CTUIR TUCANNON BASIN FISH HABITAT ENHANCEMENT PROJECT
2019-2020 BIANNUAL REPORT

A Columbia River Basin Fish Habitat Project

Report covers work performed from: April 1, 2019 to March 31, 2021

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CONFEDERATED TRIBES UMATILLA INDIAN RESERVATION

BONNEVILLE POWER ADMINISTRATION

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Introduction

The Confederated Tribes of the Umatilla Indian Reservation (CTUIR), Tucannon Basin Fish Habitat Enhancement Project was initiated by the CTUIR in 2008 to protect, enhance, and restore floodplain and instream habitat for natural production of anadromous salmonids in the Tucannon River Subbasin. The Tucannon Basin Fish Habitat Enhancement Project (Project) is coordinated with the Tucannon Habitat Programmatic (Program) and its partners: Snake River Salmon Recovery Board (SRSRB), Nez Perce Tribe (NPT), Columbia Conservation District (CCD), Pomeroy Conservation District (PCD), Washington Fish and Wildlife Department (WDFW) and U.S. Forest Service (USFS). These agencies work together with public and private landowners to enhance riverine fish habitats for focal species, including spring Chinook salmon, summer steelhead, bull trout, resident trout and other native species. Emphasis in the Tucannon Sub-basin is on improving juvenile winter rearing habitat and summer adult holding/spawning habitat by restoring floodplain connectivity and channel complexity necessary for all life histories of these species.

During the fiscal year FY19 and FY 20 (April 1, 2019-March 31, 2021), the Tucannon Project was involved in multiple project planning processes and instream restoration projects in the Tucannon Sub-basin. The Tucannon Accords Project (2008-202-00) works closely with the Tucannon Habitat Programmatic (2010-077-00) to complete Sub-basin restoration project review, restoration project design, instream project permitting, purchase of project materials and restoration project construction. The Tucannon Project coordinates closely with regional planning entities including: Snake River Salmon Recovery Board (SRSRB), Lead Entity (LE) and Regional Technical Team (RTT). Tucannon River restoration projects are thoroughly vetted by all Program members during the design phase, and instream restoration projects are coordinated through the Program before initiation and completion. The CTUIR Tucannon Project runs on a lean budget with 2 FTE, making coordination with other partners necessary to complete the restoration work in the Tucannon Sub-basin.

During the reporting period, the Tucannon Project focused on the following projects listed in Table 1. CTUIR Project specific work is identified under sponsor, and in general Tucannon Project dollars are used to pay salary, administrative, and design costs, while Tucannon Program dollars are used to fund the materials and construction of instream projects. In the Tucannon all Program partners work closely together on project design and often help each other during project construction. The purpose of the Tucannon Program table (Table 1) is to show the coordination and to identify the projects in-the-works during this reporting period.

Table 1. Tucannon Habitat Program work plan 2019-2023.

Project #	Sponsor	Implementation Year (FY)				
		FY19	FY20	FY21	FY22	FY23
PA 13	WDFW	Phase I	Phase II			
PA17/18	CTUIR	Design Phase II	Design Phase II		Phase II Construction	Phase II Construction
PA27/28.1	CTUIR	Design Phase 0.5	Construct Phase 0.5	Design/Construct Phase 1.0	Design/Construct Phase 2.0	Design/Construct Phase 3.0
PA 3	CTUIR	Adaptive Mgmt/Maintenance	Adaptive Mgmt/Maintenance			

Tucannon LiDAR	CTUIR		Data Collection	Data Analysis	Data Analysis/Final Report	
Tucannon Website/Webmap	CTUIR and Program Partners	Website development	Website development	Website/Webmap Rollout		
Tucannon CDMS Database	CTUIR and Program Partners		Database Development	Metrics Development	Standardized Reports	Rapid Habitat Data Analysis and Reporting
Little Tucannon Bridge	CTUIR/USFS		Concept development	Conceptual Design	Design Phase I	Phase I
Tumalum Culvert	NPT	Design	Design		Implement	
PA26	CCD			Phase II		Phase III
PA34.1 & 34.2	CCD	Concept Design	Final Design	Phase I	Phase II	
Tucannon Conceptual Restoration Plan Update	CCD and Program Partners	Conceptual Plan Development	Conceptual Plan Completion	Final Draft of 2021 Plan		

During 2019 and 2020, CTUIR Tucannon Project specific work included:
1) Project Area 17/18 Phase 1 construction completed in 2017, Phase 1 planting was on going through FY19 and FY20. Phase 2 private landowner coordination, planning and design through FY20/21, and Phase 3 WDFW property above the private homes, planning and design through FY20/21,
2) Project Area 27/28.1 Phase 0.5 project planning, design, and implementation (completed summer 2020), Phase 1 project planning, design, and implementation (summer 2021 restoration construction),
3) red and green bathymetric LiDAR acquisition in FY 20, with LiDAR Analysis and Report completed in FY 21,
4) Project Area 3 adaptive management, and ongoing maintenance,
5) Tucannon Website and Webmap development,
6) Tucannon CDMS Database development,
7) Little Tucannon Bridge redesign with USFS, after mass wasting event flooded the existing bridge in FY20, with the USFS Stream Team and BPA engineers to design a new solution.

Tucannon Program sponsors work together in varying degrees to complete the work necessary to make incremental changes to habitat in the Tucannon Sub-basin (see Table 1). It is through this partnership, working on public and private lands, that progress towards Tucannon salmon habitat improvement is achieved. Teamwork and collaboration with project sponsors is what enables the Program to make significant improvements with a relatively small number of FTE.

Project effectiveness monitoring in the Tucannon Sub-basin is conducted in collaboration with the Tucannon Programmatic, CTUIR Tucannon Basin Fish Habitat Enhancement Project, the CTUIR Biomonitoring Program, and the WDFW fish monitoring program. Information and data collection included photo points, water temperature, groundwater, Rapid Habitat Surveys (geomorphic and instream habitat), and fish in/out monitoring.

Background

CTUIR Natural Resource Management Philosophy and Salmon Recovery

Since time immemorial the CTUIR has relied on sustainable populations of salmon and steelhead in the Tucannon River. When the leaders of the Walla Walla, Cayuse, and Umatilla peoples (CTUIR) signed the Treaty of Walla Walla in 1855, they ceded 6.4 million acres (26,000 km^2) of their homeland that is now northeastern Oregon and southeastern Washington, in exchange for a reservation of 254,699 acres. Through this agreement, Tribal members retained their treaty rights to harvest traditional foods, including salmon, within their "usual and accustomed" territory. The Tucannon River, located in southeast Washington State, is within the "usual and accustomed" or ceded territory of the CTUIR.

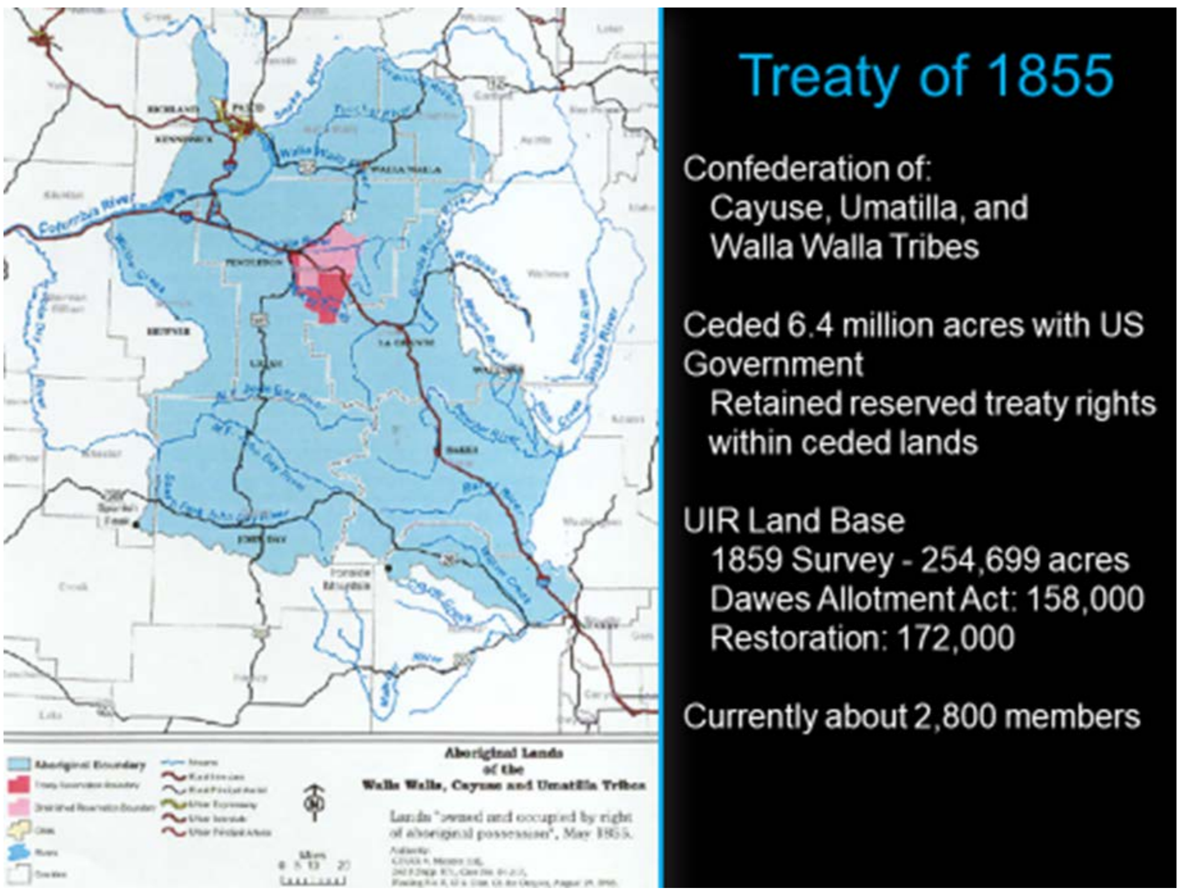


Figure 1: CTUIR Treaty of 1855. Ceded 6.4 million acres with the US Government.

In 2007, the CTUIR Department of Natural Resources (DNR) established the First Foods Policy to guide and inform CTUIR's natural resource management (Figure 1).

Figure 2: First Foods Policy organizes the CTUIR Department of Natural Resources according to five categories of traditional CTUIR subsistence foods. For each of the five categories of First Foods a program has been developed within the CTUIR DNR and is linked to the CTUIR Treaty Rights. For example, the CTUIR fisheries program manages aquatic biota (salmonids and other organisms) that are important to CTUIR members.

The First Foods are considered by the CTUIR as naturally occurring plants and animals necessary to sustain the CTUIR and their culture. These traditional subsistence foods were provided by the Creator throughout the year as depicted in Figure 2 below.

Figure 3: First Foods pictograph showing the seasonality of the traditional substance foods. A healthy functioning ecosystem provides plants and animals necessary for the CTUIR to sustain their culture during all months and seasons of the year.

The CTUIR DNR has a mission of providing sustainable harvest opportunities for aquatic species of the first food order by protecting, conserving and restoring native aquatic populations and their habitats for the Tribal community. The First Foods mission was developed in response to long-standing community First Foods traditions, and community member requests that all First Foods be protected and restored for their traditional use now and in the future.

The CTUIR First Foods Policy led to the creation of the CTUIR River Vision guidance document in 2008 (Jones et. al, 2008). River Vision identifies a healthy river capable of providing First Foods that sustain the continuity of the Tribe’s culture. River Vision requires a river that is dynamic, and shaped not only by physical and biological processes, but also by the interactions and interconnections between those natural processes necessary to sustain aquatic First Foods. CTUIR Fisheries Habitat Program staff use River Vision to prioritize and inform fish habitat restoration objectives, and guide project development, providing an all-inclusive vision of river restoration which focuses on returning floodplains to their rivers. River Vision guides CTUIR fisheries habitat enhancement projects throughout the five Sub-basins in the CTUIR’s “usual and accustomed” or ceded territory.

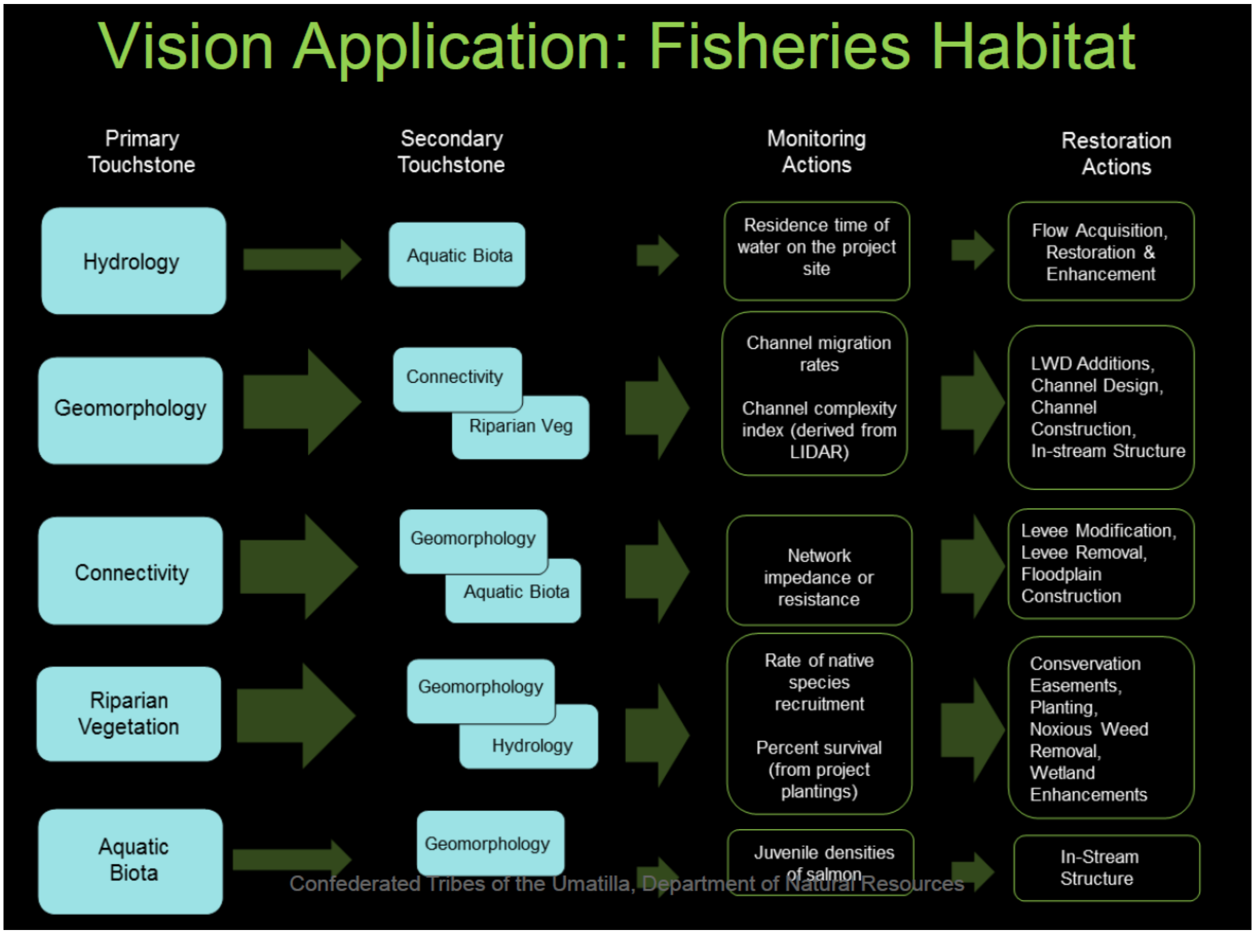


Figure 3: River Vision outlines five fundamental components or ecological "touchstones" of rivers that facilitate the sustained production of aquatic substance First Foods. The goal for all CTUIR fish habitat enhancement projects is to address all five of the River Vision touchstones for any given restoration treatment.

The CTUIR's Tucannon Basin Fish Habitat Enhancement Project (Project) was initiated by CTUIR and BPA in August of 2008. The goal of the Tucannon Project is to collaborate with federal, state, local land management agencies, while working closely with private landowners, using the River Vision guidance framework to design and implement salmon habitat restoration projects. Improving habitat conditions in the Tucannon River through the application of the CTUIR River Vision will eventually lead to an increase in abundance of ESA-listed salmonids returning to the Tucannon River.

Several local and regional documents have developed salmon recovery goals and objectives to guide aquatic habitat restoration on the Tucannon River. Habitat limiting factors for Tucannon River salmonids were first established through the Tucannon Model Watershed, and then again in the Tucannon Sub-basin Plan (CCD, 2004) and the Snake River Salmon Recovery Plan (SRSRB, 2005&2011). Initial work conducted through the Model Watershed (between 1997-2008) was opportunistic in nature. In 2009 the CCD brought together all of the restoration agencies in the Tucannon Sub-basin to begin work on a new restoration strategy. This document, the Tucannon River Geomorphic Assessment and Habitat Restoration Study (2011 Plan) (Anchor QEA, 2011) identified and prioritized stream restoration reaches and restoration actions that would best improve habitat for salmonids.

The 2011 plan explicitly incorporates salmon and steelhead life-history characteristics and site-specific physical, hydrologic and geomorphic conditions. The assessment of physical conditions and geomorphic processes from the 2011 Plan focused on high-priority areas for spring Chinook in the Tucannon River. Summer adult holding habitat and creation of spawning habitat were a focus of the 2011 Plan.

Major limiting factors influencing and degrading naturally functioning habitat conditions throughout the project areas proposed for treatment, include:

- Reduced and or limited floodplain connectivity due to channel modification, stream bank armoring, and placement of infrastructure associated with past land management practices such as logging, grazing, and agriculture. Construction of the Tucannon Lakes has further limited floodplain connectivity.
- Recent forest fires in the headwaters, have worked collectively to create an over-simplified stream channel with drastically reduced productivity, abundance and sustainability for spring Chinook populations in the Tucannon River.
- Artificial channel confinement (levees, lakes, roads) and straightening (pushing the channel to the valley wall) has increased stream velocities, increased channel incision, reduced floodplain connectivity, and reduced pool habitat. These factors combined to decrease quality habitat for adult and juvenile spring and fall Chinook salmon, steelhead, and bull trout, leaving these unique populations at risk.

In 2018 the Tucannon Programmatic and the CCD initiated an effort to update to the 2011 Plan. The purpose of the plan update (2021 Plan) is to incorporate the updated body of knowledge gained from the last decade of restoration activities on the Tucannon River (2011-2021). In 2019, after 8-years of implementing the 2011 Plan, WDFW conducted a salmonid survival study (WDFW, 2019). Results of the 2019 WDFW study suggested to implementers that habitat restoration efforts for spring Chinook needed to move further down the watershed, and target limiting factors constraining juvenile winter rearing habitat in the lower river. The 2021 Plan (Anchor QEA, 2021) reflects this new understanding by refocusing restoration efforts to include the lower Tucannon River, from river mile 20 downstream to the confluence of the Snake River.

The 2021 Plan (Anchor QEA, 2021) continues to prioritize projects into three Tiers (1-3), based on revised prioritization goals:
(1) increased channel complexity at low-winter flows (120 cfs),
(2) increased channel complexity during spring and winter peak flows (300 cfs),
(3) re-connection of disconnected and abandoned floodplains at 1 year return interval (552 cfs),
(4) improved quantity and quality of pools across all flows, and
(5) increased retention and storage of in-channel bed-load sediments.

With these newly refocused goals and objectives, Program implementers now select project areas in the Tucannon River that emphasize floodplain connectivity and channel complexity for all life histories of Tucannon spring and fall Chinook, summer steelhead, and bull trout, throughout the watershed.

