Important Feasibility Note Regarding

The Chiwawa Outlet Restoration Project Conceptual Design Report

This inserted note is intended to clarify how a subset of the feasibility assessments and design work to be performed under this upcoming contract should relate to specific conceptual alternatives shown in the Chiwawa Outlet Restoration Concept Level Design Plans and the Conceptual Design Report.

Based on additional investigation and discussion with our partners after publication of the conceptual plans, we do not intend to move forward with the modified effluent options shown on pages C2 & C3 of the Concept Level Design Plans, and as referenced as project element 6 in the Conceptual Design Report. Several reasons for this decision to exclude hatchery effluent discharge as a water source include potential water quality issues, disruption of Chiwawa Hatchery activities, and water right permitting requirements.

Despite the decision to exclude hatchery effluent discharge as a water source, Yakama Nation Fisheries is still very interested in examining opportunities to use existing and/or creating new water diversion infrastructure along the Chiwawa River to achieve similar habitat enhancement outcomes that were conceptualized under project element 6.

The contractor selected to perform design services under this current RFP will assist Yakama Nation Fisheries and the Chelan County PUD in analyzing existing water diversion and transport infrastructure related to the Chiwawa River Hatchery to determine if augmentation of such infrastructure, or creation of new infrastructure, could yield fish habitat benefits as conceived under project element 6.

Chiwawa Outlet Restoration Project: Conceptual Design Report

prepared for

Yakama Nation Fisheries

prepared by

Waterways Consulting, Inc.

1020 SW Taylor St. Suite 380
Portland, Oregon 97205

November 25, 2020

TABLE OF CONTENTS

LIST OF FIGURES, TABLES, AND PHOTOS

Figure # **Description** **Page #**

Appendices

1.0 PROJECT BACKGROUND

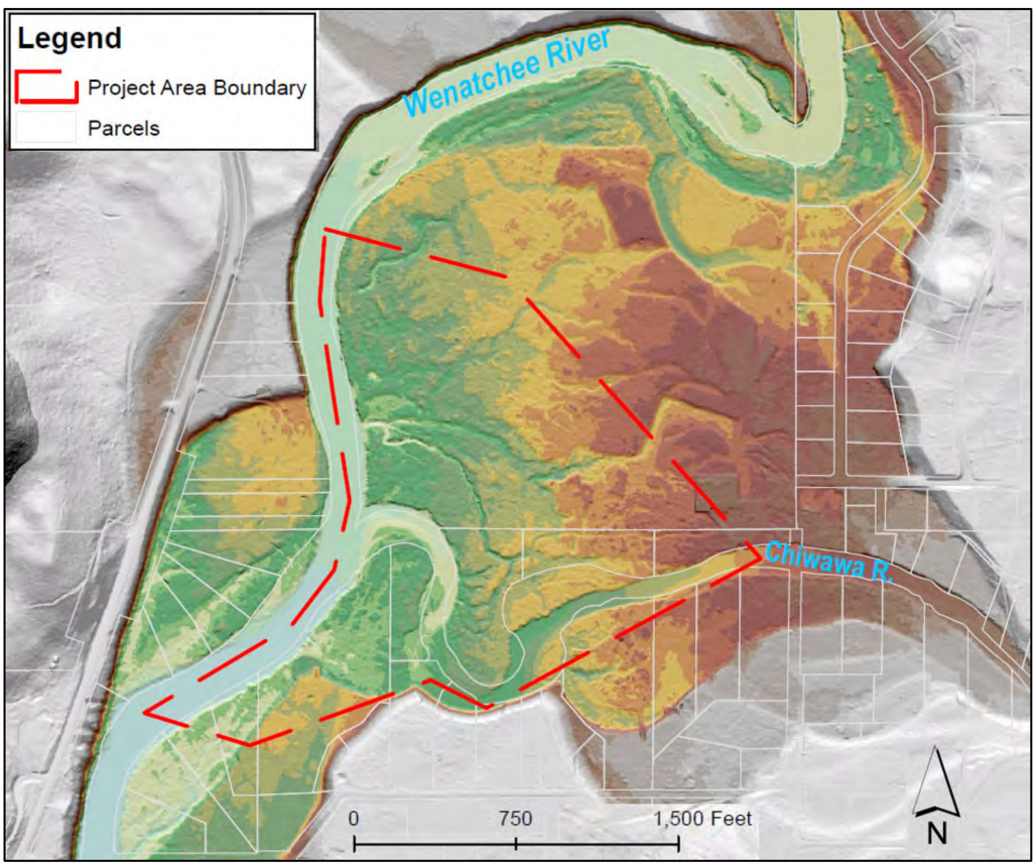
Scope of this Report

This report provides the conceptual designs and the design rationale for the Chiwawa Outlet Restoration Design Project, sponsored by the Yakama Nations Fisheries Department. The report follows the Basis of Design Report (BDR) template for documenting Bonneville Power Administration (BPA) Habitat Improvement Program (HIP) projects (BPA, 2019). This submittal covers the development of Conceptual (15%) Designs. The Conceptual Design Drawings are provided as Appendix A of this report.

Project Area

The project is located at the confluence of the Wenatchee River and its largest tributary, the Chiwawa River, near Wenatchee River mile 48.5 in Chelan County, Washington (Figure 1). This project area provides a unique opportunity to benefit fish in the Wenatchee River basin. The Chiwawa River, which drains Glacier Peak, remains cool throughout the year. In contrast, the Wenatchee River, which begins several miles upstream at Lake Wenatchee, has higher water temperatures. One aspect of the project designs is to take advantage of the temperature contrast between the two rivers to maximize the thermal benefit to fish by creating much needed cool water off-channel salmonid rearing habitat along the mainstem Wenatchee River.

Figure 1. *Topography in the Chiwawa Outlet Restoration Project Area*



1.1 Name and Titles of Sponsor, Firm and Individuals Responsible for Design

- Project sponsor - Yakama Nation Fisheries
- Sponsor project manager – Jason Breidert, Fisheries Biologist
- Engineering Design Firm - Waterways Consulting, Inc.
- Project Manager and Geomorphologist – Daniel Malmon, Ph.D, P.G.
- Lead Design Engineer – Barry Tanaka, M.S., P.E.

1.2 List of Project Elements Designed by a Licensed Professional Engineer

Barry Tanaka (P.E.) is the licensed professional engineer for the project. The proposed design concepts for the project are depicted in the Conceptual Design Drawings (Appendix A). Figure 2 provides an overview of the proposed project concepts. The overall project is broken down into 9 discrete proposed project elements, which are labeled in Figure 2 and listed in Table 1 below. Additional explanation and design rationale for each of the 9 project elements are provided in Section 1.5.

Table 1 represents a set of possible restoration actions that will eventually be used to identify a preferred alternative, which will consist of combining individual project elements into a comprehensive restoration plan for the site. Determining the preferred alternative will require further stakeholder input, analysis of costs and benefits, and further investigation of pertinent issues such as permitting, water rights, groundwater characteristics, and engineering feasibility. These factors will need to be evaluated in the next phase of the design process.

Table 1. Primary proposed project elements in the Chiwawa Outlet Restoration Design Concepts

Element No.	Proposed Project Element	Description	Purpose(s)	HIP Category	HIP Risk Level
1	**Perennial Side Channel and Cool Water Alcove on Wenatchee River above Chiwawa**	Perennial side channel(s) carrying cold Chiwawa River water to an alcove along the left bank of the Wenatchee.	Create off channel habitat (side channel and alcove); reactivate fan; supply cool water to an alcove on mainstem Wenatchee River	2a	Med-High
2	**Hyporheic channel and alcove on Wenatchee River below Chiwawa**	Create alcove along left bank of Wenatchee River and supply cool water via subsurface connection with Chiwawa River	Create off-channel habitat and cool water refuge	2a	Med-High
3	**Wenatchee River mid-channel log jams**	Two engineered log jams in Wenatchee River upstream and downstream of confluence.	Create island(s) in Wenatchee River; increase wood in mainstem; recruit more wood; create more edge habitat; help manage sedimentation at alcove #1.	2d	Low-Med-High
4	**Backwater alcoves in Chiwawa River**	As many as 5 backwater alcoves near mouth of Chiwawa River.	Create off-channel habitat	2a	Med-High
5	**Crossing at side channel**	Possible bridge or culvert across new side channel (Element #1).	Continue to provide year-round access to hatchery smolt trap.	1f	Med
6	**Rerouting hatchery effluent**	Augment the cool water flows in proposed side channel and alcove in late summer	Increase the supply of cool water in side channel and alcove in late summer	N/A	Med-High
7	**Log jams and habitat wood in Chiwawa River and alcoves**	Install apex jams, habitat logs, and bank-attached log jams in Chiwawa River.	Increase wood in Chiwawa River and alcoves; help direct low flows into side channel	2d	Low-Med-High
8	**Short side channel in lower Chiwawa River**	Reactivate low flow side channel on outside of bar on river left.	Increase off channel habitat; increase wood; increase channel complexity	2a	Med
9	**Site Revegetation**	Plant riparian vegetation where areas have been disturbed.	Improve riparian vegetation quality	2e	Low

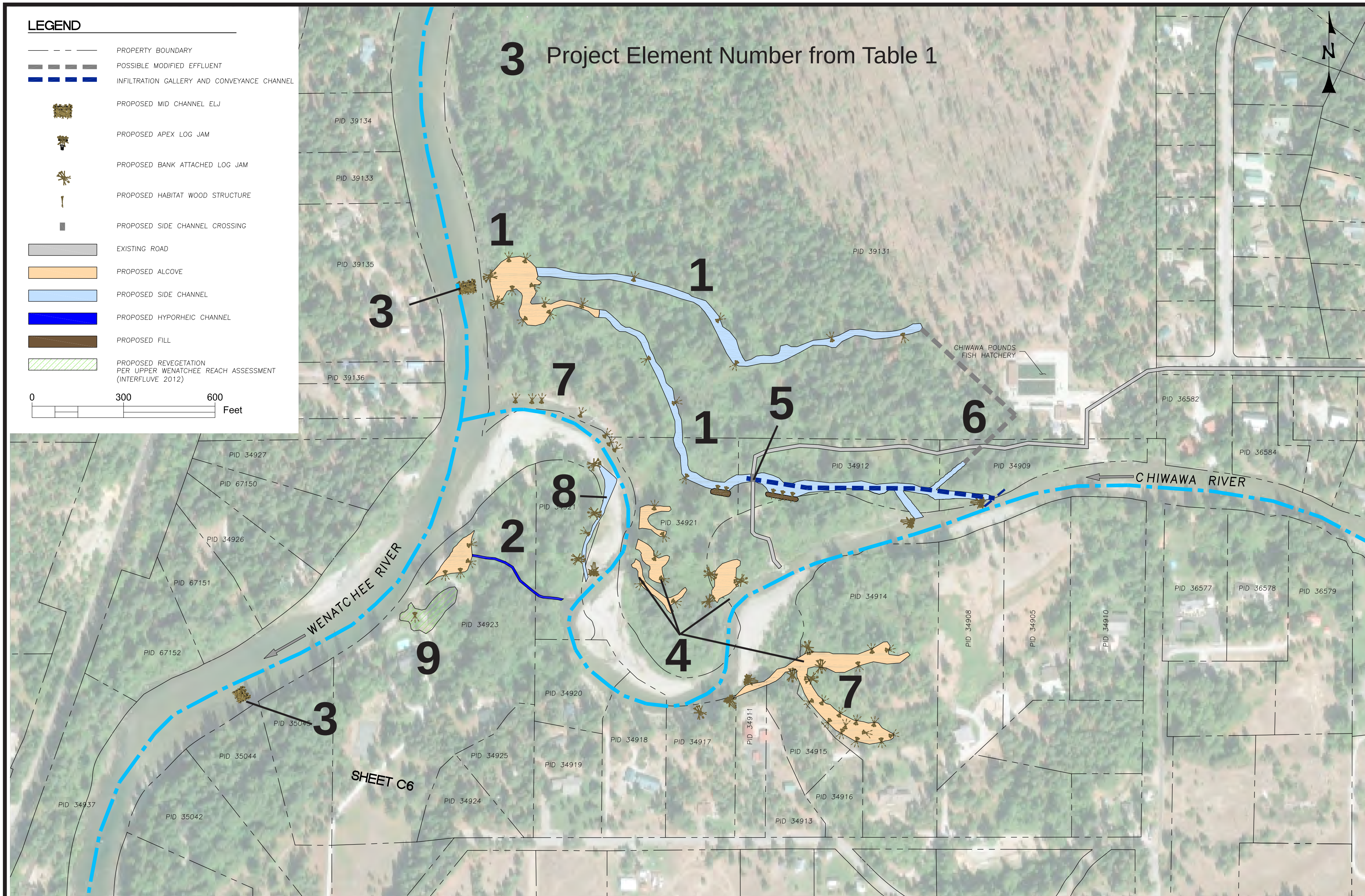


FIGURE 2

Overview of Proposed Project Design Elements

(refer to Section 1.5 for explanation of project elements)

Chiwawa Outlet Restoration Project

WATERWAYS CONSULTING, INC.
Santa Cruz, CA | watways.com | Portland, OR

1.3 Explanation and Background of Fisheries Use (By Life Stage-Period) and Limiting Factors Addressed by the Project

1.3.1 Fisheries Use

Fish use in the project area includes spring Chinook (*Oncorhynchus tshawytscha*), steelhead (*Oncorhynchus mykiss*), Bull trout (*Salvelinus confluentus*), summer Chinook salmon, Coho salmon (*Oncorhynchus kisutch*), Sockeye salmon (*Oncorhynchus nerka*) and Westlope cutthroat trout (*Oncorhynchus clarkia*). Of these, the species with special protections under the Endangered Species Act (ESA) include spring Chinook (endangered), steelhead (threatened), and Bull trout (threatened). Although Bull trout are known to spawn and overwinter in the Chiwawa River basin, the proximity of the project area to the Wenatchee mainstem likely limits their use of habitat within the project area, other than as a migratory corridor. Consequently, the focus of habitat enhancement efforts associated with this project are directed at addressing limiting factors for spring Chinook and steelhead at multiple life stages. The following summarizes the two life histories in the project area:

- ***Chinook Salmon.*** Adult spring Chinook return from the ocean to the Upper Columbia Basin in early spring with the peak of the run occurring in mid-May. Entry into the Upper Columbia tributaries typically occurs from April through July where they hold until spawning occurs in late summer, with a peak in mid to late August. Juvenile fish spend at least a year in fresh water before outmigrating in the spring. Juveniles can move around a considerable distance to find suitable habitat as their preferred habitat conditions change as they mature and grow larger.
- ***Steelhead.*** The life history strategy of steelhead is more complex than that of spring Chinook. Adults in the Columbia River basin re-enter fresh water in late summer or early fall, but most do not return immediately to their natal streams. They will typically overwinter in mainstem Columbia River reservoirs, moving upstream and over the dams in April and May of the following year to spawn. Juvenile steelhead will spend up to three years rearing in freshwater before outmigrating to the ocean. In some cases, juvenile steelhead will remain in freshwater and never migrate to the ocean. Conversely, resident rainbow trout, which are genetically indistinct from steelhead, will outmigrate to the ocean and become steelhead. The percentage of reproductive exchange between steelhead and resident rainbow trout is not known but most likely varies by region and watershed and may be a life history strategy that is dependent on factors such as habitat availability, water quality, and disturbance regime. Regardless, for all intents and purposes steelhead and resident rainbow trout populations remain separated physically, physiologically, ecologically and behaviorally with an overlap that does not need to be considered from a management perspective, especially at the project site scale.

1.3.2 Limiting Factors Addressed by the Project

The Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan (UCSRB, 2007) classifies the lower portions of the Chiwawa River as having a high to medium intrinsic spawning potential for Chinook salmon and a medium intrinsic potential for spawning on the mainstem Wenatchee. For steelhead, the lower portion of the Chiwawa River was classified as a medium intrinsic spawning potential and low intrinsic spawning potential on the mainstem Wenatchee. Wild populations for both steelhead and spring Chinook populations are considered to be at risk of extinction, though there has been some recovery of the populations since the fish were ESA listed in the late 1990's. The Upper

Columbia Spring Chinook Salmon and Steelhead Recovery Plan (UCSRB, 2007) identifies a number of threats to the population that limit production across a variety of life stages, both in freshwater and in the ocean.

Many of these limits to production fall outside of factors that can be addressed at the site scale, including poor ocean conditions, the presence of dams, and impacts to the natural hydrology. Independent of these, known factors limiting fish production can be addressed on the site scale, and are focused on addressing limits to juvenile rearing. These include pool availability, escape cover, off-channel habitat, and thermal refugia.

The location of the site at the mouth of Chiwawa provides an important opportunity to restore a rare habitat type at the confluence of a major tributary to the Upper Wenatchee River: thermal refugia that interacts with the mainstem Wenatchee through distributary fan channels and associated alcoves. Habitat in the Wenatchee River is limited due to high water temperatures in the late summer and early fall; but the Chiwawa River, which drains Glacier Peak and supplies about 15% of the flow of the Wenatchee River (Interfluve, 2012), provides a reliable source of cool water throughout the year.

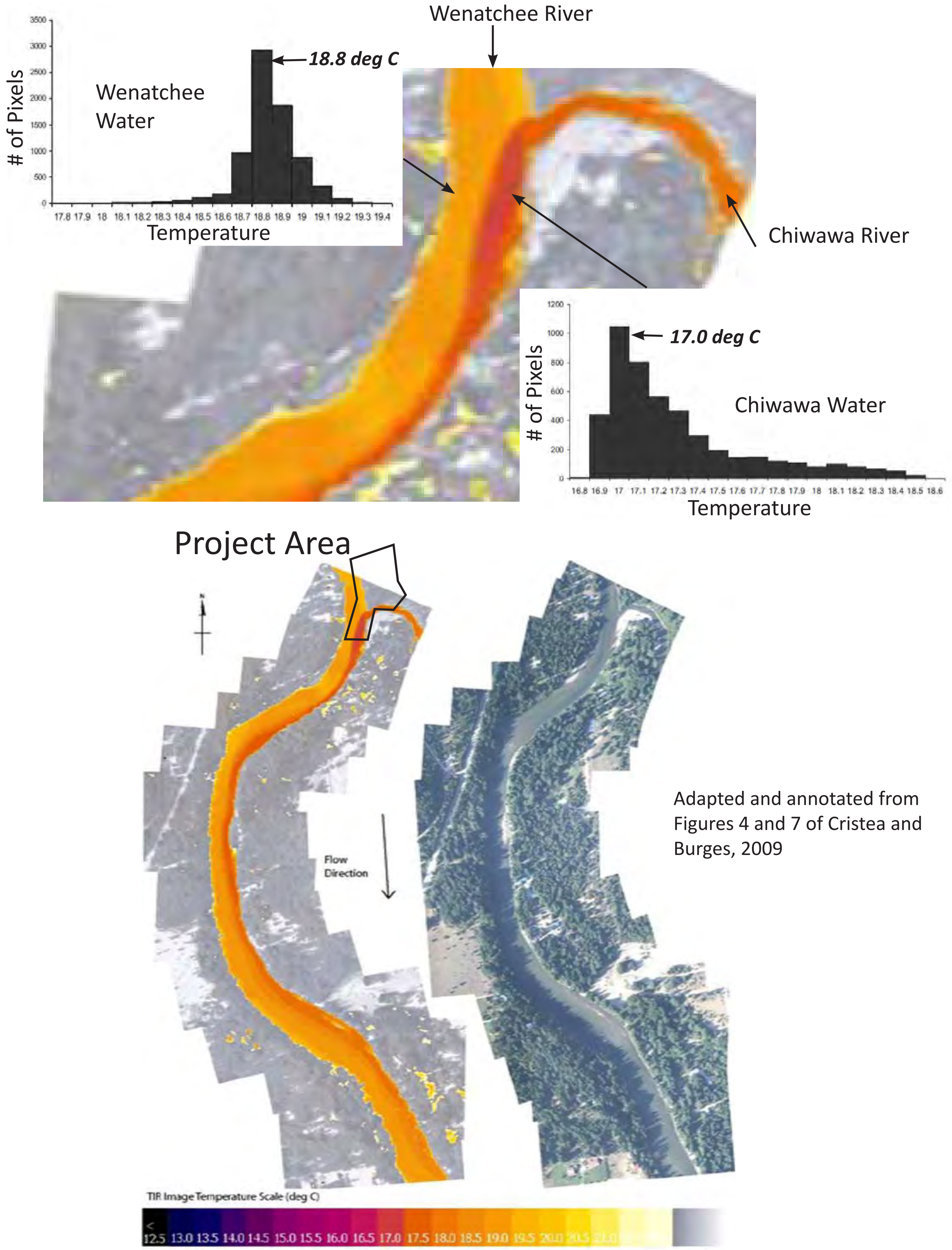
Thermal Refugia

A study by Cristea and Burges (2009) examined the use of aerial thermal infrared imagery to create detailed maps of water temperatures in rivers and used the upper Wenatchee River as a test case. One focus of that study was the temperature contrast between the two rivers at the Chiwawa Outlet project site. The study mapped the distribution of water temperatures at the confluence in detail, highlighting the difference between the two water sources (Figure 3).

On the day of the aerial imaging, August 16, 2002, the average water temperature in the Chiwawa River water was notably cooler than in the Wenatchee River: the modal (most common) temperature of the Wenatchee River water 18.8 degrees C, compared with 17.0 degrees in the Chiwawa River water. The imaging study (Cristea and Burges, 2009) also showed inefficient mixing of the two water sources below the confluence, and cooler Chiwawa River water sticks to the left bank of the Wenatchee River for a long distance downstream of the confluence (Figure 3). This phenomenon has also been described to Waterways by the property owner just downstream of the confluence.

A technical working group established by the U.S. EPA to develop temperature criteria for salmon and steelhead in the Pacific Northwest (EPA, 2001) identified a preferred range for summer habitat use of between 10 and 17 degrees C. Lethal effects occur at temperatures above 22 C for adults, and 24 C for juveniles if sustained for more than one week. Thus, Chiwawa River water may be close to the upper end of the preferred range of water temperature during late summer, while the Wenatchee River is nearly 2 degrees too warm.

Proposed project concepts include a variety of design features to convey and hold the cooler Chiwawa River water in a way that will maximize the opportunity for creating thermal refugia around the Chiwawa River fan and expand the thermal benefits of the Chiwawa River to a larger area of the Wenatchee mainstem.



Adapted and annotated from Figures 4 and 7 of Cristea and Burges, 2009

Aerial Infrared Predicted Water Temperatures in Wenatchee River, August 16, 2002	Chiwawa Outlet Restoration Project	WATERWAYS CONSULTING, INC. Santa Cruz, CA · watways.com · Portland, OR	FIGURE 3

Other Limiting Factors Addressed by the Project

In addition to creating thermal refugia, the project seeks to address other limiting factors for fish. Habitat limiting factors and requirements for the study area were defined by the Upper Wenatchee River Assessment (Interfluve, 2012), which evaluated existing habitat conditions and identified an overall restoration strategy for the mainstem Wenatchee River from Lake Wenatchee to Tumwater Canyon. The limiting factors were defined through a study of reach-based ecosystem indicators (REI), and the project area encompasses parts of Reaches 7 and 8 of that study[1]. Table 2 summarizes the limiting factors identified for Reaches 7 and 8 by Interfluve (2012).

