Lower Little Wenatchee River Reach Assessment & Restoration Strategy

SUBMITTED TO

U.S. Bureau of Reclamation and Confederated Tribes of the Colville Reservation, Fish & Wildlife Department

March 22, 2024

Lower Little Wenatchee River Reach Assessment & Restoration Strategy Report

SUBMITTED TO
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Table of Contents

List of Figures

List of Tables

1. Introduction

1.1 PROJECT OVERVIEW

The Little Wenatchee Reach Assessment and Restoration Strategy evaluates existing aquatic habitat and watershed process conditions along the lower 9.7 miles of the Little Wenatchee River. The Little Wenatchee is a tributary to the Wenatchee River in the Wenatchee watershed, Washington State Water Resource Inventory Area 45. The Wenatchee River watershed includes the eastern foothills of the Cascade Mountains in central Washington, on the western border of the Columbia Plateau (Figure 1). The Little Wenatchee River flows southeast from its headwater tributaries along the Cascade Crest into Lake Wenatchee. The assessment area extends from near the mouth of the Little Wenatchee River at its confluence to RM 9.7, just upstream from a bridge crossing on Rainy Creek Road.

This reach assessment provides a technical foundation for understanding existing conditions and for identifying restoration strategies for the lower Little Wenatchee River. Conditions are assessed at both the project area scale and reach scale. The aim is to identify restoration actions that address factors limiting the productivity of native salmonids, and to ensure that these actions fit within the appropriate geomorphic context of the river system. An emphasis is placed on understanding the underlying biological and physical processes at work and how human impacts have affected these processes and the habitat they support. Restoration measures focus on recovering, to the extent possible, these impaired processes. Although the proposed restoration measures are expected to benefit a large suite of native aquatic and terrestrial species, there is a particular emphasis on recovery of Endangered Species Act (ESA) listed Upper-Columbia Summer Steelhead (*Oncorhynchus mykiss*), Upper-Columbia Spring Chinook (*Oncorhynchus tshawytscha*), and Columbia River bull trout (*Salvelinus confluentus*).

The report includes the following components:

- Study area characterization – Evaluation of valley- and basin-scale factors influencing aquatic habitat and stream geomorphic processes.
- Reach-scale characterization – Inventory and analysis of habitat and geomorphic conditions at the reach and sub-reach scales.
- Restoration strategy – A comparison of “existing” conditions to “target” conditions at the reach-scale and identification of recommended restoration treatments that address habitat and ecological process limitations within the geomorphic context of the reach.
- Stream habitat assessment – Aquatic habitat inventory at the reach-scale.
- Reach-Based Ecosystem Indicators (REI) analysis – Comparison of habitat conditions to established functional thresholds.
- Specific project opportunities – A list and maps of specific potential project opportunities that would help to achieve the reach-scale restoration strategies.

This framework allows for the identification of restoration activities at discrete locations while considering broader scale physical and ecological factors that influence the assessment study area.

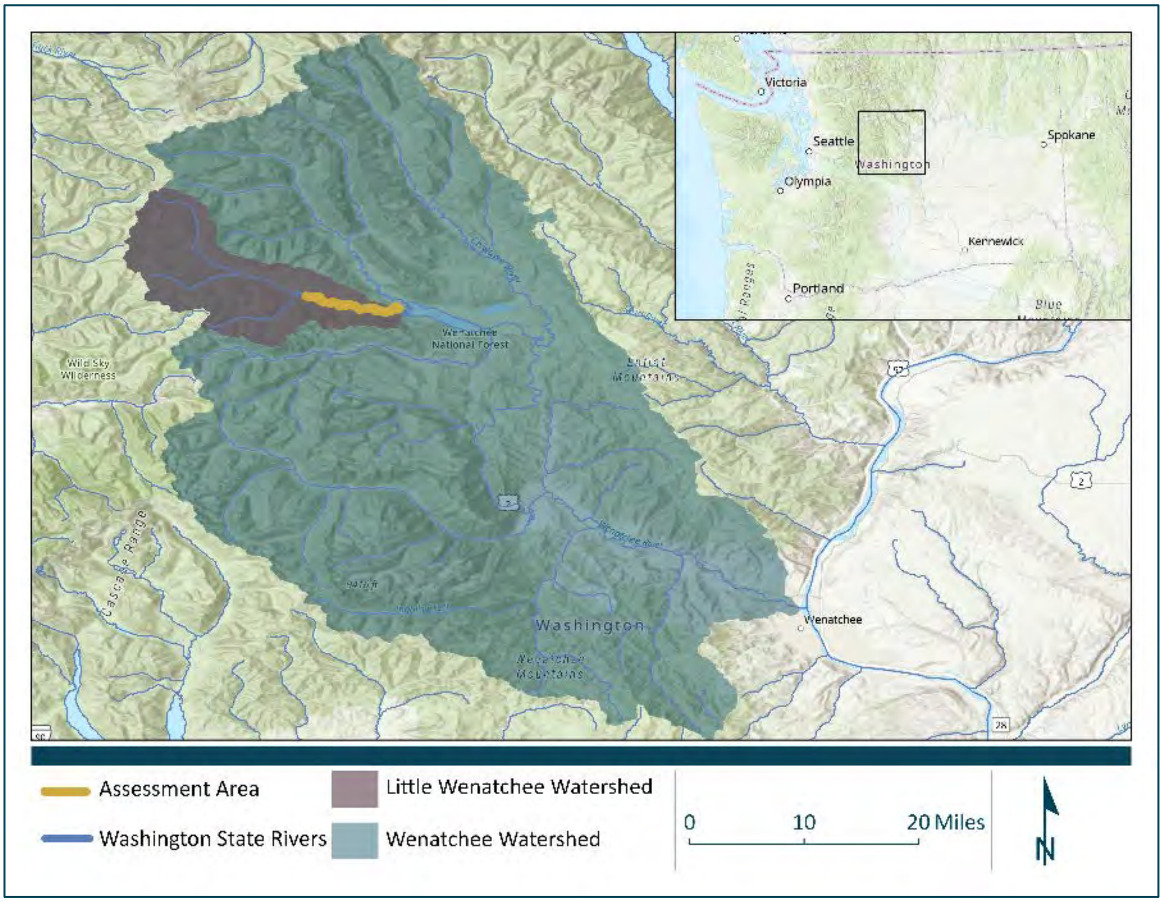

Figure 1. Lower Little Wenatchee Assessment area locator map. Basemap: ESRI world terrain maps.

1.2 BACKGROUND

This project was completed on behalf of the U.S. Bureau of Reclamation (Reclamation) and the Confederated Tribes of the Colville Reservation (CTCR). The project is part of a larger effort by Reclamation and project partners to improve access and habitat conditions for endangered salmonids in the Columbia River Basin. Reclamation contributes to the implementation of salmonid habitat improvement projects in the Pacific Northwest to help meet commitments contained in the 2020 Columbia River System (CRS) Biological Opinion (BiOp) issued by the National Oceanic and Atmospheric Administration Fisheries.

Conducting the assessment involved collecting field data of the area and combining it with existing available information on the Little Wenatchee River and the greater Wenatchee River watershed. This report does not attempt to re-create the work accomplished in existing documents, but summarizes that material and adds detail where appropriate. New data collection and analysis performed as part of this effort include a geomorphic assessment of the mainstem channel, side channels, and floodplain surfaces, as well as an aquatic habitat inventory, characterization of landforms and human impacts, and identification of habitat restoration opportunities.

1.3 PURPOSE

The purpose of this assessment is to document and evaluate hydrologic processes, geomorphic processes, and aquatic habitat conditions in the Lower Little Wenatchee River (RM 0.5 - 9) and to present a comprehensive reach-based restoration strategy to address limiting factors to aquatic habitat. Evaluations used in this assessment include historical characterization, geomorphic assessment, hydraulic assessment, and an aquatic habitat inventory.

1.4 SALMONID USE AND STATUS

1.4.1 Steelhead Trout

Steelhead (*Oncorhynchus mykiss*) were originally listed as endangered under the ESA in 1997 (50 CFR Parts 222 and 227; Endangered and Threatened Species: Listing of Several Evolutionary Significant Units (ESUs) of West Coast Steelhead, 1997) and later reclassified to threatened in 2006 (50 CFR Parts 223 and 224; Endangered and Threatened Species: Final Listing Determinations for 10 Distinct Population Segments of West Coast Steelhead, 2006). Steelhead enter and ascend the Columbia River in June and July, arriving near their spawning grounds nine to eleven months prior to spawning (Figure 2). Adult steelhead overwinter in the mainstem Columbia, returning to the Wenatchee River sub-basin from August through April of the following year prior to spawning (Chelan County & Yakama Nation, 2004). Egg survival is highly sensitive to intra-gravel flow and temperature (Peven et al., 2004) and is particularly sensitive to siltation earlier in the incubation period. Fry emerge from the redds six to ten weeks after spawning (Peven et al., 2004).

Age-0 juveniles spend their first year primarily in shallow riffle habitats, feeding on invertebrates and utilizing overhanging riparian vegetation and undercut banks for cover (Moyle, 2002). Age-0 steelhead use slower, shallower water than Chinook Salmon, preferring small boulder and large cobble substrate (Hillman & Miller, 1989). Older juveniles prefer faster moving water including deep pools and runs over cobble and boulder substrate. Juveniles out-migrate between ages one and three, though some hold over and display a resident life history form. Smolts begin migrating downstream from natal areas in March (Chelan County & Yakama Nation, 2004; Peven et al., 2004).

Summer steelhead use, including spawning and rearing, has been documented throughout the Little Wenatchee (Washington Department of Fish and Wildlife (WDFW), 2024). Redd surveys conducted in the Little Wenatchee River by WDFW in 2011 indicate two observed steelhead redds in the assessment area at approximately RM 6.4 and RM 7.7 (UCSRB (Upper Columbia Salmon Recovery Board, 2018b).

1.4.2 Spring Chinook Salmon

Spring Chinook (*O. tshawytscha*) were listed as endangered under the ESA in 1999 (Endangered and Threatened Species; Threatened Status for Three Chinook Salmon Evolutionarily Significant Units

(ESUs) in Washington and Oregon, and Endangered Status for One Chinook Salmon ESU in Washington, 1999). Adults enter the Wenatchee basin in May, and spawning occurs late July through September (Figure 2), with the peak in August (Chapman et al., 1995).Spawning typically begins when temperatures drop below 16°C (Healy, 1991a; Peven et al., 2004). Eggs are very sensitive to changes in oxygen levels and percolation, both of which are affected by sediment deposition and siltation in the redd (Peven et al., 2004). Fry emerge in the spring, which coincides with the rising hydrograph. High water forces juveniles to seek out backwater or margin areas with lower velocities, dense cover, and abundant food (Quinn, 2005). Fry are extremely vulnerable in these systems when they emerge, because their swimming ability is poor and flows are high. Near-shore areas with eddies, large woody debris, undercut tree roots, and other cover are very important for post-emergent fry (Healy, 1991b; Hillman & Miller, 1989). Age-1 parr utilize deeper pools with resting cover in mainstem habitats more than post-emergent individuals. Spring Chinook typically express a stream-type life history where they rear for 1 year in freshwater before out-migrating as yearlings. Out-migration typically begins in March (Healy, 1991b; Peven et al., 2004).

Spring Chinook are reported to use the Little Wenatchee River for spawning and rearing. Surveys between 2011 and 2016 recorded 196 redds within the assessment area, and rearing occurring in the lower reaches (UCSRB (Upper Columbia Salmon Recovery Board), 2018b; Washington Department of Fish and Wildlife (WDFW), 2024).

1.4.3 Bull Trout

Bull trout (*Salvelinus confluentus*) spawn and rear in the Little Wenatchee River, including within the assessment area. Bull trout were listed as threatened under the ESA in 1999 (Endangered and Threatened Wildlife and Plants; Determination of Threatened Status for Bull Trout in the Coterminous United States, 1999a).

Bull trout may exhibit both resident and migratory life-history strategies (Rieman & Mclntyre, 1993). Resident bull trout complete their life cycles in the tributary streams, such as the Little Wenatchee, in which they spawn and rear. Compared to other salmonids, bull trout have more specific habitat requirements that appear to influence their distribution and abundance. Critical parameters include water temperature, cover, channel form and stability, valley form, spawning and rearing substrates, and migratory corridors (Endangered and Threatened Wildlife and Plants; Determination of Threatened Status for Bull Trout in the Coterminous United States, 1999b).

Bull trout normally reach sexual maturity in 4 to 7 years and can live 12 or more years. Bull trout in the Columbia River basin typically spawn from August to November (Figure 2) during periods of decreasing water temperatures. Redd surveys in the Little Wenatchee and surrounding streams indicate a majority of bull trout spawning occurs here in September and October (Chelan County & Yakama Nation, 2004; Endangered and Threatened Wildlife and Plants; Determination of Threatened Status for Bull Trout in the Coterminous United States, 1999b; Nelson et al., 2008; Washington Department of Fish and Wildlife (WDFW), 2024). Preferred spawning habitats are generally low gradient stream reaches, or in areas of loose, clean gravel in higher gradient streams (Fraley & Shepard, 1989), and where water temperatures are between 5 to 9° C (41 to 48° F) in late summer to early fall (Goetz, 1989). Spawning areas are often associated with cold-water springs, groundwater infiltration, and are typically the coldest systems in a given watershed (Endangered and Threatened Wildlife and Plants; Determination of Threatened Status for Bull Trout in the Coterminous United States, 1999b).

Depending on water temperature, egg incubation can last between 100–200 days, and juveniles remain in the substrate after hatching. Fry normally emerge from early April through May, depending upon water temperatures and increasing stream flows (Endangered and Threatened Wildlife and Plants; Determination of Threatened Status for Bull Trout in the Coterminous United States, 1999b). Downstream migration of Bull Trout in the Wenatchee basin has been shown to be bi-modal, with one in the spring and one in the fall (Chelan County & Yakama Nation, 2004).

Within the Little Wenatchee assessment area, Bull Trout have been recorded spawning and rearing, indicating it is a critical habitat for this threatened species. Surveys conducted between 2013 and 2015 recorded 24 redds within the assessment area (Chelan County & Yakama Nation, 2004; Upper Columbia Salmon Recovery Board (UCSRB), 2018).

1.4.4 Other species

The Little Wenatchee River supports a range of other salmonids, including sockeye salmon (*Oncorhynchus nerka*) and their adfluvial variant Kokanee, resident westslope cutthroat trout (*Oncorhynchus clarki lewisi*), and rainbow trout *(Oncorhynchus mykiss)*. The Wenatchee River basin is critical habitat for sockeye, and the Little Wenatchee is a primary area for spawning and rearing (Chelan County & Yakama Nation, 2004; Washington Department of Fish and Wildlife (WDFW), 2024). Sockeye spawning is temperature driven and maintaining viable, dense riparian vegetation is essential for success. Cutthroat trout spawn and rear in cool headwater systems such as the Little Wenatchee. Resident cutthroat are not currently listed under the national Endangered Species Act, but are considered a species of concern by USFWS, due in part to hybridization with rainbow trout (Chelan County & Yakama Nation, 2004). Rainbow trout are known to be present in the Little Wenatchee, in the assessment area and into the upper reaches.

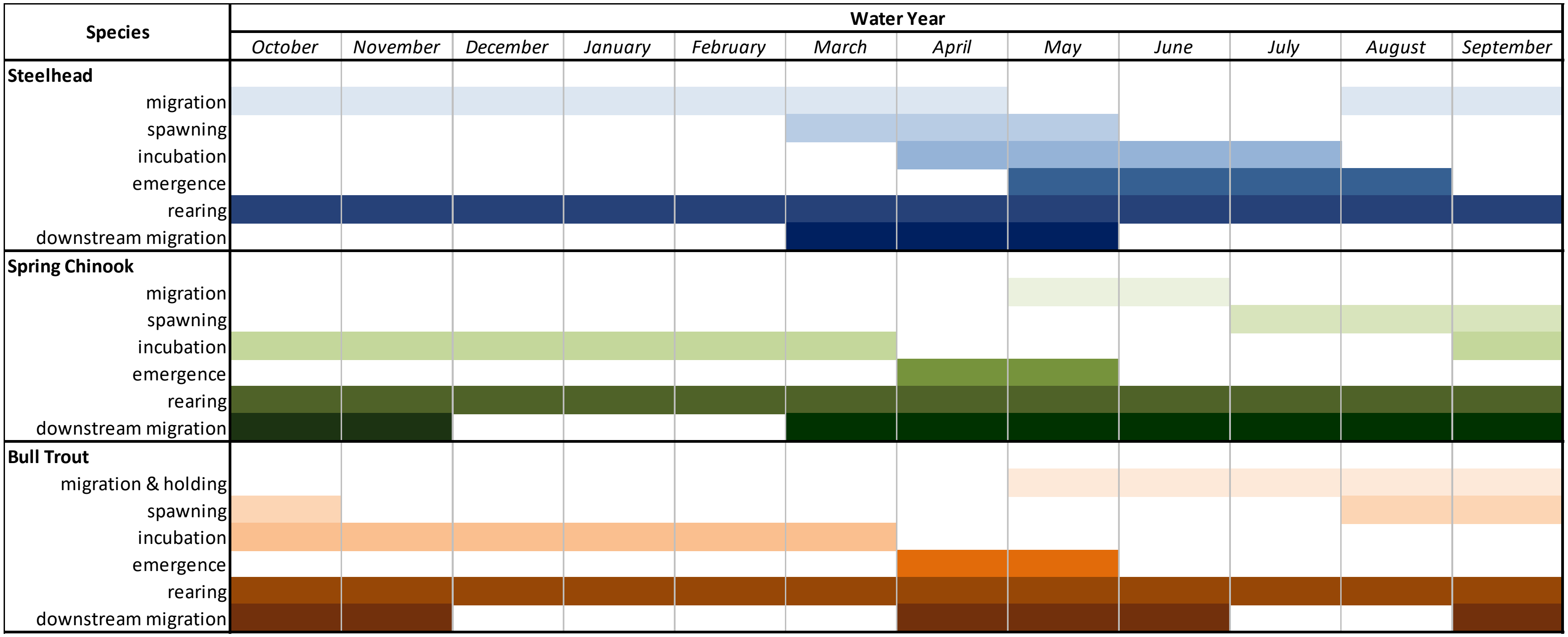

Figure 2. Fish timing for ESA-listed species in the Little Wenatchee River. Data adapted from various sources as referred to in the body of the report.

2. Assessment Area Characterization

2.1 SETTING

The Little Wenatchee River is a tributary to Lake Wenatchee, which in turn outlets to form the mainstem Wenatchee River. The Little Wenatchee River between river miles (RM) 0.5 and 9.0 is known as the Lower Little Wenatchee River Assessment Unit, which has been identified as a high priority area for habitat improvements to benefit Endangered Species Act-listed spring Chinook salmon and steelhead trout. This Reach Assessment Report encompasses the entire Lower Little Wenatchee River Assessment Unit. The assessment area was divided into six reaches to align with prior evaluation efforts, such as those conducted by the Upper Columbia Salmon Recovery Board (UCSRB). Figure 3 is a map of the assessment area with reach breaks and river miles depicted.

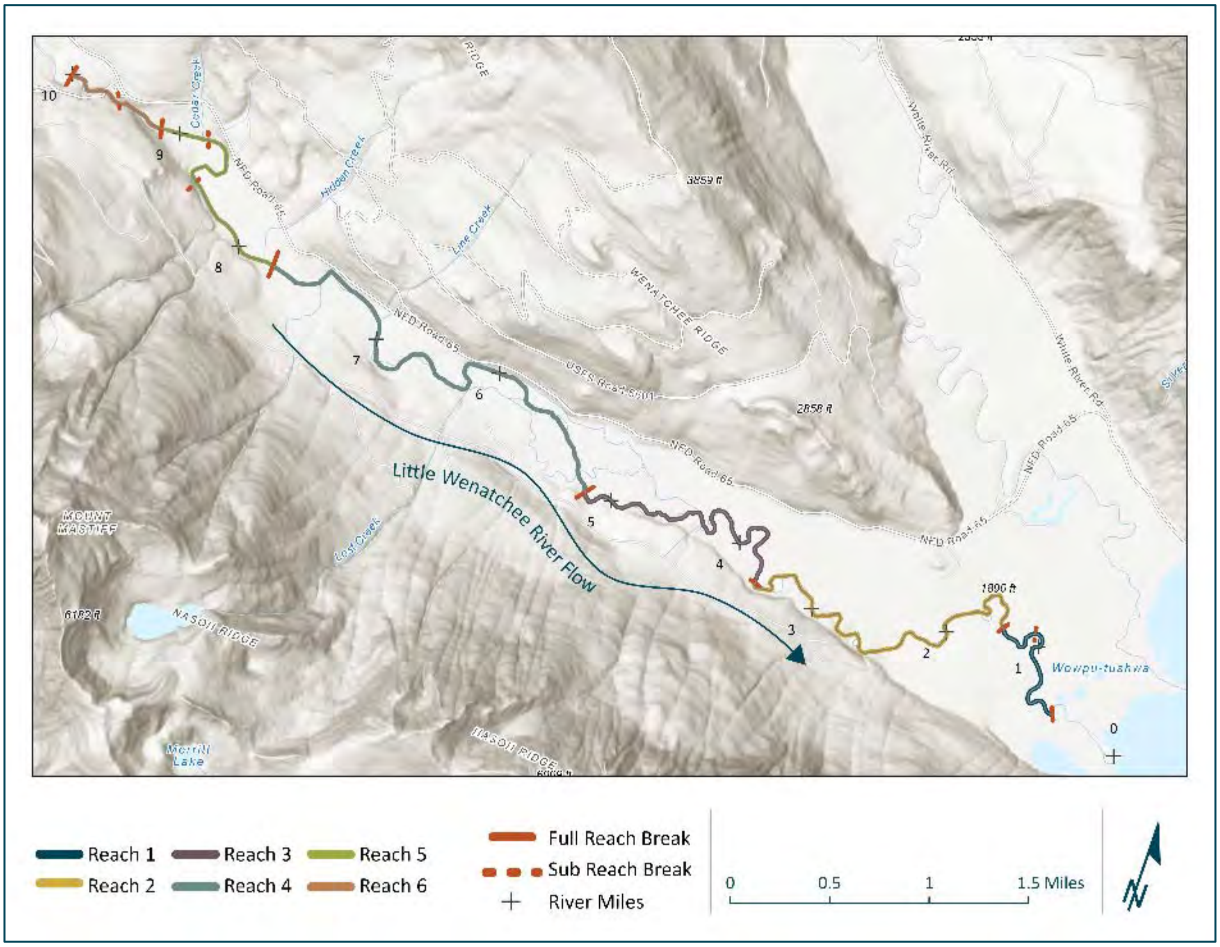

Figure 3. Lower Little Wenatchee River project area with reaches and river miles.

2.2 GEOLOGY

The lower Little Wenatchee Valley is in the Nason Terrane geologic province, located to the west of the regional-scale Leavenworth Fault which bisects Lake Wenatchee and divides rocks of the Nason Terrane from rocks of the Chiwaukum Graben (Figure 4). The Nason Terrane is composed of Late

Cretaceous high grade metamorphic rocks in the vicinity of the assessment area, including several uniquely mapped varieties of gneiss, and pods of marble and metamorphosed ultramafic rocks (Tabor et al., 1987). The lower Little Wenatchee Valley runs along the contact between the two major mapped formations found in the assessment area (Figure 5). Rocks of the Nason Terrane are intruded by various plutons, including the Late Cretaceous meta granitic rocks of the Dirtyface Pluton which is located along the north side of Lake Wenatchee. Uplift and deformation of the crust associated with the development of the Cascade Mountains likely began as early as 50 Ma, and crustal deformation and volcanism in the north Cascades has continued to shape the geology of the assessment area to the present day (Hammond, 1979). Earth surface processes including glaciation, landslides and other mass movements, and fluvial action have shaped the assessment area and deposited substantial material during the Quaternary period (2.6 Ma – present).