Native Aquatic Biota of the Tucannon River

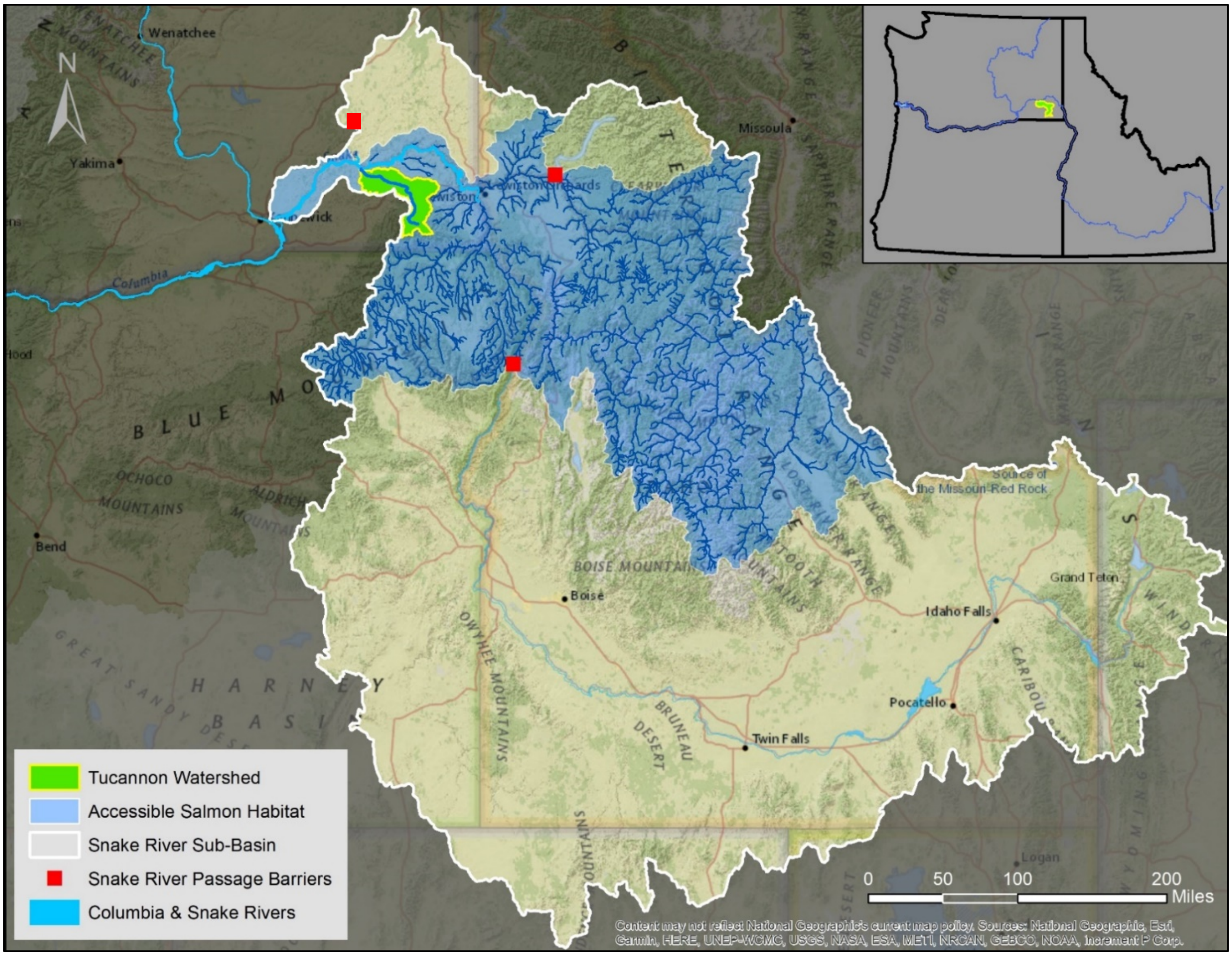


Figure 4: Geographic context of the Tucannon watershed and anadromous salmonid extent in the Snake River Sub-basin. Much of the remaining salmonid habitat in the Snake River Sub-basin is in protected wilderness. There are no significant salmon-bearing streams that occur downstream of the Tucannon River in the Snake River Sub-basin.

Both the Snake River Spring Chinook Salmon ESU and the Snake River Steelhead DPS each consist of one Major Population Group within the Tucannon River (Lower Snake MPG) and were prioritized in the Tucannon Sub-basin Plan (2004) and the Salmon Recovery Plan for Southeast Washington (SRSRB 2005, SRSRB 2011). The Sub-basin Plan focused on species with life histories represented in the basin, ESA status, cultural importance, and the level of information available. Spring Chinook were prioritized within the Tucannon Sub-basin based on the priority identified and derived from the 2008 BiOp.

Historically Chinook salmon runs in the Snake River were estimated to be more than a million fish (Matthews and Waples, 1991; National Marine Fisheries Service, 2017). But Snake River ESU Chinook populations declined throughout the 20th century and reached a critical low in the 1990s, when the number of wild adult Chinook in the Tucannon River declined to less than 200 adult fish. Due to these low numbers, in April 1992, Snake River ESU spring Chinook in the Tucannon River were listed as threatened under the Endangered Species Act.

The Tucannon watershed supports the only remaining population of spring Chinook (*Oncorhynchus tshawytscha*) in the lower Snake River. The Ecosystem Diagnosis and Treatment (EDT) model developed for the Tucannon Sub-basin Plan (2004), and the Salmon Recovery Plan for Southeast Washington (SRSRB 2011), both supported estimates of historical conditions that produced a mean returning population of over 12,000 adult Chinook and more than 26,000 adult steelhead annually in the Tucannon River. The Sub-basin now only produces a few hundred adults of each species per year. The basin also supports summer steelhead, fall Chinook, and bull trout which are also protected under ESA.

The Tucannon River is one of the lowest remaining spring Chinook spawning tributaries in the Snake River. The Snake River is one of the most important watersheds for Chinook salmon (Oncorhynchus tshawytscha) in the Upper Columbia Basin (Figure 4). This is due to the abundant, high quality salmonid habitat remaining in the watershed and the fact that a large percentage of available habitat remains undeveloped and relitively intact.

As mentioned earlier in this document, restoration planning and implementation in the Tucannon Sub-basin have been guided by the *Tucannon River Geomorphic Assessment & Habitat Restoration Study* (2011 Plan) over the past ten years of salmon habitat restoration efforts. The restoration strategies and recommendations for each of the delineated reaches or “Projects Areas” identified in the 2011 Plan were based on the *habitat limiting factors* identified in the Tucannon Sub-basin Plan (CCD, 2004) and Snake River Salmon Recovery Plan for Southeast Washington (SRSRB, 2005 & 2011). The 2011 Plan explicitly incorporates salmon and steelhead life-history characteristics and site-specific physical, hydrologic, and geomorphic conditions.

After 8-years of experience implementing this initial strategy, an update to the earlier 2011 Plan was initiated in 2018, and is now complete. Anchor QEA worked with Tucannon Programmatic partners and the Regional Technical Team (together = “the development team”) to develop methodologies and provide analytical assistance. The analysis conducted for the 2021 Plan characterizes the geomorphic conditions of the Tucannon River using key parameters selected by the development team: channel and floodplain connectivity, channel complexity, excess transport capacity, in-channel (LWD) structure and pool frequency.

The revised 2021 Plan for the Tucannon River establishes a conceptual plan for treatment and analysis of four of these parameters: (1) floodplain connectivity, (2) channel complexity, (3) excess transport capacity, and (4) pool frequency.

Physical Geography of the Tucannon River

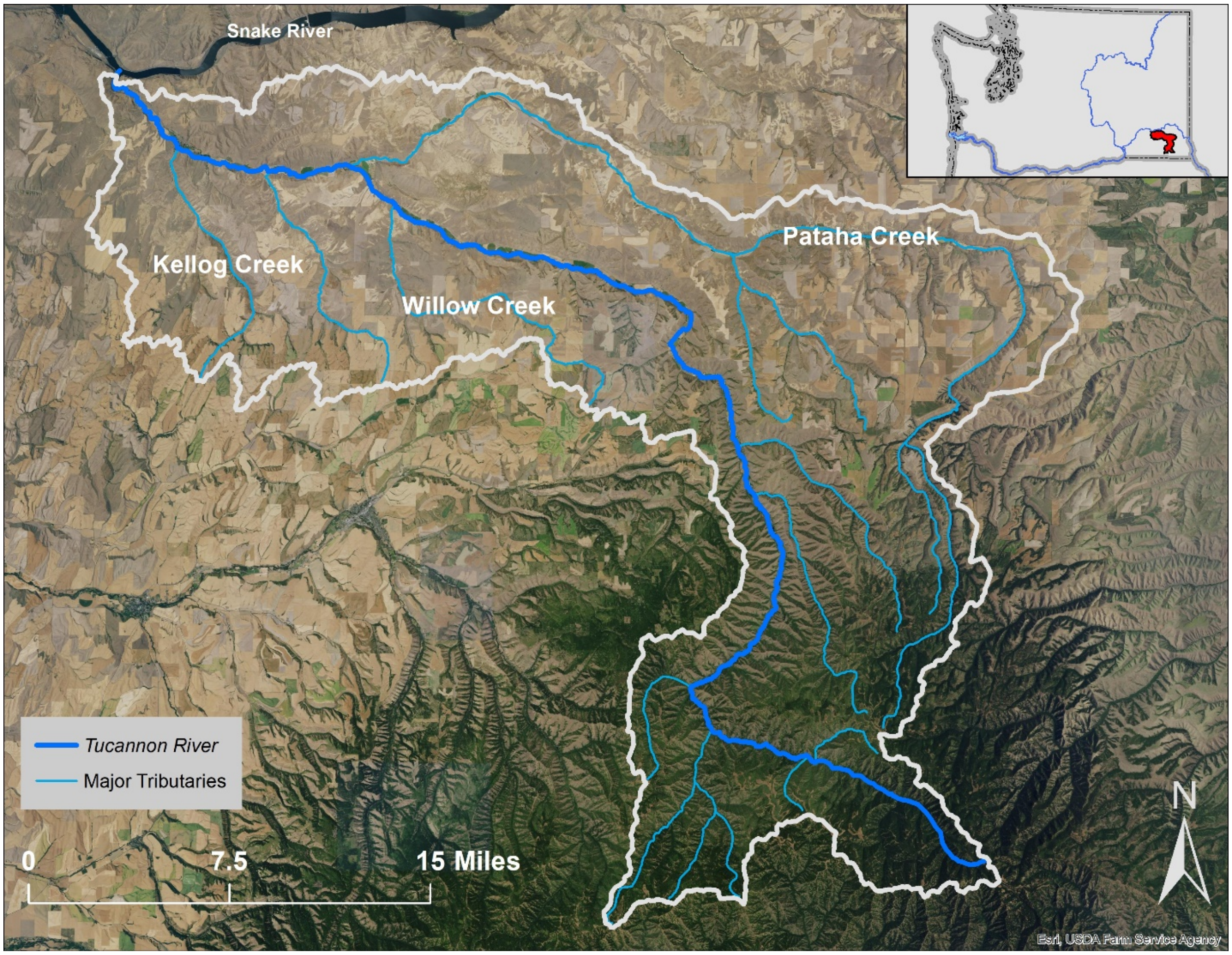


Figure 5: Map depicting the physical geography of the Tucannon River. The headwaters of the Tucannon are located at the extreme southern end of the watershed. The Tucannon River flows from the forested Blue Mountains in the south, transitions into the Palouse rangeland ecosystem, and joins the Snake River in the northwest corner of the watershed.

The geography of the Tucannon watershed is made up of a network of narrow, canyon-like valleys, each carved into Miocene-aged Columbia River Basalt flows that deposit alluvium along the valley floor forming alluvial fans. Throughout the mainstem Tucannon, alluvial fans are visible along the valley floor at the mouths of each tributary; the fans tend to be large and wide in locations where tributaries drain loess-dominated uplands, and small and narrow in basins where mainly bedrock is exposed.

The main channel of the Tucannon River is approximately 58 miles long and flows from the south, where its headwaters start in the Blue Mountains, to the north where it flows into the Snake River, draining a watershed area that is approximately 503 square miles (CCD, 2004). Several major tributaries drain into the main channel, the largest (by basin area) being Pataha Creek, which is approximately 52 miles in length with a long, narrow watershed draining 185 square miles. The second and third largest tributaries in the Tucannon Basin (by basin area) are Kellogg Creek (35 mi^2) and Willow Creek (30 mi^2).

The upper Tucannon watershed is located in the northern Blue Mountains with landcover predominated by conifer forest, and owned by the U.S. Forest Service. The lower half of the Tucannon watershed flows through semi-arid, wind-blown loess of the Palouse rangeland ecosystem, with landcover predominated by private agricultural uses such as farming and ranching.

Mean annual precipitation ranges from 10 inches at lower elevations to more than 40 inches in the high elevation headwaters. At higher elevations, much of the mean annual precipitation falls in the form of snow, with a basin mean annual snowfall of 65 inches (CCD, 2004). The basin experiences multiple unique discharge peaks throughout the water year - one peak typically occurs as the result of early winter storms and the other the result of spring snowmelt (Figure 6). For the period of record, 32 of the maximum annual discharges occurred in December, January, or February, while only 18 maximum annual discharges occurred in March, April, or May. The spring peak discharge is often similar in magnitude to the winter storm peak discharge, although with a much longer duration driven by the length of the spring snowmelt (Figure 6).

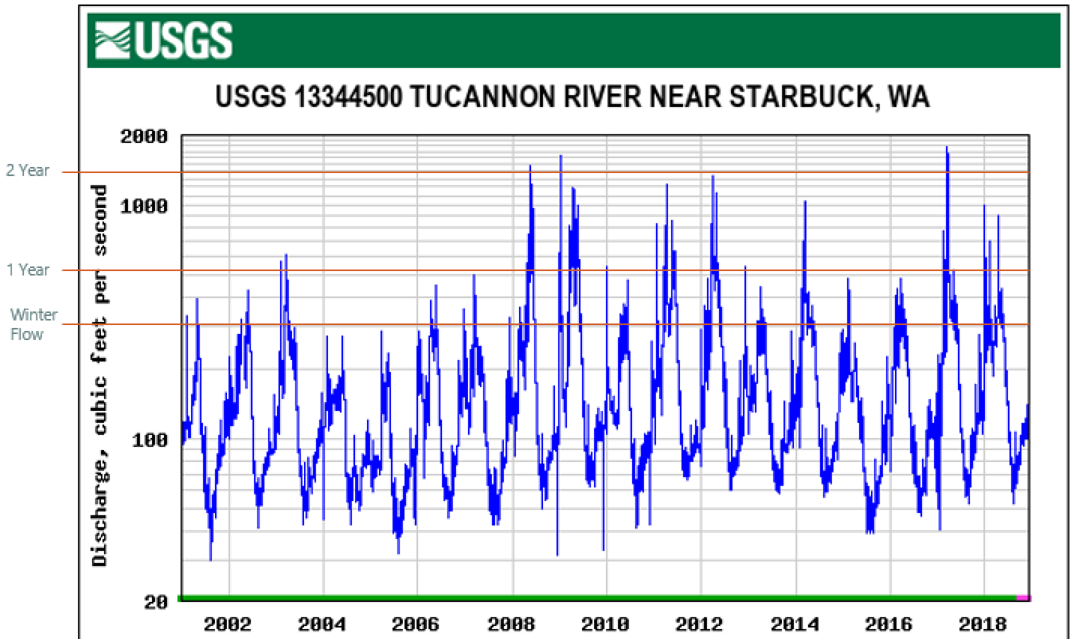


Figure 6: Annual hydrograph (discharge in cubic feet per second) for the lower Tucannon River at Starbuck, WA for the period of 2000-2019. The horizontal red lines indicate the average annual discharge for the winter base flow, one-year return interval (595cfs), and two-year return interval (1250cfs).

As part of the floodplain connectivity analysis, a basin-scale hydraulic model was produced for the 2011 Plan using the USGS gage on the Tucannon River near Starbuck, WA. This floodplain connectivity analysis indicates the Tucannon River begins to overtop its banks at ~ 20% of the model cross-sections during the 2-year recurrence interval event (~1,250 cfs). At the 5-year (2,420) and 10-year (3,713) events, the Tucannon River overtops the banks at approximately 35% and 50% of the sections, respectively. During the 50- and 100-year events, floodwater has overtopped the channel banks of the Tucannon River at over 80% of the cross-sections. During these extreme flood events, it is likely that a majority of the valley is inundated by some depth of water through bank overtopping, backwater, or flooding of side-channels and tributaries.

As you can tell by Figure 6, since 2000, the Tucannon has rarely seen flows above the 2-year event. It is believed that naturally occuring habitat-forming flows in the Tucannon River occur above the 2-year recurrence interval, which ranges from 1,275 cfs in the lower basin, to a low of 383 cfs and a high of 598 cfs in the upper basin (Figure 6). In the spring of 2020, the Tucannon received its first habitat forming flow since 2017 (Figure 7), and its largest flow since the flooding of 1996/97. The habitat work in the Tucannon relies on flows above the 2 year event to to increase channel complexity and floodplain connectivity through interaction with large wood structures. Habitat forming flows above the two-year discharge have only occurred four times since 2010 (the start of the BPA Programmatic Habitat Project). Consequently the rate of river-driven habitat formation has been slow during the last decade on the Tucannon River.

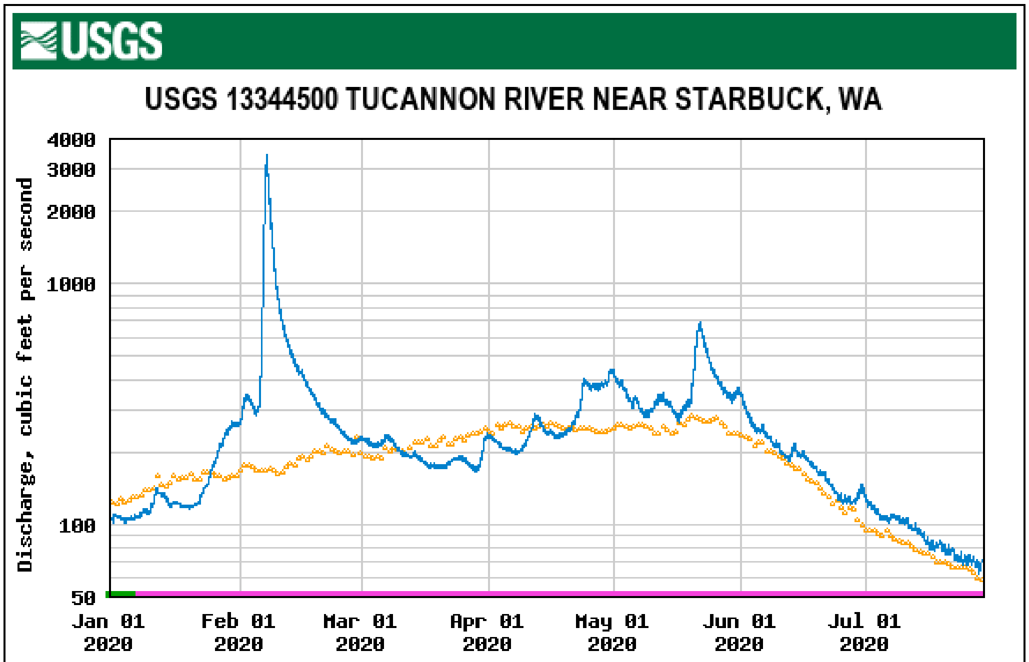


Figure 7: The 2020 hydrograph for the Tucannon River depicts the typical annual trend for Tucannon River flows: a pronounced flood peak in winter coinciding with winter storms, and another peak in spring coinciding with snowmelt in the Blue Mountains, tapering-off slowly.

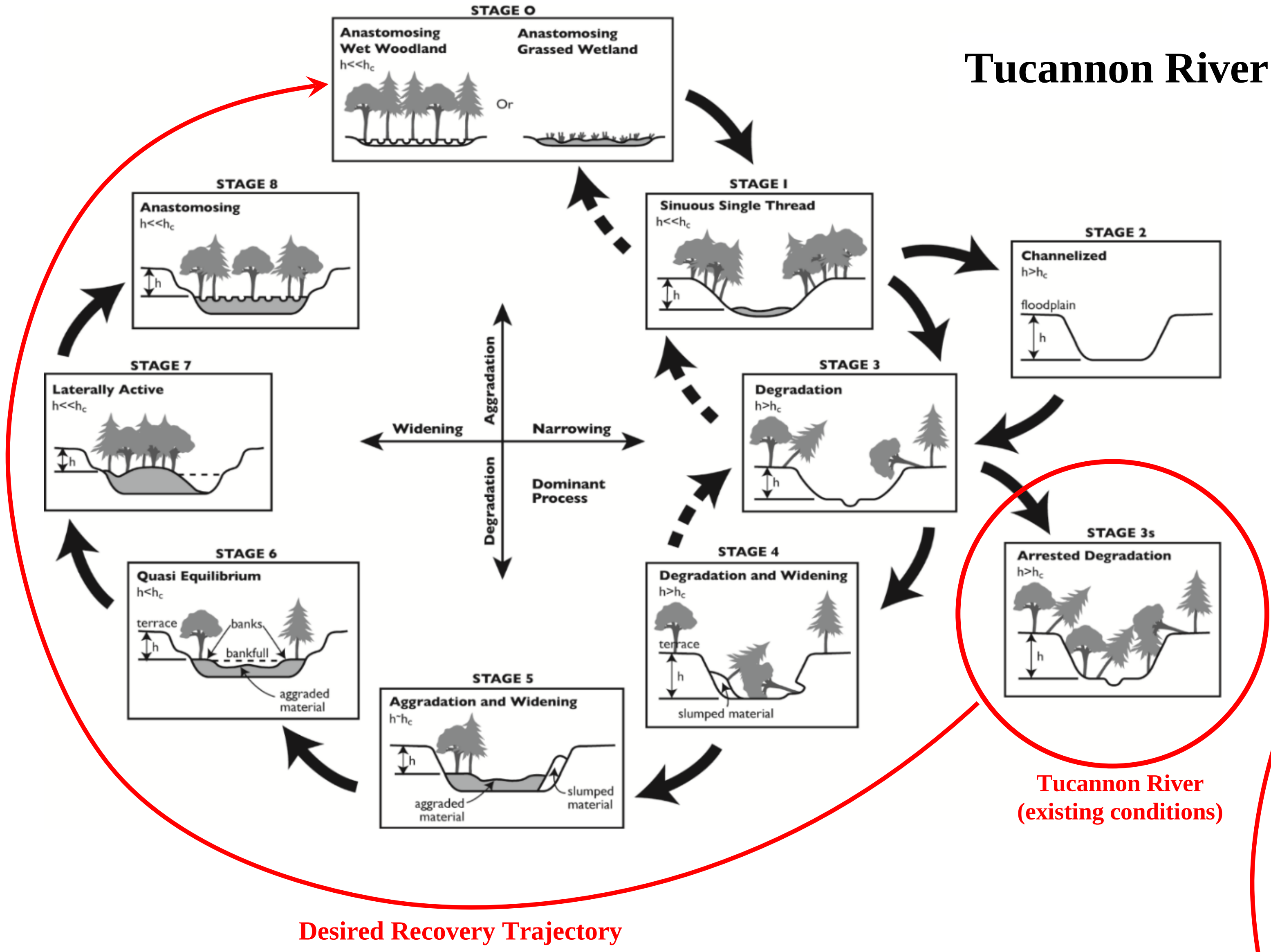
Tucannon River Habitat – Historic Impacts and Existing Conditions

The Tucannon River was historically able to move across the entire channel migration corridor within the Tucannon Valley bottom, with floodwaters accessing the floodplain more frequently than today. The Tucannon River would have been characterized as an anabranching channel form with multiple channels separated by stable, forested islands that divide flows up to the bankfull discharge.