***Table 2**. Reach Ecosystem Indicator (REI) Results for Reaches 7 and 8 of Upper Wenatchee River Assessment (from Table 10 of Interfluve, 2012)*

Reach 7 (downstream of Chiwawa R)	**Reach 8** (upstream of Chiwawa R)
"Unacceptable" Indicators	
Large Wood Debris Pools Off-Channel Habitat Floodplain Connectivity	Large Wood Debris
"At Risk" Indicators	
Vertical Channel Stability Riparian Vegetation Condition	Pools Off-Channel Habitat Floodplain Connectivity Vertical Channel Stability Riparian Vegetation Condition

The proposed restoration actions seek to address the impairments listed in Table 2 by creating new side channel and alcove habitat, building two large mid-channel Engineered Log Jams (ELJs) in the Wenatchee River, installing smaller scale habitat wood in the Chiwawa River and alcoves, and improving riparian conditions through revegetation.

[1] The Chiwawa River confluence was the boundary between reaches 7 and 8 of that study.

1.4 List of Primary Project Features Including Constructed or Natural Elements

This section describes the overall design approach and the rationale for the 9 primary project elements. The element numbers below are referenced to the numbering in Table 1 and Figure 2. The proposed project elements presented at this conceptual stage of the design will, through a process of alternatives analysis, stakeholder input, and evaluation of engineering feasibility to be carried out in the next phase of the project, be refined into a preferred alternative for advancement to preliminary and final designs.

Element 1: Cool Water Alcove and Side Channel on Chiwawa River Fan

Project Element 1 includes a perennial side channel (or possibly 2 channels) that would receive cool water from the Chiwawa River near the hatchery (Figure 3), carry the water across the Chiwawa River fan, and terminate in a large alcove along the left bank of the Wenatchee River upstream of the confluence. The channel would provide a steady inflow of cooler Chiwawa River water to help sustain low temperatures in the alcove. Abundant habitat wood would be placed within the alcove to provide cover and shade. There is a well-established beaver colony at the site of the proposed alcove. The beaver could either create problems or be beneficial to the long-term success of the alcove. The presence of beaver must be accounted for in the next phases of design of the alcove.

The perennial, cool-water side channel leading to the alcove would provide between 2,000 and 4,000 feet of off-channel habitat and help increase the frequency of the natural process of distributary flow on the Chiwawa River fan. The channel would occupy the flow path(s) of one or two existing (but rarely active distributary fan channels. Re-occupying existing channels will reduce cost and disturbance. A bridge or a culvert may be required to continue to allow the hatchery to operate a smolt trap on the far side of the proposed side channel. This is discussed as project Element 5 of the design (below).

Another possible feature of this project element could be to re-route some of the hatchery effluent into the side channels, supplementing the flow during low flow periods. Rerouting the hatchery effluent into the side channels is discussed as project Element 6 below. The feasibility of this component of the designs is not certain, as it depends on resolving multiple water rights and water quality issues that may not be possible to resolve.

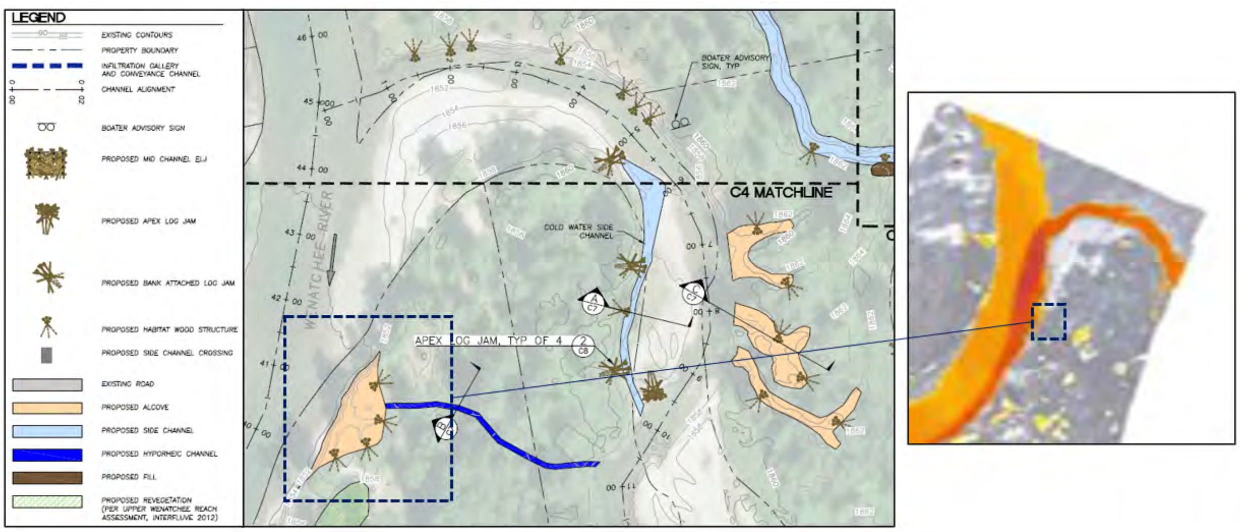
An alternative option for the side channel would be to not have a surface connection to the Chiwawa River on its upstream end, but instead to supply water to the side channel through a subsurface pipe connected to an infiltration gallery on the Chiwawa River. In this option the water would be collected from below the bed of the Chiwawa River near the hatchery and enter a pipe that daylights in the existing side channel downstream from the road crossing (see Appendix A, Sheet C3). In this case, water would be supplied to the channel and alcove while avoiding some of the complexities and complications of creating a perennial side channel inlet. This option would also eliminate the need for a bridge or culvert crossing at the road. A design alternatives analysis will be needed for this proposed project feature to determine the most effective and feasible option for supplying cool water to the side channel.

Element 2: Hyporheic channel and cool water alcove on Wenatchee River below Chiwawa

A second cool water alcove is proposed along the left bank of the Wenatchee River on private property just downstream of the mouth of the Chiwawa River. As discussed above, mixing of the cold Chiwawa River water with warmer Wenatchee River water at the confluence is delayed due to inefficient mixing, and colder water from the Chiwawa River stays close to the left bank of the Wenatchee River downstream of the confluence. This project element takes advantage of the cooler water along left bank line by building an alcove there (Figure 4). The alcove would be designed with a downstream elongated entrance in a way that would favor circulation of cold water from the mainstem at low flows.

It may be difficult to design an alcove that provides efficient mixing with the mainstem while also retaining the desired low-velocity, protected off-channel habitat needed by juvenile fish. Cool water may not circulate in some portions of the alcove. To provide a supplemental and reliable supply of cool water to the alcove, especially the more distal parts that may contain slow moving water, a steady supply of cool water could also be supplied through a constructed hyporheic channel (see design drawings, Appendix A, sheet C7) from the Chiwawa River. The hyporheic channel would provide a groundwater connection from the Chiwawa River to the back of the alcove. The subsurface flow pathway would be constructed along a short line across a peninsula separating the two rivers on private property. Because it is a subsurface rather than a surface flow pathway, it would not increase the risk of stream avulsion across the peninsula separating the Chiwawa and Wenatchee Rivers.

***Figure 4**. Cool water alcove and hyporheic channel on Wenatchee River below Chiwawa River confluence. Inset image shows water temperature contrast below the confluence (from Christea and Burges, 2009).*



Element 3 – Wenatchee River mid-channel engineered log jams

Project Element 3 includes two mid-channel engineered log jams (ELJs) in the Wenatchee River. The design of the wood jams would be modeled after existing jams and islands on the Wenatchee River upstream and downstream of the site (e.g., Figure 5). The ELJs would be designed with the intention to try to create a temporary or possibly long-lived island(s) by capturing wood and promoting gravel deposition. This reach of the Wenatchee River is particularly straight, simplified, and deficient in large wood, and lack of wood is a primary limiting factor both upstream and downstream of the confluence (Table 2). Islands created by the structures, especially if they become vegetated, would increase the amount of edge habitat in the Wenatchee River and enhance hydraulic complexity along this portion of the channel.

The upstream ELJ would be designed and built to encourage high flow velocities near the entrance of the alcove created in Project Element 1 (see Appendix A, sheet C4). Higher local flow velocities created by the flow split would aim to prevent sedimentation at the entrance of the alcove (project Element 1). Survey and proposed condition hydraulic modeling will be needed to design the structures in a way to create favorable pattern of deposition and erosion around it.

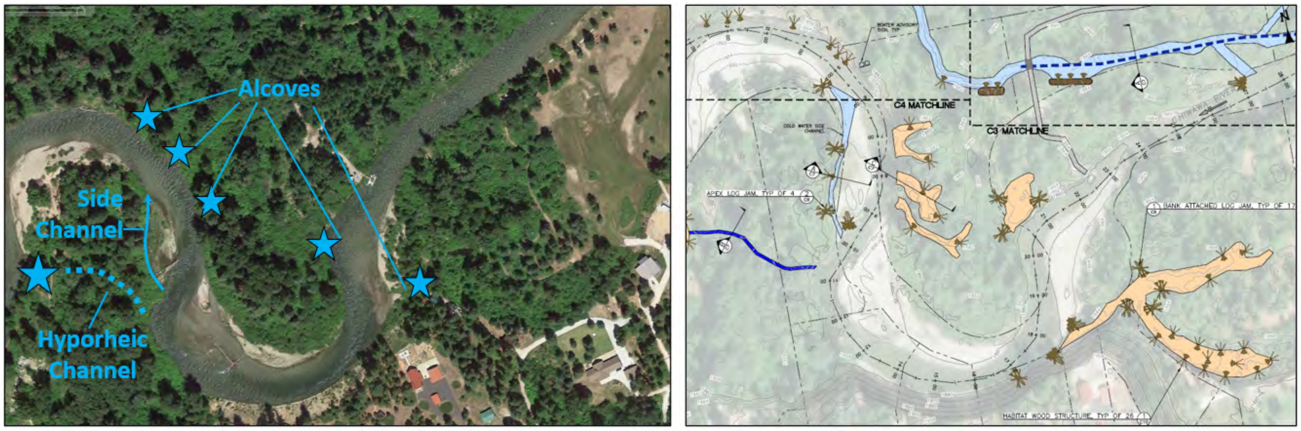
***Figure 5**. Example of Naturally Formed Mid-Channel Log Jam and Island in Upper Wenatchee River just below Lake Wenatchee*

Element 4 – Backwater alcoves in Chiwawa River

The proposed project includes several backwater alcoves along the lowermost Chiwawa River (Figure 6). These features would provide off-channel habitat upstream of the confluence with the Wenatchee River. The proposed alcoves are in existing low elevation areas, mostly at the sites of former or existing side channel connections with the mainstem Chiwawa River. The alcoves would be excavated to near the elevation of the bed of the Chiwawa River and have gradual sloping sides to increase the amount of edge habitat. Abundant habitat wood would be installed in and around the proposed alcoves.

Some of the proposed alcoves shown in Figure 6 may be prone to sedimentation. The largest and most upstream of the proposed alcoves along the river left, occupies a low zone that can be flooded during high flows and could potentially create a relatively large area of high-value off-channel habitat. However, the inlet would be at the downstream edge of an active gravel bar where future gravel deposition could potentially disconnect the alcove from the main stem Chiwawa River to sedimentation. Further field and hydraulic investigation and cost/benefit analysis may be needed to refine the alcove designs.

__Figure 6__. Proposed alcoves along the lower Chiwawa River (flow is from right to left)



Element 5 – Crossing at side channel

Depending on the design alternative that is selected, a perennial upstream connection for the side channel in Element 1 will require a vehicle crossing at the site shown as Element 5 in at a dirt road used to maintain and monitor a smolt trap along the right bank of the Chiwawa River downstream of the hatchery. If project Element 1 is built with an upstream connection with the Chiwawa River, a bridge or large culvert would need to be installed (Appendix A, sheet C5). The crossing must be able to accommodate heavy loads such as a mobile crane which is used to service the smolt trap.

If the option of supplying water to the side channel through an infiltration gallery rather than a perennial side channel connection is selected, a subsurface pipe would be installed that daylights in the side channel downstream of the road. This would avoid the need for installing a crossing.

Element 6 – Rerouting hatchery effluent

The Chiwawa Ponds fish hatchery and acclimation facility, operated by the Chelan County P.U.D, diverts water via a weir the Chiwawa River for use in its operations. Water continuously recirculates and is discharged back via a concrete pipe back into the Chiwawa River (Figure 7). Return flows to the Chiwawa River can be significant (Figure 7), even during the dry season, and this water is presumed to have water temperatures characteristic of the Chiwawa River. If instead of discharging to the Chiwawa River, some or all the effluent was rerouted to discharge into the side channel (Project Element 1, above), this cool water could supplement the flows in the side channel. This would require a pipe from the hatchery and ending at the side channel. Two possible alignment alternatives for the effluent pipe are proposed in the design drawings (Appendix A, Sheet C3) each with advantages and disadvantages. Another possible alternative, not shown in the design drawings, would be to divert a portion of the water at the intake to avoid the need

Although rerouting water from the hatchery to the side channel would supplement the supply of cool water to the alcove, there are significant hurdles that would need to be cleared for this to be feasible. One issue is related to water rights: the water right associated with the diversion specifies effluent water must be returned to the Chiwawa River. A second is water quality as the effluent water may be too high in nutrients or other constituents for use in the side channel; if so, it would need to be treated before discharge, possibly increasing the cost of the project element beyond what is reasonable.

Figure 7. *Hatchery effluent discharge in the Chiwawa River*

Element 7 – Log jams and habitat wood in Chiwawa River and alcoves

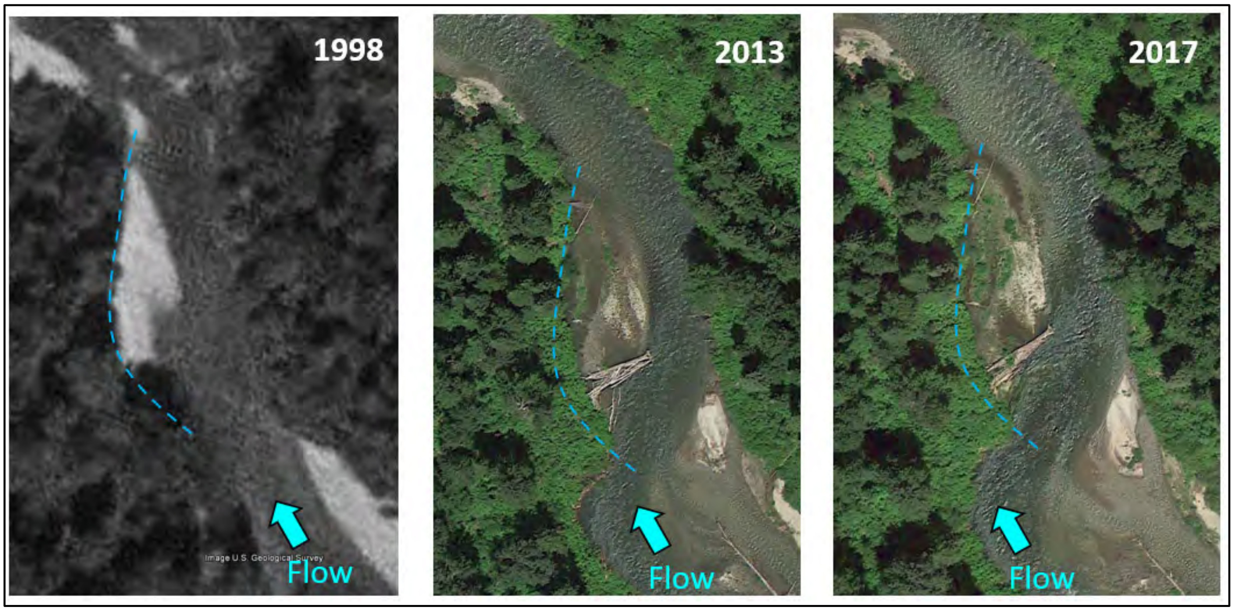
In addition to the two large mid-channel ELJs in the Wenatchee River, the project would add smaller scale wood jams – including apex jams, bank attached log jams in the Chiwawa River, and habitat wood placed in alcoves. A primary purpose of all these features is to address the deficiency of in-channel wood in the system. In addition to this purpose, log jams and habitat wood are shown in the conceptual designs at specific locations are meant to trap and store sediment, prevent sedimentation at alcove or side channel inlets, split the flow, or provide grade control.

Three primary types of wood installations are envisioned – apex jams, bank attached log jams, and habitat wood. Typical concept drawings for each of the three types of wood features are provided in the conceptual design drawings (Appendix A, Sheets C8 and C10). The ballasting materials and approach for ballasting these features will differ among the different structures. Imported boulders will not be used for ballast in these structures.

Element 8 – Short side channel in lower Chiwawa River

Project Element 8 consists of reactivating a short side channel on the back of a bar in the lower Chiwawa River through excavation. The side channel has recently been active, but the inlet was blocked by gravel deposition at the upstream end. An alcove remains at the downstream end of the proposed channel. An existing wood jam formed near the mouth of the side channel has been in place since at least 2012 (Figure 8). Habitat wood, bank attached log jams and an apex jam could be installed to increase flow and reduce the chances that the side channel inlet becomes plugged again.

***Figure 8**. Repeat aerial photos of proposed side channel (blue dashed line) behind a gravel bar in lower Chiwawa River (from Google Earth)*



Element 9 – Site Revegetation

The Upper Wenatchee River Assessment (Interfluve, 2012) determined that riparian vegetation health is “at risk” in this reach of the Wenatchee River. Revegetation of riparian floodplain is an important component of the proposed designs.

The only specific restoration opportunity identified in Reach 7 by the Upper Wenatchee River Assessment (Interfluve, 2012) was a riparian restoration action on river left at RM 48.3. According to the Assessment, trees at the site appeared to have been cleared by the property owner, and it was recommended that the area be replanted with native riparian forest vegetation and streambank shrubs and trees. We visited the site with the property owner, who described the site history and expressed interest in a low-impact restoration activity at the site.

The site is the lowest point on the peninsula separating the Chiwawa and Wenatchee Rivers. During floods, water from the Chiwawa River flows across the peninsula and into the Wenatchee River at the site, which is immediately adjacent to the residence. The hydraulic modeling confirms that the pathway closest to their house is a main overbank pathway across the peninsula (Appendix B). There is a chance that the entire Chiwawa River could avulse across the peninsula at this site, an undesirable outcome for the landowner. Headcuts have formed at this location and these have been arrested using boulders.

The site would be a good place to create a new cool water alcove. However, no alcoves or side channels are being proposed for this area due to the possibility of causing a real or perceived increase in the avulsion risk. Nevertheless, the low area supports a small wetland and revegetation of the area would improve habitat and aesthetic value of the site.

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

The proposed project would consist of the 9 project elements described above, each consisting of one or more ecological features like wood structures, alcoves, side channels, etc. The anticipated evolution of each of the features is discussed in Table 3; the performance and sustainability criteria in Table 4; and risk of consequences of failure for each of these ecological features in Table 5.

The compensating analyses to reduce uncertainty include the geomorphic and hydraulic studies discussed in Section 2 and 3 of this report, plus additional hydraulic, groundwater, and other analyses that will need to be done at subsequent design phases.

***Table 3**. Anticipated evolution of project elements in first several years following construction*

Project Element	Anticipated Evolution
Side Channels	Bed armoring/stabilization after initial removal of soil organic material and fines and adjustments to added habitat wood
Alcoves	Deposition of fine sediments (small gravels to silts) and recruitment of emergent riparian vegetation, as is typical in low-energy off-channel environments. Beaver may also impact alcoves through building dams and creating tunnels, slides, lodges, etc.
Hyporheic Conveyance Channel	Winnowing of fines from interstitial spaces and recruitment of riparian vegetation
Mid Channel ELJ	Recruitment of mobile wood; deposition of “tail” downstream of structure; establishment and growth of plantings; formation of horseshoe shaped scour hole on upstream face and sides of structure; recruitment of riparian vegetation in sediment tail and within structure
Bank Attached Log Structures	Formation of scour pool; recruitment of mobile wood; formation of low velocity shadow downstream of structure
Apex Log Structures	Recruitment of mobile wood; formation of horseshoe shaped scour hole on upstream edge of structure; recruitment of riparian vegetation in interstices of structure
Habitat Log Structures	Development of scour pools; limited channel erosion and adjustment as a result of placement of features in lower energy locations

***Table 4**. Performance and sustainability criteria for ecological project elements*

Project Feature	Performance Criteria	Sustainability Criteria
Side Channels	-Successful conveyance of cold water to Wenatchee alcove -Evidence of use by juvenile salmonids	-Maintain appropriate amount of conveyance during low flow periods -Limited sedimentation at side channel inlet -Avoid stream capture of the Chiwawa River.
Alcoves	-Reduced water temperatures relative to Wenatchee river -Ample cover and large wood to support complex ecosystem	-Limited sedimentation and conversion from open water to wetland/marsh -Beaver presence should enhance, not endanger, performance and accessibility of the alcove.
Hyporheic Conveyance Channel	-Successful conveyance of subsurface flow from Chiwawa to alcove	-Limited clogging of conveyance -Avoid stream capture of the Chiwawa River.
Mid Channel ELJ	-Successful recruitment of large wood -Successful recruitment of riparian vegetation and creation of islands -Successful at preventing sedimentation at alcove entrance (upstream ELJ)	-Limited loss of placed wood -Limit scour greater than anticipated amounts
Bank Attached Log Structures	-Successful creation of heterogeneous flow conditions -Successful creation of scour pool -Evidence of use by juvenile salmonids	-Limited loss of placed wood
Apex Log Structures	-Successful maintenance of flow diversion into side channels	-Limited loss of placed wood
Habitat Log Structures	-Evidence of use by juvenile salmonids	-Limited loss of placed wood

Table 5*. Anticipated failure mechanism and failure risk level for each of the proposed project elements*

Project Element	Failure Mechanism	Failure Risk Level
Side Channels	Sedimentation at inlet resulting in closure of side channel; avulsion of mainstem into side channel; insufficient flow entering side channel during low flow period	Medium
Alcoves	Sedimentation resulting in alcove no longer providing access or habitat for salmonids	Medium
Hyporheic Conveyance Chanel	Clogging of coarse sediments reducing the conveyance of subsurface flow	Medium
Mid Channel ELJ	Instigation of unanticipated bank erosion; loss of placed wood members	Medium
Bank Attached Log Structures	Loss of placed wood members	Low
Apex Log Structures	Unanticipated hydraulic conditions cause side channels to become closed because of sediment deposition	Low
Habitat Log Structures	Loss of placed wood members	Low

1.6 Description of Disturbance Including Timing, Areal Extent, As Well As Potential Impacts Associated with Implementation of Each Project Element

The proposed project is in the conceptual design phase and a project schedule has not yet been developed, but the following impacts can be anticipated at this stage.

