a feasible alternative due to the substantial channel and bank excavation, fill, and disturbance and potential that constructing a ford could be a partial passage barrier for juvenile fish during summer low-water conditions when juvenile fish might be migrating to access colder water upstream. Based on the reasons listed above, it is our opinion that constructing a ford crossing would be potentially damaging and not practical.

Based on site observations and topographic survey results, we determined a bridge crossing could be constructed with minimal riparian disturbance, minimal channel bed disturbance, and footings could be placed outside the Ordinary High Water Mark (OHWM). A bridge crossing would be much more practical for supporting the ranching operations and unlikely to result in a fish passage barrier. We anticipate bridge dimensions to be approximately 75 feet long and 8 feet wide. The spacing of the bridge abutments are designed to accommodate a 75-foot-long prefabricated steel bridge. The bridge abutments will be built up, and a ramp for cattle to access the bridge will be added to allow the proposed deck low chord to be 1 foot above the 100-year water surface elevation. Livestock exclusion fencing will be included on the approach up to and crossing the bridge, connecting the north and south pastures and excluding livestock from the riparian areas.

We evaluated two bridge alternatives (rail car and prefabricated steel) for the design and our recommendations are to advance the prefabricated steel bridge option for the following reasons:

- Rail car bridges are in very short supply, and it seems unlikely that we could find one with suitable dimensions.
- Rail car bridges with the dimensions needed can be very costly to purchase and haul.
- Prefabricated steel bridges can be constructed to meet specific site conditions rather than railcar bridges where we would have to modify site conditions to fit the bridge dimensions.

While the design assumes use of a prefabricated steel bridge, the use of a rail car bridge may be considered during project bidding, assuming bridge dimensions meet the minimum dimensions specified in the plans. BPA funding does not include bridge construction or installation of livestock exclusion fencing and the bridge is not reviewed/covered under HIP. The bridge will be built on Veazie-Veazie variant complex soils, which are well drained to moderately well drained alluvially derived soils composed of silt loam, gravelly silt loam, cobbly silt loam, and very cobbly silt loam within the first 36 inches of soil horizon (Natural Resources Conservation Service 2023). No subsurface investigations have been completed at the proposed crossing. The contractor is responsible for footer design and subgrade preparation. Minor excavation and subgrade preparation is required for the bridge footings. Rock for erosion and scour protection is proposed around the footings and approach ramps to mitigate against erosion.

4.0 HYDROLOGIC AND HYDRAULIC ANALYSES

4.1. Hydrology

Asotin Creek at Project Area 3.2 drains approximately 173.4 square miles in Asotin County, Washington (United States Geological Survey 2019). The basin mean annual precipitation is 22.6 inches (United States Geological Survey 2019).

Washington State Department of Ecology (Ecology) gage #35D100 (Asotin Cr. Above George Creek) is located at the project site (Washington State Department of Ecology 2023). GeoEngineers statistically analyzed this discharge data using U.S. Army Corps of Engineers Hydrologic Engineering Center’s Statistical Software Package (HEC-SSP) (United States Army Corps of Engineers 2022). We used historic discharge values from the Ecology gage to compute seasonal low flows and assumed juvenile steelhead low-flow migrations through the project area will be during the hottest periods of the year in July and August. The results of these analyses are presented in Table 1.

Although the Ecology gage is located at the project site, the gage does not have enough years of available record to compute a peak flow analysis. Additionally, the gage does not appear to be reliable at high flow events (9 of the 9 years of available data were marked as low outliers by the HEC-SSP Bulletin 17 analysis). The Ecology gage was therefore used for low-flow discharge estimates but not for peak events.

We used the basin transfer method for calculating peak flow estimates for Asotin Creek at the project site. United States Geological Survey (USGS) gage #13335050 on Asotin Creek at Asotin, Washington, is approximately 3 miles northeast and downstream of the project area on Asotin Creek with a drainage area of 323.0 square miles (United States Geological Survey 2023). George Creek is the only major tributary that enters Asotin Creek between the project area and the gage. We statistically analyzed discharge data from USGS gage #13335050 (Asotin Creek at Asotin WA) using HEC-SSP and scaled results using the basin transfer method to calculate peak flows at the project site. Results of the hydrologic analysis are presented in Table 1. We confirmed that peak flow results were similar in magnitude to those available using USGS Regional Regression Equations and other nearby gages .