During the 1960's following a number of flooding events in the Tucannon Valley, that led to a significant loss of property and infrastructure (Johnson 1995) the US Army Corps of Engineers (USACE) straightened and leveed the channel, increasing the conveyance capacity, and confining the river to a single channel at the valley margins. From 1937 through 1978, the length of the main channel of the Tucannon River had been reduced between 7% and 20% depending on the reach, and possibly as much as 50% of the total river length was lost through channelization and further confinement (Hecht, 1982).

Today much of the Tucannon River is stuck in a state of arrested degradation or what is referred to as Stage 3s in the Stream Evolution Model (Cluer and Thorne, 2013) (Figure 8). Ultimately, rivers in this stage of channel evolution are less productive biologically because of lack of floodplain connectivity and increased stream velocities that require higher energy to forage in these channel types.

Tucannon River - Characteristics of a Stage 3s River (Cluer and Thorne, 2013)



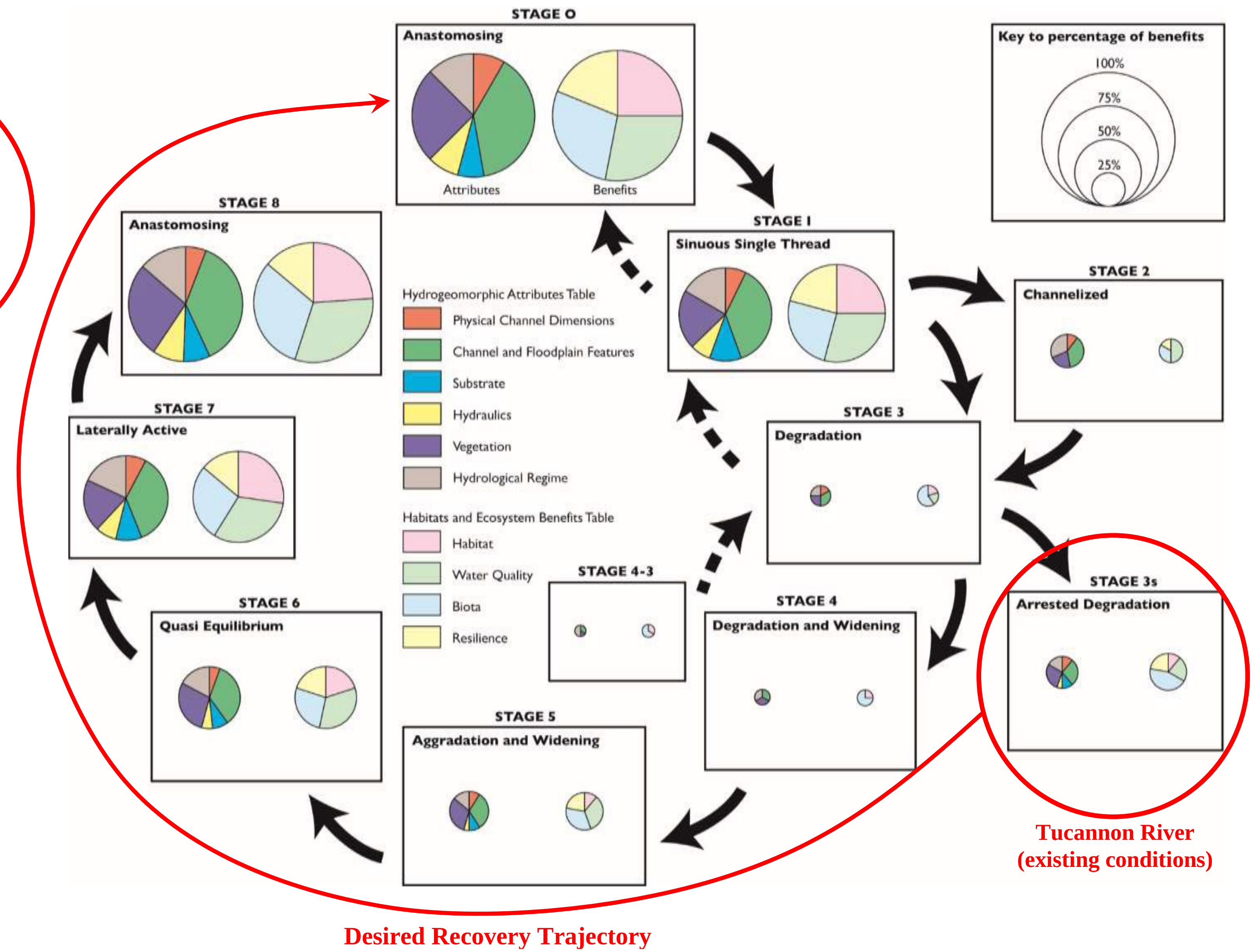


Figure 8: (*Above*) Existing channel morphology of the Tucannon River and desired recovery trajectory within the context of the Stream Evolution Model. (*Right*) Relationship between physical habitat attributes and ecosystem benefits for the different stages of the Stream Evolution Model. Diagram of the Stream Evolution Model was adapted from Cluer and Thorne, 2013.

Once the Tucannon River was confined and straightened, velocities in the river channel increased, which led to further channel incision through the floodplain. The newly formed incised channel further increased confinement and resulted in fundamental problems, which greatly decreased channel complexity and its associated ecological benefits. Channel incision, confinement, and disconnection between the channel and floodplain contribute to a variety of secondary impairments in the physical and ecological functioning of the river including spatial and structural simplification of the channel and floodplain, lowering of the water table, increased stream velocities, impairment of riparian forest communities, and a reduction in overall aquatic habitat.

The degradation of physical and ecological processes in the Tucannon River has caused three common problems for salmonids in confined and incised channels: (1) diminished velocity refuge, (2) minimal food production and availability, and (3) redd scour (Cluer, 2019). Stage 3s rivers with oversized channels usually result in decreased velocity refuge when discharge increases, limited food production and high energy expenditure for foraging salmonids (Facey and Grossman, 1990; Sommer et al., 2001a; Kemp et al., 2006; Jeffres et al., 2008; Limm et al., 2009; Henery et al. 2010; Katz et al, 2017). These oversized straightened stream channels concentrate stream power, resulting in frequent over winter bed mobilization resulting in redd scour and further decreasing spawning success.

Physical Attributes	Hydrology	Hydraulics & Substrate	Dimensions & Morphology
	A high capacity channel with conveyance capacity for a wide range of flood peaks, severely limited/reduced flood attenuation, and maximal flood pulse effects. Groundwater recharge is minimal, base flow unreliable, and hyporheic zone remains damaged or destroyed.	Simplification of in-channel geomorphic features reduces hydraulic diversity, few if any marginal deadwaters. Bed substrate continues to be scoured, with sorting impacted and patchiness reduced through extreme armoring or paving.	Minimal wetted area, shoreline length, and complexity relative to flow. Natural or artificial stabilization locks in dimensions and morphology. Limited capacity to store sediment and wood. Banks mostly stable. Functionality of the riparian zone remains diminished and channel is permanently disconnected from its floodplain.

Habitat and Ecosystem Benefits	Habitat	Biota (Thorpe et al. 2010)	Resilience & Persistence	Water Quality
	Removal of features that provide in-channel habitat. Channel isolated from floodplain habitat. Separation of channel and floodplain habitat destroys/minimizes flood and drought refugia.	Suitably adapted species may colonize the confined, incised channel so long as it remains stable. Species richness, trophic density, proportion of native species, and primary/secondary productivity are low.	Minimal resilience to disturbances such as flood and drought.	Functions responsible for water clarity and nutrient cycling weakened by bed scour, vegetation loss, and reduced groundwater interaction. Temperature buffering may recover if stable banks support riparian vegetation sufficient for shade.

Vegetation Attributes	Riparian forest limited by lowering of the water table. Relative stability allows for early succession in emergent and riparian plant communities, improving supply of leaf litter. Wood recruitment continues, but it is limited by the proximity, width, and contiguity of woodlands on surrounding floodplain and terrace surfaces.

Table 1: Tucannon River - Characteristics of a Stage 3s River (Cluer and Thorne, 2013)

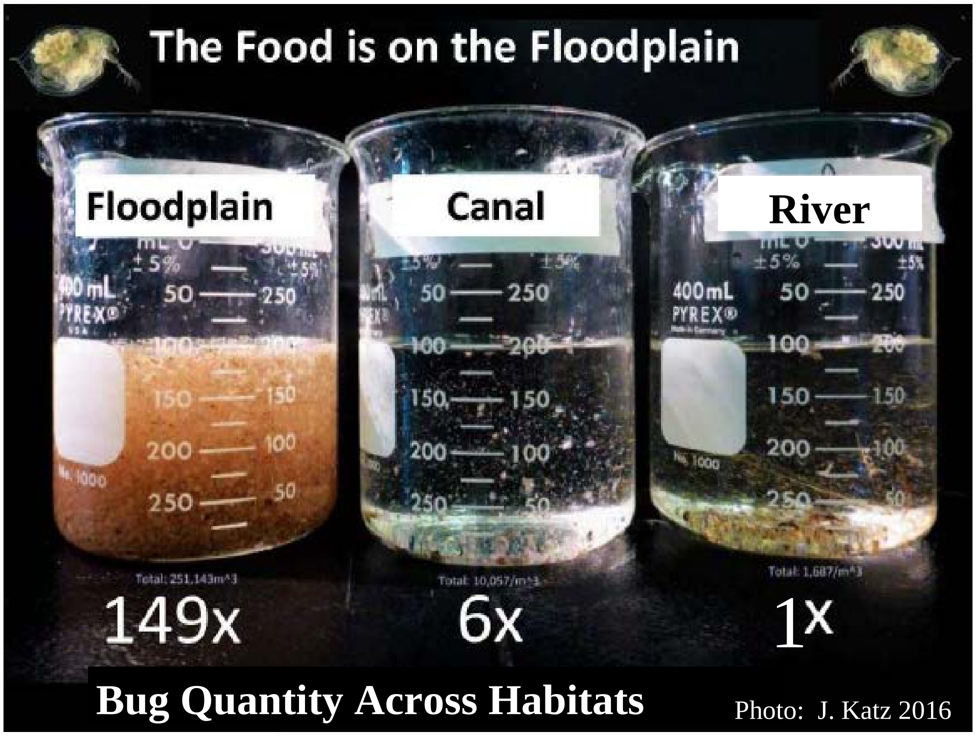
Tucannon River Habitat – Restoration Goals and Objectives

Initial habitat limiting factors for the Tucannon River were identified by an Expert Panel, and were outlined in the Snake River Salmon Recovery Plan for Southeast Washington (2005/2011). Since 2010, salmon habitat restoration on the Tucannon River has been organized into a multi-agency collaborative effort under the Tucannon Programmatic (2010-077-00). Identification and prioritization of restoration opportunities has been guided by the 2011 Plan, which served as the restoration guidance document developed under the Program. Salmon habitat restoration goals and objectives were developed in the 2011 Plan to inform and guide the development of restoration projects in the Tucannon Sub-basin over the last decade.

During WDFW's lifecycle modeling, Cram et al. (2016) identified low overwinter survival (~18%) for juvenile spring Chinook salmon throughout the Tucannon River. Juveniles were observed leaving spawning areas to overwinter in the lower river, in reaches that had not received restoration treatments. Crawford et al. (2019) concluded that restoration of areas in the lower half of the Tucannon River should continue to focus on overall river health and function, with particular emphasis on improving over-winter habitat and high flow refuge. Under existing conditions the lower half of the Tucannon River lacks high flow refuge during winter flows because of levees, decreased floodplain connectivity, and channel incision.

To improve conditions for early life history stages of Tucannon River salmonids, restoration actions should address channel confinement, channel simplification, and improve floodplain connectivity. Restoration actions that restore reaches closer to the Stage 0 condition reduce channel confinement and increase channel complexity and floodplain connectivity by spreading flows out across the floodplain more frequently which reduces stream power. The increased floodplain inundation associated with floodplain connectivity provides several improvements to the ecological function of the river system and improves habitat conditions for juvenile salmonids.

In addition to the velocity refuge created with floodplain connectivity, floodplain inundation also increased productivity available to aquatic organisms as plant carbon cycles upward through the aquatic food web increasing the production of important forage items for juvenile fish including algae, bacteria, invertebrates, these increased forage items increase fish size (Sommer et al., 2001b; Müller-Solger et al., 2002; Schemel et al., 2004.; Sommer et al., 2004; Ahearn et al., 2006; Grosholz and Gallo, 2006; Benigno and Sommer, 2008). In certain cases, increased floodplain inundation has been shown to increase juvenile growth in salmonids by ~700% (Figure 9 – Katz et al. 2017). Brian Cluer, fluvial geomorphologist for NOAA fisheries, estimates that a minimum of 90 days of floodplain inundation is necessary to achieve the food web benefits necessary to increase juvenile salmonid size and improve fitness for outmigration survival (pers. comm.).



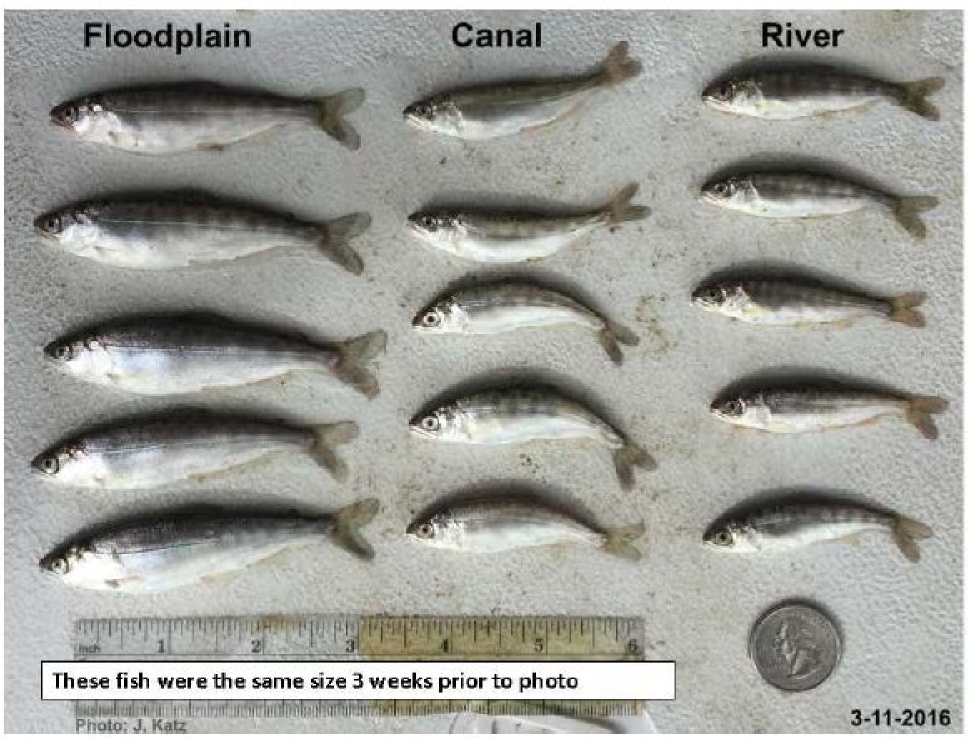


Figure 9: Results from Katz et al. 2017 – (*Top*) ephemeral inundation of floodplain habitats on a California river produced significantly larger densities of macroinvertebrates than adjacent habitats. (*Bottom*) Juveninle Chinook salmon that reared in these ephemeral floodplain habitats grew faster than their counterparts rearing in adjacent habitats.

Increased floodplain inundation and connectivity recharges groundwater, provides velocity refuge for juveniles during high flows, and moderates stream flows during flood events. Improving floodplain connectivity in semi-arid regions, like that of the Tucannon River, also has the potential to improve the resilience of riparian ecosystems in the face of climate change (Silverman et al., 2018).

The 2021 Plan continues to prioritize projects into three Tiers (1-3), but now it is based on revised and more explicit prioritization goals (Table 2): (a) increased channel complexity at low-winter flows (120 cfs; (b) increased channel complexity during spring and winter peak flows (300 cfs); (c) re-connection of disconnected and abandoned floodplains at a 1-year return interval (552 cfs); (d) improved quantity and quality of pools; and (e) increased retention and storage of in-channel bed-load sediments.

The revised assessment and restoration strategy for the Tucannon is grounded in four of these attributes, analyzed to understand and describe the performance or condition of existing physical processes: (1) floodplain connectivity, (2) channel complexity, (3) excess transport capacity, and (4) pool frequency. With these refined and focused prioritization goals, implementers select project areas and develop restoration approaches in the Tucannon within a Program framework that better emphasizes floodplain connectivity as the key component in increasing habitat access and improved conditions for adult and juvenile Snake River spring and fall Chinook, steelhead, and bull trout throughout the watershed.

Table 2: Tucannon River Restoration Goals, Objectives, and Their Driving Geomorphic Processes from the 2021 Plan (AQEA, 2021)

Assessment Goal	Assessment Objectives	Expected Ecological Response
Improve floodplain connectivity	75% of the available floodplain is connected at the 2-year event	**Improved extreme event refugia for adults and juveniles**, riparian growth, wood material availability, bedload material availability
Develop a high functioning riparian corridor	Establish a mature riparian forest (trees 80-150ft tall) that occupies 40-75% of maximum potential area	Improved temperature, shading, leaf litter to the river, and ecological diversity throughout the corridor.
Increase channel complexity at low-winter flows	Low-Winter Flow Complexity to 90th percentile of basin	**Improved habitat conditions for summer and fall juvenile rearing**
Increase channel complexity during spring and winter peaks	Mean-Winter and 1-year Flow Complexity to 90th percentile of basin	**Improved refugia habitat conditions for winter juvenile rearing**
Increase quantity and quality of pools	Total pool area is 15% of total in-channel habitat area	Improved adult holding, increased habitat diversity
Increase temporary storage of in-channel bedload sediments	The achievement of all of the above objectives	Improvement on all of the above goals and biological responses

Table 3 shows the goals used in the project prioritization to support the three tier Project Area selection. These goals were then linked to their geomorphic processes and then expected geomorphic response, moving away from the biological response and back to measureable physical responses within the watershed. These responses are tracked using our regional Rapid Habitat Surveys to look for changes before and after project construction. The Project is very interested in the results of the Rapid Habitat Surveys after the first 2 year flow after construction. As demonstrated in the USGS data from Figure 6 and 7, it may take several years after completion of habitat restoration projects until the Tucannon River receives sufficient flow to drive geomorphic change and create new habitat within treated reaches.

Table 3: Prioritization Goals, their Driving Geomorphic Processes and the Expected Geomorphic Response from the 2021 Plan (AQEA, 2021).

Goal	Driving Geomorphic Processes	Expected Geomorphic Response
Increase complexity at low-winter flows	• Bedload sediment transport and availability • Floodplain connection and inundation • Wood material recruitment	Channel systems that change primary low-winter flow paths year to year and are resilient to catastrophic change, and incision via maintenance of multiple low-winter flow pathways.
Increase complexity during spring and mean-winter peaks	• Bedload sediment transport • Floodplain connection and inundation • Wood material recruitment	Channel systems maintain low velocity alternative channels during high-flow events by causing yearly geomorphic change to the banks and floodplain. Dynamic channels mobilize sediment stored in the floodplain and recruit wood material from riparian areas.
Reconnect disconnected and abandoned floodplains	• Bedload sediment transport and availability • Floodplain connection and inundation	Floodplains that are inundated every few years allow for greater riparian growth of native species, and therefore allow for an increase of wood material on the floodplain. Low-lying connected floodplains allow for more frequent channel avulsions and increased complexity.
Improve quantity and quality of pools	• Bedload sediment transport and availability • Wood material recruitment	Pools store water, increase hyporheic exchange, and recharge groundwater, allowing for healthy riparian areas and wood material rejuvenation in the floodplain.
Increase retention and storage of in-channel bedload sediments	• Bedload sediment transport and availability • Wood material recruitment	Bedload sediment material that is mobilized on a yearly basis allows for complex dynamic channels, changing bedforms, formation of pools with instream wood, and connection to riparian floodplains.

Table 4 shows the linkages from all the past Tucannon River and Snake River restoration plans. The table attempts to link the Program goals to the CTUIR River Vision Touchstones and NOAA Ecological Concern categories. The table also shows the 2021 Plan's objectives vs target values vs the ecological response set with metrics to measure the ecological responses using

CTUIR bio-monitoring and PHAMS protocols. As you can see the physical processes are identified and measured against to show progress towards the overarching NOAA goals for the watershed, which we hope will make progress towards listed fish recovery in the Tucannon Basin.

Table 4A: Summary of CTUIR Tucannon Fish Habitat Project Objectives, CTUIR First Foods and Umatilla River Vision, NOAA Ecological Concerns, Tucannon Conceptual Restoration Plan Objectives, and Relevant Bio-Monitoring Project Metrics.

