Longley Meadows Fish Habitat Enhancement Project

Upper Grande Ronde River, Grande Ronde Subbasin, Oregon

Basis of Design Final Report

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EXECUTIVE SUMMARY

The executive summary provides a short synopsis of the design progression from 30% to 80% and 80% to final design. The final basis of design report (BDR) concludes the design process prior to implementation of the Longley Meadows Fish Habitat Enhancement Project (project). Any design changes that occur during construction will be documented separately in the construction documents.

DESIGN CHANGES SINCE THE 30% DESIGN SUBMITTAL

A significant high-flow event, of approximately 20-year recurrence, occurred in April of 2019, resulting in major activation of floodplain channels and bank migration of up to 10 feet within the Longley Meadows project area. Drone flights and ground-based photography captured the event. This allowed the design team to witness floodplain preferential flow channels and the location of significant flooding on private property and Highway 244 prior to project implementation. Additionally, the Grande Ronde River avulsed through the large floodplain on Bear Creek Ranch immediately upstream of the Longley Meadows project boundary. The river has been very dynamic in this location, and it can be expected to continue to be dynamic in the foreseeable future. As the new channel continues to evolve, it is highly likely that an increased supply of sediment from the channel banks and bed material will be transported into the project reach.

Since the development of the 30% plans and BDR, the project design has focused on minimizing the amount of disturbance to the large upstream floodplain on river left by focusing on making perennial connections to existing floodplain channels and reducing the extent of the flood swale channel excavation at the upstream most portion of the project. Additionally, where the main channel has been relocated away from the highway in the upstream floodplain, the design has focused on encouraging a depositional morphology with more flow splits and connections to the existing floodplain channels in ideal locations like alcoves in proximity to large pools and cover. This has resulted in similar inundation and habitat uplift to the original design, achieving project goals and objectives while reducing the overall disturbance and effort.

On the downstream floodplain on river right above the La Grande Rifle and Pistol Club, the design has changed significantly. In the 30% design the existing channel was conveying 30% of bankfull flow and the new re-meandered main channel was conveying 70%. This resulted in a significant increase in flooding of private property and a major grading effort. The 80% design keeps the existing channel mostly intact while adding several instream structures to encourage deposition to narrow the channel and creating a 20% capacity side channel of significant length that is perennially activated. This has resulted in less risk of flooding while still creating quality side-channel habitat and less overall disturbance.

INCLUSIONS IN THE 80% DESIGN SUBMITTAL

The 80% design submittal includes the progressions of the 30% design terrain edits mentioned above, which fed into the hydraulic modeling. Hydraulic modeling iterations aid in determination of side channel elevations, cross sectional area, and ultimately the activation of flows and associated inundation mapping. The proposed alignments and design surface were then staked out in the field using real-time kinematic (RTK) survey and reviewed in the field with the project designers and sponsor. This resulted in additional refinements to the design surface and subsequent iterations of hydraulic modeling to achieve channel and floodplain activation goals. This iterative process between computer-aided design (CAD) and modeling drove the finalized design presented in Appendix 8.1 and discussed in this BDR. Detailed analysis of the hydraulic modeling effort is included in Appendix 8.2 and summarized in the BDR. The 80% design includes the placement of large woody material (LWM) structures and bank treatments, which provide additional fish habitat as well as bank stabilization. Detailed plan and profile sheets for both the new mainstem alignment and side channels are included in this design submittal. Initial submittals for access, staging, and construction sequencing are also included in the 80% design submittal.

As part of the 80% design process, Cardno performed a LWM risk assessment following the Bureau of Reclamation's (Reclamation's) *Risk-Based Design Guidelines* (Knutson and Fealko 2014). This preliminary risk assessment was used by the design team to identify design, engineering, and stability requirements for proposed LWM structures. The risk analysis focuses on overall risk classification of the project and structure types, which helps set stability targets and safety factors for the design. A detailed discussion of the LWM Risk Assessment and LWM structure stability analysis is included in Appendix 8.5.

Habitat Suitability Index numerical modeling was performed based on hydraulic modeling outputs of depth and velocity for both existing and proposed conditions to determine the capacity of habitat uplift of the proposed project based on regional habitat utilization curves (Appendix 8.7).

Hydraulic modeling of proposed bypass channels was performed to ensure adequate fish passage requirements are achieved during project construction as it will be necessary to isolate entire sections of the river to install LWM and perform channel grading under the proposed design (Appendix 8.2).

The Monitoring and Adaptive Management Plan (MAMP) is included in Section 6 of this report following Bonneville Power Administration's (BPA's) BDR template. The MAMP plan builds upon the Bird Track Springs Project monitoring plan and incorporates lessons learned during the design and second season of construction on the upstream project.

Additional edits that occurred from the 30% to 80% submittal are summarized below:

- A portion of the main channel (area between staging areas 4 and 5) near Highway 244 was remeandered to increase abrupt 90-degree bends to create pool habitat, provide for more flow splits to create a depositional environment (and instream island), and redirect the return to the existing channel at more of an angle away from the highway. 300 feet of new side channel (side channel 2A [SC-2A]) will be constructed just north of the main channel remeander to reduce velocity and increase floodplain interaction.
- The main channel near the La Grande Rifle and Pistol Club will remain in its current location and not be remeandered to ensure protection of the club grounds and infrastructure during high flows. Approximately 345 feet of channel grading would connect existing channel features to create 900 feet of a new perennial side channel (side channel 6 [SC-6]) to increase interaction with the floodplain and provide quality side-channel habitat. Side channels 8 and 8A [SC-8 and 8A] previously included in the 30% design will no longer be necessary due to this design change.
- Side channel 2 (SC-2) objectives can be achieved with less excavation than originally planned, resulting in approximately 550 feet less ground disturbance.
- Side channel 3 (SC-3) has been combined with a portion of what was previously called side channel 5 (SC-5) in the 30% plan set and renamed SC-3. This reduces excavation needs by approximately 400 feet while meeting objectives in this area.
- Side channel 4 (SC-4) was eliminated.
- SC-6 has been redesigned to be main channel flow split with an instream island to increase interaction with the floodplain.
- Side channel 7 (SC-7) from the 30% plan set is now SC-5, a perennial side channel with multiple 90-degree bends to create quality habitat. Side channels 5A, 5B, and 5C (total of approximately 600 feet) will be added to SC-5 (replacing main channel A and B [MC-A and MC-B]) to increase floodplain interaction and create pool habitat.
- Side channels 9 and 10 (SC-9 and SC-10) and main channel C (MC-C) will be dropped to enhance protection of the La Grande Rifle and Pistol Club.

DESIGN CHANGES INCORPORATED INTO THE FINAL DESIGN SUBMITTAL

There were no significant comments received on the 80% design submittal from the restoration review team. Instead the design team focused on refining and improving the design based on the iterative design approach between modeling and terrain development in CAD to balance flow splits, inundation areas, overbank flow concentrations, and hydraulic forces acting on the channel bed and banks. Project specifications were updated and reviewed to match the drawings and quantities/work items from the bid schedule.

There were several large flood events that occurred between the 80% and final design. The northeastern region of Oregon endured a near flood of record on February 7, 2020, resulting in multiple river systems causing significant damage to infrastructure and major flooding. The flooding was caused by rain on snow at middle to low elevations. At the project site, ephemeral drainages flooded over the highway and possible additional bank erosion has occurred. The Bird Track Springs Project located 1 mile upstream allowed attenuation of the flood, and it is not known how much sediment was flushed from the Bear Creek Ranch avulsion site into Longley Meadows. Additionally, a similar large flood occurred on May 20, 2020, of equal magnitude. As a result of these major floods, existing site conditions could be different than those used during the design process.

Lessons learned from the Bird Track Springs Project were incorporated into the Longley Meadows project design. Side channel inlet elevations and alignment orientations were reviewed and adjusted based on modeling and site conditions present. Unfortunately permitting approval was not completed in time to allow for the excavation of exploratory test pits and incorporation of this information into the design plan set. Instead, the test pit exploration occurred in June 2020 and is documented in the *Longley Test Pits Report* (August 17, 2020) (Cardno 2020). The excavation test pit effort provided additional information regarding the materials present for riffle mining and assists in future groundwater modeling of the site. Based on observations of the Bird Track Springs Project during flood events and construction techniques relating to the LWM structures, a new structure was added to the final design plans. A C-9 structure was added that bridged the gap between a C-6 and C-12 structure (where the number of the structure correlates to the number of logs needed to build said structure). Additional logs in the structure also correlate to structure height and bank height roughness protection. Cross sections were reviewed at all locations of proposed LWM structures to ensure adequate coverage of bank based on structure type; however, these sections were only used for design review and were not included in the final plan submittal. Detail structure and placement adjustments required revisiting the risk assessment and structure calculations. Appendix 8.5 provides updates to the LWM structure risk assessment from the 80% submittal. The final submittal also provides final revisions and details regarding construction (access, staging, and sequencing) of the project. The text regarding phasing was removed from the plan set and instead replaced with “upper” and “lower” floodplain, designating two distinct project areas that could be built over a 2-year construction window.

Additional edits that occurred from the 80% to final submittal are summarized below:

- Additional LWM structures were added to the SC-1 inlet.
- SC-4 was removed from the final plan set as the grading required for activation and inundation did not provide enough improved habitat value.
- Additional floodplain wood was added throughout the floodplain providing additional roughness and habitat during inundation periods.
- Staging area 1 was resized and relocated slightly farther north, away from Highway 244, in what was previously SC-4 (as called out in the 80% plans).
- New staging area 1 will be graded into a low-lying groundwater-fed pond. This feature is new to the final plans and was not shown on the 80% design.
- Access and staging along Highway 244 near the Bear Creek Ranch corner/bend was removed from the final plan set. Proximity to the existing railroad grade and wetland was problematic, and

the design team concluded that a contractor could construct the LWM structure from the opposite bank once dewatered.

- Additional LWM structure length was added at STA: 30+00, and a boulder nose toe was added to protect this new bank at higher flows. Concerns over the new alignment heading toward the highway brought about these changes in the final plans.
- SC-2 LWM placement was removed from the portions of the existing channel where grading is not required. Due to the proximity to known cultural areas as well as construction disturbance associated with LWM installation in wet areas, this effort was removed from the final plan set. Minimal proposed connections were still included in the design, outside of cultural areas, to ensure proper connection throughout the SC-2 area. Instead, additional downed wood and slash will be placed where grading ends in hope that over time this wood will move downstream into SC-2 areas outside the disturbance limits.
- Now renumbered staging area 2 (previously staging area 3 in the 80% plans) was resized to avoid a cultural finding. In addition, new staging area 2 will be graded into a low-lying groundwater ponding area, which will be fed by a newly proposed blind channel connection to the mainstem. This ponded feature also includes a new wood habitat structure that was not shown on the 80% design.
- Additional fill was added along Highway 244 near STA 29+00 to 33+00 and 42+00 to 44+00 to prevent inundation and potential roadway flooding associated with the design. The additional fill added to the final plans prevented flooding events in the updated model.
- Left bank improvements previously shown around STA 55+00 along the mainstem were removed from the final plan set. Habitat benefit associated with the proposed design did not warrant the additional cost and dewatering effort needed to access and construct the gravel bar and wood structure previously shown.
- The alignment for SC-5 was altered from the 80% design. Additional chicanes were added to the final alignment. The more aggressive alignment allows for additional inundation at higher flows.
- Additional LWM structures were added at the outlet connection of SC-5 to provide protection from high flows associated with the flooding events in the mainstem.
- Construction access roads were also adjusted so that the newly created channel (SC-5) would not be used for access once constructed. This was one of the lessons learned from the Bird Track Springs Project, as the additional traffic further compacted the newly constructed riffles. This also increased the number of trees to be removed as additional access routes cause more disturbance.

1 Project Background

The U.S. Bureau of Reclamation (Reclamation) and Bonneville Power Administration (BPA) contribute to the implementation of salmonid habitat improvement projects in the Grande Ronde Subbasin to help meet commitments contained in the 2008 Federal Columbia River Power System (FCRPS) Biological Opinion (BiOp) (National Oceanic and Atmospheric Administration [NOAA] Fisheries 2008) and the 2010 and 2014 Supplemental BiOps (NOAA Fisheries 2010, 2014). This BiOp includes a Reasonable and Prudent Alternative (RPA), or a suite of actions to protect salmon and steelhead listed under the Endangered Species Act (ESA) across their life cycle. Habitat improvement projects in various Columbia River tributaries are one aspect of this RPA. Reclamation's contributions to habitat improvement are all meant to be within the framework of the FCRPS RPA or related commitments and follow the requirements of the NOAA and U.S. Fish and Wildlife Service [USFWS] BiOp as outlined under BPA's Habitat Improvement Program III (HIP III, version 4.0). Reclamation provides technical assistance to identify, prioritize, develop, design, and implement sustainable fish habitat improvement projects and to help focus those projects on addressing key limiting factors to protect and improve survival of salmon and steelhead listed under the ESA.

The Longley Meadows Fish Habitat Enhancement Project (project) is located between river miles (RM) 143.6 and 142.2 of the Upper Grande Ronde River (UGR) (Figure 1-1). The land within the project area is owned by the U.S. Forest Service (USFS) and the La Grande Rifle and Pistol Club (La Grande Gun Club). This project has the potential for a phased implementation approach that roughly coincides with the upper and lower floodplain project reaches. A phased approach would allow flexibility for project partners to implement separate phases over several seasons or the entire project within one construction season.

The long-term rehabilitation vision of the Confederated Tribes of the Umatilla Indian Reservation (CTUIR), the project sponsor, for the Longley Meadows reach of the UGR is to improve physical and ecological processes by rehabilitating and restoring the project area to achieve immediate and long-term benefits to Chinook (*Oncorhynchus tshawytscha*), steelhead (*O. mykiss*), and bull trout (*Salvelinus confluentus*) at all life stages, as well as redband trout (*O. mykiss gibbsi*), Pacific lamprey (*Lampetra tridentata*), and other aquatic species. This approach supports CTUIR's River Vision to protect, restore, and enhance First Foods by rehabilitating and restoring hydrologic processes, geomorphology, habitat and network connectivity, riverine biotic community, and riparian vegetation.

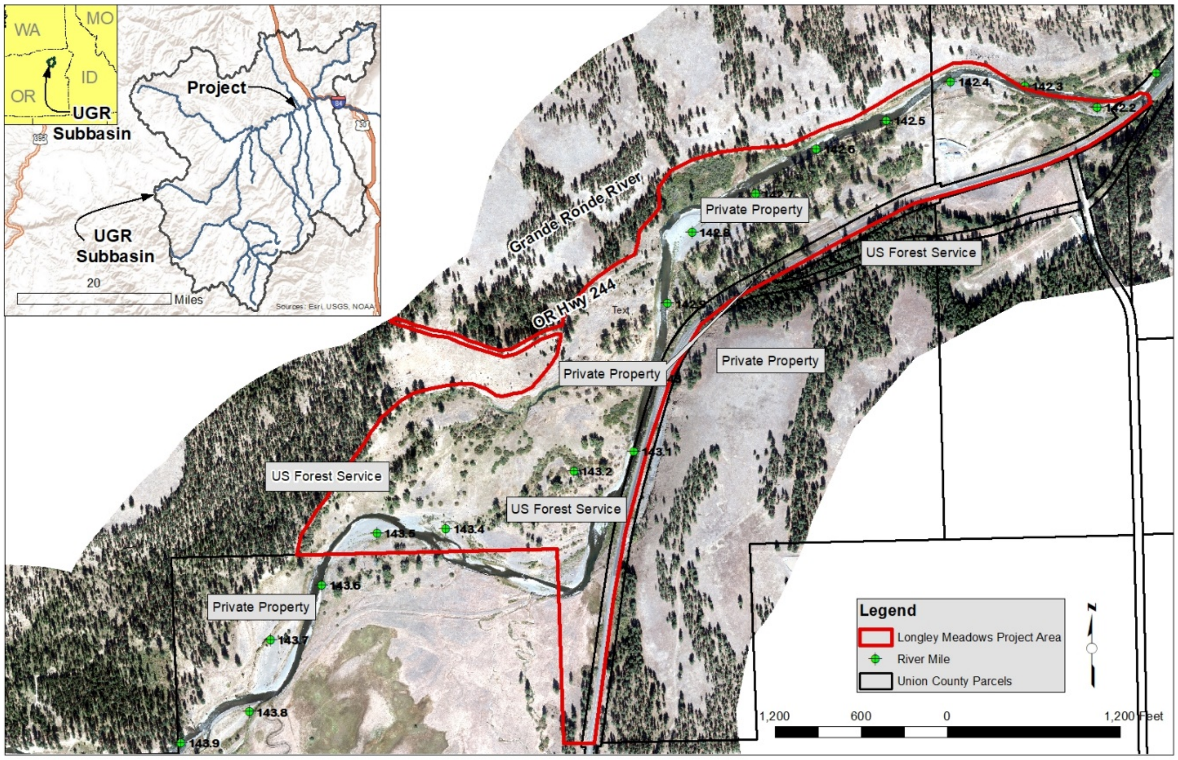


Figure 1-1 | Longley Meadows Fish Habitat Enhancement Project Area (Note: lower project area boundary has been reduced to RM 142.2)

The UGR Subbasin has been subjected to an extensive planning process to prioritize habitat enhancement based on degraded physical processes and biological limiting factors for listed species, including but not limited to: the *Grande Ronde Subbasin Plan* (Northwest Power and Conservation Council [NPCC] 2004), the *Upper Grande Ronde River Tributary Assessment* (Reclamation 2014), and most recently the *Upper Grande Ronde River Atlas* (BPA 2015). This project is located within Biologically Significant Reach UGR 11 as identified in the Atlas Process. UGR 11 was ranked as having a high geomorphic potential, fair existing habitat conditions, and poor existing temperature rating, resulting in a Tier II ranking priority. Within this reach and the UGR in general there are limited opportunities for large-scale restoration actions in unconfined sections of the river with willing landowners. This unique opportunity has high potential to improve the poor temperature rating and fair habitat conditions identified by the Atlas Process. The Longley Meadows Fish Habitat Enhancement Project has the potential to leverage the geomorphic potential of a large unconfined floodplain resulting in improved floodplain connectivity, hyporheic exchange, riparian conditions, and channel complexity. This in turn will improve habitat conditions and thermal refugia in a critical migration corridor with high potential for in-channel and off-channel juvenile rearing habitat that is lacking in this reach of river.

The Longley Meadows Fish Habitat Enhancement Project was previously included in the Bird Track Springs Project, which encompasses Bird Track Springs, Bear Creek Ranch, and Longley Meadows. Due to landowner complications that project was divided into two (i.e., Bird Track Springs and Longley Meadows). Longley Meadows is located downstream of the Bird Track Springs Project (RM 146.1 to 144.7). The Bird Track Springs Project began construction in 2018 and was completed after a second year of construction in November of 2019. Observations made during the implementation, monitoring, and completion of the Bird Track Springs Project can be applied to the Longley Meadows design.

This last iteration of the project's basis of design report (BDR) reflects the planning process and final design development. Appendices to this final BDR include the final design deliverables.

1.1 GOALS & OBJECTIVES

The intention of the goals and objectives associated with the project is to utilize them as a living text that will become more detailed as the design progresses through project planning and provide a foundation and direction. Objectives will be improved to be S.M.A.R.T. (i.e., simple, measurable, achievable, relevant, and timely) as design progresses and more details are obtained to inform a monitoring plan.

The long-term rehabilitation vision (CTUIR's River Vision) for the project have been to improve physical and ecological processes by rehabilitating and restoring the project area to achieve immediate and long-term benefits to spring-summer Chinook salmon, summer steelhead, bull trout, and resident fishery resources at all life stages.

Benefits to salmonids will be achieved through restoration and rehabilitation of the whole floodplain ecosystem. Targeting of present and specific limiting factors such as temperature will achieve immediate benefits to salmon. Long-term benefits will be realized through a focus on restoring fluvial habitat-forming processes, floodplain and groundwater hyporheic connectivity, riparian and wetland plant communities, and instream complexity and diversity commensurate with the reach's natural potential

GOALS

1. Increase habitat diversity and complexity for salmonids;
2. Improve water temperature conditions for salmonids;
3. Improve riparian corridor and floodplain vegetative diversity and health within the project area; and
4. Reconnect the UGR with its floodplain and expand quality floodplain habitat availability for salmonids within the project boundaries.

OBJECTIVES

1. Increase habitat diversity and complexity for salmonids.
    - Large Woody Material (LWM) – Maximize large wood material density within wetted channels of the project reach, within the confines of the geomorphic and physical context of the project site with consideration of risk to existing infrastructure. The wood loading objective is to exceed 80 pieces of wood per stream mile.
    - Pools – Develop 12 sustainable and complex pools per mile for fish use (adult holding and juvenile rearing) at completion of the project.
    - Side Channels – Maximize and promote ephemeral and perennial side channels that include complex cover and perennial alcove features within the hydrogeomorphic conditions/constraints of the project area at project completion. Double side channel length in relation to main channel habitats.
    - Bedload Retention/Sorting – Improve instream channel diversity within the project reach, changing the predominant plane-bed channel conditions associated with homogenous particle size retention to a pool-riffle channel with greater particle size diversity.
    - Alcoves and Off-Channel Ponds – Maximize off-channel features such as alcove and off-channel pond habitats with preferred depth, velocity, and cover for refuge and rearing of juvenile Chinook at the completion of the project.

- Beaver Habitat – Establish side channel conditions and floodplain vegetative health that will increase suitable beaver habitat within the project area within 10 years of project completion. Beaver suitability is defined by amount of off-channel habitat (side channels and alcoves) and riparian/wetland habitat (hardwood and shrub for winter food supply, and sedge/herbaceous plants for general food supply).

2. Improve water temperature conditions for salmonids.
   - Thermal Loading –
     - At project completion, have no net increase in thermal loading in as-built baseflow main channel wetted surface area through decreasing width-to-depth ratio during baseflow conditions.
     - Provide long-term decrease in baseflow water surface exposed to solar radiation within project area through increased shading from native riparian plants.
   - Thermal Diversity –
     - Channel Sinuosity – Improve thermal diversity at baseflow conditions by increasing hyporheic conductivity pathways by maximizing sinuosity of the main channel alignment within site geomorphic constraints/conditions.
     - Increase Water Table – Improve cool water supply and thermal diversity potential within the project area by increasing water storage within the floodplain through increased annual and low flow water table elevation at the completion of the project.
     - Connection to Cold-Water Sources – Improve thermal diversity during baseflow conditions by identifying and connecting the main channel to potential cold water from hyporheic and/or groundwater sources including historical relic channels and preferential subsurface flow paths.
     - Bedload Sediment Retention – Improve thermal diversity at baseflow conditions by promoting channel bed diversity resulting in reduction of bed armor, improved bedload sediment retention, vertical gradients, and sediment storage to create dynamic depositional features with increased and improved hyporheic connectivity.
3. Improve riparian corridor and floodplain vegetative diversity and health within the project area.
   - Floodplain Connectivity – Maximize floodplain connectivity within the geomorphic and stakeholder confines of the project area. Activate the floodplain on an annual basis during the spring freshet at project completion.
   - Woody Riparian Vegetation – Enhance native woody vegetation including dominant cottonwood, alder, and willows within the limitations of soil structure and hydrology within the project reach to maximize shade on water surfaces for 10 years following project completion.
   - Suspended Sediment Retention – Improve suspended sediment retention on floodplain surfaces within the project area through greater extent, frequency, and duration of floodplain inundation during spring runoff conditions at completion of the project.
   - Prevent the establishment of non-native weeds within the project boundary for first 5 years after construction through active weed management.
4. Reconnect the UGR with its floodplain and expand quality floodplain habitat availability for salmonids within the project boundaries.
   - Construct a new channel network that allows floodplain interaction with river flows at a minimum of an annual basis during spring high flow conditions.

1.2 NAMES AND TITLES OF SPONSOR, FIRMS, AND INDIVIDUALS RESPONSIBLE FOR DESIGN

The CTUIR and USFS have a vested interest in achieving and maintaining high-quality ecological conditions for aquatic species along the UGR. To assist in achieving this goal, CTUIR and USFS have partnered with Reclamation's Columbia/Snake Salmon Recovery Office and the River Systems Restoration Group to develop designs for the project on the UGR. Table 1-1 below lists the individuals and organizations collaborating on the project.

Table 1-1 | Names and Titles of Sponsors and Organizations Collaborating on the Longley Meadows Fish Habitat Enhancement Project

Name	Entity	Role/Responsibility
Allen Childs	CTUIR	Project Sponsor, Habitat Biology, Project Management, Implementation
Bill Gamble	USFS	Wallowa-Whitman National Forest District Ranger, Cooperative Landowner, Permitting
Sarah Brandy	USFS	Wallowa-Whitman National Forest District Fish Biologist, Project Liaison
Jeff Peterson	Reclamation	Columbia/Snake Salmon Recovery Office Habitat Program Manager
Darrell Dyke	Reclamation	Subbasin Liaison
Al Simpson	Reclamation	Subbasin Liaison
Mike Knutson, P.E.	Reclamation	Technical Oversight
Justin Nielsen, P.E.	Reclamation	Lead Design Engineer
Julie Bryant, P.E.	Reclamation	Hydraulic Model, Design Team
Rob McAffee	Reclamation	Design Team
Brian Drake, P.E.	Reclamation	Project Manager
Cardno, Inc.	Cardno	Reclamation Consultant: Design Support, LWM Design, Permitting, Construction Engineering Support

1.3 LIST OF PROJECT ELEMENTS THAT HAVE BEEN DESIGNED BY A LICENSED PROFESSIONAL ENGINEER

Critical engineered large woody material (LWM) structures, constructed sections of main and side channels, and alcoves/ponds with small wood placement acting similar to naturally occurring beaver dams were designed by licensed professional engineers. Staging and access, specifications, erosion control, removal and care of water, construction sequencing, and other design details are also being completed or overseen by licensed engineers experienced with river and habitat projects.

Primary project features include:

- Sections of main channel realignment and fill of existing main channel alignment;
- Construction of riffles that mimic natural features;
- Construction of gravel bar features;
- Construction of channel banks;
- Placement and compaction of native fill material;

- Construction of network of side channels and connections to existing off-channel features including swales, remnant channel scars, and low areas to create side channels and ponds;
- LWM structures (e.g., apex jams, meander jams, channel-margin jams, sweeper jams, cover wood, floodplain roughness, habitat structures, and flood fence);
- Individual large wood habitat pieces (e.g., sweepers, floodplain roughness);
- Bioengineered bank treatments; and
- Creation and enhancement of alcoves and oxbows.

1.4 EXPLANATION AND BACKGROUND ON FISHERIES USE (BY LIFE STAGE – PERIOD) AND LIMITING FACTORS ADDRESSED BY PROJECT

Focal species for the project are Chinook salmon and steelhead; however, bull trout and other aquatic species are also expected to benefit from the proposed habitat actions. Fish species of concern in the UGR include:

- Snake River spring/summer-run Chinook salmon: ESA listed as Threatened April 22, 1992; reaffirmed June 28, 2005, and April 14, 2014. Critical habitat was designated December 28, 1993, and revised October 25, 1999.
- Snake River Basin steelhead: ESA listed as Threatened August 18, 1997; reaffirmed January5, 2006, and updated on April 14, 2014. Critical habitat was designated September 2, 2005.
- Columbia River bull trout: ESA listed as Threatened June 10, 1998. Critical habitat was designated September 30, 2010.
- Redband trout: This species is present in the UGR Subbasin and is listed as a sensitive species by the USFWS and NOAA Fisheries.
- Pacific lamprey: This species was historically present, and current remnant populations may persist, but their distribution and abundance are unknown. They are listed as a sensitive species by the USFWS and NOAA Fisheries.

Additional information for each of the ESA-listed species and their current use within the project reach is provided below.

UPPER GRANDE RONDE RIVER SPRING/SUMMER-RUN CHINOOK SALMON

In general, adult spring Chinook salmon return to their natal streams to spawn from ages 3 to 6, after spending 1 to 4 years in the ocean. The UGR adults begin their upstream migration in early spring and enter the Columbia River Basin in April and May (Oregon Department of Fish and Wildlife [ODFW] et al. 1990). They then proceed upstream to their natal tributaries where they hold from June through August and spawn from August through September. Their eggs are deposited as redds in the gravel beds where they incubate over the winter and emerge as fry between March and May. The UGR spring Chinook salmon juveniles typically rear in the UGR Subbasin for 1 year before migrating to the ocean as smolts from March through May. However, some juveniles will begin their downstream migration from June through October and will continue to rear in fresh water until they smolt the following spring.

Chinook life stage utilization within the project reach, as determined during the UGR Atlas Process, is provided in Table 1-2.

Table 1-2 | Chinook Life Stage Utilization

Life Stage	Timing	Utilization[1]	Notes
Adult Immigration	May through mid-July	High	No passage barriers but high temperatures affecting immigration, especially late arrivals.
Adult Holding	June through August	High	Adult holding questionable due to high temperature. Significant pre-spawn mortality in this reach. Unclear on where they hold. Literature states they drop back to spawn and hold upstream.
Spawning/Incubation/ Emergence	Mid-August through March	High	
Juvenile Emigration	Age 0: May through mid-June/mid-September through November Age 1: February through June	Low	
Summer Rearing	June through September	High	
Winter Rearing	October through May	High	

[1] High – Critical life stage use in need of immediate action for salmonid population performance
Medium – Life stage use that is import to the long-term salmonid population performance
Low – Life stage use that is minimally affected by existing conditions

SNAKE RIVER BASIN STEELHEAD

Adult steelhead enter tributaries weeks to months before they spawn, preferring clear, cool streams with suitable gravel sizes and flow velocities. UGR adults begin their upstream migration in early spring and pass Bonneville Dam in July and John Day Dam in August. The adults swim upstream to their natal tributaries where they begin holding as early as July through October. Most adult steelhead enter the Lower Grande Ronde River from September through March with spawning occurring from March through mid-June (NPCC 2004). Their eggs are deposited in the gravel beds where they incubate for about 1.5 to 4 months depending on water temperatures before they emerge. Steelhead are capable of spawning more than once before death, but rarely spawn more than twice before dying (Nickelson et al. 1992). The juveniles rear in fresh water from 1 to 4 years. During the summer, rearing young-of-the-year juveniles tend to be denser in glides and riffles, whereas the older juveniles tend to be denser in the faster parts of pools. In the winter, rearing juveniles tend to disperse across a range of fast and slow water habitats. A small percentage of older juveniles migrate downstream to rear in larger tributaries and rivers (Nickelson et al. 1992). The most productive steelhead habitats are characterized by instream large and small wood accumulations that create diverse and complex hydraulic conditions.

Steelhead life stage utilization within the project reach, as determined during the UGR Atlas Process, is provided in Table 1-3.