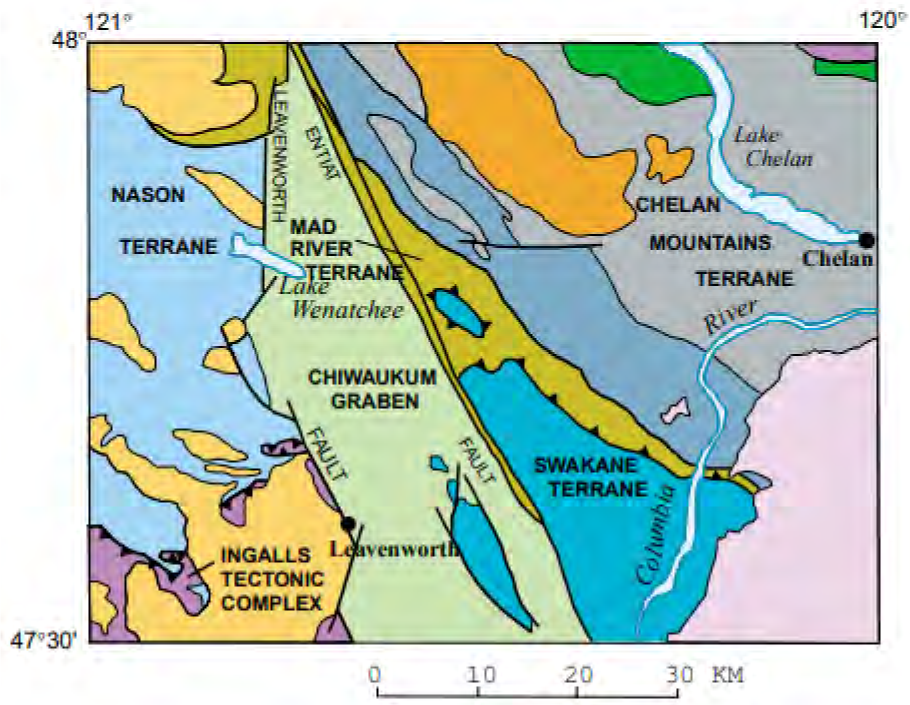

Figure 4. Map of geologic provinces in the vicinity of the lower Little Wenatchee Valley (Tabor et al. 1987).

2.2.1 Geologic Units

Late Cretaceous age banded gneiss formations compose most of the bedrock of the lower Little Wenatchee assessment area, and these gneissic rocks have been subdivided into several unique formations in the vicinity of the study area. Small pockets of similar age marble and metamorphosed ultramafic rocks are also present in the lower Little Wenatchee Basin (Figure 5). The bedrock geologic units identified and described by Tabor and others (1987) in the lower Little Wenatchee Basin include the following:

- Late Cretaceous banded gneiss units (Kb…) associated with the Nason Terrane, which include the following:

- Gneiss, schist, and amphibolite (Kbgn) – Interlayered heterogeneous light-colored tonalite to granodiorite gneiss, mica schist, and amphibolite. Outcrops of this unit are composed of 10% or more of gneiss, and some outcrops in the vicinity of the assessment area contain up to 80% gneiss. This unit is a large map scale unit on Nason Ridge and much of the Little Wenatchee Basin above Rainy Creek.
- Light-colored gneiss of Wenatchee Ridge (Kbw) – Heterogeneous fine-grained to pegmatitic tonalite and granodiorite gneiss. Similar lithology to Kbgn but primarily composed of gneiss. This unit is a large map scale unit on Wenatchee Ridge.
- Light-colored gneiss of Wenatchee Ridge and ultramafite (Kbwu) – Similar lithology to Kbw but interspersed with ultramafite pods of Ku. This unit is a large map scale unit on Wenatchee Ridge.

- Late Cretaceous ultramafite (Ku) associated with the Nason Terrane -- Serpentinized peridotite and metaperidotite. This unit is found as pods throughout Kbwu, and as small, isolated pods located within Kbw.
- Late Cretaceous marble (Kcm) associated with the Nason Terance -- Coarsely crystalline marble with gray streaks. This unit is found as map scale units near the contact of Kbgn & Kbw and as small pods located within Kbgn.

Several Quaternary age unconsolidated deposits are identified by Tabor and others (1987) in the assessment area. Glacial deposits including drift & till (Qgd) and outwash (Qtg) are mapped along the valley walls and in tributary valleys in the assessment area; these deposits are discussed in detail in the following subsection. Alluvium (Qa) deposited by the Little Wenatchee River and its tributaries is found in floodplain, terrace, and alluvial fan deposits. Large bedrock-cored landslides (Qls) are mapped on Nason and Wenatchee Ridge, and field evidence points to these slides being active in the last ~10,000 years and contributing large volumes of sediment to valley bottoms when they fail (Tabor et al., 1987). Last, while not voluminous or laterally continuous enough to be mapped, volcanic tephra deposits sourced from eruptions in the Cascades are present within all mapped Quaternary deposits, and resultantly ash may compose a considerable portion of some sedimentary deposits.

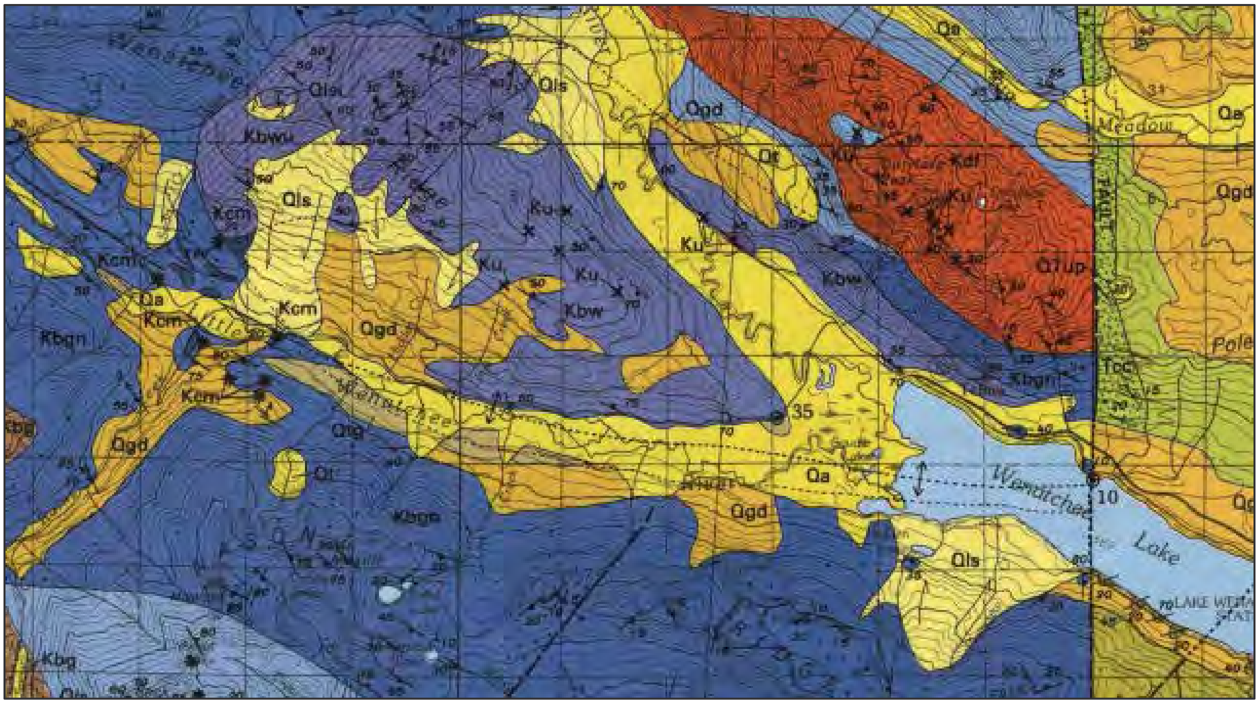

Figure 5. Map of geologic units of the lower Little Wenatchee Valley (Tabor et al. 1987).

2.2.2 Glacial Geology

Late Pleistocene glaciation had a profound effect on the lower Little Wenatchee Valley, eroding the underlying bedrock and depositing thick layers of glacial till and outwash. The lower Little Wenatchee Valley and Lake Wenatchee are located in a wide, over deepened valley formed by glacial erosion. Substantial deposition of glacial till and outwash sediments in the glacial trough have formed large outwash terraces on both sides of the modern channel, till deposits along the valley walls, and a major recessional end moraine located at the outflow of Lake Wenatchee.

Six episodes of glaciation have been documented via their till deposits in the upper Wenatchee Basin, circa 13 k.a., 17 k.a., 70 k.a., 93 k.a., 105,000 k.a., and at least 165,00 k.a. (Porter & Swanson, 2008). Most till deposits found along the lower Little Wenatchee River are believed to be associated with the most recent glaciation, though some patches of older glacial deposits may be preserved in places on the valley sides (Tabor et al., 1987). In the lower Little Wenatchee Valley, glacial till deposits are generally found higher on the valley sides, while outwash deposits are inset within till deposits and bound the modern valley bottom. Lateral channel migration following the last major glaciation has likely removed substantial volumes of glacial deposits in the lower Little Wenatchee Valley, and lateral channel processes have produced terraces and a large floodplain between preserved glacial deposits on the valley sides.

Table 1. Regional glacial cycles derived from study of deposits in the Icicle Creek drainage, and the relative ages of these respective glacial periods (adapted from Porter and Swanson 2008).

Glaciation periods that correlate with till deposits in the upper Wenatchee Basin	Approximate age of deposits
Rat Creek I and II	12,500±500 and 13,300±800
Leavenworth I and II	16,100±1100 and 19,100±3000
Mountain Home	70,900±1500
Pre-Mountain Home	93,100±2600
Peshastin	105,400±2200
Boundary Butte	At least 165,000

2.3 LAND USE

Human-built features have the potential to influence or inhibit geomorphic and ecologic processes depending on their proximity to a channel and its floodplain. These features include constructed components on the modern landscape such as levees, roads, bridges, culverts, irrigation structures or piping, buildings, riprap and other bank protection, and utility crossings. Land uses and condition within the watershed has changed over time. Historical aerial imagery from 1974, 1985, 2006, and 2021 was assessed in order to document changes to river planform and land use within the project area. Notable changes to channel planform were minimal to nonexistent, however, several land use changes were observed. Between 1974 and 1985 a gravel mine was opened near River Mile 2. This mine was expanded between 1985 and 2006, and the footprint of the mine stayed relatively constant from 2006 to 2021 (Figure 6 - Figure 8). Additionally, aerial imagery shows that Forest Service Road 6702 south of Little Wenatchee River, was completed between 1974 and 1985 (Figure 9 - Figure 10). Finally, several forest clearcuts and thinning units were observed in the project area between 1974 and 1985. Based on both field observation and historical air photo's it appears valley bottom harvest occurred primarily within assessment reaches 1 and 2. Subsequent aerial imagery from 2006 and 2021 show regrowth within these harvested patches, and does not show significant clearing after 1985 (Figure 11).

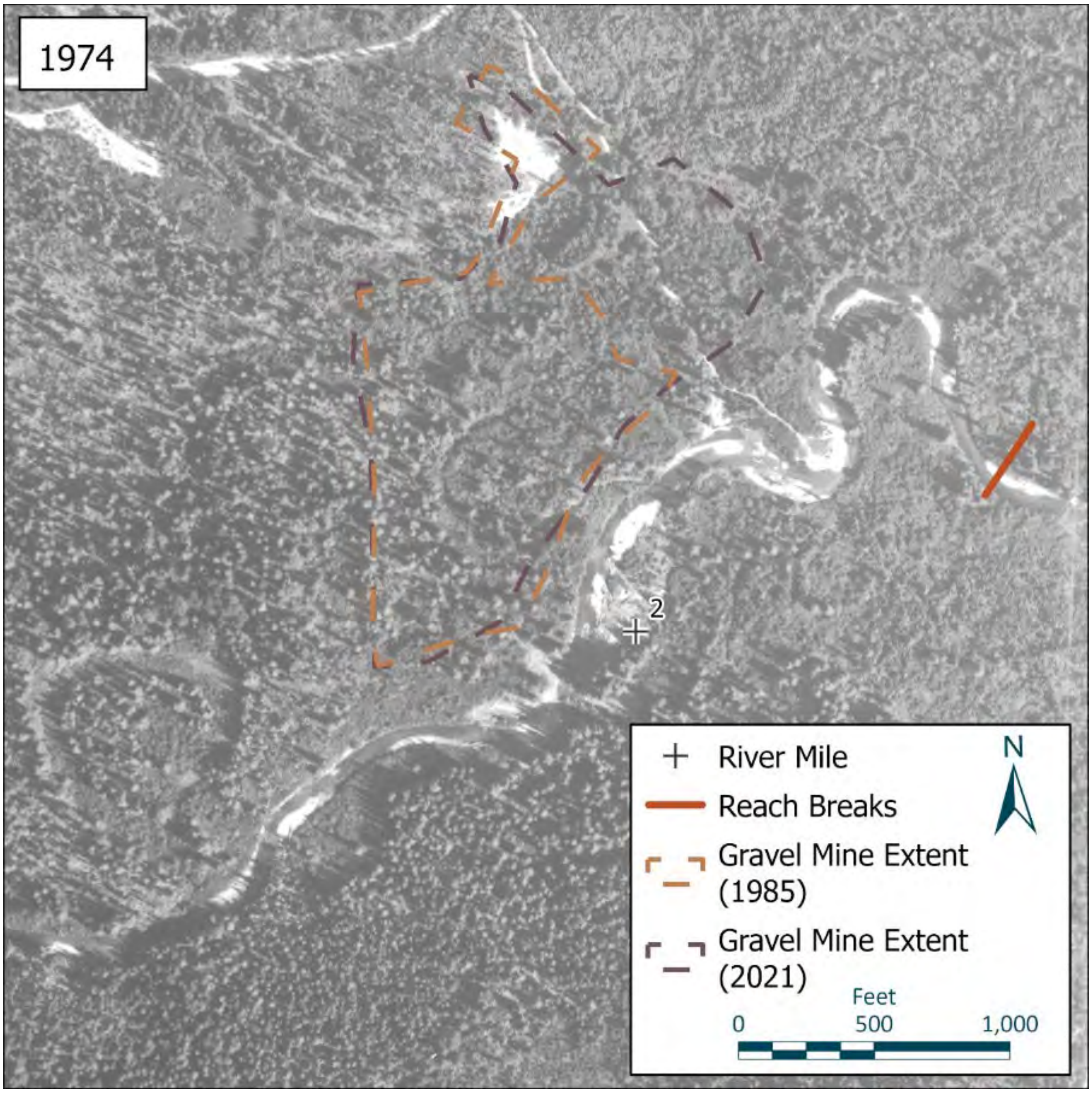

Figure 6. Aerial imagery from 1974 showing the location of a gravel mine near River Mile 2 on the Little Wenatchee River prior to its development.

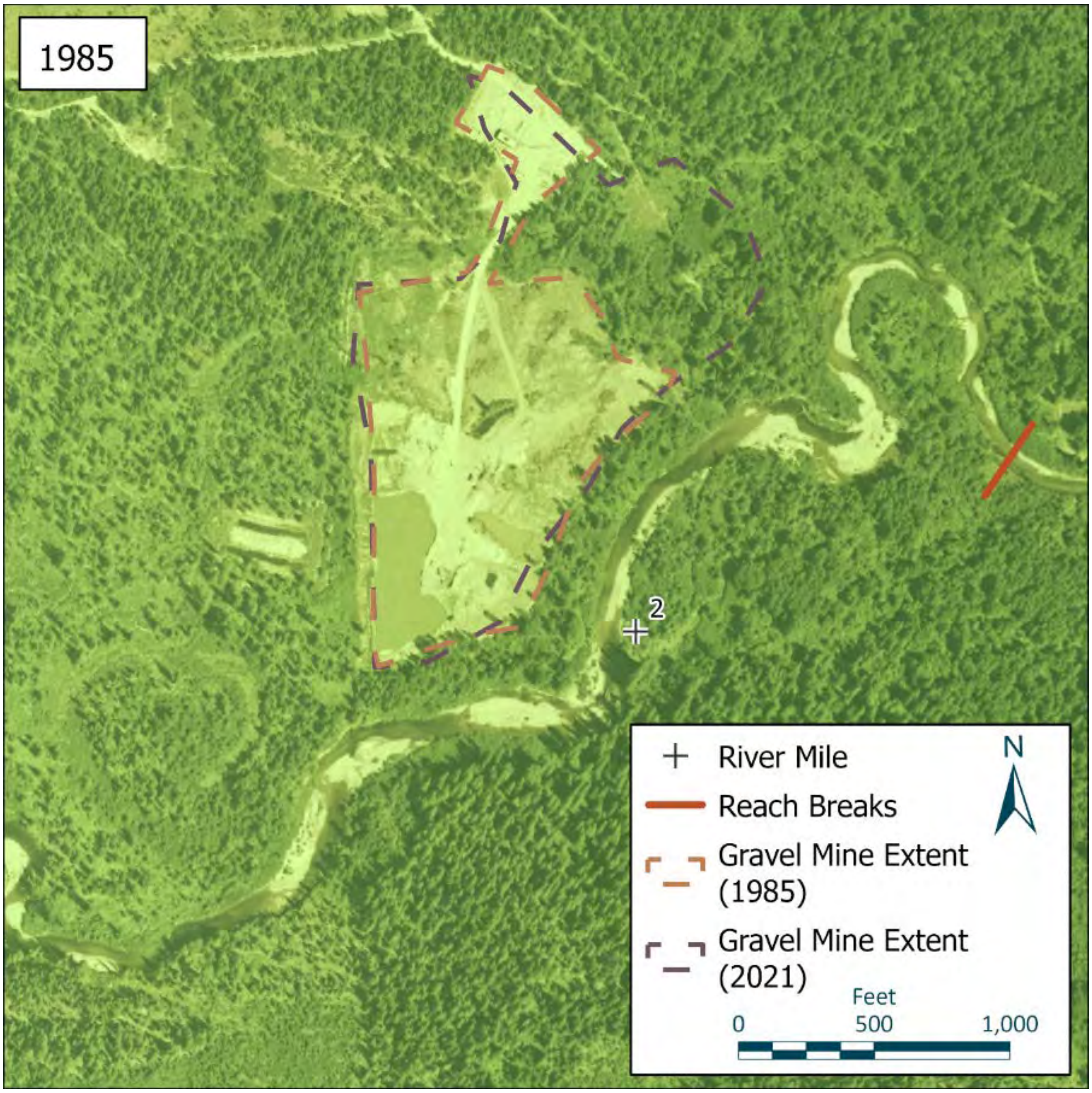

Figure 7. Aerial imagery from 1985 showing extent of a gravel mine near River Mile 2 on the Little Wenatchee River.

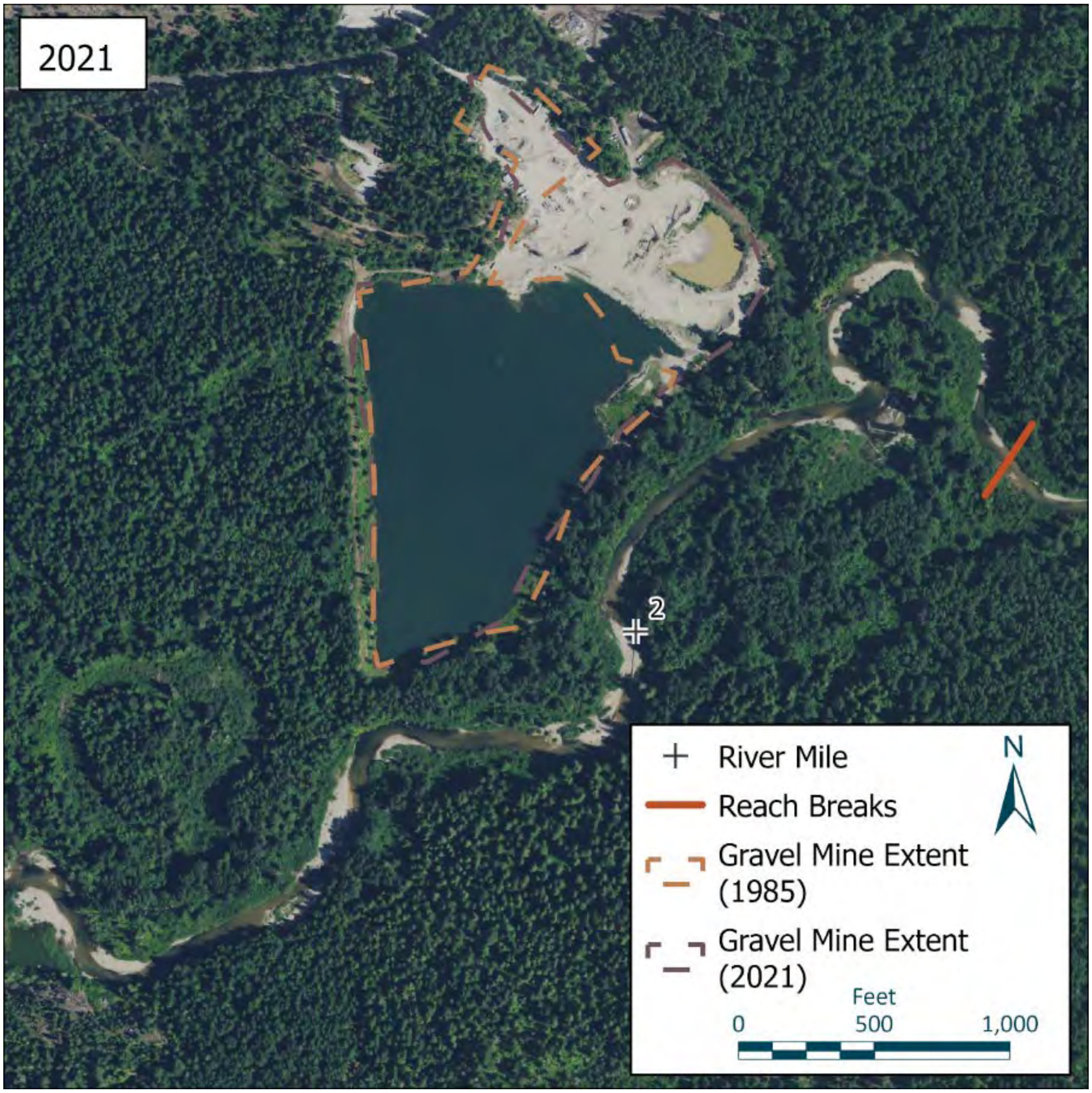

Figure 8. Aerial imagery from 2021 showing the expansion of a gravel mine near River Mile 2 on the Little Wenatchee River from its 1985 extent.

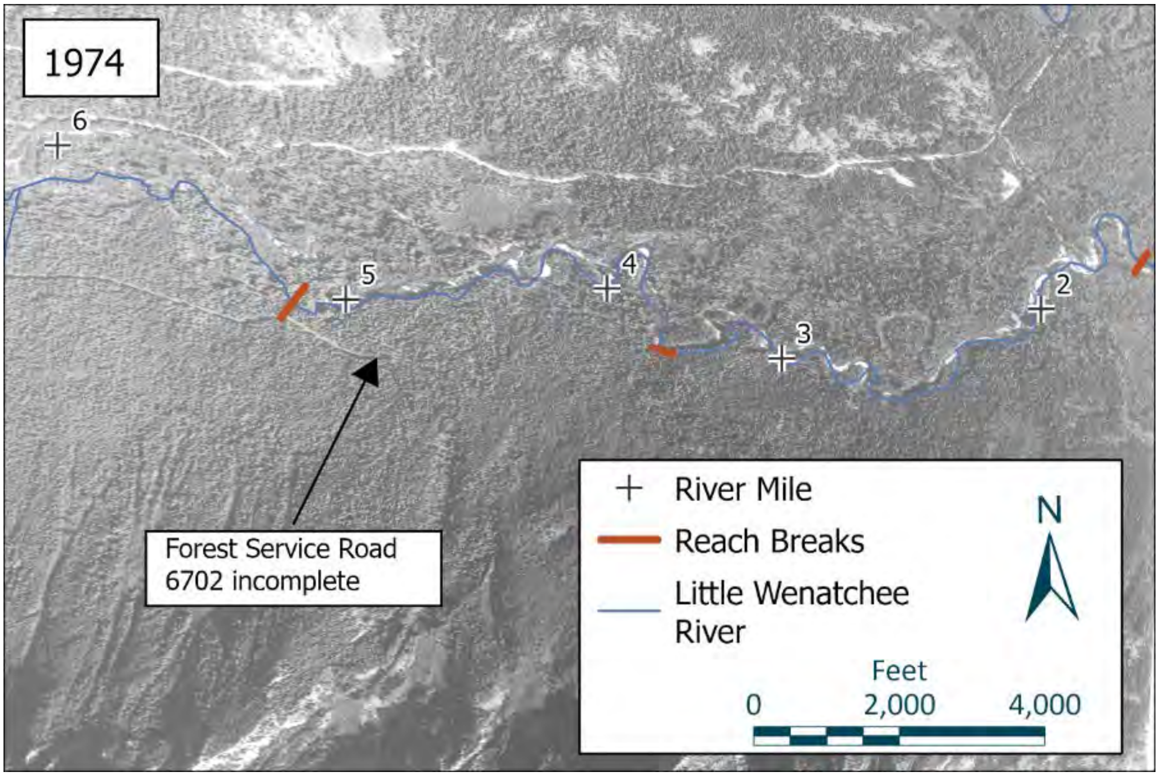

Figure 9. Aerial imagery from 1974 shows incomplete status of Forest Service Road 6702 and lack of forest clearing.