Tucannon Programmatic Enhancement Goals	CTUIR River Vision Touchstones	Primary CTUIR First Foods	NOAA Ecological Concern Sub-Category	Tucannon Conceptual Restoration Plan			Metrics identified by CTUIR Bio-Monitoring Project and within the PHAMS Document
				Objectives	Target Value	Ecological Response	
Increase channel complexity at low-winter flows	Primary: Geomorphology Secondary: Aquatic Biota Tertiary: Hydrology	Water & Salmon	6.1 Bed and Channel Form 6.2 Instream Structural Complexity	Low-Winter Flow Complexity to levels of current 90th percentile of basin	Low Winter Flow Complexity = 0.32	Improved habitat conditions for summer and fall juvenile rearing	Primary Channel Length - Secondary Channel Lengths - Bankfull & Wetted Width - Sinuosity – Bankfull Cross-section Area - Width/Depth Ratio - Entrenchment Ratio
Increase channel complexity during spring and winter peaks	Primary: Geomorphology Secondary: Aquatic Biota Tertiary: Hydrology	Water & Salmon	6.1 Bed and Channel Form 6.2 Instream Structural Complexity	Mean-Winter and 1-year Flow Complexity to levels of current 90th percentile of basin	Mean Winter Flow Complexity = 0.5 1-Year Flow Complexity = 0.645	Improved refugia habitat conditions for winter juvenile rearing	Primary Channel Length - Secondary Channel Lengths - Bankfull & Wetted Width - Sinuosity – Bankfull Cross-section Area - Width/Depth Ratio - Entrenchment Ratio
Increase quantity of pools	Primary: Geomorphology Secondary: Aquatic Biota Tertiary: Hydrology	Water & Salmon	6.1 Bed and Channel Form	Increased Pool Frequency	1 Pool per 7 Channel Widths	Improved adult holding, increased habitat diversity	Pool Frequency or Spacing – Percent Pool / Channel Length - Residual Pool Depth
Improve quality of pools	Primary: Geomorphology Secondary: Aquatic Biota Tertiary: Hydrology	Water & Salmon	6.1 Bed and Channel Form	Large, deep, channel spanning pools	15% of wetted channel area is pool habitat	Improved adult holding, increased habitat diversity	Pool Frequency or Spacing – Percent Pool / Channel Length - Residual Pool Depth

Table 5B: Summary of CTUIR Tucannon Fish Habitat Project Objectives, CTUIR First Foods and Umatilla River Vision, NOAA Ecological Concerns, Tucannon Conceptual Restoration Plan Objectives, and Relevant Bio-Monitoring Project Metrics.

Tucannon Enhancement Goals	CTUIR River Vision Touchstones	Primary CTUIR First Foods	NOAA Ecological Concern Sub-Category	Tucannon Conceptual Restoration Plan			Metrics identified by CTUIR Bio-Monitoring Project and within the PHAMS Document
				Objectives	Target Value	Ecological Response	
Improve Floodplain Connectivity	Primary: Connectivity Secondary: Geomorphology Tertiary: Riparian Vegetation	Water, Salmon, Deer, Cous	5.1 Side Channel and Wetland Condition 5.2 Floodplain Condition	The available 5-year recurrence floodplain is connected at the 2-year event	2-yr Connected Inundation = 5-yr Available in 2017	Improved habitat conditions for summer and fall juvenile rearing	River Complexity Index - Sinuosity – Channel Migration Rate - Meander Belt Width - Confinement Width – Off Channel Habitat Length Frequency of Floodplain Inundation
Improve Riparian Condition	Primary: Riparian Vegetation Secondary: Geomorphology Tertiary: Connectivity	Water, Salmon, Deer, Cous	4.1 Riparian Vegetation 4.2 LWD Recruitment	The available 5-year recurrence floodplain is vegetated with maturing riparian trees	Riparian zone is intact with 81-150 feet in height	Improved temperature, shading, leaf litter to the river, and ecological diversity throughout the corridor	Hardwood - Survival & Change in Distribution Softwood – Survival & Change in Distribution
Increase temporary storage of in-channel bedload sediments	Primary: Geomorphology Secondary: Hydrology	Water, Salmon	7.1 Decreased Sediment Quantity	No river segments significantly above the excess transport capacity regression line	Variation of 10% or less from transport capacity regression line	Improved habitat conditions for summer and fall juvenile rearing	Sediment Size Distribution: Channel Sediment Size Distribution: Bars Embeddedness Bank Stability

Other Noteworthy Accomplishments, 2019-2020

- Project Leader participated in the NOAA/AA Tributary Habitat Steering Committee
- Project Leader participated in the RRNW as a member of the board of directors.
- Project Leader participated on the Snake River Salmon Recovery Board monthly meeting.
- Project Leader participated on the SRSRB Lead Entity Committee during regional RCO restoration project ranking and project funding selection process.
- Project staff participated in the SRSRB Regional Technical Team, during the month RTT meeting. The Project leader is also the RTT liaison for the SRSRB providing updates during the monthly SRSRB board meetings.
- Project staff collaborated with NPT, SRSRB, WDFW, USFS, and CCD to update the Tucannon Conceptual Restoration Plan.
- Project staff supported Rapid Habitat Assessments conducted yearly in coordination with the Tucannon Programmatic.
- Project staff presented at numerous symposia, meetings, and information sessions including; Monthly Snake River Salmon Recovery Board meetings
- CTUIR Habitat Program meetings,
  CTUIR Department of Natural Resources Open House,
  Native American Fish and Wildlife Society,
  2019 Washington State Salmon Recovery Conference,
  2019 and 2020 River Restoration Northwest Symposia,
  2019 Stage 0 Restoration Training,
  2019 Tri State Steelheaders annual membership meeting,
  Tri-Cities Rotary Club, and
  2018 and 2019 Columbia County Fair

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A Columbia County salmon enthusiast visits the CTUIR Tucannon Fisheries Habitat Enhancement booth at the 2019 Columbia County Fair.

Discussion of Completed Work

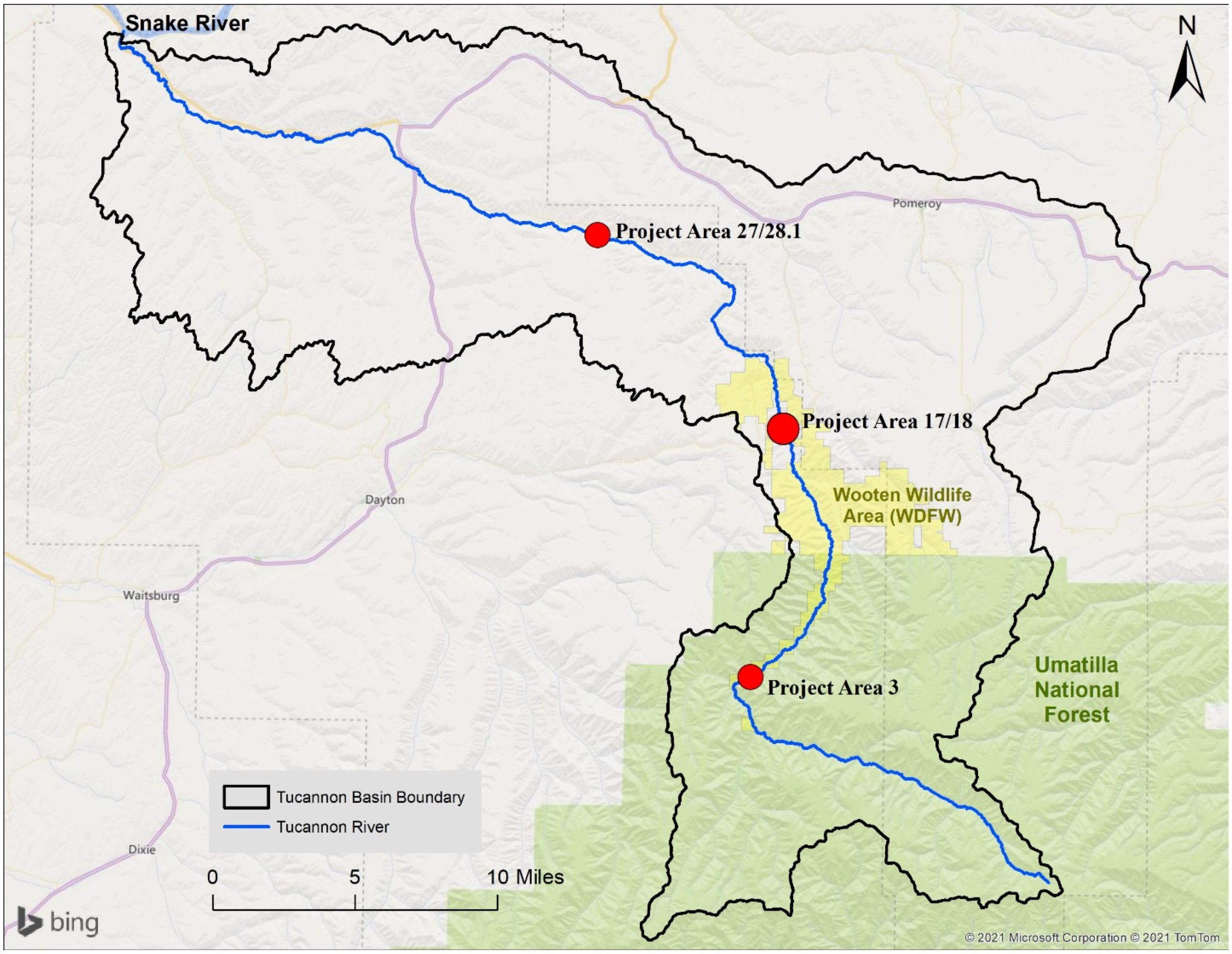


Figure 10: Overview map of restoration projects that were planned, completed, and monitored/maintained during the 2019-2020 reporting period.

PA 17/18 Floodplain Connectivity and Channel Complexity Project – Tucannon River, miles 33.1- 37.0

CTUIR Accords Funding (2008-202-00): $92,000 for design (73982 REL 100) during 2020; $164,535 (73982 REL 72) during 2019.

BPA Tucannon Programmatic Funding (2010-202-00): In 2020 $625,500 (73982 REL 111) construction support, in 2019 $5,000 (84038) design support and in 2018 - $35,700 (73982) design funds.

Matching Funds: No other matching funds have been identified for this project area at the time, but it is anticipated that CTUIR would consider pursuing floodplains by design or SRFB grant as match in 2021-22.

Location: The project reach is located between RM 33.1 and 37.35. With a start Lat/Lon 46.343913 -117.681008 and end Lat/Lon 46.352667 -117.684059

Project Time Line: Coordination and outreach 2017; concept development and build landowner support 2018-19; preliminary design 2020; final design and construction 2021-22.

Priority Populations & Life Stages: Snake River ESU Spring/Summer Chinook (Threatened), Snake River DPS Summer Steelhead (Threatened) and all life stages, Columbia River bull trout and other native species.

Project Goal & Objectives: The project goal will be to enhance the Primary Touchstones of CTUIR River Vision (Jones et. al. 2008) within PA17/18, to the maximum extent possible. The goals of the Southeast Washington Salmon Recovery Plan included instream wood replenishment, increasing channel complexity, and reconnecting the river to its floodplain. Increase hydration of an inset floodplain through the construction of log jams, and the connection/creation of side channels. Specific project objectives will be developed during the design process in 2020-21.

Objectives: Note: The following objectives will be refined as the design nears completion.
1) Replenish instream wood to > 2 key pieces of wood per channel width.
2) Design large wood structures to:

- Raise the bed elevation, reconnecting the river and floodplain
- Decrease stream velocities and increase sediment deposition throughout the reach
- Increase connectivity using old side-channels throughout the reach
- Increase the local water table through hyporheic exchange with the alluvial aquifer

3) Replenish the floodplain forest with native tree plantings.

Background

In 2015, the Columbia Conservation District (CCD) implemented a restoration project on WDFW property in the furthest upstream portion of the proposed project reach. The CCD effort was intended to increase channel roughness and channel connectivity. In 2017, CTUIR implemented a restoration project in the lowest one mile of the project area, connecting habitats within PA 17/18. Ongoing work in PA 17/18 includes wide ranging efforts to enhance salmonid habitat in one of the most highly developed and impacted reaches within the priority spring Chinook domain of the Tucannon basin. There are multiple opportunities to work within the reach to improve the impacts of habitat degradation that have occurred over the decades.

The proposed PA 17/18 treatment reach covers the active channel and floodplain of the Tucannon River and extends 2.7 miles upstream from the PA 17/18 treatment (completed in 2017). The land area in PA17/18 between river mile 34.3-37.0 is subdivided into private parcels that are between one and five acres. WDFW owns land on the Tucannon River in the upstream portion of the proposed project area between river mile 36.1-37.0. In working with landowners in the larger PA17/18 project area it was determined that the next step would be to work from upstream to downstream, through the area where the greatest habitat gains could be realized quickest, building off habitat gains from recent project work completed by the CCD in 2015.

Ongoing work in PA 17/18 includes wide ranging efforts to enhance salmonid habitat in one of the most highly developed and impacted reaches within the priority spring Chinook domain of the Tucannon basin (currently there are 29 different landowners located within the proposed project reach). There are multiple opportunities to work within the reach to improve the impacts of habitat degradation that have occurred over the decades. In 2017, CTUIR implemented a restoration project in the lowest one mile of the project area, connecting habitats within PA 17/18. In 2015, the CCD worked on the stream reach located on WDFW and private properties located upstream and contiguous with this effort, to increase channel roughness and channel connectivity. In working with landowners in the larger PA17/18 was determined that the next step would be to work from the top down through the area where the most habitat gains could be realized quickest, building off habitat gains from recent project work completed by the CCD in 2015.

Summary
The PA 17/18 floodplain and channel complexity project development goals in 2020, were to make contacts with private landowners through a number of public meetings and events held within the basin. These efforts have resulted in sufficient interest amongst the landowner group to move forward from concept development to preliminary design (Figure 11) and the development of landowner agreements. The primary goal of the project design concepts developed in 2020 focus on increasing floodplain connectivity and increasing channel complexity through side channel reconnection and strategic channel roughness elements (Figure 11). A combination of channel spanning and channel apex structures will be placed to encourage increased flows onto the left bank floodplain where a number of long flow paths have developed (Figure 12) from recent floods. Discontinued land management practices had previously inhibited movement of the river into this left bank floodplain area.

Current Emphasis

In 2020, CTUIR continued to work with private landowners within this high priority (Tier I) reach to identify and implement restoration objectives that have high fish benefit while working with the 22 property owners within this reach. As of the winter of 2019 the majority of the landowners within the ~3 mile reach have expressed interest in doing some level of restoration and have returned signed agreement forms to CTUIR based on their review of the concept drawing. CTUIR has continued working with a design engineer (using Tucannon Accord funding) to produce a preliminary designs for BPA technical EC review to complete a final design in early 2021.

A site assessment was completed in 2020 in support of concept design development with the metrics from that survey provided below (Table 6). Project implementation would target a potential 50% increase in perennial flow (Figure 12) channels and an overall increased frequency of inundation. The project concepts focus heavily on two reaches where floodplain flow paths on the left bank may be relatively easy to reconnect (Figure 13) at a more beneficial flow (<1 year return interval). The floodplain channels will be roughened using a number of embedded logs to aid in channel formation over time. A full revegetation plan will be developed to initiate riparian vegetation over the length of the project. Prior to implementation a pre-construction and post-construction surveys would be conducted in order to capture and document project implementation and the as-built condition.

Table 5: Pre-project habitat metrics collected in floodplain expansion reach identified in PA17/18. Project metrics in this table include main channel length in meters, side channel length for both perennial channels and ephemeral channels in meters, LWD key pieces (>6 m long and 0.3m dia.), the number and type of LWD jams or single logs and the frequency depth and areas of pools.

Project Area Survey Type	Main Channel Length (km)	Side Channel (m)		LWD Key Piece (#)	Structure #		Pools		
		Peren	Ephem		Jams	Single Log	Freq. (#)	Area (m^2)	Mean Depth Range (m)
Preliminary Reach Obj.	None	958	1,258	177	25	70	20	2,400	1.0-1.5
Pre-project (2020)	1.11	407	1,576	128	14	5	16	2,093	1.0-1.5

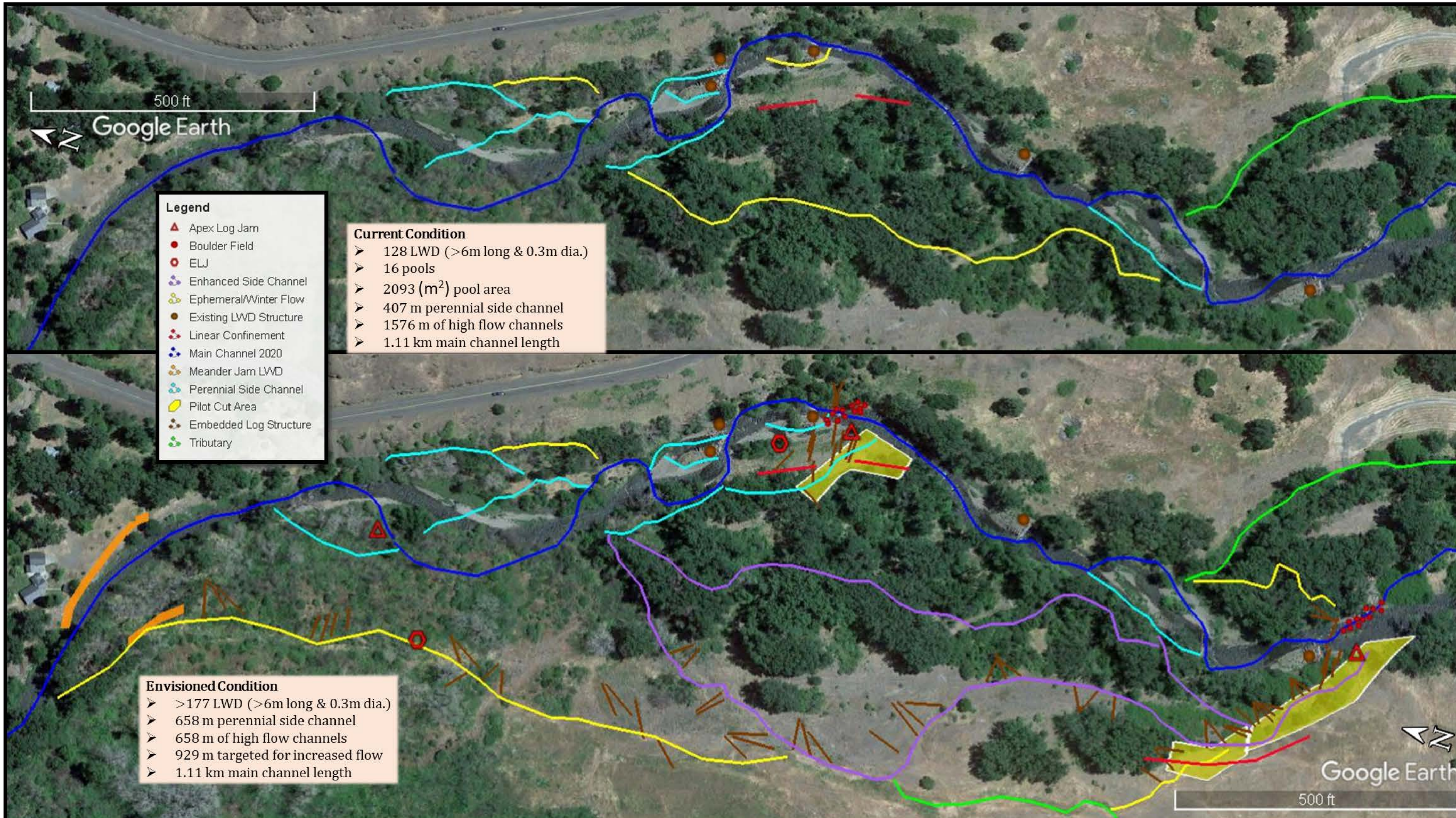


Figure 11: Project 17/18 Phase II project reach identified current design effort. In 2020, a rapid habitat survey was conducted of the entire project reach being designed (upper map) and is being compared to the desired condition developed for the design concept. The design concept will focus on removing remain confining features and increase connectivity to existing disconnected flow paths.