Table 1-3 | Steelhead Life Stage Utilization

Life Stage	Timing	Utilization[2]	Notes
Adult Immigration	Mid-February through May	Low	
Adult Holding	Mid-February through May	Low	Adults typically do not hold in the UGR. They tend to quickly migrate, spawn, and then leave.
Spawning/Incubation/ Emergence	N/A[1]	Low	
Juvenile Emigration	February through June/mid-September through mid-November	Low	
Summer Rearing	June through September	High	
Winter Rearing	October through May	High	

[1] Timeframe not identified in the Atlas Process fish periodicity worksheet

[2] High – Critical life stage use in need of immediate action for salmonid population performance
Medium – Life stage use that is import to the long-term salmonid population performance
Low – Life stage use that is minimally affected by existing conditions

COLUMBIA RIVER BULL TROUT

UGR bull trout exhibit two distinct life history forms. Fluvial bull trout mature in their natal streams and then migrate to larger streams or rivers where they can grow quite large, whereas resident bull trout spend their lives in their natal streams or small tributaries at higher elevations and remain smaller in size.

Fluvial bull trout can move in and out of the UGR Subbasin from the Lower Snake River and are also able to move throughout the UGR Subbasin during fall, winter, and spring. However, warm water temperatures and low flows in the mainstem UGR during the summer months can limit their movements, thus reducing population connectivity.

Bull trout sexually mature after approximately 4 years and can live up to 10 years. Adults can withstand water temperatures of up to 64 degrees Fahrenheit (°F) but prefer much cooler water temperatures. Adults spawn every year or every other year, and they require cold-water streams with suitable gravel sizes that are silt-free. Spawning usually takes place in the tributaries and headwater areas from late July to September, and spawning success is strongly influenced by water temperatures and siltation that can significantly decrease egg survival. Bull trout eggs do best with water temperatures around 36°F, and their survival rates dramatically decrease with increasing water temperatures. For example, water temperatures up to 46°F can reduce egg survival by at least 75%. Following emergence, the juveniles typically rear in the cooler waters found in the tributaries and headwater areas.

Bull trout life stage utilization within the project reach, as determined during the UGR Atlas Process, is provided in Table 1-4. Table 1-5 summarizes the timing and use of each of the ESA-listed species described above.

Table 1-4 | Bull Trout Life Stage Utilization

Life Stage	Timing	Utilization[1]	Notes
Adult Immigration	Mid-March through June/mid-September through mid-December	Medium	No passage barriers but high temperatures affecting immigration.
Adult Holding	October through mid-June	Low	
Spawning/Incubation/ Emergence	N/A	N/A	
Juvenile Emigration	October though	Low	
Summer Rearing	NA	N/A	No current summer rearing due to high temperatures.
Winter Rearing	October through mid-June	Medium	

[1] High – Critical life stage use in need of immediate action for salmonid population performance
Medium – Life stage use that is import to the long-term salmonid population performance
Low – Life stage use that is minimally affected by existing conditions
N/A – Life stage does not utilize the area

Table 1-5 | Timing and Use of Steelhead, Spring Chinook, and Bull Trout within the Project Area

		Jan		Feb		Mar		Apr		May		June		Jul		Aug		Sept		Oct		Nov		Dec	
Species	Life Stage	1-15	16-31	1-15	16-28	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-31	1-15	16-31	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-30	1-15	16-31
Steelhead (Summer)	Adult Immigration																								
	Adult Holding																								
	Adult Spawning																								
	Incubation																								
	Emergence																								
	Juvenile Rearing																								
	Juvenile Emigration																								
Spring Chinook Salmon	Adult Immigration																								
	Adult Holding														?	?	?								
	Adult Spawning																								
	Incubation																								
	Emergence																								
	Juvenile Rearing																								
	Juvenile Emigration Age 0									Age 0	Age 0	Age 0							Age 0	Age 0	Age 0	Age 0	Age 0		
	Juvenile Emigration Age 1			Age 1	Age 1	Age 1	Age 1	Age 1	Age 1	Age 1	Age 1	Age 1	Age 1												
Bull Trout (Fluvial)	Adult Immigration																								
	Adult Holding																								
	Adult Spawning																								
	Incubation																								
	Emergence																								
	Juvenile Rearing																								
	Juvenile Emigration																								

Source: BPA 2015

Limiting factors for Snake River summer steelhead and Snake River spring/summer Chinook on the UGR have been identified by NOAA Fisheries (NOAA Fisheries 2012). Those limiting factors are listed below in Table 1-6 and Table 1-7. Tables 1-6 and 1-7 also note the project goal(s) that address each limiting factor either directly (bold type) or indirectly.

Table 1-6 | Limiting Factors for Grande Ronde River Upper Mainstem Population of Snake River Steelhead

Assessment Unit	Geographic Area	Limiting Factor	Addressed by Goal (directly or indirectly)
UGS4	Upper Grande Ronde River Mainstem - Upstream End of Grande Ronde Valley to Meadow Creek	4.1: Riparian Condition: Riparian Vegetation	**3,** 1, 4
		4.2: Riparian Condition: LWD Recruitment	**3,** 1, 4
		6.1: Channel Structure and Form: Bed and Channel Form	**1, 2**
		6.2: Channel Structure and Form: Instream Structural Complexity	**1, 2**
		7.2: Sediment Conditions: Increased Sediment Quantity	**3, 4**
		8.1: Water Quality: Temperature	**2**
		9.2: Water Quantity: Decreased Water Quantity	**4**

Source: NOAA Fisheries 2012

LWD = large woody debris

Table 1-7 | Limiting Factors for Grande Ronde River Upper Mainstem Population of Snake River Spring/Summer Chinook

Assessment Unit	Geographic Area	Limiting Factor	Addressed by Goal (Directly or Indirectly)
UGC2	Middle Grande Ronde Mainstem (Five Points Cr. To Meadow Cr.)	1.1: Habitat Quantity: Anthropogenic Barriers	
		4.1: Riparian Condition: Riparian Vegetation	**3,** 1, 4
		4.2: Riparian Condition: LWD Recruitment	**3,** 1, 4
		6.1: Channel Structure and Form: Bed and Channel Form	**1, 2**
		6.2: Channel Structure and Form: Instream Structural Complexity	**1, 2**
		7.2: Sediment Conditions: Increased Sediment Quantity	**3, 4**
		8.1: Water Quality: Temperature	**2**
		9.2: Water Quantity: Decreased Water Quantity	**4**

Source: NOAA Fisheries 2012

LWD = large woody debris

1.5 LIST OF PRIMARY PROJECT FEATURES INCLUDING CONSTRUCTED OR NATURAL ELEMENTS

The following design elements have been developed to best achieve project goals and objectives. The combination of these design elements make up the final design plan set. The final plan set and proposed overview map are included in Appendix 8.1.

CHANNEL NETWORK

Where geomorphically appropriate, this project intends to re-establish an island-braided channel planform with relatively narrow, deep channel(s) between vegetated islands. The design includes the realignment of sections of the existing mainstem. The proposed mainstem alignment attempts to increase channel length, reduce the width-to-depth ratio, reduce mainstem channel energy, provide channel complexity (pools/riffles/bed diversity), and decrease risk to existing infrastructure (State Highway 244 [Highway 244]). A primary focus of the design is increased floodplain connectivity during high flows into existing floodplain features throughout the project area to promote off-channel habitats, floodplain restoration, and distribution of stream power throughout the floodplain. In combination with realignment of sections of the mainstem, a network of side channels, alcoves, off-channel rearing ponds, and other remnant floodplain features that provide habitat were enhanced or developed through constructed connections. The channel network was also developed with considerable effort to improve thermal diversity by promoting hyporheic exchange at the floodplain scale.

LARGE WOOD STRUCTURES

LWM structures have been strategically placed within the project design reach to create new/improved habitat features and to serve as hydraulic forcing agents to provide horizontal and vertical stability to newly constructed channel features and to create pools. The locations and structure types depicted in the accompanying final design plans (Appendix 8.1) vary in size and complexity. Types of large wood structures include but are not limited to apex structures (mid-channel), meander bend structures, channel margin structures (3, 6, 9, and 12 logs), floodplain roughness structures, reinforced habitat structures, as well as sweeper logs and cover logs. Structures are designed to be overtopped by raft ice at key locations to promote sustainability and longevity. Pool structures are designed to encourage energy dissipation, abrupt forcing, and scour to maintain pool depths and encourage submergence of LWM during low flow conditions. Design of all large wood structures was improved upon based on data from the LWM structures constructed at the upstream Bird Track Springs Project. Previously built structures were reviewed to incorporate lessons learned, identify constructability issues, understand how changes to the structures in the field should be incorporated, and improve the design detail of the Longley Meadows project's LWM structures. The design of all wood structures attempts to mimic natural large wood accumulations using locally sourced large wood.

BANK TREATMENT

Constructed sections of the mainstem and side channels will require bank treatment in key areas to provide initial bank stability and to support the establishment of native riparian vegetation. Bank treatments incorporate native vegetation and large wood to mimic natural channel banks. They are designed to provide energy dissipation and erosion resistance to allow natural vegetation to become established for long-term riparian development, shading, and large wood recruitment, and to promote natural rates of channel migration. Bank treatment locations shown on the final design plans are based on channel design iterations, bank heights, improvements to the design details, and hydraulic modeling results. Modeling results ensured the appropriate bank treatment placement locations in areas with high shear stress.

RESTORE RIPARIAN AND FLOODPLAIN VEGETATION

The project reach contains various levels of riparian health with native cottonwood, willow, wild rose, hawthorn, and ponderosa pine at various densities, widths, and seral stages. Current impacts to the health of native vegetation likely include some ungulate browse, invasive weeds, lack of annual flooding, and lack of sediment deposition for native riparian propagation. Treatments include re-establishment of river-floodplain interaction, promotion of sediment deposition on floodplains, and active planting. Active irrigation of plantings is not expected as there are no known water rights available for irrigation at the project site. Fencing and deterrents such as Plant-Skydd will be further investigated and addressed upon completion of the construction project if ungulate browse appears to be a critical impediment to revegetating the project area. Planting locations are designed based upon water surface elevations and flood frequencies of occurrence based on the hydraulic modeling results. Areas of disturbance, swales, channel banks, and floodplains receive restoration planting treatments ranging from seed and mulch to live plants to encourage and promote colonization of native plants to improve riparian conditions and succession. Limits of disturbance will be minimized and strictly enforced to protect existing plants. Existing vegetation in areas of disturbance will be salvaged and repurposed whenever feasible.

ANTHROPOGENIC FEATURE REMOVAL

Anthropogenic features within the project include Highway 244, which includes reaches of riprapped bank adjacent to the UGR, Mount Emily historic railroad grade and associated borrow ditches, various structures and berms that encompass the La Grande Gun Club, and electric power lines. Riprapped banks along Highway 244 are currently armoring the road prism and will remain in place per communications with Oregon Department of Transportation (ODOT) to provide highway protection. Though the riprap is to remain in place, placement of native fill material against the riprap is acceptable. The placement of fill in several areas aids in moving the river away from the highway, effectively burying the riprap in place and promoting a natural vegetated bank line away from the highway. A few sections of the historic railroad grade impede floodplain interaction while others currently protect Highway 244 from flooding. The 15% design concept included removal of the railroad berm in the vicinity of the La Grande Gun Club. Due to constraints related to impacts to the railroad grade and the difficulty of constructing project elements near the highway, all project activities downstream of the Gun Club property were abandoned. This area can possibly be part of a separate project phase in the future. Impacts to the railroad grade will only involve placing fill in locations to protect Highway 244. Borrow sites will be evaluated individually and will remain and/or be enhanced where beneficial to project goals and may be filled in key locations to maintain 100-year floodplain extents against the highway as necessary. Shooting berms located at the La Grande Gun Club were evaluated for relocation; however, due to the site layout and usage, the berms are slated to remain in their existing locations. If there is excess fill material from the project it will be placed to enhance and heighten the berms to provide additional public safety to recreational river users from target shooting.

1.6 DESCRIPTION OF PERFORMANCE/SUSTAINABILITY CRITERIA FOR PROJECT ELEMENTS AND ASSESSMENT OF RISK OF FAILURE TO PERFORM, RISK TO INFRASTRUCTURE, POTENTIAL CONSEQUENCES, AND COMPENSATING ANALYSIS TO REDUCE UNCERTAINTY

Performance/sustainability criteria for the primary project features described above were developed for each proposed element. Using the hydraulic model, project elements' performance and sustainability were evaluated to ensure that the elements were able to meet specific project goals, objectives, and analysis. Physical data and information were incorporated into the design of each element, aiding in the reduction of its risk of failure and elevating its sustainability. There are areas in the project reach that pose some limited risk to public and private infrastructure (near and upstream of the La Grande Gun Club); however, for the entire project as a whole, the risk is limited. Whenever possible, the project is designed to promote natural processes, with inherent natural risks associated with flooding, avulsion, and ice jams. Natural processes are balanced with measures to protect existing infrastructure that mimic natural features whenever possible. To manage risk and uncertainty, significant planning, design, and monitoring along with action planning are required for individual project elements. The following subsections describe the methods for planning and design of primary project elements.

CHANNEL NETWORK

Channels were designed and analyzed using a two-dimensional (2D) HEC-RAS model for both existing and proposed conditions. An iterative modeling approach was performed using inputs of hydrologic data systematically collected by the U.S. Geological Survey (USGS) at approximately five sites on the UGR, the earliest of which was installed in 1903, and adjusted for the project reach through standard hydrologic methods. For additional information regarding project hydrology, refer to Section 3.3. Hydraulic model outputs were compared to data collected at the site to include discharge and velocity measurements, water surface elevation field markers, and sediment size, gradation, and location. Channel designs were adjusted to be stable at the completion of construction for various discharge frequencies depending on location and risk to infrastructure, which were reviewed and determined through design progression. Additionally, as part of the Union County Floodplain Development Permit a hydraulic analysis was performed to compare the proposed water surface elevations compared with the existing conditions at the 100-year flood interval (see Appendix 8.11).

LARGE WOOD STRUCTURES

Large wood structures were designed and located to mimic natural large wood accumulations. These structures are designed and analyzed for stability following Reclamation's *Risk-Based Design Guidelines* (Knutson and Fealko 2014). This risk-based design approach requires the evaluation of stream hydraulics along with evaluating risk associated with potential property damage as well as public safety concerns. Design analysis as well as in situ site conditions promote prioritizing use of native backfill for ballast followed by progressively greater stabilizing methods such as large boulders, wood piles, roped connections, and finally steel connections, all within current guidelines permitted by BPA's HIP program. Both public and property risk ratings were evaluated for each of the proposed LWM structures shown on the final design plans (Table 1-8). These risk ratings determined the Factor of Safety (FOS) values for buoyancy, sliding, rotation and overturning. Detailed discussion regarding the risk assessment criteria can be found in Appendix 8.5.

Table 1-8 | Longley Meadows Summarized LWM Design Criteria Results

LWM Structure Type	Public Safety	Property Damage Risk	Hydraulic Design Event
Type A – Apex Jam	Low	Moderate	25-Year
Type B1 – Meander Jam – Mallet Jam	High	Moderate	50-Year
Type C3 – 3-Log Channel Margin Jam	Low	Moderate	25-Year
Type C6 – 6-Log Channel Margin Jam	Low	Moderate	25-Year
Type C9 – 9-Log Channel Margin Jam	High	Moderate	50-Year
Type C12 – 12-Log Channel Margin Jam	High	Moderate	50-Year
Type D - Single Log Sweeper Jam	Low	Moderate	25-Year
Type F - Floodplain Roughness	Low	Moderate	25-Year
Type G- Reinforced Habitat Structure	Low	Moderate	25-Year

BANK TREATMENTS

Within the project reach, the UGR is wide and shallow, and has a plane homogenous bed. It is surmised that one of the primary pathways of channel evolution has been the removal of riparian vegetation and the rapid widening of channel banks consisting of silty-sand soils, representative of the project reach. Therefore, development of bank resistance for both the short term and long term will be critical to project success. Bank treatments are designed to provide short-term resistance using dead woody materials and long-term stability utilizing live materials and riparian plantings. Risks to success include: shear or avulsion from a large flood event occurring in the near term (5 years) following project completion; ice shear and plucking of bank materials; drought; and ungulate browse. These identified risks were evaluated using hydraulic modeling and specific reach conditions to locate vulnerable treatment areas. Risks will be minimized using strict specifications, construction oversight, and project monitoring.

RESTORATION OF RIPARIAN AND FLOODPLAIN VEGETATION

Risks to successful restoration of riparian and floodplain vegetation are many and can be heavily influenced by climatic conditions following project completion along with potential animal browse and soil conditions. Successful vegetation restoration risks will be minimized and mitigated as much as possible using the hydraulic modeling results for planting locations, incorporating vegetation surveys and sediment surveys, as well as collecting local seed sourcing, and maximizing use of existing and functioning vegetation within the project site. Additionally, the Bird Track Springs Project was implemented by the same planting/revegetation team and project sponsor and has provided additional insight to project revegetation success. Lessons learned from the Bird Track Springs Project have been incorporated into all project elements to improve success of vegetation plantings. Project implementation is mostly located on USFS property and the riparian and floodplain planting is being contracted and overseen by the USFS except for grass seed and mulch being placed by the construction contractor in areas of disturbance not within channels. Once planting has occurred, project monitoring will evaluate planting conditions and recommend potential treatments to include additional planting, application of browse deterrents, and removal of invasive species.

1.7 DESCRIPTION OF DISTURBANCE INCLUDING TIMING AND AERIAL EXTENT AND POTENTIAL IMPACTS ASSOCIATED WITH THE IMPLEMENTATION OF EACH ELEMENT

Potential disturbance from project implementation will include but may not be limited to:

- Construction of temporary access routes and staging areas;
- Fish salvage/aquatic species disturbance related to the removal and care of water during large wood structure isolation and stream bypass during channel construction;
- Turbidity impacts to water quality;
- Removal and relocation of existing vegetation;
- Impacts to existing wetland resources; and
- Potential impacts to historic and cultural resources.

Details including the timing and areal extent of these impacts are further detailed in the final design drawings and specifications. Minimizing the disturbance to existing resources is a project priority, and project goals were evaluated taking into consideration potential impacts. It is expected that impacts to wetlands and existing vegetation will be mitigated by enhancing connectivity and physical processes to create additional wetlands and promote riparian vegetation succession.

Impacts to project resources have been addressed through the project planning and permitting process. For this large-scale habitat enhancement project, the project permitting required extensive analysis and documentation to receive all required permits. Environmental considerations include those typical for stream habitat restoration projects where ESA-listed fish are present. All federal, state, and local permits have been obtained by the project sponsor (CTUIR). The USFS and BPA will satisfy the National Environmental Policy Act (NEPA) requirements through their extensive public process. This project followed and adhered to all required stipulations and guidance within the BPA's HIP program for ESA Section 7 compliance. Additional discussion regarding environmental compliance, cultural resource analysis/reporting and confirmation as well as permitting can be found in Section 5.

2 RESOURCE INVENTORY & EVALUATION

2.1 DESCRIPTION OF PAST AND PRESENT IMPACTS ON CHANNEL, RIPARIAN, AND FLOODPLAIN CONDITIONS

In the project reach, the UGR was historically likely an unconfined, forced alluvial channel with alternating pool-riffle and run bedforms. Beechie and Imaki (2014) empirically determined that intermediate-sized unconfined channels, similar to the UGR, that transport their sediment primarily as bedload and retain wood long enough to establish erosion-resistant points were transitional, and generally favored island-braided patterns in forested mountain systems (Cardno 2016a). Beechie and Imaki's (2014) data also show that island-braided channels are continually adjusting to intermittent perturbations, which sustains a high degree of successional states, resiliency, and habitat diversity (Cardno 2016a). Analysis of aerial imagery, light detection and ranging (LiDAR) and elevation data, and field observations of existing conditions and features including existing riparian vegetation and floodplain features was utilized to estimate the historical planform of the UGR within the project area. Based on the results of the analysis, field observations, and literature findings, it is believed that the UGR within the project area was a multi-thread channel with interconnected beaver wetland complexes.

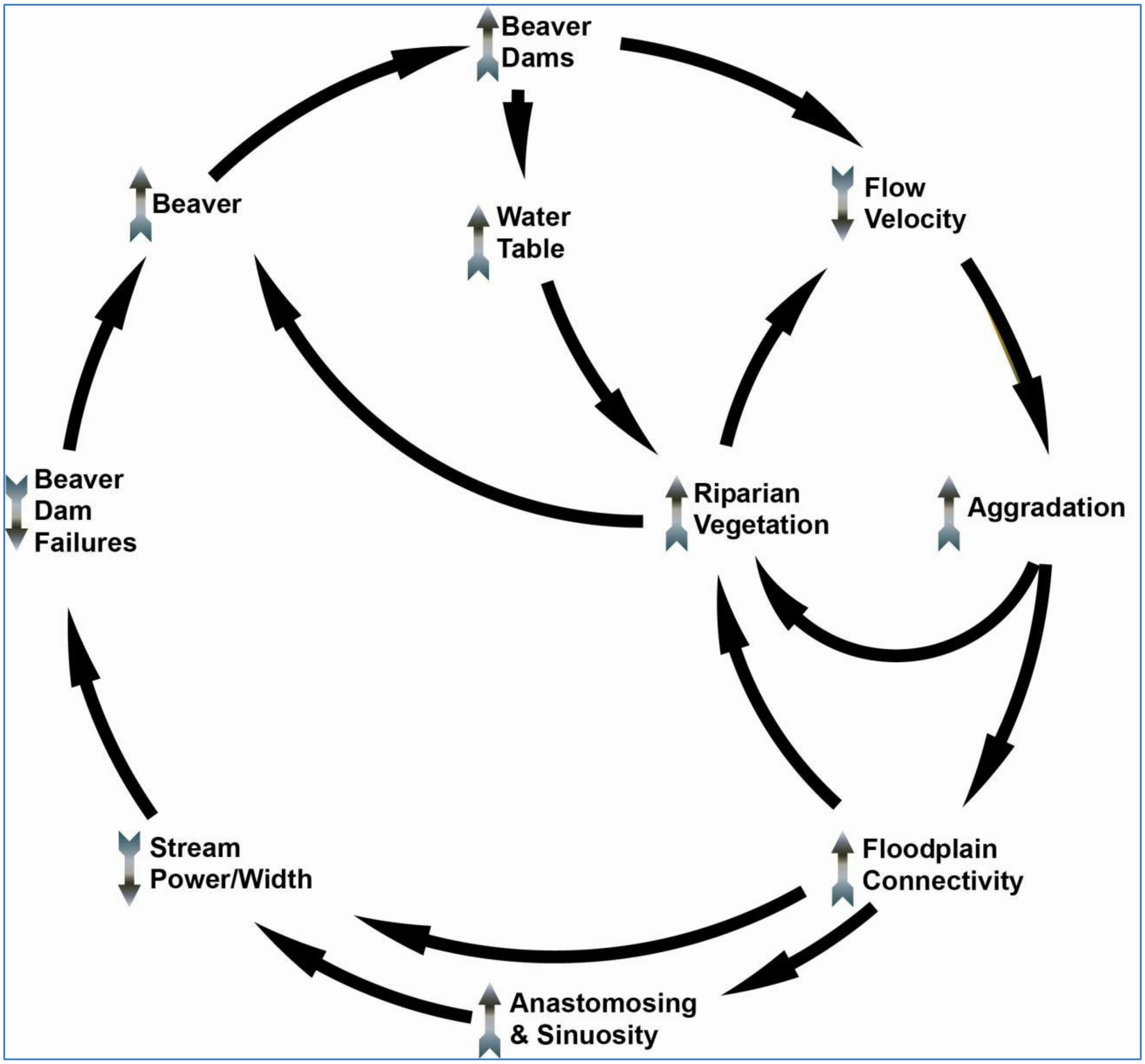
Within the UGR Subbasin, riparian and instream habitat degradation has negatively affected Chinook salmon, steelhead, bull trout, and other sensitive aquatic species. The habitat degradation is the result of several anthropogenic disturbances that include, but are not limited to:

- Extirpation of beaver;
- Agricultural development;
- Livestock grazing;
- Hydraulic and gravel mining;
- Logging and use of splash-dams; and
- Railroad/road construction (NPCC 2004).

The timing of these historical activities as well as ongoing impacts to the UGR Watershed is outlined in the *Grande Ronde Tributary Assessment* (Reclamation 2014).

BEAVER EXTIRPATION

The first (temporally) and arguably the most detrimental impact to the channel, riparian, and floodplain conditions was the extirpation of beaver in the early 1800s. Beaver dams can alter the river planform to a network of ponds and/or wetlands connected by single- or multiple-thread channels, rather than the predominantly single-thread channel currently observed (Naiman et al. 1988). Beaver dams can affect sediment transport characteristics by increasing sediment retention through attenuated peak flows and low-velocity environments that promote deposition. Beaver pond complexes or increased floodplain inundation as a result of beaver activity can increase groundwater recharge and retention, which in turn can increase in-channel flow at low flow conditions. Beaver ponds and pond complexes also tend to increase areas of riparian vegetation (Pollock et al. 2003). Figure 2-1 below illustrates multiple positive feedback loops that are created and sustained by beaver and beaver activity on multiple forms, processes, and conditions. The removal of beaver and/or beaver dams can reverse each positive feedback loop.



Source: Pollock et al. 2014

Figure 2-1 | Effects of Beaver and Beaver Dams on Physical Processes and Form

AGRICULTURE, MINING, LIVESTOCK GRAZING, AND ROAD CONSTRUCTION

Additional impacts include agricultural development and livestock grazing, gravel mining in the floodplain, and the construction of Highway 244. These actions have altered the hydraulic and geomorphic processes and the riparian and floodplain vegetation and have lasting topographic signatures upon the floodplain.

LOGGING

Historical logging practices have also had considerable impacts on not just riparian, floodplain, and upland vegetation but also hydraulic and geomorphic processes. For example, the channel was likely homogenized (i.e., straightened) and geomorphic features (large wood or other) removed in order to improve log transport efficiency via splash-dam logging. Floodplain disconnection is also associated with logging, particularly the construction of the railroad to transport logs via train.

RESULTING TRENDS

The effects of impacts to riparian and floodplain vegetation, hydraulics, and geomorphology are inter-related. The effects of the removal of beaver are discussed above, while the channel alterations associated with vegetation and channelization are discussed below.

VEGETATION ALTERATION

The alteration of riparian vegetation has multiple impacts to process and form. Instream large wood is a geomorphic feature that interacts with hydraulic forces to create and maintain diverse form and structure at a range of spatial scales. By reducing the amount of in-channel large wood and the amount of large wood available to enter the channel, the ability of the channel to adjust and evolve from disturbances is limited. Removal of riparian vegetation along the banks increases the risk of local bank erosion due to loss of resistance to erosion provided by rootmass. The amount of stream nutrients provided by leaf litter and decaying trees is lower with reduced riparian vegetation. Reduction of vegetation on the floodplain reduces floodplain roughness, which increases the risk of channel capture through avulsion when flow does access the floodplain. Reduction in riparian and floodplain vegetation also increases the amount of solar absorption at the water surface, thus contributing to increased stream temperatures.

CHANNEL ALTERATION

In rivers where straightening and clearing has occurred, the effects of these processes are numerous. Lowered overall instream roughness, reorganized bed topography, and increased bedload transport rates persist due to an increase in shear stress, increased transport capacity, and the coarsening of bed material (Montgomery et al. 2003). In reaches where large wood or other geomorphic features are creating diverse bed morphology, such as pool-riffle, removal of large wood combined with straightening can allow the morphology to degrade to plane bed and increase potential for further degradation through incision.

The cumulative effect of these impacts is the existing degraded channel segment. The existing conditions are discussed further in Section 2.3, Description of Existing Geomorphic Conditions and Constraints on Physical Processes.

2.2 INSTREAM FLOW MANAGEMENT AND CONSTRAINTS IN THE PROJECT REACH

There are currently no instream flow management requirements or constraints within the project reach.

2.3 DESCRIPTION OF EXISTING GEOMORPHIC CONDITIONS AND CONSTRAINTS ON PHYSICAL PROCESSES

Based on geophysical investigations conducted in association with the Bird Track Springs Project, a simplified description of the general geologic conditions of the active floodplain of the UGR within the Longley Meadows Fish Habitat Enhancement Project area would be approximately 20 feet of alluvial material overlying bedrock with the bedrock shallowing to depths of approximately 15 to 18 feet in the downstream end of the project area. The valley bottom alluvium has been identified as the Gulliford-Collegecreek-Bullroar complex (U.S. Department of Agriculture [USDA] 1995).

Within the project area, the UGR is unconfined—defined here as having a floodplain width greater than two but less than four times the bankfull width (Oregon Watershed Enhancement Board [OWEB] 1999).

The project area was delineated into three geomorphic reaches for the preferred concept based on physical characteristics including degree of confinement, channel sinuosity, and land use. Levels of channel and floodplain dynamics were also considered in the reach delineation. With further evaluation of various aspects including construction feasibility and cost to benefit, Reach 3 was not considered during the advancement of the design to the 30% and subsequent milestones. Table 2-1 and Figure 2-2 provide a summary of the geomorphic characteristics and show surficial geology for Reaches 1 and 2 for the project area.

The overall average stream gradient is 0.5% in both Reach 1 and 2 (Figure 2-3).