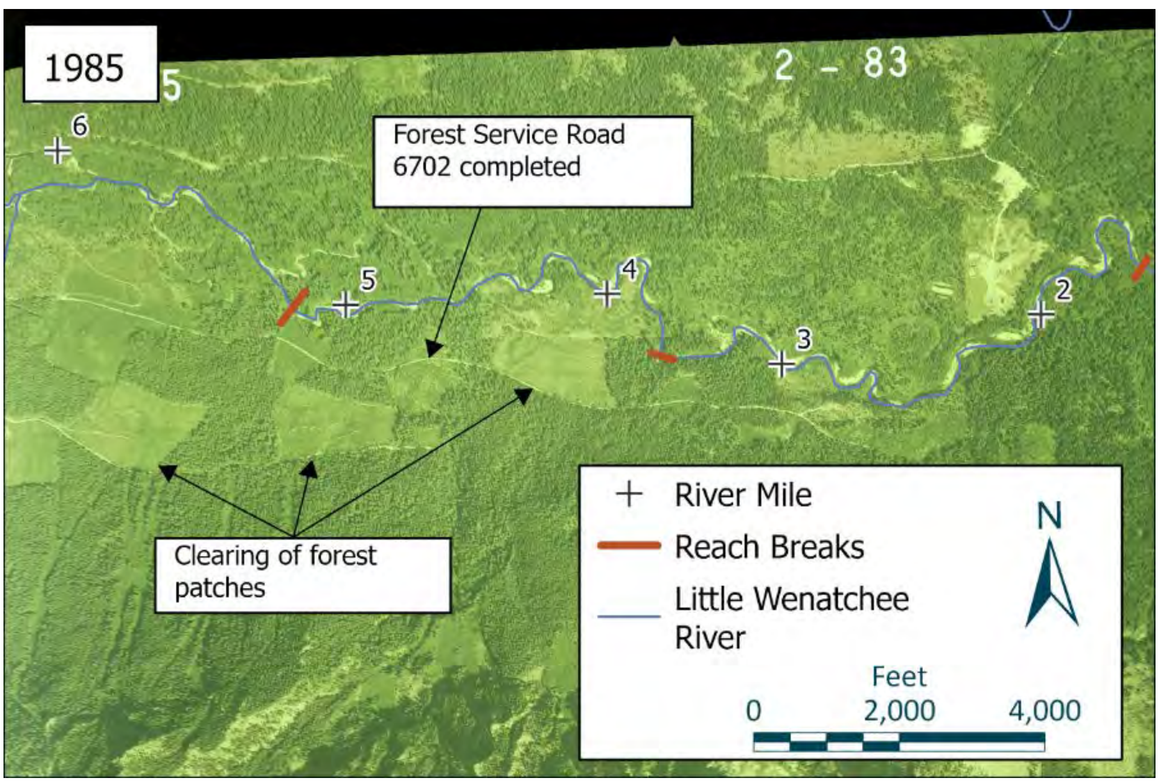

Figure 10. Aerial imagery from 1985 shows completion of Forest Service Road 6702 and forest clearing in patches within the project area including valley bottom harvest activity.

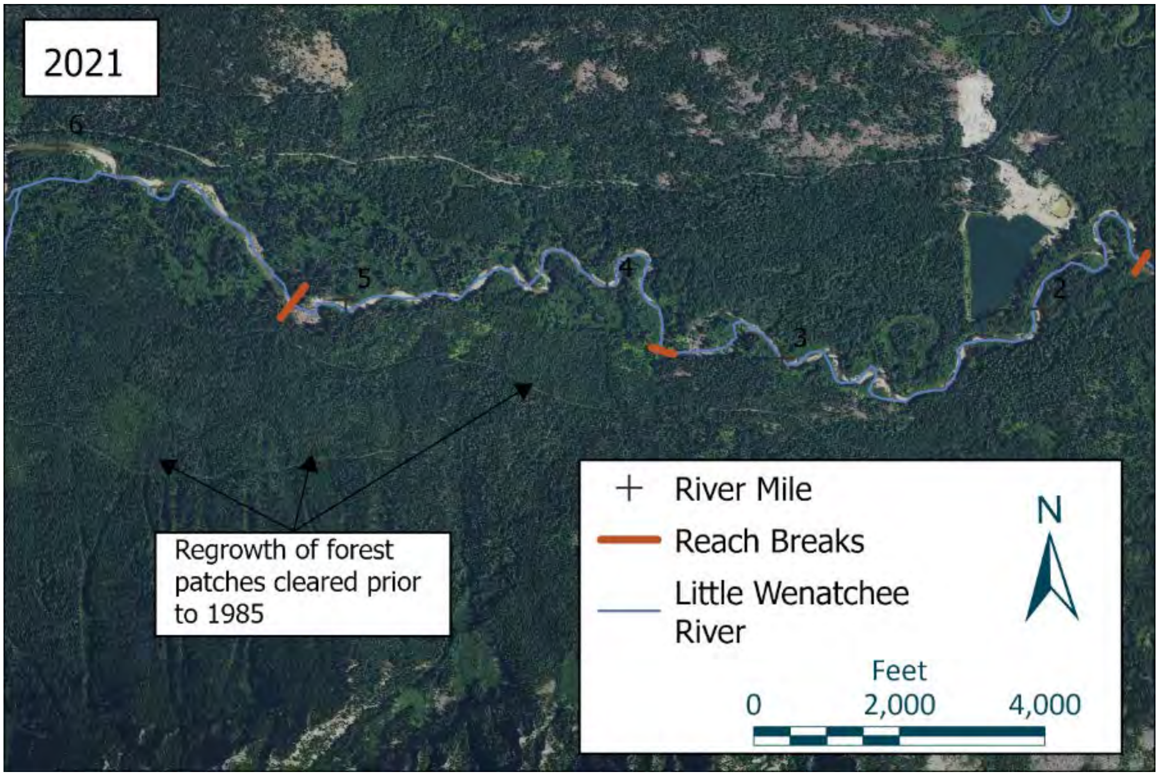

Figure 11. Aerial imagery from 2021 showing regrowth of vegetation within forest patches cleared between 1974 and 1985.

Although the Little Wenatchee River is a predominately forested watershed with no permanent residences, human-built features have and do influence natural channel processes within some portions of the assessment area. These will be described in more detail in the Reach Scale Conditions, Section 3.

2.4 HYDROLOGY

The Little Wenatchee River, along with the White River, is one of two major tributaries to Lake Wenatchee, which forms the headwaters of the Wenatchee River. At its mouth the Little Wenatchee River drains 102 miles^2 -- approximately 7.7% of the Wenatchee River basin (1,328 miles^2). The Little Wenatchee River is estimated to contribute approximately 15.4% of annual flow on average to the Wenatchee River (WA-ECY, 1995). The Little Wenatchee drains the eastern side of the Cascade Mountains, flowing approximately 24.5 miles to the southeast from its headwaters near Dishpan Gap (approximately 5,600 feet elevation) to Lake Wenatchee (approximately 1,870 feet elevation). Mean basin elevation is 3,990 feet and the average river gradient from headwaters to outlet is roughly 150 feet/mile. Nason Ridge and Wenatchee Ridge define the southern and northern drainage divides of the Little Wenatchee Basin, respectively. Major tributaries in the Little Wenatchee Basin include Cady Creek, Fish Creek, Lake Creek, Rainy Creek. Figure 12 shows the location of the Little Wenatchee Basin and the lower Little Wenatchee Basin.

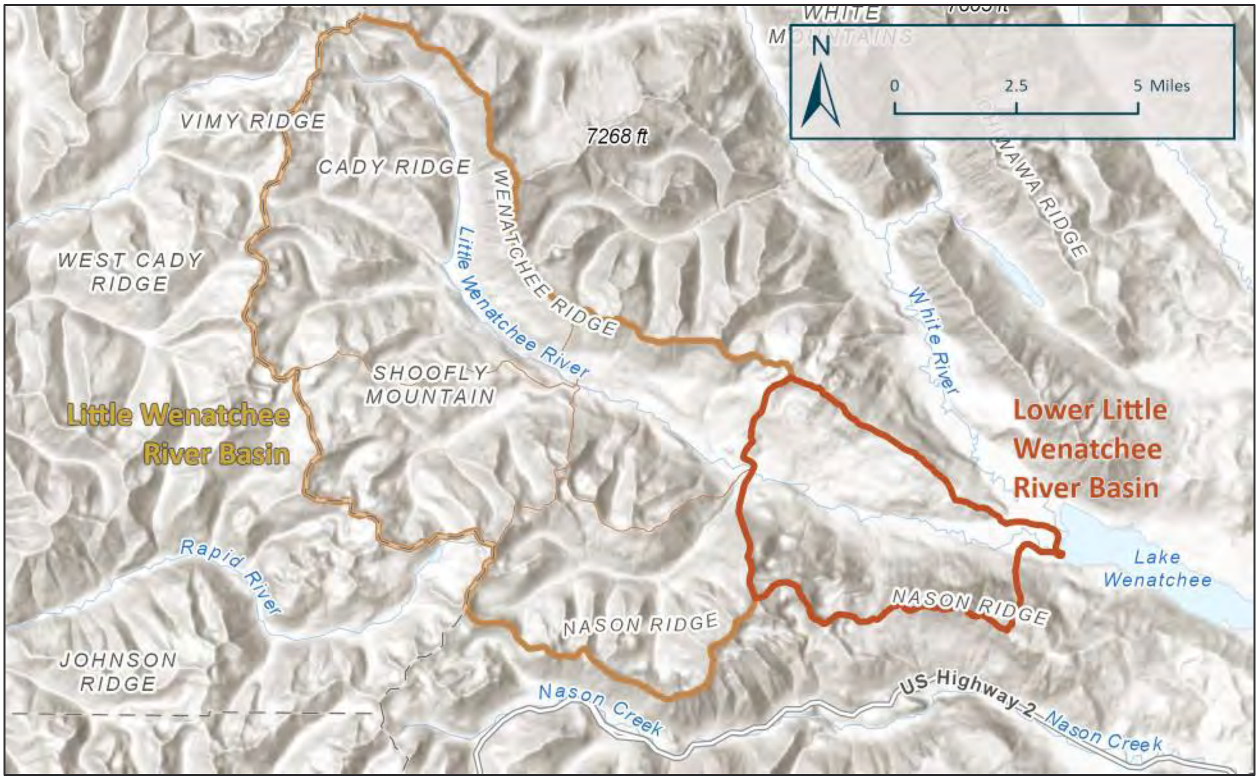

Figure 12. Location map of the Little Wenatchee River Basin, and the lower Little Wenatchee Basin, which contributes flow to the lower Little Wenatchee assessment area.

Mean annual precipitation in the Little Wenatchee Basin is spatially variable, ranging from 30–110 inches, and 84 inches when averaged across the basin (PRISM (Oregon State University), 2024); increases in precipitation are positively correlated with elevation in the Little Wenatchee Basin. Most of the annual precipitation in the Little Wenatchee Basin falls from October through March, much as snow, especially at higher elevations.

2.4.1 Assessment Area Hydrology

This assessment focusses on the hydrology of the lower Little Wenatchee River, which extends downstream from the confluence of Rainy Creek with the Little Wenatchee (RM 9.0) to the river's mouth at Lake Wenatchee (Figure 12). The assessment area receives upstream watershed inputs as well as direct inputs from within the lower Little Wenatchee Basin, which comprises about 20% of the overall Little Wenatchee Basin. The largest tributary within the lower Little Wenatchee Basin is Lost Creek which joins the river near river mile 5.7. Otherwise, contributing tributaries within the assessment area have relatively small contributing upstream drainage areas, though field observations point to several of these small tributaries flowing perennially.

Streamflow in the Little Wenatchee River varies seasonally, with snowmelt-driven high flows commonly peaking in May and June, and the lowest flows typically occurring in August and September (Figure 13). Lower portions of the Little Wenatchee basin fall within elevation ranges which commonly experience heavy rain and rain-on-snow events during late fall and winter, and these events have produced floods of record in other upper Wenatchee Basin tributaries, so wintertime high flows associated with large rain events likely occur in the Little Wenatchee Basin.

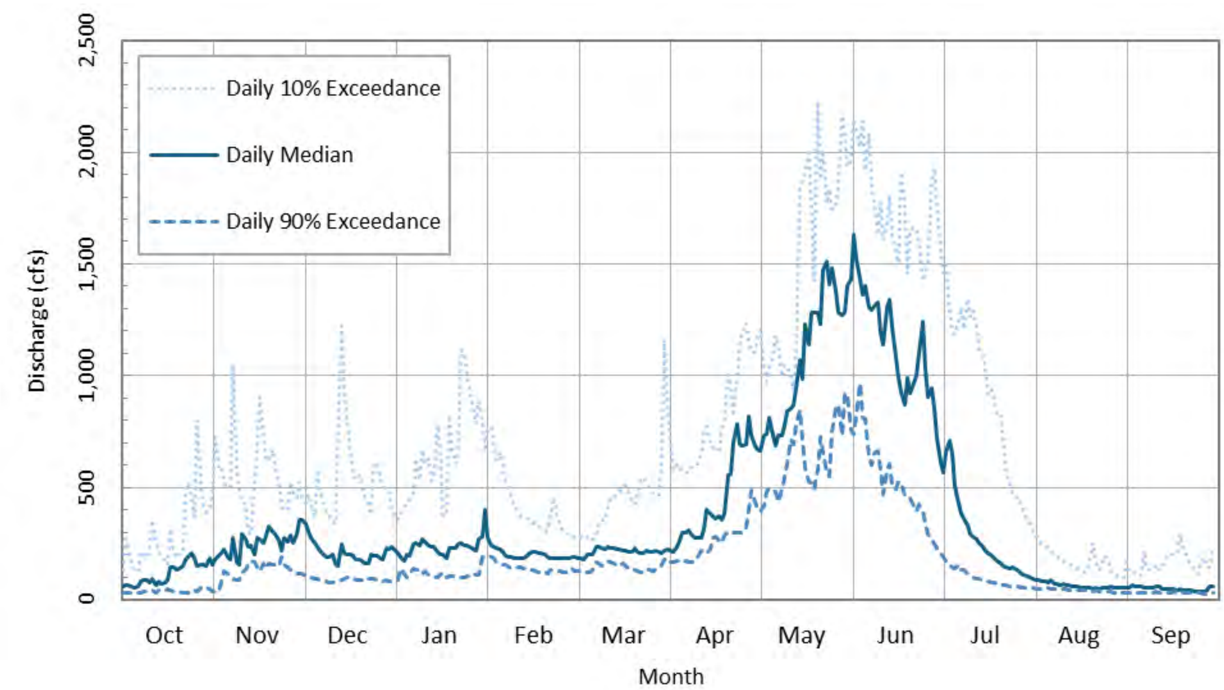

Figure 13. Annual hydrology statistics for WA-ECY gage 45L110, Little Wenatchee River below Rainy Creek, WA | Water Years 2002 to 2012.

2.4.2 Seasonal Hydrology Analysis

Seasonal flow statistics for the lower Little Wenatchee River were calculated from data recorded by a Washington State Department of Ecology stream gage (WA-ECY 45L110) which was located at approximately river mile 8.7, near the upstream boundary of the assessment area. The available period of record for this gage is 10 years (2002-2012). However, data gaps and some uncertainty regarding discharge magnitudes exist for portions of this dataset due to data recording errors, disturbance to the gage, lack of verification of flow magnitudes, and the effects of ice at the station. Mean daily streamflow values from the WA-ECY gage were averaged per month to calculate average daily discharge for each calendar month ("monthly average flows").

Monthly average streamflow estimates calculated from the historical Little Wenatchee gage are summarized in Table 2. Monthly average discharge estimates discussed in this report were not scaled to reflect tributary and other flow inputs to the lower portions of the assessment area due to uncertainties regarding the magnitude and timing of the hydrologic processes delivering flow to the lower portions of the assessment area.

Table 2. Summary of monthly average discharge estimates for the Little Wenatchee assessment area.

Month	***Little Wenatchee River Mean Daily Flow Estimates (cfs)***
October	161
November	312
December	285
January	340
February	255
March	269
April	507
May	1060
June	1131
July	411
August	101
September	81

2.4.3 Peak Flow Hydrology Analysis

A hydrologic analysis was performed to estimate the discharge of common flood recurrence intervals for the lower Little Wenatchee River.

Peak flows for the assessment area were estimated by applying a drainage area scaling relationship to peak flow statistics calculated from approximately 30 years of peak flow data recorded at a USGS stream gage (USGS 12454000) on the White River near Lake Wenatchee (period of record: 1954–1984). Peak flow discharge values for the White River were estimated by conducting a Bulletin 17-C EMA Flood Frequency Analysis (FFA) on the White River gage data using HEC-SSP software (USACE, 2017). Peak flow statistics calculated for the White River are summarized in Table 3. Peak flows for the lower White River were subsequently scaled using a simple ratio of drainage areas for the upstream boundary, downstream boundary, and the midpoint of the lower Little Wenatchee River assessment area. The resultant peak flow statistics are summarized in Table 3.

Table 3. Summary of peak flow discharge estimates for the lower Little Wenatchee River assessment area.

Location	Drainage Area (mi^2)	Peak Flow Discharge Estimates (cfs)					
		2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
Lower Little Wenatchee River - Upstream (RM 9)	83.6	2,437	3,216	4,077	5,231	7,357	9,577
Lower Little Wenatchee River - Midpoint (RM 5)	93.9	2,738	3,612	4,580	5,876	8,263	10,757
Lower Little Wenatchee River - Downstream (RM 0)	101.9	2,971	3,919	4,970	6,376	8,967	11,674
Lower White River	149.1	4,347	5,735	7,272	9,330	13,121	17,081

Peak flows discharges scaled for the midpoint of the lower Little Wenatchee River were selected for modeling peak flows in the assessment area. These flows are scaled for a contributing area which includes the largest tributaries to the Little Wenatchee River in the assessment area but does not overestimate peak flow discharge estimates in the upper portions of the study area as much as using full-basin scaled discharge values. At future design phases, where conservative estimates of peak flow discharges are necessary, full-basin scaled peak flows may be used.

2.4.4 Response to Climate Change

Global climate models used to accurately capture the 1.4°F warming measured in the Pacific Northwest over the 20th century have been applied to predict future climate trends (Srinivasan et al., 2007). These models predict an average increase in annual temperature in the region of 2.0° F by the 2020s, 3.2° F by the 2040s, and 5.3°F by 2080 (Mote & Salathé, 2010). Climate simulations indicate precipitation and streamflow in the Pacific Northwest will respond to a changing climate through increased intensity of winter storm events resulting in higher streamflow, and decreased summer precipitation resulting in longer periods of, and decreased, low streamflow (Mantua, Tohver, and Hamlet 2009). These changes are predicted to have some of the most substantial implications for snowmelt driven watersheds such as the Little Wenatchee.

The Little Wenatchee watershed is predicted to see an increase in summer streamflow temperatures. These increases are predicted increase summer temperatures by 2 - 3°F by 2080. In addition to stressors associated with temperature, the extended low streamflow period during the summer season is expected to have implications for stream-type lifecycle salmon habitat, while the enhanced winter flooding will likely result in reduced egg-to-fry survival (Mantua, Tohver, and Hamlet 2009).

2.5 HYDRAULIC ANALYSIS

A planning-level two-dimensional (2D) hydraulic model of the Lower Little Wenatchee River was developed for the existing conditions of the site. Hydraulic modeling was performed using the U.S. Army Corps of Engineers HEC-RAS software, version 6.4.1 (USACE, 2023). The planning-level model is intended to assess the hydraulics, sediment dynamics, and habitat conditions of the site at the reach scale. Model results are used within this assessment to evaluate the characteristics of the Little Wenatchee River including the distribution of energetics, the availability of different aquatic habitat types under vary flow conditions, and the frequency and degree of channel-floodplain connections, among other characteristics. The model will be refined at future design phases to help evaluate design parameters such large wood stability. The input data and underlying assumptions used to develop the 2D model are described in the following subsections.

2.5.1 Model Geometry

2.5.1.1 Digital Terrain Model

The model geometry for the planning-level model is based on a combination of digital terrain models (DTM) that were developed from topographic LiDAR collected in 2007 (Watershed Sciences, 2007), 2015 (Quantum Spatial, 2015), and 2018 (Quantum Spatial, 2018). To develop the model terrain, the LiDAR DTMs were combined into a mosaic, where elevation values were sampled from the most recently acquired LiDAR DTM. All LiDAR datasets utilized for model terrain development were collected during relatively low flows periods when large portions of the bankfull channel was unlikely to be inundated (acquisition dates: October 2007; September 2015; October 2018), and therefore the terrain of only small portions of the channel is represented by interpolated surfaces created during LiDAR processing by the LiDAR provider. No topographic or bathymetric surveys were completed as a part of this modelling effort to check the accuracy of the LiDAR datasets used to create the model terrain or to update and/or add topobathymetric detail to the model terrain. Future design phases may require more detailed and/or modern topographic and bathymetric data to improve the accuracy of hydraulic modeling at the sub-reach scale.

2.5.1.2 Computational Domain

The planning-level model covers the entire valley bottom of the lower Little Wenatchee River, extending from the major waterfall located at approximately river mile 9.2 downstream to Lake Wenatchee (Figure 14). Additionally, the lowermost portion of the White River from approximately river mile 2.6 to Lake Wenatchee was included to examine the interactions between flood flows sourced from both watersheds on the floodplain located between both rivers near their mouths.

The model domain consists of a computational grid with average cell spacing ranging between 15 and 30 feet within the active channel to approximately 50 feet in the floodplain. The resolution of the grid was adjusted based on terrain complexity and areas of interest, with smaller cell sizes applied to areas where higher resolution results were desired. Break lines were added along channel alignments, and at various high ground features or channel and/or floodplain obstructions, including levees and road prisms, to further refine the computational mesh where needed. Refinement regions were utilized to add detail to the computational mesh on the floodplain in areas where many side channels and swales were present to add detail to these regions. Additional mesh refinements at the sub-reach scale are expected as the project progresses, and the utility of the model evolves.

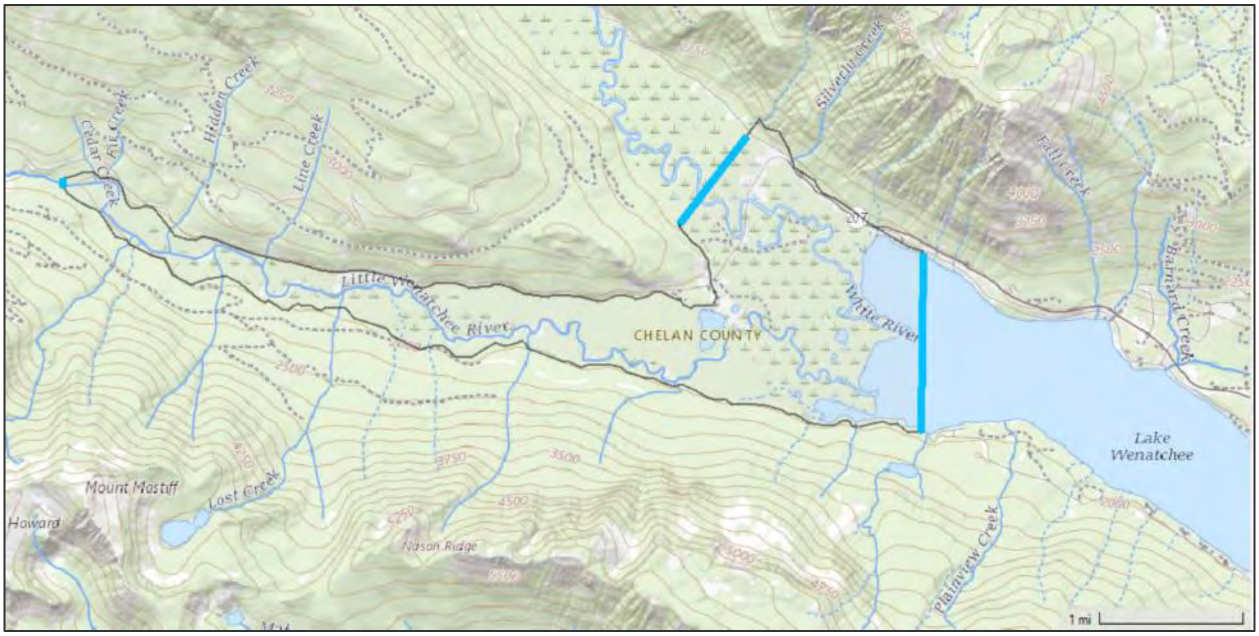

Figure 14. Map of lower Little Wenatchee model computational domain. The black polygon represents the perimeter of the domain, and the blue lines represent the location of model boundary conditions.