Timing: Upland work can occur at any time of the year; we anticipate that upland project elements will occur between June and late October as weather and soil conditions allow. In-channel work will occur during the approved work window for fish protection as provided by the Washington Department of Fish and Wildlife (WDFW, 2018). For both the Wenatchee and Chiwawa Rivers, the in-water work is July 1 through August 15.

Aerial Extent: In total approximately 3.7 acres of land are anticipated to be permanently affected; this includes project elements such as alcoves and side channels. Temporary impacts are anticipated to be approximately 1.1 acres.

Impacts: Both temporary and permanent impacts to upland areas and channels are associated with installation of wood, excavation at side channels and alcoves, and installation the hyporheic channel and subsurface pipes.

Temporary disturbance in uplands will occur during construction as a result of the construction of large wood project elements such as the mid-channel engineered log jams (ELJs), bank attached log jam locations, and habitat wood structures. Impacts related to access and staging will include reduced forest canopy cover and reduction in upland plant community areal extent. These will be minimized through application of Best Management Practices as outlined in the most recent HIP guidance manual (BPA, 2019) as well as those presented in the Washington State Department of Ecology Stormwater Management Manual for Eastern Washington (WSDE, 2019). These upland impacts would be offset as the project re-vegetation matures.

In-channel work will consist of installation of large wood structures as well as bank disturbance associated with alcove and side channel grading. In-channel work will occur during the approved work window for fish protection as provided by the Washington Department of Fish and Wildlife (WDFW, 2018). In-channel impacts will be minimized by use of BMPs for turbidity control and requirements for biodegradable machinery lubricants.

1.7 Identification and Description of Risk to Infrastructure or Existing Resources

The HIP III Handbook (BPA, 2016) identified this section as required information for the General Project and Data Summary Requirement (GPDSR) for reporting, but it is not called for in the more recent version of the manual (BPA, 2019). For completeness this information is provided in Table 6.

***Table 6**. Potential Risks to Infrastructure or Existing Resources*

Existing Infrastructure/Resources	Risk Exposure
Hatchery Diversion Facilities and Diversion Weir	*Low*: These features are located upstream of proposed project elements; proposed project elements are not anticipated to create backwater effect that would impact these facilities.
Smolt Trap and Access Road	*Medium*: Potential impact to access to the smolt trap at the intersection of project element 1 and the road. This will be mitigated with a crossing if needed. The smolt trap itself is located on a pontoon structure; dislocation of logs from the proposed apex log structures may become lodged on the pontoon. This risk could be reduced through the installation of bumper log piles placed in the channel upstream of the smolt trap.
Pit Array for Smolt Counts	*Low*: The pit array is located downstream of two proposed apex log structures. The array could be damaged if logs detach from the structures. However, the pit array is on the bed of the Chiwawa river channel and floating logs are unlikely to contact the array.
Private Residence and Bank Revetment	*Low*: There are no in-channel features proposed immediately upstream of the residence. No proposed features would create backwater effects near the residence. None of the proposed project features will affect the existing avulsion risk for the Chiwawa River adjacent to the residence.
Recreation Boating	*Medium*: The proposed in-channel log structures present entrainment risks to boaters. This risk would be minimized through installation of signage, bumper logs, and optimization of sight lines for boaters

2.0 RESOURCE INVENTORY AND EVALUATION

A site-scale hydraulic analysis and geomorphic assessment were performed to help understand the current hydraulic and geomorphic functions of the site and to identify opportunities and constraints. The results of those analyses were used to inform the conceptual design.

2.1 Description of Past and Present Impacts on Channel, Riparian, and Floodplain Conditions

The project area includes portions of Reaches 7 and 8 of the Upper Wenatchee River Stream Corridor Assessment and Restoration Strategy (Interfluve, 2012). The Assessment reconstructed the human disturbance history of the Upper Wenatchee River watershed and channel, which included pre-historic and historic land uses, including fire management, timber harvest, log drives, residential development and roadways. The Assessment determined that the most important impairments in Reaches 7 and 8 were lack of large wood, pools, lack of floodplain connectivity, and lack of off-channel habitat (see Table 2 above).

2.2 Instream Flow Management and Constraints in the Project Reach

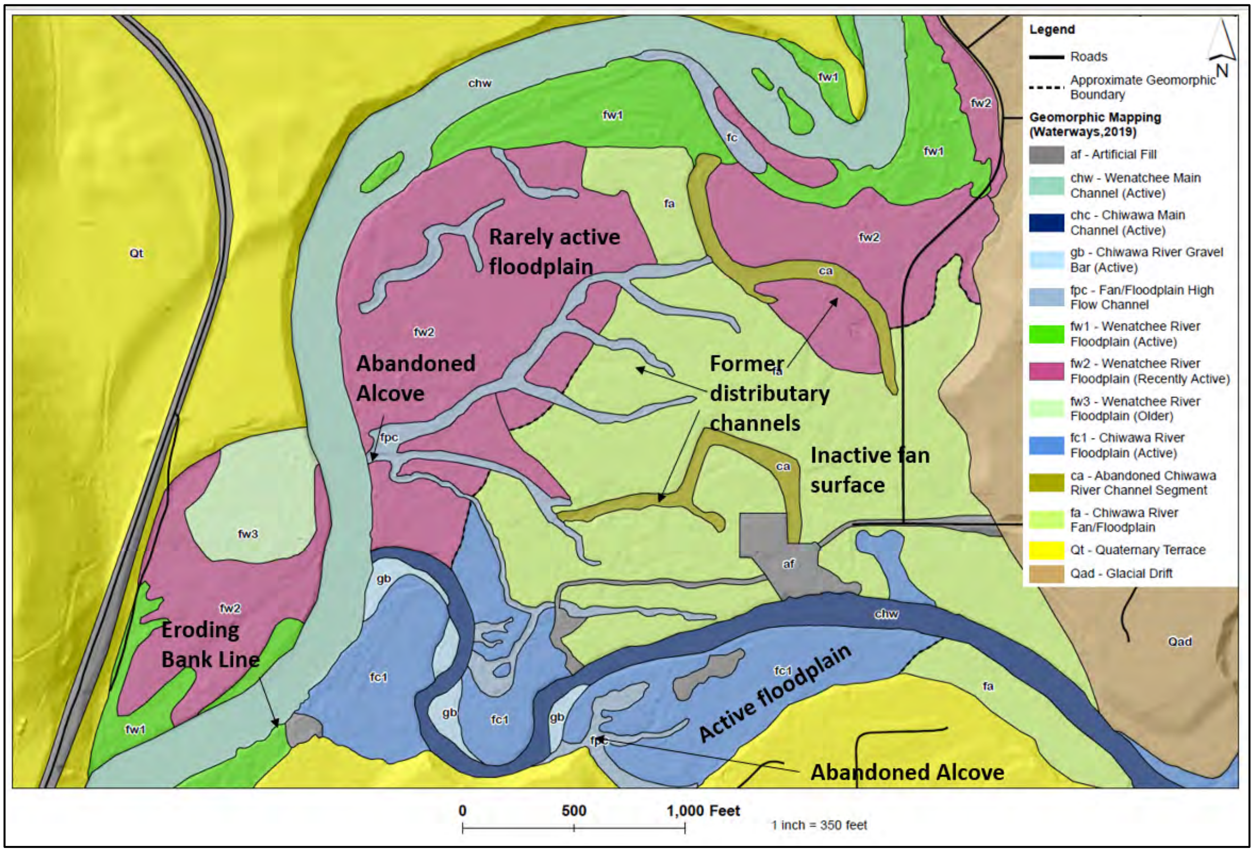
The Chiwawa Ponds fish hatchery (operated by Chelan Public Utilities District) diverts water from the Chiwawa River for use in hatchery and acclimation ponds. The water continually circulates through the ponds and effluent water is discharged through a pipe back into the Chiwawa River. One project concept involves rerouting some or all of the hatchery effluent into a side channel that leads to a cool water alcove along the Wenatchee River in order to supplement cool water flows in the side channel during the dry season. The water right concerning this diversion may contain a stipulation that the return flow must go to the Chiwawa River (Ian Adams, hatchery operations manager, personal communication, 2019). That water right issue, along with any water quality concerns, may affect the feasibility of Project Element #6, and would need to be investigated during later stages of the design process.

2.3 Description of Existing Geomorphic Conditions and Constraints on Physical Processes

The geomorphic history, conditions and constraints are represented in the geomorphic map of the Chiwawa Outlet project area (Figure 9). The map shows that the Chiwawa River deposited a fan where it emerges into the wider valley of the Wenatchee River. The fan is constrained by high terraces composed of glacial drift and former fill terraces deposited during or after past glacial periods. Following the end of the last glacial advance, the Chiwawa and Wenatchee Rivers eroded through glacial till and created fill terraces (yellow in Figure 9). More recently, the Chiwawa River has deposited a fan at its mouth. The fan contains remnants of distributary channels that show the Chiwawa River at one time moved back and forth across the fan, but now appears to be entrenched into the fan. The distributary channels carry flow only during floods (Section 3.5 below). The concept designs propose to reactivate some of these channels so they contain perennial flow and are accessible for fish use.

The fan deposits merge with and are eroded by floodplains of the Chiwawa and Wenatchee Rivers. The fact that the floodplain deposits truncate the fan deposits suggests the fan has been abandoned as the rivers have incised and narrow active floodplains are inset into the fan surface (dark blue and bright green areas in Figure 9). Frequent flooding is now constrained to relatively narrow areas inset into the abandoned fan.

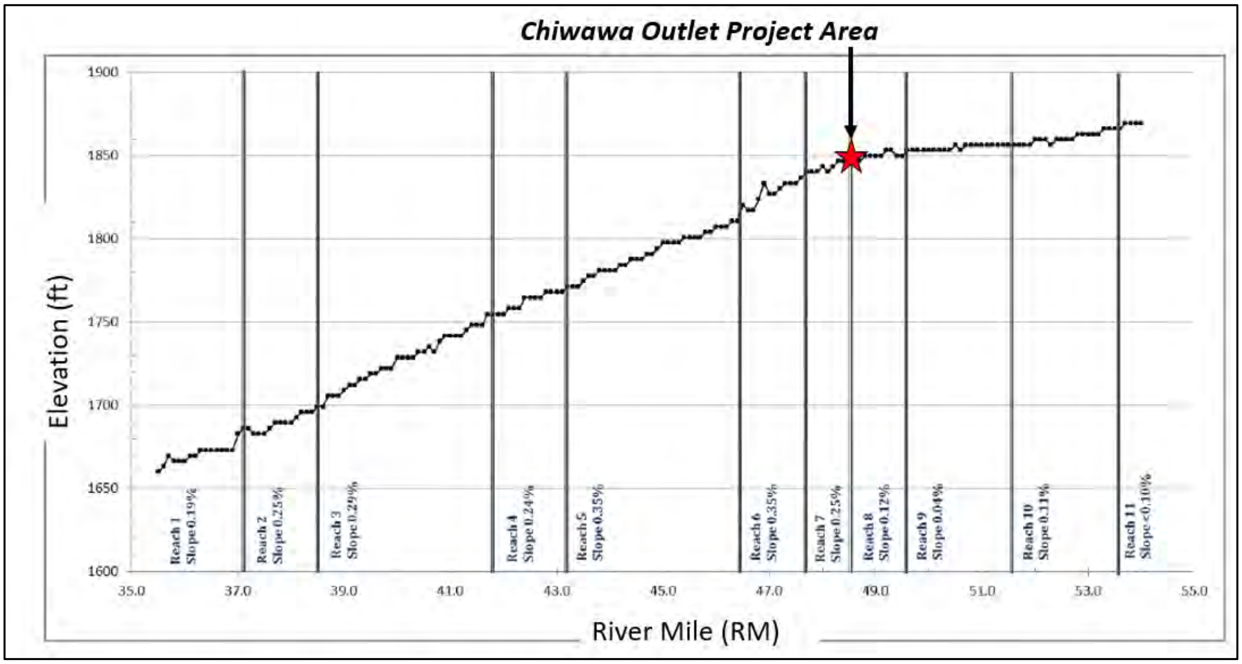
Figure 9*. Annotated geomorphic map of Chiwawa River confluence area showing abandoned fan and a loss of active floodplains (by Waterways)*



The project area is at a major transition in gradient along the upper Wenatchee River valley. The gradient of the Wenatchee River is about 0.05 to 0.1% upstream of the Chiwawa River but increases to about 0.25 to 0.3% downstream of the project area (Figure 10, adapted Interfluve, 2012). This scale of a profile discontinuity may be associated with the site being near the downstream extent of glaciation in the Wenatchee River valley.

Current geomorphic processes in the project area include typical meandering, gravel bed river channels that form active point bars and occasional islands. Meandering is constrained in places by glacial, fan, and river terrace deposits (Figure 10). Narrow, discontinuous active floodplains 4 to 8 feet above the channel are present along both the Chiwawa and Wenatchee Rivers. The floodplains are composed of gravel overlain by silty sand and contain mature forest cover.

***Figure 10**. Longitudinal profile of the Upper Wenatchee River showing slope transition at the project area (adapted from Figure 28 of Interfluve, 2012 with annotations added)*



2.4 Description of Existing Riparian Condition and Historical Riparian Impacts

The riparian areas in the project area are generally mature forest consisting of willow, cottonwood, dogwood, Douglas fir and Ponderosa pine. Species assemblages typically follow geomorphic map unit boundaries (Figure 9), with the floodplain surfaces having denser understory with more cottonwood and willows. The abandoned distributary floodplain channels contain particularly dense thickets of dogwood. The abandoned fan units contain widely spaced, mature pine and fir trees with little understory due to recent prescribed burns.

2.5 Description of Lateral Connectivity to Floodplain and Historic Floodplain Impacts

Based on the interpretation of the geomorphic mapping above (Section 2.3), it appears that both rivers have incised and abandoned most of the formerly active Chiwawa River fan. The lowermost Chiwawa River may have incised at this location because of incision of the Wenatchee River. Based on their 1D model of the entire upper Wenatchee River, Interfluve (2012) interpreted that in this reach the Wenatchee River has incised slightly relative to the floodplain. The most likely explanation for incision of the Wenatchee, and in turn the Chiwawa, is anthropogenic impacts – mainly wood removal from the channel, watershed changes, log drives, and confinement by roads and hardened banks.

An existing conditions 2D model of the project area, discussed more in section 3 and the hydraulic map book (Appendix B), shows the extent of lateral connectivity of the floodplain. The modeled inundation patterns in Appendix B indicate that inundation amount and frequency corresponds with the geomorphic map units shown in Figure 9. Surfaces mapped as active floodplain in Figure 9 appear to flood during relatively frequent events, such as occurred in 2017[2]. In such events, channelized floodplain flow can occur through some of the abandoned floodplain distributary channels, and ponding occurs in parts of the floodplain. The geomorphic units mapped in Figure 9 as abandoned floodplain units are only activated in rare, extreme high flow events like the 1995 flood. Parts of the Chiwawa River fan north of the hatchery appear to never flood even in extreme events.

2.6 Tidal Influence in the Project Reach and Influence of Structural Controls (Dikes or Gates)

Not applicable to this project.

[2] For this project the 2017 event is considered to be a large, but fairly frequent event (return interval between 2 and 10 years), whereas the 1995 event, the flood of record, is used to illustrate hydraulics in an extreme event. The details of the hydrological analysis are provided in Section 3.

3.0 TECHICAL DATA

3.1 Incorporation of HIP III Activity-Specific Conservation Measures for All Included Project Elements

The General and Species-Specific Conservation Measures as defined the HIP Handbook (BPA, 2019) will be incorporated throughout the design and implementation of the project. If departures from this guidance are necessary at later design stages, a variance request will be submitted to justify any deviation from the standard conservation measures.

3.2 Summary of Site Information and Measurements Used to Support Assessment and Design

3.2.1 Elevation Data

The project used a 1-m resolution aerial LiDAR data set acquired in summer 2015 (Quantum Spatial, 2016) as a base for mapping, hydraulic analysis and design. The LiDAR is referenced to the Washington State Plane North coordinate system with vertical datum of North American Vertical Datum 88 (NAVD 88). Field work and geomorphic mapping confirmed that in the floodplain, the LiDAR elevation data is accurate for design purposes, even in forested areas. For the wetted channels, LiDAR overestimates the channel bed elevation because LiDAR returns are from the water surface, not the channel bed. For detailed design purposes additional survey data will be needed to better define the channel bed elevation. However, in the conceptual design development phase the LiDAR was judged to be sufficient and was used exclusively for the existing conditions hydraulic modeling[3].

Waterways performed limited topographic survey as needed for this stage of the design; specifically, relative elevation data was primarily needed at this stage to identify the most hydraulically favorable locations for two separate inlets of a proposed cool water side channel (Project Element 1). Waterways surveyed the bed and right bank line of the Chiwawa River downstream of the hatchery to define the bank elevation profile, its height relative to the bed elevation, and map the locations of natural overflow points leading to the side channel. The survey was conducted on an arbitrary horizontal and vertical datum and is not shown on the conceptual plans.

Future surveys to support final design will be tied to Washington State Plane North and NAVD 88.

3.2.2 Geomorphic Mapping

A geomorphic map of the site (Figure 9) was developed to help understand the processes and landforms and better define restoration opportunities. The map was developed through a process of field reconnaissance, desktop analysis, and field verification. A field reconnaissance was used to initially identify the key landforms and determine the mapping units. The desktop analysis used interpretations of LiDAR and aerial photographs along with the results of the existing condition 2D hydraulic model to define the map unit boundaries, and then the linework was field verified and updated.

[3] Section 3.4 discusses the limitations of the model results due to using LiDAR data directly as the modeling terrain.

Results and interpretations of the geomorphic mapping are discussed in Section 2.3 above, and in the project element descriptions (Section 1.5). The map was used to identify opportunities and constraints and to define locations and extents of project features in the design drawings.

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

A near-continuous flow record dating to 1911 is available for USGS Gage 12457000 (Wenatchee River at Plain, WA), about 2.2 miles downstream of the project site. No significant tributaries enter between the project site and the gauging station, so flow at the gage approximates flow in Wenatchee River in the part of the project reach below the confluence. The Chiwawa River, the largest tributary of the Wenatchee, has also been gaged at station 12456500 (Chiwawa River near Plain, WA) since 1911. The Chiwawa River contributes about 15% of the annual flow of the Wenatchee River (Interfluve, 2012), but the contribution can be much more or much less at different flows and seasons.

Flow magnitudes for a range of recurrence intervals for the Chiwawa River and Wenatchee River gaging records were computed using USGS Bulletin 17B guidelines (Table 7). Flows for the Chiwawa River were computed using the program PeakFQ (Flynn et al., 2006) using data through Water Year 2019. For consistency with past work, the table provides magnitudes for the Wenatchee River as reported in the Upper Wenatchee River Assessment (Interfluve, 2012).

For design purposes, the value of using different recurrence interval flows at the confluence of two major rivers is complicated because the timing of peak flows in the two rivers rarely coincide. The Chiwawa River drains a glaciated alpine watershed that includes Glacier Peak, whereas floods in the Wenatchee River are influenced by the buffering effect of Lake Wenatchee. Because of this, the estimated steady state recurrence interval flows in Table 7 were not used for hydraulic modeling. Instead, actual historic flood events were modeled to understand hydraulic conditions during floods.

Two distinct types of floods occur in the Wenatchee and Chiwawa Rivers: shorter rain-driven events during fall and winter and more extended spring snowmelt floods in May and June (Table 8). The largest event on record in both rivers was the 1995 event, a rain-on-snow event in late fall, but some large historic floods have also been snowmelt-driven.

For the purposes of hydraulic modeling of the existing condition, we simulated two discrete events:

- The 1995 flood of record, meant to simulate an extreme flood
- Spring 2017 runoff event, considered to be representative of a moderately large (2 to 10 year) spring snowmelt event that was recent enough to allow for anecdotal corroboration of model

The hydrographs for the two simulated flood events are shown in Figure 11.

***Table 7**. Flood Recurrence Intervals for Wenatchee and Chiwawa Rivers near Plain, WA*

Return interval (yrs)	Annual Percent Chance Exceedance	Flow in Wenatchee River[1] (cfs)	Flow in Chiwawa River[2] (cfs)
500	0.2	37,285	8,853
100	1	29,045	7,354
50	2	25,799	6,699
20	5	21,728	5,812
10	10	18,764	5,112
5	20	15,827	4,365
2	50	11,683	3,200
1.25	80	8,870	2,321
1.01	99	5,824	1,281

Notes:
1. Based on USGS Bulletin 17B flood frequency analysis of annual peak flow series.
2. Wenatchee River at Plain (USGS station 124570000), as reported by Interfluve (2012).
3. Chiwawa River near Plain (USGS station 12456500), based on Bulletin 17B analysis run on February 20, 2020.