TABLE 1. SUMMARY OF DESIGN FLOWS

Discharge Statistics	Discharge (cfs)
90 percent July/August exceedance[1]	26.8
50 percent July/August exceedance[1]	34.3
10 percent July/August exceedance[1]	50.9
2-year	431
5-year	892
10-year	1,299
25-year	1,933
100-year	3,128

Note:

[1] 90 percent July/August exceedance is defined as the discharge exceeded 90 percent of the time in July and August based on historic Ecology gage data. 50 percent and 10 percent July/August exceedance are calculated similarly.

4.2. Hydraulic Model Development

GeoEngineers developed a two-dimensional hydraulic model of the project reach using the U.S. Army Corps of Engineers' Hydraulic Engineering Center River Analysis System (HEC-RAS) Version 6.3.1 computer program, a two-dimensional (2D) hydraulic numerical model (United States Army Corps of Engineers 2022).

Development of a two-dimensional hydraulic model requires the modeler to:

- Define the model domain (Section 4.2.1)
- Create or obtain a surface that is an accurate representation of the river system's topography including bathymetry (Section 4.2.2)
- Generate a mesh that accurately defines the surface for input into the model (Section 4.2.3)
- Generate a layer that defines the Manning's n roughness parameter (Section 4.2.4)

- Define the boundary conditions which describe how flow enters and exits the model's mesh (Section 4.2.5)
- Define model controls including simulation time and time step (Section 4.2.6)

We developed an existing (Section 4.3) and proposed (Section 4.4) conditions model for the site. The model development steps listed above are described in the sections below for both the existing and proposed conditions models.

4.2.1. Model Domain

The model encompasses an approximately 6,500-foot reach of Asotin Creek through the project site. Laterally, the model spans roughly 650 feet. Figures B-1 and B-2 in Appendix B show the model domain.

4.2.2. Model Elevation Surface

HEC-RAS requires a topographic surface to represent bathymetric and overbank areas in the model. We obtained overbank and bathymetric survey data in the vicinity of the project from RSI that was collected in January 2023 and from Light Detection and Ranging (LiDAR) collected in 2011. GeoEngineers developed the proposed conditions model elevation surface by modifying the existing 2D model elevation surface to reflect conditions described as the proposed project elements (Section 3).

4.2.3. Mesh Development

The mesh is the geometry input into the 2D model and is made up of elements with varying shapes. The edges of elements define key elevation information for the model. These elevations are extracted from the model surface. Development of the mesh requires creation of breaklines to define where element edges should be (i.e., on important features such as the channel, banks, side channels, and elevated features). Breaklines created during the development of the model surface were used to define these key features. Both the existing conditions and the proposed conditions model meshes cover approximately 91 acres and include more than 52,000 elements. Elements are spaced approximately 3 feet apart in the river channel and increase to up to 20 feet in the floodplain areas.

4.2.4. Model Roughness

Manning's n is a parameter used in the model to represent roughness of surfaces and are defined within HEC-RAS using coverages that define Manning's n value regions with polygons. Manning's n regions throughout the existing model domain include the main channel, floodplain (tree, scrub-shrub, grass, and feed lot areas), paved and gravel roads, and structures such as barns (Table 2). Regions were delineated using the survey basemap, aerial photography, and site visit photos. Existing and proposed conditions main channel Manning's n values are composite values based on combining tabular and photographic guidance (Yochum 2018). Floodplain Manning's n values were estimated from V.T. Chow's Open Channel Hydraulics Manning's reference table (Chow 1959). Manning's n regions throughout the proposed model domain include the same categories as the existing condition but with an increased main channel roughness to account for the placement of LWM and habitat boulders, which were represented by increasing composite channel roughness (Addy Wilkenson 2019 Yochum 2018). Due to their size and density of wood, proposed Flow Deflection Jams were represented as discrete roughness regions within the proposed model (Table 2). Proposed rock for scour protection at the proposed livestock bridge was also represented as discrete roughness regions in the model. Manning's n extents are shown in Figures B-1 and B-2 in Appendix B.