2.5.2 Input Parameters

2.5.2.1 Boundary Conditions

2D hydraulic models require boundary conditions at locations where flow is expected to enter or exit the computational domain. Inflow hydrographs were used in the model to represent incoming flow from the Little Wenatchee River and White River (Figure 14). These inflow hydrographs are based on the hydrology estimates discussed in Section 2.4 and the discharges used in the hydraulic modeling are summarized in Table 4. The downstream boundary condition is located in Lake Wenatchee, downstream of the mouths of the Little Wenatchee and White Rivers (Figure 14), and a stage hydrograph was used in the model for the downstream boundary conditions.

Table 4. Summary of flow statistics and discharge magnitudes used at 2D model inflow boundary conditions.

Flow Statistic	*Little Wenatchee Discharge (cfs)*	*White River Discharge (cfs)*
Assessment Flow	37	116
Sept Avg	81	333
Jan Avg	340	355
April Avg	507	710
June Avg	1131	2410
Q2	2738	4347
Q5	3612	5735
Q10	4580	7272
Q25	5876	9330
Q50	8263	13121
Q100	10757	17081

Discharges were incorporated into synthetic quasi-steady state hydrographs with periods of steady flow (at the discharges of interest and other intermediate discharges) connected by smooth transition periods to create a stair-step like pattern. A representative quasi-steady flow hydrograph is depicted in Figure 15. The periods of steady flow allow the model to come to a quasi-steady state condition, which facilitates the interpretation of hydraulics at specific discharges. This approach does not allow for analysis of the receding limb of the hydrograph, and likely provides conservatively high results with respect to large floods, as floodplain storage areas generally fill completely to allow the model to reach a steady state. Further, the timing of flood peaks at the two inflow points is modeled to be coincident, which likely provides additional conservativism with respect to larger flood events.

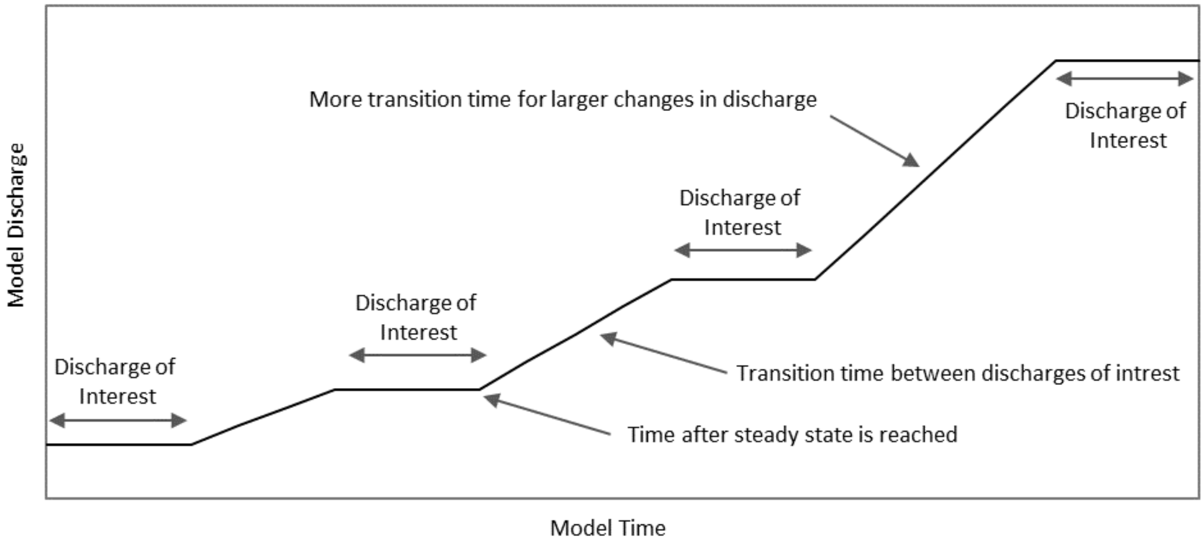

Figure 15. Demonstrative quasi-steady flow model input hydrograph.

The downstream boundary condition consists of a temporally static stage hydrograph (1872.5 feet) based on the average elevation of the interpolated water surface of Lake Wenatchee as represented in the LiDAR based DTM. Both the upstream and downstream boundary conditions were placed as far as possible from the focus of the assessment area to dampen the effects of any potential uncertainties associated with boundary condition assumptions. It is worth noting that the downstream end of the model domain is located in Lake Wenatchee and that the water surface elevation of the lake varies seasonally, which may affect the hydraulics of the Little Wenatchee and White Rivers near their mouths due to backwatering. Additionally, field observations point to small tributaries and hillslopes contributing water to the Little Wenatchee channel and floodplain within the model domain under all flow conditions, and these flow inputs aren't explicitly included as inflow boundary conditions in the model, which may lead to the model under predicting the volume of water on the floodplain of the assessment area for any given flow statistic. Additional refinements and sensitivity analyses regarding model boundary conditions may occur as the project progresses to later design phases.

2.5.2.2 Hydraulic Roughness

A spatially varying hydraulic roughness (Manning's n) layer was created using a combination of LiDAR derived vegetation heights and hand-digitized landcover regions. Roughness values were assigned to each landcover region based on published guidelines, field observations, and professional judgement (Table 5). Roughness coefficient assumptions were based on guidelines for one-dimensional characterization of corresponding channel types and vegetation conditions (Arcement & Schneider, 1989), with the understanding that 2D roughness values can often vary substantially from those published for 1D models (Robinson et al., 2019). Figure 15 summarizes the roughness coefficients used in the existing condition model.

Table 5. Roughness coefficients used in the 2D model.

Land Cover Description	*Manning's n Value*
Active Main River Channel (cobble w. minor vegetation and LWM)	0.045
Wetland / Floodplain - Herbaceous Vegetation (veg. < 5 ft)	0.08
Wetland / Floodplain - Shrub Vegetation (veg. 5 - 15 ft)	0.2
Wetland / Floodplain - Sapling / Seedling Vegetation (veg. 15 - 30 ft)	0.12
Forested Floodplain - Small Trees (veg. 30 - 50 ft)	0.09
Forested Floodplain - Second Growth Trees (veg. 50 - 100 ft)	0.075
Forested Floodplain - Old Growth Trees (veg. > 100 ft)	0.065
Existing Wood Accumulations (10+ pieces LWM)	0.3

2.5.3 Review of Model Results

Model results were used to gain a high-level understanding of hydraulic characteristics throughout the assessment area. Under existing conditions, the model results demonstrate the following characteristics regarding hydraulic connectivity and variability:

- Hydraulic connection between the main channel and-off-channel habitat features (side channels, alcoves, floodplain swales, etc.) occurs in much of the assessment area, even under the lowest flow conditions modeled (37cfs), which is less than the lowest monthly average flow for the Little Wenatchee River.
- Substantial floodplain inundation, including inundation of higher floodplain topography occurs in portions of the assessment area under high flow conditions which occur annually (e.g., June average flow: 1,131cfs). Backwatering of the floodplain upstream of large, channel-spanning wood accumulations likely drives large-scale floodplain inundation.
- Inundation during 2-year (2,738cfs) and 5-year (3,612cfs) recurrence interval peak flows extends across most of the Little Wenatchee valley bottom downstream of approximately river mile 1 and from approximately river mile 2 – 5. Valley bottom features including fluvial and glacial terraces, and alluvial fans reduce the area of regularly-inundated floodplain upstream of river mile 5, and these confining features particularly reduce floodplain connection and hydraulic diversity upstream of river mile 7.
- Anthropogenic levees associated with gravel mining obstruct floodplain flow between river miles 1.5 – 2, and gravel mining activities have disconnected approximately 50-75% of the floodplain in this vicinity.

A compilation of modeled inundation and velocity patterns is provided as Appendix C.

2.6 STUDY AREA GEOMORPHOLOGY

The following describes existing geomorphic conditions and processes with reference to the six-habitat assessment reaches and hydraulic analysis presented in later sections of this report. Maps of each assessment reach and hydraulic outputs presented above can be found in later segments of this report.

2.6.1 Substrate Type, Distribution and Availability

River substrate falls within full spectrum of grain sizes from fine silt up to large boulders and bedrock. With the exception of bedrock contacts, river channels are mobile bed channels constructed within post glacial alluvium that has been reworked following glacial retreat. A significant portion of the glacial till has been delivered from steep first order channels that have formed on steep valley walls. Debris torrent activity within these first order channels have delivered both colluvial and glacial sediment to the valley floor, forming alluvial fans. Alluvial fans have then been eroded during the post glacial Holocene period and the sediment reworked across the valley bottom. Stone sizes and distribution within and between each assessment reach can be viewed in Wolman pebble count data collected during the field work. Alluvial sediment composing the floodplain, bed and banks of the river mirrors the watershed geology and is composed of intrusive and metamorphic rocks originally eroded by glacial advance. Sediment gradation varies within the study area and is largely controlled by slope which is locally controlled by alluvial fan impingements within the valley, bedrock and Lake Wenatchee. Larger stone sizes are found within steeper upstream reaches that transition to smaller gradations working downstream to Lake Wenatchee. A major bedrock contact forms a steep bedrock grade control and fish passage barrier between Reach 5 and 6. Upstream and downstream of the bedrock contact alluvial channel type dominates.

2.6.2 Sediment Transport and Response Conditions

Within the context of the base level control formed by Lake Wenatchee and bedrock contact between Reach 5 and 6, sediment transport and response are controlled by local variations in slope created by large wood deposits and varying degrees of meander bend development. Some large wood deposits within the study area are channel spanning. In these instances, the backwater created by them maintain anastomosing channel networks that avulse back and forth across the valley as wood accumulates or degrades over time within channel spanning deposits. This channel type occurs in Reach 3 and is dominate in Reach 4.

Reach 1 and 2 are primarily outside of the influence of channel spanning wood deposits. Local sediment transport is influenced to a greater degree by meander bend processes. As meander bends laterally eroded, they mature (become more sinuous), reducing local slope to the point that upstream sediment aggradation creates a meander bend cutoff, thereby increases slope, beginning the process anew. Several meander bend cutoffs have occurred throughout reach 1 and 2 across the valley bottom and illustrates a more dominate process than anastomosing channel conditions found upstream. Reach 1 and 2 are in a stable sediment transport equilibrium within the continuum of local meander bend processes.

Reach 5 downstream to Reach 4, is comparatively less responsive, steeper and more transport driven. In Reach 5 alluvial fan processes have impinged on the valley floor. A glacial outwash terrace and adjacent alluvial fans have been eroded laterally through time, forming a 100-foot eroding embankment adjacent to the USFS 6500 road. Downstream the channel is locally braded but quickly becomes a steeper transport dominate channel. As fan impingements lessen and the valley widens, local slope lowers and transitions to alluvial response reaches from Reach 4 downstream to Reach 1.

Reach 6 grade is controlled by downstream bedrock. Upstream of the bedrock, the channel is similar to the large wood dominated processes and anastomosing channel conditions found in Reach 3 and 4. The channel in Reach 6 is in a stable sediment transport equilibrium.

2.6.3 Influence and Role of Large Wood Debris

Large wood heavily influences the study area. As previously addressed, large channel spanning wood deposits are capable of controlling local grade and sediment transport conditions conducive to developing and maintaining anastomosing channel networks. Tree size, volume and function found within the study area has a greater similarity to west side cascade ecosystems than commonly found on the east side of the cascades. Wood sources found in the Little Wenatchee appear to be most often delivered through channel migration. However, debris torrents and snow avalanche activity can deliver large volumes of wood debris to the valley bottom and in many cases directly into the river channel. We do not understand relative volumes that may have historically deposited through channel migration, snow avalanche or debris torrent processes but do know all of those processes exist within the study area and all can deliver wood to the valley bottom. Large trees and smaller wood material are often transported to natural depositional areas on bar surfaces or incorporated in large channel spanning wood accumulations once delivered to the channel.

2.6.4 Floodplain, Channel Migration Zone and Habitat Connectivity

Riparian ecological processes are highly dependent on functional floodplain inundation (connectivity) and free and unbound channel migration zones. Based on field observations and existing conditions hydraulic model results, the channel is well connected to the valley bottom floodplain. Hydraulic inundation results can be viewed in the appendix. Complex channel networks, floodplain sloughs and ground water wall-based channels exist within the study area. With the exception of an active gravel mine within Reach 2, the channel migration zone is intact and capable of accepting future river erosion and channel movement. However, past logging activity within segments of Reach 1 and 2 have degraded channel migration zone processes by removing future reserves of large diameter trees important for creating natural habitats.

2.6.5 Surface and Subsurface Flow Interaction

Evidence of both valley wall hyporheic and surface flow interactions within historic meander bend cutoffs and anastomosing channel networks was observed within large segments of the valley bottom. Steep first order tributaries were observed maintaining flow within larger former mainstem channels and side channels that have been abandoned except during larger spring flows. The degree of hyporheic flow collection appears most present near valley walls and within anastomosing channel networks where they exist. In some cases, flows are connected during base flows. More commonly they were observed to be intermittently connected to the mainstem but wetted year-round.

2.6.6 Channel Incision and Channel Evolution Trend

Hydraulic inundation analysis indicates that there are no segments of channel within the study area that are incised. While logging activity has in the past occurred and gravel mining is occurring within the channel migration corridor (valley toe to valley toe), those activities have not yet significantly impacted floodplain inundation, sediment transport equilibrium and channel habitat. However, logging activity has altered future large wood reserves and therefore may cause a reduction in long-term total habitat due to the disruption of large wood availability created during natural channel migration processes. Mining activity within the channel migration zone has removed a significant volume of alluvium within the valley bottom. If and when the river migrates into the gravel mine it is possible the sediment conveyance to downstream channel segments will be disrupted and water quality reduced. The resulting disequilibrium in sediment transport and local habitat degradation following mine capture is difficult to quantify. Migration into the mine site is not imminent.

2.7 AQUATIC HABITAT CONDITIONS

This section summarizes the results of the six channel reaches surveyed from October 9-14, 2023, between RM 0.5 and RM 9.7 on the lower Little Wenatchee River. For more information on habitat conditions, please see Appendix A.

2.7.1 Channel Habitat

The surveyed reaches of the Lower Little Wenatchee River are a mix of long pools and glides (41% and 21% of the total habitat in the assessment area, respectively), interspersed with short riffles in the lower portion of the assessment area and with more extended riffles in the upper reaches. The channel form is primarily single threaded with several long, complex side channels winding through broad floodplain valleys in the lower reaches.

Side channel habitat was primarily confined to the middle of the survey area in Reaches 2, 3, and 4 and accounted for 15% of the habitat unit area in the surveyed system. There were 23 side channel units observed in total, with an average length of 668 feet and an average wetted width of 13.26 ft.

Side channels contained similar loads of large woody material as the main channel, with a total of 293 pieces, 168 small, 55 medium, and 70 large across the 23 mapped side channels.

2.7.2 Large Woody Material

Pieces of large wood (≥ 6 inches diameter) in a channel contribute nutrients, shade, cover, and promote habitat complexity suitable for many riverine species (Langford, Langford, and Hawkins 2012). Large woody material (LWM) (≥12-in dbh and at least 35 feet long) can influence local geomorphic processes and increase channel complexity by promoting scour and erosion relative to flow hydraulics around them and by redirecting or splitting flow pathways (Grabowski & Gurnell, 2016; Langford et al., 2012; Montgomery & Piégay, 2003). The quantity of LWM within a riverine system depends on the presence of mature or maturing forests upstream and locally, as well as the processes of recruitment (infall from banks, debris flows or landslides off hillslopes, in-channel transport, etc.) occurring within the watershed. Tree size (length and diameter) compared to active channel width, channel form, and flow regimes control retention and accumulation patterns of LWM.

Depending on the reach, LWM found in the Little Wenatchee plays a moderate to large role in the geomorphology and habitat complexity of the channel. A total of 1311 channel influencing LWM were counted during the October 2023 field survey within the 9.7 miles included in the assessment area. Of the LWM identified in the 2023 survey, Reach 2 contained the highest proportion of LWM, 31% of the total in the assessment area (410 pieces) and Reach 6 contained the lowest with 2% (24 pieces). The remaining reaches contained a wide range in the number of LWM, Reach 1 contained 3% (36 pieces), Reach 3 contained 28% (371), Reach 4 contained 21% (281 pieces), Reach 5 contained 14% (189 pieces). There were 24 large wood jams (>10 pieces of LWM accumulated) surveyed in October 2023. Of the 24 jams, 10 were located in Reach 2, four in Reach 3, eight in Reach 4 and one each in Reaches 5 and 6.

Prior to European settlement and associated anthropogenic activity in the watershed, most of the assessment area would likely have been forested with mature conifers and a complex mosaic of channel, off-channel, and floodplain features would have been present in the valley bottom. This is still true in many areas. However, land use practices within the Lower Little Wenatchee River have resulted in impacts to both channel and floodplain processes. Primary among these are harvest activity and gravel mining within the valley bottom that has occurred in the past and in the case of mining is currently an active presence. At the watershed scale, upslope logging and associated road building often, make steep slopes of the watershed more prone to erosion, increasing sediment inputs and perhaps landslide and debris torrent frequency.

2.7.3 Riparian Vegetation

Riparian vegetation in the Lower Little Wenatchee River generally consists of a mixed mid-seral stage coniferous overstory with a frequently dense shrub/sapling understory. The primary overstory species included Western red cedar (*Thuja plicata*) (48%) and cottonwood (*Populus trichocarpa*) (35%), with some alder (*Alnus spp*.) (10%), and western hemlock (*Tsuga heterophylla*) (6%) scattered through the riparian areas. Douglas fir (*Pseudotsuga menziesii*) was also seen scattered throughout the assessment area, generally seen mixed in with western red cedars and cottonwoods in the overstory. Generally, tree size and age increased moving upstream through the assessment area, with the largest size class of overstory tree canopy ("mature tree") recorded in Reach 5. The understory canopy predominately consisted of small deciduous trees, saplings, and shrubs. Understory species composition was varied throughout the assessment area, most commonly consisting of dogwood (*Cornus spp*.), vine maple (*Acer circinatum*) (23%), alder (19%), willow (*Salix spp*.) (16%), and cottonwood (16%).

2.8 REACH-BASED ECOSYSTEM INDICATORS

This section presents an overview and summary of the Reach-based Ecosystem Indicators (REI) analysis, which is presented in more detail in the REI Report (Appendix B). A summary table of the REI analysis results is provided below in Table 6. The REI applies habitat survey data and other analysis results to a suite of REI indicators in order to develop reach-scale ratings of functionality with respect to each indicator. Functional ratings include adequate, at risk, or unacceptable. The REI analysis helps to summarize habitat impairments and to distill the impairments down to a consistent value that can be compared among reaches. This analysis is also used to help derive restoration opportunities presented later in this document. The rating definitions, and explanations of how the ratings were made, can be found in Appendix B.

At the watershed-scale, the Little Wenatchee River was rated **At Risk** for the Drainage Network and Hydrologically Impaired Surfaces indicator and the Disturbance Regime indicator, due to the number of roads and residential/agricultural clearing, particularly in the lower basin. The Streamflow indicator was also rated **At Risk** for the Little Wenatchee, while Water Quality – including water temperature and contaminants – was rated as **Unacceptable**.

At the reach-scale, Reaches 5 and 6 of the Lower Little Wenatchee River had the highest number of **Unacceptable** ratings. Reach 2, though it had fewer **Unacceptable** ratings, still had a high number of **At Risk** ratings, largely due to the gravel mine impacting floodplain connection and increasing channel confinement. Reaches 3 and 4 showed the greatest number of adequately functioning ecosystem metrics.

The ratings relating to salmonid habitat ranged from Adequate to Unacceptable across the study area. All six reaches were given **Adequate** ratings for the Habitat Access Pathway- Main Channel Barriers indicator since there were no anthropogenic barriers within the main channel that completely excluded fish passage. A natural waterfall that is assumed to act as at least a partial barrier to fish migration was observed in Reach 6, however, the REI ratings are based on non-natural barriers present in the main channel, of which there were none in the assessment area.

For the Dominant Substrate/Fine Sediment indicator, Reach 3 was rated **At Risk** due to the relatively high proportion of fine sands and silt sediments present in the substrate. All other reaches had high proportions of gravels and cobbles appropriate for salmonid spawning and rearing with low amounts of fine sediments, and therefore given **Adequate** ratings.

Large Woody Material (LWM) ratings varied between **Adequate** in Reaches 2, 3, and 5 and **At Risk** in Reaches 1 and 4. Only Reach 6 had low numbers of large wood pieces present in the channel and lacked potential for future large wood recruitment, earning a rating of **Unacceptable**. Pool frequency was rated **At Risk** or **Unacceptable** in all reaches due to the very low pool frequency and, in the case of Reaches 5 and 6, somewhat low quality of the pools (low residual depths and minimal/no large wood cover or habitat). The Off-channel Habitat indicator was rated as **Unacceptable** for Reaches 1 and 5 and **At Risk** for all other reaches, due to either the complete lack or very infrequent occurrence of alcoves and side channels connected at baseflows.

Riparian vegetation condition indicators – Structure and Disturbance – are functioning relatively well across all reaches due to minimal roads and development located within the riparian zone of these reaches. Reaches 2, 4, and 6 received **At Risk** ratings for Riparian Vegetation Structure, while Reaches 1, 3, and 5 received **Adequate** ratings. For Riparian Vegetation Disturbance, Reaches 1, 2, 4, and 6 are functioning in an **At Risk** condition, while reaches 3 and 5 were rated as **Adequate**.

At Risk ratings for riparian vegetation condition indictors were largely due to the relatively young seral stage of the overstory in those reaches where historically a more complex mosaic of mature overstory would have been expected but has been lost due to past tree harvest. Canopy Cover was rated as **Unacceptable** for all reaches since a majority of the low-flow wetted channel is not shaded by adjacent riparian trees.

Channel dynamics for Reaches 1 and 2 are mostly functioning well. Floodplain connectivity was rated **At Risk** for all reaches except Reach 4. Reach 2 was the only reach that received **At Risk** ratings for Bank Stability/Channel Migration and Vertical Channel Stability. All other reaches were rated as Adequate for the Bank Stability/Channel Migration and Vertical Channel Stability indicators.

For the study area as a whole, **Adequate** was the most common reach-scale rating (30), followed by **At Risk** (25), then **Unacceptable** (11).

Table 6. Summary ratings for the Reach-based Ecosystem Indicators for each reach in the Little Wenatchee assessment area.

Pathway	General Indicators	Specific Indicators	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6
Habitat Access	Physical Barriers	Main Channel Barriers	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate
Habitat Quality	Substrate	Dominant Substrate / Fine Sediment	Adequate	Adequate	At Risk	Adequate	Adequate	Adequate
	LWM	Pieces per Mile at Bankfull	At Risk	Adequate	Adequate	At Risk	Adequate	Unacceptable
	Pools	Pool Frequency and Quality	At Risk	At Risk	At Risk	At Risk	Unacceptable	Unacceptable
	Off-Channel Habitat	Connectivity with Main Channel	Unacceptable	At Risk	At Risk	At Risk	Unacceptable	At Risk
Riparian Vegetation	Condition	Structure	Adequate	At Risk	Adequate	At Risk	Adequate	At Risk
		Disturbance (Human)	At Risk	At Risk	Adequate	At Risk	Adequate	At Risk
		Canopy Cover	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable
Channel	Dynamics	Floodplain Connectivity	At Risk	At Risk	At Risk	Adequate	At Risk	At Risk
		Bank Stability / Channel Migration	Adequate	At Risk	Adequate	Adequate	Adequate	Adequate
		Vertical Channel Stability	Adequate	At Risk	Adequate	Adequate	Adequate	Adequate

3. Reach Scale Conditions

The Lower Little Wenatchee River assessment area was divided into six reaches to align with prior evaluations of the project area conducted by others (UCRTT, 2021) as shown in Figure 16.
In general, reaches delineate major physical transitions in channel form, gradient, degree of sinuosity, bedload and floodplain connectivity. Reaches are numbered from downstream to upstream within the assessment area. Geomorphologists walked each reach in the assessment area to characterize physical conditions and channel processes. Specifically, we focused on: 1) sediment transport and response conditions, 2) channel incision and channel evolution trends (erosion and stability), 3) substrate types, distribution, and availability, 4) influence and role of large woody debris, 5) floodplain, channel migration zone, and habitat connectivity, 6) surface and subsurface flow interactions, 7) influence of past and current human structures and activities (road crossings, wood harvest, etc.), and 8) interaction of the stream with riparian ecological processes. Information from the reach-scale geomorphic assessment is also used to inform the REI analysis. Table 7 includes a set of metrics used to help characterize each reach. In addition to a discussion of the metrics provided in Table 7, vegetation condition, and the location of human-built features that influence channel processes are provided below for each reach.