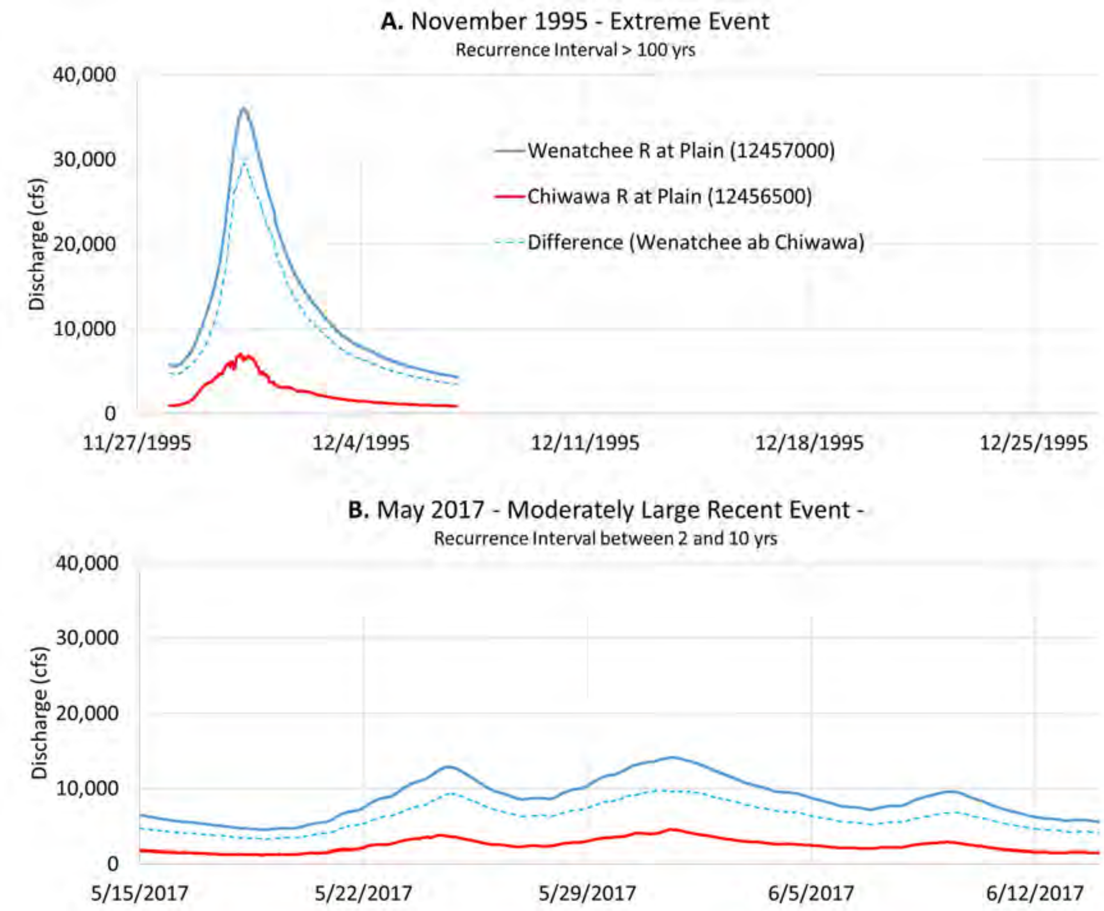
***Table 8**. Historic Flood peaks Recorded in Chiwawa and Wenatchee Rivers*

USGS 12457000 WENATCHEE RIVER AT PLAIN, WA				USGS 12456500 CHIWAWA RIVER NEAR PLAIN, WA			
Rank	Date	Peak Flow (cfs)	Approx. Recurrence Interval[1]	Rank	Date	Peak Flow (cfs)	Approx. Recurrence Interval[1]
1	11/30/1995	36,100	500	1	11/30/1995	7,030	75
2	11/25/1990	33,200	200	2	11/25/1990	6,810	60
3	11/7/2006	23,600	40	3	5/29/1948	5,880	20
4	5/29/1948	22,700	30	4	6/17/1999	5,550	15
5	12/13/1921	21,100	20	5	6/1/1956	5,080	10
6	12/30/1917	18,700	10	6	5/19/2006	4,790	8
7	6/17/1974	18,500	10	7	6/13/1955	4,730	8
8	12/4/1975	18,000	8	8	5/31/2017	4,550	7
9	6/11/1972	17,900	8	9	5/16/1997	4,370	5
10	5/21/1956	17,100	7	10	5/19/2008	4,340	5
27	5/31/2017	14,100	4				

Notes:
1. Based on flow exceedance curves for the two stations (Bulletin 17B Analysis)

Red and blue highlighted cells indicate the flood events that were modeled using the existing conditions 2D hydraulic model. Red (1995 flood) represents an historic extreme event, and blue (2017 event) represents a recent, moderately large event that was observed by hatchery staff.

***Figure 11**. Two historic hydrographs used for existing condition hydraulic modeling*



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

Field measurements of particle size and sediment transport analyses have not been conducted for this study, as they were not determined to be essential for this phase of the design.

Initial hydraulic modeling (described in Section 3.5 below) showed that in large floods, backwater from the Wenatchee River can cause a drop in shear stress just above the confluence (See Appendix B, Figure B4). This drop in shear stress may contribute to a possible zone of gravel deposition and meander growth in the lowermost Chiwawa River during large floods. The backwater effect is not as evident in the smaller flood event that was modeled.

Future design phases may include additional sediment analyses if they are determined to be important to inform the development of the design details. These could include surface gradation for sizing materials or making sediment transport calculations, as well as subsurface gradation to understand groundwater fluxes.

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

3.5.1 Model Purpose

A planning-level 2-Dimensional (2D) existing conditions hydraulic model was developed for the project site using the U.S. Army Corps of Engineers software HEC-RAS. The purpose of the model at this stage was to better understand patterns of inundation, velocity, and flow pathways to help determine the most favorable locations for side channels, alcoves, wood structures and other features. The model is not intended to be used to for any floodplain management purposes.

3.5.2 Model Set Up

Model Terrain. The model uses the 2015 LiDAR (Quantum Spatial, 2016) as a modeling terrain, and no ground-based survey data were added. Because LiDAR does not penetrate water, the terrain does not accurately represent the channel bed elevation, especially in pools, which were submerged in summer 2015 when the LiDAR was flown. Therefore, the model is not accurate for simulating low flows. The model is more reliable for simulating floods, when low-flow features such as riffles and pools are drowned out.

Modeling Mesh. The 2D model was represented with a variable mesh size, with denser cell spacing in and around the channels and side channels, and larger cells in the floodplain. The mesh was organized around breaklines that were derived from the geomorphic site map (Figure 9).

Roughness. The USGS has measured and reported the roughness in the Wenatchee (0.037) and Chiwawa (0.043) rivers. Long term gaging stations 12457000 (Wenatchee River at Plain, WA) and 12456500 (Chiwawa River near Plain, WA) are among the rivers with verified roughness values that are used to estimate roughness in other rivers (https://wwwrcamnl.wr.usgs.gov/sws/fieldmethods/Indirects/nvalues/index.htm).

Variable floodplain roughness was assigned based on rough mapping of the floodplain vegetation pattern and using standard values for each mapped unit. Some aspects of the geomorphic map, such as abandoned channels, were incorporated into the roughness map.

Boundary Conditions. The model has two upstream boundary conditions in the Wenatchee and Chiwawa Rivers. Because of the difference in timing of floods in the two rivers, inserting of steady state recurrence interval floods (e.g., the 100-year peak flow) at the two boundary conditions does not represent real conditions. To try to represent floods more realistically, the model simulated non-steady state conditions in two historic flood events that have been recorded on both rivers. The 2017 flood was selected to represent a recent, moderately large flood (2- to 10-year event) and the 1995 event is representative of an extreme event (>100 year flood). More information on floods is provided in Section 3.3.

3.5.3 Model Results and Interpretations.

The modeling results are presented in a digital map book that highlights patterns of flooding and its relationship to the geomorphology on the Chiwawa River fan (Appendix B). Some interpretations of model results relevant to the conceptual designs are provided below.

Figure 12 compares modeled flooding patterns in a moderate event with an extreme flood:

In a moderate event (left panel), there is limited floodplain flooding along the Wenatchee and lower Chiwawa Rivers. Some channelized flooding and ponding occurs on the Chiwawa River fan at the proposed side channels and alcove, but the remainder of the Chiwawa fan does not flood. A substantial amount of overbank flow crosses the floodplain at the two curved bends on the Chiwawa River just upstream of the confluence.

In an extreme flood (right panel), flow from the Wenatchee River overtops a divide in the northern part of the fan, causing inundation of most of the lower fan surface. On the Chiwawa River, much of the floodplain north and south of the river is inundated, and the hatchery area is partially flooded. The Chiwawa River appears to have been backwatered by flow in the Wenatchee, leading to a significant drop in shear stress and velocity just upstream of the confluence. There are large gravel bars in this zone, which led to the development of the two sharp curves, and this was probably an area of gravel deposition during the 1995 flood.

***Figure 12**. Modeled maximum water depths during two simulated historic floods*

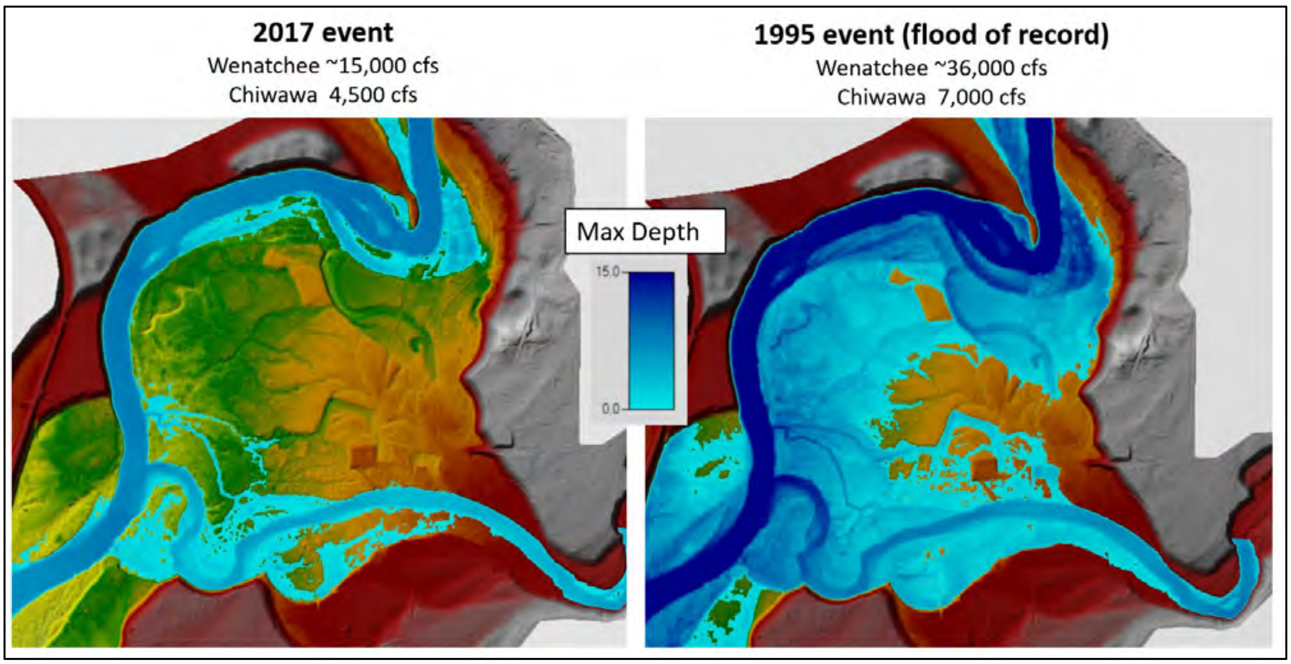
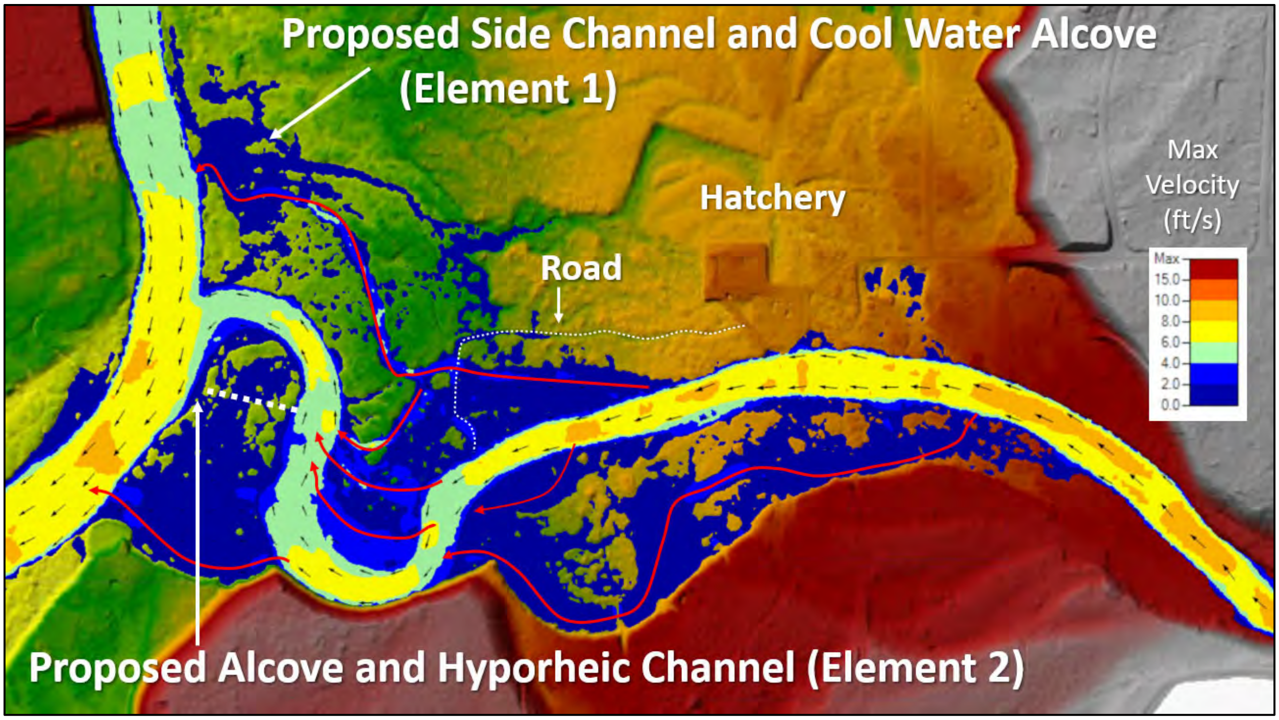


Figure 13 highlights velocity patterns and flow pathways in the vicinity of the project elements during the 2017 high flow event. Under existing conditions, in moderate floods, water leaves the Chiwawa River channel at several specific overtopping points, concentrating as channelized floodplain flow in several remnant fan distributary channels. These include the side channel that would be used to carry water from the Chiwawa River to the proposed cool water alcove along the Wenatchee River. Flow across the peninsula at the mouth of the Chiwawa River is concentrated against the high ground to the south, close to the private residence, creating an avulsion risk that is known to the property owner. There is a drop in velocity in the main channel where floodplain flow is more extensive. This probably contributes to continuing growth of the bars in the two sharp bends in the lowermost Chiwawa River.

Figure 13. *Modeled maximum water velocity and velocity vectors during the 2017 high flow event, with annotations. Red arrows identify main overbank flow pathways based on interpretation of model results*



3.6 Stability Analyses and Computations for Project Elements, and a Comprehensive Project Plan

The proposed project is in the conceptual design phase; final project elements have not been selected at this time. Project element which will require stability calculations include: Mid-channel ELJs, Apex Log Jams, Bank Attached Log Structures, Habitat Logs, and the side channel crossing. Stability analyses will utilize industry standard best practices and guidelines including Barnard et al. 2013 for stream crossing design, and Knutson et.al. 2014 and USBR/ERDC 2016 for large wood design.

3.7 Description of How Preceding Technical Analysis has Been Incorporated into and Integrated with the Construction

The existing conditions analyses discussed above and in the Appendices are the basis for the conceptual designs. The geomorphic analysis included mapping that identified opportunities for project elements such as side channels, alcoves, and other features that would improve the geomorphic function and habitat values of the site. The planning-level existing conditions hydraulic analysis was used to understand inundation patterns and natural flow pathways in moderate and large floods. At future design phases, additional survey and proposed condition modeling may be required to refine designs to ensure the final project that is constructed will meet the project and stakeholder objectives.

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

Not applicable.

3.9 For projects that address profile discontinuities (e.g., grade stabilization, small dam and structure removals), a minimum of three cross-sections (one downstream of the structure, one through the reservoir area upstream of the structure, and one upstream of the reservoir area outside of the influence of the structure) shall be used to characterize the channel morphology and quantify the stored sediment.

Not applicable.

4.0 CONSTRUCTION – CONTRACT DOCUMENTATION

4.1 Incorporation of HIP General and Construction Conservation Measures

To be included on stamped 100% design drawings and specifications.

4.2 Design – Construction Plan Set Including but Not Limited to: Plan, Profile, Section, and Detail Sheets That Identify All Project Elements and Construction Activities of Sufficient Detail to Govern Competent Execution of Project Billing and Implementation

Concept level design drawings are provided as Appendix A. These include plan, profile, sections, and typical details. These concept level designs are not yet of sufficient detail to govern project billing or implementation as specific project elements have yet to be selected and refined. The final stamped plans and specifications will be of sufficient detail for project contracting, billing, and implementation.

4.3 List of All Proposed Project Materials and Quantities

To be included in future Preliminary design drawings.

The proposed project is in the conceptual design phase. As such, specific project elements have not been determined; some proposed project elements are mutually exclusive (e.g., infiltration gallery vs. side channel). Future design phases will select project elements and refine locations of those elements. Subsequent to refinement of the concept designs, project quantities can be estimated more accurately. Anticipated materials for the proposed project include:

- Site derived or imported logs;
- Rock materials (e.g., boulders, cobbles, and gravels);
- Rebar or fasteners for log to log connections in large wood structures;
- Pipe for infiltration gallery and hatchery effluent conveyance;
- Prefabricated stream channel crossing (i.e., bridge or culvert); and
- Temporary erosion control materials

4.4 Description of Best Management Practices That Will Be Implemented and Implementation Resource Plans

The proposed project in in the conceptual design phase. Best management practices to be implemented will be selected in future phases of design such that temporary impacts associated with construction are minimized and mitigated. The final stamped plans and specifications will include the following plans and associated BMPs:

- Site access and staging plan;
- In-channel work area isolation and dewatering plan with specific provisions for anticipated aquatic species;

- Temporary Erosion and Sediment Control Plan (TESC);
- Spill pollution prevention plan;
- Site restoration plan; and
- List of proposed equipment and equipment fuel/lubricant management plan.

4.5 Calendar Schedule for Construction/Implementation Procedures

A construction timeframe has not been determined at this time.

The proposed project is in the Conceptual design phase; as such, a specific timeline for implementation has not yet been determined. The project proponent, Yakima Nations Fisheries, will develop an implementation schedule following securing of funding and obtaining permits for implementation.

4.6 Site or Project Specific Monitoring to Support Pollution Prevention and/or Abatement

Given that the project is in the conceptual design phase and project elements are yet to be refined/selected, a specific monitoring plan for pollution prevention cannot be established. However, the final stamped plans and specifications will include requirements for monitoring protocols to support pollution prevention. These protocols and BMPs will likely include:

- Turbidity monitoring for in-channel activities,
- Establishment of fueling/lubricating facilities a minimum of 150' from ordinary highwater,
- Fuel/lubricant spill containment and absorbent measures,
- Weather forecast monitoring to anticipate precipitation events and temporarily stabilize soils,
- Construction dust control, and
- Other practices as needed for construction pollution prevention.

5.0 MONITORING AND ADAPTIVE MANAGEMENT PLAN

It has not yet been determined whether an Adaptive Management Plan is required for this project. This will be decided at a future time by Yakama Nation Fisheries.

6.0 REFERENCES

Barnard, R. J., J. Johnson, P. Brooks, K. M. Bates, B. Heiner, J. P. Klavas, D.C. Ponder, P.D. Smith, and P. D. Powers (2013), Water Crossings Design Guidelines, Washington Department of Fish and Wildlife, Olympia, Washington.

Bonneville Power Administration. 2016. HIP III Handbook: Guidance of Programmatic Requirements and Process. Version 4.1.

Bonneville Power Administration. 2019. HIP Handbook: Guidance of Programmatic Requirements and Process. Version 5.2. Accessed via the World Wide Web at: https://www.bpa.gov/efw/Analysis/NEPADocuments/esa/2019(HIP4)HandbookVer5.2(FINAL).pdf

Bureau of Reclamation and U.S. Army Engineer Research and Development Center (USBR and ERDC). 2016. National Large Wood Manual: Assessment, Planning, Design, and Maintenance of Large Wood in Fluvial Ecosystems: Restoring Process, Function, and Structure. 628 pages + Appendix. Available: www.usbr.gov/pn/ and http://cwenvironment.usace.army.mil/restoration.cfm (click on “River Restoration,” then “Techniques”)

Cramer, Michelle L. (managing editor). 2012. Stream Habitat Restoration Guidelines. Co-published by the Washington Departments of Fish and Wildlife, Natural Resources, Transportation and Ecology, Washington State Recreation and Conservation Office, Puget Sound Partnership, and the U.S. Fish and Wildlife Service. Olympia, Washington.

Cristea, N.C. and Burges, S.J., 2009. Use of thermal infrared imagery to complement monitoring and modeling of spatial stream temperatures. Journal of Hydrologic Engineering, 14(10), pp.1080-1090.

Flynn, K.M., Kirby, W.H. and Hummel, P.R., 2006. User's manual for program PeakFQ, annual flood-frequency analysis using Bulletin 17B guidelines (No. 4-B4).

Interfluve. 2012. Upper Wenatchee River Stream Corridor Assessment and Habitat Restoration Strategy. Prepared for Yakama Nation Fisheries. August 2012.

Knutson and Fealko. 2014. Pacific Northwest Region Research and Technical Services Large Woody Material – Risk Based Design Guidelines. United States Department of the Interior. Bureau of Reclamation. Pacific Northwest Region. Boise, Idaho.

Quantum Spatial. 2016. 2015 OLC Chelan FEMA. Prepared for Department of Geology and Mineral Industries. April 2016.

U.S. Environmental Protection Agency (EPA). 2001. Technical Synthesis: Scientific Issues Relating to Temperature Criteria for Salmon, Trout, and Char Native to the Pacific Northwest. A summary report submitted to the Policy Workgroup of the EPA Region 10 Water Temperature Criteria Guidance Project. EPA 910-R-01-007. August 2001.

Upper Columbia Salmon Recovery Board. 2007. Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan.

Washington Department of Fish and Wildlife. 2018. Times When Spawning or Incubating Salmonids are Lease Likely to be Within Washington State Freshwaters. Accessed from World Wide Web on April 28th, 2020 at: https://wdfw.wa.gov/sites/default/files/2019-02/freshwater_incubation_avoidance_times.pdf

Washington State Department of Ecology. 2019. Stormwater Management Manual for Eastern Washington. Publication Number 18-10-044

WATERWAYS CONSULTING, INC.