TABLE 2. EXISTING AND PROPOSED CONDITIONS MANNING'S N VALUES

Category	Manning's n Value
Existing Main Channel	0.039
Proposed Main Channel	0.044
Trees	0.09
Scrub-Shrub	0.08
Grass	0.04
Pasture	0.035
Gravel	0.023
Road	0.013
Structure (barn, etc.)	5
Proposed Flow Deflection Jam	0.2
Rock for Erosion and Scour Protection	0.07

4.2.5. Boundary Conditions and Structures

HEC-RAS utilizes user-defined boundary conditions to define flow that enters and exits the model. Inflows are defined at the upstream boundary condition and normal depth water surface elevations are defined at the downstream boundary conditions. Flows identified from the hydrologic analysis (Section 4.1) were used as the inflow values (Table 1). Two downstream normal depth boundary conditions were used—one in the main channel and one in overbank areas. The normal depth water surface elevation for each simulated flow at both downstream boundary conditions was calculated using the downstream average slope (0.01 feet/feet) and the composite Manning's n value from the HEC-RAS roughness coverage.

Boundary conditions, roughness coverages, and model results extraction cross section locations are shown in Figures B-1 and B-2 in Appendix B for the existing and proposed conditions models, respectively.

4.2.6. Model Run Controls

All models were run using the HEC-RAS full momentum equation: Shallow Water Equations, Eulerian-Lagrangian Method (SWE-ELM). The initial condition for all simulations was set to dry. The simulation time was set to 2 hours to achieve steady state flows throughout the model. The time step was defined as 0.1, 0.2, or 0.3 or seconds, depending on stability and Courant number requirements for the given simulation.

4.3. Existing Condition Model Results

Results from the existing conditions model were used to characterize existing conditions through the project reach, inform the development of the design, and serve as the baseline for comparing proposed conditions. Model output showing depth and velocities throughout the project reach are presented in Appendix B, Hydraulic Modeling Results.

Velocities are roughly uniform throughout the main channel. Maximum velocity observed through the project reach at the main channel centerline averaged approximately 3.9 feet per second (ft/s) at the

July/August 10 percent exceedance discharge, 7.7 ft/s at the 2-year discharge, 10.6 ft/s at the 10-year discharge, and 12.6 ft/s at the 100-year discharge.

During the July/August 10 percent exceedance discharge, modeling predicts that flow is almost completely contained within the main channel of Asotin Creek. Water flows into some existing side channels at the 2-year discharge but is largely still within the main channel. Water does not breach the existing downstream left bank levee until the 5-year discharge.

The model results for the 10-year discharge predict floodplain and side channel activation at various locations throughout the reach. Model results for the 100-year discharge predict inundation of much of the left floodplain. Under the 100-year discharge, maximum water depths in the main channel average approximately 7 feet and water depths in the floodplain approach 2 feet to 4 feet in the deepest sections of the existing side channels.

4.4. Proposed Conditions Model Results

The proposed conditions model incorporates the proposed addition of LWM and habitat boulders, side channel grading, terrace grading, and the proposed bridge ramp approach, abutment, and scour protection.

Model results for the proposed conditions predict decreased main channel velocity. Maximum velocity predicted under proposed conditions through the project reach, at the main channel centerline, averaged approximately 3.6 feet per second (ft/s) during the July/August 10 percent exceedance discharge, 7.1 ft/s at the 2-year discharge, 9.7 ft/s at the 10-year discharge, and 11.5 ft/s at the 100-year discharge. Depths in the main channel do not differ by more than 0.2 feet from existing conditions.