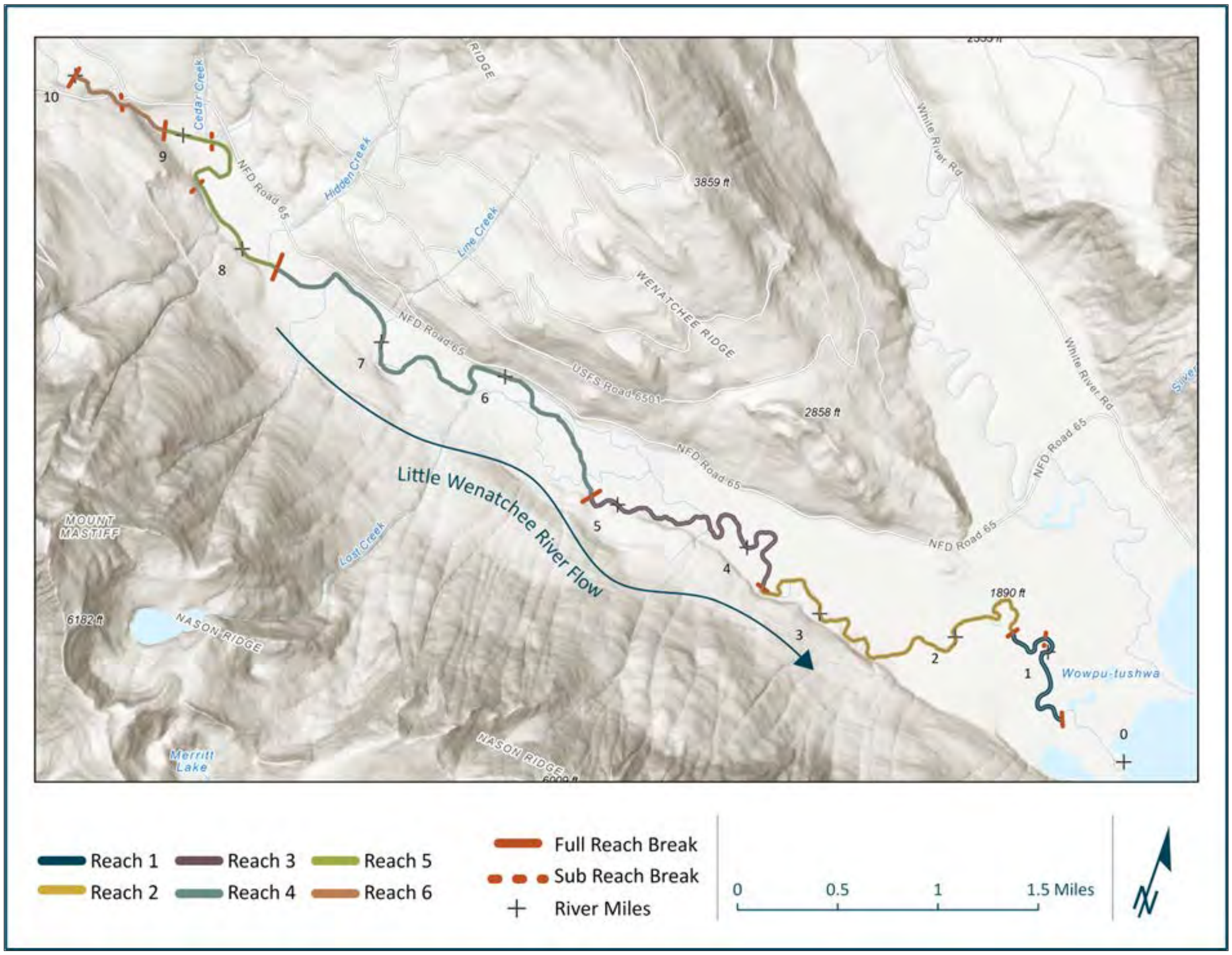

Figure 16. Six reaches of the Lower Little Wenatchee River habitat assessment.

Table 7. Channel metrics for each reach surveyed during the field habitat assessment on the Lower Little Wenatchee River.

	Metric	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6
Channel Metrics	**River Miles Surveyed**	0.25	2.15	1.7	2.6	1.3	0.6
	River Mile	1.1 -1.35	1.35 - 3.5	3.5 - 5.2	5.2 - 7.8	7.8 – 9.1	9.1 - 9.7
	Sinuosity	1.72	1.69	1.75	1.35	1.47	1.08
	Dominant Channel Habitat Unit Type	Pool	Pool	Pool	Pool / Riffle	Riffle	Riffle
	Average Bankfull Width (ft)	97	116.8	111	110.6	114.5	66
	Dominant Substrate	N/A	Gravel	Gravel	Gravel	Gravel	Gravel
	Gradient	0.10%	0.14%	0.21%	0.22%	0.47%	3.55%
Channel Habitat %	**Pool**	59%	70%	70%	38%	24%	44%
	Glide	29%	19%	26%	25%	29%	10%
	Riffle	12%	11%	4%	38%	46%	46%

NOTES:
Average Bankfull Width and Channel Habitat Unit Types surveyed in the field per (USFS, 2016.See Habitat Assessment for analysis and results (Appendix A).
Dominant Substrate characterized by ocular field observations.

3.1 REACH 1 (RM 0.5-1.35)

3.1.1 Overview

Reach 1 of the assessment area is 0.85 river miles long and extends from approximately RM 0.5 near the mouth of the Little Wenatchee River at its confluence with Lake Wenatchee up to RM 1.35. Throughout Reach 1, the river is a single-thread channel with a sinuosity of 1.72 and a reach gradient of 0.10%. Average bankfull width measured during the Habitat Assessment (Appendix A) of the channel is 97 feet.

The habitat in Reach 1 is dominated by extended slow water units, with 59% of the area surveyed as pool. The remaining was surveyed as glide (29%) and riffle (12%) units (Figure 17). Pool habitat in Reach 1 was generally deep, with a residual depth averaging nearly 9 ft. There were no connected side channels observed in Reach 1.

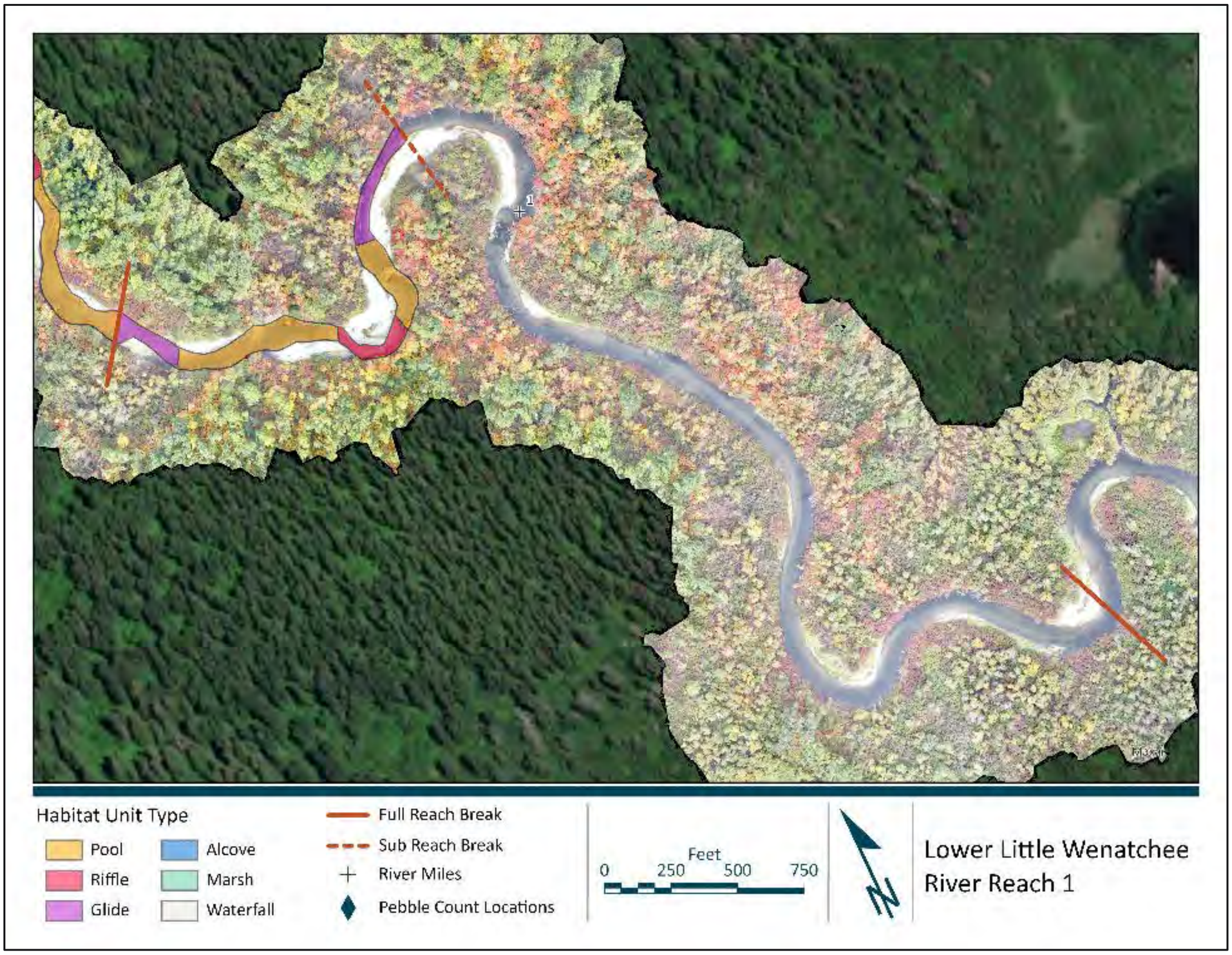

Figure 17. Salmonid habitat units mapped in Reach 1.

3.1.2 Channel and Floodplain Geomorphology

Reach 1 is influenced by Lake Wenatchee backwater during higher flows. Hydraulic analysis indicates the floodplain within the reach is well connected. Meander bend migration processes are dominate in this reach. As meander bends mature, they cutoff and form wetland slough habitats. While large wood can play a strong role in channel habitat and sediment transport it is currently less dominant in the reach and limited to localized habitat cover and pool scour. Substrate size is silt and sand dominate due to the backwater influence created by Lake Wenatchee. No pebble count was collected.

3.1.3 Vegetation and Large Woody Material

Reach 1 had a total of 36 pieces of LWM, the majority of which were classified as "small" (6 inches in diameter and at least 20 feet long) (Figure 18). A total of 8 medium and large pieces of LWM – referred to as "quality" large wood, large wood pieces that fall within the "medium" and "large" size classes ("medium" is considered at least 12 inches in diameter and at least 35 feet long; "large" is considered at least 20 inches in diameter and at least 35 feet long) – were recorded in Reach 1. No large wood jams were identified in Reach 1. Vegetation in the riparian area consisted of a relatively young seral stage overstory of alder, with an understory of dense sapling alder and dogwood.

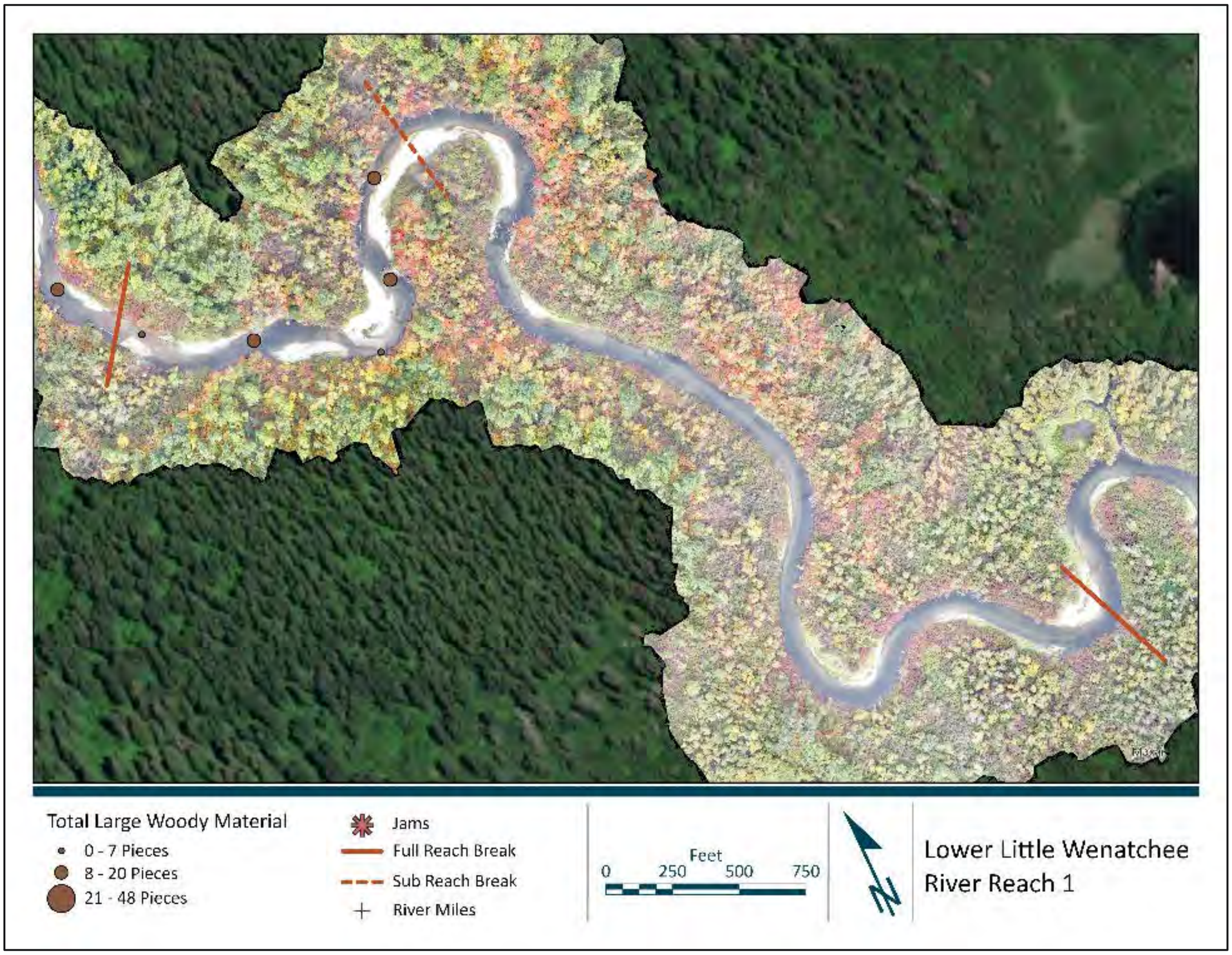

Figure 18. Large woody material observed in Reach 1 summarized by count of qualifying large wood pieces per channel habitat unit. LWM counts include all small, medium, and large size classes of wood.

3.1.4 Human Alterations

Little evidence of human alteration to the channel and floodplain are present in Reach 1 (Figure 19), with the exception of possible legacy impacts to riparian vegetation stand age and complexity resulting from historical timber harvest in the floodplain or adjacent hillslopes.

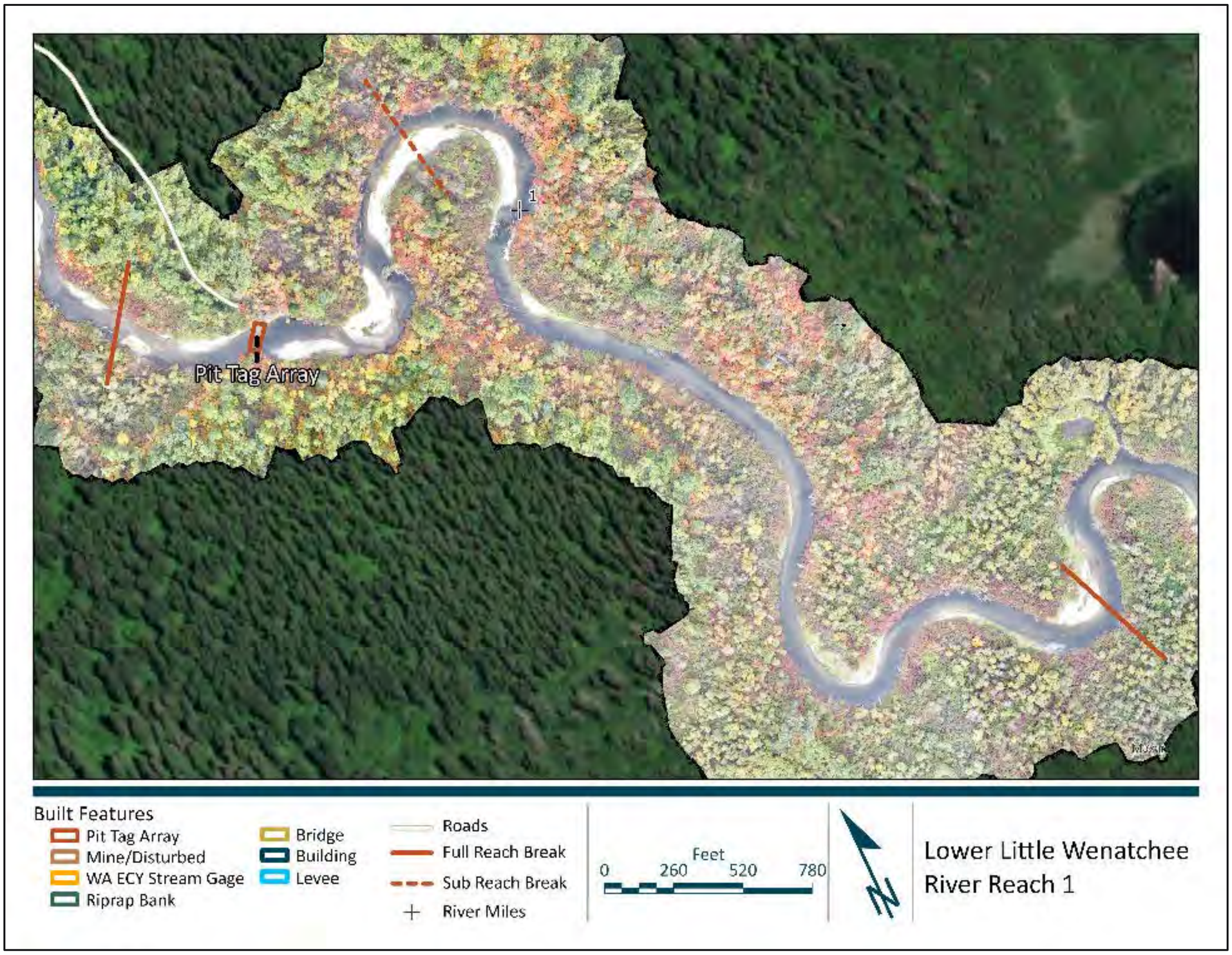

Figure 19. Human disturbance or built features mapped within the Reach 1 channel or floodplain.

3.2 REACH 2 (RM 1.35-3.5)

3.2.1 Overview

Reach 2 of the assessment area is 2.15 river miles long and extends from RM 1.35 to RM 3.5. Throughout Reach 2, the river is predominately a single-thread channel with a sinuosity of 1.69 and a reach gradient of 0.14%. Average bankfull width measured during the Habitat Assessment (Appendix A) of the channel is 118 feet.

Reach 2 has the highest proportion of pools compared to other reaches, with 60% of the mainstem Little Wenatchee within this reach classified as a pool unit. Glide habitat units accounted for 18% of the reach habitat, while side channel units were 12% of the reach area and riffle units only 10% (Figure 20). A total of 18 pools were counted in Reach 2, with a majority of the pools having a residual depth greater than 3 ft (89%). Side channels in Reach 2 were extensive, accounting for 12% of the reach area.

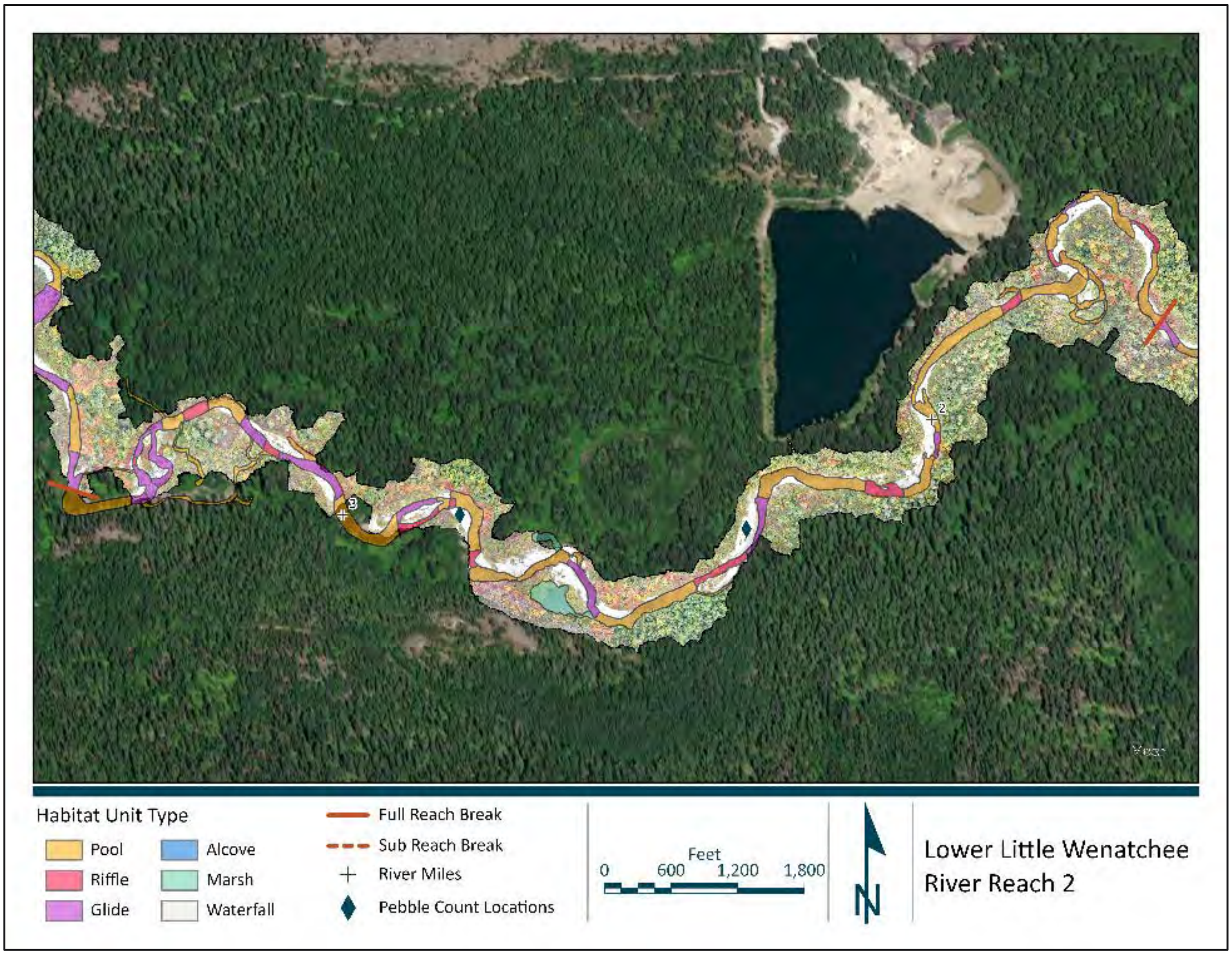

Figure 20. Salmonid habitat units mapped in Reach 2.

3.2.2 Channel and Floodplain Geomorphology

Hydraulic inundation analysis indicates the reach is well connected to the floodplain The reach is primarily outside of the influence of channel spanning wood deposits and dominated by channel migration and meander bend processes. As meander bends laterally eroded, they mature (become more sinuous), reducing local slope to the point that upstream sediment aggradation creates a meander bend cutoff, thereby increases slope, beginning the process anew. Several meander bend cutoffs have occurred throughout the valley bottom and these processes have historically dominated compared to anastomosing channel processes. The reach is in a stable sediment transport equilibrium within the continuum of local meander bend processes. Figure 21 displays pebble count data and a photo from a representative bar surface in the reach. Habitat created by large wood is localized and found within meander bends and on some gravel bar surfaces.

There is evidence of past logging activity in the reach and an active gravel mine operation within the channel migration zone. The logging activity has removed future large diameter tree reserves that are required to develop natural habitat as the river migrates. The active gravel mining operation will impact habitats in the future when the river migrates into the mine footprint. The primary impact will be the disruption of sediment transport and degradation in water quality. While mine capture is not imminent, it is likely to occur at some point in the future. Post mine reclamation and river capture prevention may avoid or mitigate impacts when the channel migrates nearer or into the mine footprint.