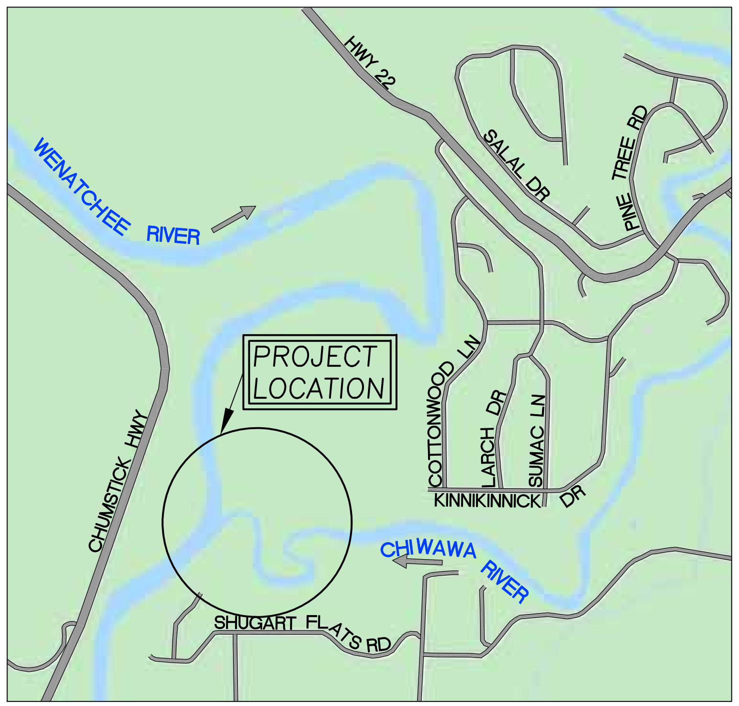
Chiwawa Outlet Restoration Project

APPENDIX A

Conceptual Design Drawings

CHIWAWA OUTLET RESTORATION

CONCEPT LEVEL DESIGN PLANS



VICINITY MAP
N.T.S. (GOOGLE)

REGIONAL MAP
N.T.S. (GOOGLE)

SHEET INDEX

C1	COVER
C2	PROJECT OVERVIEW
C3	UPSTREAM SIDE CHANNELS SITE PLAN
C4	DOWNSTREAM SIDE CHANNELS SITE PLAN
C5	SIDE CHANNELS PROFILES AND SECTION
C6	CHIWAWA RIVER CONFLUENCE SITE PLAN
C7	TYPICAL CROSS SECTIONS AND PROFILE
C8	TYPICAL LARGE WOOD DETAILS
C9	MID CHANNEL ELJ DETAIL
C10	HABITAT WOOD STRUCTURE DETAIL

PROJECT DESCRIPTION

THIS PROJECT WILL IMPROVE JUVENILE SALMON HABITAT BY INCREASING IN-CHANNEL COMPLEXITY, IMPROVING FLOODPLAIN CONNECTIVITY, AND EXPANDING COLD WATER REFUGIA IN THE WENATCHEE AND CHIWAWA RIVERS. THE PROJECT IS FURTHER DESCRIBED IN THE CHIWAWA OUTLET RESTORATION PROJECT CONCEPTUAL DESIGN REPORT, 2020. PROJECT ELEMENTS INCLUDE EXCAVATION OF SIDE CHANNELS IN THE CHIWAWA RIVER ALLUVIAL FAN, ALCOVE GRADING, AND PLACEMENT OF LARGE WOOD STRUCTURES

PROJECT LOCATION

LATITUDE: 47°47'15.92"N
LONGITUDE: 120°39'20.94"W

SECTION 1, TOWNSHIP 26 N, RANGE 17E

WATERBODY: CHIWAWA RIVER
TRIBUTARY OF: WENATCHEE RIVER

*** CALL BEFORE YOU DIG ***

CONTACT UNDERGROUND SERVICE ALERT (USA)
PRIOR TO ANY CONSTRUCTION WORK 1-800-227-2600

ABBREVIATIONS

AVG.	AVERAGE
CC	CONCRETE
CY	CUBIC YARDS
DIA.	DIAMETER
E	EXISTING
EG	EXISTING GROUND
ELEV.	ELEVATION
ELJ	ENGINEERED LOG JAM
FG	FINISHED GRADE
FT	FEET
INV	INVERT
N	NEW
NIC	NOT IN CONTRACT
N.T.S.	NOT TO SCALE
O.C.	ON CENTER
PID	PROPERTY IDENTIFICATION NUMBER
RC	RELATIVE COMPACTION
RSP	ROCK SLOPE PROTECTION
SPK	SPIKE
SQ.FT.	SQUARE FOOT
T	TREE
T.B.D.	TO BE DETERMINED
TYP	TYPICAL
UNK	UNKNOWN
WSE	WATER SURFACE ELEVATION
YR	YEAR

SECTION AND DETAIL CONVENTION

SECTION OR DETAIL IDENTIFICATION (NUMBER OR LETTER)

5
C3

SHEET REFERENCE

GENERAL NOTES

1. LIDAR MAPPING WAS PERFORMED BY:
   Quantum Spatial
   421 SW 6th AVENUE
   PORTLAND, OR 97204
   SURVEY DATES; AUGUST, 2015.
2. ELEVATION DATUM: NAVD88.
3. HORIZONTAL DATUM: NAD83 WASHINGTON STATE PLANE NORTH
4. AERIAL PHOTO SOURCE: AUTOCAD CIVIL3D GEOLOCATION MAP.
5. CONTOUR INTERVAL IS TWO FOOT. ELEVATIONS AND DISTANCES SHOWN ARE IN DECIMAL FEET.
6. THIS IS NOT A BOUNDARY SURVEY. PROPERTY LINES ARE NOT SHOWN HEREON.
7. ALL CONSTRUCTION AND MATERIALS SHALL CONFORM TO THE STATE OF WASHINGTON DEPARTMENT OF TRANSPORTATION STANDARD SPECIFICATIONS (HEREAFTER REFERRED TO AS "STANDARD SPECIFICATIONS").
10. THESE DESIGNS ARE INCOMPLETE WITHOUT THE FINAL STAMPED TECHNICAL SPECIFICATIONS PREPARED BY WATERWAYS CONSULTING, INC. REFER TO TECHNICAL SPECIFICATIONS FOR DETAILS NOT SHOWN HEREON.

WATERWAYS CONSULTING INC.
1020 SW TAYLOR STREET, STE. 380
PORTLAND, OR 97205
PH:(503)227-5979 / FAX:(888)819-6847
WWW.WATWAYS.COM

PRELIMINARY
NOT FOR CONSTRUCTION

PREPARED AT THE REQUEST OF:
YAKIMA NATION FISHERIES

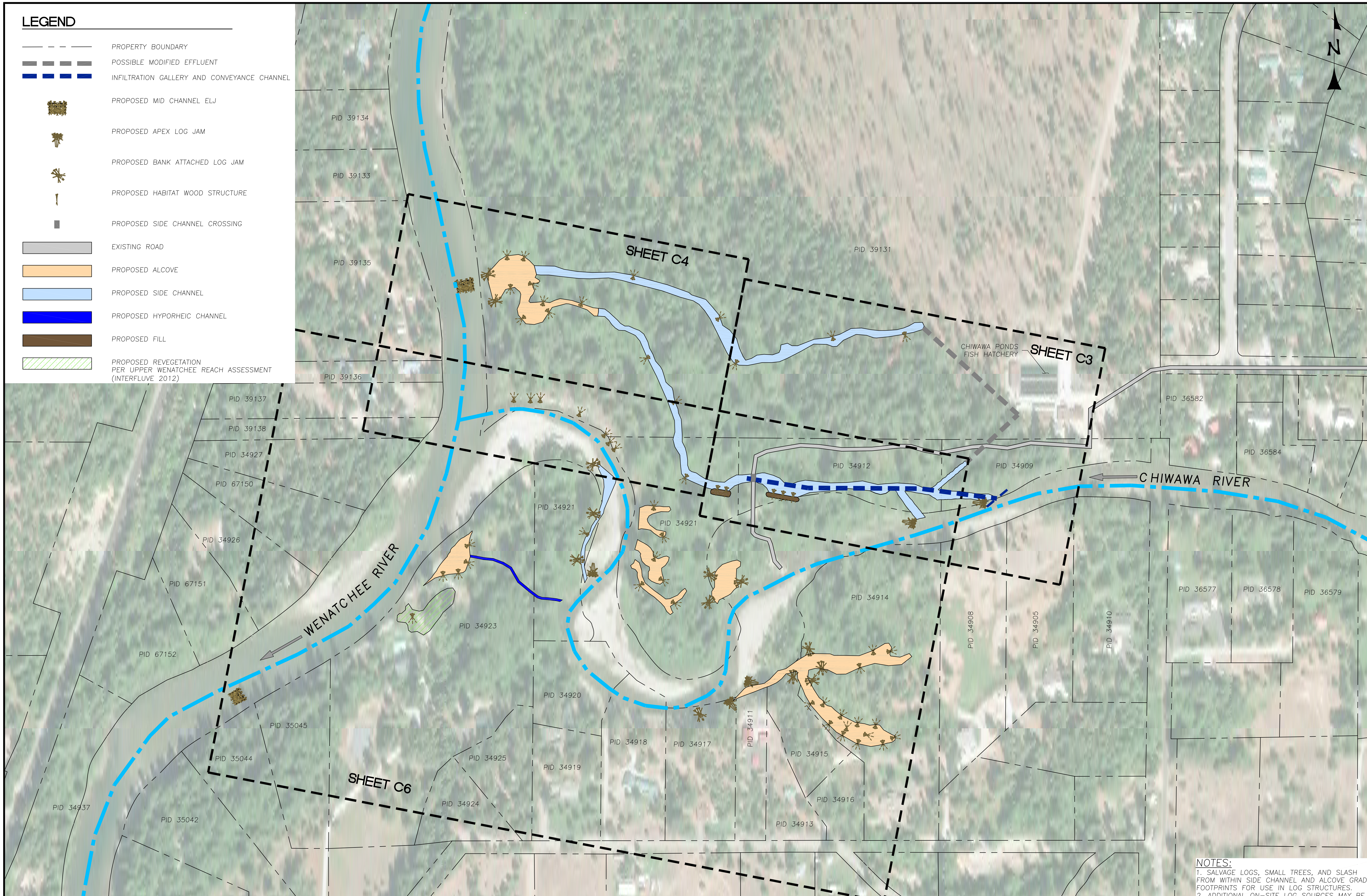
COVER

CHIWAWA RIVER FAN RECONNECTION CONCEPT PLANS

DESIGNED BY: B.T.
DRAWN BY: M.M.
CHECKED BY: J.H
DATE: 05/12/20
JOB NO.: 19-040

BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS
0 1"

C1



NOTES:

1. SALVAGE LOGS, SMALL TREES, AND SLASH FROM WITHIN SIDE CHANNEL AND ALCOVE GRADING FOOTPRINTS FOR USE IN LOG STRUCTURES.
2. ADDITIONAL ON-SITE LOG SOURCES MAY BE IDENTIFIED AT FUTURE DESIGN PHASES.

PROJECT OVERVIEW

SCALE: 1" = 150'

WATERWAYS CONSULTING INC.
1020 SW TAYLOR STREET, STE. 380
PORTLAND, OR 97205
PH:(503)227-5979 // FAX:(888)819-6847
WWW.WATWAYS.COM

PRELIMINARY
NOT FOR CONSTRUCTION

PREPARED AT THE REQUEST OF:
YAKIMA NATION FISHERIES

PROJECT OVERVIEW

CHIWAWA RIVER FAN RECONNECTION CONCEPT PLANS

DESIGNED BY: B.T.
DRAWN BY: M.M.
CHECKED BY: J.H
DATE: 05/12/20
JOB NO.: 19-040

BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS
0 1"

C2

LEGEND

	EXISTING CONTOURS
	PROPERTY BOUNDARY
	PIPE ALIGNMENT
	INFILTRATION GALLERY AND CONVEYANCE CHANNEL
	CHANNEL ALIGNMENT
	PROPOSED APEX LOG JAM
	PROPOSED HABITAT WOOD STRUCTURE
	PROPOSED SIDE CHANNEL CROSSING
	EXISTING ROAD
	PROPOSED SIDE CHANNEL
	PROPOSED FILL

UPSTREAM SIDE CHANNELS SITE PLAN

SCALE: 1" = 40'

WATERWAYS CONSULTING INC.
1020 SW TAYLOR STREET, STE. 380
PORTLAND, OR 97205
PH:(503)227-5979 / FAX(888)819-6847
WWW.WATWAYS.COM

PRELIMINARY
NOT FOR CONSTRUCTION

PREPARED AT THE REQUEST OF:
YAKIMA NATION FISHERIES

UPSTREAM SIDE CHANNELS SITE PLAN

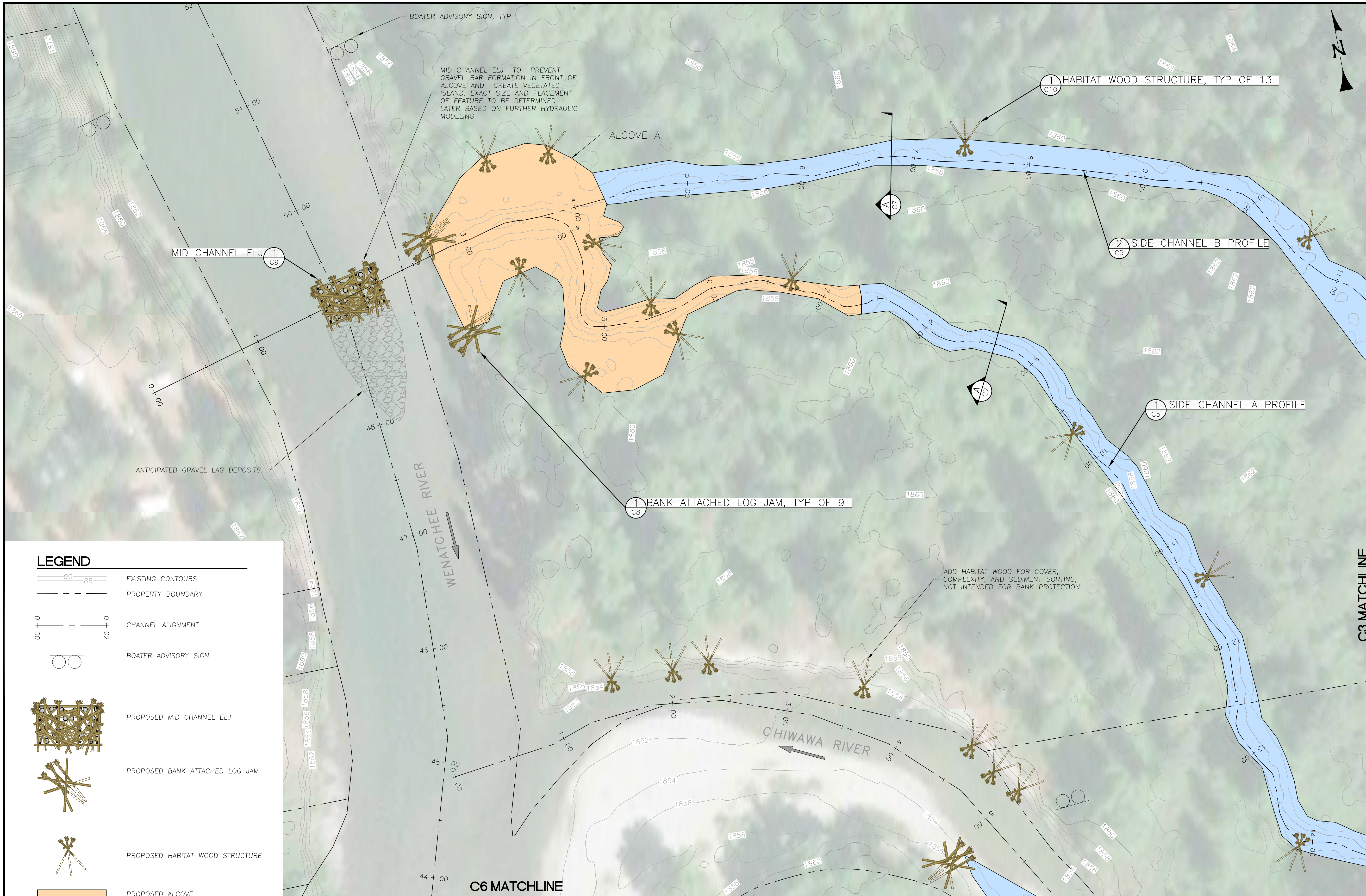
CHIWAWA RIVER FAN RECONNECTION CONCEPT PLANS

DESIGNED BY:	B.T.
DRAWN BY:	M.M.
CHECKED BY:	J.H
DATE:	05/12/20
JOB NO.:	19-040

BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS
0 1"

C3

f:\Projects\19-040_chiwawa_outlet_design\CAD\19-040 SITE PLAN SIDE CHANNELS.dwg - 5/12/2020 4:31 PM



DOWNSTREAM SIDE CHANNELS SITE PLAN

SCALE: 1" = 40'

WATERWAYS CONSULTING INC.
1020 SW TAYLOR STREET, STE. 380
PORTLAND, OR 97205
PH:(503)227-5979 / FAX(888)819-6847
WWW.WATWAYS.COM

PRELIMINARY

NOT FOR CONSTRUCTION

PREPARED AT THE REQUEST OF:
YAKIMA NATION FISHERIES

DOWNSTREAM SIDE CHANNELS SITE PLAN

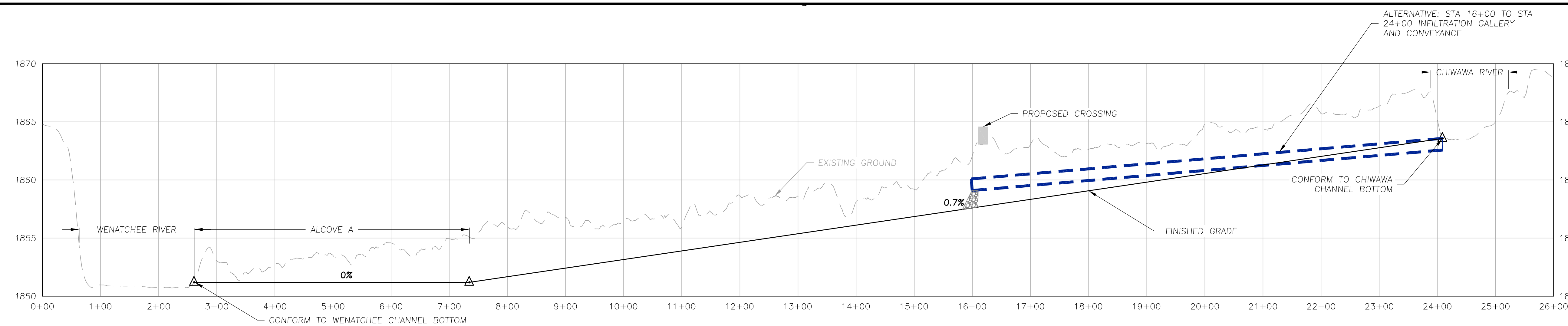
CHIWAWA RIVER FAN RECONNECTION CONCEPT PLANS

DESIGNED BY:	B.T.
DRAWN BY:	M.M.
CHECKED BY:	J.H
DATE:	05/12/20
JOB NO.:	19-040

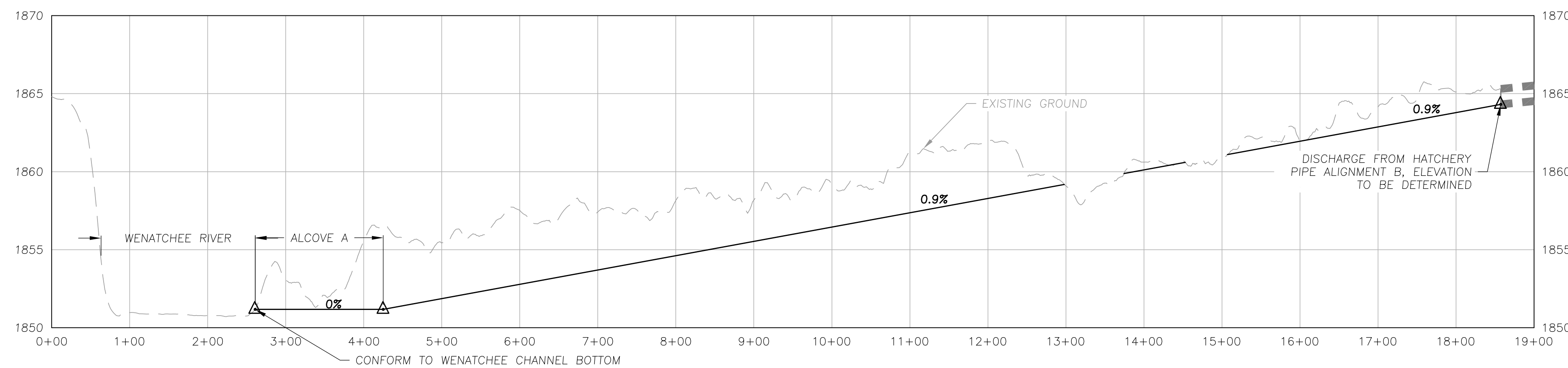
BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS

0 1"

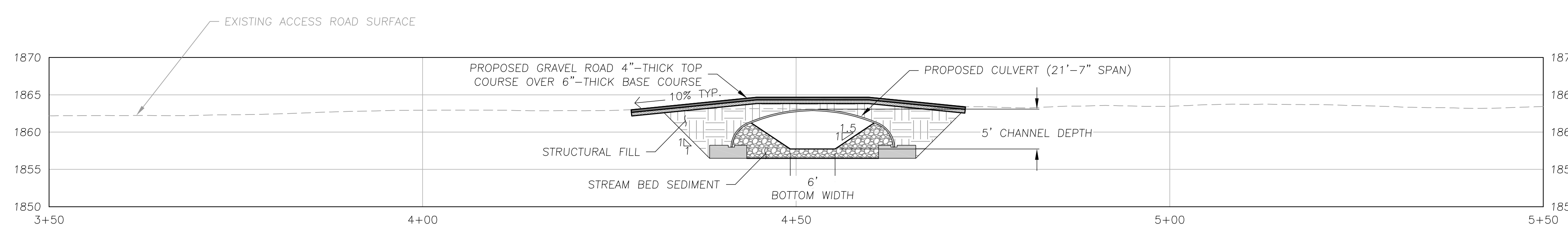
f:\Projects\19-040_chiwawa_outlet_design\CAD\19-040 SITE PLAN SIDE CHANNELS.dwg - 5/12/2020 4:32 PM



SIDE CHANNEL A PROFILE (SHOWN AT 20X VERTICAL EXAGGERATION) 1 C3 C4
HORZ SCALE: 1" = 100' VERT: 1" = 5'



SIDE CHANNEL B PROFILE (SHOWN AT 20X VERTICAL EXAGGERATION) 2 C3 C4
HORZ SCALE: 1" = 100' VERT: 1" = 5'



CROSSING NOTES:

1. CROSSING TYPE NOT DETERMINED AT THIS PHASE OF DESIGN. CROSSING MAY CONSIST OF A BRIDGE OR CULVERT.
2. CHANNEL AND CROSSING DIMENSIONS SHOWN ARE APPROXIMATE. CROSSING DIMENSIONS TO BE DEVELOPED AT A LATER STAGE OF DESIGN.
3. CROSSING WILL BE DESIGNED TO ACCOMMODATE LOADS SUCH AS A MOBILE CRANE TO REMOVE THE SMOLT TRAP

SIDE CHANNEL A CROSSING STRUCTURE SECTION A C3
SCALE: 1" = 10'

WATERWAYS CONSULTING INC.
1020 SW TAYLOR STREET, STE. 380
PORTLAND, OR 97205
PH:(503)227-5979 / FAX(888)819-6847
WWW.WATWAYS.COM