Table 2-1 | Key Channel and Streambank Characteristics by Geomorphic Subreach

Reach ID	Length (ft)	Average Slope (ft/ft)	Sinuosity (ft/ft)	Average Riffle Spacing at Low Flow		% of Riffle, Run or Pool by Length at Low Flow			% of BFW Area that is Bar (vegetated and non-vegetated) at Low Flow	% of Channel Length with Eroding Banks
				ft	xBFW*	Riffle	ft/ft	Pool		ft/ft
1	5,394	0.0051	1.4	301	2.2	27	61%	12	51%	57%
2	2,796	0.0051	1.1	209	2.4	48	N/A	0	44%	NA

* Multiples of bankfull width

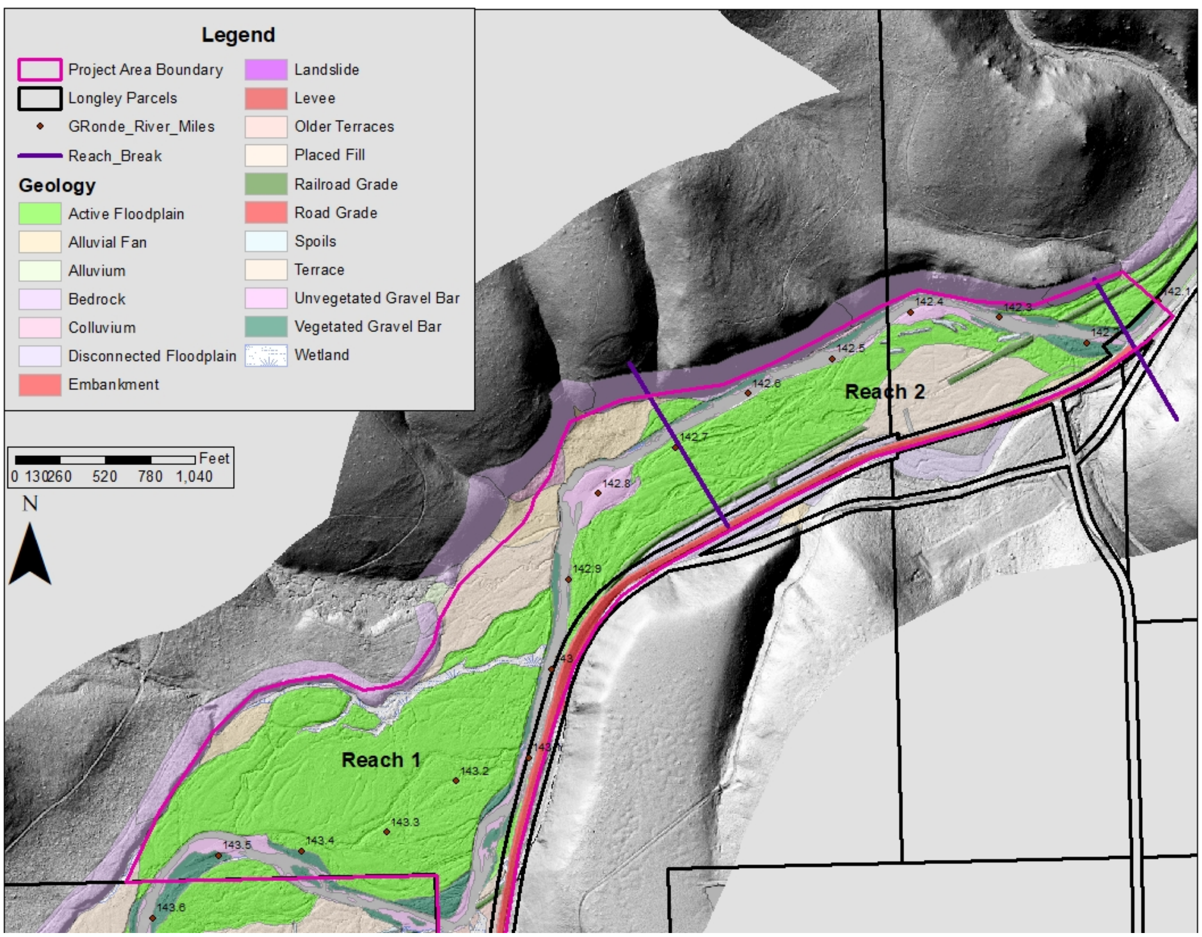


Figure 2-2 | Preliminary Surficial Geology of the Longley Meadows Fish Enhancement Project Area

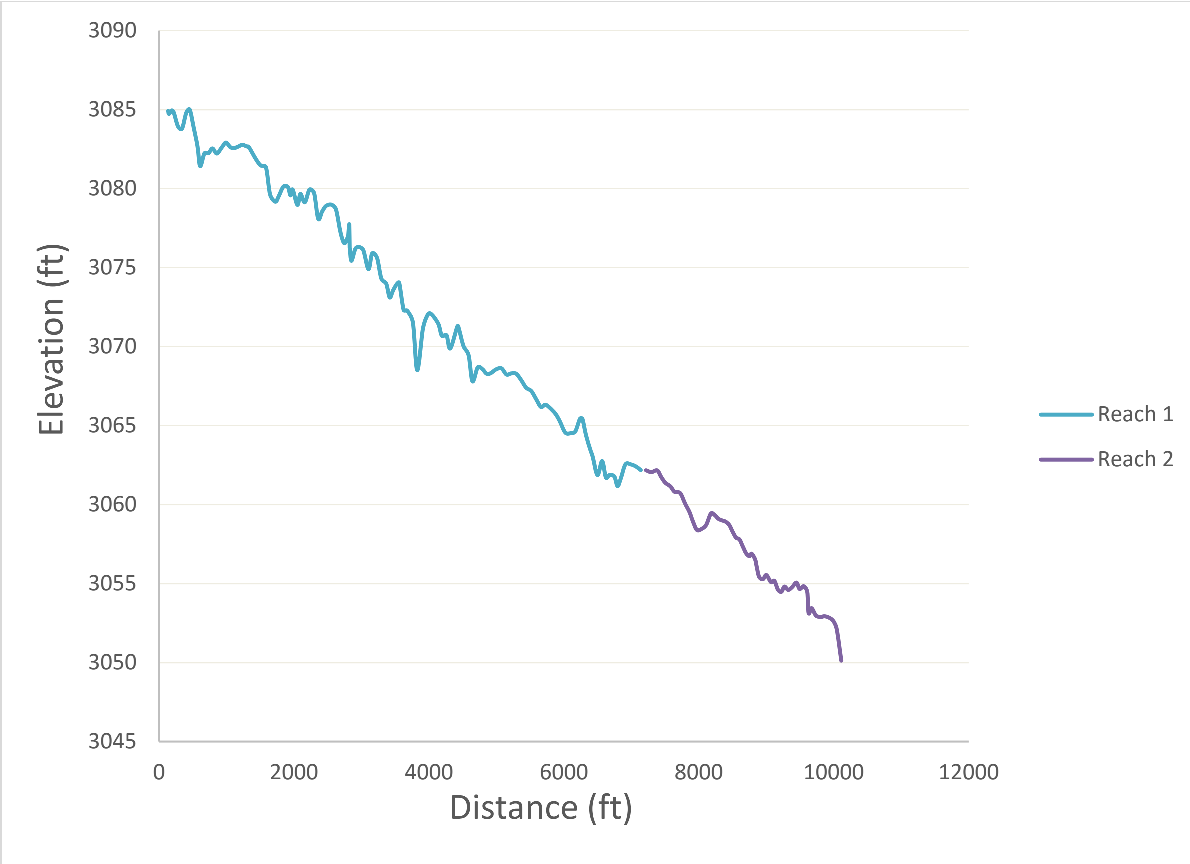


Figure 2-3 | Longitudinal Profile for the Geomorphic Reaches within the Longley Meadows Fish Habitat Enhancement Project

Key physical, geomorphic, and habitat conditions and process for each geomorphic reach are summarized below, along with observed restoration opportunities and/or constraints. These conclusions were drawn from the datasets described above.

GEOMORPHIC REACH 1 – UPPER FLOODPLAIN

Within Reach 1 of the project area, the UGR is unconfined with a straight (sinuosity <1.5) channel planform. The bedform is predominantly run, and bed material consists mostly of gravel and cobble-sized material. The runs are typically long, with average lengths of 226 feet, with common instances of residual depth of up to 2 feet. Geomorphic elements (wood or other) are not present in the reach aside from some structures placed in the stream associated with past restoration activities. However, during the winter months, ice can potentially act as a geomorphic element to raise water surface elevations and/or redirect water onto adjacent floodplain surfaces and scour bed and bank surfaces. Based on field observation and existing condition floodplain inundation at bankfull, 2-year, and 5-year recurrence interval discharges, the UGR in Reach 1 is interpreted to be incised by roughly 3 to 4 feet.

The banks within Reach 1 consist of a basal layer comprising varying percentages of cobble and gravel with sand and silt overlain by floodplain deposits of silts and fine sand. The thickness of the floodplain deposit ranges in depth from a few inches up to 4 feet (Figure 2-4).

Figure 2-4 | Basal Layer of Coarser Material Overlain by Fine Grained Flood Deposits of Varying Thickness

Within Reach 1 approximately 47 acres of floodplain is located along river left. The floodplain area contains a wetland complex that flows into the mainstem along the left bank. The source of the wetland is believed to be groundwater upwelling, and is a cold-water source. At the downstream end of Reach 1 approximately 8 acres of floodplain is located on river right. Highway 244 and the historic railroad grade occupy and/or disconnect approximately 3 additional acres of floodplain. Floodplain connectivity for Reach 1 is discussed in Section 2.5, Description of Lateral Connectivity to Floodplain and Historical Floodplain Impacts.

Bank erosion takes place through approximately 57% of the length of the reach (Figure 2-5). Major erosion takes place in the form of lateral migration that coincides with point bar development at RMs 143.5, 143.3, and 142.8 and is discussed in Section 3.4, Summary of Sediment Supply and Transport Analysis.

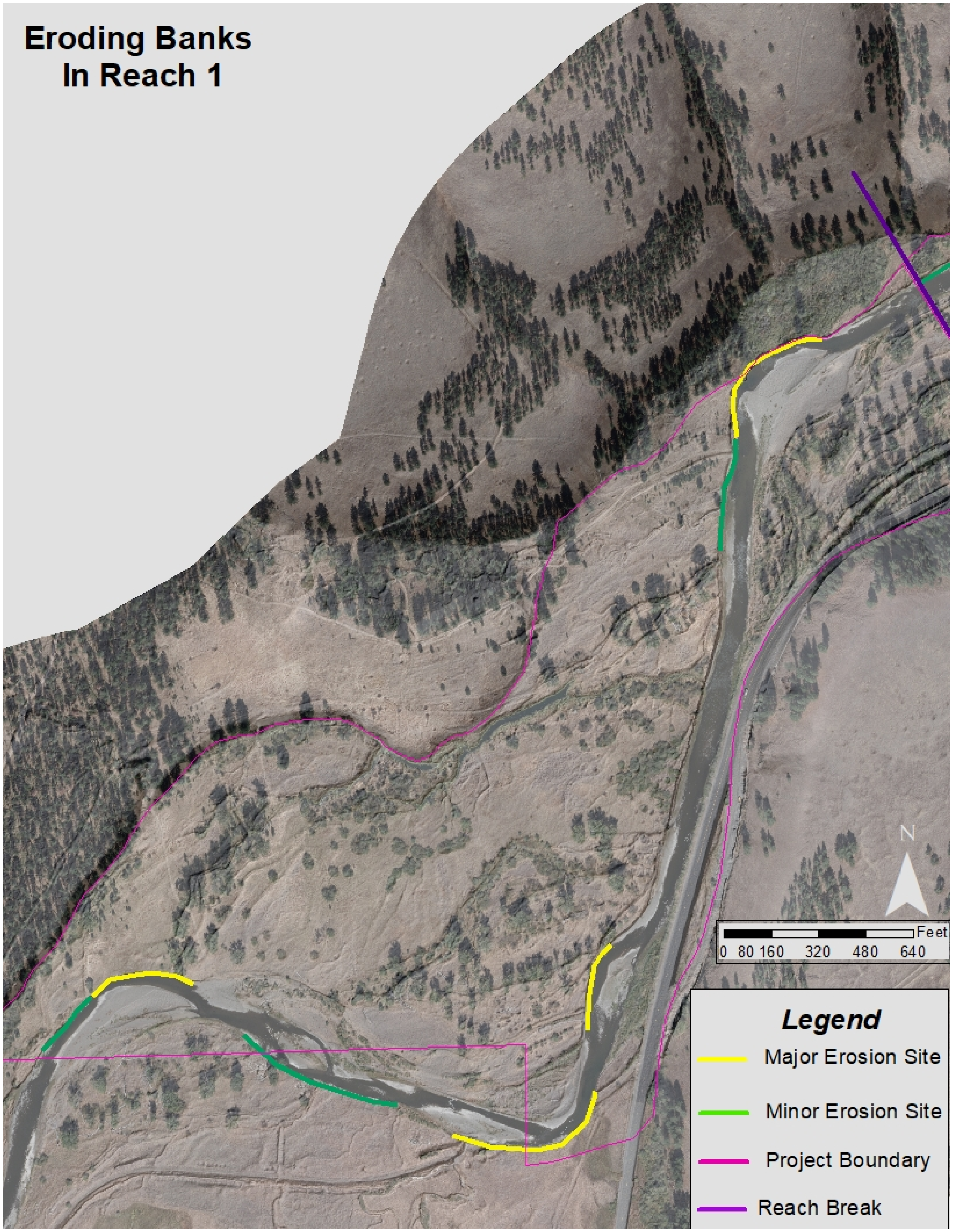
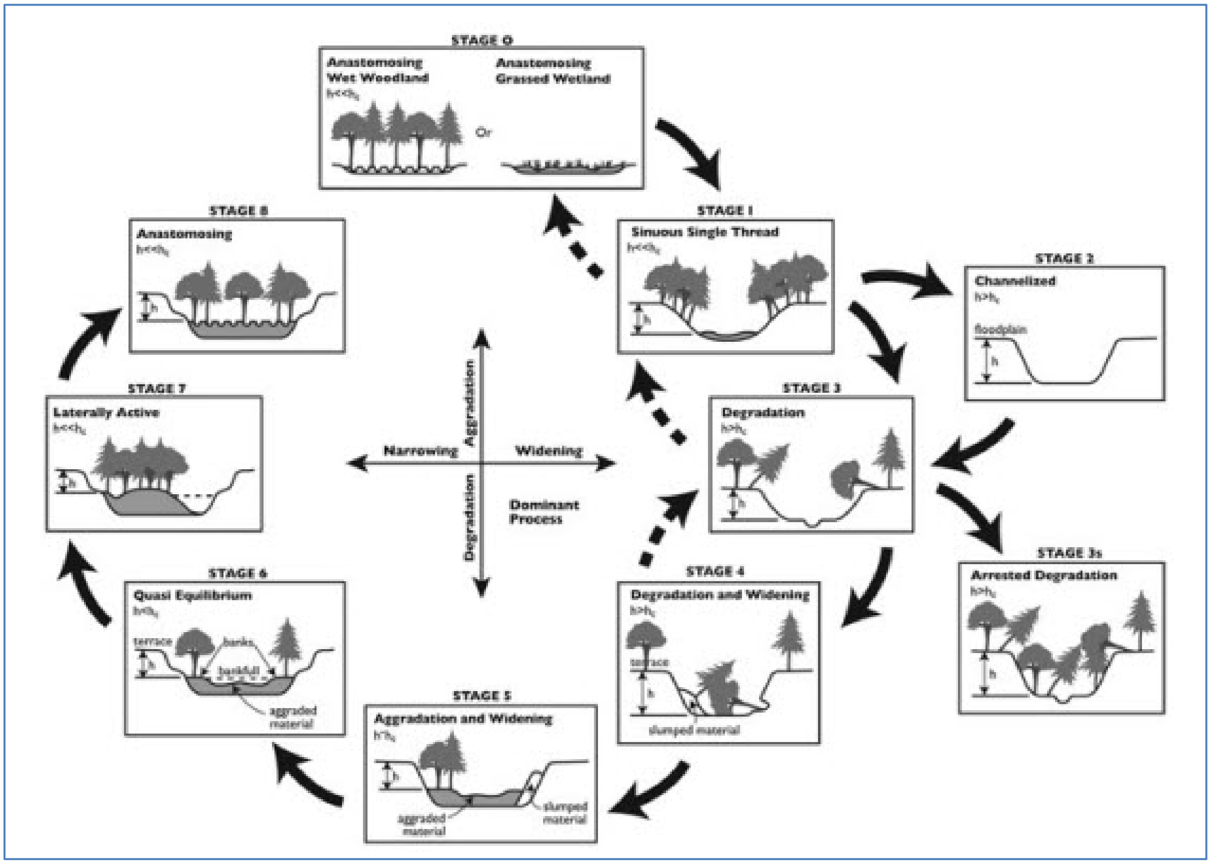


Figure 2-5 | Bank Erosion in Reach 1 on 2013 Aerial Image

Hydraulic, geomorphic, and riparian processes are degraded from theorized historical conditions due to historical impacts and the degradational trends initiated by those impacts previously described in Section 2.1, Description of Past and Present Impacts on Channel, Riparian, and Floodplain Conditions. Utilizing Cluer and Thorne's Stream Evolution Model (2013) (Figure 2-6), the UGR in Reach 1 is believed to currently represent at least three evolutionary stages. Throughout the majority of the reach, the stream alternates between laterally active (stage 7) and aggrading (with and without widening) (stage 5). In the downstream end of the reach, the channel is interpreted to be at a stage of arrested degradation (stage 3s) (Figure 2-7).



Source: Cluer and Thorne 2013

Figure 2-6 | Progression of Degradation and Recovery of a Stream and Floodplain

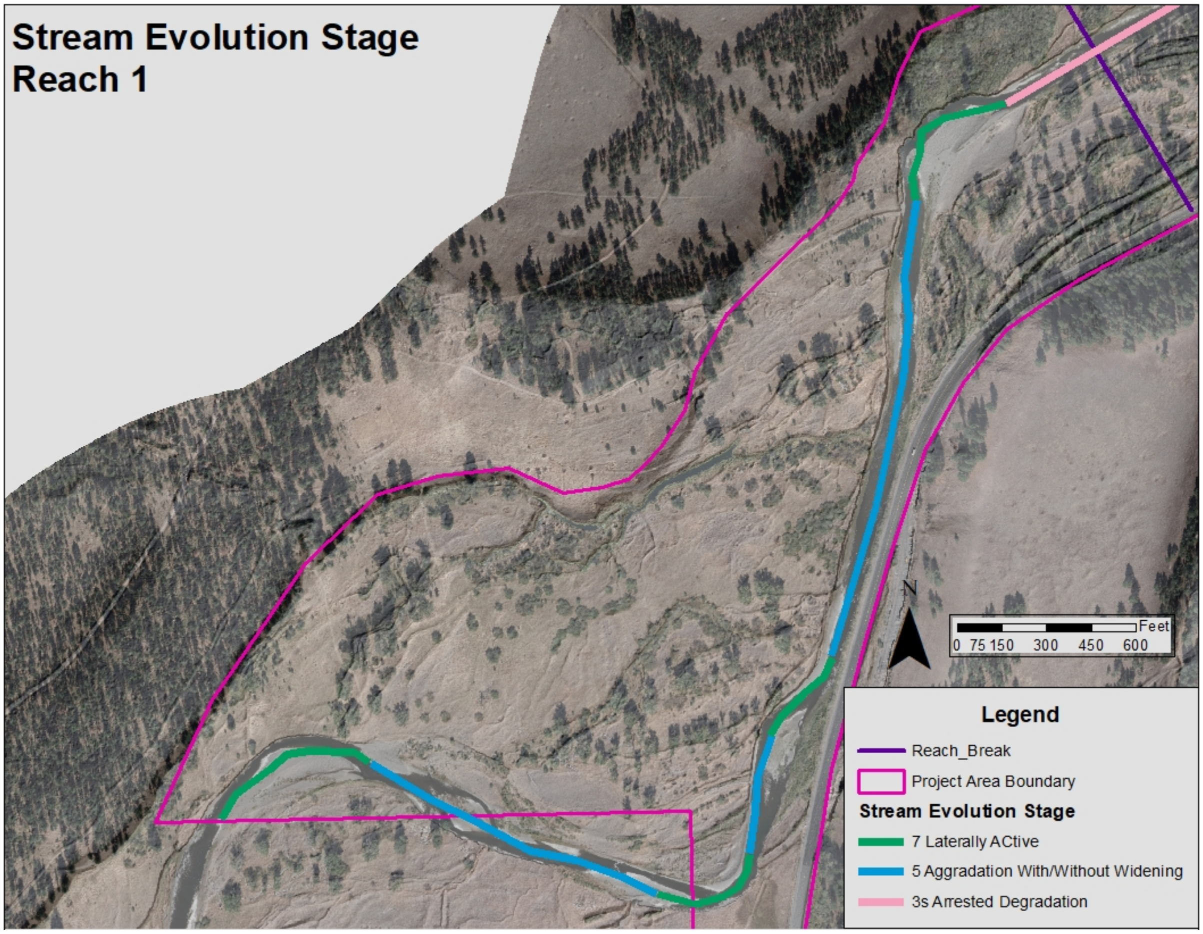


Figure 2-7 | Stream Evolution Stages Based on Cluer and Thorne's Stream Evolution Model on 2013 Aerial Image with Transparent LiDAR

Previous efforts to restore geomorphic and hydraulic processes within the project area have included channel-spanning rock weirs and bank-barbs constructed of rock and wood. While the structures can promote aggradation, with or without widening, they were unsuccessful at significantly altering planform or instream complexity or increasing floodplain inundation. To alter the geomorphic and hydraulic processes to a degree sufficient to initiate recovery of hydraulic, geomorphic, riparian, and floodplain vegetation, aggressive measures should be taken that include but are not limited to:

- Increase overall length of the main channel
- Capitalize on/improve existing cold-water features
- Reduce width-to-depth ratios in the main channel
- Increase geomorphic and hydraulic structure and diversity in the main channel (large wood)
- Increase floodplain activation at flows at or below bankfull discharge
- Increase floodplain complexity as well as hydraulic and geomorphic structure and diversity with existing or created ponds and side channel networks
- Replant and protect riparian vegetation

CONSTRAINTS

- The right bank landowner at the upstream end of the reach is not interested in work being done on their property, which impacts the ability to work in the mainstem channel and at the confluence of Jordan Creek.
- The design cannot increase flooding potential to Highway 244.
- Ice scour and ungulate browse may limit regeneration of cottonwood and other riparian vegetation.

GEOMORPHIC REACH 2 – LOWER FLOODPLAIN

In Reach 2 of the project area, the UGR is unconfined with a straight planform (sinuosity of 1.1). The bedform is plane bed with a riffle-run morphology consisting of predominantly cobble and gravel-sized material. The riffles and runs are long, averaging 190 feet and 210 feet in length, respectively. Also similar to Reach 1, geomorphic elements (wood or other) are not present in the reach. In winter months, ice can potentially act as a geomorphic element to raise water surface elevations and/or redirect water onto adjacent floodplain surfaces and scour bed and bank surfaces. Based on field observation and existing condition floodplain inundation at bankfull, 2-year, and 5-year recurrence interval discharges, the UGR in Reach 2 is interpreted to be incised by 3 to 5 feet.

Banks comprise varying percentages of cobble and gravel, with sand and silt overlain by floodplain deposits of silts and fine sand.

Approximately 24 acres of active floodplain is located along river right. Approximately 10 additional acres of floodplain are occupied or disconnected due to the presence of Highway 244 and the historic railroad grade. Floodplain connectivity for Reach 2 is discussed in Section 2.5, Description of Lateral Connectivity to Floodplain and Historical Floodplain Impacts.

No instances of notable bank erosion or lateral channel migration were noted when available aerial imagery was analyzed. However, sections of raw vertical bank and bank undercutting have been observed in the upstream section of the reach along the right bank, indicating at least minor erosion is occurring.

Again using Cluer and Thorne's Stream Evolution Model (2013) (Figure 2-6), the UGR in Reach 2 is believed to currently represent only one evolutionary stage: arrested degradation (stage 3s) (Figure 2-8).

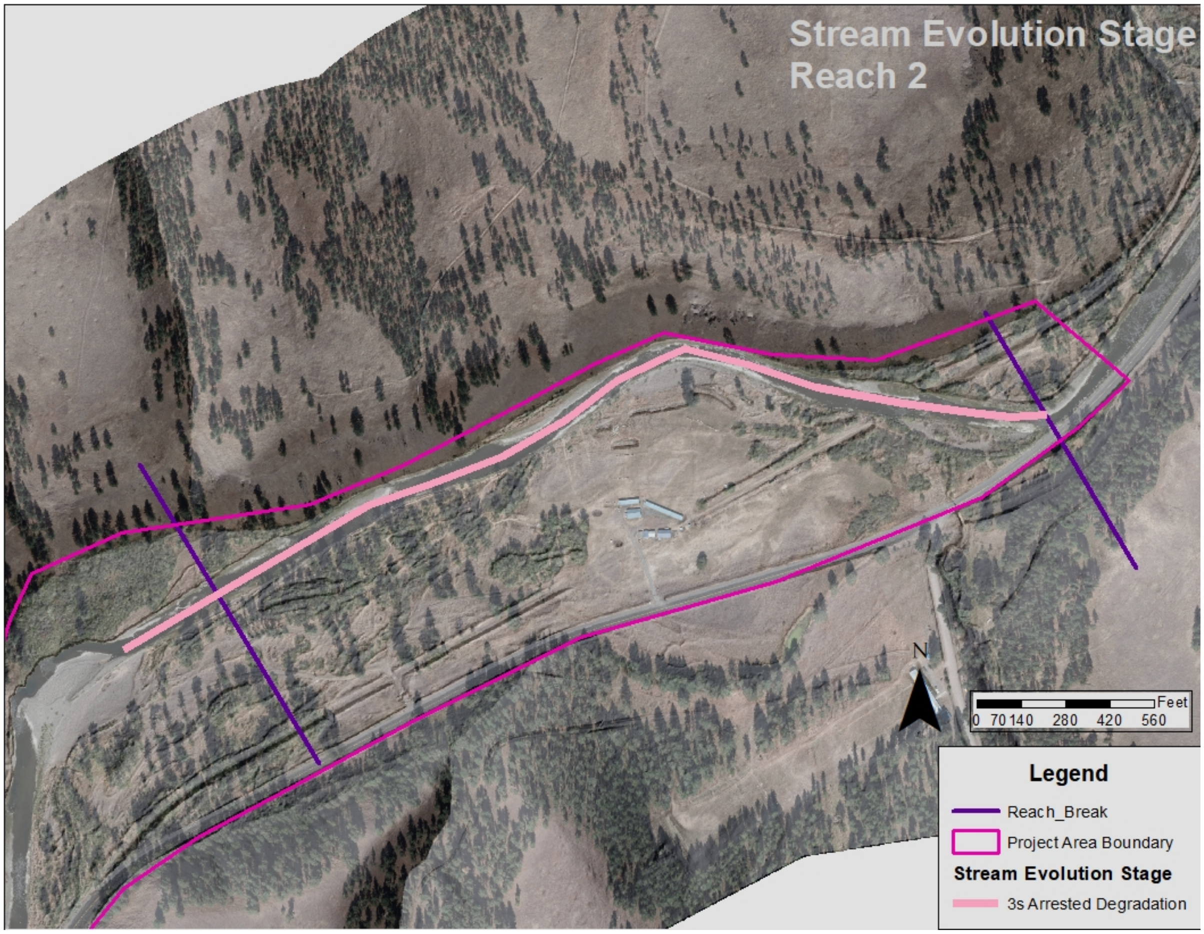


Figure 2-8 | Interpreted Stream Evolution Stages based on Cluer and Thorne's Stream Evolution Model on 2013 Aerial Image with Transparent LiDAR

To alter the river processes to a degree sufficient to initiate recovery of hydraulic, geomorphic, and riparian processes and floodplain vegetation, aggressive measures should be taken that include but are not limited to:

- Increase overall length of the main channel
- Capitalize on/improve existing cold-water features
- Reduce width-to-depth ratios in the main channel
- Increase geomorphic and hydraulic structure and diversity in the main channel (large wood)
- Increase floodplain activation at flows at or below bankfull discharge
- Increase floodplain complexity as well as hydraulic and geomorphic structure and diversity with existing or created ponds and side channel networks
- Replant and protect riparian vegetation

CONSTRAINTS

- The design cannot increase the flooding potential to Highway 244.
- The design must take into consideration the existing infrastructure and land use at the La Grande Gun Club.

2.4 DESCRIPTION OF EXISTING RIPARIAN CONDITION AND HISTORICAL RIPARIAN IMPACTS

Existing riparian vegetation conditions include scattered patches of decadent cottonwood galleries with an understory of woody shrubs and immature trees. These patches are in larger areas of herbaceous vegetation with shallow rooting depths where the floodplain vegetation has been altered by past land use practices previously described in Section 2.1, Description of Past and Present Impacts on Channel, Riparian, and Floodplain Conditions. Beaver are uncommon since their extirpation in the early 1800s (Gildemeister 1998) and no longer play a major role in wood delivery to the channel or maintaining diverse off-channel habitats, complex planform, and riparian conditions.

Historically, the riparian vegetation would have likely included woody species such as cottonwood (*Populus*), willow (*Salix*), river birch (*Betula nigra*), and alder (*Alnus*) of varying ages (seral stages). The upland areas adjacent to the active floodplain likely supported mature ponderosa pine. Impacts include the alteration or removal of riparian and floodplain vegetation associated with the implementation of agricultural and grazing practices in addition to commercial logging.

2.5 DESCRIPTION OF LATERAL CONNECTIVITY TO FLOODPLAIN AND HISTORICAL FLOODPLAIN IMPACTS

Historical impacts to the floodplain within the project area have been previously described in Section 2.1, Description of Past and Present Impacts on Channel, Riparian, and Floodplain Conditions. Those impacts have resulted in a degraded channel condition that includes incision ranging between 3 and 5 feet among other conditions. The incision reduces the degree of floodplain connectivity compared to estimated historical conditions.

For this discussion, the floodplain is defined as sections of the valley bottom that have been mapped as active floodplain or fill material that lies beyond the edge of water at bankfull discharge. It does not include the wetted area of the main channel at bankfull discharge or sections of the historical floodplain that are disconnected by the railroad grade or Highway 244. Also, for this discussion, three flows were analyzed—1,432 cubic feet per second (cfs), 2,113 cfs, and 3,210 cfs—which correlate to 1.25-, 2-, and 5-year recurrence intervals, respectively. The 1.25-year recurrence interval is considered bankfull.

Within the project area, floodplain connectivity ranges from poorly connected at bankfull discharge to well-connected at discharges with a 5-year recurrence interval. Table 2-2 below summarizes floodplain inundation under existing conditions at the three discharges previously listed. Inundation characteristics of Reach 1 and Reach 2 are described subsequently.

Table 2-2 | Summary of Acres of Inundation Compared to Acres of Available Floodplain

Reach ID	1,432 cfs (1.25-year recurrence)		2,113 cfs (2-year recurrence)		3,210 cfs (5-year recurrence)	
	Inundated Acres (approx.)	% of Available Floodplain Area	Inundated Acres	% of Available Floodplain Area	Inundated Acres	% of Available Floodplain Area
Reach 1	2	4%	17	30%	31	55%
Reach 2	0.03	<1%	0.5	2%	12	50%

REACH 1 – UPPER FLOODPLAIN

During bankfull discharge, there is minor floodplain inundation that wets approximately 2 acres of floodplain surface. The activation of the floodplain is due to natural grade control in the form of a riffle just downstream of a historical channel scar on the outside of a meander bend. At the 2-year recurrence interval, the area of inundated floodplain increases to approximately 17 acres. The inundated area includes historical channel swales, the existing wetland complex area, and margin area along the edge of the channel just beyond the bankfull boundary. At flows with a 5-year recurrence interval, the area of inundation increases to 31 acres.