Model results for the proposed conditions predict activation of side channels A, B, and C at the July/August 10 percent exceedance discharge with between 0.5 feet to 1.0 feet of water. At the 2-year discharge there is between 2.0 feet and 3.0 feet of water within side channels A, B, and C. Model results predict activation of Side Channel D at the 2-year discharge under proposed conditions with approximately 0.5 feet to 1.0 feet of water. The floodplain area, downstream of Side Channel D, is currently activated at the 5-year discharge under existing conditions.

The proposed bridge abutments are located outside of the 5-year flood extents and the proposed bridge low chord is 1,052.0 feet (NAVD88), more than 1 foot above the 100-year water surface elevation (WSE), which is an average of 1,050.6 feet within the main channel.

The project results in an increase in floodplain connectivity during peak flows. Results of the hydraulic model show that within the project limits, the 2-year flow inundates 5.3 acres under existing conditions and 6.3 acres under proposed conditions. This represents a 1.0 acre (19 percent) increase in floodplain connectivity.

4.5. Floodplain Analysis

The project is located within a Federal Emergency Management Agency (FEMA) designated Special Flood Hazard Area, Zone A, and does not contain an effective base flood elevation (Federal Emergency Management Agency 1988). Impacts on water surface elevation throughout the project reach were evaluated by comparing existing and proposed model results for the 100-year flow. Proposed condition model results show less than 0.2 feet of increase in WSE from existing to proposed 100-year WSE within the vicinity of the bridge as result of abutment fill. Model output showing depth and velocities throughout the project reach are presented in Appendix B, Hydraulic Modeling Results.

5.0 DESIGN ANALYSES

5.1. Large Woody Material

5.1.1. Risk Assessment and Design Factors of Safety

We completed a public safety risk assessment and property damage assessment for the project reach following guidance from the Bureau of Reclamation's Large Woody Material – Risk Based Design Guidelines (Bureau of Reclamation 2014) to evaluate the design discharge and factors of safety used in LWM design.

Throughout the reach there is low risk to public safety because there is no public access and therefore limited recreation users. Risk to infrastructure is also limited as the surrounding reach is used for ranching and agriculture and contains few structures including barns and outbuildings. The nearest road crossing is Cloverland Road, approximately 4,000 feet downstream of the project limits. Between Cloverland Road and PA 3.2 there is approximately 2,000 feet of riparian forest that would act as a sink for mobilized woody debris within the floodplain. These results suggest a reach with a low public safety risk and moderate property damage risk. BOR guidelines recommend using a design recurrence interval discharge equal to or greater than the 25-year event to calculate structure stability (Bureau of Reclamation 2014). Recommended factors of safety from the BOR guidance are provided in Table 3 and were used in the LWM stability calculations (Appendix C).

TABLE 3. RECOMMENDED DESIGN FACTORS OF SAFETY

Stability Calculation	Factor of Safety
$FOS_{sliding}$	1.5
$FOS_{bouyancy}$	1.75
$FOS_{rotation}$ / $FOS_{overtuning}$	1.5

5.1.2. LWM Stability Calculations

We completed stability calculations for LWM located within the main channel, including the Flow Deflection Jams, Bank Rootwad Jams, Sweeper Logs, and Single Rootwads (see Appendix A for structure details). Multi-log structures (Flow Deflection Jams and Bank Rootwad Jams) were evaluated for stability and designed to meet the BOR guidance on FOS (Table 3). Single log structures (Sweeper Logs and Single Rootwads) located in the main channel were evaluated for stability and designed to have a FOS against sliding and buoyancy equal to or greater than 1.5 for the 25-year event. Side channel logs were not evaluated as these logs will not be placed within the main channel, will have an average diameter less than 12 inches, and will be partially embedded or pinned between existing trees which will limit movement.