PRELIMINARY
NOT FOR CONSTRUCTION

PREPARED AT THE REQUEST OF:
YAKIMA NATION FISHERIES

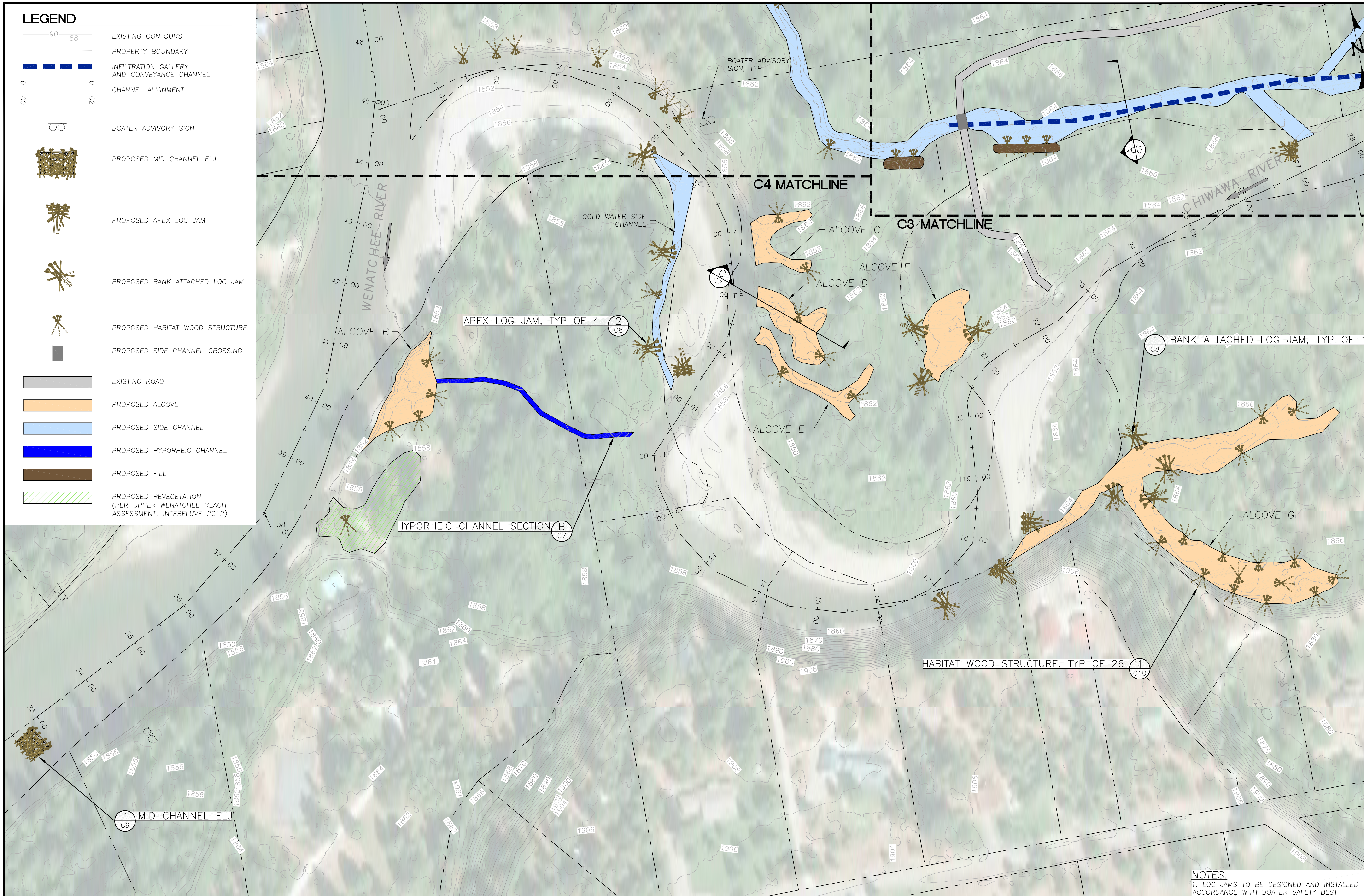
SIDE CHANNELS PROFILES AND SECTION

CHIWAWA RIVER FAN RECONNECTION CONCEPT PLANS

DESIGNED BY: B.T.
DRAWN BY: M.M.
CHECKED BY: J.H
DATE: 05/12/20
JOB NO.: 19-040

BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS
0 1"

C5



NOTES:
1. LOG JAMS TO BE DESIGNED AND INSTALLED IN ACCORDANCE WITH BOATER SAFETY BEST PRACTICES.

CHIWAWA RIVER CONFLUENCE SITE PLAN

SCALE: 1" = 75'

WATERWAYS CONSULTING INC.
1020 SW TAYLOR STREET, STE. 380
PORTLAND, OR 97205
PH:(503)227-5979 / FAX:(888)819-6847
WWW.WATWAYS.COM

PRELIMINARY
NOT FOR CONSTRUCTION

PREPARED AT THE REQUEST OF:
YAKIMA NATION FISHERIES

CHIWAWA RIVER CONFLUENCE SITE PLAN

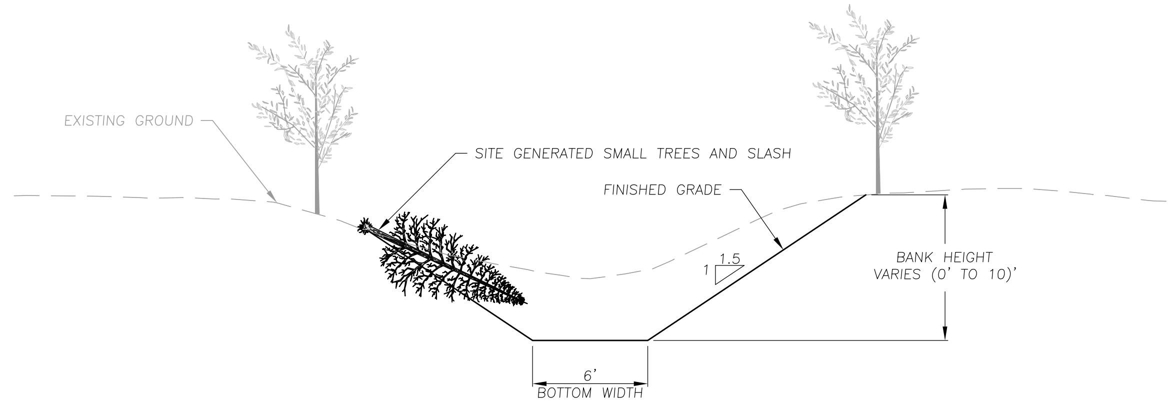
CHIWAWA RIVER FAN RECONNECTION CONCEPT PLANS

DESIGNED BY: B.T.
DRAWN BY: M.M.
CHECKED BY: J.H
DATE: 05/12/20
JOB NO.: 19-040

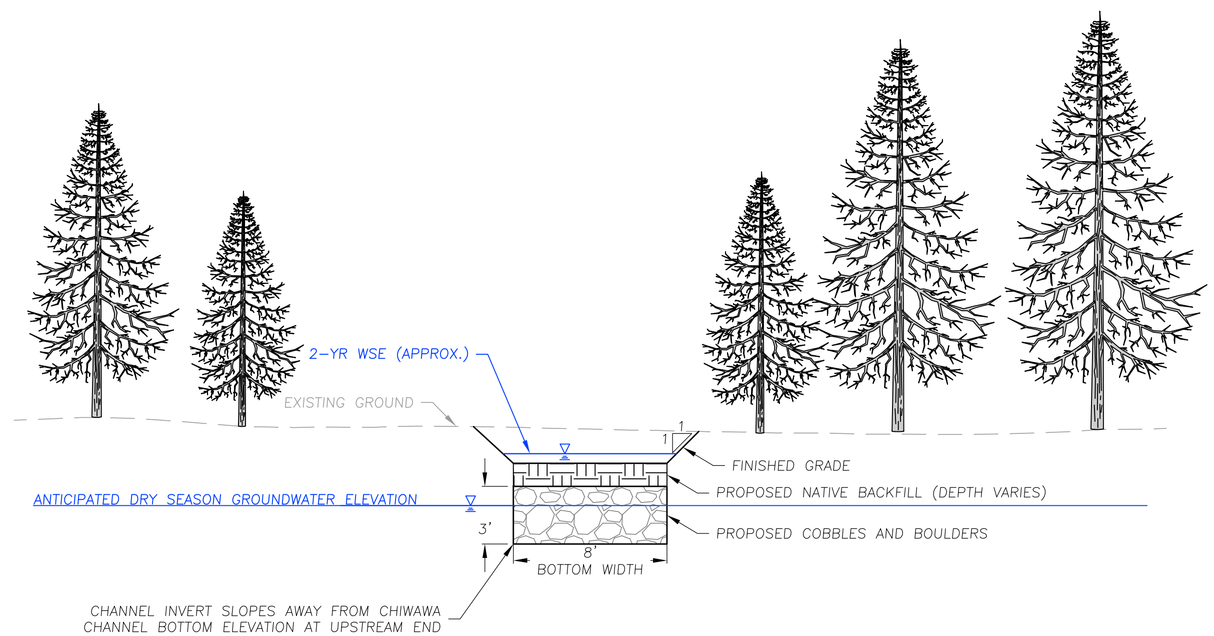
BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS
0 1"

C6

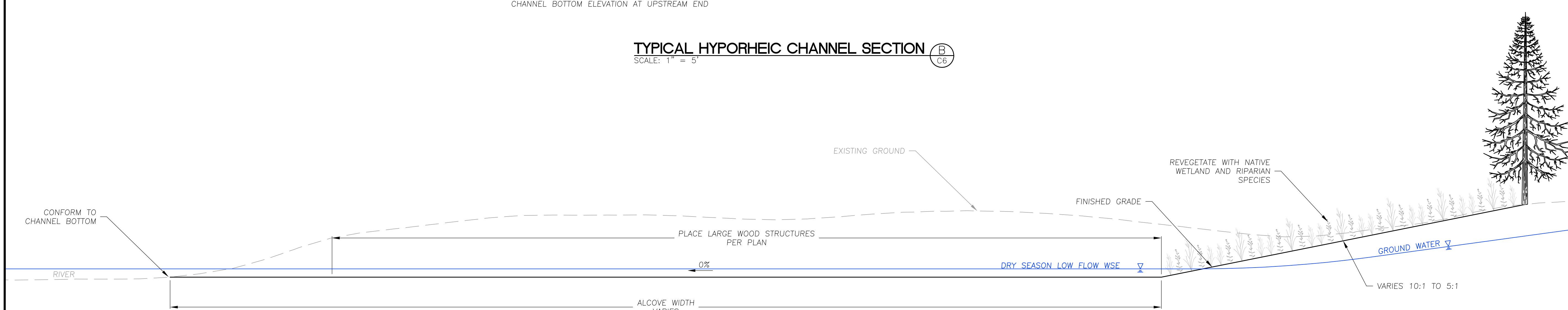
f:\Projects\19-040_chiwawa_outlet_design\CAD\19-040 SITE PLAN CHIWAWA.dwg – 5/12/2020 4:41 PM



TYPICAL SIDE CHANNEL SECTION (A) C3 C4 C6
SCALE: 1" = 5'



TYPICAL HYPORHEIC CHANNEL SECTION (B) C6
SCALE: 1" = 5'



NOTES:
1. TYPICAL ALCOVE PROFILE APPLIES TO ALCOVES B–G.

TYPICAL ALCOVE PROFILE (NOTE 1) (C) C4 C6
SCALE: 1" = 5'

WATERWAYS CONSULTING INC.
1020 SW TAYLOR STREET, STE. 380
PORTLAND, OR 97205
PH:(503)227-5979 / FAX:(888)819-6847
WWW.WATWAYS.COM

PRELIMINARY
NOT FOR CONSTRUCTION

PREPARED AT THE REQUEST OF:
YAKIMA NATION FISHERIES

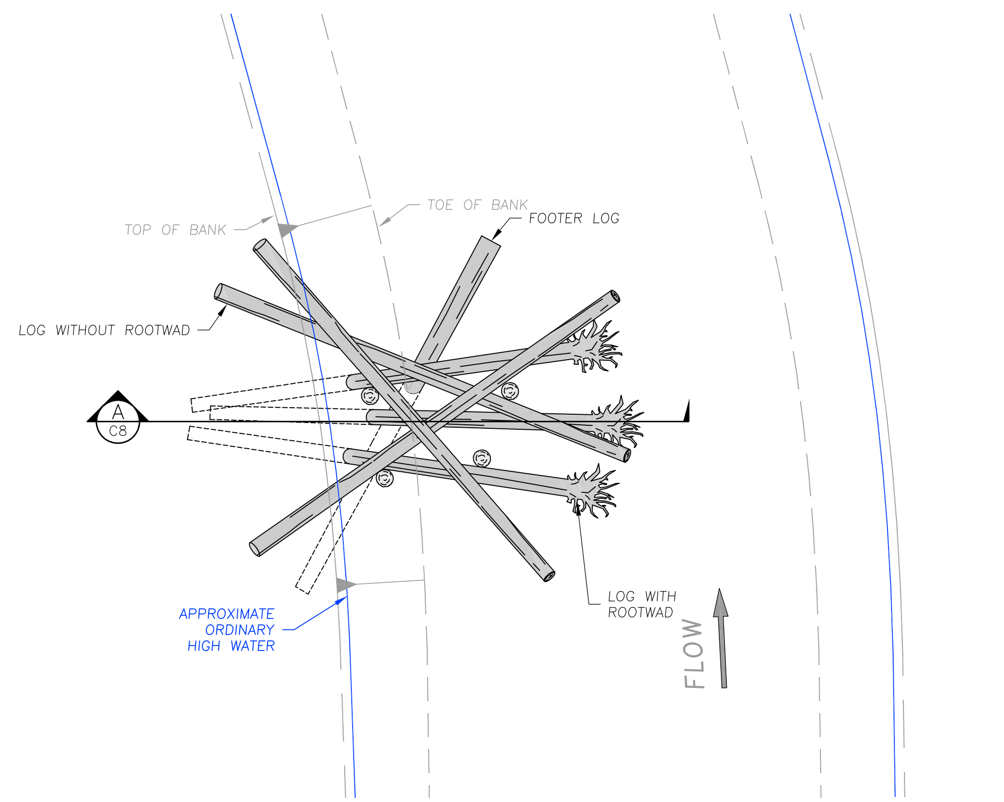
TYPICAL CROSS SECTIONS AND PROFILE

CHIWAWA RIVER FAN RECONNECTION CONCEPT PLANS

DESIGNED BY: B.T.
DRAWN BY: M.M.
CHECKED BY: J.H
DATE: 05/12/20
JOB NO.: 19-040

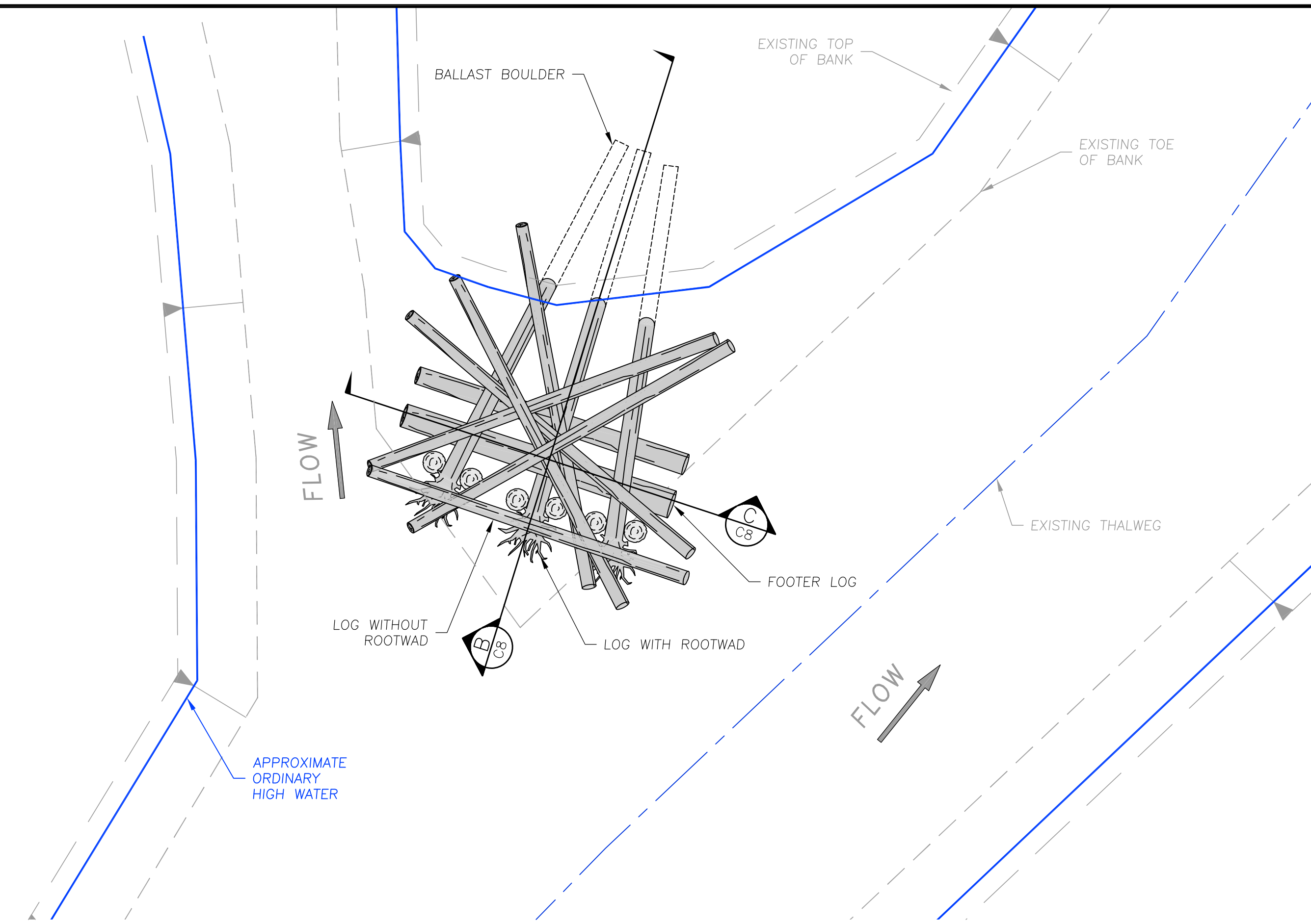
BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS
0 1"

C7
7 OF 10



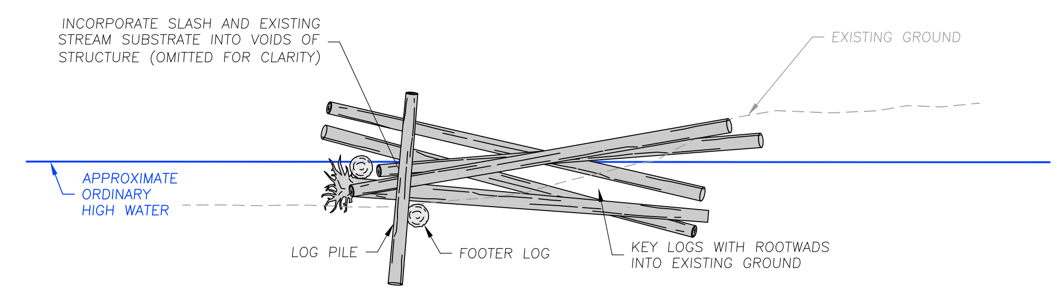
TYPICAL BANK ATTACHED LOG JAM 1 (C4 C6)

SCALE: 1" = 10'



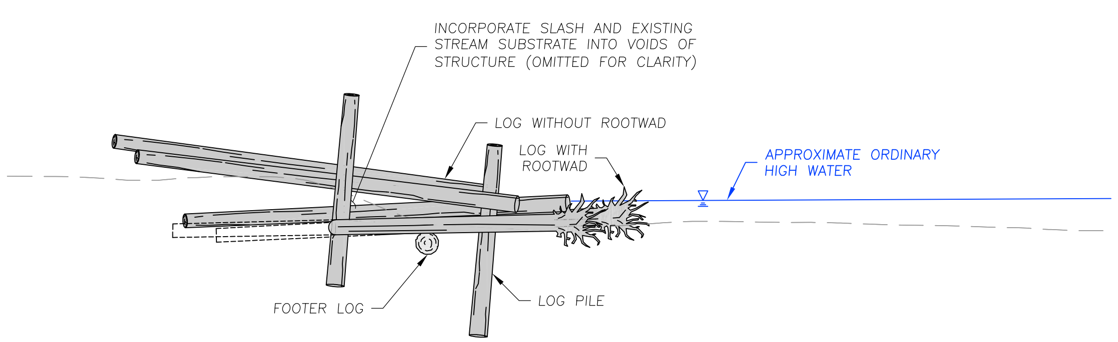
TYPICAL APEX LOG JAM 2 (C3 C6)

SCALE: 1" = 10'



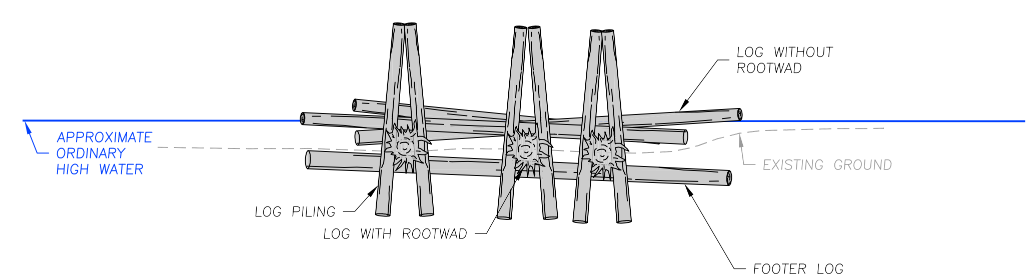
TYPICAL PROFILE B (C8)

SCALE: 1" = 10'



TYPICAL SECTION A (C8)

SCALE: 1" = 10'



TYPICAL SECTION C (C8)

SCALE: 1" = 10'

LOG STRUCTURE NOTES:

1. LOG DIMENSIONS, ORIENTATIONS, AND QUANTITIES ARE SHOWN FOR CONCEPT DESIGN AND WILL BE REFINED IN THE NEXT PHASE OF DESIGN.
2. LOG TO LOG AND LOG TO BOULDER CONNECTIONS OMITTED FOR CLARITY.
3. BALLASTING MATERIALS AND APPROACH NOT YET DETERMINED.