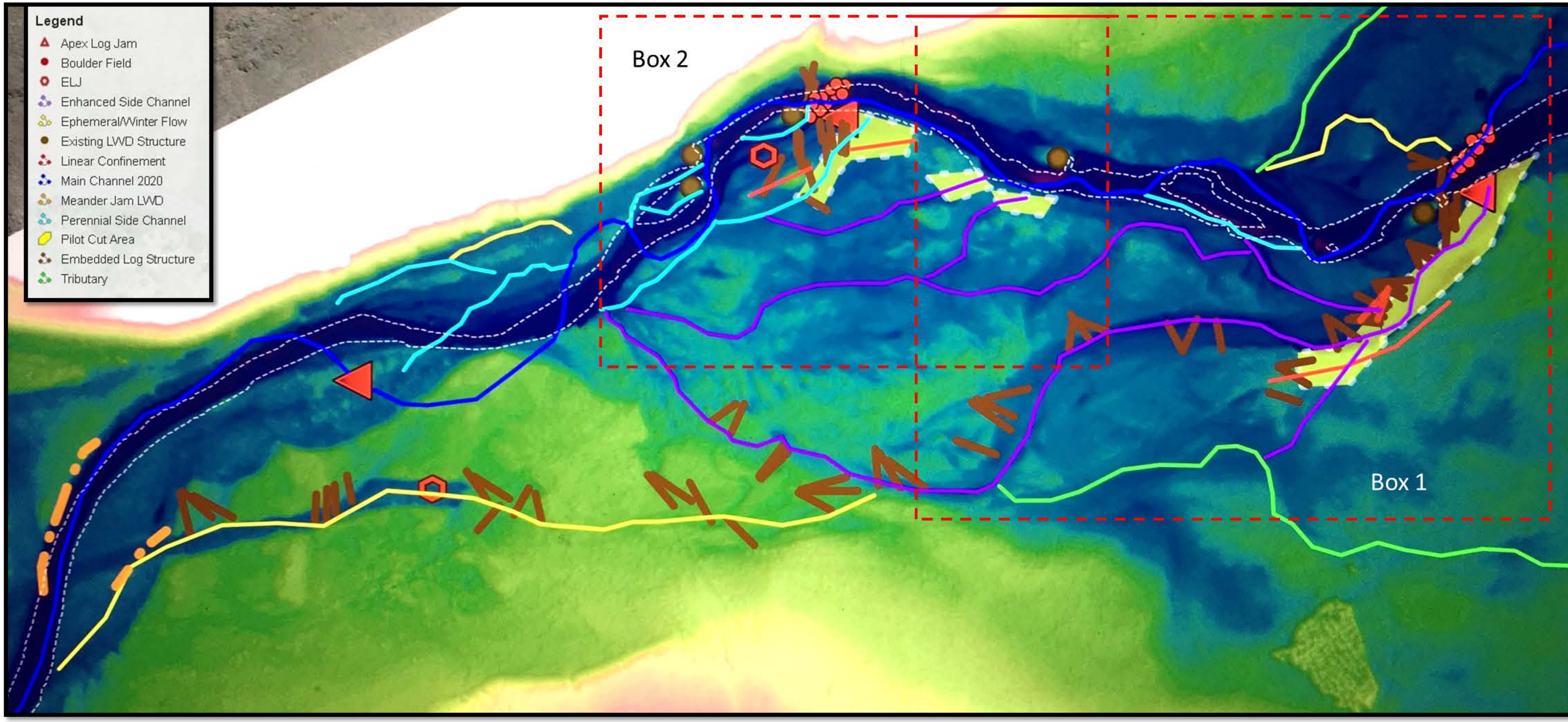
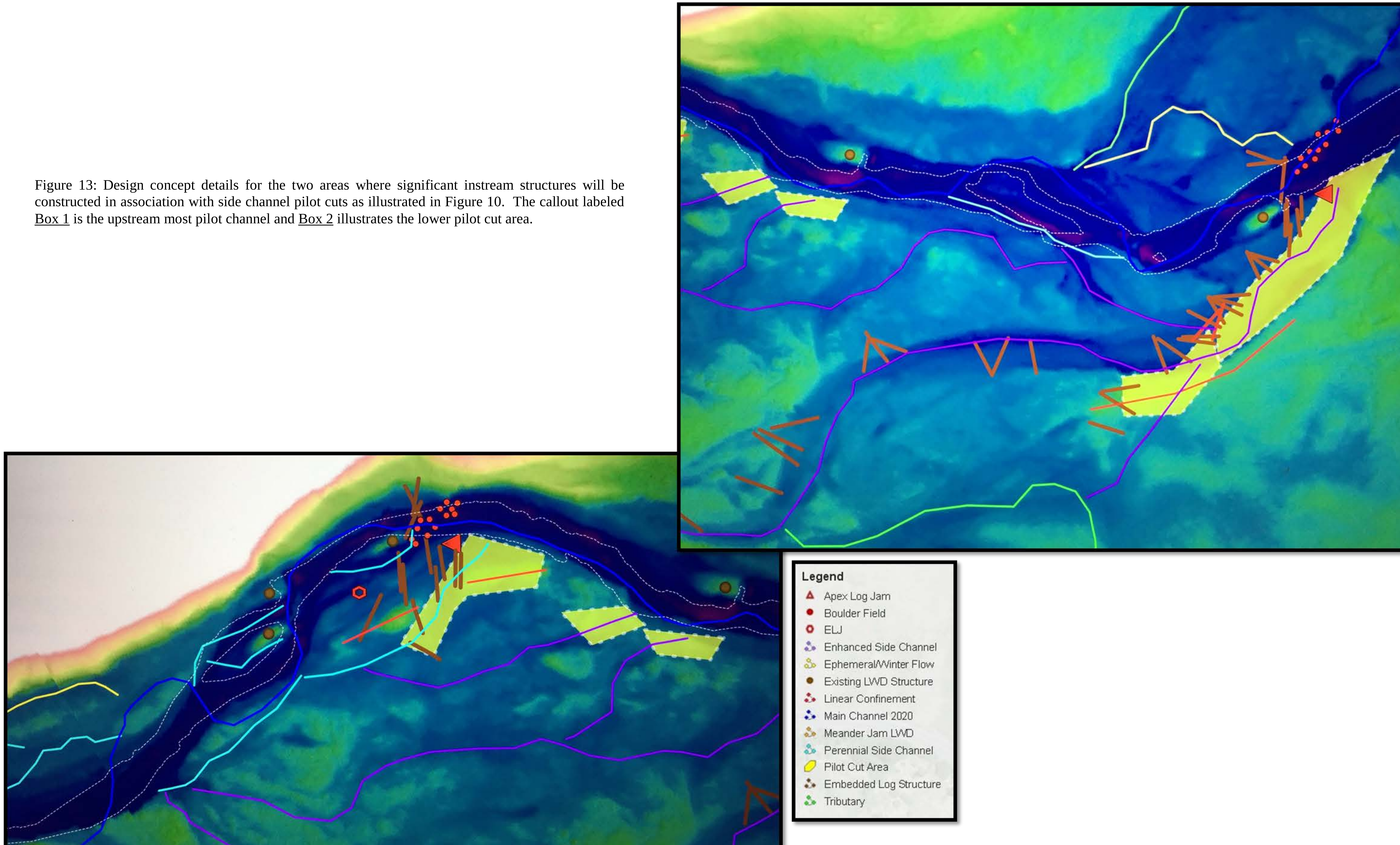


Figure 12: Relative elevation model developed using 2017 bathymetric LiDAR for the current design in Phase II of PA 17/18. The map illustrates the current position of the main channel following the 2020 flooding as well as existing LWD structures placed in 2015. The two dashed boxes indicate the location where significant LWD structures will be paired with side channel cuts to increase channel complexity and floodplain connectivity (Figure 11).

Figure 13: Design concept details for the two areas where significant instream structures will be constructed in association with side channel pilot cuts as illustrated in Figure 10. The callout labeled Box 1 is the upstream most pilot channel and Box 2 illustrates the lower pilot cut area.



Project Area 27/28.1 Treatment Reach – Tucannon River, miles 22.2-23.1

CTUIR Accords Funding (2008-202-00): ~$411,063 committed in 2020 (73982 REL 130).

BPA Tucannon Programmatic Funding (2010-077-00): $337,350 (73982 REL 111) during 2021; $827,500 (#73982 REL 98) during 2020; $73,112 (73982 REL 42) during 2019.

Matching Funds: Non-BPA matching funds have not been quantified for this project area, but could be in the donation of existing low lying agricultural lands for conversion to floodplain.

Location: Tucannon River mile 22.2 to 23.1 With a start Lat/Lon 46.453672 -117.816916 and end Lat/Lon 46.456387 -117.832140

Project Time Line: Project design was initiated late in 2019 (73982 REL 98) with the first half phase (Phase 0.5) being completed in the summer of 2020. This project was split into multiple phases to accommodate both available funding and permitting timelines in 2020-22, and further Phase 1 was divided into two phases (Phase 0.5 and Phase 1) in 2020 to fit within available funding and work window that was shortened because of Covid-19 restrictions. Initial project Phase 0.5 was implemented in 2020 (73982 REL 98), with the final Phase I design planned for completion in early 2021 and planned implementation planned in 2021 (73982 REL 130 & 73982 REL 132). PA27/28.1 will also have a second phase (Phase II) planned to be designed in 2021 for implantation in 2022-23 based on available funding.

Recovery Expectations: This project is located in a dynamic section of the Tucannon River Valley, and it is expected that change in channel form and habitat complexity will occur at a relatively fast rate compared to other locations within the basin. The flow rate required to activate bed load in this reach occurs in a 1-2 recurrence interval, so the project is expected to contribute significantly to habitat uplift within 2-5 yrs. Additionally, the aggressive design approach will significantly alter habitat conditions within the reach. Periodic site visits and rapid surveys (+2 yrs. or following high water events) will continue to follow development in side channel and floodplain connectivity (Table 7).

Priority Populations: Snake River ESU Spring/Summer Chinook (Threatened), Snake River DPS Summer Steelhead (Threatened), Columbia River bull trout (threatened), Pacific Lamprey (SPP of Concern).

Priority Life Stages Targeted: All life stages

Potential Future Actions: It may be necessary in to revisit pilot channel cuts and associated LWD structures to ensure side-channel and floodplain goals and objectives are continuing to be met. Additional floodplain structures may also be required once the floodplain connectivity objectives are achieved. It may also be necessary to continually assess and revisit riparian planting and health over time as the floodplain continues to evolve from shrub step or agriculture to a more functional riparian habitat.

Project Goals and Objectives: The goal of the proposed project is to restore approximately one mile of river within project area 27/28.1 closer to its historic, naturally functioning state, increase fish habitat quality/quantity, and increase floodplain connectivity. The treatment reach and proposed actions are identified in the 2021 Conceptual Restoration Plan (Anchor QEA, 2021).

The project aims to address the Primary Limiting Factors identified for the Tucannon River in the 2008 Fish Accords (Three Treaty Tribes-Action Agencies 2008), incorporating the primary touchstones described in the Umatilla River Vision (Jones, et al, 2008), and maintain consistency with the Snake River Salmon Recovery Plan for Southeast Washington (SRSRB 2006), Draft Columbia River Bull Trout Recovery Plan (USFWS, 2010), and the Tucannon Sub-basin Plan (CCD, 2004).

Objectives: restoration objectives for this project area are based on pre-project Rapid Habitat Survey data and incorporate the recommendations for floodplain complexity, LWD key pieces, pool frequency, and pool area, are identified in the 2021 Conceptual Restoration Plan (Anchor QEA, 2021). Final objectives for this restoration project will be identified in early 2021 as part of the final Phase I Basis of Design Report.

- Short Term Objectives (3 years):
    a. Approximately 24 acres of low-lying floodplain is currently in agricultural production and infrequently inundated during moderate flows (at < 5yr return). One objective is to increase floodplain connectivity and frequency of inundation closer to historical and natural conditions (1-2 yr return) throughout the 24 acres of low-lying floodplain. Re-engaging this portion of the floodplain will decrease channel confinement, decrease stream power, increase quantity and variability of gravel deposition, increase base flows, increase groundwater tables, and decrease water temperatures through the project reach.
    b. Increase channel complexity (channel planform complexity, and in-channel structural complexity) closer to historical and functional maximum; create a minimum of 1,600 meters of perennial side-channel, and 1,000 meters of ephemeral side channel.
    c. Installing greater than 134 large wood structures within the bank full channel and on low-lying floodplain to create pool habitat, instream cover habitat, channel complexity, substrate sorting, and floodplain connectivity and roughness.
- Long Term Objectives (3-5 years):
    a. Restore natural channel forming processes and increase channel complexity through the addition of large wood structures.
    b. Restore sediment routing processes through the removal of levees and other floodplain impediments.
    c. Reestablish native floodplain plant communities and riparian function with site-appropriate native vegetation and off-channel habitat that reflects CTUIR First Food values.
    d. Restore a floodplain and upland terrace forest.

Project Summary: The PA 27/28.1 treatment reach covers approximately 1 mile of active channel and floodplain, between river mile 22.2-23.1. The entire treatment reach is owned by one private land owner. Land use includes irrigated agriculture and cattle grazing, with a USDA

Conservation Reserve Enhancement Program (CREP) easement along the river. King Grade Road crosses the Tucannon River within the project area. An open irrigation ditch withdraws water from the river channel at approximately river mile 23. The PA 27/28.1 treatment reach suffers from the same problems as the rest of the Tucannon wherein the channel has been pushed to the side of the valley and confined in place in order to create space for human uses such as agriculture. The project is identified as a priority for restoration in the 2021 Conceptual Restoration Plan (Anchor QEA, 2021). Due to the size and potential cost of this project in relationship to The Programmatic annual budgets, the project is being phased over a number of fiscal and construction periods:

Status (FY20): The project design was completed for Phase 0.5 (see contract #73982 REL 42) the first half of Phase 1, and advanced by CTUIR project staff working within the CTUIR Tucannon project (2008-202-00) funds. The first half of Phase 1 (Phase 0.5) was implemented in 2020 and the remaining elements be included in the final 2021 Phase I design and implementation.

Status (FY21): Phase I (second half of Phase I) will be implemented during the 2021 in-water work window. Final implementation of the full Phase 1 design will complete the majority of the in-water work that is proposed for PA27/28.1l. Phase 2 project concepts will be initiated during FY21 and may include modifications to improve efficiency of existing on-site irrigation infrastructure. Improvements in efficiency of the on-site irrigation infrastructure will help reduce the impacts of agricultural practices on the riverscape.

Phase 0.5 As-built Conditions*:* In 2020, CTUIR completed implementation management and supervision for: pre-construction site preparation, permitting, design finalization and Phase 0.5 implementation at PA-27/28.1. The Phase 0.5 design involved final design and construction of the floodplain connectivity and LWD placement for about half of the overall project elements planned in Phase 1 (Table 7).

Project Area Reach	Main Channel Length (km)	Side-channel (m)		LWD Key Pieces	Structure #		Pools		
		Perennial	Ephemeral		Jams	Single log	Freq.	Area (m^2)	Mean Depth Range (m)
PA27 Pre-project Phase 0.5 (2020)	0.43	204	49	24	7	6	11	571	0.5-1.0
PA27 Post-project as-built Phase 0.5 (2020)	0.43	204	0	85	10	4	11	571	0.5-1.0
PA28.1 Pre-project Phase 0.5 (2020)	0.98	270	620	83	19	16	32	1385	0.5-1.0
PA28.1 Post-project as-built Phase 0.5 (2020)	1.01	776	854	392	112	15	31	1373	1.0-1.5

Table 6: Pre-construction and post-construction salmon habitat metrics for Phase 0.5 of Phase 1. Data were collected by the Tucannon Habitat Programmatic using a Rapid Habitat Survey methodology.

The design focused on creating multiple habitat structure, floodplain connection, and improving stream function deficiencies associated with this reach of the Tucannon River (Figure 14). Enhancing and restoring instream habitat in this project area is being accomplished through a variety of treatment actions in the main channel, along the banks, and within the floodplain. In total, the Phase 0.5 restoration efforts in 2020 increased perennial side channel length by >500 m through channel connectivity measures and increased large wood frequency (Table 7). Pools were not directly developed during construction and are expected to develop following changes in channel geomorphology during high flow events, and will be reported in future reports (2021-2023). These design features are intended to benefit spring Chinook by providing better refuge and spawning habitat for adults, reducing redd scour during winter flood events, and increasing rearing habitat and over-winter survivals for juvenile salmonids.

This project has been designed to achieve Stage 0 conditions (Cluer and Thorn, 2013) for the treatment reach. Stage 0 requires some additional explanation given its relative infancy as a restoration approach. The goal of a Stage 0 restoration approach to address channel-floodplain disconnection through lowering (grading) of artificially high (i.e. disconnected) floodplain areas and filling of incised channels. These actions equalize floodplain and channel elevations to maximize floodplain engagement, minimize stream power per unit width, re-initiate sediment deposition, and raise groundwater tables to promote vegetation success. Specific elements of this restoration design that are designed for a Stage 0 treatment approach include:

- Floodplain grading that targets removal of artificially high areas (such as berms and roads). Importantly, low areas such as those containing wetlands are avoided with floodplain excavations.
- Designs err on the side of more rather than less connectivity to allow the stream to find its natural multi-threaded dynamic equilibrium. Maximum connectivity is achieved through partial filling of the channel with material excavated from high floodplain areas. Excavation of narrow side channels are de-emphasized.
- Placement of loose logs and other roughness elements further decrease unit stream power (stream power per unit width) across the floodplain.

A focus on less engineered elements of a Stage 0 approach, including loose logs and broad (low-detail) excavations, can save significant construction costs.

Large wood structures installed in PA27/28.1 during Phase 0.5 implementation. Image was taken from a drone survey on February 2021.

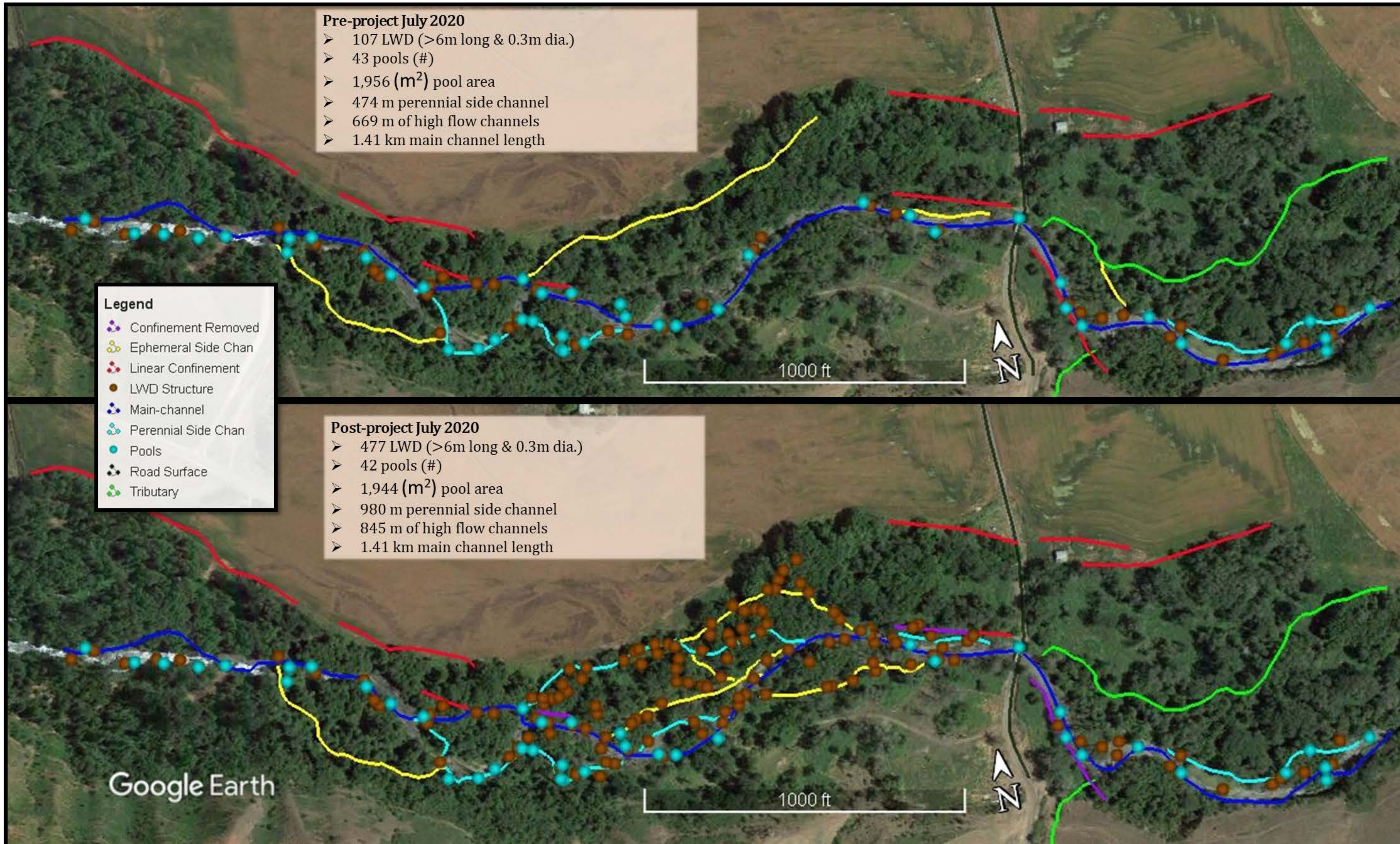


Figure 14: Pre-project and post-project conditions for Phase 0.5 of the PA27/28 floodplain connection and LWD project, implemented in 2020.