Figure 2-9 below compares floodplain inundation at bankfull and 5-year recurrence interval.

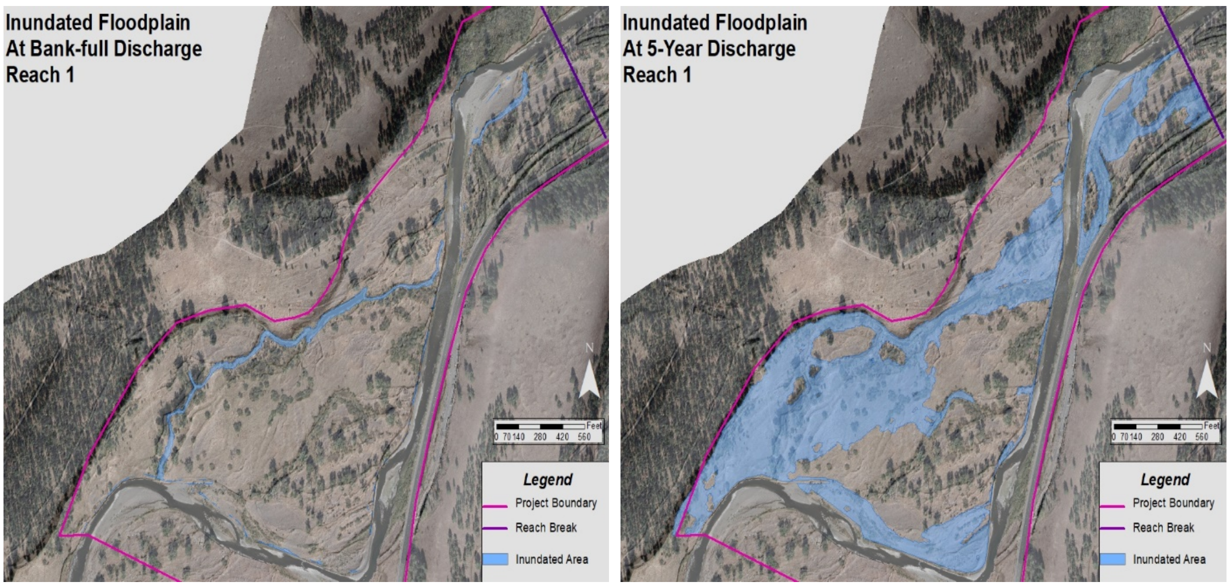


Figure 2-9 | Floodplain Inundation at Bankfull Discharge (left) and at 5-Year Recurrence Interval (right)

REACH 2 – LOWER FLOODPLAIN

In Reach 2, there is very little inundation of the floodplain at the bankfull and 2-year discharges. At both discharges the inundation is limited to expansion of the margin areas along the banks. At the 5-year recurrence interval, approximately 50% of the available floodplain is inundated (Figure 2-10).

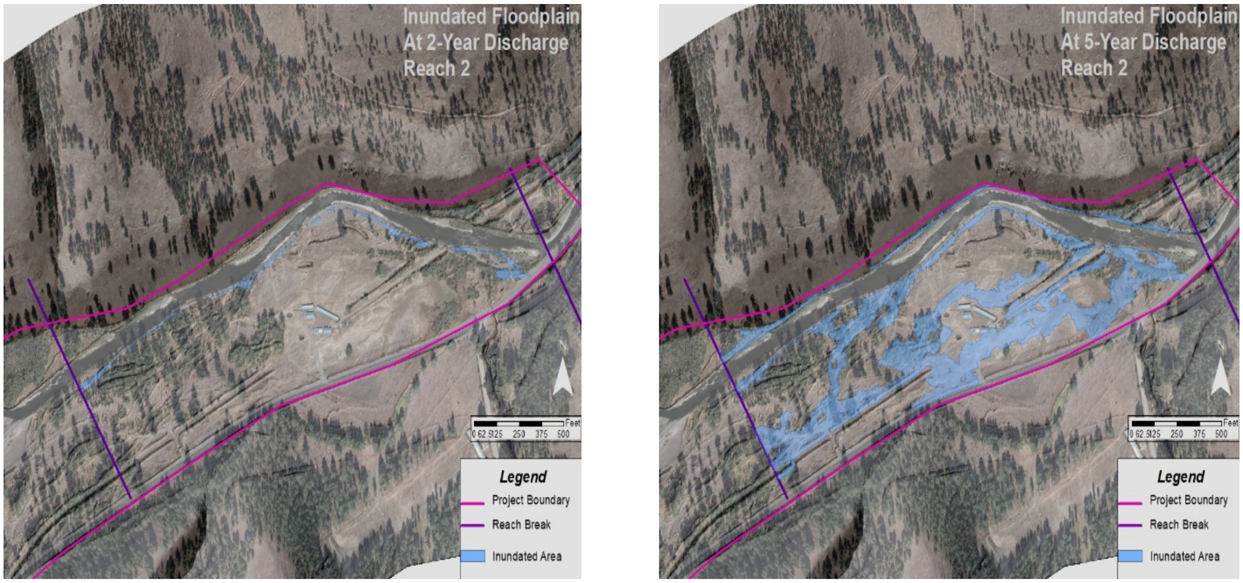


Figure 2-10 | Floodplain Inundation at 2-Year Recurrence Interval (left) and at 5-Year Recurrence Interval (right)

2.6 TIDAL INFLUENCE IN PROJECT REACH AND INFLUENCE OF STRUCTURAL CONTROLS (DIKES OR GATES)

Tidal influence is not present at the project site.

3 TECHNICAL DATA

3.1 INCORPORATION OF HIPIII-SPECIFIC ACTIVITY CONSERVATION MEASURES FOR ALL INCLUDED PROJECT ELEMENTS

HIP III conservation measures are included as sheets in the design drawings and specifications. All state and federal permits have been obtained by the project sponsor with support from the project design team with the exception of Stormwater Pollution Prevention Plans (SWPPPs) and other permits related to construction, which will be obtained by the successful bidder/construction contractor.

The anticipated in-water work window will be July 1 to October 15. Components of this project can likely be constructed outside of the in-water work window as long as the project elements are outside the ordinary high water and are in compliance with all permits and ESA stipulations. It is anticipated that there will be one temporary crossing consisting of temporary bridges in use during the in-water work window as detailed in the plan set. Suggested work area isolation, dewatering, and temporary stream bypass plans are detailed in the plan set and the construction contractor will be required to provide submittals of plans should they differ from those suggested. Requirements for informing the project sponsor of the timing for construction activities are included in the plan set as are specifications to allow for fish salvage and isolation according to HIP III conservation measures. It is anticipated that personnel experienced in local fish populations from the project sponsor, ODFW, and others will participate in fish salvage operations. Fish species will likely include steelhead, Chinook, bull trout, lamprey, freshwater mussels, and other native fish species. Stream bypass plans will be submitted to local ODFW biologists and coordinated with state and federal bypass hydraulic review.

Temporary access roads, staging areas, and stockpile areas are clearly delineated in the plan set and will be flagged by the project sponsor to minimize site disturbance. Sensitive areas including wetlands and archaeological sites if located in proximity to the working area will be flagged as off limits unless disturbance is shown in plans. Erosion control best management practices are incorporated into the plans and specifications and will be monitored closely by the project sponsor on a daily basis. Refueling, equipment lubricants and fluids, and spill prevention control and countermeasures will be detailed in the plan set and strictly enforced. Invasive species control will also be required and is included in plans and specifications. Construction and discharge water will likely be discharged onto floodplains with monitoring of turbidity by the construction contractor in accordance with project permits, plans, and specifications.

3.2 SUMMARY OF SITE INFORMATION AND MEASUREMENTS (SURVEY, BED MATERIAL, ETC.) USED TO SUPPORT ASSESSMENT AND DESIGN

SURVEY/TOPOGRAPHIC

The existing surface was developed with a combination of the resources below:

- Watershed Science, Inc. LiDAR (April 9–10, 2013) - Hillslopes and areas beyond floodplain
- Anderson Perry & Associates topographic survey (August 2014) – Floodplain and existing channels
- Reclamation ancillary topographic survey (June 2018) – Floodplain areas not surveyed by Anderson Perry & Associates
- Reclamation ancillary topographic survey (September and October 2019) – Dynamic areas changed significantly by high flows

The survey data through the project area are approximately 4 to 5 years old. There were significant high flow events in April of 2019, February of 2020, and May of 2020 corresponding with approximately a 20, 50, and 50 -year floods respectively. Banklines in dynamic areas have retreated upwards of 10 feet and there was significant bar growth in several areas. In general, the floodplains remained largely intact although there are areas within floodplain channels where localized erosion/head cutting occurred. Floodplains have largely been un-impacted and are expected to have not changed significantly. Key areas of noticeable change as a result of high flows, channel realignment, and connections to upstream and downstream existing channel sections were resurveyed in the fall of 2019. In addition, main channel realignment and side channel locations in the floodplain were staked out in the field with real-time kinematic (RTK) global positioning system (GPS) equipment between the 30% and 80% design stages as part of design verification. Elevations were spot checked and compared with the existing surface to verify accuracy. The project design team reviewed the staked alignments in the field. The project goals and objectives were considered with the layout of the proposed design. Several areas were adjusted to provide protection to existing vegetation and sensitive intact quality habitat features, to minimize disturbance, and to leverage existing floodplain features to enhance habitat as part of this design verification effort.

GEOTECHNICAL INFORMATION

The following resources were used for geotechnical analysis:

- **Groundwater wells (piezometers)** – In October of 2017, five piezometers were installed in the Longley Meadows reach to support project monitoring. Continuous monitoring of water levels and temperature is ongoing to support pre-project implementation vs. post-project assessment. Additionally, the development of the wells included logging the size and type of sediment, depth to groundwater, and depth to refusal. The well locations are shown in Figure 3-1 below.

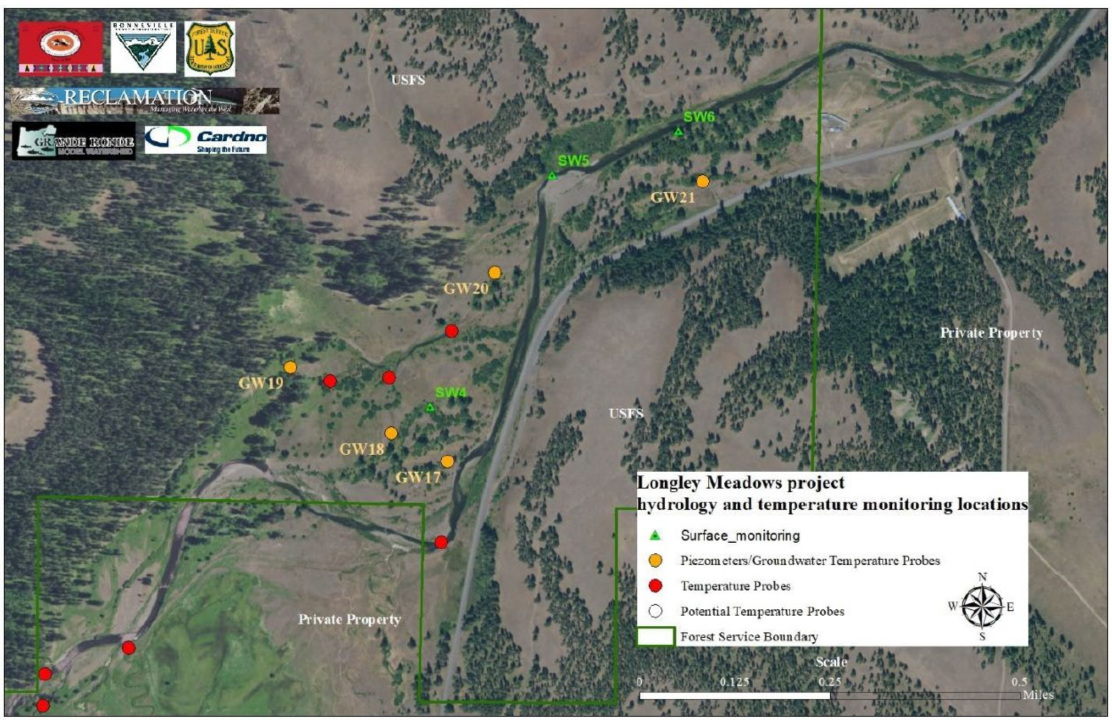


Figure 3-1 | Longley Meadows Reach Groundwater Well Locations

Preliminary data collection and analysis shows a strong correlation between river stage and floodplain groundwater elevation (Figure 3-2) (CTUIR 2019). Groundwater temperatures are inversely related to water elevations, with the lowest temperatures occurring during the highest water elevations and the highest water temperatures occurring in the lowest water elevations (Figure 3-3) (CTUIR 2019).

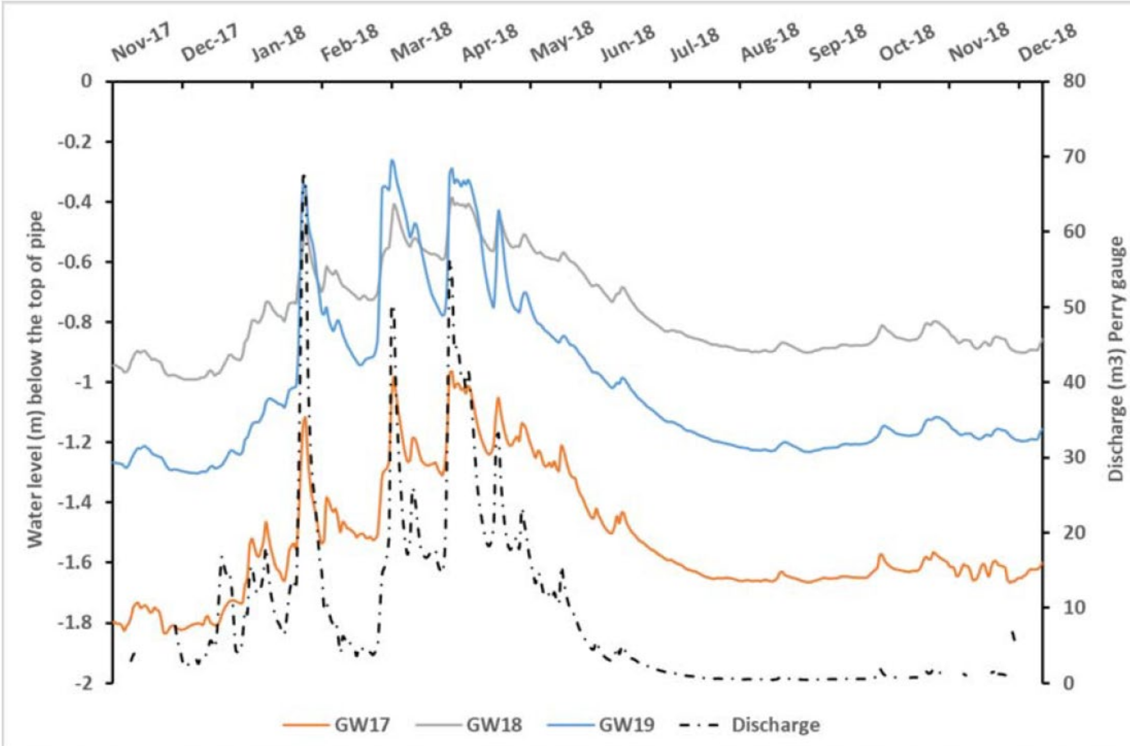


Figure 3-2 | Longley Meadows Reach Average Daily Groundwater Levels and Discharge at Perry Gage for Wells 17–19, November 2017 to December 2018

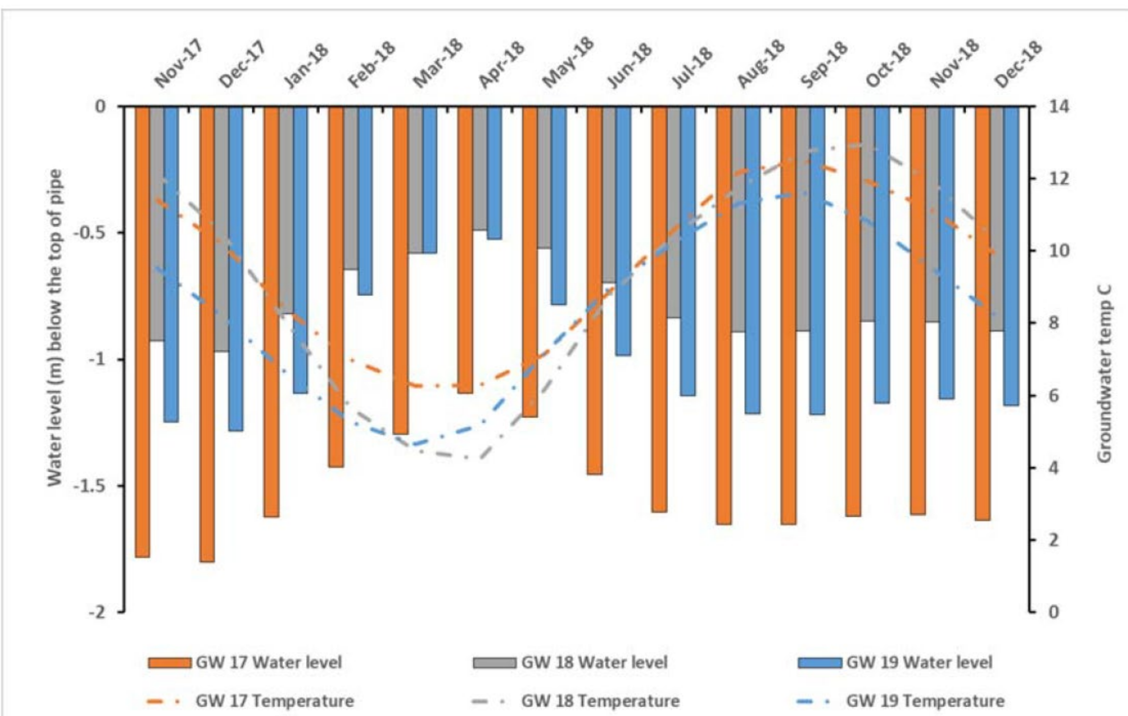


Figure 3-3 | Longley Meadows Reach Monthly Average Groundwater Levels for Wells 17–19 and Corresponding Groundwater Temperatures, November 2017 to December 2018; Colors for Groundwater Temperatures and Levels are Matching

- **Sonophones/Seismic Refraction Survey** – A seismic refraction survey was completed in August 2016 to characterize the alluvial stratigraphy and depth to bedrock as part of the Bird Track Springs Project (Cardno 2016c). Valley cross section profiles were spaced approximately 1,000 feet apart as shown in Figure 3-4 below.

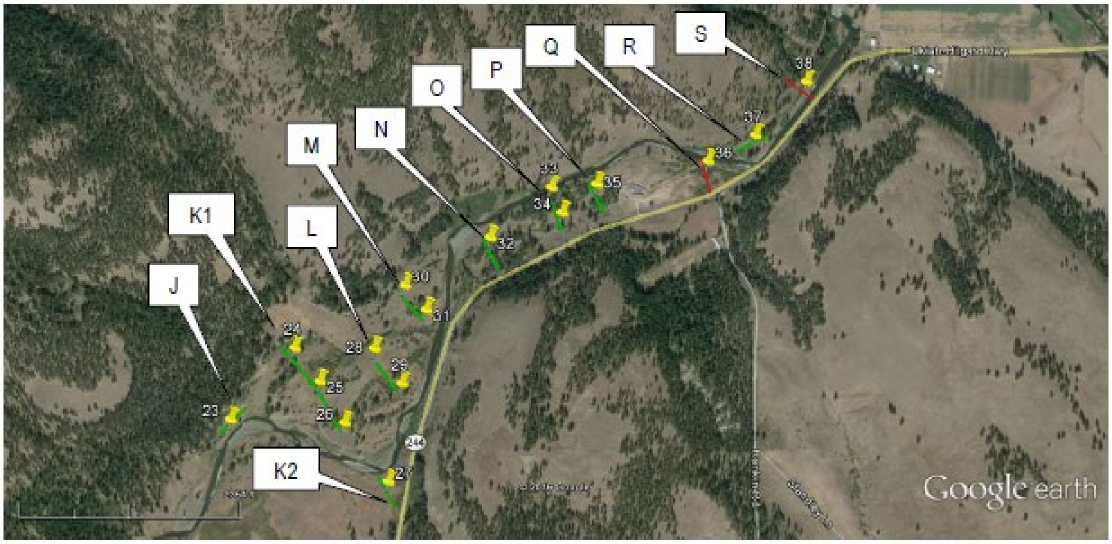


Figure 3-4 | Longley Meadows Reach Seismic Cross Sections

The geophysical survey results are summarized in a depth to bedrock map (Figure 3-5) below. The depth to bedrock begins to shallow in the Longley Meadows reach (cross sections L–R). In addition, the unconfined floodplain also becomes narrower near section M (lower floodplain). Due to a combination of narrowing both horizontally and vertically it is likely that groundwater upwelling and/or increased velocity in the groundwater/hyporheic zone occurs.

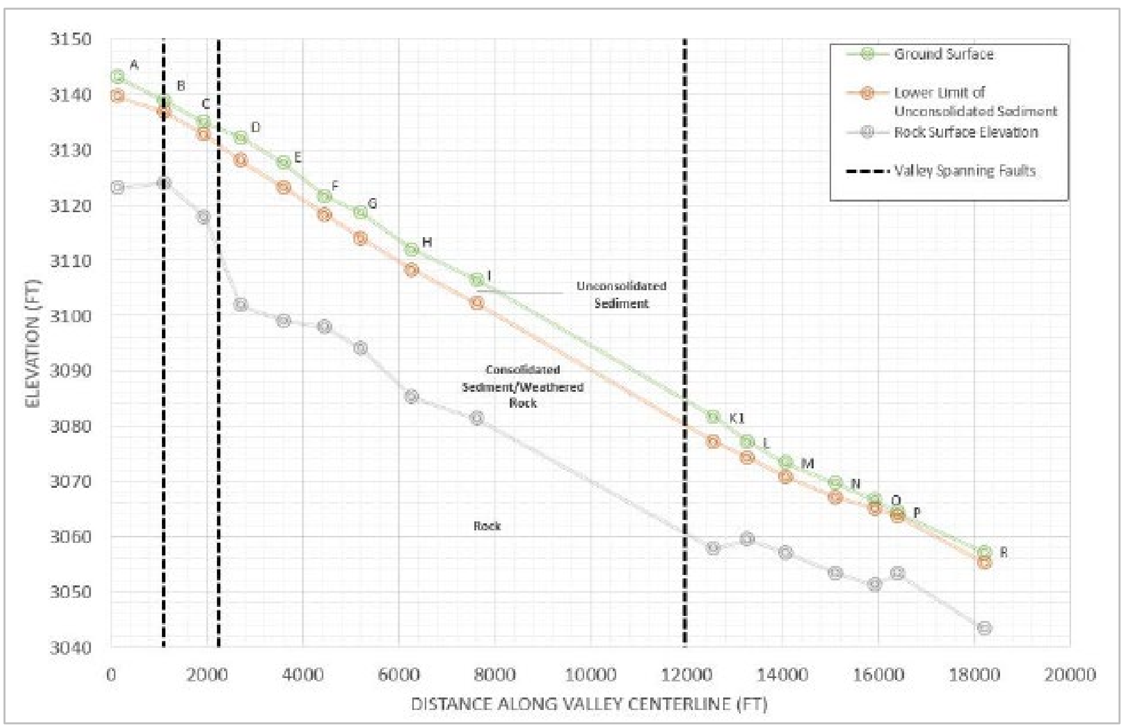


Figure 3-5 | Longley Meadows Reach Seismic Cross Sections Valley Profile

- **National Historic Preservation Act (NHPA) Section 106 test pits** – As part of the Section 106 permitting effort, multiple shovel probe test pits have been excavated within the project area. From this effort a general depth to alluvium can be informative of the amount of soil within the project reach.
- **Test Pits (June 2020)** – A total of 25 test pits were excavated in the project area to evaluate stratigraphy and depth to groundwater. This effort informed the design team about what types of materials are available on-site for channel materials, specifically for riffle construction. The test pit locations are shown in Figure 3-6 below. The test pits were completed the week of June 15. Final documentation of this effort was supplied as a supplemental report, which included laboratory material analysis.

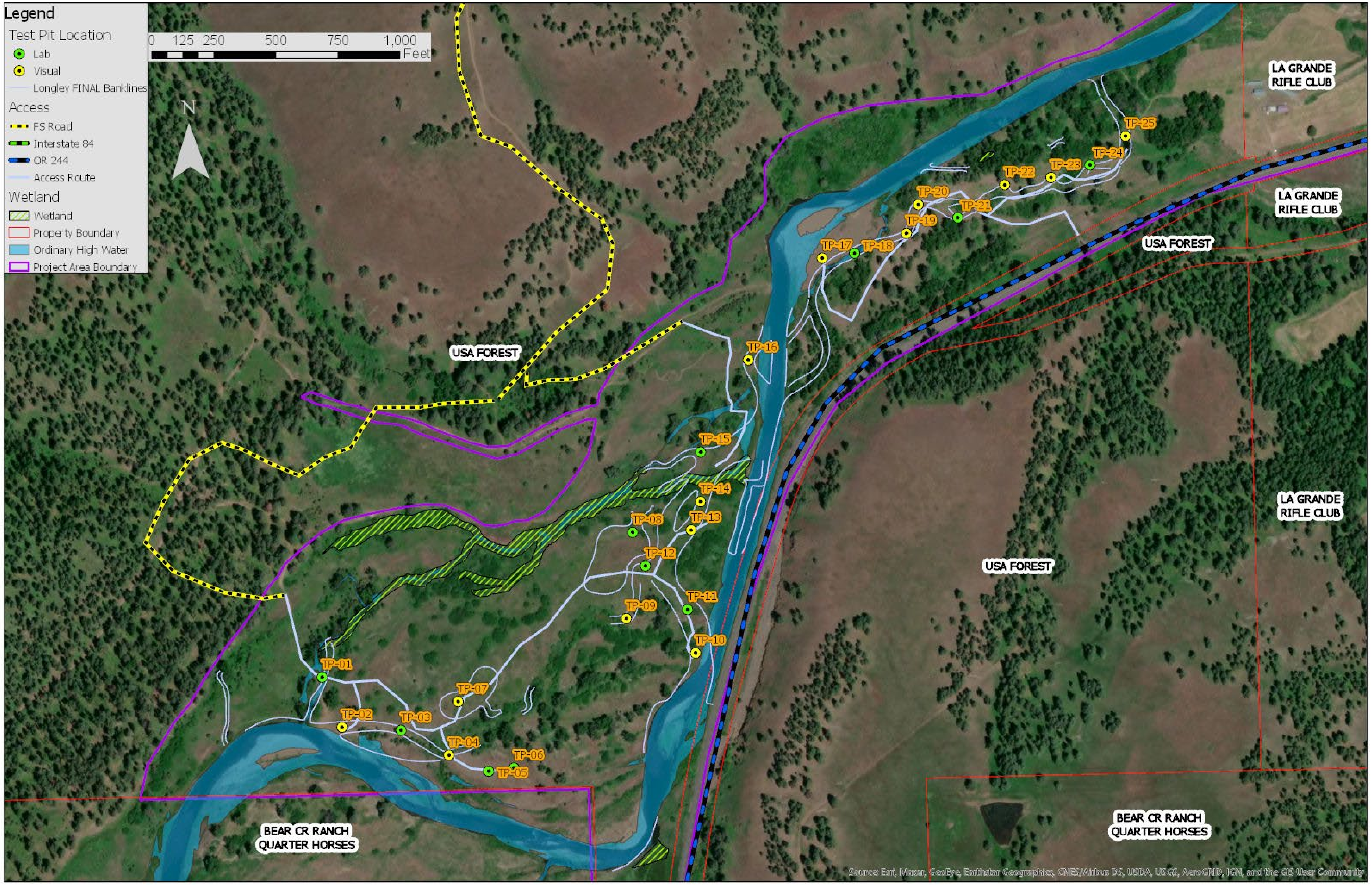


Figure 3-6 | Longley Meadows Upper Floodplain Test Pit Locations

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

An extensive hydrologic analysis was completed to determine flood and annual exceedance statistics as part of the Bird Track Springs Project in March of 2016 during 30% design for that project. Prior to 30% design, the greater Bird Track Springs Project included the area between RMs 146.1 and RM 141.9, which consisted of Bird Track Springs, Bear Creek Ranch, and Longley Meadows. Thus the hydrologic study included the Longley Meadows reach of the UGR, as well as tributary streams occurring through the project reach. Minor modifications to the Bird Track Springs Project hydrologic analysis are necessary to adjust flows for application to the Longley Meadows Fish Habitat Enhancement Project, primarily moving the upstream boundary of the analysis from RM 146.1 to RM 143.6, the beginning of the Longley Meadows reach. Additionally, 3 years have passed since the Bird Track Springs Project analysis was completed. Provisional data downloaded from the gage at Perry, Oregon, were included in the revised analysis for 2015–2018. A general summary of the basin characteristics, methods, data sources, and design flows for the Longley Meadows Project are provided below. Appendix 8.3 provides further details of the analysis performed.

GENERAL SETTING

The project reach sits at approximately 3,080-foot elevation and drains an approximately 474-square-mile (mi^2) watershed extending to a maximum elevation of 7,923 feet. The mean annual precipitation is 26.2 inches, most of which falls as snow during winter months. As a result, the annual hydrograph is dominated by snowmelt-derived high flows from April to May. Peak flows also occasionally occur from winter rain storms. The low flow season typically extends from August through December. Most of the basin is forested (over 73%) and has very little development (less than 0.1% estimated impervious area) (USGS 2014). Watershed characteristics of key points (Figure 3-7) along the mainstem UGR are shown in Table 3-1.