WATERWAYS CONSULTING INC.
1020 SW TAYLOR STREET, STE. 380
PORTLAND, OR 97205
PH:(503)227-5979 / FAX(888)819-6847
WWW.WATWAYS.COM

PRELIMINARY

NOT FOR CONSTRUCTION

PREPARED AT THE REQUEST OF:
YAKIMA NATION FISHERIES

TYPICAL LARGE WOOD DETAILS

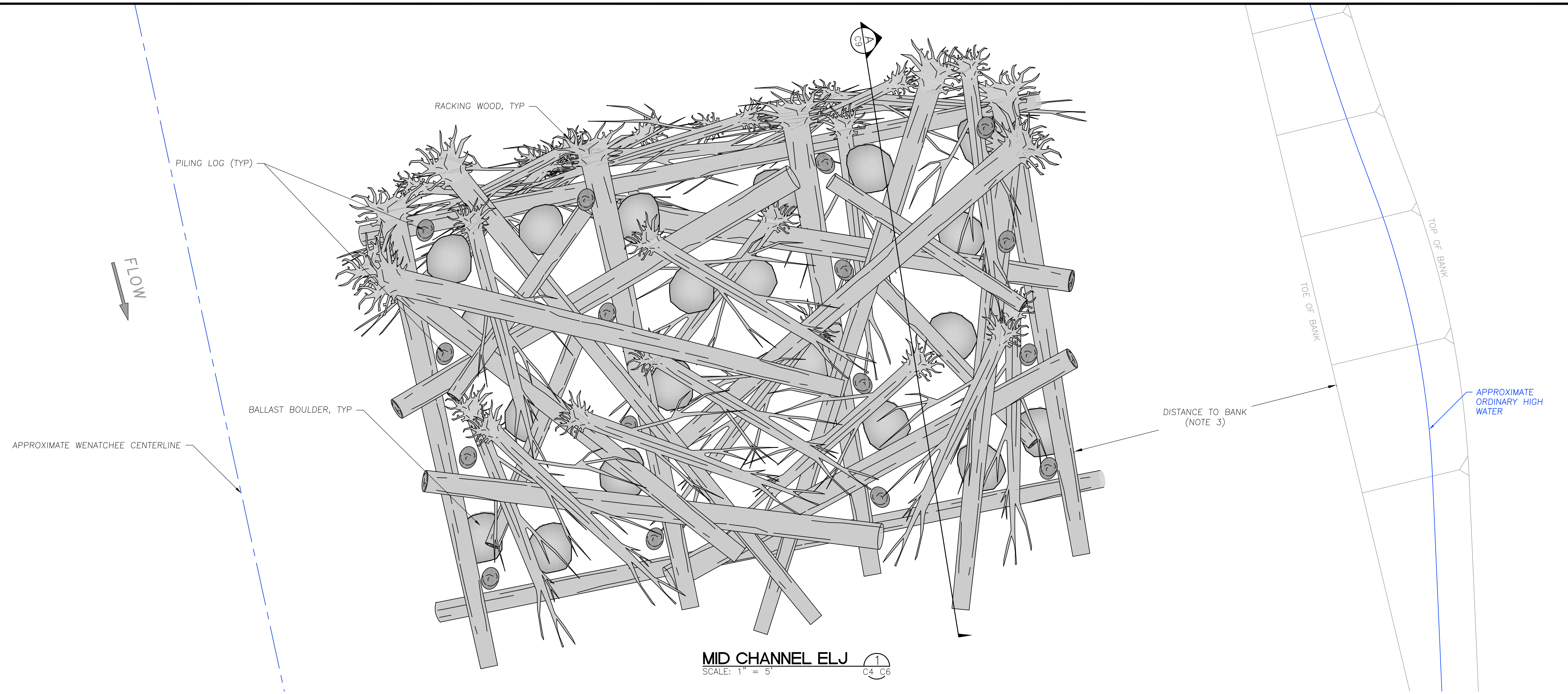
CHIWAWA RIVER FAN RECONNECTION CONCEPT PLANS

DESIGNED BY:	B.T.
DRAWN BY:	M.M.
CHECKED BY:	J.H
DATE:	05/12/20
JOB NO.:	19-040

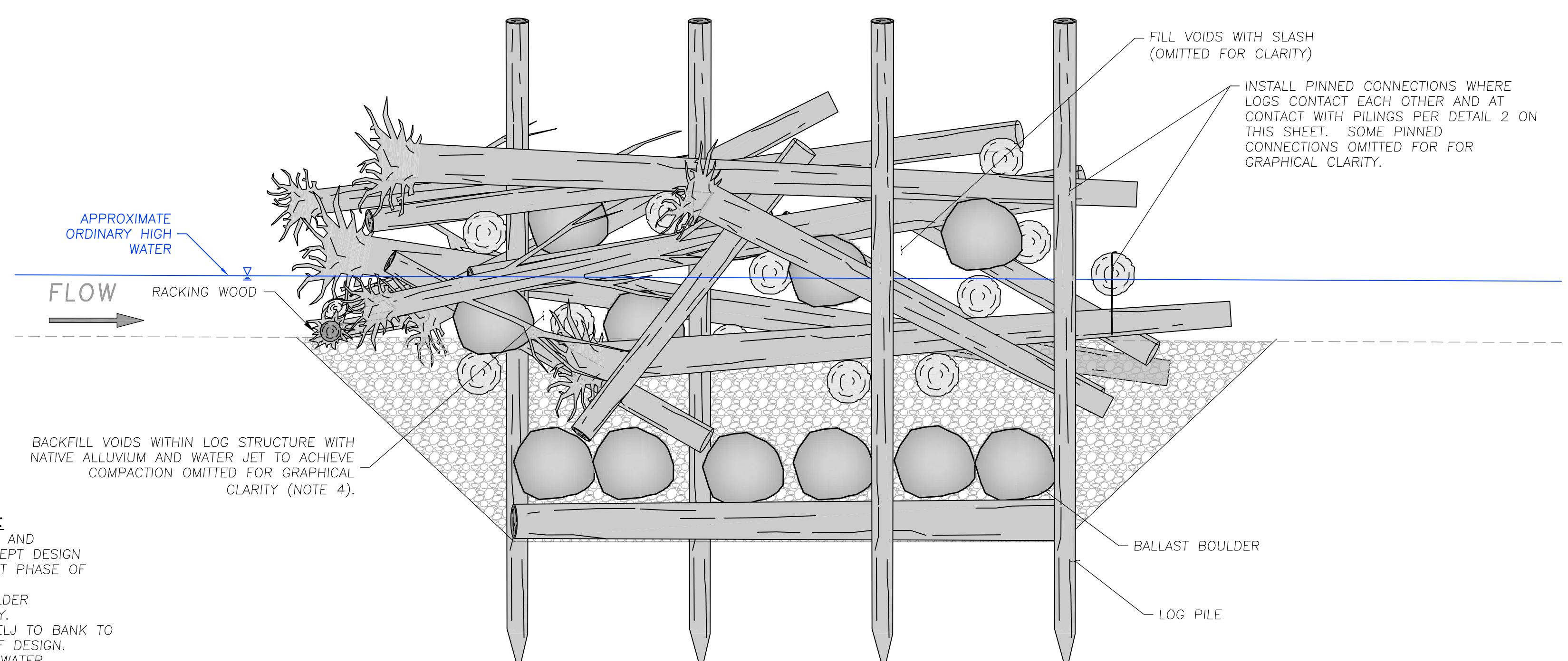
BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS

0 1"

C8



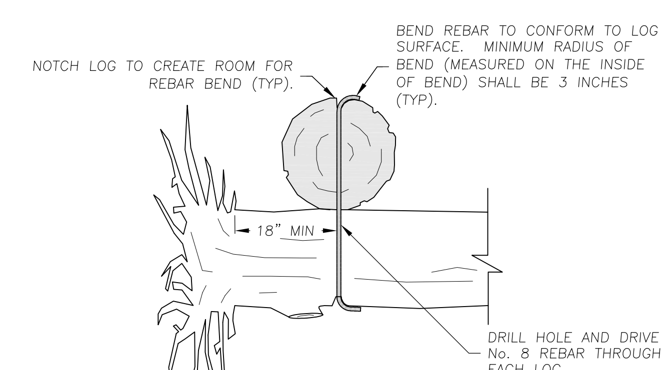
MID CHANNEL ELJ (1) C4 C6
SCALE: 1" = 5'



TYPICAL PROFILE (A) C9
SCALE: 1" = 5'

LOG STRUCTURE NOTES:

1. LOG DIMENSIONS, ORIENTATIONS, AND QUANTITIES ARE SHOWN FOR CONCEPT DESIGN AND WILL BE REFINED IN THE NEXT PHASE OF DESIGN.
2. LOG TO LOG AND LOG TO BOULDER CONNECTIONS OMITTED FOR CLARITY.
3. DISTANCE FROM MID CHANNEL ELJ TO BANK TO BE DETERMINED IN NEXT PHASE OF DESIGN.
4. AT AND ABOVE ORDINARY HIGH WATER ELEVATION, STABILIZE NATIVE ALLUVIUM WITH RIPARIAN VEGETATION. PLANTINGS MAY INCLUDE SEEDING, PLUGS, CONTAINER STOCK, AND LIVE STAKES.



LOG PINNING NOTES:

1. LOG PIN MAY CONSIST OF REBAR OR THREADED ROD WITH FASTENERS. LOG PINNING METHOD TO BE FINALIZED IN FUTURE PHASE OF DESIGN.

PINNED LOG CONNECTION (2) C9
SCALE: 1" = 2'

WATERWAYS CONSULTING INC.
1020 SW TAYLOR STREET, STE. 380
PORTLAND, OR 97205
PH:(503)227-5979 / FAX:(888)819-6847
WWW.WATWAYS.COM

PRELIMINARY
NOT FOR CONSTRUCTION

PREPARED AT THE REQUEST OF:
YAKIMA NATION FISHERIES

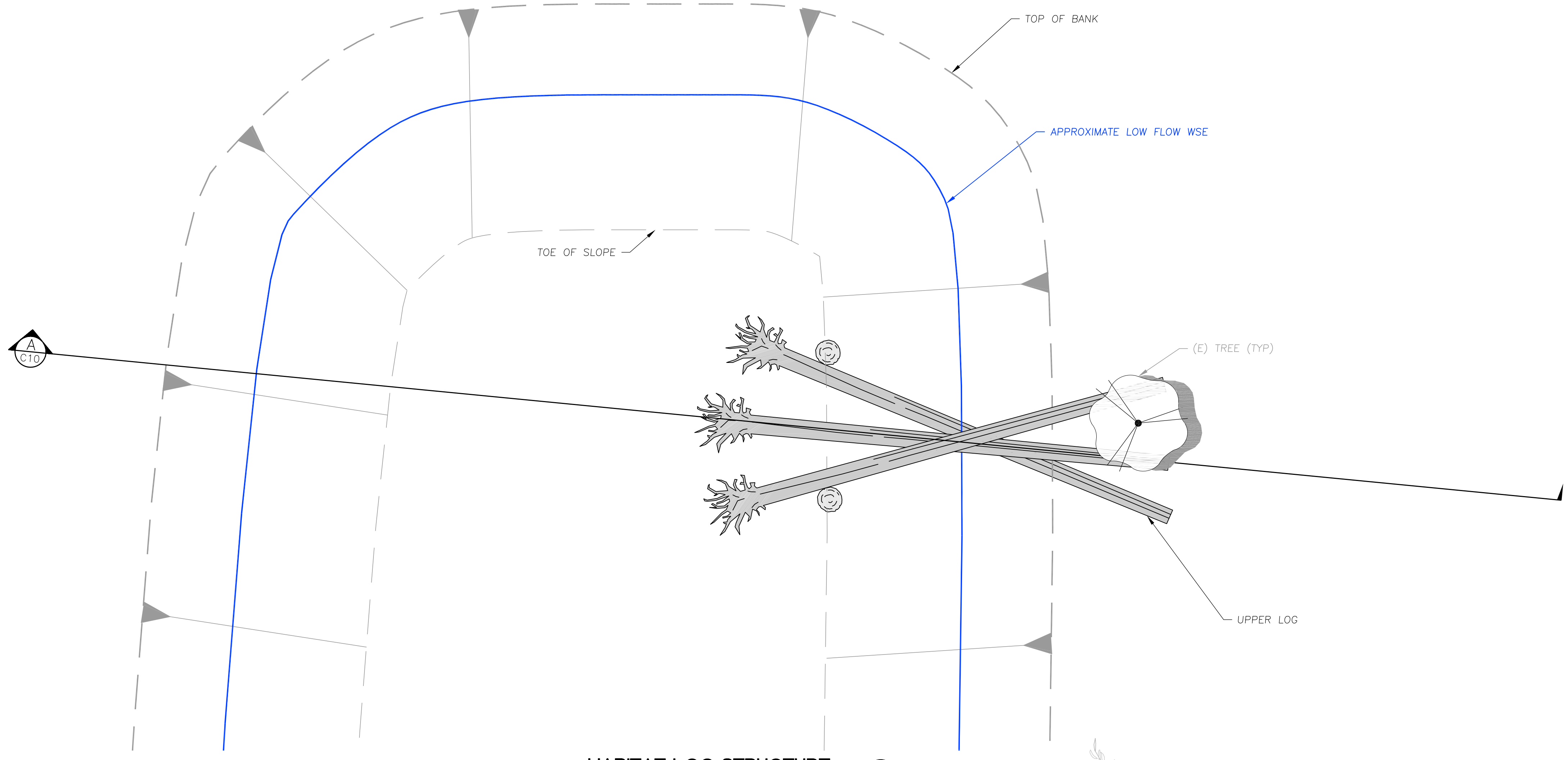
MID CHANNEL ELJ DETAIL

CHIWAWA RIVER FAN RECONNECTION CONCEPT PLANS

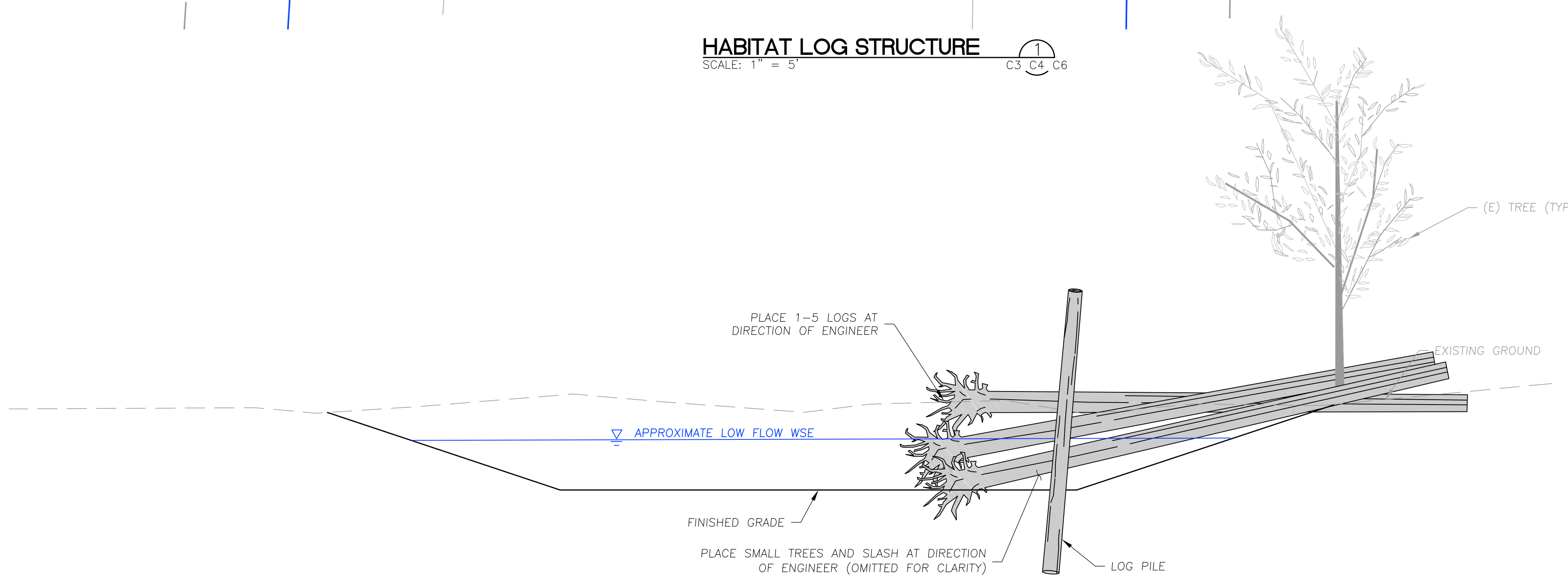
DESIGNED BY:	B.T.
DRAWN BY:	M.M.
CHECKED BY:	J.H
DATE:	05/12/20
JOB NO.:	19-040

BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS
0 1"

C9



HABITAT LOG STRUCTURE 1 C3 C4 C6
SCALE: 1" = 5'



TYPICAL PROFILE A C10
SCALE: 1" = 5'

LOG STRUCTURE NOTES:

1. LOG DIMENSIONS, ORIENTATIONS, AND QUANTITIES ARE SHOWN FOR CONCEPT DESIGN AND WILL BE REFINED IN THE NEXT PHASE OF DESIGN.
2. SMALL TREES AND SLASH OMITTED FOR CLARITY.
3. BALLAST AMOUNT TO BE DETERMINED IN FUTURE DESIGN PHASE. BALLASTING MATERIALS AND APPROACH NOT YET DETERMINED.

WATERWAYS CONSULTING INC.
1020 SW TAYLOR STREET, STE. 380
PORTLAND, OR 97205
PH:(503)227-5979 / FAX(888)819-6847
WWW.WATWAYS.COM

PRELIMINARY
NOT FOR CONSTRUCTION

PREPARED AT THE REQUEST OF:
YAKIMA NATION FISHERIES

HABITAT WOOD STRUCTURE DETAIL

CHIWAWA RIVER FAN RECONNECTION CONCEPT PLANS

DESIGNED BY: B.T.
DRAWN BY: M.M.
CHECKED BY: J.H
DATE: 05/12/20
JOB NO.: 19-040

BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS
0 1"

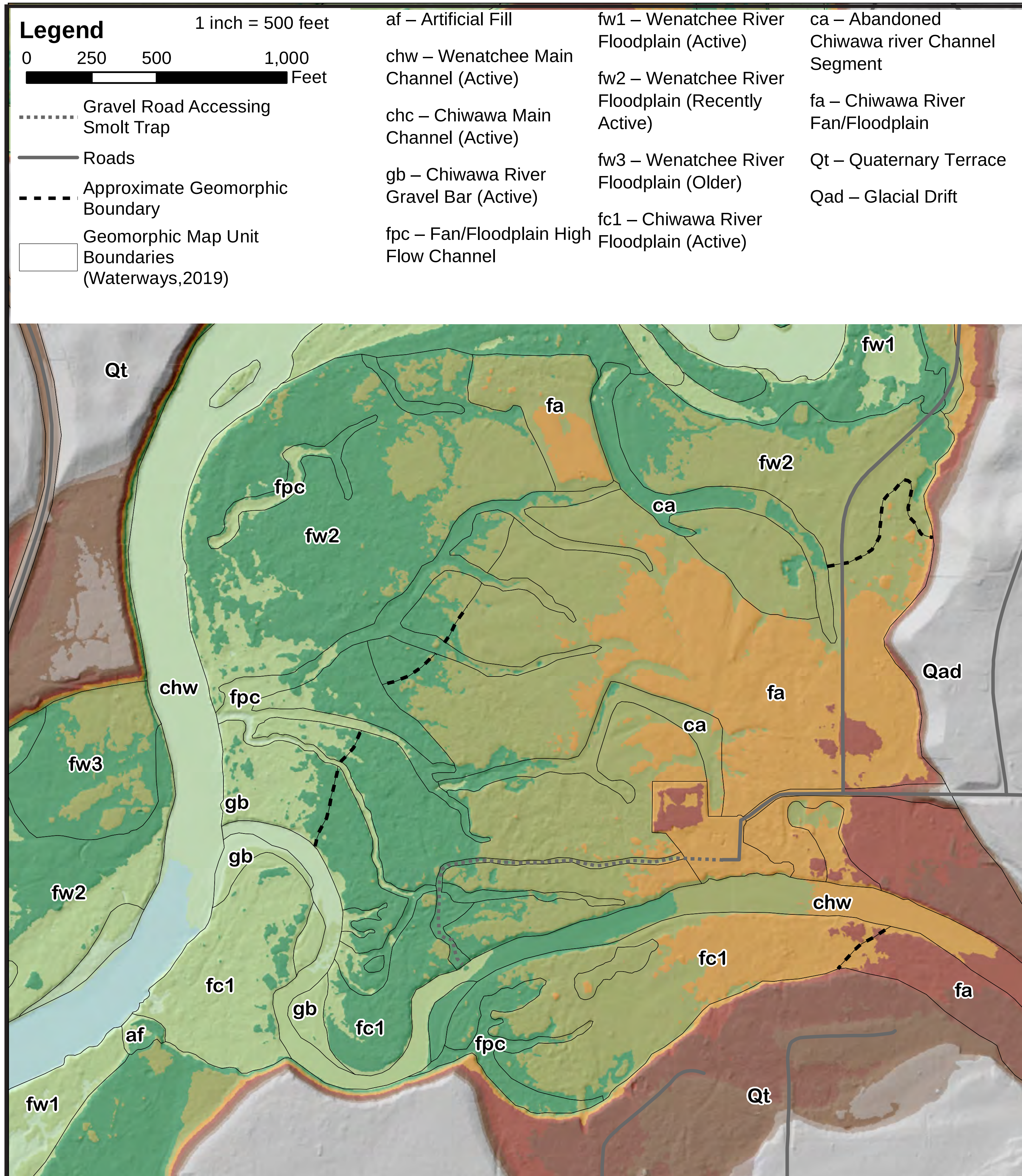
C10

WATERWAYS CONSULTING, INC.