PA28 Phase 0.5 - Pre-construction and Post-construction Photos

Station 36+00 Before

Station 36+00 After

Station 32+00 Before

Station 32+00 After

Station 29+00 Before

Station 29+00 After

Station 28+00 Before

Station 28+00 Before

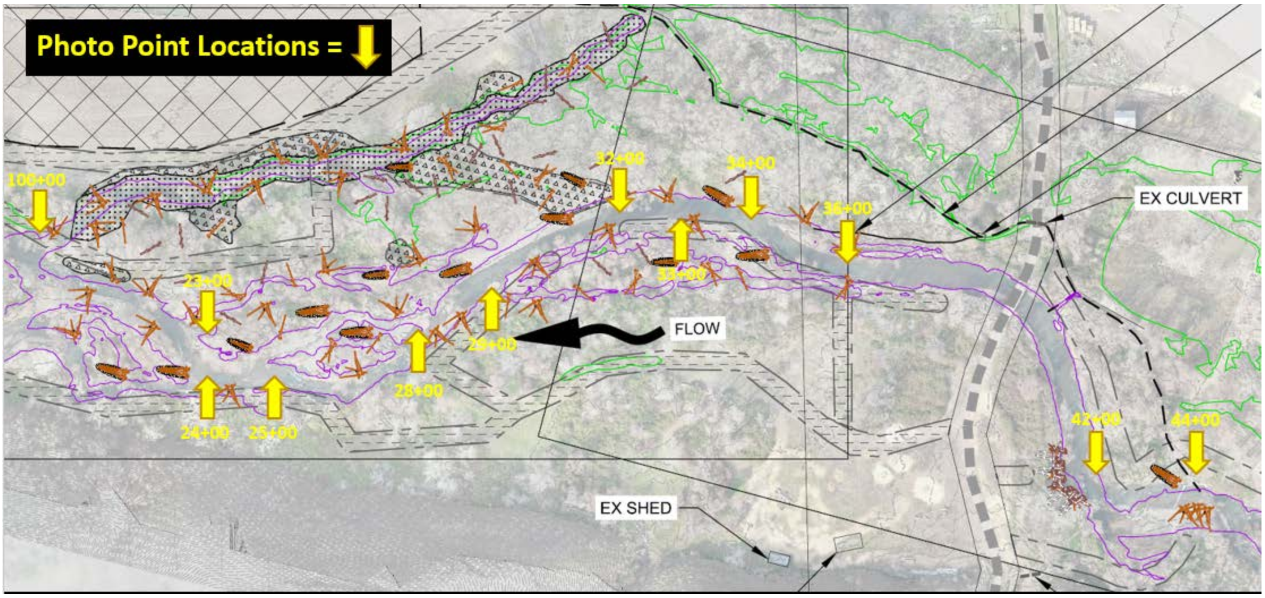
Station 23+00 Before

Station 23+00 After

Station 100+00 Before

Station 100+00 After

PA28 Phase 0.5 - Location of photo point stations within the treatment reach



2020 Tucannon River LiDAR Data Collection and Analysis

BPA Programmatic Funding (2010-077-00): The Program supported the CTUIR in the 2020 Tucannon River Basin Terrestrial NIR LiDAR, Topo-bathymetric LiDAR, 4-Band Orthophotography Acquisition, Post-processing and Data Analysis. In 2020, $182,785 (86158)

Matching Funds: Matching funding toward this project came from the FY20 SRFB program funds, at a sum of $73,000 (IAA 20-2013).

Location: Entire Tucannon Basin floodplain and major tributaries.

Project Time Line: LiDAR acquisition in November 2020 and 4-Band Orthophotography acquisition in May 2021. In 2021, the Program, QSI and Anchor QEA will work together to analyze the 2011, 2017, and 2021 LiDAR datasets. A final draft document is planned for completion in the spring of 2022.

Priority Populations: The 2020 LiDAR data acquisition and analysis will support natural habitats and native flora and fauna of the Tucannon basin through improving natural river process. Although these efforts are targeting Snake River ESU Spring/Summer Chinook (Threatened), Snake River DPS Summer Steelhead (Threatened), Snake River Fall Chinook (Threatened), Columbia Basin Bull trout (Threatened) analysis of this data is intended to help restore natural process that will provide habitat for all species present including pacific lamprey and bivalves.

Priority Life Stages: All life stages.

Project Goal & Objectives: The overall goal of the 2020 LiDAR data acquisition and analysis is to provide a topographic layer to compare geomorphic changes (floodplain connectivity and channel complexity) since the 2017 LiDAR data collection. 2020 was chosen for the next LiDAR data collection because of the 25 year flood event in the Tucannon in the spring of 2020, which is the highest flow event since Programmatic restoration started in the Tucannon in 2011.

Objectives:

LIDAR DATA ACQUISITION

Topobathymetric LiDAR

Point Cloud

- All Classified Returns, *Las 1.4 format*
  Point files will include the following fields: X,Y,Z, Return Intensity, Return Number, Point Classification (topographic ground, default, bathymetric ground, water column, water surface), Scan Angle, Adjusted GPS Time

Surface Models

- Combined Topobathymetric Bare Earth Digital Elevation Model (DEM), 1 m resolution, *ESRI Grid format*

- Highest Hit Digital Surface Model (DSM), 1 m resolution, *ESRI Grid format*
- Relative Elevation Model (REM), 1 m resolution, *ESRI Grid format*
- Water Surface Elevation Model, 1 m resolution, *ESRI Grid format*
- Intensity Images, 0.5 m resolution, *GeoTiff format*

Vectors

- 2D Water's Edge Breaklines, *shapefile format (polyline)*
- Submerged Topography Density Coverage Polygon, *(shapefile format)*

- Survey Boundary, *shapefile format*
- Tile Delineation, *shapefile format*
- Ground Survey Points and Monument Locations

Orthophotography

Imagery

- Orthophoto tiles, 15 cm GSD/resolution or better, *GeoTIFF format*

Vectors

- Survey Boundaries, *shapefile format*
- Orthophoto Index, *shapefile format*

Geodatabase

- Previous lidar collection layers (2010, 2017)
- All raster and vector layers (including but not limited to 2020 DEM, relative elevation, wetted width and flood elevations)

Reporting

- Data Collection Report: Methods, Results, Accuracy Assessments
- FGDC-compliant Metadata
- Presentation Ready Graphics

Coordinate System *(unless otherwise specified before final contracting)*

- Projection: UTM Zone 11N
- Horizontal Datum: NAD83
- Vertical Datum: NAVD88 (GEOID12B, or other as specified)
- Units: Meters

DATA ANALYSIS

Geomorphic Change Analysis

- Geomorphic Change GIS Data: channel traces, lidar differencing, change locations shapefile
- Geomorphic Change Summary Memorandum

HEC-RAS Update

- HEC-RAS file packages for both the 1D and 2D models

Floodplain Connectivity Analysis

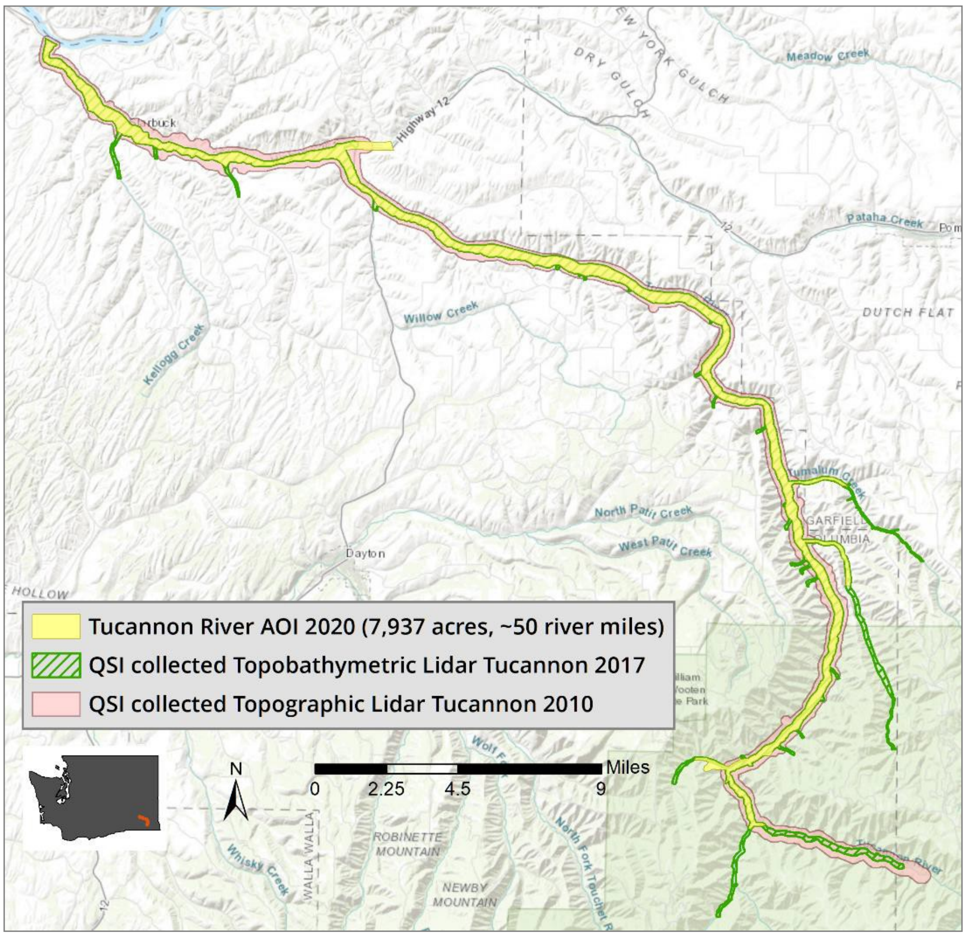
- Model Result Layers in GIS Meeting CTUIR Data Standards:
    - Inundation shapefiles and depth rasters at low-winter, mean-winter, 1-year, 2-year, 5-year, 10- year, and 25-year flow events
    - Connected, disconnected, and unavailable areas as part of the connectivity analysis
- Detailed Data and Calculations for Connectivity Analyses
- Connectivity Analysis Report

Habitat Complexity Analysis

- Model Result Layers in GIS Meeting CTUIR Data Standards:
  - Island, river thalweg, and valley line shapefiles used for the complexity analysis
- Detailed Data and Calculations for Complexity Analyses
- Complexity Analysis Report

Presentation Ready Graphics

- To be determined in collaboration with CTUIR and Anchor QEA throughout the post-processing period.



Coverage Map for 2020 Tucannon River LiDAR data acquisition.

Tucannon River Website

In 2018 the Tucannon Project started working with the CTUIR GIS department to initiate a new website, TucannonRiver.org. The new website will be used to create a central clearinghouse for all of the existing information on salmon recovery in the Tucannon Sub-basin. CTUIR TFHP is collaborating with other salmon recovery agencies including WDFW, Columbia Conservation District, and Snake River Salmon Recovery Board to upload all existing salmon recovery data to a single file server. Data on the file server will then be accessible via the worldwide web by visiting TucannonRiver.org.

Figure 15: A banner displayed on TucannonRiver.org lists all of the past and present participants in the salmon recovery process on the Tucannon River.

Stewardship of the data server and website will be provided by the CTUIR GIS department and Office of Information Technology. The data will be organized and displayed on the website in a manner that is digestible for a wide audience including Tucannon landowners. Two segments of the website, a publicly accessible segment and a password-protected segment, were created for the website in order to protect private and sensitive information.

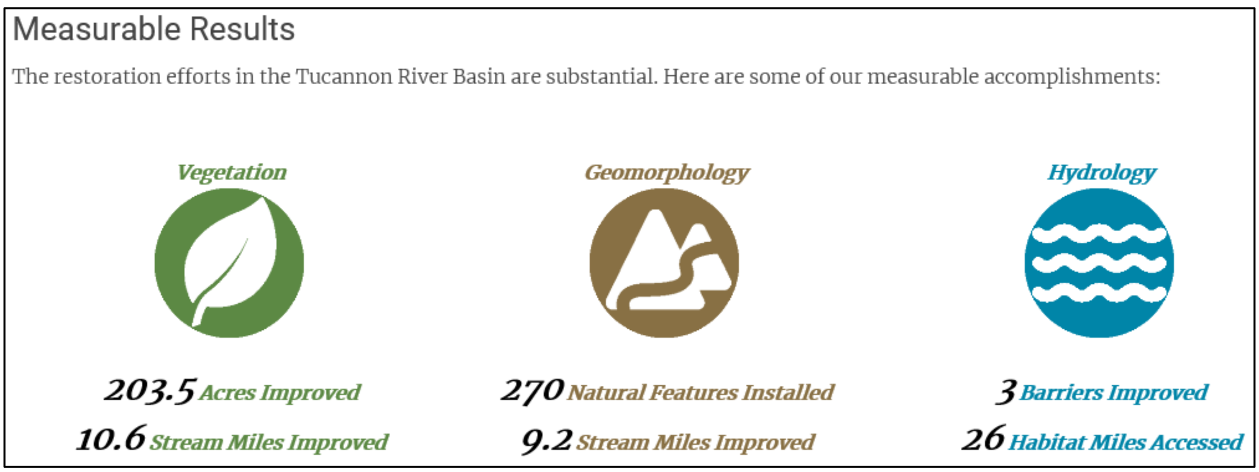


Figure 16: Project partners can upload habitat data to TucannonRiver.org. The CTUIR database that supports TucannonRiver.org is designed to roll-up habitat metrics into a summary format guided by the CTUIR River Vision touchstones: Hydrology, Geomorphology, Connectivity, Riparian Vegetation, and Aquatic Biota.

Project Goal

To work with private and public landowners in the Tucannon Basin to protect, enhance, and restore functional floodplain, channel, and watershed processes to provide sustainable habitats for aquatic species for all residents of the Tucannon Basin.

Project Objective

Find solutions that will benefit all residents of the Tucannon Basin, by addressing systemic problems associated with channel confinement, by allowing the Tucannon River to move freely within its floodplain and provide the maximum amount of ecological benefit for the fish and the people of the basin.

Project Funders

Funder	Funding Amount
Bonneville Power Administration	$2,202,077
CTUIR	$1,201,000
Pacific Coastal Salmon Recovery Fund	$406,864
Snake River Salmon Recovery Board	$275,000
Washington Department of Fish and Wildlife	$41,500
US Forest Service	$5,000

Figure 17: Providing transparency about the salmon recovery process on the Tucannon River will help improve people's understanding about everything that is required to achieve the goals and objectives of the salmon recovery effort.

The purpose of the website is to make all of the Tucannon salmon recovery information accessible to stakeholders and interested parties, foster strong collaborative relationships though common understanding, strengthen connections to the Tucannon River and its salmon, improve workflows for reporting, and to organize and protect all Tucannon salmon recovery data for permanent accessibility and use by all interested parties.

Current features of the website include:

1) Story Maps

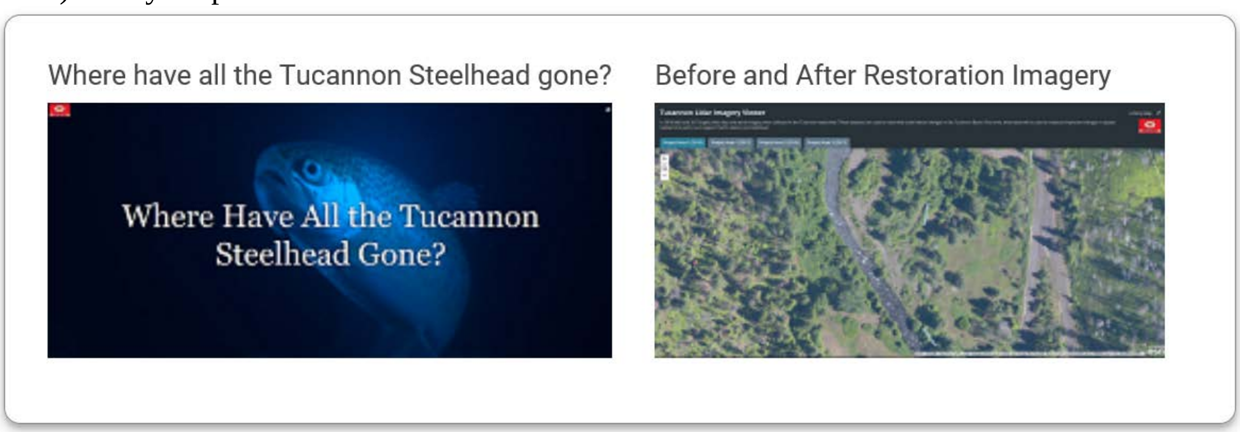


Figure 18: A banner displaying the two story maps that have been developed for TucannonRiver.org.

Story maps use maps and other graphic media to give a sense of place to a narrative and illustrate spatial relationships in an aesthetically pleasing manner that enhances understanding about a topic or issue. Two story maps have been created for TucannonRiver.org. The first story map tells the story of Tucannon River summer steelhead, and the status of this very popular sport fishery in southeast Washington. The second story map provides a primer on LiDAR technology and how it is used for watershed assessment and restoration planning in the Tucannon Sub-basin.

2) An inventory of completed restoration projects

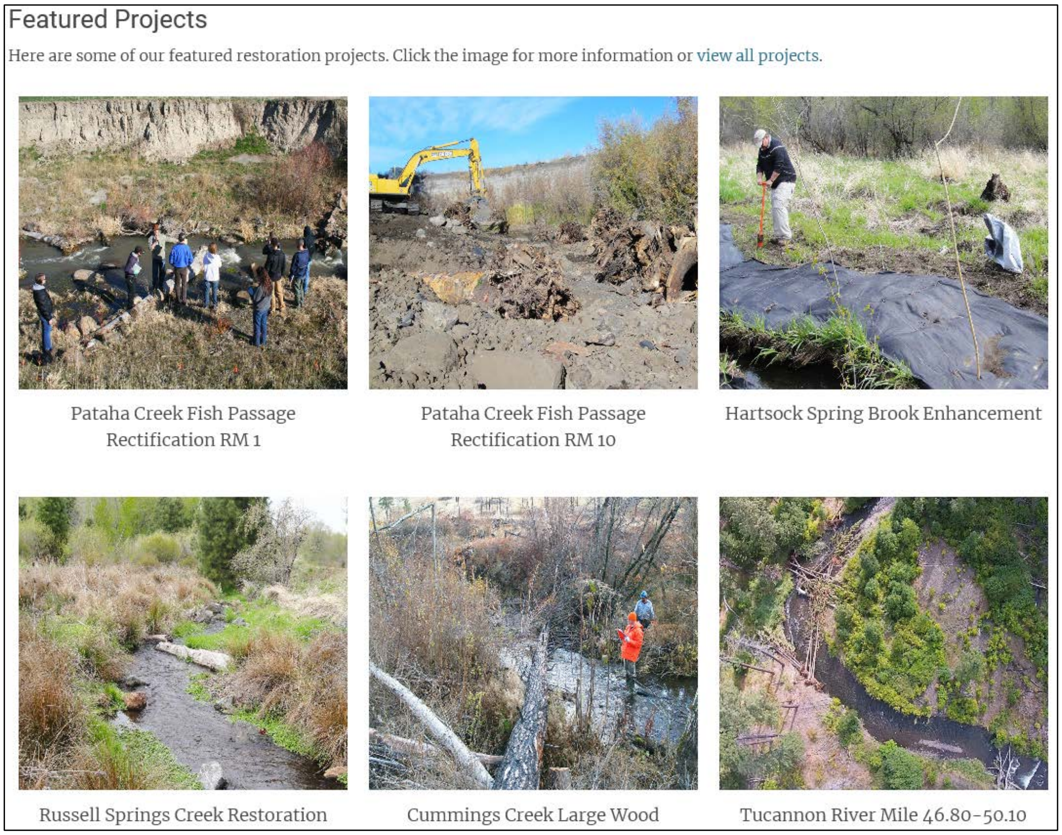


Figure 19: An interactive, hyperlinked banner from TucannonRiver.org that showcases some of the completed salmon habitat restoration work on the Tucannon River.

TucannonRiver.org will provide a living inventory of restoration projects, past and present. This will allow the public and technical collaborators to maintain an ongoing, collaborative understanding about the salmon habitat restoration process on the Tucannon River. The goal is to provide sufficient transparency and communication about the evolution of the salmon habitat restoration process on the Tucannon River to start generating and maintaining ongoing consensus about how to move forward with a unified vision for salmon recovery.

3) Links to reports and data

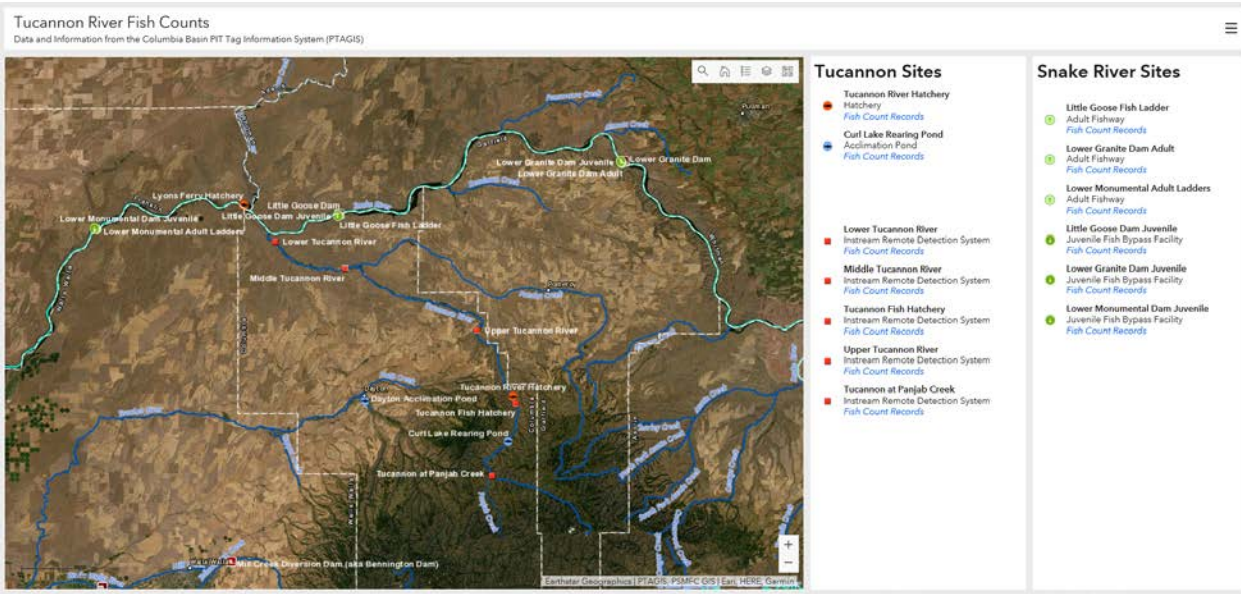


Figure 20: An interactive, hyperlinked map displays PTAGIS data relevant to the Tucannon River. PTAGIS is a software program that is used to track the movement of PIT-tagged fish. There are Four PIT tag arrays (PIT tag antennae) distributed throughout the Tucannon River.