Table 3-1 | Watershed Characteristics of Key UGR Mainstem Sites and Tributaries Contributing to the Project Reach

Watershed Outlet Description	River Mile	Drainage Area (mi^2)	Outlet Elevation (feet)	Maximum Elevation (feet)	Mean Annual Precipitation (inches)
Mainstem Grande Ronde					
Upper Project Reach Boundary	143.6	474.0	3,080	7,923	26.4
Historic Stream Gage Location (13318500)	142.9	495.7	3,060	7,923	26.2
Lower Project Reach Boundary	141.9	525	3,050	7,923	26.3
Tributary Outlets					
Unnamed Tributary 1 (enters left)	145.6	1.3	3,144	4,247	22.9
Moss Creek (enters right)	144.0	2.7	3,090	4,705	21.0
Bear Creek (enters right)	143.8	7.9	3,090	4,729	22.0
Jordan Creek (enters right)	143.3	17.7	3,078	6,057	26.0
Unnamed Tributary 2 (enters left)	143.1	2.8	3,074	4,352	23.0
Spring Creek (enters left)	141.95	26.6	3,050	4,650	27.3

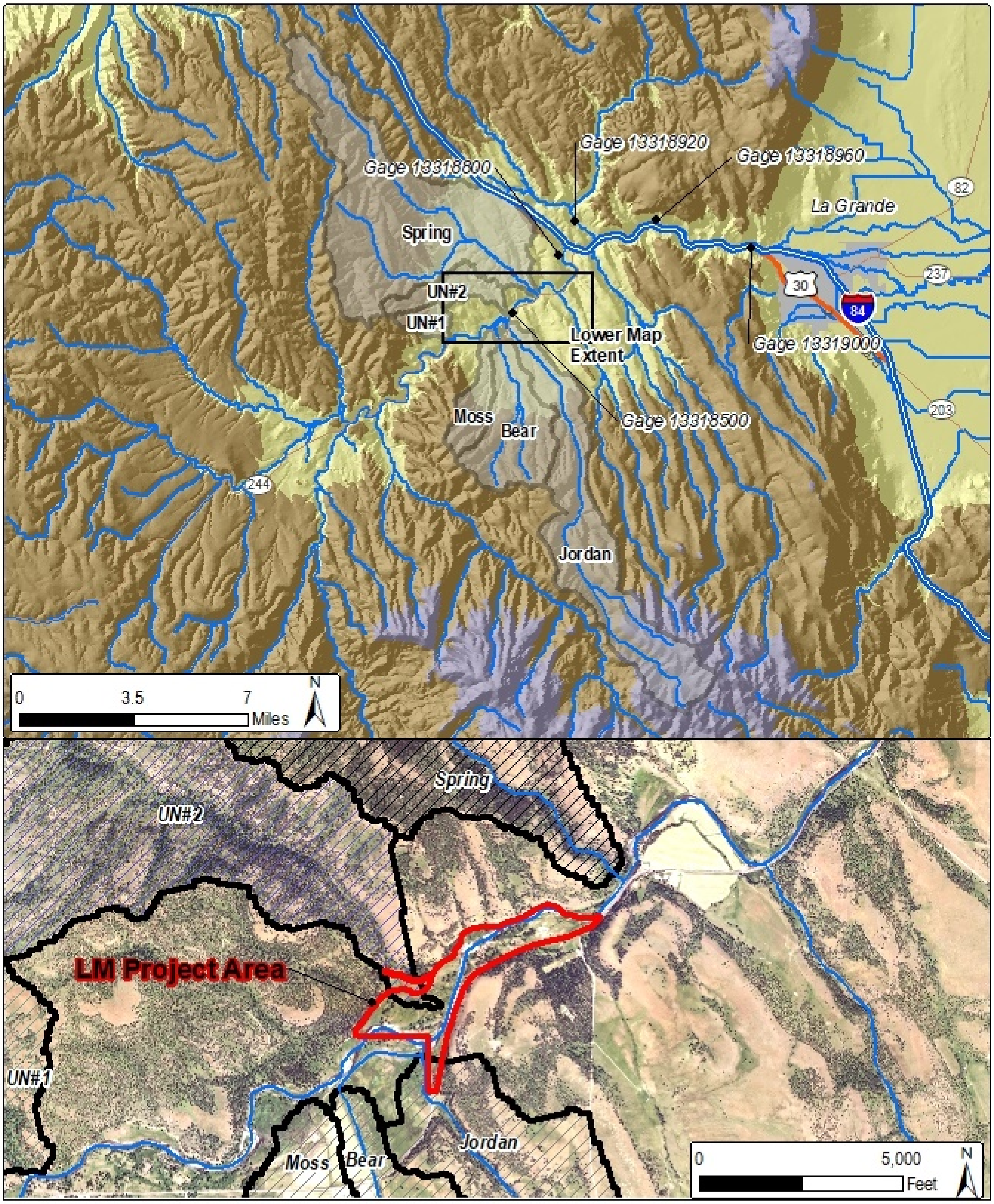


Figure 3-7 | Key Watershed Characteristics along the Mainstem UGR

Six tributary streams enter the project area from adjacent valley walls. Figure 3-7 shows the project reach and the watersheds of Moss, Bear, and Jordan Creeks entering from the south (river right), and Spring Creek and two unnamed tributaries entering from the north (river left). None of the six tributary streams have stream gaging records. A summary of the general attributes of the tributary basins is provided in Table 3-1. Despite their small drainage areas, the two unnamed tributaries (Unnamed Tributary 1 and 2) were included in the analysis to provide a full picture of possible flow inputs along the project reach.

Stream gages used in the analysis are listed in Table 3-2 below.

Table 3-2 | Stream Gages in the Grande Ronde River Basin Used in the Hydrologic Analysis

Station Number	Name	Agency	River Mile	Drainage Area (mi^2)	Start Year	End Year
13319000	Grande Ronde R at La Grande, OR	USGS	132	686	1903	1989
13318960	Grande Ronde R Near Perry, OR	OWRD	135.9	677	1997	Current
13318920	Five Points Cr at Hilgard, OR	OWRD	137.7	71.9	1992	Current
13318800	Grande Ronde R at Hilgard, OR	USGS	139.3	544	1966	1981
13318500*	Grande Ronde R Near Hilgard, OR*	USGS	142.9	495.7	1937	1956

*Historical gage 13318500 is located within the project reach.

OWRD = Oregon Water Resources Department

GENERAL APPROACH

The goals of the hydrologic analysis were to estimate stream flows in the mainstem UGR and tributary streams (see locations noted in Table 3-1) along the project reach. Flows were estimated both in terms of peak flows and flow exceedance statistics. In terms of recurrence intervals, 1.05-, 1.1-, 1.25-, 1.5-, 2-, 2.33-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year peak flows were estimated. Flow duration estimates included 5%, 10%, 25%, 50%, and 95% annual flow exceedance values, and informed project design flows. Except for a historical stream gage in the lower project reach, flow estimates are at ungaged sites and thus required various flow estimation techniques as described below.

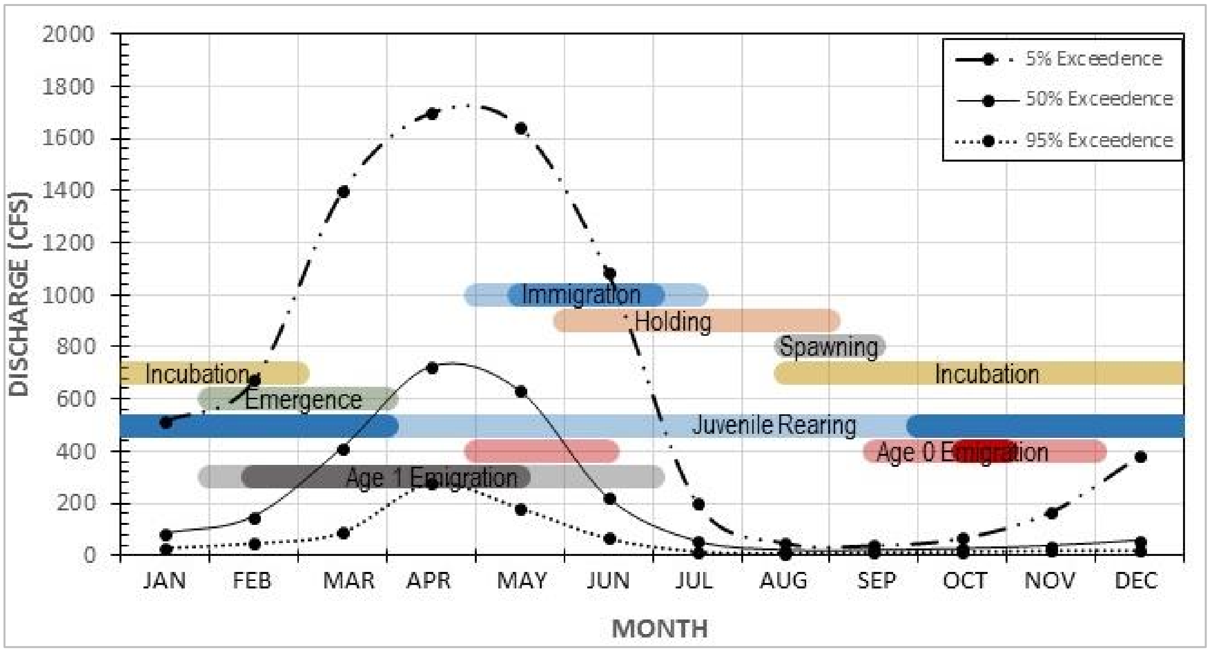
The two primary flow estimation approaches used to estimate flows at ungaged sites included the drainage area-ratio method and regional regression equations. The drainage area-ratio method (Cooper 2005) ties flow estimates at ungaged sites to gaging records up- or downstream, and thus was the preferred method of flow estimation. Since the drainage area-ratio method is only applicable at sites on the same stream and for drainage areas between 0.5 and 1.5 times that of the gaged site (Cooper 2005), it could only be employed at mainstem locations where downstream UGR stream gages (IDs 13319000 and 13318960) were within the specified range. Given that tributary basin outflow points were outside the applicable range of the drainage area-ratio method, regional regression equations for peak discharges (Cooper 2005) and annual flow duration (Risley et al. 2008) were needed to estimate flow. To corroborate regression equation estimates, Cardno used data from an active stream gage on Five Points Creek (ID 13318920, see Table 3-2), a gage with a small drainage basin entering the UGR 4.2 miles below the lower project boundary.

A summary of the peak return interval discharges for the upstream end of the project area as well as the three contributing tributaries is provided in Table 3-3 below. The predicted discharges were used for modeling and design.

Table 3-3 | Annual Peak Flows Used for Hydraulic Modeling Efforts

Annual Probability	Annual Return Interval	Q – Grande Ronde River (RM 143.6) (cfs)	Q – Jordan Creek (cfs)	Q – Unnamed Tributary 2 (cfs)	Q – Spring Creek (cfs)
0.95	1.05	1,002	47	12	64
0.9	1.1	1,174	55	14	75
0.8	1.25	1,432	67	17	91
0.6667	1.5	1,731	81	21	110
0.5	2	2,113	90	22	122
0.4292	2.33	2,314	108	28	146
0.2	5	3,210	148	37	200
0.1	10	4,025	190	48	257
0.04	25	5,153	245	62	332
0.02	50	6,062	288	73	389
0.01	100	7,031	332	85	448
0.005	200	8,069	377	96	509
0.002	500	9,557	440	113	594

In addition to an evaluation of the flow hydrograph in the project reach, a key outcome was a determination of design flows relating to key periods of salmonid use in the project reach. Winter and summer rearing were identified as the target life stages for Chinook salmon (Figure 3-8). The proposed biologically-focused design flows (habitat design flows) are listed in Table 3-4.



Chinook salmon periodicity data generated in the Atlas Process are shown. Darker portions of the bands show the critical period and lighter portions show secondary periods of a given life stage.

Figure 3-8 | Annual Hydrograph at the Upstream End of the Project Reach (RM 146.1)

Table 3-4 | Habitat Design Flows for the Upstream Project Boundary (RM 143.6)

Design Flow Description	Flow (cfs)	Exceedance Statistic
Low flow (winter and summer)	19	95% exceedance for critical winter rearing period (October–March) 50% exceedance flow for August
Winter median flow	86	50% exceedance for critical winter rearing period (October–March)
Median March flow	418	Approximately the 50% exceedance flow for March
Winter high flow	941	5% exceedance for critical winter rearing period (October–March)

3.4 SUMMARY OF SEDIMENT SUPPLY AND TRANSPORT ANALYSES CONDUCTED, INCLUDING DATA SOURCES INCLUDING SEDIMENT SIZE GRADATION USED IN STREAMBED DESIGN

SEDIMENT SUPPLY

Sediment sources include upstream sources as well as sources within the project area where active bank erosion is occurring. Within the project area, major bank erosion occurs mainly at locations with high meander angles in Reach 1. Analysis of aerial imagery for a time span of 11 years (between 2006 and 2017) yielded migration rates that range between 5 and 11 feet per year. Factors contributing to the lateral migration rates include:

- High-volume spring freshet events;
- Lack of riparian vegetation at the site of the lateral migration;

- Meander bend amplitude and wave length; and
- Point bar building on the inside of the bend resulting in increased shear stresses on the outside bank.

Several pebble count efforts have been conducted within the project area utilizing a modified Wolman method (Wolman 1954) and photo analysis using the Federal Highway Administration's (FHWA's) Hydraulic Toolbox Software. Collection sites are concentrated in Reach 1 and include point bars, riffle crests, and cross-channel locations between bankfull indicators (Figure 3-9).

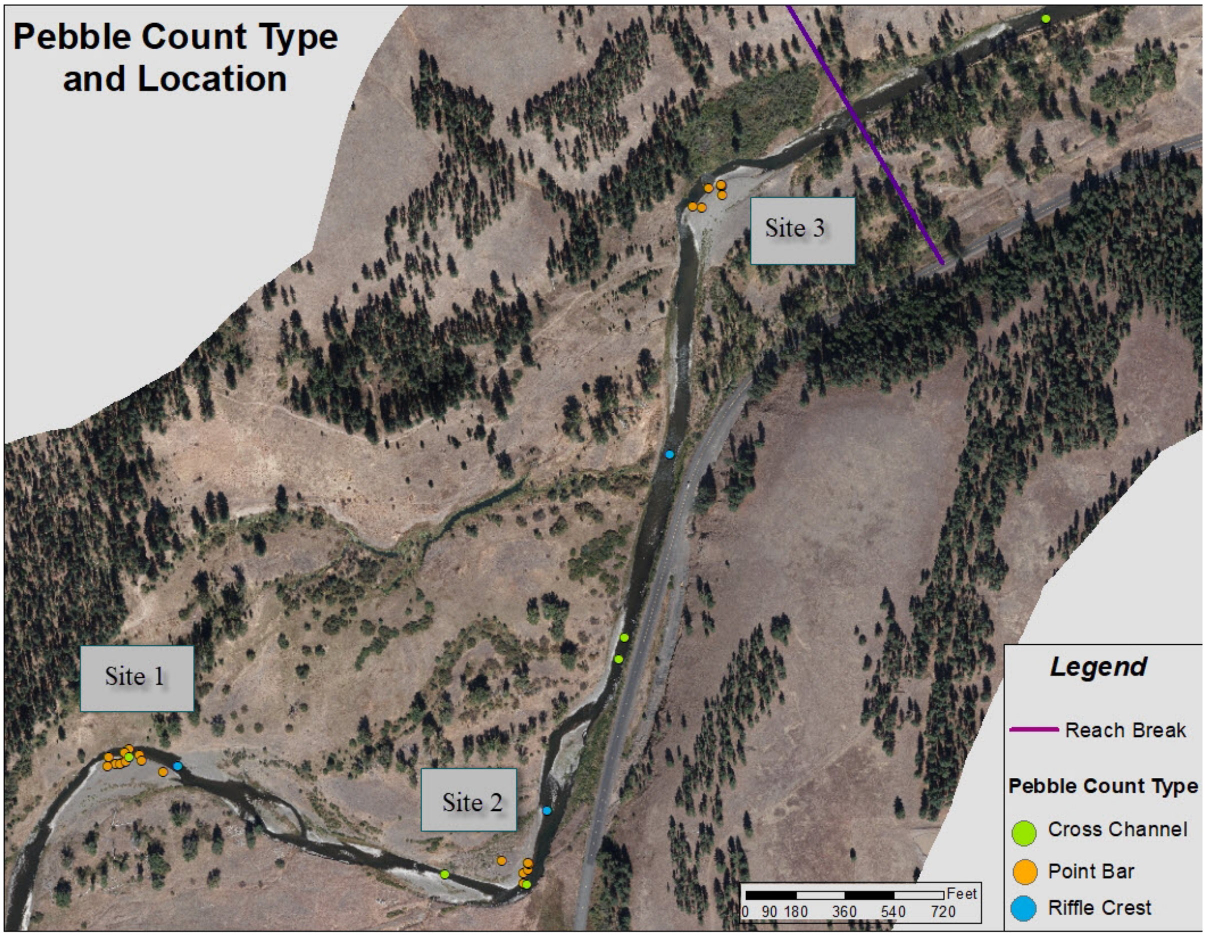
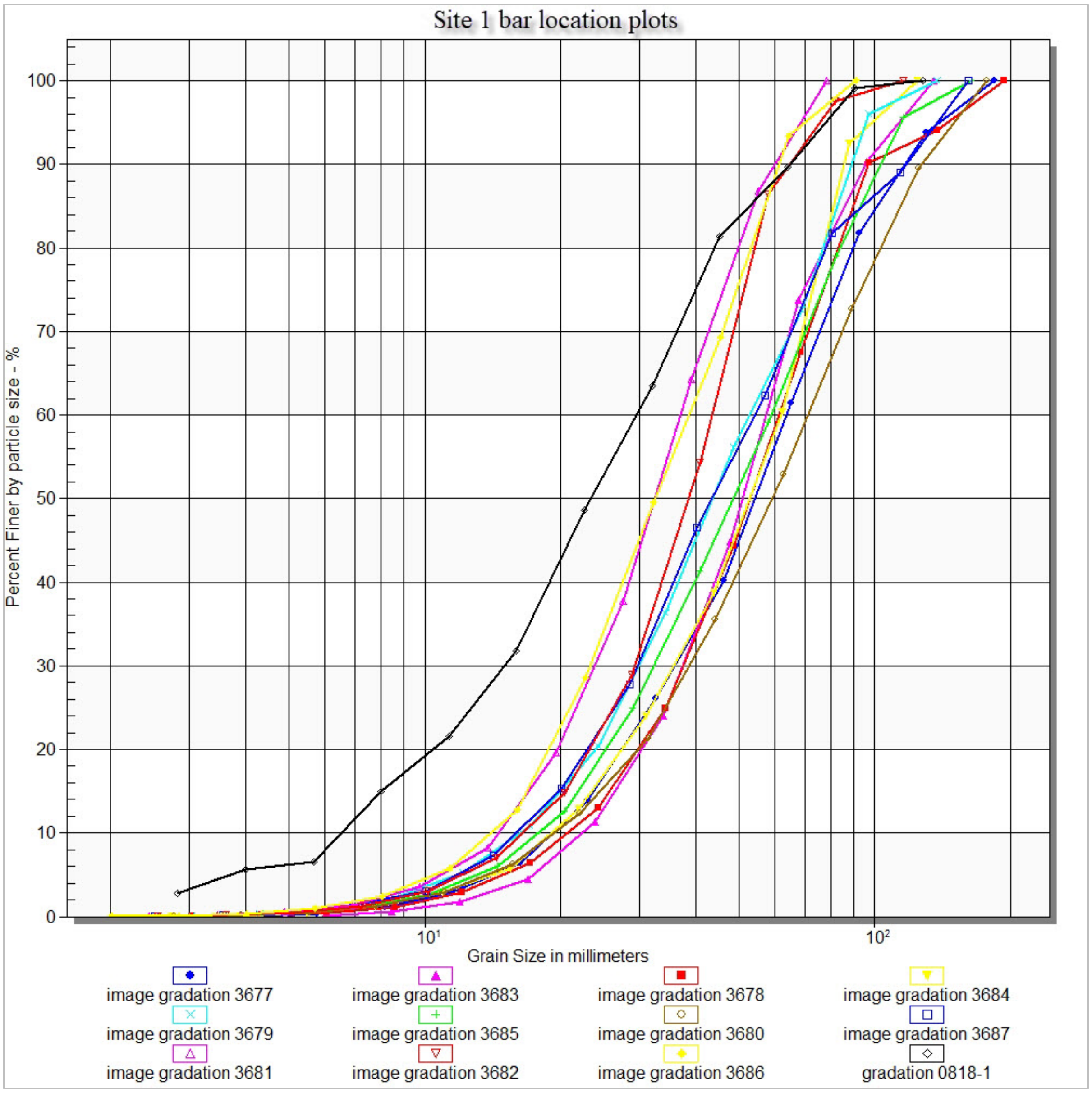


Figure 3-9 | Pebble Count Type and Locations with 2012 Aerial Imagery

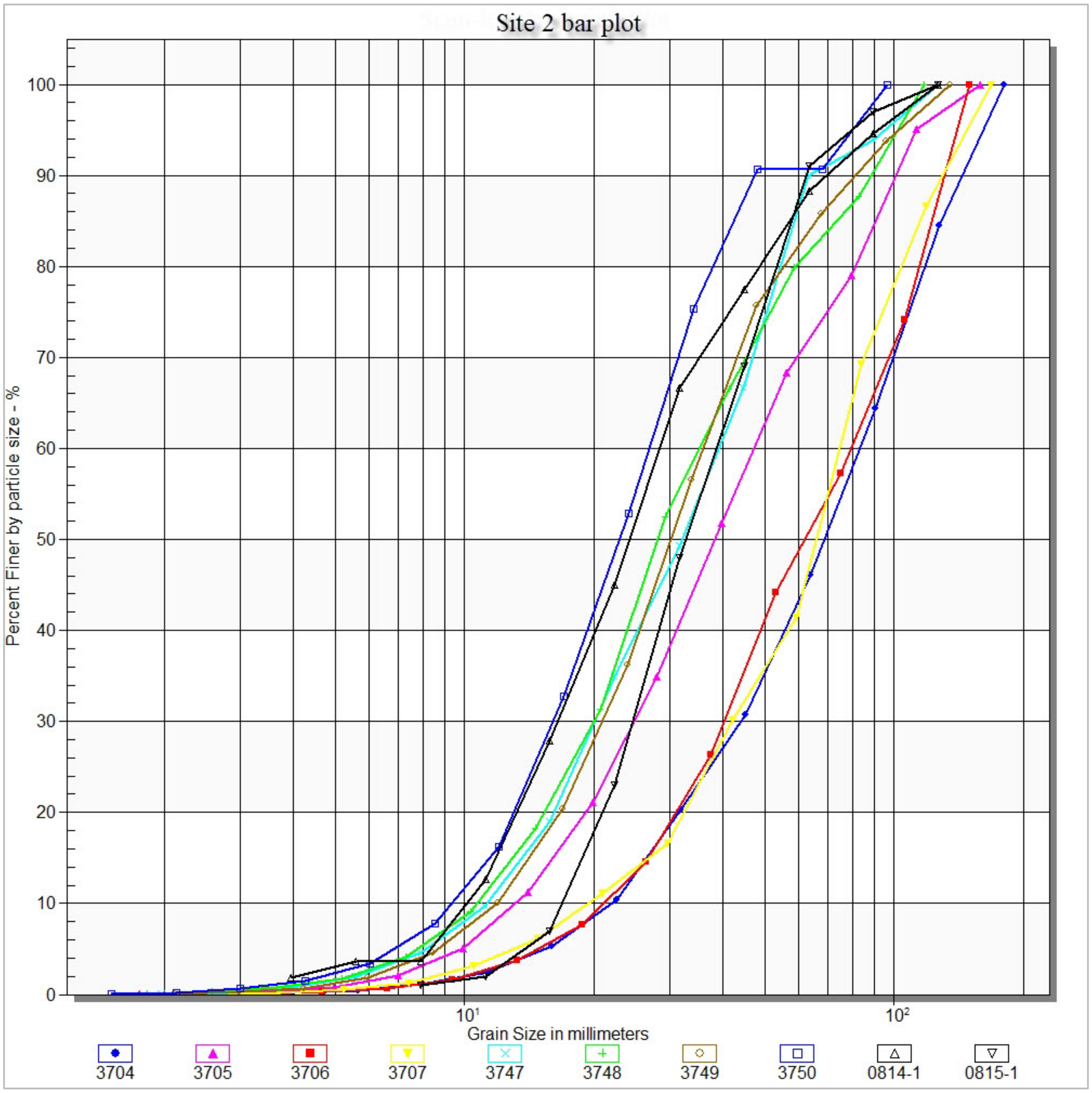
Gradation plots showing the results of point bar measurements at Sites 1, 2, and 3 are shown below in Figure 3-10, Figure 3-11, and Figure 3-12. Methods used on the point bars included modified Wolman pebble counts and photo analysis using the Hydraulic Toolbox Software.



Note: Gradation 0818-1 is a modified Wolman pebble count.

Figure 3-10 | Cumulative Gradation Plot of Sediment Samples Taken on the Point Bar at Site 1

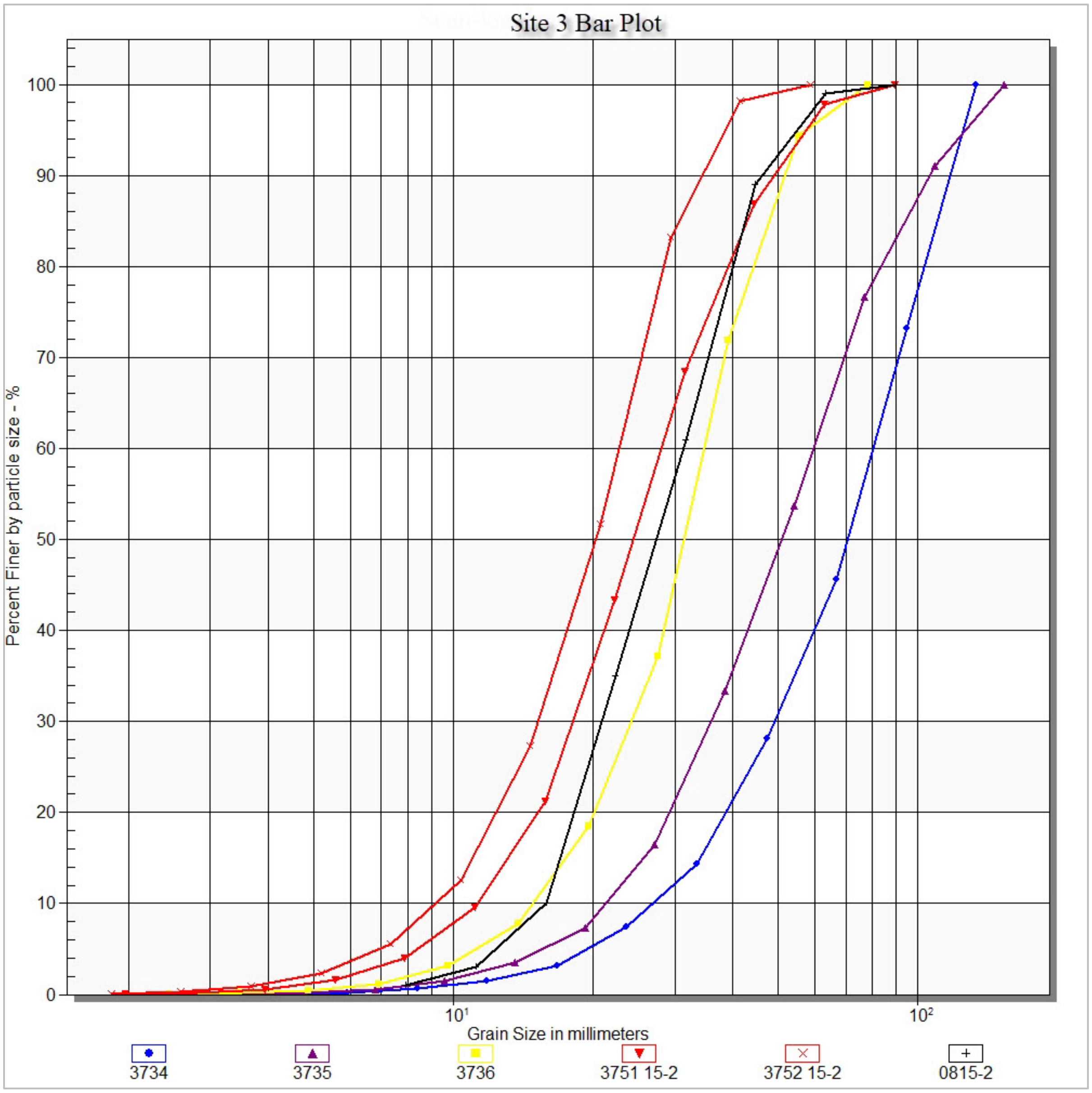
At Site 1, the D_{50} sediment sizes for the point bar material range between 33 millimeters (mm) and 60 mm, which represents gravel-sized material.



Note: Gradations 0814-1 and 0815-1 are modified Wolman pebble counts.

Figure 3-11 | Cumulative Gradation Plot of Sediment Samples Taken on the Point Bar at Site 2

At Site 2, the D_{50} sediment sizes for the point bar material range between 28 mm and 70 mm, which represents gravel up to small cobble.



Note: Gradations 3751 15-2, 3752 15-2, and 0815-2 are modified Wolman pebble counts.

Figure 3-12 | Cumulative Gradation Plot of Sediment Samples Taken on the Point Bar at Site 3

At Site 3, the D_{50} sediment sizes for the point bar material ranges between 22 mm and 71 mm, which represents gravel up to small cobble.

Table 3-5 below summarizes the average sediment gradations of the point bar measurements taken at all three sites. The overall average D_{50} at the three point bars is 41 mm or gravel-sized material.

Table 3-5 | Average Gradation Sizes for Point Bar Measurements at Sites 1, 2, and 3

Location	Average Gradation Sizes				
	D_5 (mm)	D_{15} (mm)	D_{50} (mm)	D_{85} (mm)	D_{100} (mm)
Site 1	13	21	45	81	141
Site 2	11	18	41	84	138
Site 3	13	20	38	62	101

A modified Wolman method was used to collect pebble count data at six cross-channel locations; five cross-channel sites are located in Reach 1 and one cross-channel site is located in Reach 2. Figure 3-13 below shows the cumulative gradation curves for all the cross-channel pebble counts.