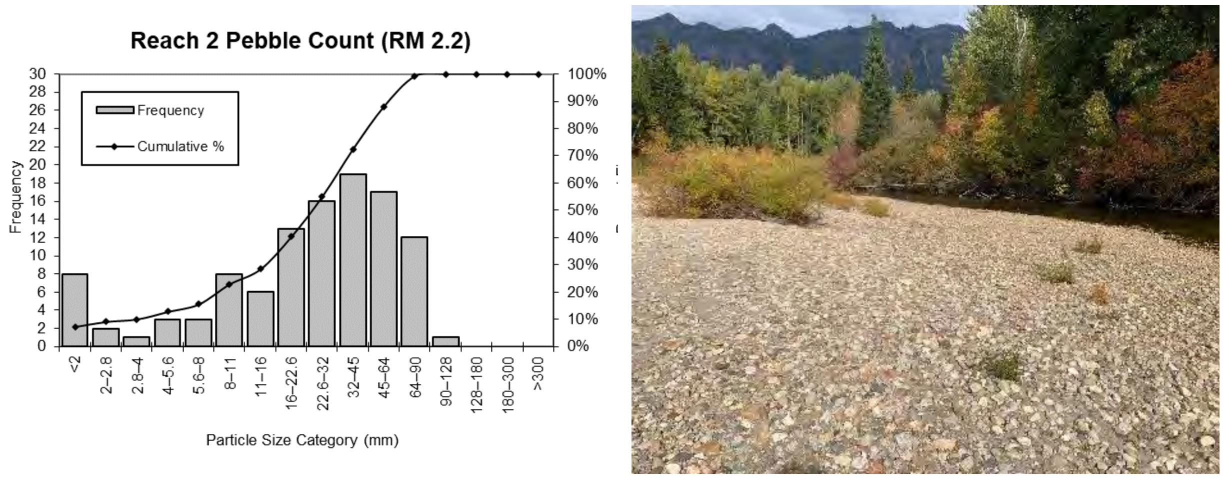

Figure 21: Reach 2 (RM 2.2) pebble count data and photo of sample location.

3.2.3 Vegetation and Large Woody Material

Reach 2 contained the greatest number of LWM pieces in the assessment area with 410 pieces (Figure 22), or approximately 264 pieces per mile. Over a third of those pieces were “quality” large wood: large wood pieces that fall within the “medium” and “large” size classes (“medium” is considered at least 12 inches in diameter and at least 35 feet long; “large” is considered at least 20 inches in diameter and at least 35 feet long). The dominant overstory class in Reach 2 was exclusively classified as large trees, mixed coniferous (Western red cedar) and deciduous (cottonwood). The dominant understory in Reach 2 was comprised of 50% sapling/pole (DBH = 5.0 – 8.9 in.) and 50% shrub/seedling (DBH = 1.0 – 4.9 in) size classes, with a wide variety of understory species observed. Vine maple accounted for 50% of understory species, and willow, dogwood, cottonwood, and alder each made up 13% of the dominant understory species within the riparian zone of Reach 2.

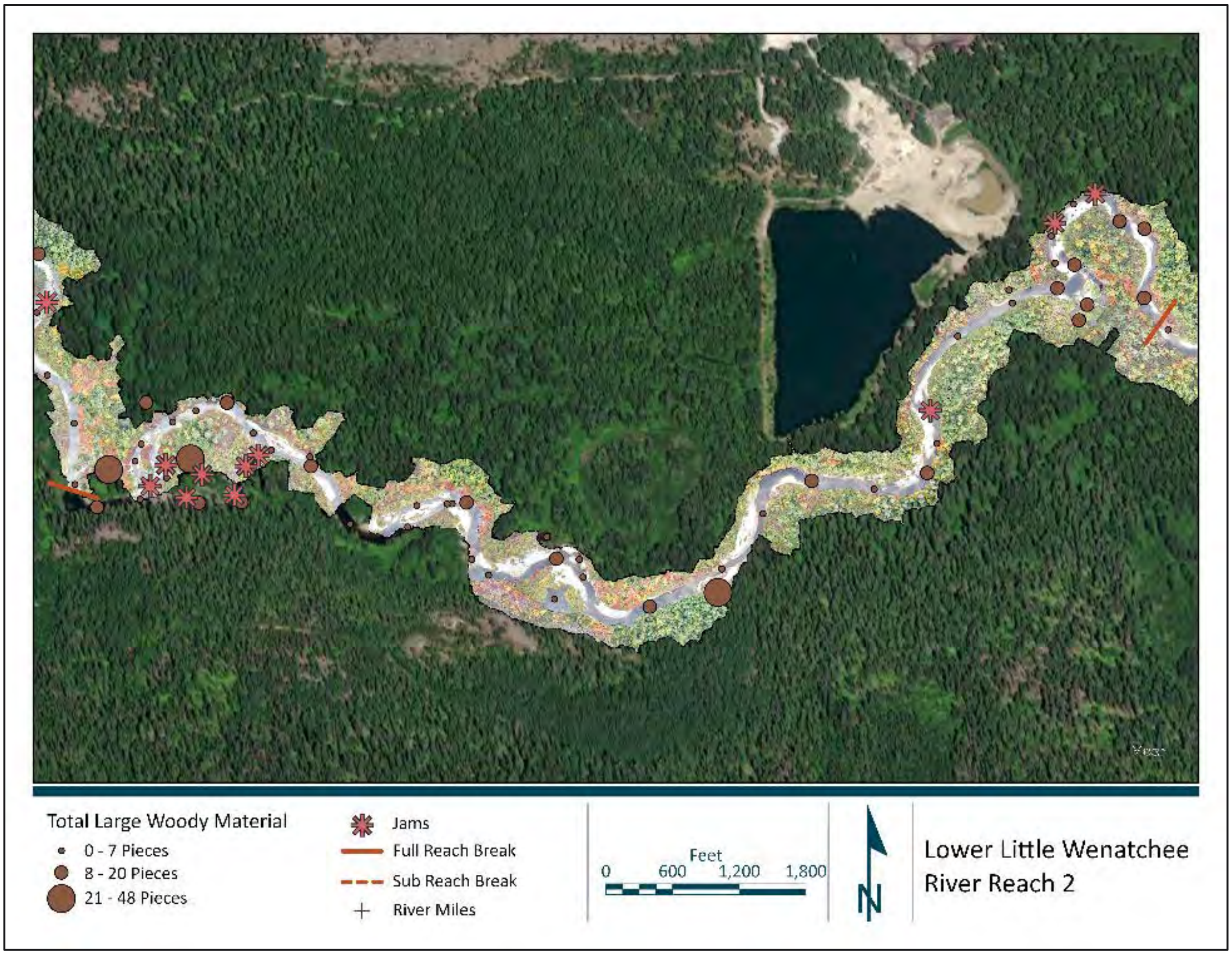

Figure 22. Large woody material observed in Reach 2 summarized by count of qualifying large wood pieces per channel habitat unit. LWM counts include all small, medium, and large size classes of wood.

3.2.4 Human Alterations

The floodplain of Reach 2 is the most impacted of all reaches in the assessment area due to the gravel mine located in the river-left floodplain between approximately RM 1.5 – 2.1 (in the lower half of the reach; Figure 23). Some evidence of historical timber harvest activities (e.g., road grades) were observed in the floodplain of Reach 2.

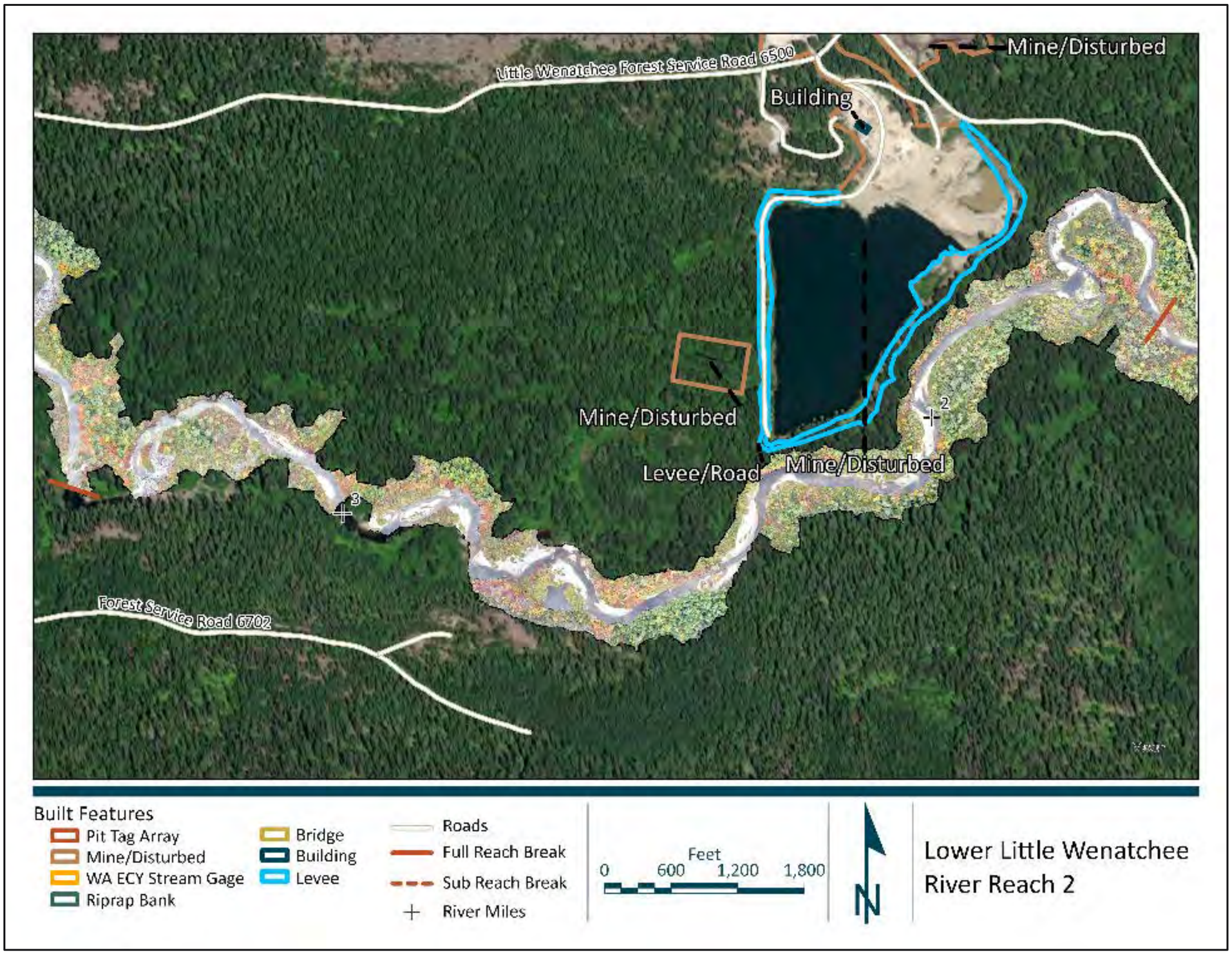

Figure 23. Human disturbance or built features mapped within the Reach 2 channel or floodplain.

3.3 REACH 3 (RM 3.5-5.2)

3.3.1 Overview

Reach 3 of the assessment area is 1.7 river miles long and extends from RM 3.5 to RM 5.2. Throughout Reach 3, the river is a predominately single-thread channel with a sinuosity of 1.75 and a reach gradient of 0.21%. Average bankfull width measured during the Habitat Assessment (Appendix A) of the channel is 114 feet.

Side channels accounted for 25% of the surface area in Reach 3, making it the reach with the highest proportion of off-channel habitat observed within the assessment area. Pools accounted for the vast majority of main channel habitat in Reach 3 (52%), with glides (19%) and riffles (3%) representing a much lower proportion (Figure 24). Of the 17 pools identified in the reach, 13 had a residual depth greater than 3 ft (76%), and 4 (24%) had residual depths less than 3ft.

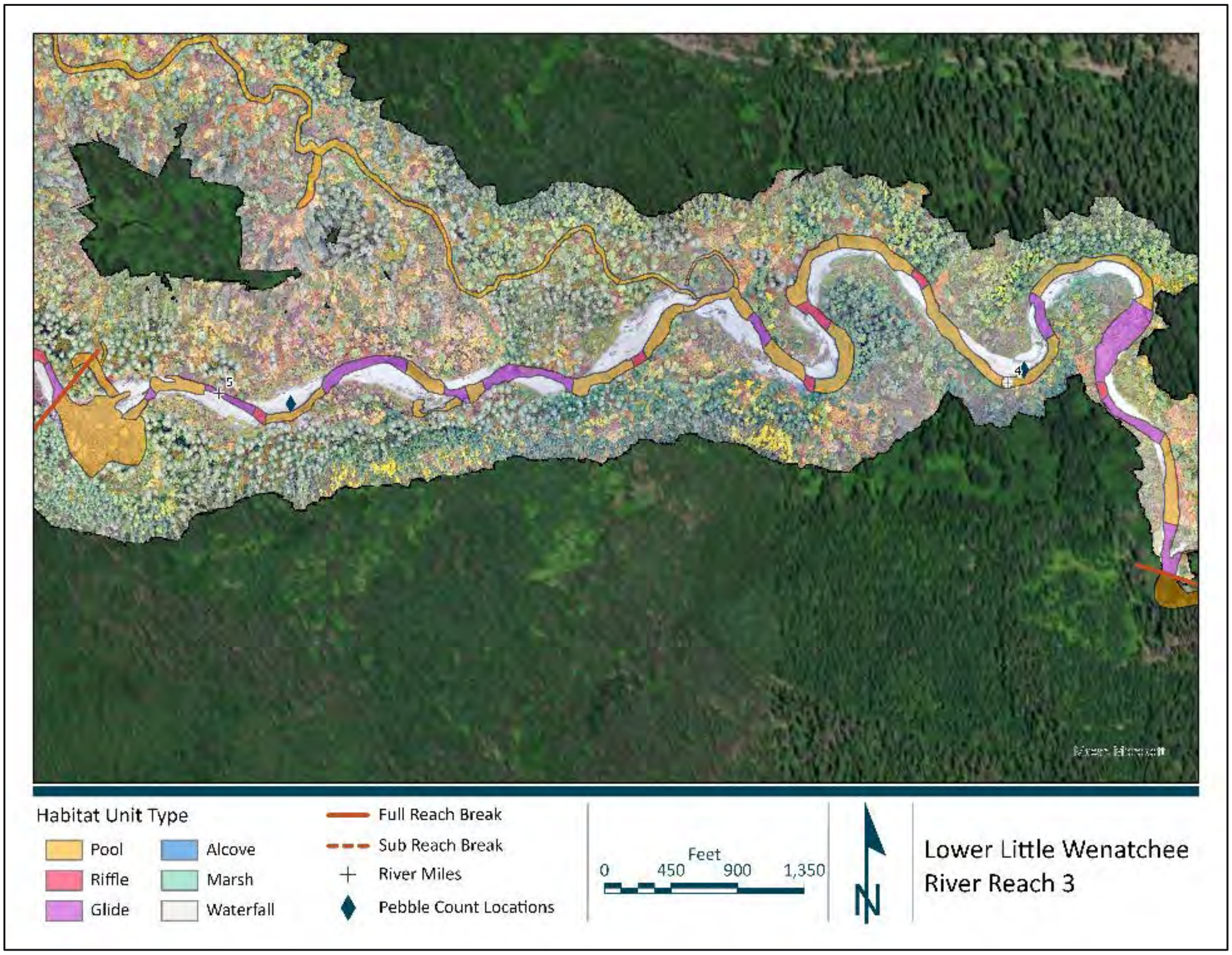

Figure 24. Salmonid habitat units mapped in Reach 3.

3.3.2 Channel and Floodplain Geomorphology

Hydraulic inundation analysis indicates the reach is well connected to the floodplain. The reach is influenced by both channel spanning wood deposits and channel migration and meander bend processes similar to Reach 2. Although the reach is dominated by meander bend processes, a large channel spanning wood deposit has created and maintained an anastomosing channel network on the north side of the valley bottom.

The reach is in a stable sediment transport equilibrium within the continuum of local meander bend processes and anastomosing channel processes. Figure 25 displays pebble count data and a photo from a representative bar surface in the reach. Within the larger geomorphic processes described above, localized large wood habitat exists throughout the reach. Habitat created by large wood is found within meander bends and on some gravel bar surfaces.

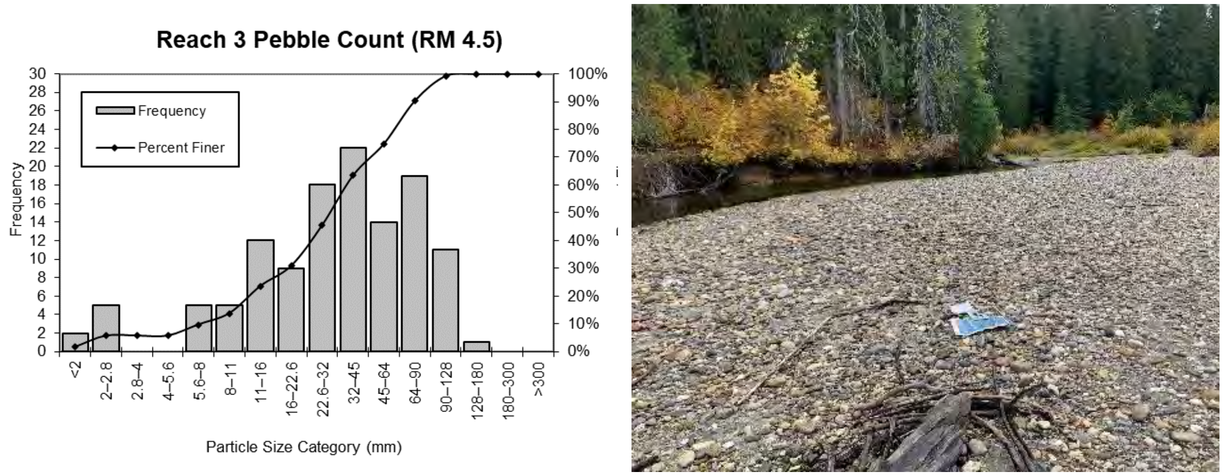

Figure 25: Reach 3 (RM 4.5) pebble count data and photo of sample location.

3.3.3 Vegetation and Large Woody Material

Reach 3 also contained the highest volume of LWM per mile in the assessment area with 301 pieces per mile, nearly half of which were in the "Medium" and "Large" size classes (Figure 26; "medium" is considered at least 12 inches in diameter and at least 35 feet long; "large" is considered at least 20 inches in diameter and at least 35 feet long). Four substantial large wood jams were identified in Reach 3. The dominant observed overstory size classes in Reach 3 were large trees (86%) and mature trees (14%). Cottonwoods accounted for 86% of overstory species in Reach 3, with cedar made up the remaining 14%. Shrub/seedlings were the dominant understory class throughout Reach 3, and were primarily vine maples (43%), dogwood (29%), and willow (29%).

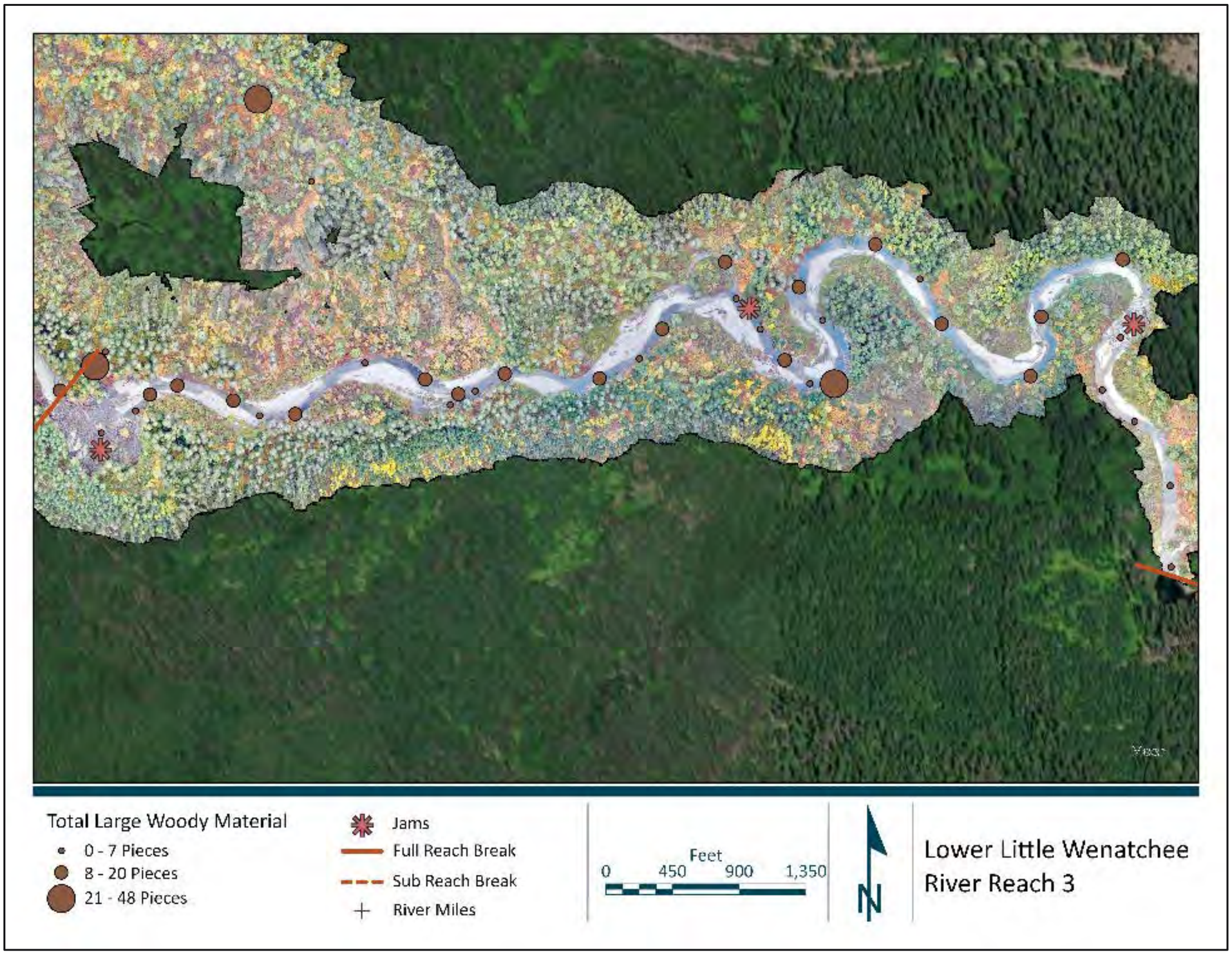

Figure 26. Large woody material observed in Reach 3 summarized by count of qualifying large wood pieces per channel habitat unit. LWM counts include all small, medium, and large size classes of wood.

3.3.4 Human Alterations

Little evidence of human alteration to the channel and floodplain are present in Reach 3 (Figure 27), with the exception of legacy impacts to riparian vegetation stand age and complexity, and potential future large wood recruitment by the channel, resulting from historical timber harvest in the floodplain or adjacent hillslopes.

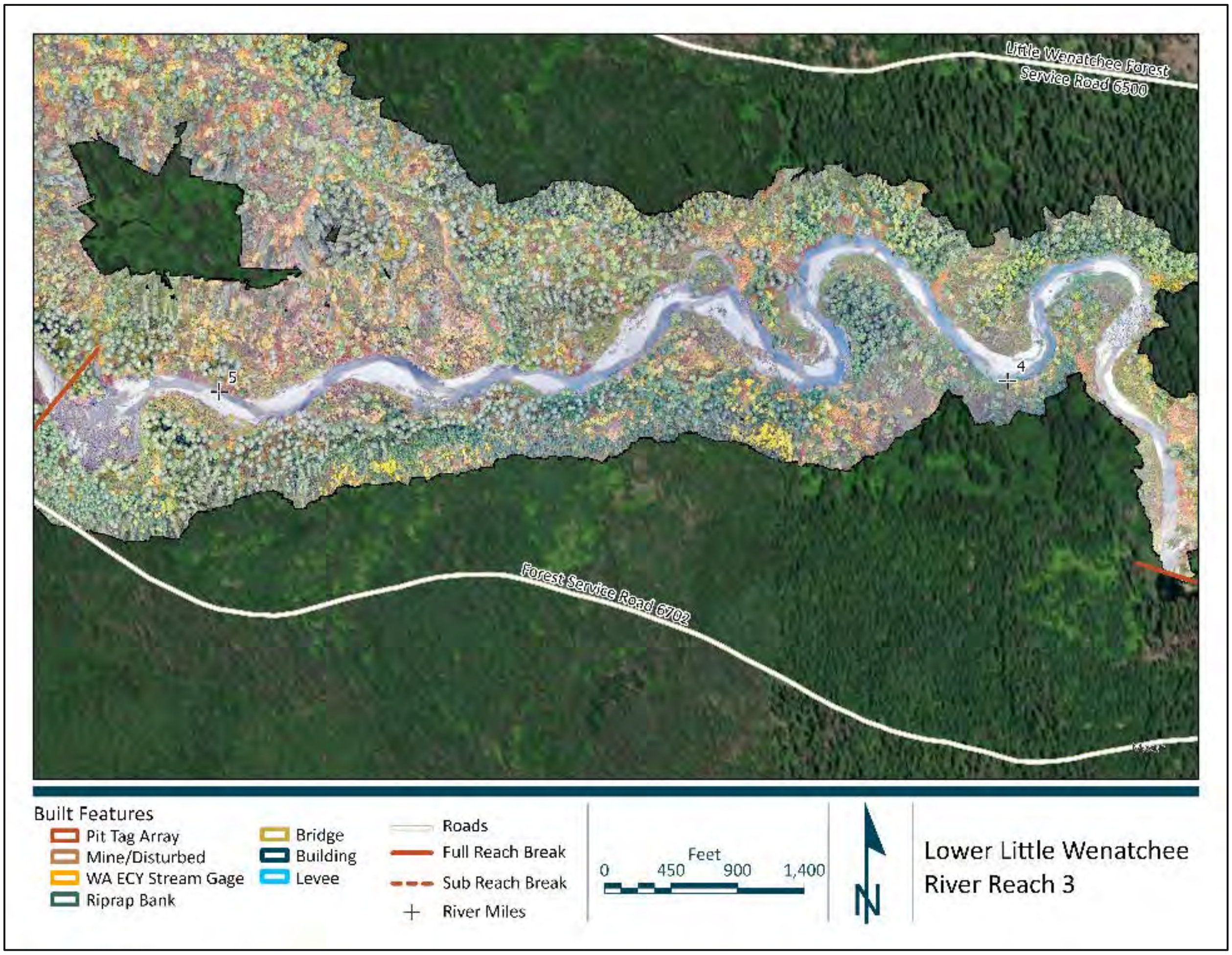

Figure 27. Human disturbance or built features mapped within the Reach 3 channel or floodplain.