The website includes links to streamgage data, Snotel data, and fish count data made available through PTAGIS. Additionally, any report or assessment of salmon stocks and/or physical habitat conditions in the Tucannon River has been included on the website.

Ongoing Work Elements

The following sections present work elements followed by discussion of accomplishments for the project during the contract period.

Manage and Administer Projects

This work element includes a suite of management actions required to administer the project, including preparation of annual operations and maintenance budgets, managing and preparing statements of work and budgets, and milestone and metrics reporting in Pisces, supervising and directing staff activities, conducting vehicle and equipment maintenance and management, payroll, purchasing, subcontracting for services, and administering/inspecting habitat enhancement activities. CTUIR staff administered the Tucannon Project Area 17/18 restoration design and landowner coordination, and the design and construction of Project Area 27/28.1, including design and construction subcontract solicitation, field stakeout, and observation and inspection. Staff also administered subcontract solicitation for LiDAR data collection and analysis on the Tucannon River in 2020.

Environmental Compliance and Permits

Environmental compliance involves development of appropriate documentation under various federal and state laws and regulations governing federally funded project work. This work requires coordination with various federal and state agencies and development, oversight, and submittal of permit applications for restoration projects, biological assessments, cultural resource surveys, etc.

Primary accomplishments during the reporting period included coordination with BPA environmental compliance personnel to prepare supplemental documentation and reporting for ongoing and planned management actions.

Environmental Compliance is ongoing for all phases of the proposed Project Area 17/18 restoration treatment, as well as future construction phases of the Project Area 28 restoration treatment. Environmental Compliance is also ongoing for Project Area 3 maintenance activities.

Coordination and Public Outreach/Education

Coordination and public education were undertaken to facilitate development of habitat restoration and enhancement on private lands, participate in Sub-basin planning, ESA recovery planning, BiOp/Remand project development and selection processes, and assist with providing watershed restoration education. CTUIR technical staff coordinates restoration efforts on the Tucannon River through the Snake River Salmon Recovery Board (SRSRB), to help facilitate development of management policies and strategies, project development, project selection, and priorities for available funding resources.

The CTUIR Tucannon Project Leader participates in multiple programs and processes associated with project prioritization and selection, funding, and technical review. Focus during the reporting period included participation on the Snake River Salmon Recovery Board, Snake River

Region Lead Entity Committee, the SRSRB Regional Technical Team, and the Tucannon River restoration co-implementer committee. Tasks associated with these boards and committees include evaluation and selection of projects for funding recommendations through the Washington State Recreation and Conservation Office (WA State salmon recovery process) and the Tucannon Habitat Programmatic (watershed-specific BPA funding for salmon habitat restoration). Additionally, CTUIR staff coordinated closely with BPA and SRSRB to update the Tucannon River Geomorphic Assessment and Conceptual Restoration Plan for the next decade of salmon habitat restoration on the Tucannon River.

CTUIR staff also participated in a several educational and public outreach activities including: setting up and staffing informational booths at the Columbia County Fair, presentations to the Snake River Salmon Recovery Board, presentations at annual meetings for the CTUIR Department of Natural Resources and the broader tribal membership, presentations at the Washington State salmon recovery conference, and presentations at the River Restoration Northwest Symposium.

Planting and Maintenance of Vegetation

The CTUIR habitat program annually participates and/or assumes the lead role in re-vegetation activities on individual habitat restoration and enhancement projects. Planting and seeding methods are developed to address site specific conditions and vegetation objectives. Natural colonization and manual techniques are utilized.

Staff efforts associated with planting during the reporting period included the purchase, staging, and installation of approximately 5,000 containerized plants in PA 17/18. Planting activities in PA 27/28.1 included installation of approximately 150 native trees and over 3,000 native willow cuttings. PA 27/28.1 was also seeded with a native grass seed mix that was developed and donated by the U.S. Forest Service. Containerized plants were installed by the Washington Conservation Corps, an Americorps program operated by the Washington State Department of Ecology.

Identify and Select Projects

Habitat protection, restoration and enhancement project opportunities continued to be identified, evaluated, and developed during the reporting period. Activities included coordination with basin partners and private landowners to discuss and develop opportunities for future fish habitat and watershed protection and enhancement. Staff developed a project prospectus for acquisition of the Tucannon Ranch conservation properties and continued to scope projects elsewhere on private property in the lower Tucannon Sub-basin. Project development and scoping is ongoing with 28 private landowners in PA 17/18.

Address road impacts to floodplain function in Project Area 3

In 2019, CTUIR initiated design consultation and Environmental Compliance with BPA and US Forest Service (USFS) in order to divert flood waters away from a road, through historic side-channels on the floodplain in PA3. In February 2020 a massive rain-on-snow event throughout the northern Blue Mountains resulted in historic flooding and significant damages to many USFS roads and infrastructure. As a consequence, the PA 3 side-channel bypass project has been put on hold while USFS prioritizes and addresses the myriad repair projects that resulted from the 2020 rain-on-snow flooding.

Lessons Learned and Adaptive Management

> *"Empirical channel pattern relationships indicate that, for the characteristic reach slope and bankfull geometry and flow rate, the river planform should tend toward a single, relatively straight channel (Leopold and Wolman 1957; van den Berg 1995; Millar 2000, 2005; Eaton et al. 2010). The reach slope is characteristic of a pool-riffle channel, with a potential alternate plane bed state when large wood is absent (Montgomery and Buffington 1997)."*
>
> ~ Language from a 2016 Basis of Design Report for a Tucannon River Restoration Project

Walter and Merrits (2008) concluded that "The current condition of single thread, gravel-bedded channels with high, fine-grained banks and relatively dry valley-flat surfaces disconnected from groundwater is in stark contrast to the pre-settlement condition of swampy meadows and shallow anabranching streams" (p. 303). They proposed that foundational river science studies such as Leopold and Wolman (1957; cited in the quote at the beginning of this section) which established relationships between the dominant discharge, channel form, and floodplain building processes, were based on river systems that are the products of prior anthropogenic disturbance. The conclusions drawn by Walter and Merrits (2008) are supported by the work of other river scientists working in the western United States and Europe (Pollock et al. 2003; Collins et al. 2003; Montgomery et al. 2004; Sear and Arnell, 2006; Brown and Sear, 2008; Woelfle-Erskine et al., 2012). This new perspective has been crystallized into the overarching concept of the Stream Evolution Model (Cluer and Thorne, 2013).

The quote at the beginning of this section is from a Basis of Design Report for a Tucannon River Restoration Project and it is representative of the historical (albeit changing) perspective on river restoration within the Tucannon River basin. It was formed over decades, through incremental improvements in understanding, by a lineage of brilliant physical scientists whose contributions form the bedrock of river science. More recently, Tucannon river restoration practitioners have been including the Stream Evolution Model (Cluer and Thorne, 2013) and Stage 0 river restoration concepts (Powers et al., 2018) within their approaches to river restoration design.

Lessons Learned

Information about lessons learned is exchanged formally through the SRSRB Regional Technical Team and the Tucannon Habitat Programmatic co-implementers committee. CTUIR also maintains open and regular communication with all other co-implementers and co-managers, facilitating consistent information exchange on a more informal basis.

Lessons learned by all the co-implementers during the last decade of restoration on the Tucannon River are being used to update the Tucannon Geomorphic Assessment and Restoration Prioritization (Anchor QEA, 2020) for more effective implementation of restoration treatments over the next decade of salmon habitat restoration on the Tucannon River. For example, due to the limited sediment budget and infrequent high-stream-power events, a gravel supplementation plan is being developed through the updated 2021 Plan in order to help increase the rate of channel aggradation, increase habitat complexity, and improve floodplain connectivity.

Infrastructure in the floodplain will continue to be an obstacle to increasing floodplain connectivity and habitat complexity on the Tucannon River. The manner in which a restoration project is implemented is partially dependent on the attitude of the landowner whether it be public or private land. A properly motivated private landowner can facilitate rapid development and execution of restoration projects. An indifferent public land manager can grind the entire process to a halt. If salmon habitat restoration is going to keep pace with declining salmon populations, greater cooperation and coordination between natural resource management agencies will be necessary.

The ability to achieve the objectives of increased floodplain connectivity and habitat complexity, set forth by the 2021 Plan. In 2019, CTUIR and BPA worked with a willing landowner to purchase a conservation property, Tucannon Ranch, located on the lower Tucannon River. The attempt to purchase Tucannon Ranch was inhibited by two obstacles: 1) properties often sell at higher prices than the yellow book valuation, and (2) private buyers can move through the purchasing process much faster than public buyers. Property owned by individuals or entities that are invested in salmon habitat recovery (private landowners in PA 24, 27, and 28, and WDFW) have been the places where the most successful projects have been implemented on the Tucannon River.

While a lot of good restoration work has been accomplished in the Tucannon River, future projects should continue to attempt more aggressive approaches when and where possible. This will be largely dictated by the landowner and the presence and/or absence of infrastructure in a given treatment reach. PA3, which is located on property owned by WDFW, is an example of successful adaptive management on the Tucannon River (see case at the end of this report). As mentioned in the conclusion of the last Tucannon annual report (Seilo and Fischer, 2019), however, the geomorphic change that is being sought through restoration treatments is occurring at an overly slow rate due to the infrequent occurrence of 2 year event channel forming flows in the Tucannon.

While it may be more costly to initiate an aggressive approach such as a full-scale geomorphic reset, it is likely that full geomorphic resets are more effective at achieving the long-term goals and objectives set forth for restoration projects on the Tucannon River. It is also possible that more aggressive geomorphic resets will reduce the amount of long-term maintenance and tinkering that has become a necessity on older, less aggressive large wood treatments of the main channel. A more aggressive geomorphic reset could result in faster achievement of restoration goals and objectives and a reduced overall cost per project reach, due to the decreased maintenance and adaptive management required.

Success During the Reporting Period

1. Adaptive management in PA 3 has proven to be successful at achieving the objective of increased floodplain connectivity through increased wood loading (refer to the case study at the end of this report).
2. Several of the permanent residents in PA 17/18 have signed a "*Construction Access, Implementation, and Maintenance Agreement*", granting CTUIR permission to construct a restoration treatment on the portion of the Tucannon River that runs through their

property. There is robust support for a restoration project amongst those that have signed agreements.
3. CTUIR successfully completed subcontractor selection(s), project design, project permitting, and Phase 1 construction in PA 27/28.1 within nine months of initiating the project.

Obstacles During the Reporting Period

1. Attempts to implement restoration actions in PA 4, 5, and 7 have lost momentum. These project areas are located on US Forest Service and Washington State Parks properties and they contain many infrastructure concerns. Working with the US Forest Service to achieve consensus on project elements worthy of salmon habitat funding has proven challenging. Successfully navigating the NEPA process with USFS has also been a challenge.
2. Getting the 28 landowners in PA 17/18 to agree on alterations to the river that runs through their property has been a slow process. This becomes increasingly difficult when critical participants renege on signed agreements. As stated earlier in this report, the largest landowner in PA17/18 owns 17% of the project area and they recently pulled out of participation in the project.
3. Acquisition of conservation properties from willing sellers along the Tucannon River has been challenging. In 2019 CTUIR attempted to purchase a conservation property on the Tucannon River with assistance from BPA. Unfortunately a private buyer was willing to pay above the fair market value and they were able to move quickly to finalize the purchase.

Adaptive Management

Geomorphic Change Detection (Wheaton et al., 2010a; Wheaton et al. 2010b; Wheaton, 2008) that was initiated by the CHaMP and AEM programs, has been used to support adaptive management actions on the Tucannon River over the last decade (See PA3 case study below). To replace the loss of the CHaMP and AEM programs, Tucannon implementers in the Tucannon Sub-basin are collecting and using topobathymetric LiDAR data. These datasets collect high-resolution topographic information for the river channel and floodplain over the entire Tucannon Sub-basin.

Collecting topobathymetric LiDAR data every high flow events (>5 year events) will allow continued assessment of geomorphic change in the Tucannon River at a much larger spatial scale and a fraction of the cost (time and money) of the CHaMP and AEM programs. This information will help Tucannon implementers continue to improve their understanding about how the different reaches of the Tucannon respond to different treatment techniques over various time scales. It will assist with monitoring progress toward the goals and objectives outlined in the updated 2021 Plan.

Additional habitat monitoring is conducted through the Tucannon Habitat Programmatic. The Tucannon Habitat Programmatic uses a Rapid Habitat Survey methodology to collect information relevant to limiting factors within the channel and floodplain of a given treatment reach. Data is collected before and after implementation of restoration projects within the reach. Rapid Habitat Surveys collect information about large wood quantities, pool quantities, and numbers/lengths of side channels. This information is used to inform project performance and adaptive management through time. The adaptive management activities highlighted in the PA3 case study (see case study at the end of this document) were partially informed by the Program's Rapid Habitat Survey data.

Topographic LiDAR datasets collected for the Tucannon River, combined with Rapid Habitat Survey data, helped inform the analyses that were conducted as part of the updated 2021 Plan (Anchor QEA, 2021). Results of the updated analyses show that large portions of the Tucannon River remain below the desired targets for floodplain connectivity and channel complexity. These data show minimal geomorphic change and minimal increases in habitat complexity in areas where restoration treatments were too light in their approach (i.e. not enough wood loading). These data and analyses continue to support the need for more aggressive restoration projects that increase floodplain connectivity and channel complexity over shorter timeframes. A more aggressive approach will hopefully create more durable restoration outcomes on the Tucannon River moving forward.

The results of adaptive management projects such as the one completed in PA 3 (see case study at the end of this report) have demonstrated how increased wood loading in low risk reaches can increase the rate at which geomorphic responses are observed on the Tucannon River. This is particularly important in light of the relatively infrequent occurrence of high-stream-power flow events (>5 year events) on the Tucannon River. With these observations in mind, the CTUIR Tucannon Basin Fish Habitat Enhancement Project seeks to move toward a more aggressive approach to restoration treatment, pursuing full-scale geomorphic resets to a Stage 0 condition when and where it is appropriate.

The work being conducted in PA 27/28.1, is adapting to the slow rate of geomorphic response to restoration treatments that was observed during the last decade of restoration work, by applying a more aggressive restoration approach. PA 27/28.1 will attempt to push the river toward a partial Stage 0 condition, immediately upon completion of construction. This approach will reduce the waiting period for this project to reach fully mature, and minimize the amount of future maintenance that will be required for this treatment to continue meeting desired habitat metrics.

In PA 17/18, where progress has been slow due to the large number of landowners within the reach, focus has been shifted to a portion of the reach owned entirely by the Washington Department of Fish and Wildlife. The proposal in this portion of the PA17/18 reach is to conduct restoration treatments that improve habitat conditions for Tucannon salmonids and demonstrate the potential benefits to downstream private landowners. At a minimum, this will ensure continued progress toward salmon habitat restoration on the Tucannon River. Hopefully as an added benefit it will also serve to persuade the 28 landowners in PA 17/18 to unify toward implementation of a restoration treatment within their properties.

Critical Landmarks or Challenges Anticipated for the Future

- PA3 side-channel by-pass continues to take a backseat to higher priorities within CTUIR Tucannon Habitat Program and USFS. Serves as an example of how existing infrastructure in the floodplain continues to hamper efforts to increase floodplain connectivity.

- PA 4, 5, and 7 – Another example of how existing infrastructure in the floodplain continues to hamper efforts to increase floodplain connectivity. It has been challenging to achieve consensus with USFS on project scoping and design that would be an appropriate application of salmon recovery funding.

- PA17/18 – It is a massive challenge to coordinate and direct 28 landowners toward a unified vision for river restoration that is beneficial to salmon and other native aquatic biota.

A Case Study of Successful Adaptive Management in the Tucannon Sub-basin

Project Area 3 Treatment Reach – Tucannon River, miles 46.7- 48.2

"Two key pieces of wood per channel width" is the wood loading target for habitat restoration projects on the Tucannon River (SRSRB 2011). In the summer of 2014 large wood was placed in PA3 to aggrade the channel bed and increase in-stream habitat complexity. Prior to the addition of large wood in 2014, the PA3 reach possessed a high capacity for conveying river flows and sediment and the river was incised ~6 feet or more into the floodplain (Figure 21).

Figure 21: Pre-treatment condition of PA3, circa 2014. The difference in elevation between the stream bed and top of bank was approximately six feet. The channel width was also larger than expected for the reach.

After the addition of large wood in 2014, monitoring and assessment using Geomorphic Change Detection from the Columbia Habitat Monitoring Program confirmed that large wood structures were helping to aggrade the stream bed within the PA3 reach (Figure 22). But there were no significant improvements in floodplain connectivity within the reach after completion of the 2014 large wood treatment. Additional post-treatment rapid habitat survey data revealed that wood loading for PA3 had dropped below the target threshold by 2018. This informed the decision to conduct adaptive management within the reach by adding additional large wood to this restoration reach.

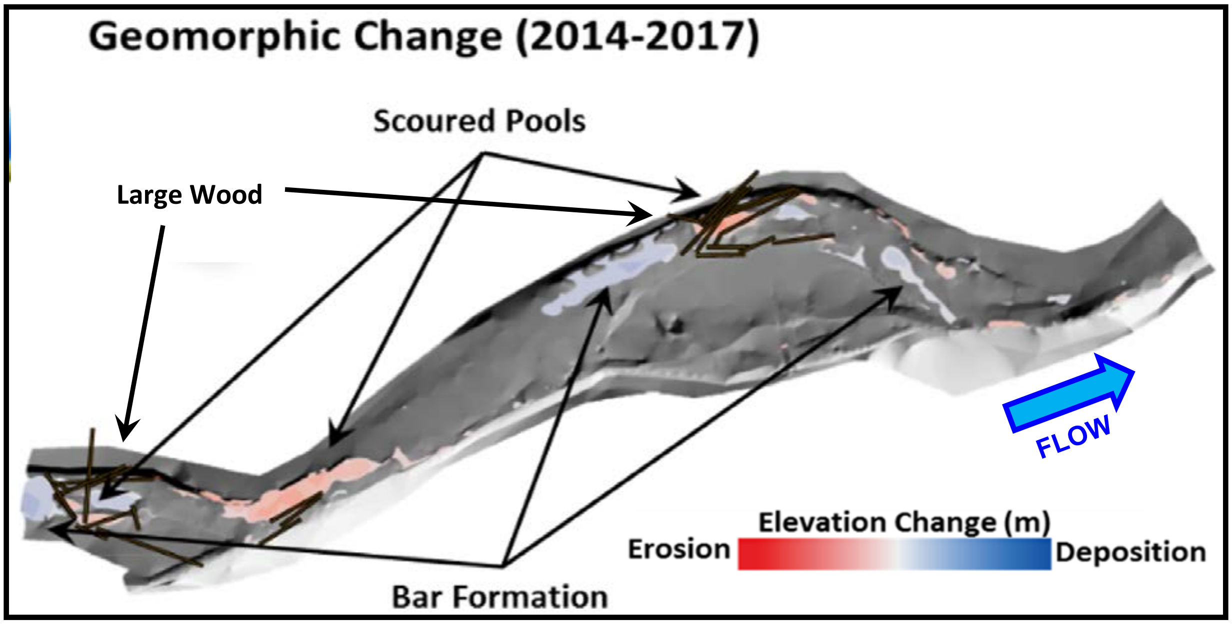


Figure 22: Geomorphic Change Detection data revealing areas of aggradation and erosion around constructed log structures in PA3. Data were collected under the Columbia Habitat Monitoring Program (CHaMP).

In order to optimize the benefits of the proposed large wood replenishment, River Complexity Index (Brown, 2002) was used to model potential improvements in floodplain connectivity and habitat complexity through reconnection of historic side-channels. A topographic assessment of PA3 using Relative Elevation Models revealed a network of relic channels on the floodplain surface, adjacent to a single, high-capacity channel (Figure 23). Modeling revealed that one specific section of floodplain within PA3 could be inundated by reconnecting three to four historic side-channels (Figure 23 and Figure 24).