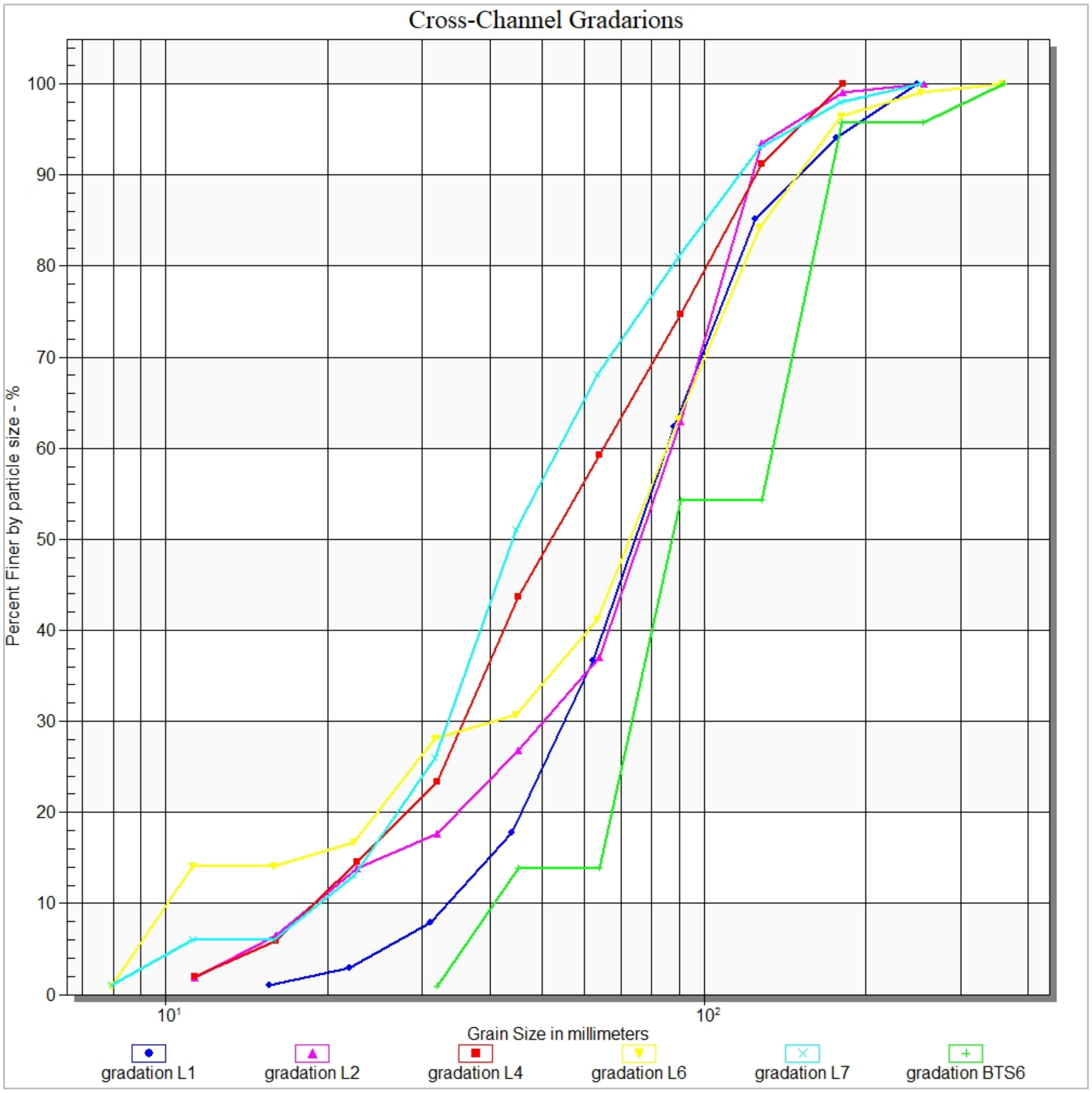


Figure 3-13 | Cumulative Gradation Plots of the Six Cross-channel Modified Wolman Pebble Counts

With the cross-channel gradations, the overall average D_{50} was 69 mm, which represents small cobble.

Modified Wolman methods were used to collect pebble count measurements at three riffle crest locations within Reach 1. The D_{50} results ranged between 43 and 63 mm, which represents gravel and small cobble-sized material. It should be noted that the 43-mm D_{50} measurement was at a location closer to Site 3 that is a depositional site, and although it is a riffle crest at low flow, during bankfull discharge the material is likely mobilized. New material from upstream sources is likely deposited on the descending limb of the hydrograph. Additional sediment data including, but not limited to, test pits and additional gradation analysis will be obtained to improve understanding of sediment size in the project reach as the design moves forward.

SEDIMENT TRANSPORT

For the sediment transport analysis, the GeoHECRAS 2D hydraulic model output for shear stress during bankfull, 2-year, and 5-year flows were evaluated for both the existing and proposed conditions at the 80% design step. Final hydraulic modeling results demonstrated similar conditions, and the analysis, tables, and figures below have not been updated to the final model results. Hydraulic model outputs for shear stress from the 80% design were evaluated to estimate the areas where hydraulic forces have the potential to mobilize typical sediment size classes within the channel and floodplain. This analysis is based on the stability thresholds of the materials forming the channel boundary and floodplain surface resisting the hydraulic forces at each flood flow to predict areas where sediment transport would likely occur. The addition of significant forcing agents and roughness on the channel boundary and floodplain surface will greatly enhance the diversity of shear stress and hydraulic forcing of the proposed condition. The following section provides a summary of the sediment transport findings. For further information on the sediment transport analysis refer to Appendix 8.4.

The evaluation of sediment transport characteristics utilized grain size classifications and critical shear stress (τ_{cr}) as provided in Table 3-6 based on Fischenich (2001). The GeoHECRAS 2D outputs for shear stress at bankfull, 2-year, and 5-year flows were then binned based on these classifications.

Table 3-6 | Grain Sizes Correlated to Shear Stress Values

Grain Size		
Material	**Diameter (Inches)**	**τ_{cr} (lbs/sqft)**
Silt	0.001–0.003	0.001–0.002
Sand	0.003–0.08	0.002–0.03
Fine Gravel	0.08–0.3	0.03–0.12
Medium Gravel	0.3–0.6	0.12–0.25
Coarse Gravel	0.6–2.5	0.25–1.1
Cobble	2.5–5	1.1–2.5

For the existing bankfull discharge (1.25 year [1,432 cfs]), the critical grain size that is mobilized within the main channel is predominantly coarse gravel-sized material as shown in Figure 3-14. Additionally, for the existing conditions at bankfull flow the critical diameter ranges from silt to gravel in the floodplain in minimal areas as a result of the lack of significant floodplain inundation.

Under the proposed condition the variance of the shear stresses increases to form a mosaic of different transport capacities. For example, in the area near highway 244, medium to coarse gravel will be deposited under the proposed condition. This was an intentional design outcome increasing channel complexity and creating more floodplain connectivity. Additionally, the floodplain for the proposed conditions at bankfull flow primarily mobilizes particle sizes ranging from silt to coarse gravel with a significant improvement of floodplain inundation. Coarse gravel transport potential occurs in areas with existing ephemeral channels that have been designed to be activated perennially. Silts and sand transport potential occurs in areas where there is less stream power on the broad floodplain.

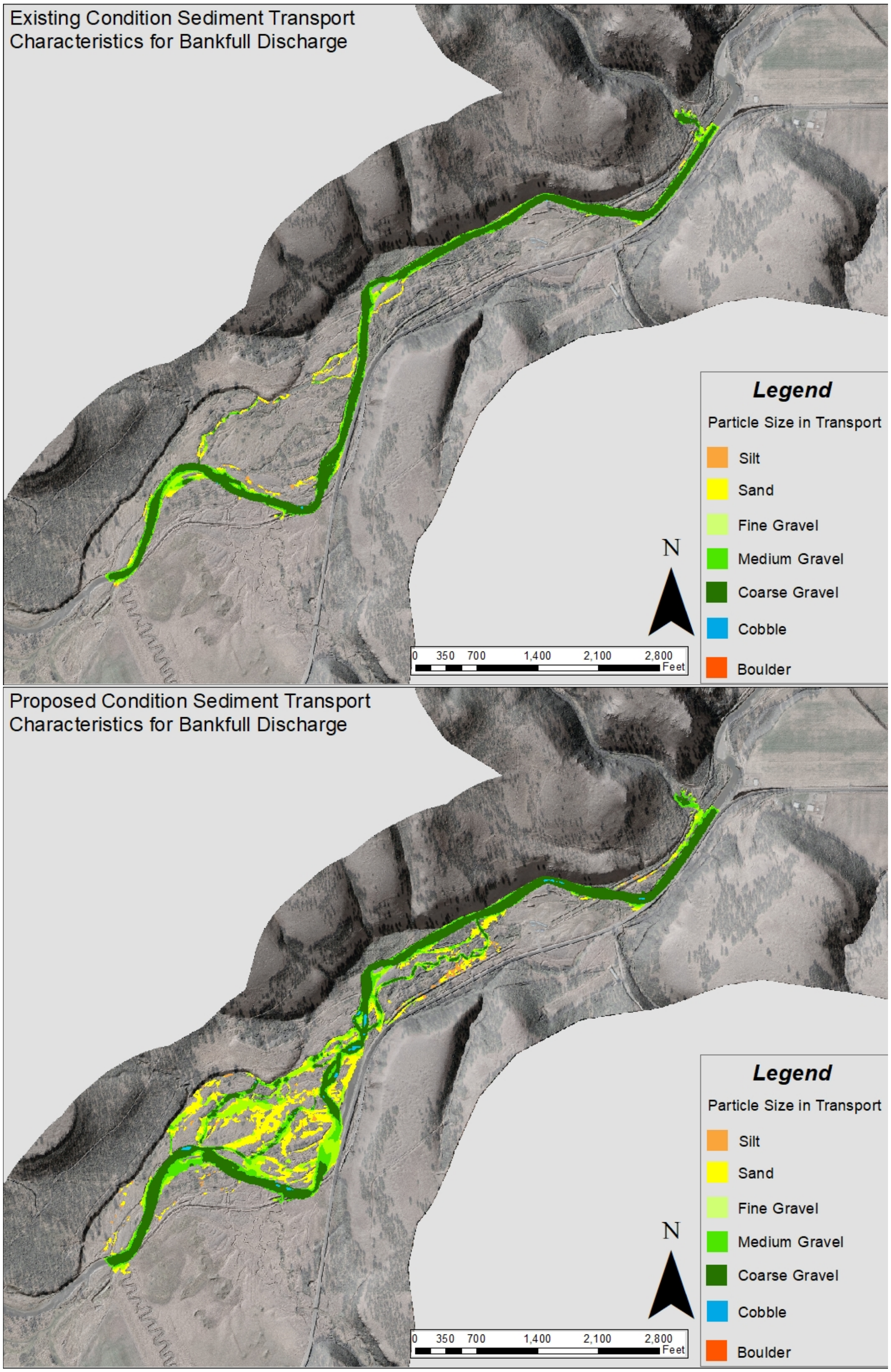


Figure 3-14 | Shear Stress Outputs at Bankfull Flow for Both Existing and Proposed Conditions

Under existing conditions, the 2-year discharge demonstrates a similar transport potential at bankfull flows. There is a slight increase in floodplain inundation; however, the connectivity is still lacking as shown in Figure 3-15 below.

For 2-year discharge for the proposed conditions, the main channel primarily mobilizes coarse gravels with increased areas of cobble mobilization. The floodplain is even further inundated, resulting in more transport and deposition potential.

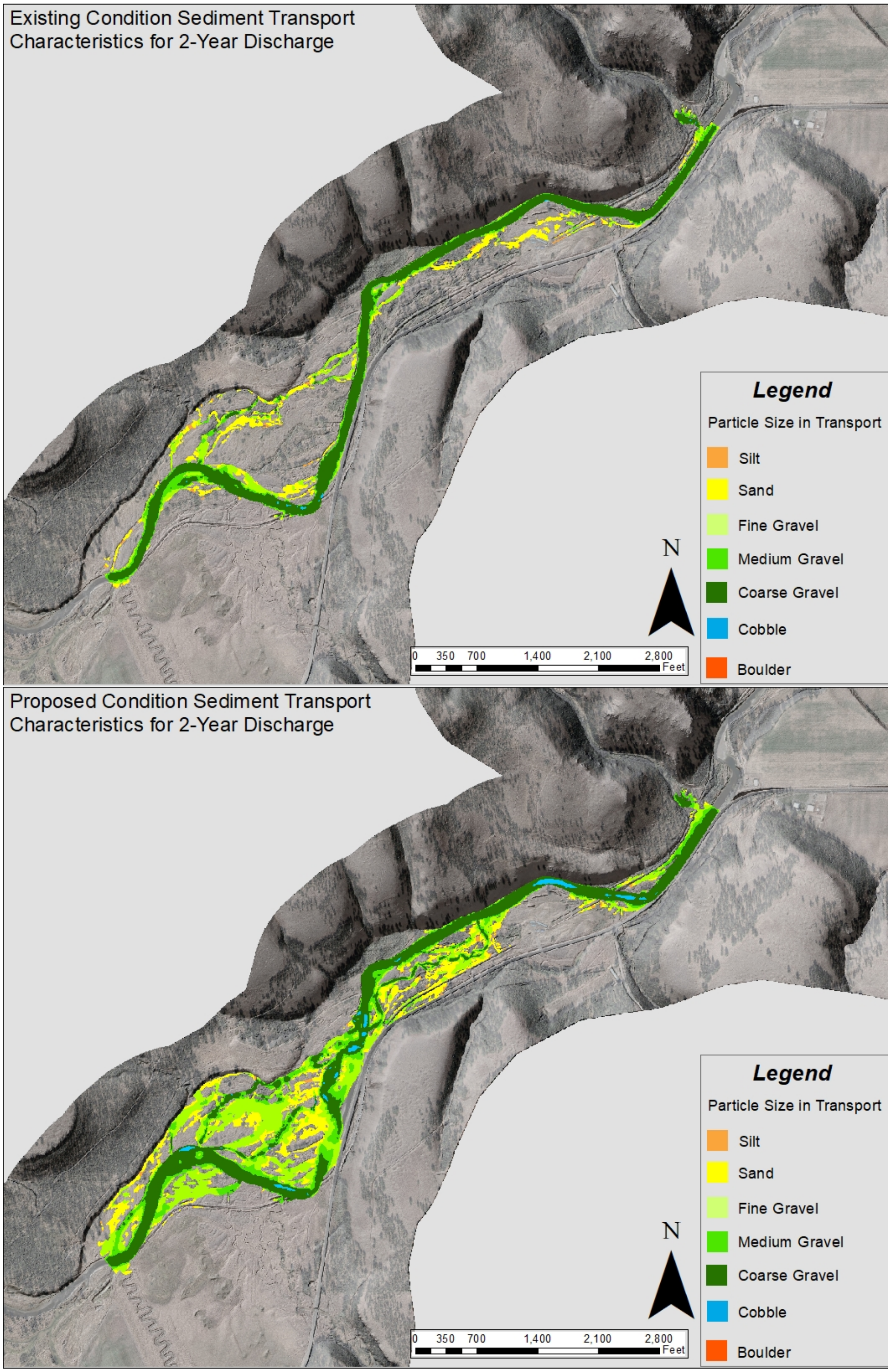


Figure 3-15 | Shear Stress Outputs at the 2-Year Flow for both Existing and Proposed Conditions

For 5-year discharge for existing conditions, the main channel primarily mobilizes coarse gravels with a few limited areas of cobble mobilization as shown in Figure 3-16 below. There is relatively no difference between the shear stress results for the main channel between the 2- and 5-year discharges. The floodplain for the existing conditions 5-year flow primarily mobilizes particle sizes ranging from sand to fine gravel as the floodplain actually becomes connected at a relatively significant flood flow.

For 5-year discharge for the proposed conditions, the main channel primarily mobilizes coarse gravels with increased areas of cobble mobilization. The floodplain for the 5-year discharge for the proposed conditions primarily mobilizes particle sizes ranging from sand to medium gravels. As shown in Figure 3-17 below there is a much larger amount of the floodplain that is inundated.

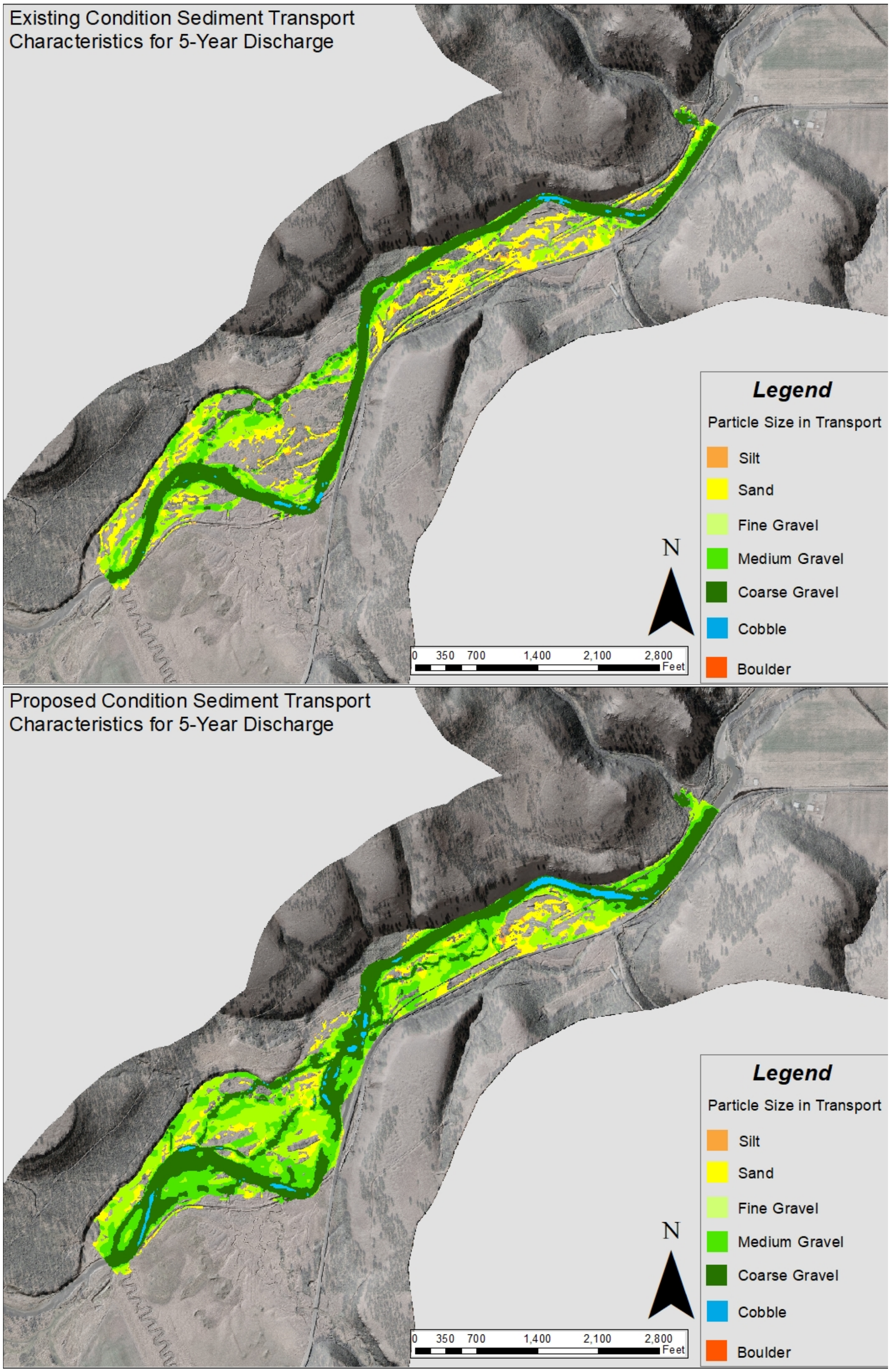


Figure 3-16 | Shear Stress Outputs at the 5-Year Flow for both Existing and Proposed Conditions

In summary, while the proposed design does not drastically alter the particle sizes mobilized in either the main channel or floodplains, it does provide a vast improvement in the amount of area inundated on the floodplain and greater diversity within the channel creating a mosaic of shear stress which will promote dynamic behavior with areas providing transport and other areas with low shear stress depositing those particles mobilized in higher shear stress areas. This type of diversity is desirable to provide enhanced fish habitat and to achieve project goals and objectives related to thermal refugia. The addition of LWM and roughness not demonstrated in this analysis will greatly enhance the sediment transport and deposition potential.

3.5 SUMMARY OF HYDRAULIC MODELING OR ANALYSES CONDUCTED AND OUTCOMES—IMPLICATIONS RELATIVE TO PROPOSED DESIGN

The project design utilizes hydraulic modeling for multiple components of the overall design including but not limited to main channel and side channel activation thresholds, velocity and shear stress outputs to determine hydraulic forces acting on the channel boundary including LWM and bed/floodplain materials, habitat uplift, flooding extents, and bypass channels utilized for project implementation.

TWO-DIMENSIONAL HYDRAULIC MODELING

The U.S. Army Corps of Engineers (USACE) HEC-RAS (version 5.0.7) hydraulic model was used to develop an existing conditions 2D model. The basis of this existing model consisted of a professional survey of the channel and surrounding floodplain completed in June 2014 by Anderson Perry & Associates. The existing conditions model was completed in the fall of 2017 and then updated in early 2020 to include additional topographic survey data from areas that had significantly changed within the project reach. The bankfull, 1.5-, 2-, 5-, 10-, 25-, and 100-year return interval discharges as well as critical habitat flows were modeled.

In addition to the existing conditions HEC-RAS model, Reclamation’s Technical Services Center (TSC) in Denver completed an SRH-2D model of the larger Bird Track Springs Project, which encompassed Bird Track Springs, Bear Creek Ranch, and Longley Meadows.

The existing conditions HEC-RAS model was migrated to CivilGEO Inc.’s GeoHECRAS program, which is being used for development and analysis of the proposed conditions. The existing conditions GeoHECRAS model was used to compare uplift of the final design, which was also modeled in GeoHECRAS. The proposed design surface is presented in Figure 3-17 below. In addition to the peak flows, modeled habitat design flows were also analyzed (see Appendix 8.2 for further details). The GeoHECRAS program uses USACE HEC-RAS (version 5.0.7) software for model computations.

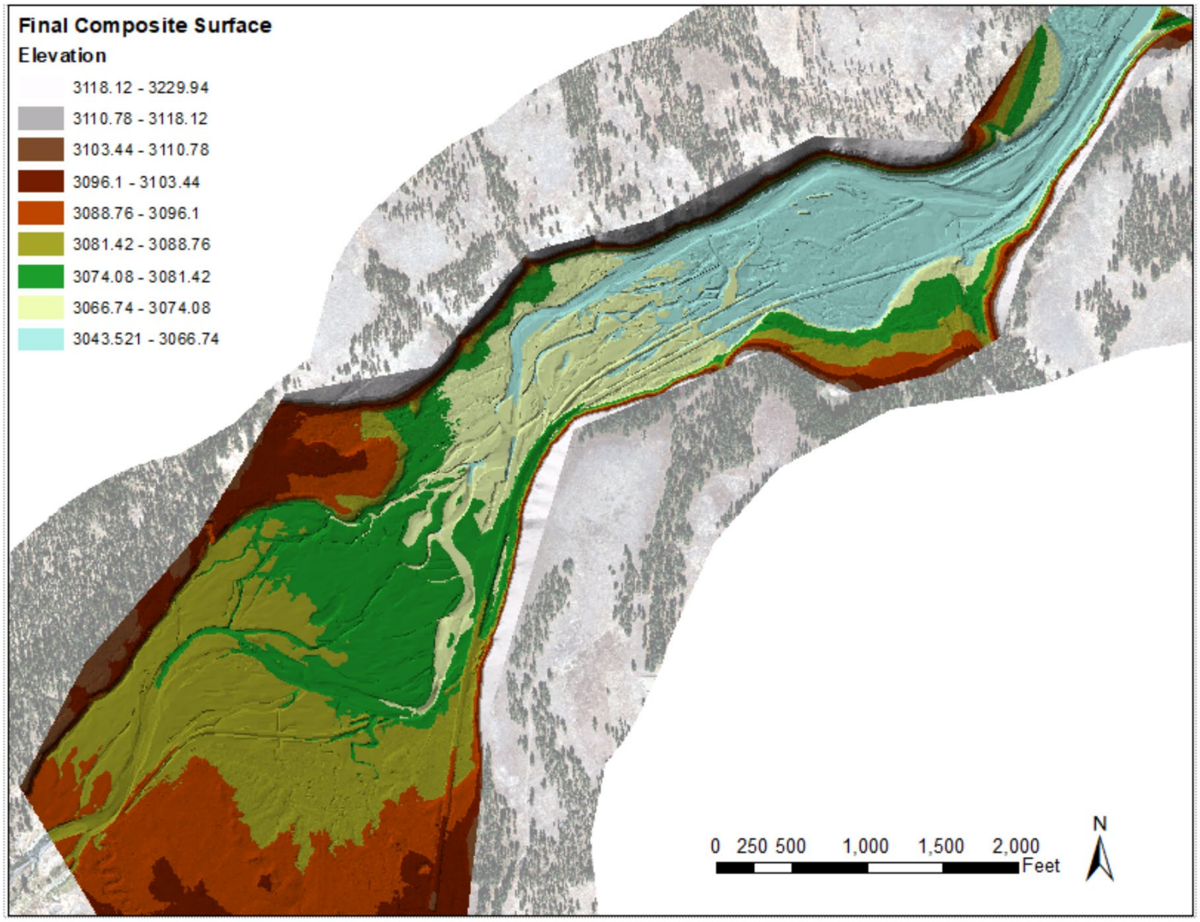


Figure 3-17 | Proposed Surface Terrain Used for Hydraulic Modeling

The existing conditions GeoHECRAS model was calibrated to the water surface elevations and inundation areas obtained from the LiDAR dataset of 2013 for the UGR. On April 9–10, 2013, LiDAR data were collected during an approximate annual flood event, 900 cfs. See Appendix 8.2 for further discussion on the calibration of the hydraulic model.

MODELING RESULTS

Model outputs for key peak flow events are provided below in Figure 3-18 and Figure 3-19 for existing and proposed conditions, respectively.

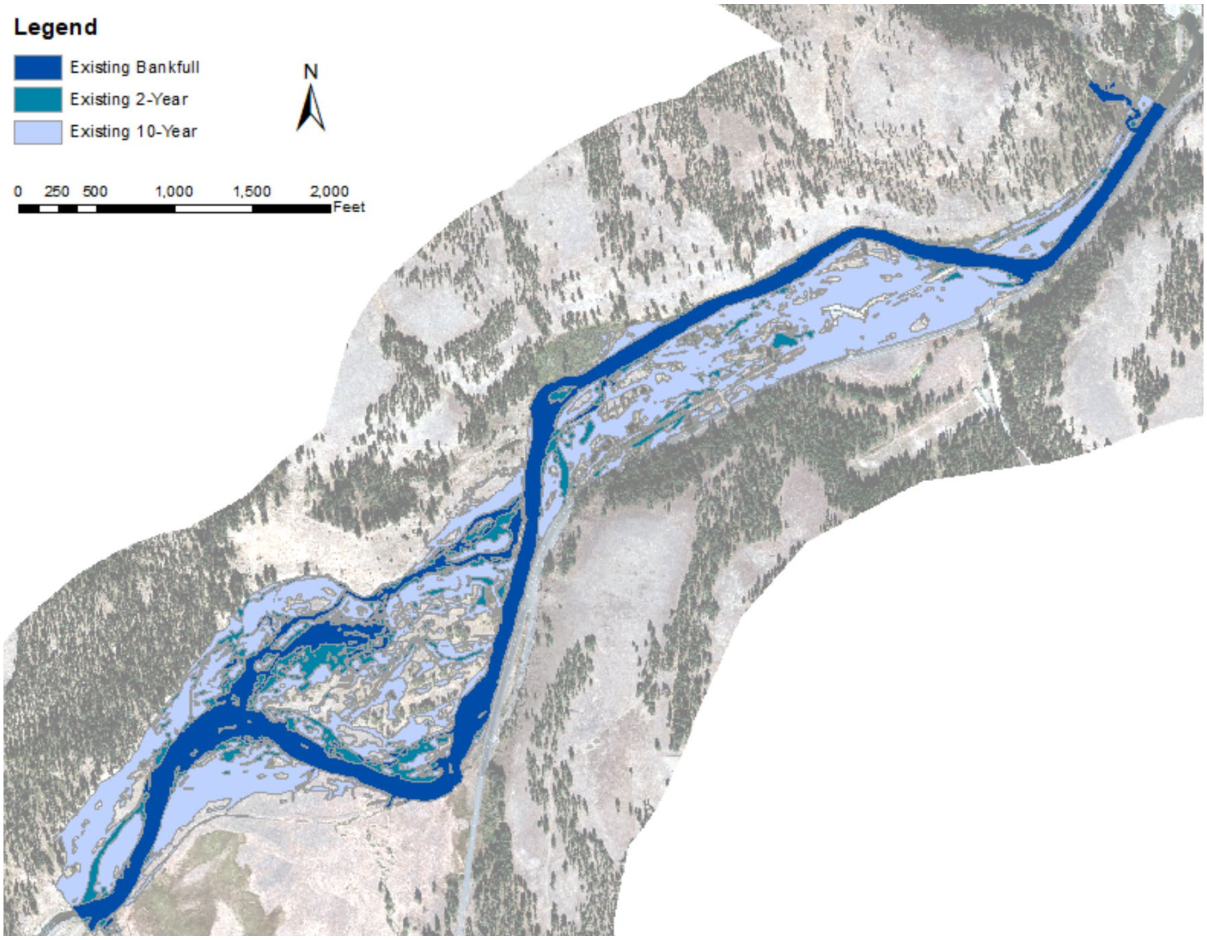


Figure 3-18 | Existing Conditions Inundation for the Bankfull, 2-Year, and 10-Year Flows

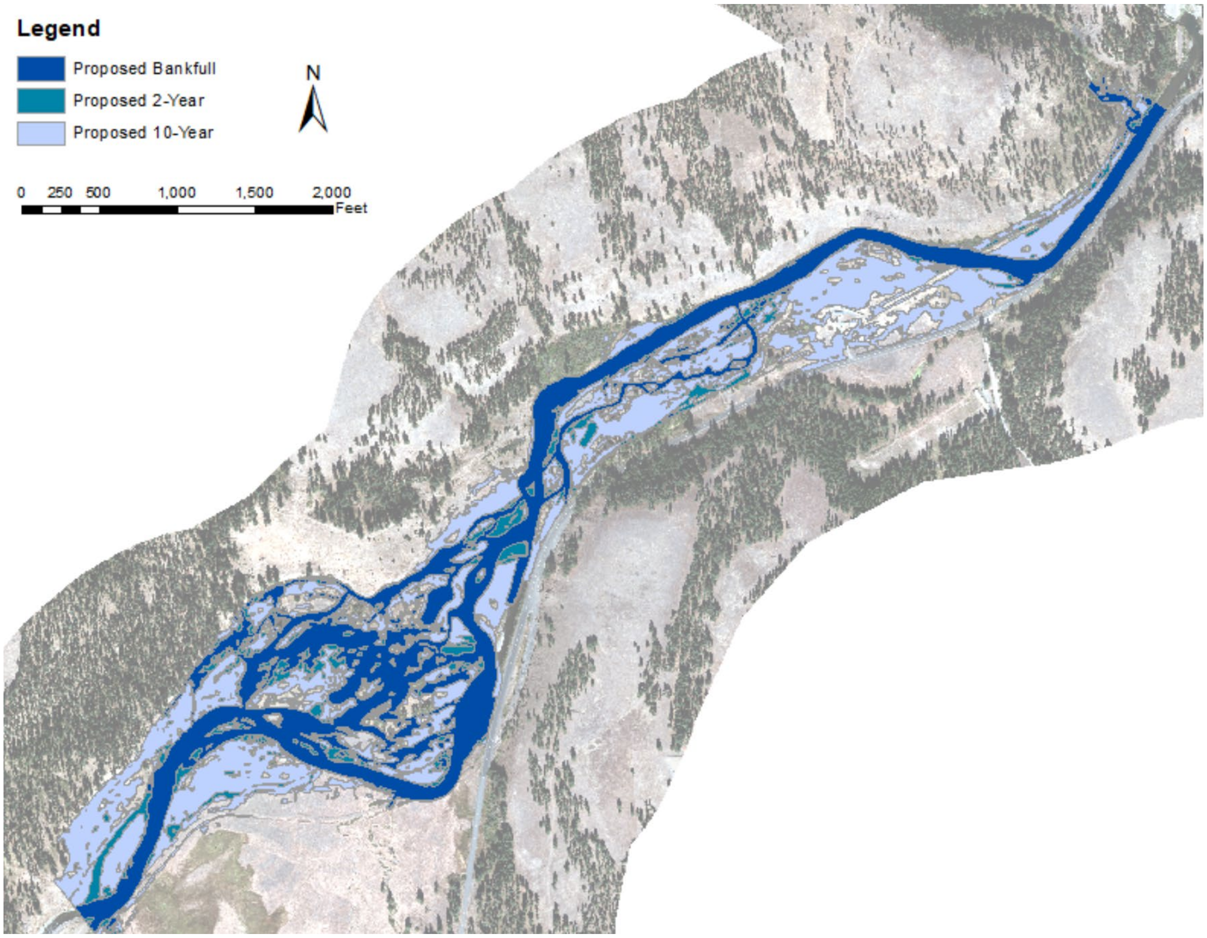


Figure 3-19 | Proposed Conditions Inundation for the Bankfull, 2-Year, and 10-Year Flows

The proposed design increases the inundation area for the bankfull flow by approximately 40% and 30% for the 2-year recurrence interval. The increased area provides more access to the floodplain and decreases flow velocities. Additional uplifts for habitat design flows and key peak flows are provided in Table 3-7 below. As summarized in Table 3-7 the inundation area of the proposed condition has the maximum increase in acres inundated and trends toward convergence with the existing condition inundation after the winter high flow. This is important as the proposed condition intends to not increase the effects of the 100-year flood (zero rise) on existing infrastructure. Refer to Figure 3-20 below for a visual of the proposed increase in inundation area and convergence with existing conditions at the 100-year. For further information on the modeling and results refer to Appendix 8.2.