3.4 REACH 4 (RM 5.2-7.8)

3.4.1 Overview

Reach 4 of the assessment area is 2.6 river miles long and extends from RM 5.2 to RM 7.8. Throughout Reach 4, the river is a predominately multi-thread channel with a sinuosity of 1.35 and a reach gradient of 0.22%. Average bankfull width measured during the Habitat Assessment (Appendix A) of the channel is 125 feet.

The habitat area in Reach 4 was nearly evenly split between fast and slow water habitat types (Figure 28). Riffles and glides accounted for 51% of habitat area in Reach 4 (31% and 20%, respectively). Pools and side channels accounted for the remaining habitat area (31% and 18%, respectively). Of the 17 pools identified, 9 had a residual depth greater than 3 ft (69%), and 4 (31%) had residual depths less than 3ft. Side channels in Reach 4 were largely limited to the lower half of the reach, and all of them were categorized as slow water units.

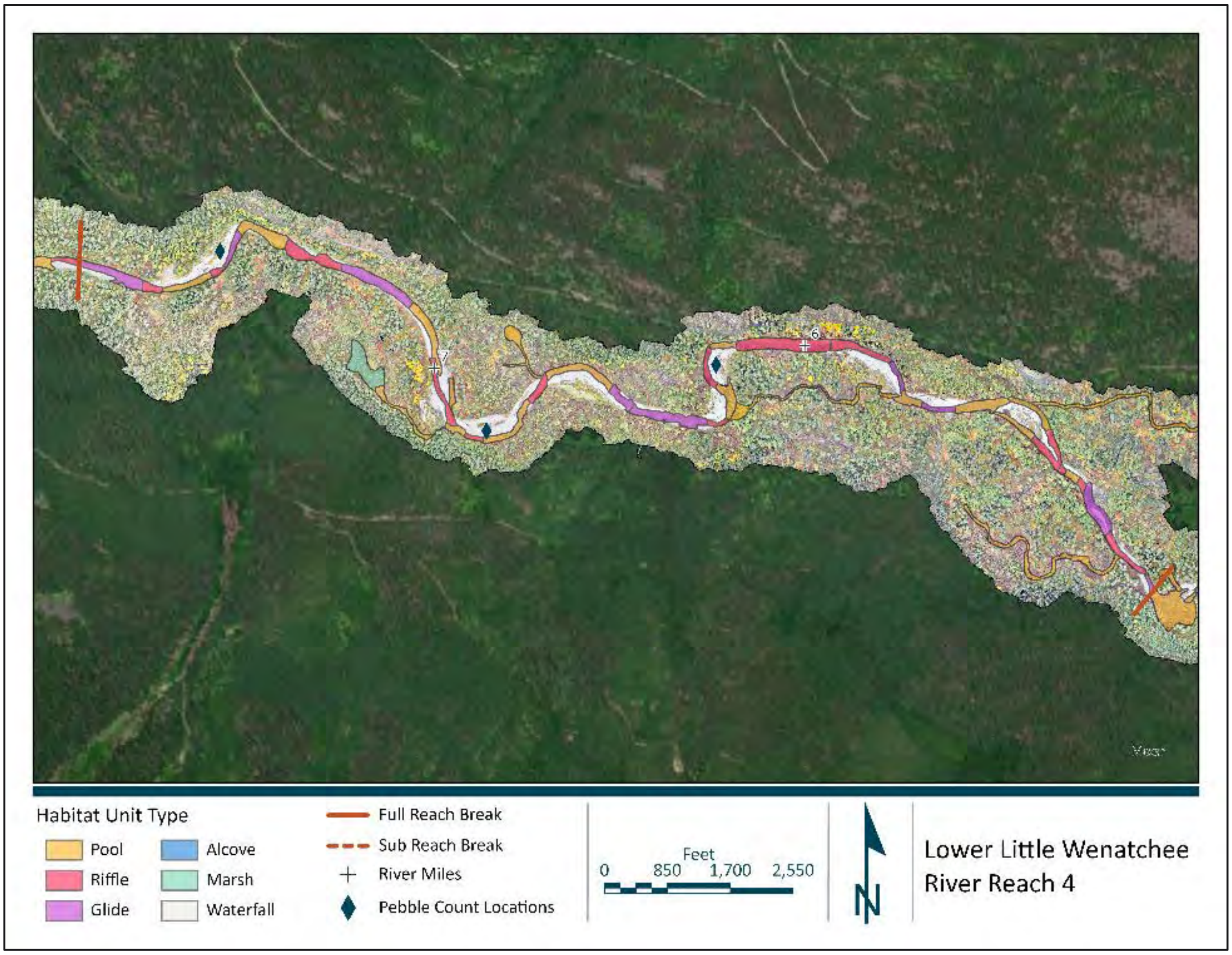

Figure 28. Salmonid habitat units mapped in Reach 4.

3.4.2 Channel and Floodplain Geomorphology

Hydraulic inundation analysis indicates the reach is well connected to the floodplain. In contrast to Reaches 1-3, Reach 4 is dominated by channel spanning large wood deposits that create backwater conditions supporting anastomosing channel networks. Anastomosing channel networks with Reach 4 are capable of avulsing back and forth across the valley as wood accumulates or degrades over time within large channel spanning deposits.

The reach is in a stable sediment transport equilibrium within the continuum of local meander bend processes and anastomosing channel processes. Figure 29 displays pebble count data and a photo from a representative bar surface in the reach. Within the larger geomorphic processes described above, localized large wood habitat exists throughout the reach. Localized habitat created by large wood is also found within meander bends and on some gravel bar surfaces.

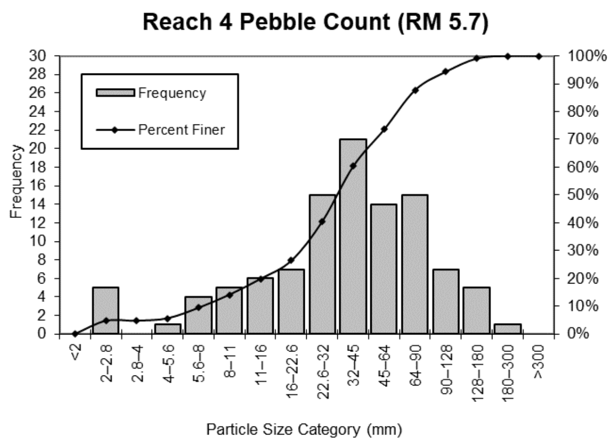

Figure 29: Reach 4 (RM 5.7) pebble count data and photo of sample location.

3.4.3 Vegetation and Large Woody Material

Reach 4 contained 281 pieces of large woody material (Figure 30), with approximately half in the "Medium" and "Large" categories. There were 8 log jams identified in Reach 4, many of which were smaller than the jams observed in Reaches 2 and 3. The dominant observed overstory size classes in Reach 4 were large trees (86%) and small trees (14%). Cottonwoods accounted for 86% of overstory species in Reach 4, with cedar made up the remaining 14%. Shrub/seedlings accounted for 57% of the understory class, with sapling/pole size class making up the remaining 43%. Cottonwood made up 57% of the understory species, with dogwood accounting for 29%, and alder making up the remaining 14%.

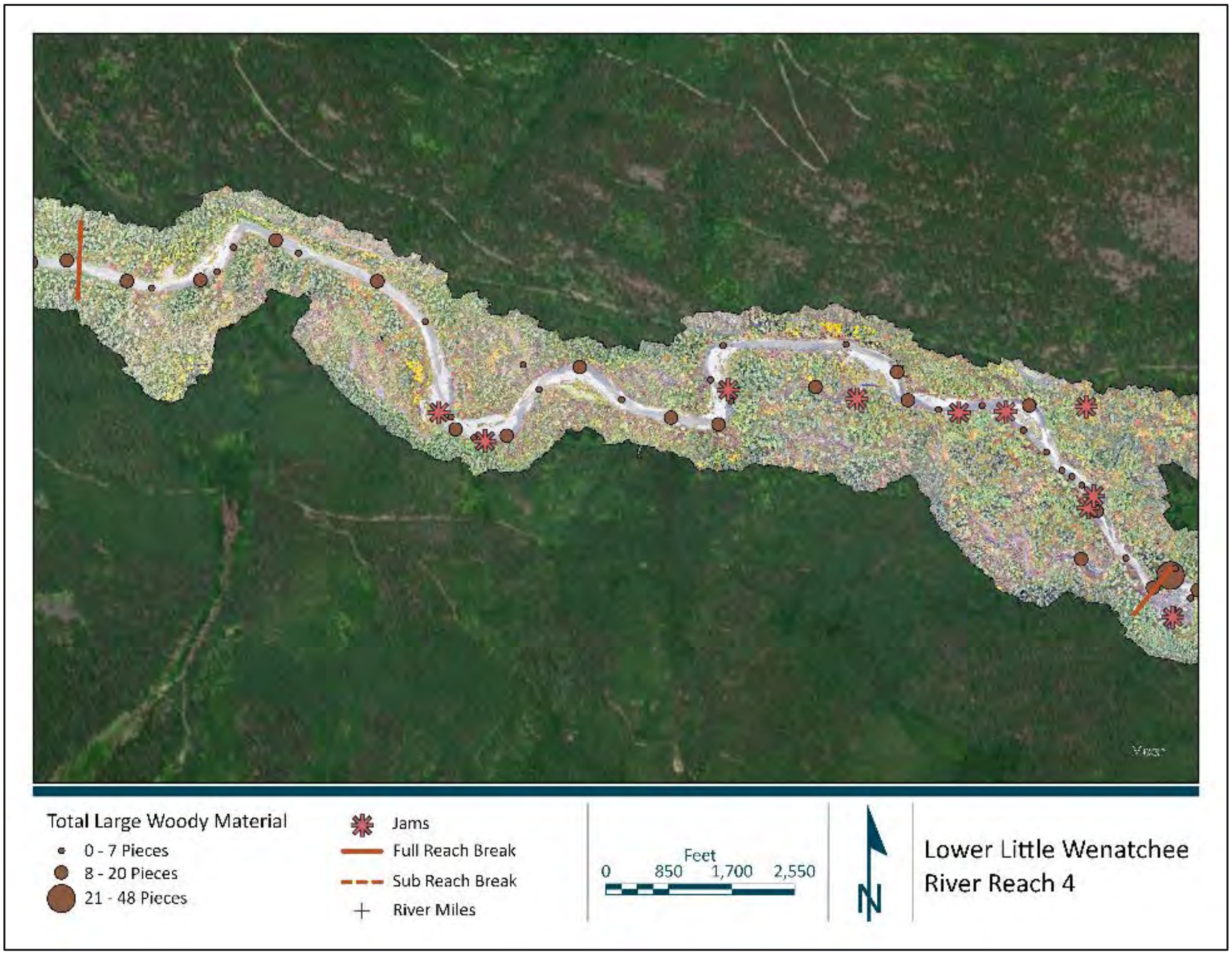

Figure 30. Large woody material observed in Reach 4 summarized by count of qualifying large wood pieces per channel habitat unit. LWM counts include all small, medium, and large size classes of wood.

3.4.4 Human Alterations

Little evidence of human alteration to the channel and floodplain are present in Reach 4 (Figure 31), with the exception of legacy impacts to riparian vegetation stand age and complexity, and potential future large wood recruitment by the channel, resulting from historical timber harvest in the floodplain or adjacent hillslopes.

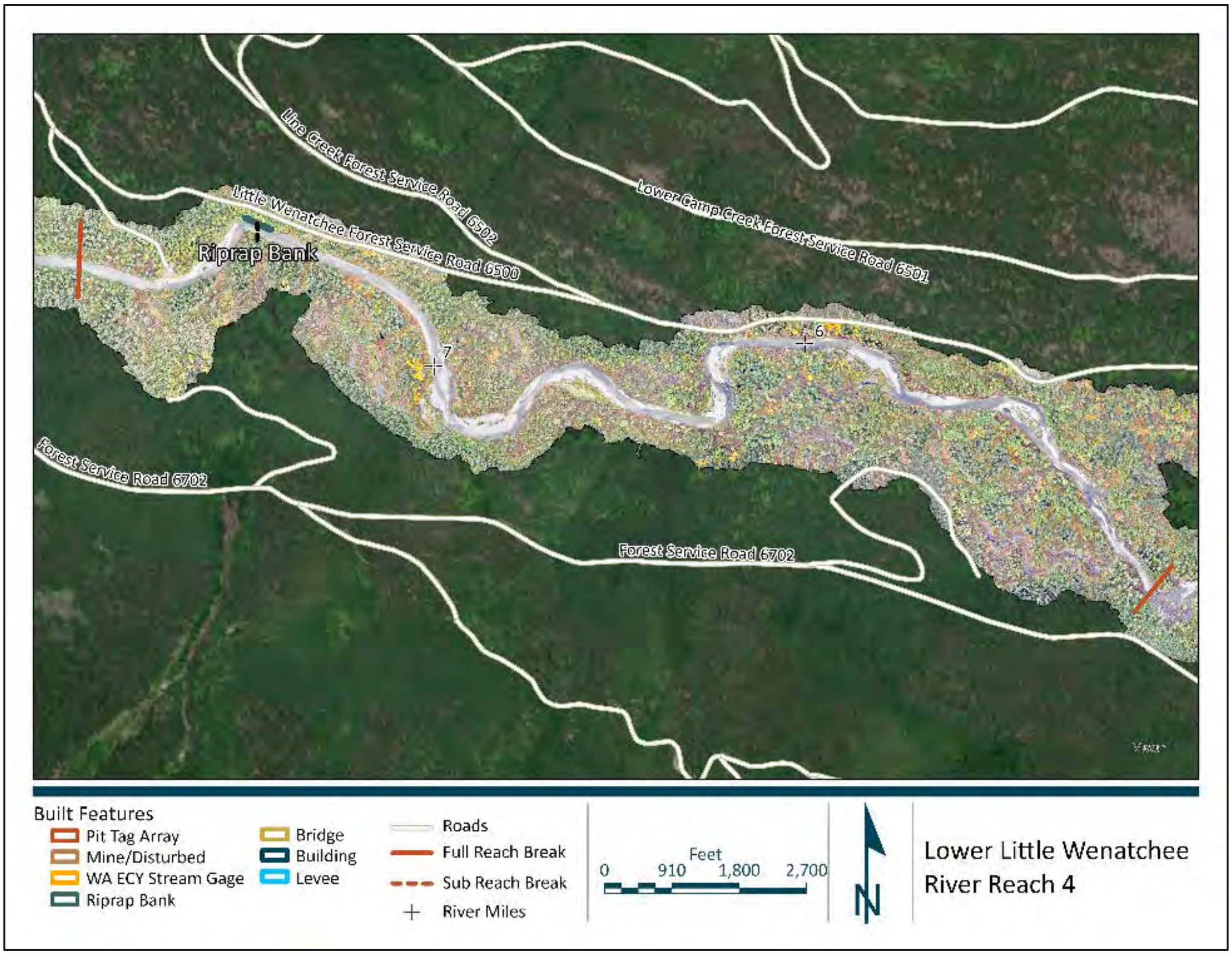

Figure 31. Human disturbance or built features mapped within the Reach 4 channel or floodplain.

3.5 REACH 5 (RM 7.8-9.1)

3.5.1 Overview

Reach 5 of the assessment area is 1.3 river miles long and extends from RM 7.8 to RM 9.1. Throughout Reach 5, the river is predominately a somewhat confined, single-thread channel with a sinuosity of 1.47 and a reach gradient of 0.47%. Average bankfull width measured during the Habitat Assessment (Appendix A) of the channel is 98 feet.

The habitat area in Reach 5 is dominated by fast water habitat, with 46% of the area surveyed as riffles and 29% as glides, with only 24% categorized as pools and no side channels identified (Figure 32). Of the 5 pools identified, only 2 had a residual depth greater than 3 ft (40%), and 3 (60%) had residual depths less than 3ft.

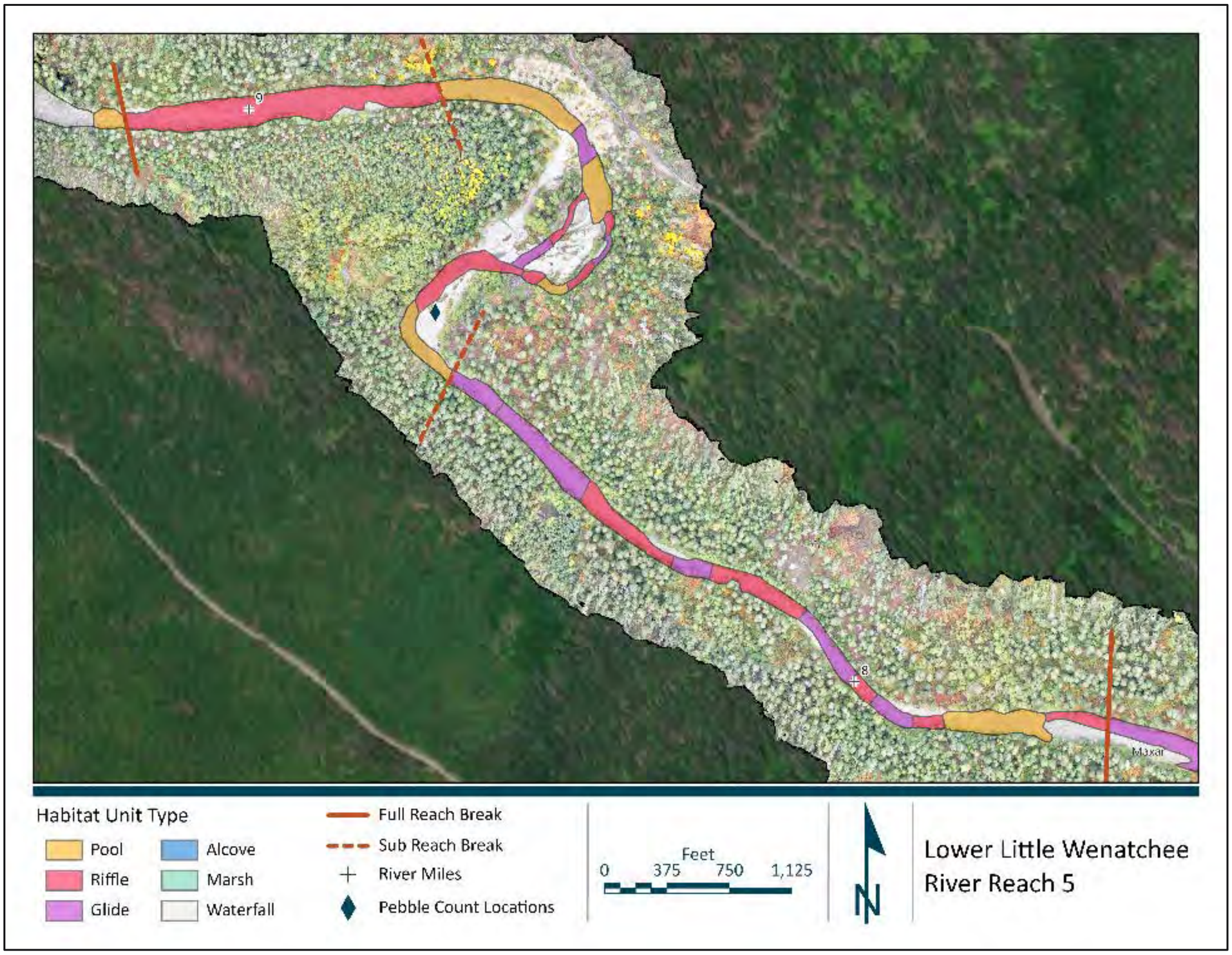

Figure 32. Salmonid habitat units mapped in Reach 5.

3.5.2 Channel and Floodplain Geomorphology

Reach 5 from a bedrock fish barrier downstream to Reach 4, is comparatively less responsive, steeper and a more transport driven reach. Within much of Reach 5, alluvial fan processes have impinged on the valley floor. A glacial outwash deposit flanked by two smaller alluvial fans have been eroded laterally through time, forming a 100-foot eroding embankment adjacent to USFS 6500 road. Downstream, the channel is locally braded but quickly becomes a relatively steep and more confined transport dominate channel. As fan impingements lessen and the valley widens local slope lowers and transitions into the alluvial response reaches previously described from Reach 4 downstream to Reach 1.

Large wood processes are less dominate in Reach 5 and concentrated within a braided channel segment downstream of the 100-foot eroding embankment (terrace). Here, large wood processes are possible and exist in areas with lower stream power on bars and against eroding banks. The reach is in a stable sediment transport equilibrium and could be considered transport dominant in terms of both sediment and large wood. Reach 5 is steeper and more easily transports both sediment and large wood to flatter downstream reaches that respond to delivery of both sediment and wood.

Figure 33 displays pebble count data and a photo from a representative bar surface in the reach. The bimodal nature of the pebble count is the result of the predominantly fine-grained nature of the eroding outwash deposit immediately upstream.

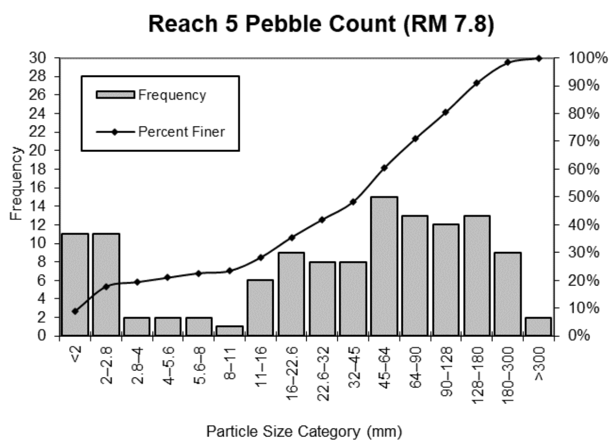

Figure 33: Reach 5 (RM 7.8) pebble count data and photo of sample location.

3.5.3 Vegetation and Large Woody Material

Reach 5 contained 189 pieces of large woody material (Figure 34), with nearly 40% of the recorded LWM in the "Medium" and "Large" categories. There was one log jam identified in Reach 5. The Reach 5 overstory included both coniferous and deciduous species (predominately Western red cedar and alders) of varying size classes: mature trees (40%), large trees (20%), and sapling/poles (40%). The understory was primarily sapling/poles (60%), with shrub/seedlings (20%) and small trees (20%) accounting for the remaining understory. Dominant understory species were dogwood (40%), willow (40%) and alder (20%).