Chiwawa Outlet Restoration Project

APPENDIX B

Hydraulic Results Map Book

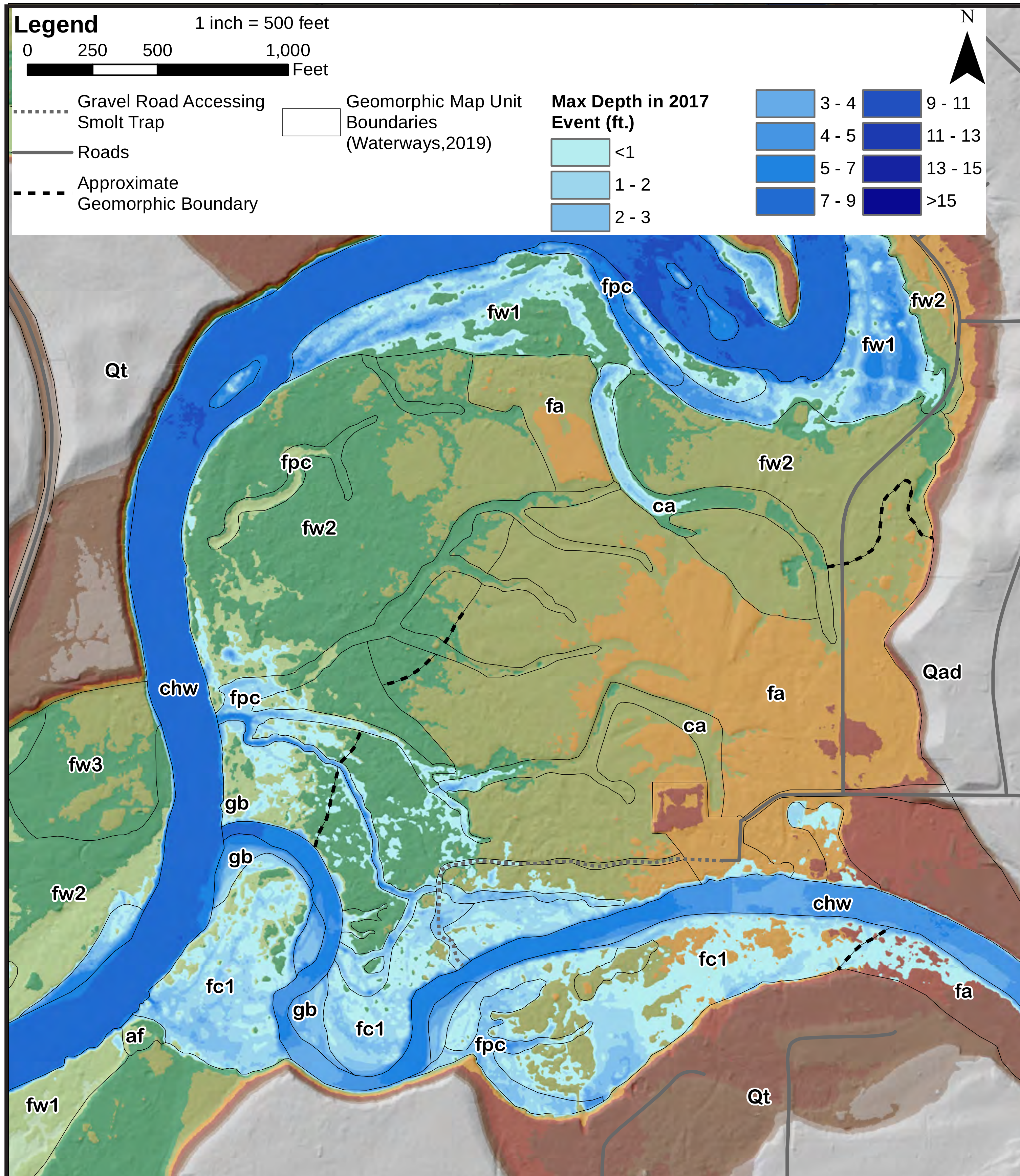


A) Chiwawa River LiDAR and Geomorphic Site Map
B) Chiwawa River Aerial Site Map

Chiwawa Outlet Restoration Project

WATERWAYS CONSULTING, INC.
Santa Cruz, CA | watways.com | Portland, OR

FIGURE
B1

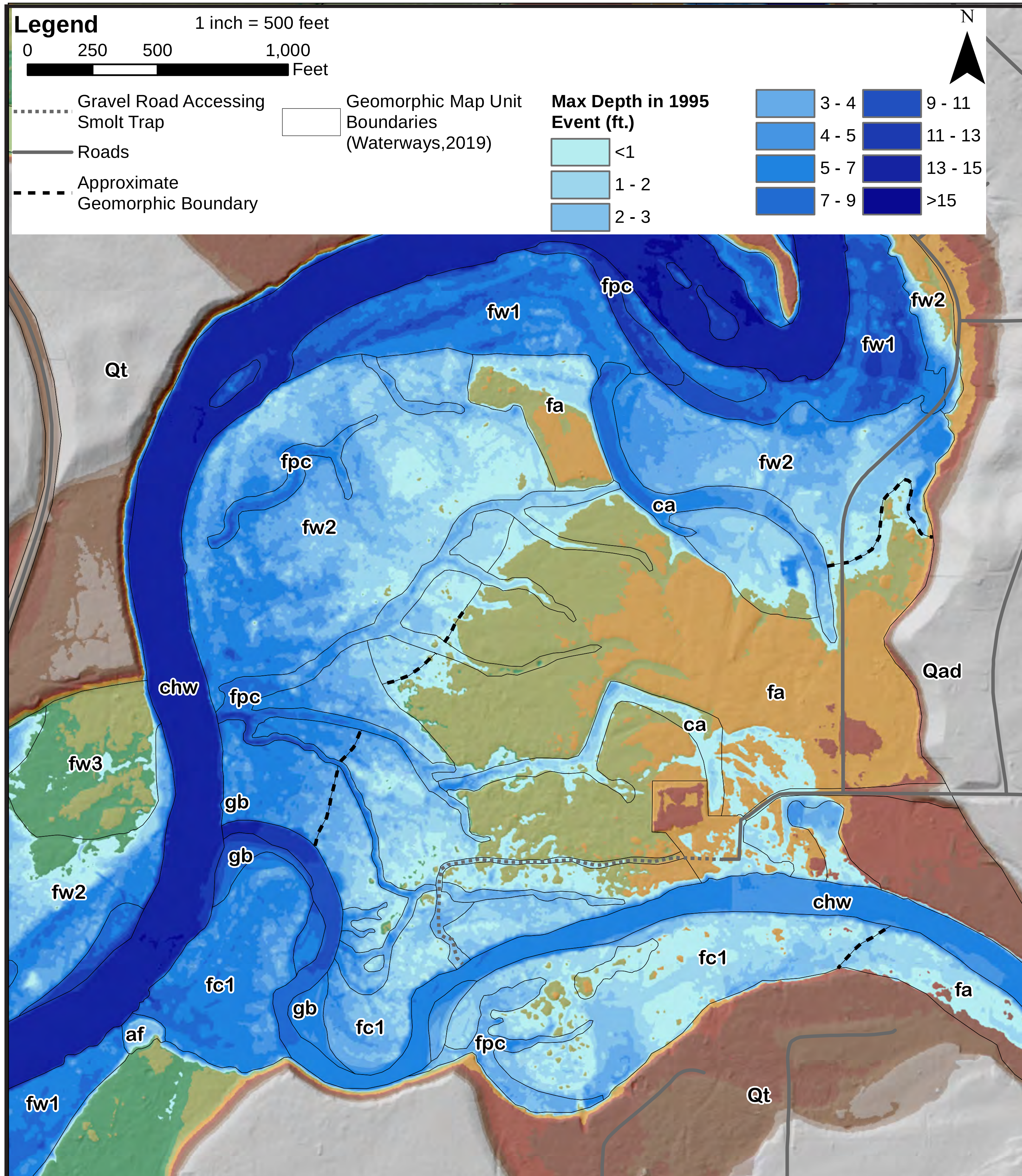


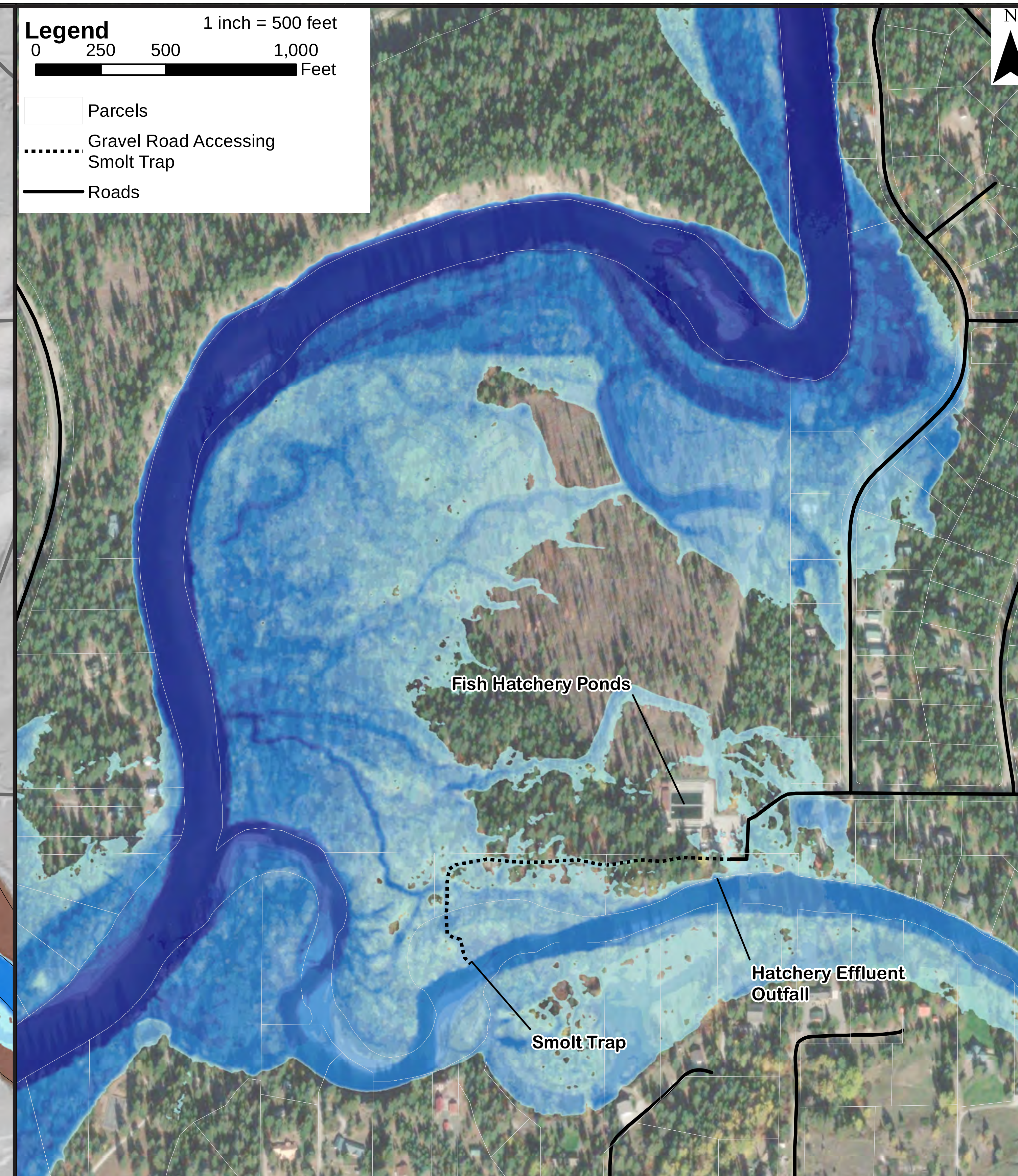
A) Chiwawa River LiDAR and Geomorphic Site Map - Depth May 2017 Flood
B) Chiwawa River Aerial Site Map - Depth May 2017 Flood

Chiwawa Outlet Restoration Project

WATERWAYS CONSULTING, INC.
Santa Cruz, CA | watways.com | Portland, OR

FIGURE
B2



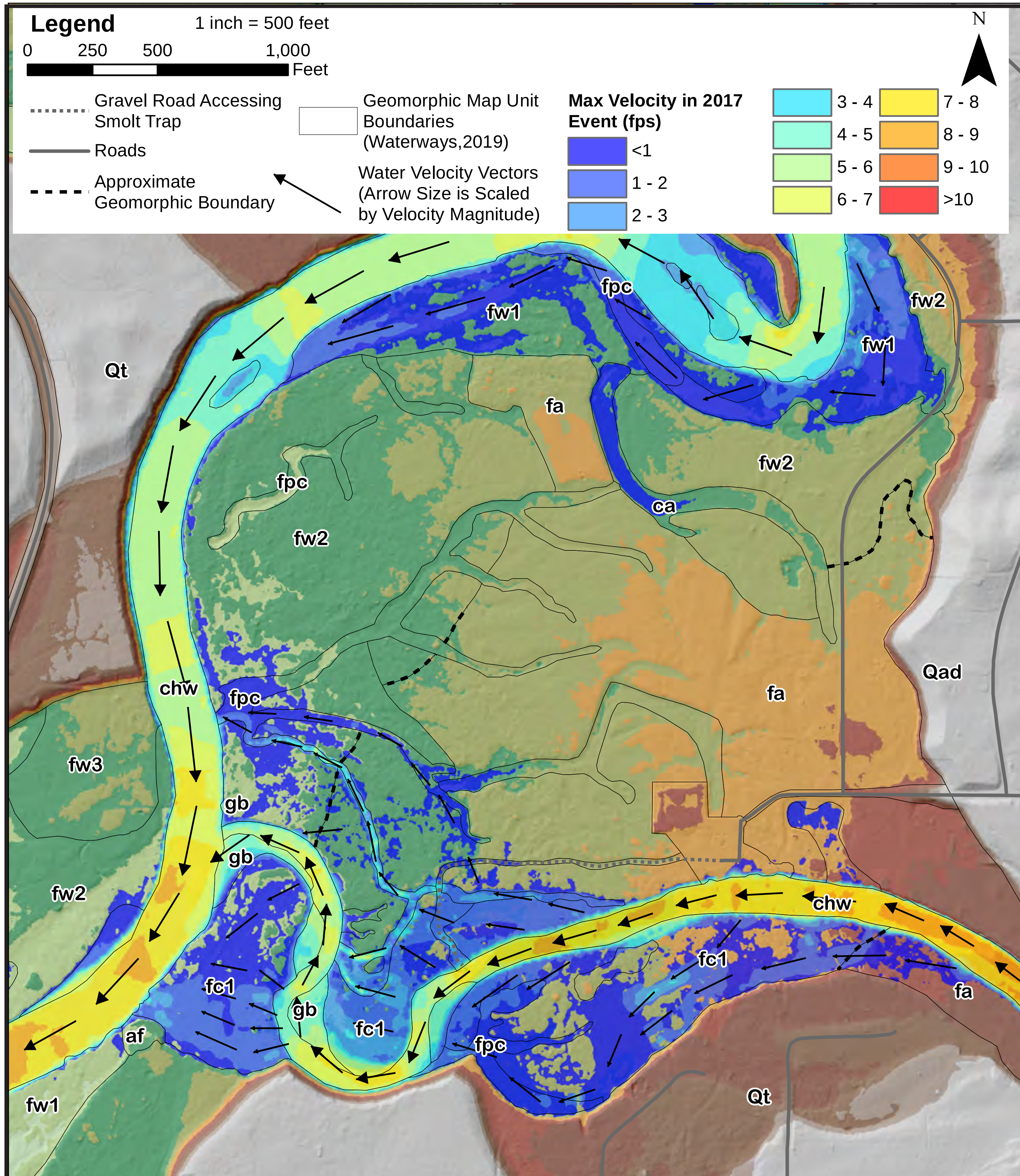


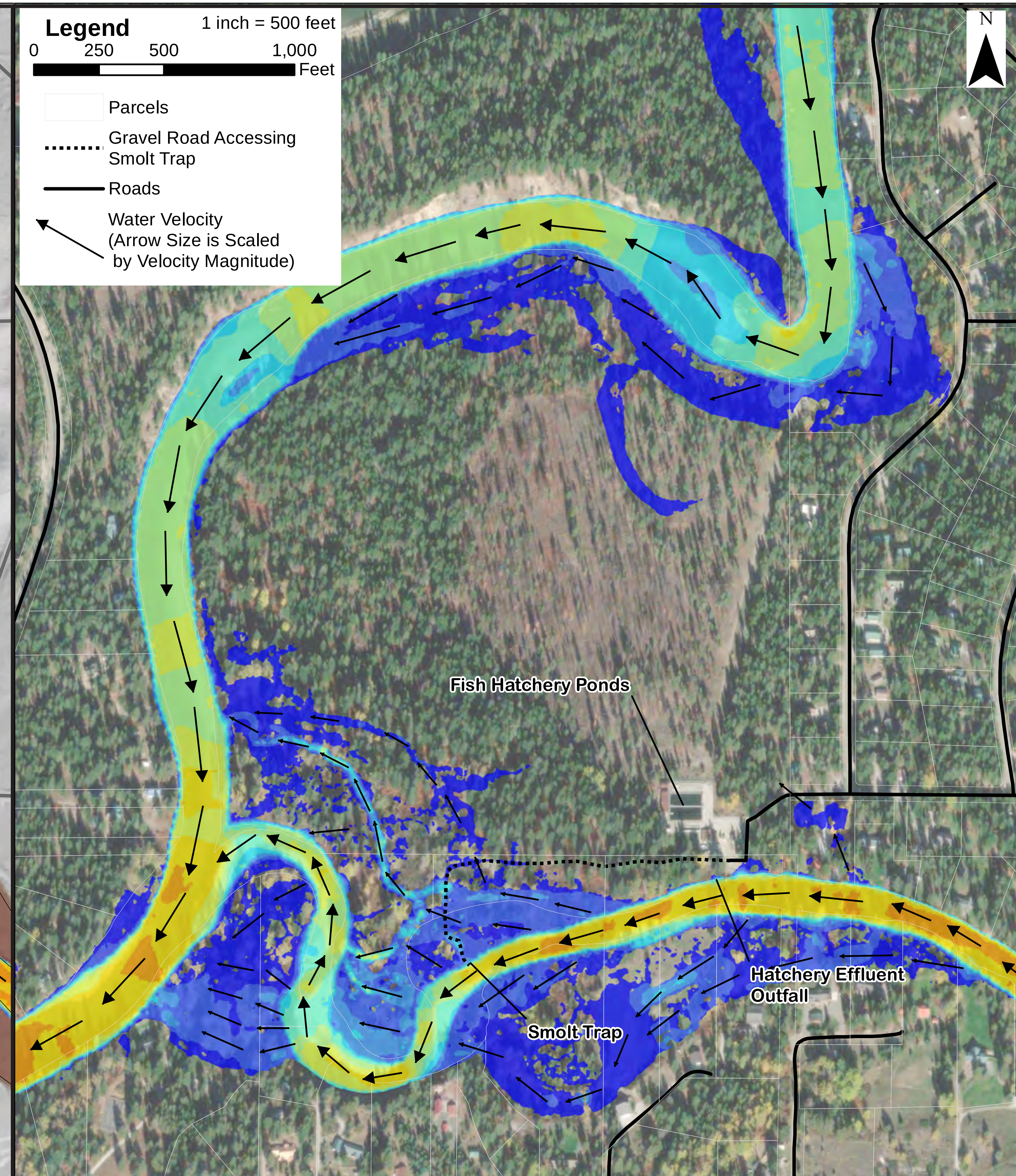
A) Chiwawa River LiDAR and Geomorphic Site Map - Depth Nov. 1995 Flood
B) Chiwawa River Aerial Site Map - Depth Nov. 1995 Flood

Chiwawa Outlet Restoration Project

WATERWAYS CONSULTING, INC.
Santa Cruz, CA | watways.com | Portland, OR

FIGURE
B3



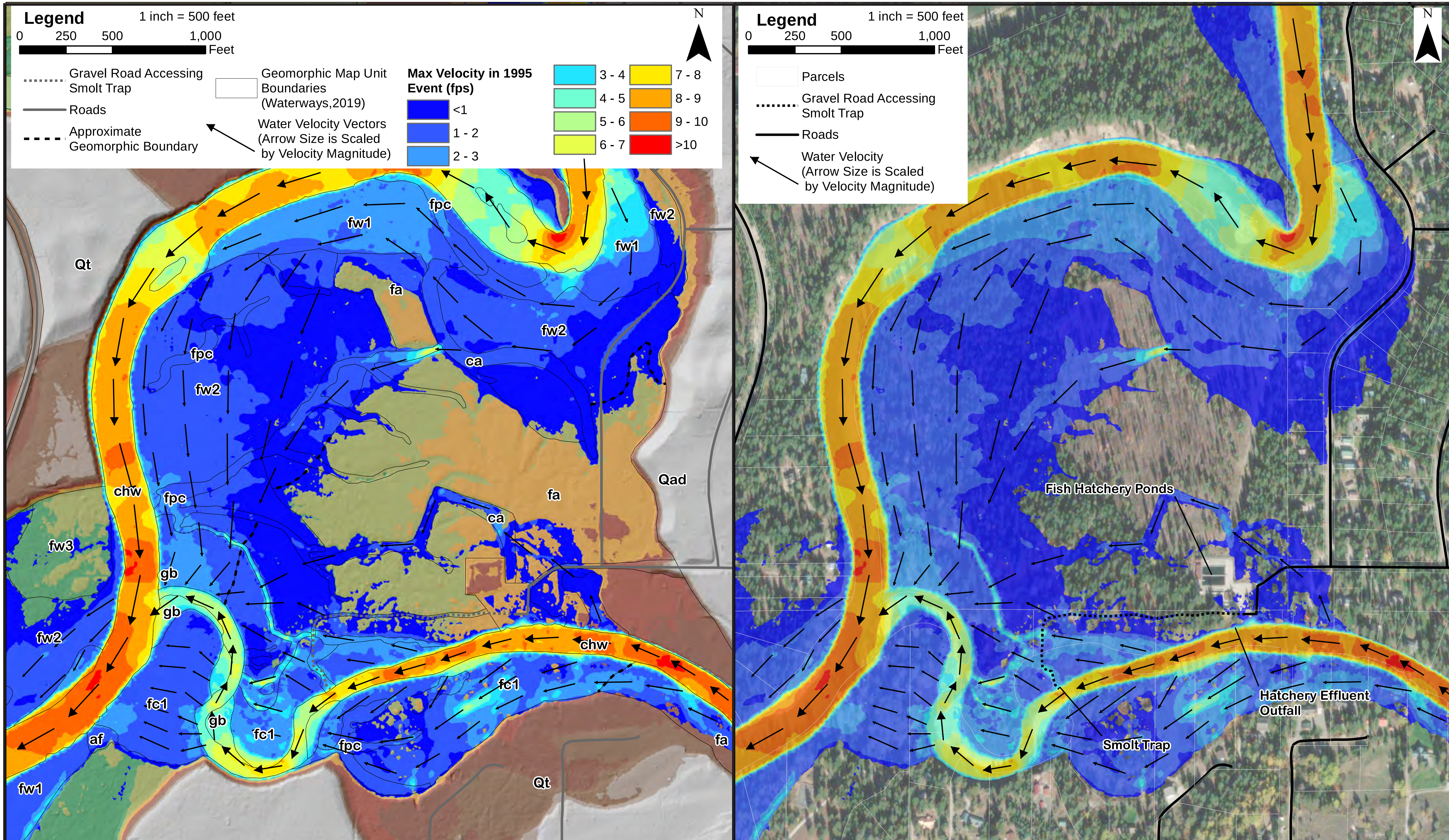


A) Chiwawa River LiDAR and Geomorphic Site Map - Velocity May 2017 Flood
B) Chiwawa River Aerial Site Map - Velocity May 2017 Flood

Chiwawa Outlet Restoration Project

WATERWAYS CONSULTING, INC.
Santa Cruz, CA | watways.com | Portland, OR

FIGURE
B4



A) Chiwawa River LiDAR and Geomorphic Site Map - Velocity Nov. 1995 Flood
B) Chiwawa River Aerial Site Map - Velocity Nov. 1995 Flood

Chiwawa Outlet Restoration Project

WATERWAYS CONSULTING, INC.
Santa Cruz, CA | watways.com | Portland, OR

FIGURE
B5