Table 3-7 | Floodplain Inundation Area Comparison of Existing and Proposed Conditions

Flow Condition	Discharge (cfs)	Inundation Area (Acres)		Increase
		Existing	Proposed	
Low Flow	19	11.26	13.58	21%
Winter Median	86	15.29	18.25	19%
Median March	418	20.53	27.42	34%
Winter High	941	25.25	41.64	65%
Bankfull (1.25)	1,432	35.97	50.51	40%

Flow Condition	Discharge (cfs)	Inundation Area (Acres)		Increase
		Existing	Proposed	
2-year	2,113	49.83	64.54	30%
5-year	3,210	94.35	96.70	2%
10-year	4,025	120.29	123.56	3%
25-year	5,153	141.23	143.49	2%
50-year	6,062	148.86	149.45	0%
100-year	7,031	153.37	153.27	0%

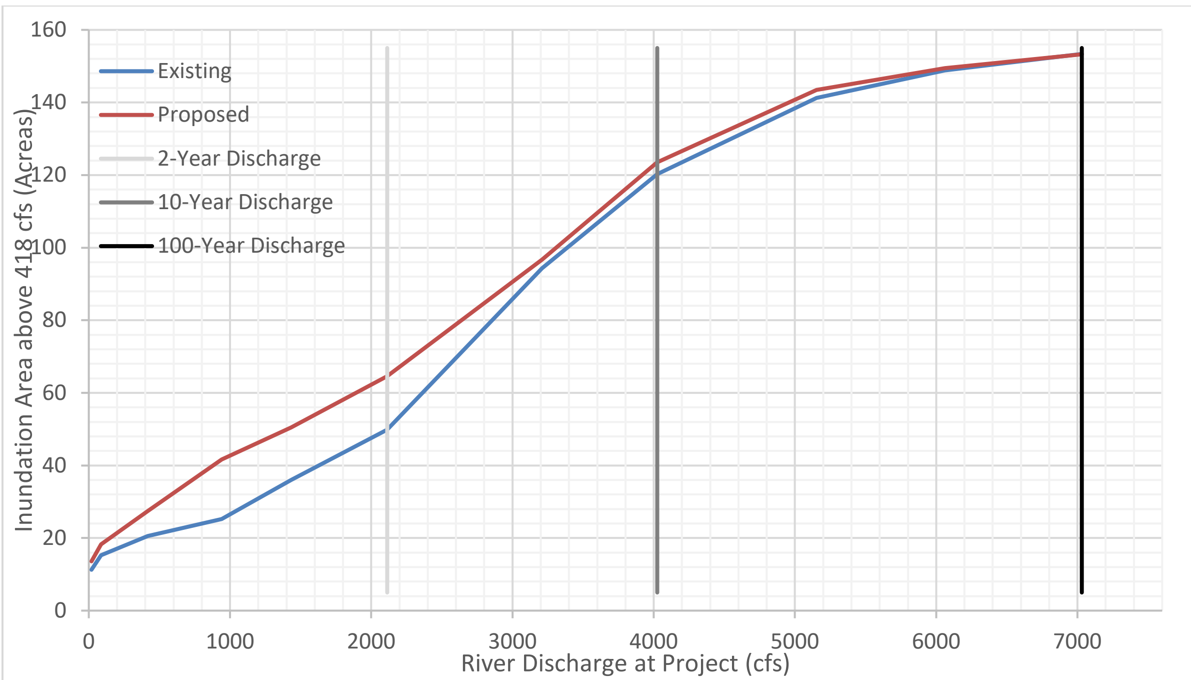


Figure 3-20 | Floodplain Inundation Area Comparison for Existing and Proposed Conditions above the Median March Flow (i.e., 418 cfs)

A major benefit of utilizing the hydraulic model is being able to dial in the activation and flow splits for islands and side channels. A summary of the flow percentages at various design flows is provided below in Table 3-8.

Table 3-8 | Summary of Expected Channel Flow Percentages at Various Design Flows

Channel	Low Flow	Winter Median Flow	Bankfull Flow
SC-1	0%	0%	2%
SC-2	20%	13%	12%
SC-3	34%	32%	24%
SC-5	6%	8%	15%
SC-5A	0%	0%	-1%

Channel	Low Flow	Winter Median Flow	Bankfull Flow
SC-5B[1]	23%	41%	45%
SC-5C[1]	50%	47%	40%
SC-6	0%	0%	1%
MC A	1%	17%	43%
MC B	63%	50%	32%

[1] Percentages for side channels with split flows are relative to the side channels total flow.

As previously discussed, the 30% model caused major revisions to the lower floodplain design. The proposed final design targeted 20% of the bankfull flow for SC-5, leaving 80% of the flow in the existing main channel. Previously this portion of the 30% design was targeting 70% of the bankfull flow. The proposed final design splitting flows at 20/80 reduces the risk to existing infrastructure and still meets the specific goals of the design, thus balancing overall risk and uplift.

HABITAT SUITABILITY INDEX MODELING

Rearing habitat suitability was assessed for juvenile Chinook salmon using the Habitat Suitability Index methodology under existing and proposed conditions using local (Favrot and Horn [2016]) and regional (Maret et al. [2006]) suitability curves. This analysis was limited to the hydraulic model outputs for depth and velocity from the 80% design hydraulic modeling results and likely under-predicts uplift of the proposed condition due to the lack of LWM being utilized in the hydraulic modeling and without adding the proximity to cover in the Habitat Suitability Index analysis. Habitat Suitability Index methods and results are reported in Appendix 8.7.

BYPASS MODELING DURING PROJECT IMPLEMENTATION

To construct elements of the design within the existing main channel it is necessary to bypass flow to isolate and dewater several areas. This will require constructing bypass channels that will accommodate typical flows during the in-water work window (July 1–October 15) and allow for fish passage for all life stages in accordance with ODFW guidelines. One-dimensional hydraulic models were created to analyze the proposed bypass channels typically consisting of trapezoidal channels with riffles to break up velocity. The channel profiles, dimensions, and construction methodology are detailed in Temporary Bypass Plans 1-4 in the project drawings. The modeling approach and results are detailed in Appendix 8.6.

3.6 STABILITY ANALYSES AND COMPUTATIONS FOR PROJECT ELEMENTS, AND COMPREHENSIVE PROJECT PLAN

LWM STRUCTURES

The LWM structure stability analysis was completed at the 80% design stage and included as an appendix in the 80% BDR. The project team continued to review and seek improvements for each of the structures implemented at the upstream Bird Track Springs Project with the intent to incorporate changes, modify the design, and improve the constructability of these previously constructed log structures for implementation at the Longley Meadows reach. The risk stability analysis performed follows Reclamation's *Risk-Based Design Guidelines* (Knutson and Fealko 2014) aiding in identifying, designing, and engineering proposed structures that meet stability requirements. As discussed above in Section 1.6, the design of LWM structures attempts to mimic natural log accumulation in a river system. Structure stability is provided by piles, ballast in the form backfill (boulders and native material) and embedment. Stability analysis results for each of the proposed large wood structure types are summarized below in Table 3-9 and detailed discussion and analysis can be found in Appendix 8.5.

Table 3-9 | Longley Summarized LWM Stability Analysis Results

LWM Structure Type	Public Safety	Property Damage Risk	Hydraulic Design Element	$FOS_{Bouyancy}$ >1.75	$FOS_{Sliding}$ >1.5	$FOS_{Rotation}$ >1.5	$FOS_{Overturning}$ >1.5
Type A – Apex Jam	Low	Moderate	25-Year	2.9	1.6	2.6	1.6
Type B1 – Meander Jam – Mallet Jam	High	Moderate	50-Year	1.8	2.8	1.6	1.7
Type C3 – 3-Log Channel Margin Jam	Low	Moderate	25-Year	3.0	4.2	1.9	3.6
Type C6 – 6-Log Channel Margin Jam	Low	Moderate	25-Year	2.8	2.9	1.5	3.1
Type C9 – 9-Log Channel Margin Jam	High	Moderate	50-Year	1.8	10.7	4.2	4.6
Type C12 – 12-Log Channel Margin Jam	High	Moderate	50-Year	1.8	8.6	4.1	8.7
Type D – Single Log Sweeper Jam	Low	Moderate	25-Year	2.7	2.4	2.3	3.1
Type F – Floodplain Roughness	Low	Moderate	25-Year	3.8	1.5	2.3	3.3
Type G – Reinforced Habitat Structure	Low	Moderate	25-Year	2.6	8.8	9.9	2.7

RIFFLE DESIGN

Based on the implementation of the Bird Track Springs project, the riffle design for Longley Meadows was revised to reduce the amount of screening required to produce the larger particle sizes required for stable riffle design. Two riffle classes were designed based on hydraulic forces acting on the channel boundary and side channel activation goals. Class 1 Riffles are located in key locations typically where there are multiple channel flow splits and/or areas of higher shear stress determined from hydraulic modeling. Class 2 Riffles are located in less critical areas and typically exhibit lower shear stress. Class 1 Riffles will be constructed by over-excavation of the native materials by approximately 2 feet and replaced with an engineered mix of native and imported sediment of specific gradation. Class 2 Riffles are to be composed of native materials exposed from channel rough grading at finish grade elevations. Each Class 2 Riffle area will be inspected and compared with the specified Class 2 gradation specifications and will be approved or rejected, requiring replacement by over-excavation by approximately 2 feet and replacement with native sediment of an acceptable gradation. Each riffle location, Class 1 or Class 2, will mimic natural riffles found in the UGR in appearance, generally wide depositional features that control hydraulic grade. Newly constructed riffles are intended to be at least as stable as those found upstream of the project to allow the channel to mature gradually. However, riffles are expected to move and transform at higher discharge frequencies. The channel shape will be stable vertically for varying discharge values dependent upon location. In general, constructed riffles crests will be stable for discharges at and below the 10-year return interval flood, and most riffle faces will be stable through the 2-year return interval. At discharges exceeding the 2-year peak, it is expected that channel substrate at riffle locations may adjust within the project area like natural stream reaches in this setting.

To determine the require gradation for the riffle matrix the GeoHECRAS 2D modeling outputs for the 2 and 10-year shear stress were evaluated at each of the riffle locations. The maximum shear stress was recorded for each riffle for the evaluated design flows which was then used to determine the gradation required for the riffle matrix.

For this project, the potential entrainment of the D_{84} particle sizes within proposed riffles were analyzed as this size class creates the structural framework of the riffle. To analyze the proposed riffle framework material, the modified critical shear stress equation was utilized (Andrews 1983; Bathurst 1987; Komar 1987, 1996; Komar and Carling 1991) which allows designers to determine the particle size of interest based upon the D_{50} particle. This equation is applicable for plane-bed type channels (gradually varied) with bed gradients of 5% or less, and D_{84} ranging between 10 to 250mm, both of which fit the proposed riffles.

$$\tau_{ci} = 102.6\, \tau^*_{D50}\, D_i^{\,0.3}\, D_{50}^{\,0.7}$$

Where,

τ_{ci} = the critical shear stress at which the sediment particle of interest (D_{84}) begins to move.

τ_{D50} = the dimensionless Shield’s parameter for D_{50} particle size

D_{50} = diameter of the median particle size of riffle gradation

D_i = diameter of the particle size of interest (D_{84})

Based on experience from Bird Track Springs and pebble counts from existing riffle locations in the Longley Meadows reach, a D_{50} of 3 inches was assumed. Using an iterative approach the D_{84} particle was increased in size until stability was achieved at each riffle location for each riffle class. For Class 1 Riffles, a D_{84} of 7 inches was determined to be stable compared with the modeled hydraulic forces. Particles of this size and greater required a considerable amount of effort to screen native materials and as a result this size class and above is to be mostly imported and blended with native alluvium to produce the required gradation. For Class 2 Riffles, a D_{84} of 5 inches was determined to be stable. By having two riffle types the overall screening will be reduced while maintaining riffle stability. It is anticipated that only a portion of the Class 2 Riffles will require replacement after inspection as this size class and gradation is likely more readily available in the underlying sediments.

For the smaller particle sizes in the riffle gradations the Fuller Thompson equation was utilized to calculate the D_{30}, D_{16}, and D_{10} particle sizes to round out the gradations

The gradations detailed in the Riffle Materials Sheet in the project drawings have been analyzed with this process to create a stable D_{50} and D_{84} particle and a well graded engineered matrix. The construction methodology is detailed in the Riffle Construction Sheet to create a well compacted riffle to meet hydraulic objectives of the design.

3.7 DESCRIPTION OF HOW PRECEDING TECHNICAL ANALYSIS HAS BEEN INCORPORATED INTO AND INTEGRATED WITH THE CONSTRUCTION – CONTRACT DOCUMENTATION

Sections in Chapter 3 include technical analysis associated with the project reach. Data collection of in situ site information included: topographical and LiDAR surveys, groundwater monitoring, seismic refraction, hydrology, sediment supply/transport, and hydraulic modeling. Additional technical analysis will include the collection of test pit material aiding the design with the location and material available for gravel mining as well as stability calculations for LWM structures.

The collection of survey data provides the base map information for the existing terrain present for the site. The terrain data is incorporated into computer-aided design (CAD) for development of the existing surface. Using the base map terrain, the proposed design (channel alignments, sections, and elevations) are graded to create a new terrain surface. The comparison between existing and proposed surfaces allows for the calculation of cut and fill quantities. The existing and proposed surfaces are also used for hydraulic modeling. Geotechnical analysis provides data related to groundwater movement and the connection of hyporheic zones between the mainstem UGR and adjacent floodplains. Analysis of these data assists in the design of proposed alcoves and side channels. Depth to bedrock assists with amount of riffle/cobble material available and provides a general idea of the historical longitudinal channel extents.

Hydrologic analysis provides the design team with expected flow regimes for the UGR. Expected annual and bankfull discharge flows as well as flood events aid in determining side channel activation, bank protection, and LWM structure heights. Flow analysis also correlates and aids in the determination of target fish life stages. Sediment supply and transport analysis provides the design team with grain size distribution, average diameter of material present, and critical diameter of material moving through the project area. Determining the critical diameter of sediment aids in sizing riffle material. Pebble count data determine the median material size present, aiding in quantifying the amount of material available for screening and riffle construction. Additionally, proposed test pit exploration will map and log material excavated, taking into account lessons learned from the Bird Track Springs Project. The goal of this exploratory effort is to assist in determining whether or not enough riffle material is present on-site, or if additional riffle material will be needed (import) for the proposed design.

Hydraulic modeling of the proposed design provides inundation mapping, aiding with the determination of flow split volumes and activation of side channels. This iterative process allowed the design team to adjust inlet controls, riffle crest elevations, channel widths, and pool depths, improving the proposed design. Additionally hydraulic modeling provided velocities and shear force evaluation of the proposed design flows. These values aid in the development of bank stabilization/protection and risk calculations associated with proposed LWM structures. This iterative process between hydraulic modeling, surface terrain edits, and input for developing LWM structures was repeated through the final design deliverable stage as the team advanced and enhanced the final proposed design.

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

Not present at this project site.

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

Not present at this project site.

4 CONSTRUCTION – CONTRACT DOCUMENTATION

4.1 INCORPORATION OF HIPIII GENERAL AND CONSTRUCTION CONSERVATION MEASURES

The HIP III General Aquatic Conservation and Construction Measures are included in the final design plan set note sheets (Appendix 8.1). These measures were reviewed and updated accordingly prior to final submittal.

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

The final design plan set is included in Appendix 8.1 and includes plans and profiles for side channel and main channel proposed alignments. The design also includes the location of LWM features as well as LWM structure details, access and staging, water bypass, and a proposed construction sequencing plan.

4.3 LIST OF ALL PROPOSED PROJECT MATERIALS AND QUANTITIES

The quantities for the final design are called off in the final plan set (Appendix 8.1). The materials and quantities are also included in the engineer's estimate or bid sheet.

4.4 DESCRIPTION OF BEST MANAGEMENT PRACTICES THAT WILL BE IMPLEMENTED AND IMPLEMENTATION RESOURCE PLANS

The final design plan set includes a few temporary erosion and sediment control (TESC) details as well as the proposed location for these best management practices (BMPs). Details are included for fiber rolls, silt fencing, temporary access routes, staging and stockpiling areas, and stabilized construction entrances. Fiber rolls and silt fencing will aid in addressing the stockpiling of spoil material and preventing associated stormwater runoff from leaving the site. The temporary access route detail will assist with runoff and roadway rutting, while the stockpile detail assists with runoff and run-on associated with precipitation events. The stabilized construction entrance helps to prevent erosion associated with heavy equipment entering the site and also provides an area for washout prior to construction equipment leaving the site.

SITE ACCESS STAGING AND SEQUENCING PLAN

The access and staging plan is provided in Appendix 8.1. Vehicular access points are strategically located throughout the project area. Key entrance points are shown based on land type, access from the highway, proposed design element locations, and access across the river. All staging areas are currently shown outside the ordinary high water delineation, but within the adjacent floodplain and near proposed working locations.

Construction sequencing plans are included in the final design plan set. The plans shown depicts two project reaches (Lower and Upper Floodplain). It is anticipated that the project will likely be constructed and phased over two construction seasons. Phasing of the project provides flexibility with regard to weather, river flows, fire season, permitting of the project, and/or permitting construction constraints. As phased over two construction seasons, the Lower Floodplain reach would be prioritized due to the shortened construction window anticipated. As depicted on the plans the Lower Floodplain reach would be dewatered, mined, subject to construction of channels and log structures, revegetated, and constructed first. The Upper Floodplain reach (or second phase) would be built in similar fashion upon completion of Lower Floodplain reach. Swapping construction of the Lower and Upper Floodplain reaches would be possible; however the contractor will be required to show their sequencing plan for review and ensure reach completion prior to winter setting in.

WORK AREA ISOLATION AND DEWATERING PLAN

Details for the removal of water while constructing islands, side channels, confluence locations, and wood structure placement are shown in the final design plan set. Additional details include supersack cofferdam installations, options for adjusting the cofferdam, and a procedure for diverting channels. The final plan set includes key river/water bypass locations for use during construction. These sheets show the location, profile, and proposed grade control checks needed for bypass construction. In addition, Appendix 8.6 discusses additional bypass information.

EROSION AND POLLUTION CONTROL PLAN

The final design plans include HIP III General Aquatic Conservation Measures applicable to erosion control, stockpiling, dust abatement, spills, and invasive species control measures. In addition, upon award, the contractor will be required to submit a SWPPP for approval and permitting. The SWPPP will detail specific BMP usage, placement, care of water measures, and monitoring locations for the project. The final plan set submittal includes best management practice details and a temporary crossing detail to be incorporated during construction.

SITE RECLAMATION AND RESTORATION PLAN

The site reclamation and restoration plan is embedded in the revegetation/seeding and planting plans. Additional details are included in the final design submittal. Additional planting plans will be developed and implemented by the USFS including planting of native trees and shrubs.

LIST PROPOSED EQUIPMENT AND FUELS MANAGEMENT PLAN

The final design plans include HIP III General Aquatic Conservation Measures applicable to construction equipment and spill prevention, control, and countermeasures.

4.5 CALENDAR SCHEDULE FOR CONSTRUCTION/IMPLEMENTATION PROCEDURES

The anticipated construction schedule for the project is set to begin in August of 2020. The final project is shown with two reaches (upper and lower floodplain); due to unforeseen circumstances (COVID-19 pandemic), it is anticipated that the project will be broken by reach and constructed over two construction seasons. Other outside factors, such as fires, permit conditions, or inclement weather delay or a shortened construction season, will likely require that the lower floodplain reach of the project be constructed first, with the upper floodplain reach or second phase of the project constructed the following year ending in 2021. In this scenario, ideally the entire lower floodplain reach construction work would be completed, limiting the winterization of the project.

4.6 SITE OR PROJECT-SPECIFIC MONITORING TO SUPPORT POLLUTION PREVENTION AND/OR ABATEMENT

All monitoring and abatement plans associated with the SWPPP will be developed (as required) by the contractor. The SWPPP will be reviewed by the contracting officer (CO) and Reclamation for approval prior to beginning any construction work on-site.

5 ENVIRONMENTAL COMPLIANCE AND PERMITTING

5.1 INTRODUCTION

A review of environmental compliance and permitting associated with the project is provided below. Copies of the approved permits are contained in Appendix 8.9, and BPA's HIP programmatic agreement approval authorization letter is included in Appendix 8.10.

5.2 NATIONAL ENVIRONMENTAL POLICY ACT (NEPA) COMPLIANCE

USFS prepared an Environmental Assessment (EA) for the project. The preliminary EA was released in August 2019. Comments were received and responses published in November 2019. The objection period closed in late-December 2019, and no objections are were received. Following completion of cultural resources and ESA consultations (discussed in further detail below), USFS published a Final EA, Correction Notice, and Decision Notice on April 13, 2020, to provide NEPA coverage for public lands within the project area. BPA issued a Finding of No Significant Impact (FONSI) on April 15, 2020, to provide NEPA coverage for private lands within the project area. NEPA decision documents can be found in Appendix 8.9.

5.3 CULTURAL RESOURCES, NHPA SECTION 106 CONSULTATION

Reclamation and BPA initiated consultation in compliance with Section 106 of the NHPA with the Oregon State Historic Preservation Office (SHPO) in November 2017. Oregon SHPO agreed with the delineation of the Area of Potential Effects in December 2017. On February 5, 2020, BPA submitted the survey report and determination of effects letter to the consulting parties. On March 2, 2020, CTUIR provided comments requesting revisions and clarification of eligibility determinations and avoidance measures. BPA, with input from Reclamation and the USFS, submitted a revised determination letter on March 8, 2020 (included in Appendix 8.9). On March 9, 2020, SHPO asked for completion of the SHPO coversheet. BPA responded on March 9, 2020, stating that the coversheet was completed with the consultation package delivered in February 2020. On March 13, 2020, BPA contacted SHPO to determine if they had substantive comments on the report. BPA never received a response. On April 1, 2020, BPA submitted the final report addressing CTUIR's comments. BPA received confirmation of receipt from CTUIR and SHPO on April 2, 2020, and from Wallowa-Whitman National Forest on April 6, 2020. Although no formal response providing explicit concurrence from SHPO was received, on April 6, 2020, BPA assumed concurrence with the determination of no adverse effect, per 36 Code of Federal Regulations 800.5(c)(1) (email included in Appendix 8.9 to document consultation) based on the expiration of the 30-day consultation period. This date marked completion of NHPA Section 106 consultation and BPA's and Reclamation's intent to move forward with project implementation.

5.4 ENDANGERED SPECIES ACT, SECTION 7 CONSULTATION

Consultation with National Marine Fisheries Service (NMFS) and USFWS for threatened and endangered species was completed for this project through the BPA HIP III programmatic agreement.

The BPA initiated programmatic consultation with NMFS (also referred to as NOAA Fisheries in some documents) and the USFWS to comply with the requirements of the ESA and the Magnuson-Stevens Fishery Conservation Act. The original consultation resulted in a BiOp from NOAA Fisheries (reference number 2003/00750) on August 1, 2003. After the relisting of critical habitat for ESA-listed salmon and steelhead, consultation was initiated anew and concluded on January 10, 2008 (reference number 2007/03996). This consultation was initiated due to the expiration of the 2008 BiOp at the end of calendar year 2012.

This consultation now includes green sturgeon, eulachon, bull trout, Oregon chub, and their critical habitats. The action area for this consultation is the Columbia River Basin within the contiguous United States that is also within the range of ESA-listed fish and their designated critical habitats, as well as within the range of essential fish habitat for many species. BPA funds habitat improvement activities to fulfill its obligations under the Pacific Northwest Electric Power Planning and Conservation Act of 1980 (Public Law 96-501) and in response to the requirements of various BiOps, including the 2008 BiOp on the Operation of the FCRPS (NOAA Fisheries 2008). BPA and the other Action Agencies, USACE and Reclamation, are continuing to implement the habitat improvement actions described in that BiOp.

It is BPA's determination that the HIP III proposed action is likely to adversely affect anadromous salmon and steelhead, and freshwater fish. Based on BPA's determinations under the HIP III biological assessment, the Longley Meadows Project is likely to adversely affect the following species that are present in the Grande Ronde watershed:

- Spring Chinook and critical habitat
- Steelhead and critical habitat
- Bull trout and critical habitat

This project will have short-term construction-related effects but will greatly benefit the listed species in the long term.

The Longley Meadows project under this HIP III biological assessment and opinion is considered a high-risk activity in the River, Stream, Floodplain and Wetland Restoration category, and more specifically the Channel Reconstruction subcategory. High-risk projects in the Channel Reconstruction subcategory require review by the Restoration Review Team and the NMFS Hydro Division. The review process followed the Channel Reconstruction activity Guidelines for Review contained in the HIP III biological assessment and opinion. The Restoration Review Team provided feedback and/or concurred with the project development for the 15%, 30%, and 80% design packages. Following receipt and review of the final design package, BPA determined that the project fell within the scope of NMFS's and USFWS's ESA Section 7 Formal Programmatic Opinions for BPA's HIP III for spring Chinook, steelhead, and bull trout. ESA compliance authorization for the Longley Meadows Fish Habitat Enhancement Project was issued on March 25, 2020 (Appendix 8.10).

5.5 STATE AND FEDERAL PERMITS

Following completion of the 80% design drawings, applications were submitted to the USACE for Clean Water Act (CWA) permits, Oregon Department of State Lands (DSL) for the Removal-Fill permit, and ODOT for temporary highway approach permits. On May 28, 2020, the USACE verified and authorized the project for Regional General Permit 6 (RGP-6) and CWA Section 404 coverage under Nationwide Permit #27, Aquatic Habitat Restoration. Projects that are authorized under RGP-6 receive blanket 401 Water Quality Certification from the Department of Environmental Quality. The DSL Removal-Fill permit was issued on July 7, 2020, and ODOT temporary state highway approach application approvals were granted on June 8, 2020. The ODOT temporary highway approach permits to construct were issued on July 14, 2020, which concluded all permits needed for construction. All permits referenced above are included in Appendix 8.9.

6 MONITORING AND ADAPTIVE MANAGEMENT PLAN

6.1 INTRODUCTION

The monitoring and adaptive management plan (MAMP) described below was developed at the 80% design deliverable stage, and builds upon the Bird Track Springs Project plan. Improvements to the Longley Meadows MAMP include reviewing and incorporating lessons learned from the upstream Bird Track Springs Project. The ability to complete monitoring activities described below will be subject to funding availability.

6.2 EXISTING MONITORING PROTOCOLS

Several monitoring and performance protocols have been developed for restoration projects. Table 5-1 describes the most popular protocols used in the Pacific Northwest and their monitoring targets. These protocols provide guidance for obtaining field data for monitoring habitat. Roper et al. (2010) evaluated the performance and data compatibility of these monitoring protocols while being used by various field data collection groups. They found that these five protocols (Aquatic Riparian Effectiveness Monitoring Program [AREMP], PACFISH/INFISH Biological Opinion [PIBO], Environmental Monitoring and Assessment Program [EMAP], ODFW Aquatic Inventories Project, and Columbia Habitat Monitoring Program [CHaMP]) led to high internal consistency within monitoring groups. This supports the idea that each of the current protocols (CHaMP is no longer being used) have adequate means and methods for collecting habitat metrics, especially when used by experienced personnel.

Table 5-1 | Summary of Popular Protocols Used for Monitoring Restoration Projects in the Northwest

Protocol	Description
Aquatic Riparian Effectiveness Monitoring Program (AREMP)	Designed to assess the condition of aquatic, riparian, and upslope ecosystems under the jurisdiction of the Northwest Forest Plan
PACFISH/INFISH Biological Opinion (PIBO)	Designed to determine whether a suite of biological and physical attributes, processes, and functions of upland, riparian, and aquatic systems are being degraded, maintained, or restored, particularly in reference to livestock grazing and other federal land management practices
Environmental Monitoring and Assessment Program (EMAP)	Designed by the Environmental Protection Agency (EPA) to produce unbiased estimates of the ecological condition of surface waters across a large geographic area of the West (Peck et al. 2001)
ODFW Aquatic Inventories Project (ODFW)	Assesses aquatic habitat, conducts fish presence/absence surveys, monitors fish populations, establishes salmonid watershed prioritization, monitors habitat restoration projects, and reconstructs historical salmonid life history.
Scientific Protocol for Salmonid Habitat Surveys within the Columbia Habitat Monitoring Program (CHaMP). (No longer being used as a monitoring protocol.)	Designed to assess the quantity and quality of stream habitat for salmonids. Draws together methods from several protocols to collect and analyze channel geomorphic data (i.e., topographical features, channel units, and geomorphic reaches).