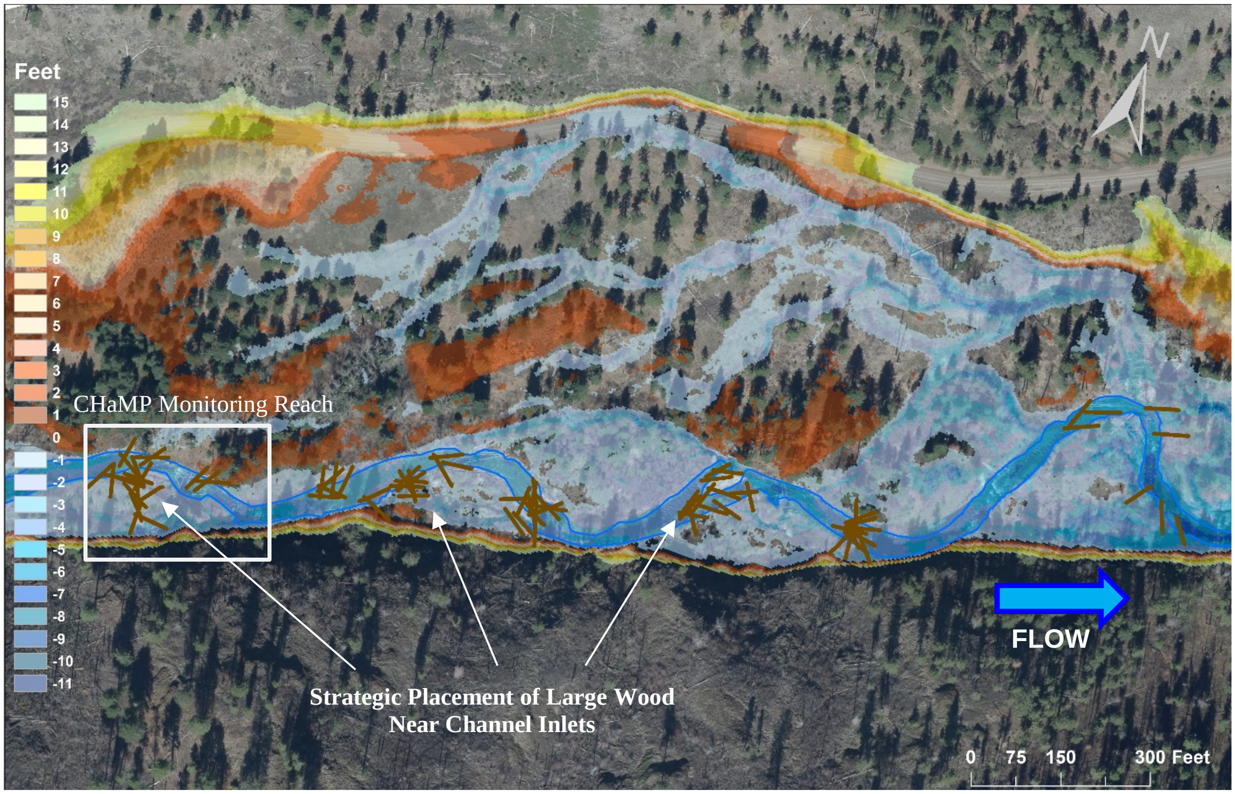


Figure 23: An example Relative Elevation Model for the portion of the Tucannon floodplain that had been identified for strategic reconnection with the main channel in PA3. This Relative Elevation Model was developed using the Geomorphic Grade Line tool (Powers et al., 2018). The "zero" elevation is the approximate elevation for the bankfull return interval. The darker blue ribbon is the main channel of the Tucannon River. Under these existing conditions the main channel has inset benches that are below the bankfull elevation. This means that there is a high capacity "overflow" channel surrounding the Tucannon River, which limits the expression of bankfull discharges at, or above bankfull elevations. In other words, the floodplain rarely gets inundated under these conditions in the absence of wood or aggradation.

Based on the insight provided by monitoring data and modeling of the reach, CTUIR worked with engineers from WDFW to plan the layout and design of 60 new large wood structures in PA3. The new large wood structures were placed in strategic locations and designed to push water onto the floodplain through inlets to historic side-channels. If the placement of large wood was successful at reconnecting targeted areas of floodplain through historic side-channels, it would significantly increase floodplain connectivity and channel complexity within the restoration reach.

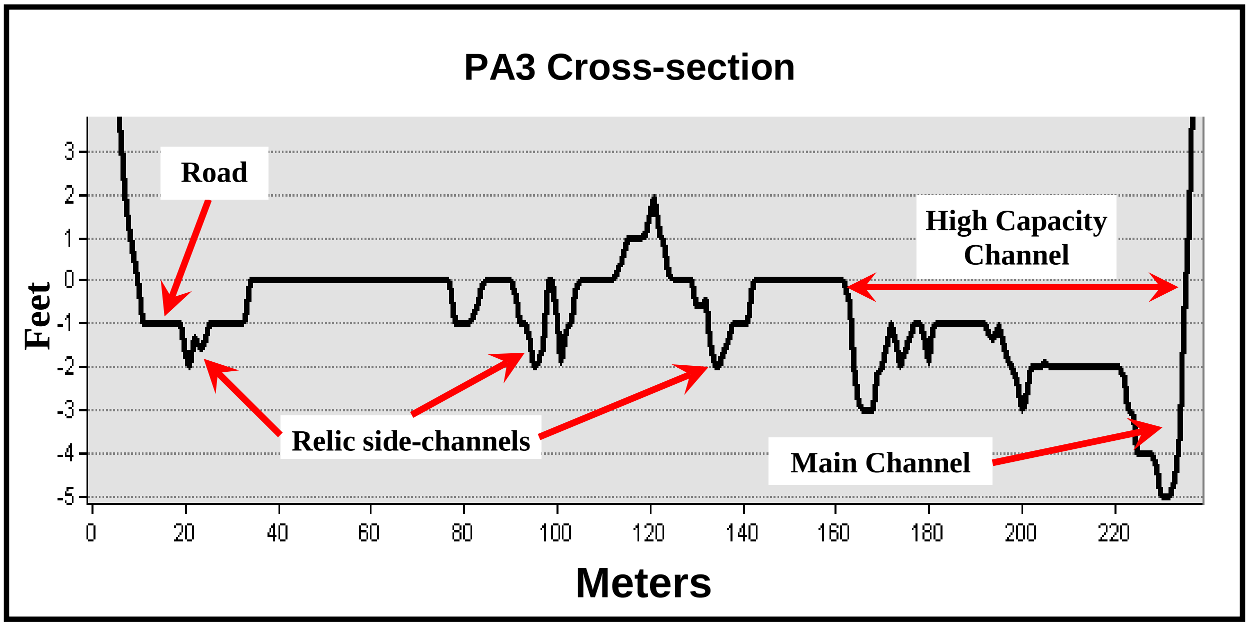


Figure 24: A cross-section view for the portion of the Tucannon floodplain that had been identified for strategic reconnection with the main channel in PA3. This cross-section was developed using the Geomorphic Grade Line tool (Powers et al., 2018). Prior to the 2018 large wood treatment in PA3, the relic side channels were almost never activated except during rare flood events. The lack of floodplain in PA3 connectivity was largely due to an oversized, high-capacity channel through the reach.

PA3 Treatment Outcomes

This restoration treatment had four objectives: 1) establish two key pieces (> 6m long, > 0.3m diameter) of large wood per channel width, (2) increase channel complexity, (3) aggrade the active channel, and (4) reconnect the floodplain.

The minimum number of key pieces of wood necessary to achieve the target quantity for PA3 was ~330. During the summer of 2018, approximately 360 large trees with rootwads and 47 ballast boulders were used to construct 55 large wood structures in PA3. For each key log a corresponding "tree top" log was placed upstream of log structures to provide racking. The resulting total number of key pieces of wood added to the reach was 720. All logs and ballast boulders for this project were placed by helicopter in order to minimize disturbance of the mature riparian forest throughout the reach.

In April 2019 (less than a year after completion of the 2018 large wood treatment), targeted portions of the floodplain within PA3 were inundated under an estimated discharge of ~400-600 cfs (USGS Stream Stats; Tetra Tech, 2014) in PA3 (Figure 25 and Figure 26). Stream discharge in PA3 was estimated to be somewhere between bankfull and the two-year return interval during this time. Floodplain inundation had only been observed twice in PA3 during the 30 years prior to 2019 (Figure 27).

Figure 25: Imagery of PA3 floodplain inundation on April 10, 2019. Imagery was acquired by the CTUIR drone program. Discharge was estimated to be ~400-600 cfs within the reach. These estimates were derived from USGS Stream Stats and regression models developed by design engineers (Tetra Tech, 2014).

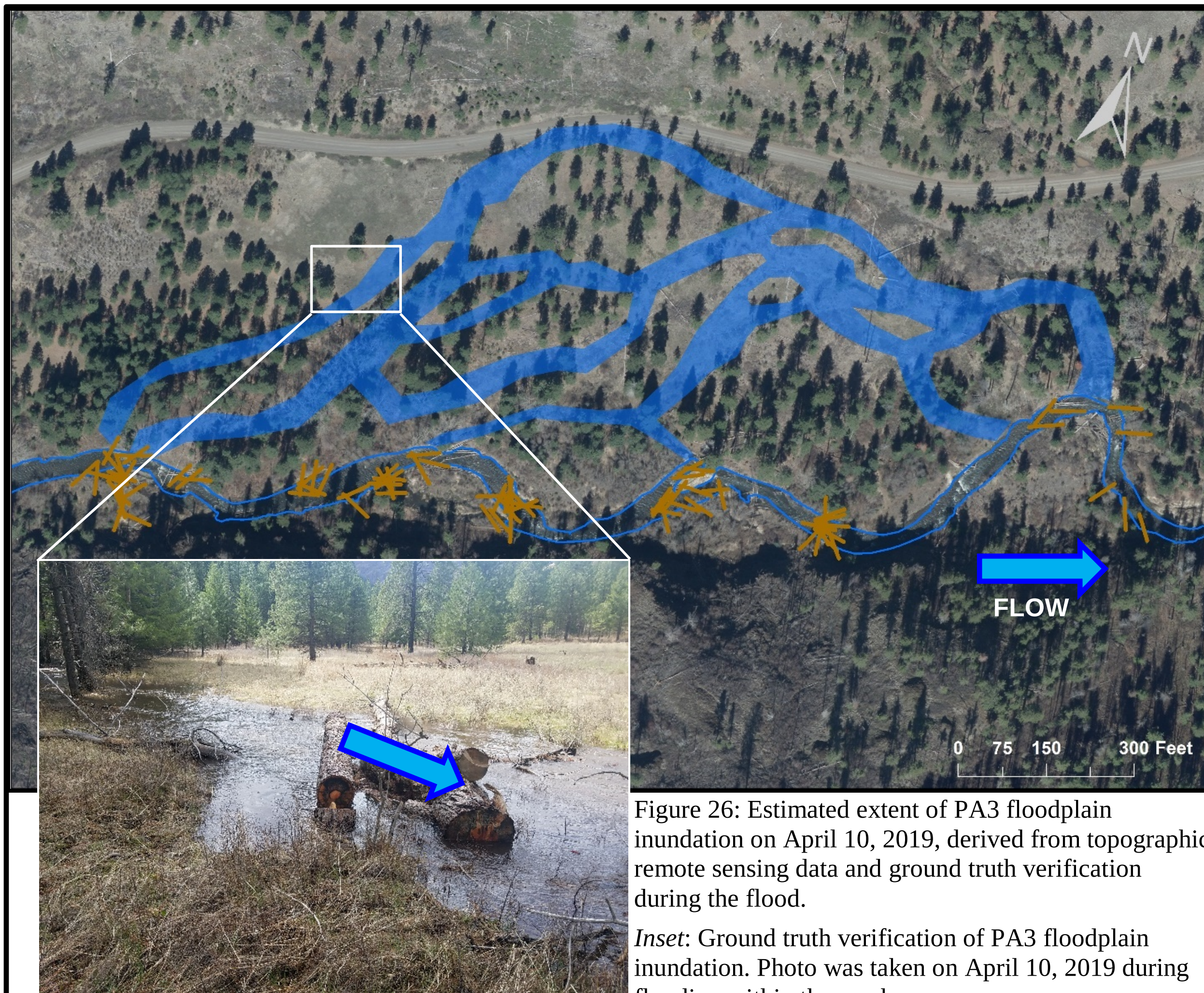


Figure 26: Estimated extent of PA3 floodplain inundation on April 10, 2019, derived from topographic remote sensing data and ground truth verification during the flood.

Inset: Ground truth verification of PA3 floodplain inundation. Photo was taken on April 10, 2019 during flooding within the reach.

In 1996 during the fourth-largest flood for the period of record, Tucannon River discharge was measured as 5,580 cfs at the USGS gage at Starbuck, WA (13344500). The eighth-largest flood of record occurred in 1997 and was measured as 3,310 cfs at USGS gage at Starbuck, WA (13344500). The only other observation of floodplain inundation in PA3 during that 30 year period occurred in 2019 (immediately after large wood additions in summer 2018). The peak flow measured in 2019 was measured at 1,040 cfs at USGS gage at Starbuck, WA (13344500).

The floodplain inundation that was observed in PA3 during 2019 suggests that the large wood treatment was successful at achieving the objective of increased floodplain connectivity in PA3. For reference, the maximum discharge on the Tucannon River in 2017 was 1,790 cfs. The maximum discharge in 2018 was measured at 1,010 cfs, neither of these flows produced floodplain inundation in PA3.

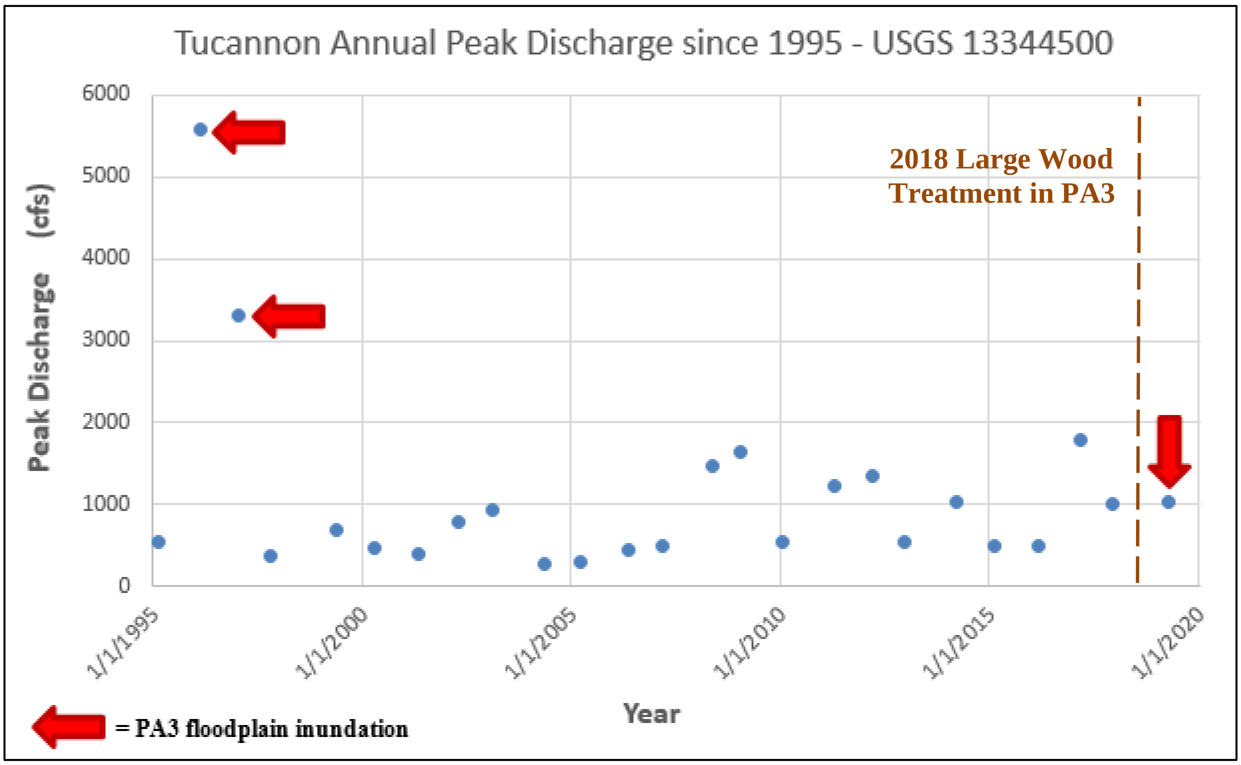


Figure 27: Annual peak streamflows measured at USGS gauging station 13344500 in Starbuck, WA. Red arrows indicate the three instances of floodplain inundation that were observed in PA3 during the last 30 years. Flows in April 2019 were significantly lower than they were in 1996 and 1997. Large wood structures, designed to increase floodplain inundation through PA3, were installed in the summer of 2018.

PA3 Summary

The large wood treatments implemented by CTUIR have increased floodplain connectivity in PA3, and have resulted in improvements to aquatic habitat availability that did not previously occur at the bankfull to two-year return interval (Table 8). Most of the objectives set for the 2018 large wood treatment have been met, including 2 key pieces per channel width (Figure 28). Table 8 shows increases, in floodplain connectivity (days and acres of floodplain inundation), and complexity (braid-channel ratio and river complexity index). The one objective that has proven difficult to measure is aggradation, though it is suspected that increased floodplain connectivity in the PA3 reach is partially supported by aggradation.

Since the termination of the CHaMP program in 2018, it has proven difficult to continue monitoring sediment movement in the Tucannon River. Tucannon implementers have filled this data-gap by collecting additional bathymetric LiDAR data. Periodic collection of bathymetric LiDAR data will allow for continued Geomorphic Change Detection (GCD) (Wheaton et al., 2010a; Wheaton et al. 2010b; Wheaton, 2008) at a fraction of the cost for running the CHaMP protocols. Future reporting will include an assessment of sediment movement, including active channel aggradation and erosion in response to these 2018 restoration actions.

Habitat Metrics at ~Q2	Pre-project (2018)	Post-project (2019)
Braid-channel Ratio	1	1.6
River Complexity Index	1.1	18.93
Side-channel length	760 meters	1,740 meters
Area floodplain inundation	< 1 acre	~7 acres
No. days flood inundation	< 1 day	~ 18 days

Table 7: Estimated changes in metrics related to floodplain connectivity in PA3, before and after installation of large wood structures in the summer of 2018. Data are specific to areas of floodplain that were specifically targeted for reconnection between historic side-channels and the main channel.

Given the location of PA3 within the Tucannon watershedc months-long floodplain inundation seems unlikely for the restoration reach. Nonetheless, it is clear from hydraulic modeling and remote sensing analyses of the topographic data, that the active channel at PA3 is over-sized within the reach. The goal of reducing the conveyance capacity, and increasing the floodplain connectivity and channel complexity within PA3 has far reaching benefits for ESA-listed species. The PA3 reach is important because it is located within the spawning reaches of ESA-listed spring Chinook, summer steelhead, and bull trout. Our hope is that this restoration project will reduce the conveyance capacity of the channel, by increasing channel complexity and increasing the floodplain connectivity of the restoration reach and one day provide important high-flow refugia for adult, juvenile, fry, and egg life history stages during high flows.

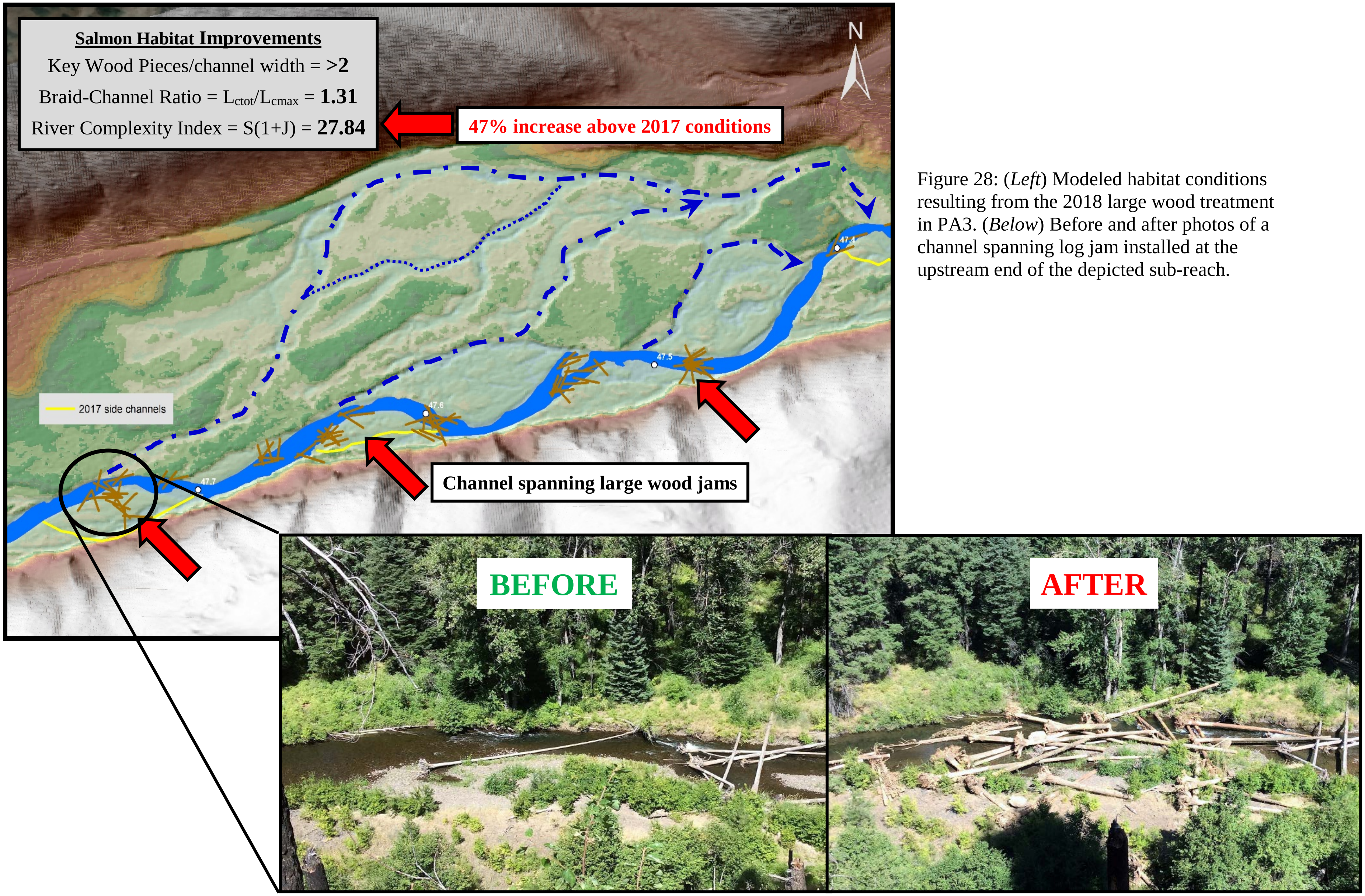


Figure 28: (*Left*) Modeled habitat conditions resulting from the 2018 large wood treatment in PA3. (*Below*) Before and after photos of a channel spanning log jam installed at the upstream end of the depicted sub-reach.

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