We used the 25-year recurrence flow to evaluate water depths and channel velocities affecting buoyancy, drag, and rotational forces and to estimate stability for all key members (Table 4). We calculated the balance of vertical, horizontal, and rotational forces for each LWM structure types at representative locations using the maximum 25-year water depth and maximum channel velocity observed at representative cross sections within the project reach. Maximum velocity and maximum depth were used in LWM stability analyses such that the structures should remain in place even if the channel thalweg shifts to their location. All structures were submerged at the 25-year event so that FOS against buoyancy will remain the same at higher flow events. We designed all LWM to either be self-ballasting (stabilized by their own weight); anchored with pinning members; secured with boulders; or ballasted with bank overburden. Each of the LWM structures was evaluated for buoyancy and resistance to sliding following the standard force balance approach (D'Aoust Miller 2000 Rafferty 2017). LWM stability calculations are included in Appendix C.

TABLE 4. 25-YEAR DEPTH AND VELOCITY INPUTS USED IN STABILITY CALCULATIONS

Structure Type	Maximum Depth (ft)	Maximum Velocity (ft/s)	Buoyancy (Vertical) Factor of Safety [a, b]	Drag Force (Horizontal) Factor of Safety [a, c]
Flow Deflection Jams	7.7	12.7	2.0	4.1
Bank Rootwad Jams	9.9	16.3	1.8	4.1
Sweeper Logs	9.9	16.3	1.6	3.1
Single Rootwads	9.9	16.3	1.5	1.5

Note:

[a] Multiple FOS scenarios were examined for a variety of locations and configurations. The Minimum resulting FOS is reported within the table.

[b] Buoyancy (vertical) FOS is calculated as the ratio of resistant forces (weight of log, ballast) over driving forces (buoyancy, lift force). See Appendix C for details.

[c] Drag (horizontal) FOS is calculated as the ratio of resistant forces (bed friction, passive soil resistance) over driving forces (drag, rotational moment). See Appendix C for details.

5.1.3. Risk to Proposed Livestock Bridge

LWM structures located upstream of the livestock bridge include Flow Deflection Jams, Bank Rootwad Jams, Sweeper Logs, and Single Rootwads. Of these structures, the most susceptible to movement at flows greater than the 25-year event are the Sweeper Logs and Single Rootwads. These are also the smallest of the logs proposed (between 10 and 16 inches in diameter and between 15 and 30 feet in length). If large wood was to mobilize, it may result in localized bank erosion and the log may be transported downstream in the main channel, rack on downstream log structures and live trees, or be deposited on the adjacent floodplain.

Interaction of mobilized wood with the livestock bridge is not anticipated because the bridge deck will be set 1.0 foot above the 100-year water surface elevation. Mobilized woody material may be deposited at the left bank bridge footing and approach ramp which are subject to flow events greater than a 5-year flow. Rock for erosion and scour protection is proposed around the footings and approach ramps to mitigate against erosion. The rock will be keyed into the bank and will add some protection against scour resulting from racked debris. Visual monitoring for erosion and racked debris at the approaches will also be part of the Adaptive Management Plan (Appendix G) and should be completed after large peak flow events (>5-year flow).

5.2. Boulder Stability Analysis

Proposed habitat boulders range in size between 24 and 48 inches. Sizing is based on observations made during the site reconnaissance of boulders functioning well as instream structures. We completed stability calculations for habitat boulders following methods described in Chapter 7, *Boulder Clusters and Isolated Rocks*, of the Rock Ramp Design Guidelines (Mooney, Holmquist-Johnson Broderick 2007). Forces acting upon the boulders are compared to the forces required to initiate movement. The resulting factor of safety indicates the ability of the boulder to resist movement, with a minimum factor of safety of 1.2 recommended for design (Mooney, Holmquist-Johnson Broderick 2007). During the 100-year flow event a 24-inch boulder has a factor of safety equal to 1.6. Factor of safety increases with increasing boulder diameter. Additional detail on the stability analysis is included in Appendix D.

5.3. Scour Countermeasure Design

Sizing of rock at the bridge abutment and approach ramp follows guidance outlined in Hydraulic Engineering Circular (HEC) 23, Design Guidance 4, for rock revetments which can be used to protect embankments and to counter erosion mechanisms. Rock sizing uses channel velocity and depth as primary design inputs as well as bank slope (Federal Highway Administration, 2009). The resulting recommended D_{50} for the rock revetment countermeasure is 0.4 feet. Class A Rock for Erosion and Scour Protection, which has a D_{50} equal to 1.0 foot and D_{100} equal to 1.5 feet, is proposed and meets the sizing criteria. The material will be keyed into the bank 2.0 feet below grade and extend to 1.0 foot above the 100-year water surface elevation. Additional detail on the scour countermeasure design is included in Appendix E.