6.3 PROJECT EFFECTIVENESS MONITORING PLAN

Effectiveness monitoring for the project is designed to measure progress toward achieving the project objectives, inform maintenance needs, and provide input into whether the restoration project is trending toward or away from achieving project goals. Based on the project goals, and in compliance with the programmatic BiOp, physical and biological parameters will be monitored using standard field techniques that will produce data compatible with the various protocols previously mentioned.

Monitoring approaches for each of the project objectives are described below. In addition to objective-specific monitoring, annual inspections of the project, including photo documentation as described in Section 5.6, will be conducted.

Roles and responsibilities of the CTUIR, ODFW, USFS, Reclamation, Grande Ronde Model Watershed (GRMW), and the Columbia River Intertribal Fish Commission (CRITFC), will be determined and agreed upon to ensure that monitoring data, as outlined in this report, are collected and distributing to the project review team in the form of annual reports. All monitoring activity will depend on available funding of the entities performing the work.

OBJECTIVE 1

Improve channel-floodplain connectivity (groundwater wells)

In the UGR, habitat for cold-water fish has been steadily degraded since the mid-1800s due to a long list of alterations to the landscape, with water temperature being arguably one of the most impaired and influential factors for ESA-listed fish in the basin (Justice et al. 2016). In the early 1990s Bohle completed a modeling study of water temperatures within the UGR and concluded that overall poor water temperature conditions were a result of alterations to the river's width/depth relationship along with degradation to its riparian vegetation community and that improvements could be made if the wetted width were reduced and riparian stream shading increased in altered reaches (Bohle 1994).

Surface and groundwater temperature monitoring has been implemented by CTUIR, ODFW, and Reclamation, within and adjacent to the site. Baseline data are being collected and will continue to be collected and analyzed prior to and post project. Data collection includes, but is not limited to, the metrics listed in Table 5-2.

Table 5-2 | Summary of Channel-Floodplain Connectivity Monitoring Metrics

Project Objective	Monitoring Technique	Monitoring Metrics	Baseline Value	Design Channel (as-built)	Desired Condition	Frequency Duration
Improve channel-floodplain connectivity	Channel & floodplain cross-sections	Avg. riffle width to depth	77	18	14–20	1 pre-project / 3+ post
		Channel cross-sectional area	70–321 sq. ft.	175–321 sq. ft.	150–325 sq. ft.	1 pre-project / 3+ post
	Groundwater wells	Water depth	TBD	TBD	Increased water table	Continuous for 10 years

OBJECTIVE 2

Improve altered thermal regime

In the UGR, habitat for cold-water fish has been steadily degraded since the mid-1800s due to a long list of alterations to the landscape, with water temperature being arguably one of the most impaired and influential factors for ESA-listed fish in the basin (Justice et al. 2016). In the early 1990s Bohle completed a modeling study of water temperatures within the UGR and concluded that overall poor water temperature conditions were a result of alterations to the river's width/depth relationship along with degradation to its riparian vegetation community and that improvements could be made if the wetted width were reduced and riparian stream shading increased in altered reaches (Bohle 1994).

Surface and groundwater temperature monitoring has been implemented by CTUIR, ODFW, GRMW, CRITFC, and Reclamation, within and adjacent to the site. Baseline data are being collected and will continue to be collected and analyzed prior to and post project. Data collection includes, but is not limited to, the metrics listed in Table 5-3.

Table 5-3 | Summary of Temperature Monitoring Metrics

Project Objective	Monitoring Technique	Monitoring Metrics	Baseline Value	Design Channel (as-built)	Desired Condition	Frequency Duration
Improve altered thermal regime	Thermographs	7-day daily maximum	20°F	N/A	<20°F	Continuous for 10 years

OBJECTIVE 3

Maintain fish passage (annually and at high and low flows)

Current levels of fish passage in the mainstem will be maintained or improved. To this end, visual inspections will be used to determine if there are fish passage concerns during periods of low water as summarized in Table 5-4. Given this project includes a multi-threaded channel there is the potential for an increase in stranding in side channel habitats; however, the profiles, bed forms, and flow partitioning have been optimized to minimize this risk.

Table 5-4 | Summary of Fish Passage Monitoring Metrics

Project Objective	Monitoring Technique	Monitoring Metrics	Baseline Value	Design Channel (as-built)	Desired Condition	Frequency Duration
Maintain fish passage	Fish passage	Connectivity	NA	Surface connectivity	Surface connectivity	Annual low flow
		Jump height	<6”	<6”	<6”	Annual low and high flow
		Water depth	2–3”(riffle)	>2–3” (riffle)	>2–3” (riffle)	Annual low flow

6.4 PROJECT REVIEW TEAM TRIGGERS

Restoration of natural streams is an evolving science that seeks to combine natural processes with engineering and construction techniques to provide for maximum habitat potential, which necessitates the gradual adjustment of the stream system over time; however, rapid channel change is generally not desired and often has a negative impact on habitat and species. The proposed monitoring plan will include key monitoring attributes that will provide a feedback loop of the trends and trajectory of the restoration efforts (Table 5-5). The project review team will be notified if monitoring demonstrates values outside of the below outlined thresholds. If a Monitoring Metric is a “Pass,” then there is no action required. If, however, the Monitoring Metric is a “Fail,” then the project review team will evaluate the failure and determine whether and what type maintenance and/or corrective actions is necessary.

Table 5-5 | Monitoring Data Trends, Conclusions, and Responses for Selected Metrics

Monitoring Technique	Monitoring Metric	Threshold	Decision Pathway	Applicability
Longitudinal profile	Channel length	>10,000 ft	1. > 10,000 & < 20000 ft (Pass) 2. < 10,000 or >N/A (Fail)	Total channel length (main and side channels)
	Sinuosity	1.3–1.5	1. > 1.3 and < 1.5 (Pass) 2. < 1.3 or > N/A (Fail)	Total channel length (main and side channels)
Habitat survey	LWM structure stability	Each structure retains 75%–125% of LW	1. >75–125% of structure retained (Pass) 2. < 75% or > 125% of structures retained (Fail)	LWM structures
	Substrate size (D_{50})	65–75 mm	1. >65 and <75 mm (Pass) 2. <65 or >75 mm (Fail)	Riffles @ monumented cross-sections
	Avg. residual pool depth	10–14 ft	1. > 10 ft. (Pass) 2. < 10 ft. (Fail)	Pools
UAV imagery	Percent cover	> 60% cover by native species in restoration area in Year 5 and 75% by Year 10	1. 60% survival required by year 5, 65% after 5 years, 75% at year 10 (Pass) 2. < 60% survival after 4 years, less than 65% after 5 years, less than 75% at 10 years (Fail)	Floodplain
Line-intercept	Percent cover	> 60% cover by native species in restoration area in Year 5 and 75% by Year 10	1. 60% survival required by year 5, 65% after 5 years, 75% at year 10 (Pass) 2. < 60% survival after 4 years, less than 65% after 5 years, less than 75% at 10 years (Fail)	Banks and bars
Channel & floodplain cross-sections	Avg. riffle width to depth ratio	14–20	1. >14 and <20 (Pass) 2. <14 or >N/A (Fail)	Riffles
	Cross-sectional area	150–325 sq. ft	1. Cross-sectional area > 150 or <325 (Pass) 2. Cross-sectional area <150 or >325 (Fail)	Riffles
Groundwater wells	Water depth	TBD	1. Stable or increasing over baseline (Pass) 2. Declining compared to baseline (Fail)	Floodplain
Thermograph	7-day daily max temp.	<22°F during low water	Measureable increase in thermal refugia	Pools

Monitoring Technique	Monitoring Metric	Threshold	Decision Pathway	Applicability
Fish passage	Connectivity	Surface connectivity	1. Side channel providing fish passage/flow between channel and pond (Pass) 2. Side channel not providing fish passage/flow between channel and pond (Fail)	Side channels
	Jump height	Beaver dams present, but no unnatural barriers exceeding 6 inches	1. No barriers exceeding 6” (Pass) 2. Unnatural barriers present. (Fail)	Entire channel
	Water depth	Depth of main channel thalweg of sufficient depth to allow passage of fish present	1. Continuous flow (low-flow depth) of at least 2–5” (Pass) 2. Discontinuous or very shallow flow depth (Fail)	Thalweg

6.5 MONITORING FREQUENCY, TIMING, AND DURATION

Monitoring surveys will occur frequently enough to capture change that could result in a significant reduction in the desired habitat conditions. Surveys should occur during a similar timeframe each cycle, and should occur under similar flow conditions. Monitoring surveys will be conducted prior to construction (i.e., baseline condition), immediately post-construction or the as-built condition, and after the first bankfull event. If the monitoring metrics fall within the desired range following a bankfull event, then the next monitoring survey trigger is the 5-year flow event. If the monitoring results fall outside of the desired range following a bankfull event (a Fail), then monitoring will continue after each bankfull event until the desired conditions are achieved. Similarly, if the monitoring results following a 5-year flow event are within the desired range, then monitoring is complete. If, however, the desired range is not achieved, monitoring will continue until the desired range following a 5-year event is achieved.

Monitoring based on actual flow events is more meaningful than simply undertaking a monitoring effort every year. However, no more than 5 years will lapse between any monitoring event to ensure that a significant number of post-construction monitoring events occur within the first 10 years following construction. Vegetation will be monitored every year to ensure survival of plants and plant communities. Photo and visual inspection surveys will be conducted on an annual basis. CTUIR, ODFW, and GRMW are responsible for monitoring activities associated with the project.

BASELINE SURVEY

An existing conditions survey has been completed on the existing channel to determine the pre-project conditions of the described reach. The survey included a longitudinal profile, pool quantity and dimensions survey, cross-sectional profiles in varying habitat units, pebble counts, a large wood survey, temperature monitoring, and percent shade determination. Baseline conditions will be used as benchmarks for restoration accomplishments.

Field data collection occurred in 2014, 2016, 2017, and 2019 to characterize and survey the existing stream corridor and floodplain conditions. Data collection included longitudinal profile and cross-section surveys of the existing channel and topographic surveys of the valley bottom and floodplain areas. Surveys were completed with survey-grade GPS system including the establishment of project control points to georeference the project site. Survey included channel cross-sections, profiles, and general channel characteristics. Additional features, changes in floodplain topography, habitat features and infrastructure (including groundwater wells), were located to further characterize the project reach.

Multiple cross-sections, top of bank lines, bankfull stage indicators, thalweg, and water surface elevations and representative channel features were surveyed throughout the existing active channel and adjacent floodplain. The longitudinal profile extended from the top of the project reach to the bottom. The profile included consistent measurement of left and right channel bankfull indicators, channel thalweg, and water surface elevations at select locations along the profile typically at delineated channel habitat units (e.g., riffles). Pebble counts were collected through the existing channel to characterize bed material characteristics (Wolman 1954) as well as to complement hydraulic and sediment incipient motion modeling.

AS-BUILT SURVEY

Immediately upon completion of the new channel construction, an as-built survey that follows the same parameters as those listed above in the baseline survey will be completed for the constructed channel alignment. Monumented cross-sections will be established throughout the reach and surveyed to determine channel dimensions. A longitudinal profile will be completed to determine channel length, sinuosity, and gradient. Pebble counts will be completed at a minimum of three selected riffle cross-sections. Large wood will be tallied and tagged, and notes will be recorded about the configuration of the wood and the percent within the bankfull channel. Percent shade will be estimated and recorded at each of the monumented cross-sections. Thermographs will be deployed at the top and bottom ends of the reach and will record temperature data continuously. Full protocol of monitoring methods is provided in Section 5.6 of this document.

MONITORING SITE LAYOUT

Following construction and completion of the as-built survey, the following methodology will be used to establish the baseline monitoring condition, which will then be used as the foundation for the bankfull survey and future surveys (see below).

1. The total site length will be measured following the center of the channel from the downstream end of the constructed reach to the upstream tie-in point with the existing channel alignment. The constructed reach length is then divided by the number of cross-sections to determine the distance between established cross-sections. This distance should then be divided in half to determine the location of the first monumented cross-section.
2. Cross-section locations should be marked at each distance moving upstream with flagging tape and labeled sequentially (e.g., XS1, XS2, XS3).
3. Any pools that are encountered moving upstream should also be marked with flagging tape, and labeled sequentially (e.g., Pool 1, Pool 2).
4. Identify and mark the riffles selected in the reach as a pebble count locations.
5. After the cross-section locations are established, monument each cross-section by driving rebar into the ground on both right and left banks perpendicular to the bankfull channel and above the bankfull elevation.

POST-BANKFULL EVENT SURVEY

Upon project completion and in accordance with the monitoring site layout plan, when the Longley Meadows Fish Habitat Enhancement Project experiences a bankfull (1.25-year) or greater event, surveys will be performed.

FUTURE SURVEY (RELATED TO FLOW EVENT)

After the bankfull survey occurs as outlined in the Monitoring Site Layout section, if no significant changes that require corrective action are detected, then the next survey will take place after a 5-year flood event. If changes that require corrective actions are detected during the bankfull survey, then monitoring surveys will continue to occur after each bankfull event until no corrective action is necessary. As a contingency, monitoring surveys will be scheduled for every fifth year after construction to ensure that at least three surveys are completed in the first 10 years following construction. Monitoring will cease after 10 calendar years from the date of project construction or as mutually agreed upon by the project review team.

6.6 MONITORING TECHNIQUE PROTOCOLS

The following section outlines the field methods that will be used to perform the above described monitoring surveys. This section is largely developed from the field techniques described in the established monitoring protocols described in Table 5-1.

PHOTO DOCUMENTATION AND VISUAL INSPECTION

To track the general project trend and changes over time, visual inspections, including photo points, will be an annual part of the monitoring plan. The following protocol will be used annually for photo documentation:

1. The site will be photographed at the start and end of the reach, and at each monumented cross-section each year during a period of lowest flow.
2. Standing on the left bank at each monumented cross-section, take a photo looking upstream, looking downstream, and across the cross-section.
3. Establish several photo points at high points along the ridge and mark them with rebar and flagging and save a GPS point of the location. Take at least one photo looking up valley and one photo looking down valley from each of these locations. See Figure 6-1 for a map of these established photo monitoring sites.
4. Anecdotal observations of fish and wildlife presence, habitat feature utilization, and other qualitative assessments of site condition will be recorded and included within the monitoring report as relevant.

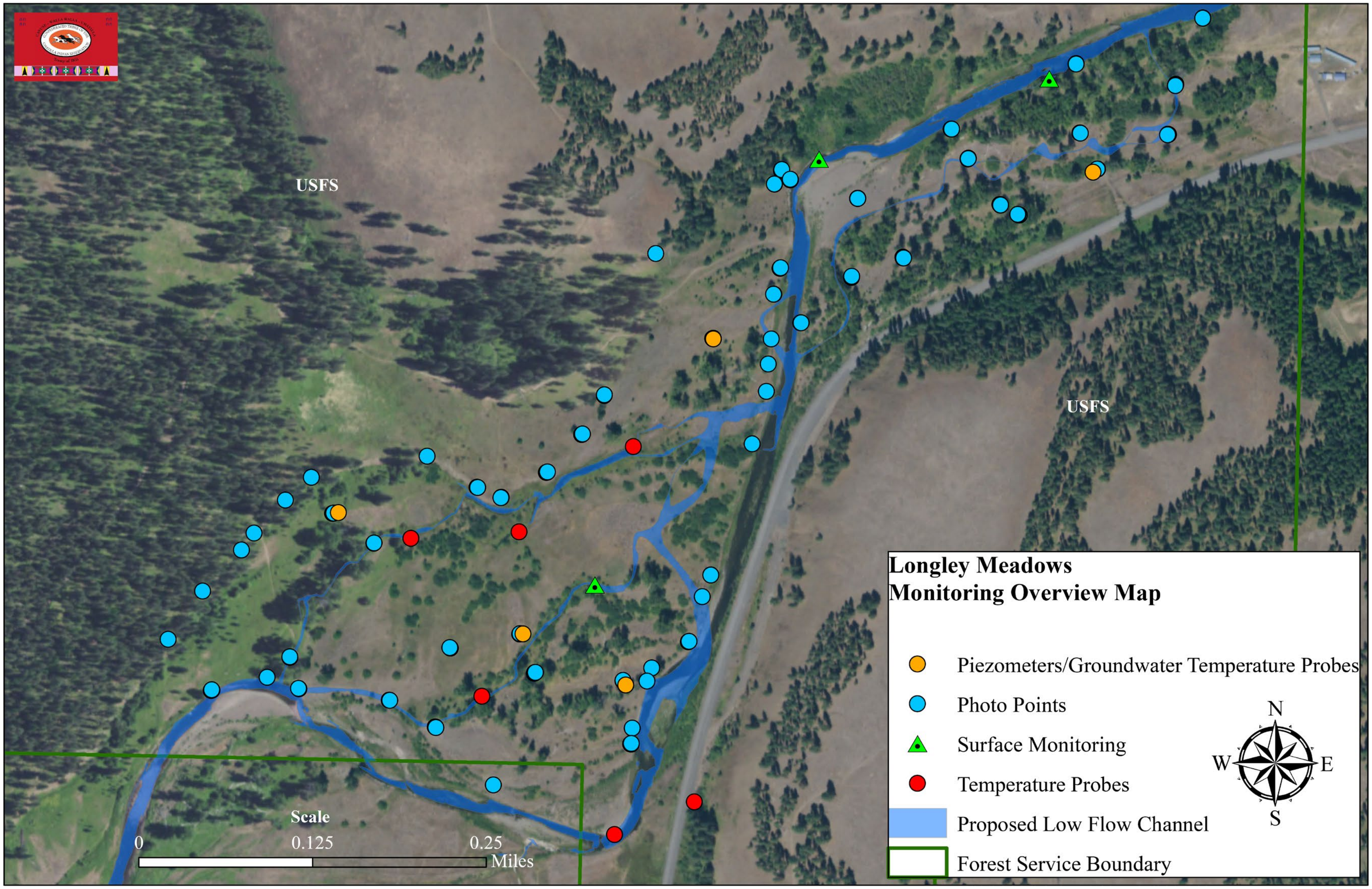


Figure 6-1 | Photo Monitoring Locations for the Longley Meadows Fish Habitat Enhancement Project

LONGITUDINAL PROFILE

Channel length, sinuosity, and gradient are parameters that can be analyzed through a longitudinal profile survey. Because length, sinuosity, and gradient are not independent variables, any of the three can be used to indicate a change in channel stability or function.

Sinuosity characterizes the maintenance of channel form. Sinuosity will be assessed via longitudinal survey as described below. Monitoring data results outside the desired range will result in a site assessment and evaluation of potential maintenance actions.

1. A longitudinal profile will be completed from the downstream end of the constructed channel to the upstream tie-in point within the existing channel alignment.
2. The profile should capture all significant slope breaks and habitat unit delineations along the channel bed.
3. Points should be taken along the thalweg and should adequately capture the sinuosity and topography of the channel. Maximum distance between any two points should not exceed 50 feet.
4. All pools flagged during site layout will have a minimum of three shots taken. A point will be collected at the pool tail crest, the maximum depth of the pool, and the pool head. Label these pools with the number of the pool determined during site layout (e.g., PT 1, PM 1, PH1). These points will be used to calculate residual pool depth.
5. All off channel ponds will have a minimum of two points collected. A point will be collected at the deepest point of the pond, and at the water surface of the pond. Note whether the pond is connected to the main channel.

HABITAT SURVEY

LARGE WOOD STRUCTURE STABILITY

Large wood structure stability is critical to maintain pool scour, hydraulic roughness for velocity reduction, and bankline resiliency. A 75% to 125% retention in large wood per structure indicates that the structure is largely functional while allowing for a level of geomorphic deformity. Displaced large wood is expected to persist and provide habitat benefits in the project area based on large wood size and shape relative to channel characteristics. Monitoring data results below this threshold will result in a site assessment and evaluation of potential maintenance actions.

SUBSTRATE SIZE (PEBBLE COUNTS)

1. Substrate will be measured at each of the selected cross-section locations.
2. 10 substrate particles will be measured at each transect. Measure the bankfull width and divide by the number by 11 to obtain the sampling locations within the bankfull channel.
3. Standing at left bank, move to the first sampling location and bring a measuring stick lightly down to touch the substrate. Reach down to the tip of the measuring stick and pick up the first substrate that you touch with the tip of your finger.
4. Measure the substrate along the intermediate axis with a measuring stick and record to the nearest millimeter. Classify anything smaller than 2 mm as silt or sand.

RESIDUAL POOL DEPTH

Residual pool depth is an indicator of pool quality in providing fish habitat. A residual pool depth that does not meet the desired condition indicates loss of pool volume due to deposition/lack of maintaining pool scour. Residual pool depth will be assessed via longitudinal profile survey as described in Section 5.6 above.

UAV IMAGERY

Vegetation establishment is critical to channel stability and providing shade to improve stream temperatures and cover for wildlife habitat. Greater than 85% survival of transplants/container plantings and 60% survival of cuttings is indicative of providing site condition conducive to establishment and colonization by native plants. To document survival by the plantings and natural establishment of native species within the restoration site over time, percent area covered by target plant community will be mapped and compared using unmanned aerial vehicle (UAV) imagery from low altitude. The imagery will be flown in the summer once leaf-out has occurred, and will be flown at approximately the same time each year. Plant communities will be digitized and mapped in geographic information system (GIS) on the aerial imagery, and the percent change in cover by the target plant communities will be compared to the pre-project condition and over time. The desired condition is 60% cover after 5 years and 75% cover 10 years after construction in the restoration area.

LINE-INTERCEPT (PERCENT COVER)

The line-intercept sampling method provides a relatively rapid quantification of relative cover by dominant and sub-dominant species and age structure (Scott and Reynolds 2007). The line-intercept surveys will occur along the topographic cross-sections (minimum 10 cross sections), which will extend across the floodplain on both left and right banks, to document vegetation composition and structure in relation to the stream channels and geomorphic surface. Cover by size class of woody shrub and tree species will be collected as part of the survey to provide an index of stand structural diversity over time. Size classes will be identified as: seedling, pole, or overstory. Cover is calculated as the proportion of the total length of the cross-section. The desired condition is 60% cover with a diverse age structure after 5 years and 75% cover 10 years after construction in the restoration area.

CHANNEL AND FLOODPLAIN CROSS-SECTIONS

The channel and floodplain cross-sections will be used primarily to determine the average riffle width to depth ratio and the cross-sectional area to determine the connectivity between the stream and floodplain. A width to depth ratio of greater than 20 suggests aggradation, which could cause increased shear stress. A width to depth ratio less than 12 suggests channel incision and decreased floodplain connectivity. Cross-sectional area is a robust measure of channel incision or aggradation, which can result in disconnection of the channel from the floodplain in the case of incision, or avulsion in the case of aggradation. An increase or decrease of channel cross-sectional area of more than 20% on average for all cross-sections may indicate broader channel stability issues. Width to depth ratios and cross-sectional areas will be assessed via cross-section profiles as described above in Section 5.5. Monitoring data results outside the desired range will result in a site assessment and evaluation of potential maintenance actions.

The following protocol will be used to determine the riffle width to depth ratio and cross-sectional area:

1. A detailed cross-section profile will be collected at each of the monumented cross-sections.
2. Starting at the left bank, collect enough points to capture any significant slope breaks in the channel profile. Points to include besides slope breaks are left and right caps on rebar, left and right bankfull, left and right wetted edge, and the thalweg.
3. The maximum distance between any two points should not exceed 10% of the bankfull width.

GROUNDWATER WELLS

Five groundwater monitoring wells were installed throughout the floodplain in October 2017 containing data loggers recording hourly water level data. Each monitoring well location was surveyed and tied to current project site benchmarks. Corresponding stream surface water level measurements were also surveyed at locations perpendicular to the existing monitoring well locations to evaluate the relationship between surface water level and groundwater level at equal elevations. Water surface level measurements are taken periodically throughout the full range of river stages (approximately every 3 months).

THERMOGRAPHS (TEMPERATURE MONITORING PROBES)

1. Thermographs have been deployed at the top and bottom of the constructed reach.

2. A number of thermographs have been deployed in off-channel ponds/side channels.

3. Thermographs are secured in a steel pipe or polyvinyl chloride (PVC) housing and connected to a permanent anchor point such as a tree with a length of steel cable.

4. Thermographs have been placed in areas of deep flowing water, typically in the thalweg or other areas that ensure the thermograph remains underwater throughout the summer. Thermographs installed in PVC housing are epoxyed (below the water surface) on large boulders.

5. Thermographs are calibrated using a National Institute of Standards and Technology (NIST)–approved thermometer, and the water temperature, date, and time of day are recorded when the thermograph begins logging.

6. Thermographs have been geo-referenced with GPS by collecting the coordinates of the thermograph locations.

7. Thermographs are downloaded three to four times per year. During the download procedure, water temperature, date, and time of day are recorded when the thermograph ends logging and is removed from the water. A NIST-approved thermometer will collect water temperatures.

FISH PASSAGE

Upstream and downstream fish passage through the reach is critical to the success of the project. Headcutting of the newly constructed channel has the potential to create hydraulic drops that exceed statewide standards for fish passage for both juvenile and adult salmonids. If unnatural barriers of greater than 6 inches are present within the reach at the time of the survey, a site assessment and evaluation of potential maintenance actions will occur.

6.7 DATA STORAGE AND ANALYSIS

DATA STORAGE

Monitoring data will be stored and maintained by CTUIR, ODFW, and GRMW. Data will be maintained in standard database(s), and will be made available to the project review team within 30 days of such a request. Data tables will be normalized to avoid redundant data structures and to ensure consistent data formats among sampling events.

DATA ANALYSIS AND REPORTING

Photo documentation and visual inspection, along with vegetation survey data, will be analyzed annually; however, a monitoring report will not be required. Following a bankfull or 5-year event, a monitoring report will be generated to summarize the findings of a complete monitoring survey. CTUIR, ODFW, and GRMW will prepare a monitoring report that includes:

- Summary of metrics for which data were collected;
- Deviations from established methods and protocols used to collect data;

- Tabular and graphical summaries of results;
- Narrative discussions to explain results in the context of project goals, success criteria, and performance standards; and
- Any recommended actions.

These reports will be submitted to the project review team for review and comment on or before October 1. If significant issues or concerns are identified, CTUIR, ODFW, and GRMW will convene the project review team to discuss any comments, recommendation, and future actions at the sites.

6.8 MONITORING QUALITY ASSURANCE PLAN

To ensure the quality of the monitoring program, CTUIR, ODFW, and GRMW will meet post project construction and agree upon the roles and responsibilities to ensure implementation of the monitoring program as well as the quality assurance (QA) and control (QC) procedures. QA and QC procedures will be applied to the following aspects of the monitoring plan:

1. Data collection
2. Data storage
3. Data analysis and reporting

The designated monitoring program manager will be responsible for QA.

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8 APPENDICES

8.1 FINAL PROJECT PLAN SHEETS

The Longley Meadows Fish Habitat Enhancement Project final design drawings are included in Appendix 8.1.

UPDATED PLANTING PLAN

An updated revegetation/planting plan is included in the final plan set on pages 93 to 94 (Appendix 8.1).

8.2 OTHER SUPPORTING REPORTS: HYDRAULIC MODELING STUDY

The updated detailed hydraulic modeling study reflecting the final design is provided in Appendix 8.2.

8.3 OTHER SUPPORTING REPORTS: HYDROLOGIC ANALYSIS

The hydrologic analysis report is provided in Appendix 8.3.

8.4 OTHER SUPPORTING DOCUMENTS: SEDIMENT TRANSPORT ANALYSIS

The sediment transport analysis is provided in Appendix 8.4.

8.5 OTHER SUPPORTING REPORTS: LARGE WOODY MATERIAL RISK ASSESSMENT

The LWM risk-based design documentation is included as Appendix 8.5. Stability calculations were performed and results are provided in this document.

8.6 OTHER SUPPORTING DOCUMENTS: WATER BYPASS PLAN

The Water Bypass Plan is included in Appendix 8.6 and provides additional details regarding the bypass of water during construction and fish rescue plan.

8.7 OTHER SUPPORTING DOCUMENTS: HABITAT SUITABILITY INDEX ANALYSIS

The Habitat Suitability Index Memorandum is included in Appendix 8.7.

8.8 OTHER SUPPORTING DOCUMENTS: HIP REVIEW COMMENTS AND RESPONSES

Comments from BPA and NMFS were received on the 30% design submittal. The project team reviewed these comments and included them in Appendix 8.8. Additionally the project team has responded to the comments and where appropriate incorporated changes into the 80% design submittal.

There were no comments received on the 80% submittal and thus ended BPA's HIP III review process.

8.9 OTHER SUPPORTING DOCUMENTS: ENVIRONMENTAL COMPLIANCE AND PERMITTING

The Final EA, Correction Notice, and Decision Notice from the USFS as well as BPA's FONSI regarding NEPA coverage are both included in Appendix 8.9. The Section 106 consultation and concurrence email is also provide in Appendix 8.9. Other federal and state permits, which include the USACE CWA permit (included as part of RG-6), the DSL Removal-Fill permit, and the ODOT temporary highway approach permit, can all be found in Appendix 8.9 as well.

8.10 OTHER SUPPORTING DOCUMENTS: HIP III COMPLIANCE

BPA's HIP III BiOP approval is provided in Appendix 8.10. Further discussion regarding the ESA Section 7 consultation can be found in Section 5.4.

8.11 OTHER SUPPORTING DOCUMENTS: UNION COUNTY FLOODPLAIN HYDRAULIC ANALYSIS

Reclamation's technical memorandum to Union County is provided in Appendix 8.11. Further discussion regarding the ESA Section 7 consultation can be found in Section 5.4.

APPENDIX 8.1

Final Project Plans
(see Plan Set)

APPENDIX 8.2

Hydraulic Modeling Study

APPENDIX 8.3

Hydrologic Analysis Report

APPENDIX 8.4

Sediment Transport Analysis

APPENDIX 8.5

LWM Risk Based Design Documentation

APPENDIX 8.6

Water Bypass Plan

APPENDIX 8.7

Habitat Suitability Index (HSI) Analysis

APPENDIX 8.8

HIP Comment and Response Table (From 30%)

APPENDIX 8.9

Environmental Compliance and Permitting

APPENDIX 8.10

HIP III Compliance

APPENDIX 8.11

Union County Floodplain Hydraulic Analysis