6.0 CONSTRUCTION

6.1. Disturbance Areas and Conservation Measures

Project disturbance areas are defined and shown on the Design Drawings in Appendix A. HIP IV Conservation measures applicable to all actions will be included in the final Design Drawings in Appendix A (Bonneville Power Administration 2023). The anticipated in-water construction window is July 15 to September 15. The project will be split into two phases occurring over two in-water work windows. Phase 1 work includes installation of the livestock bridge, terrace and side channel B, C, and D, grading and all habitat elements downstream of the new livestock bridge. Phase 2 work includes side channel A grading and installation of all habitat elements upstream of the new livestock bridge. Both phases include seeding and revegetation following construction.

6.2. Construction Costs

GeoEngineers calculated anticipated construction quantities and applied unit costs based on recent project experiences and engineering judgment and included a 10 percent contingency. We included a summary of the anticipated construction costs and bid tables in Appendix F. The estimated construction costs, including taxes, contingency and construction observation services for Phase 1 are $655,625 and for Phase 2 are $241,938.

6.3. Adaptive Management

An adaptive management plan is required for channel reconstruction and process-based wood placement projects, as discussed under the Activity-Specific Conservation Measures and negotiated throughout the

HIP Review Process (Bonneville Power Administration 2023). Appendix G contains the Adaptive Management Plan for this project.

7.0 CONCLUSION

The design described within this Basis of Design report provides elements to address limited channel functionality, fish habitat availability, and fish habitat quality within Project Area 3.2 located on Asotin Creek. Large wood and boulders will provide hydraulic and structural complexity within the main channel and side channels, reducing main channel velocities, providing resting habitat, encouraging accumulation of additional large wood, and encouraging sediment sorting within the main channel. Riparian plantings will develop into mature riparian plant communities, providing shade and reducing water temperatures. Increased floodplain hydrologic connectivity will similarly lead to decreased water temperatures through increased alluvial aquifer recharge and hyporheic exchange within the primary and side channels.

8.0 LIMITATIONS

We have prepared this report for the ACCD and their authorized agents for the Asotin Creek Project Area 3.2 Restoration Design located in Asotin County, Washington, as illustrated on Drawing No. 1.0 in Appendix A.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices in the field of stream and river habitat enhancement, stabilization, and restoration design engineering in this area at the time this report was prepared. The conclusions, recommendations and opinions presented in this report are based on our professional knowledge, judgment, and experience. No warranty, express or implied, applies to our services and this report.

Any electronic form, facsimile, or hard copy of the original document (email, text, table and/or figure), if provided, and any attachments should be considered a copy of the original document. The original document is stored by GeoEngineers, Inc. and will serve as the official document of record.

Please refer to Report Limitations and Guidelines for Use, Appendix H, for additional information pertaining to the use of this report.

9.0 REFERENCES

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FIGURES

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Existing Large Woody Material

Asotin Creek PA 3.2 Fish Habitat Restoration
Asotin County, Washington

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Figure 1

Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

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Existing Large Woody Material

Asotin Creek PA 3.2 Fish Habitat Restoration
Asotin County, Washington

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Figure 2

22281-009-00 Date Exported: 06/30/2023

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Existing Large Woody Material in Existing Side Channel, Existing Boulders

Asotin Creek PA 3.2 Fish Habitat Restoration
Asotin County, Washington

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Figure 3

Notes:

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Existing Boulder Clusters

Asotin Creek PA 3.2 Fish Habitat Restoration
Asotin County, Washington

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Figure 4

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Proposed Bridge Location

Asotin Creek PA 3.2 Fish Habitat Restoration
Asotin County, Washington

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Figure 5

APPENDICES

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