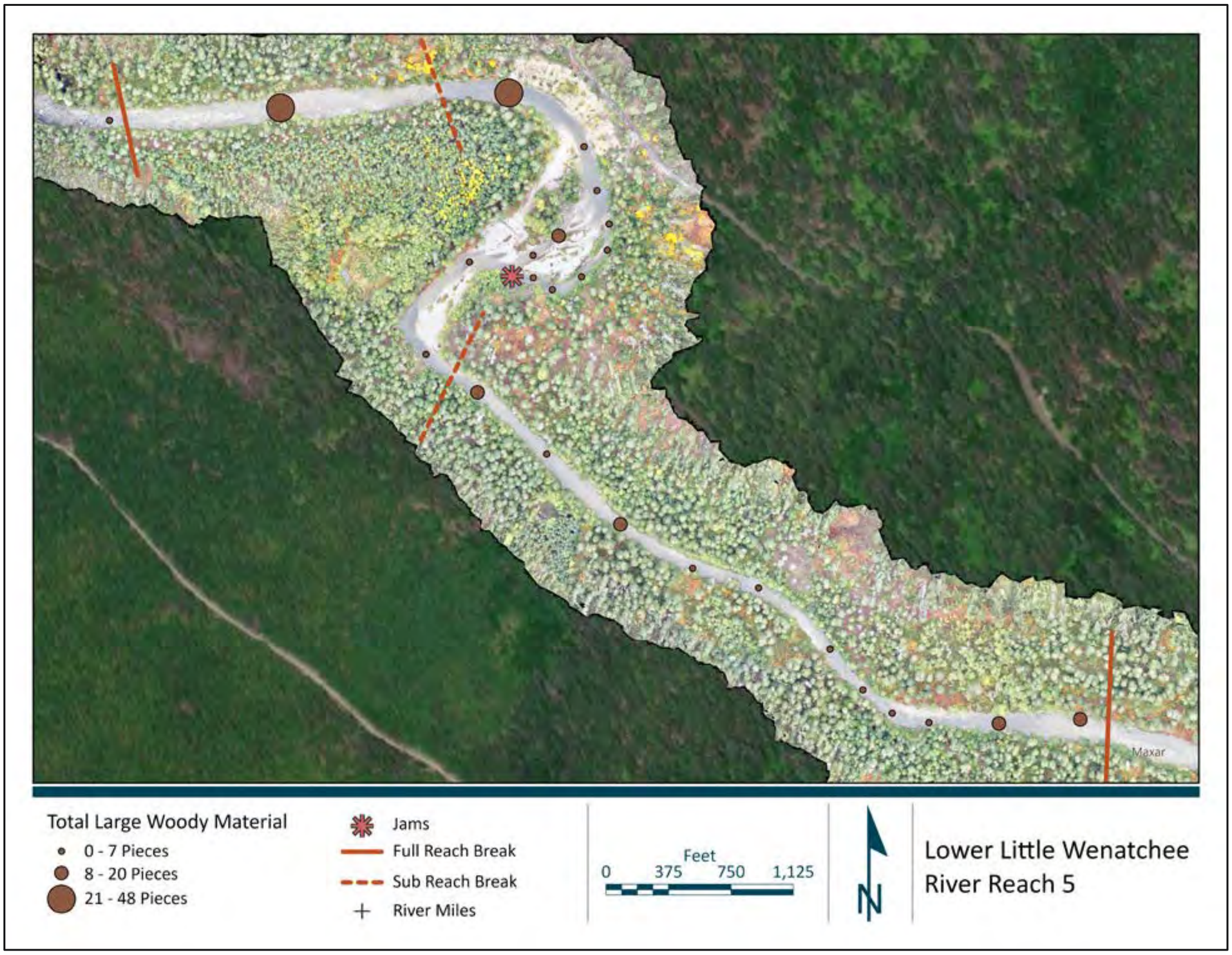

Figure 34. Large woody material observed in Reach 5 summarized by count of qualifying large wood pieces per channel habitat unit. LWM counts include all small, medium, and large size classes of wood.

3.5.4 Human Alterations

Little evidence of human alteration to the channel and floodplain are present in Reach 5 (Figure 35), with the exception of legacy impacts to riparian vegetation stand age and complexity, and potential future large wood recruitment by the channel, resulting from historical timber harvest in the floodplain or adjacent hillslopes.

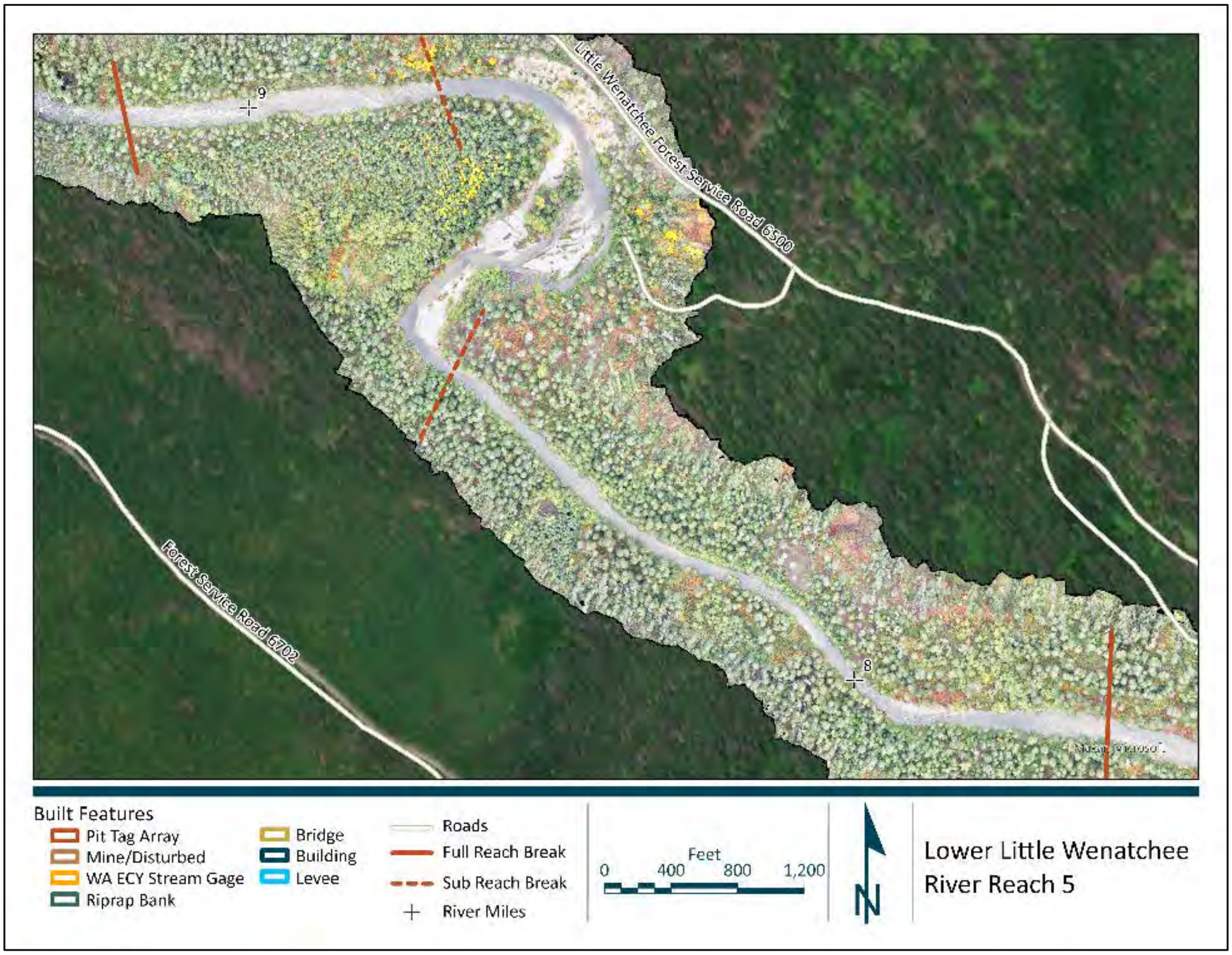

Figure 35. Human disturbance or built features mapped within the Reach 5 channel or floodplain.

3.6 REACH 6 (RM 9.1-9.7)

3.6.1 Overview

Reach 6 of the assessment area is 0.6 river miles long and extends from just below the falls at RM 9.1 to RM 9.7. Throughout Reach 6, the river is a confined single-thread channel with a sinuosity of 1.08 and a reach gradient of 3.55%. The natural waterfall is assumed to be a fish migration barrier under most circumstances; WDFW includes the falls as a natural barrier with unknown barrier status and fish passability in the SalmonScape Fish Passage interactive mapping tool (accessed online at apps.wdfw.wa.gov/salmonscape/map.html). Average bankfull width measured during the Habitat Assessment (Appendix A) of the channel is 66 feet.

The habitat area in Reach 6 was nearly evenly split between fast and slow water habitat types. Riffles and glides accounted for 56% of habitat area, while pools comprised the remaining 44% of habitat area (Figure 36). Of the 4 pools identified, half had a residual depth greater than 3 ft (50%), and the remaining two had residual depths less than 3ft. No side channels were identified in Reach 6.

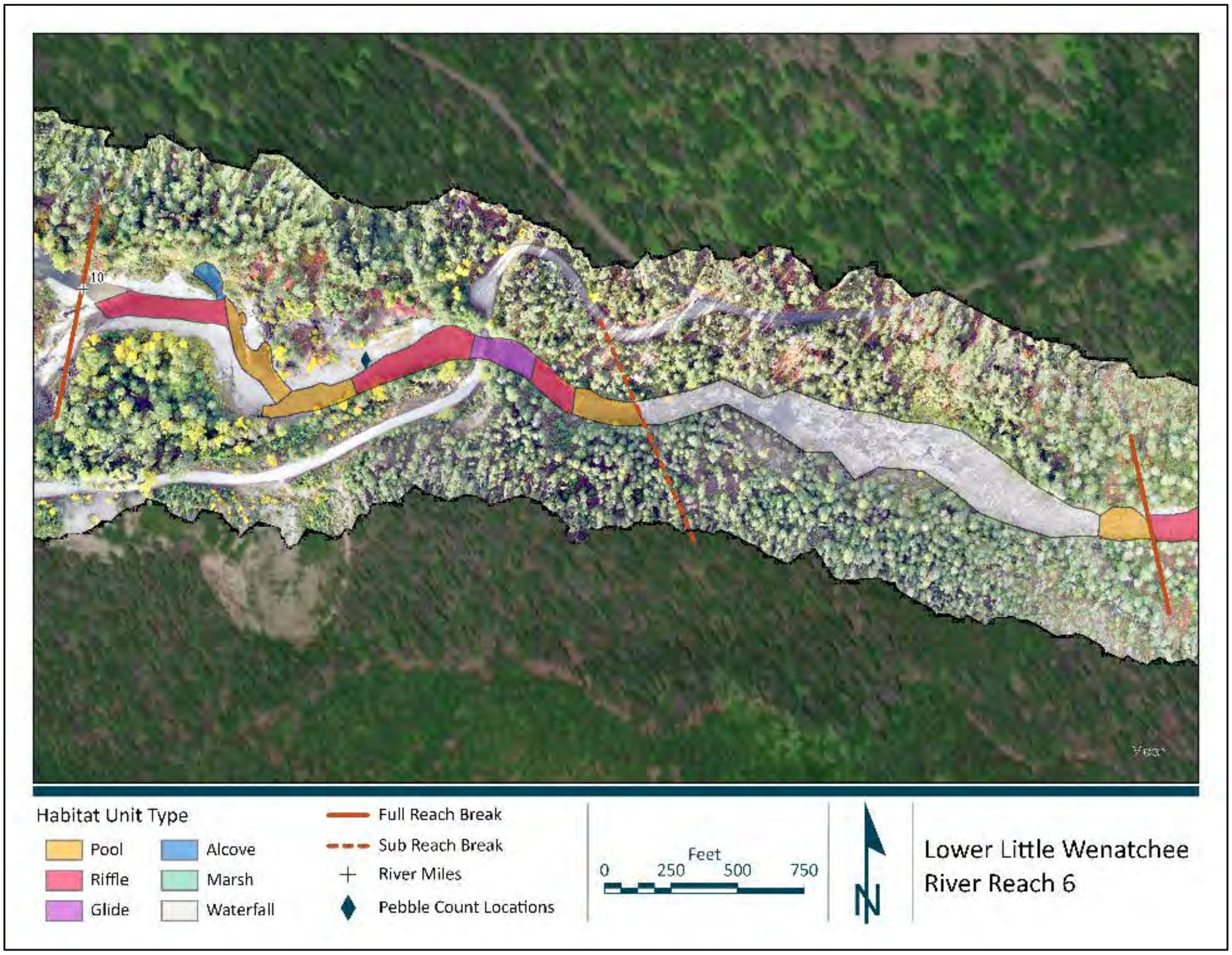

Figure 36. Salmonid habitat units mapped in Reach 6.

3.6.2 Channel and Floodplain Geomorphology

Reach 6 includes a bedrock canyon that is impassible to all fish species. The channel runs over bedrock and can readily transport alluvial sized substrate and smaller sized wood that may enter the channel. Upstream of the USFS 6500 bridge the channel has characteristics similar to those found in Reach 4. Channel spanning large wood deposits have developed and a complex anastomosing channel pattern exists upstream of the last assessment unit. The alluvial channel segment upstream of the bedrock canyon is in a stable sediment transport equilibrium within the continuum of anastomosing channel and large wood processes. Figure 37 displays pebble count data and a photo from a representative bar surface in the reach.

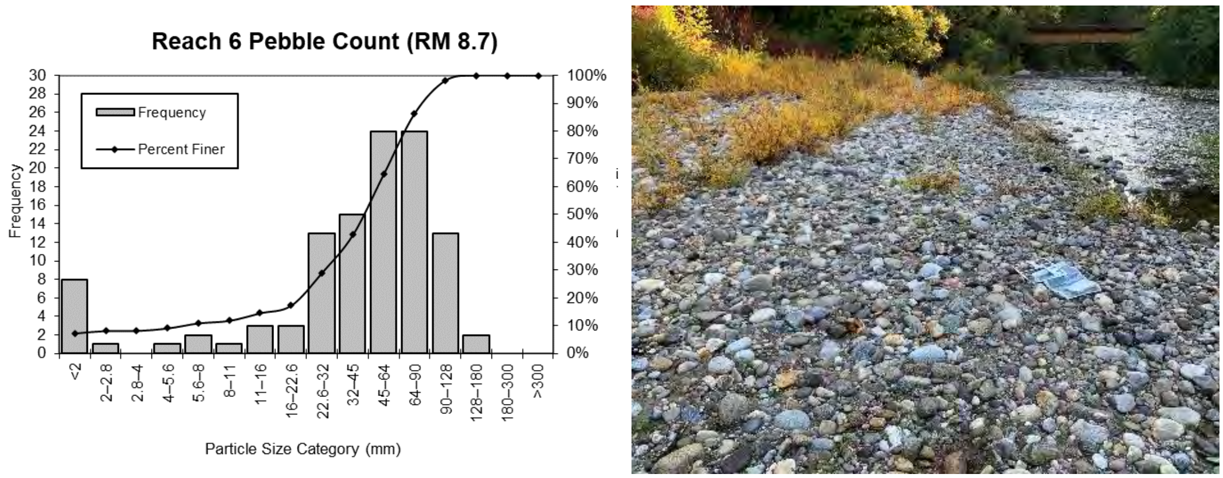

Figure 37: Reach 6 (RM 8.7) pebble count data and photo of sample location.

3.6.3 Vegetation and Large Woody Material

Reach 6 contained the least amount of LWM among all the reaches, with only 24 pieces recorded (Figure 38). A single log jam identified was in Reach 6. The riparian vegetation was assessed in two nth units, and the in the overstory was entirely comprised small western hemlocks (100%) and the understory was comprised of entirely alder shrub seedlings (100%).

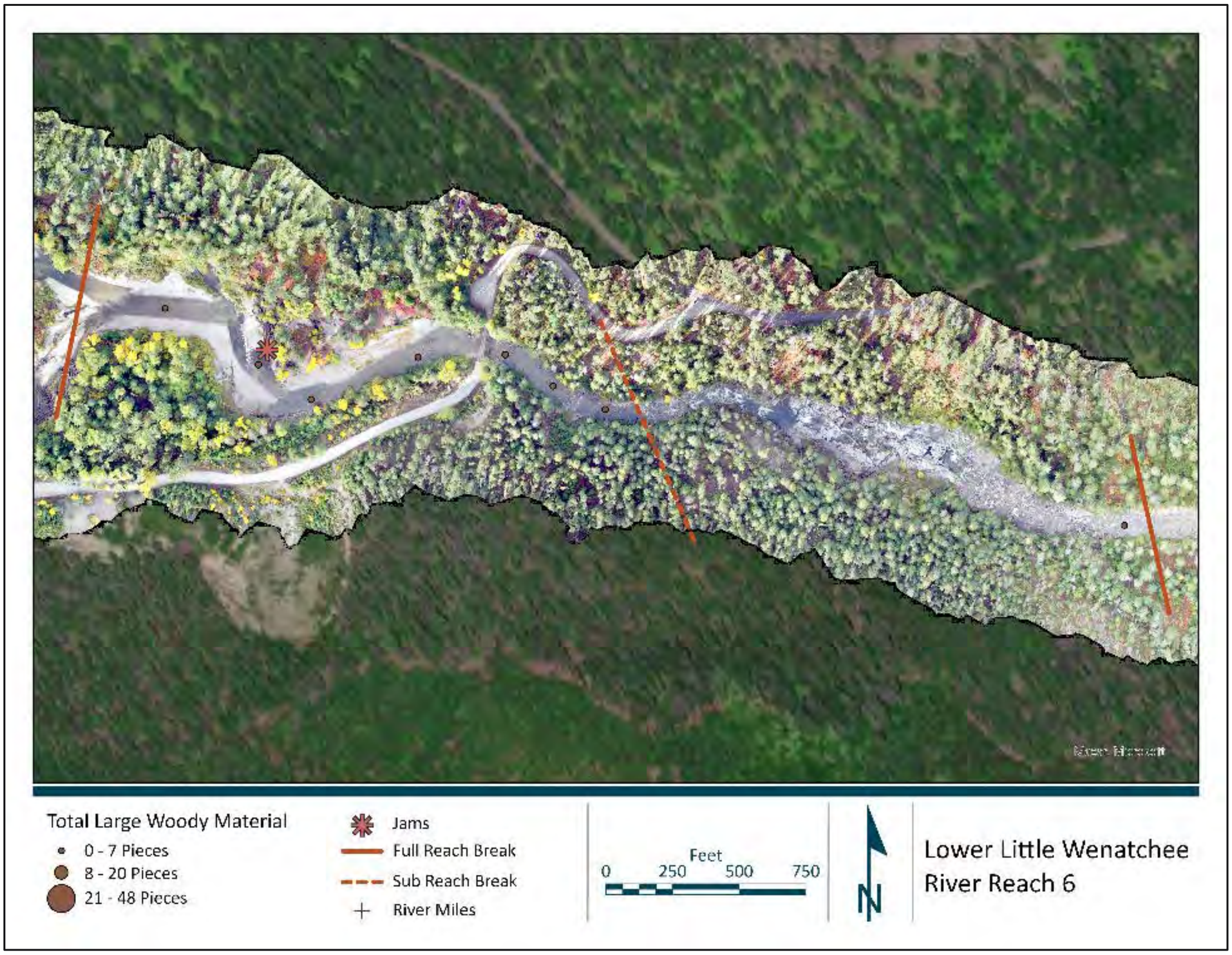

Figure 38. Large woody material observed in Reach 6 summarized by count of qualifying large wood pieces per channel habitat unit. LWM counts include all small, medium, and large size classes of wood.

3.6.4 Human Alterations

Some evidence of human alteration to the channel and floodplain are present in Reach 6 as a result of the Little Wenatchee Road bridge over the channel and riprap associated with the road. Other legacy impacts in this reach include impacts to riparian vegetation stand age and complexity, and potential future large wood recruitment by the channel, resulting from historical timber harvest, campground use and road building. Riprap has been placed in the channel to protect a walk-in campground site located on the river-left floodplain just upstream from the bridge.

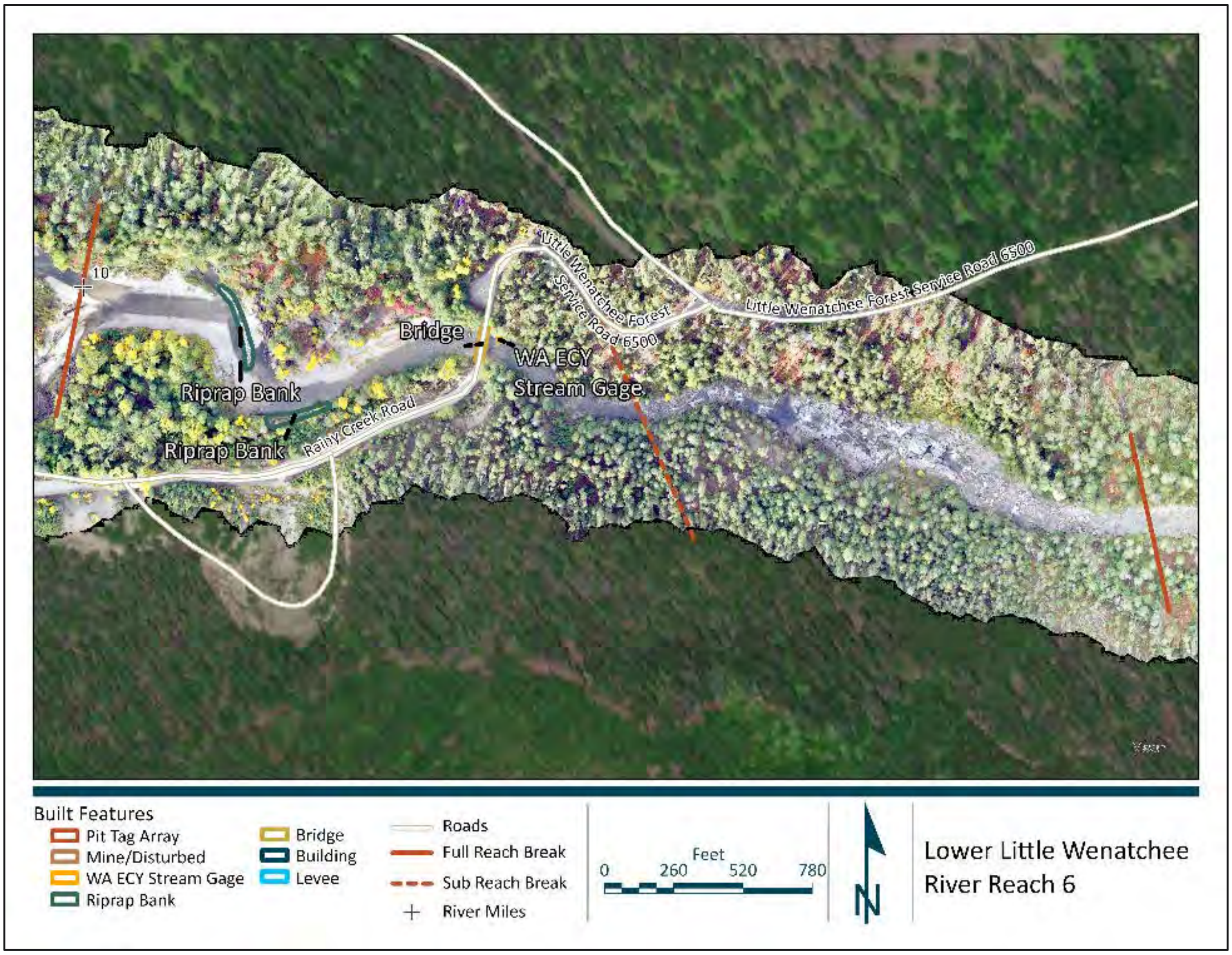

Figure 39. Human disturbance or built features mapped within the Reach 6 channel or floodplain.

4. Restoration Strategy

4.1 INTRODUCTION

The Restoration Strategy uses the field surveys, inventories, and analyses performed in the Reach Assessment (Sections 1-4) as the technical basis for identifying and prioritizing restoration actions. Opportunities are focused in areas with anadromous access downstream of a fish barrier between Reach 5 and 6. The intent is to provide a direct linkage between the technical analyses, identified limiting factors, and the actions that are moved forward towards implementation. For each reach, existing and target conditions are compared based on the habitat survey and REI analysis, which helps to identify the types of actions that need to be performed. Other factors are also considered, including the potential for the site to support the focal species and whether or not it is possible to address the root causes of impairments.

The Restoration Strategy describes the potential restoration opportunities identified in the assessment area to address salmonid limiting factors. Planform concept maps are included for each project area below the descriptions.

4.2 PROJECT OPPORTUNITIES

Projects were identified through field surveys and analysis performed in the Reach Assessment. Project elements were identified that are believed to best achieve target conditions and to address key factors limiting ESA-listed spring Chinook and steelhead populations and improve their habitat conditions in the Lower Little Wenatchee River. These projects represent an initial first step in this process; it is expected that projects will be modified as appropriate once project-specific surveys, analysis, and stakeholder coordination are performed as part of design. Reach-scale project descriptions and maps are provided in the subsections below.

Much of the study area is in very good condition and in many areas arguably representative of historical conditions or analog conditions restoration practitioners may strive to emulate elsewhere. The degree of valley and anastomosing channel inundation shown in the 2-year return discharge hydraulic model illustrates a high degree of channel floodplain connectivity. Large scale channel spanning log jams play a large role in maintain side channels by backwatering flows upstream into anastomosing channel networks. Evidence of very old channel spanning log jams and/or their geomorphic signatures throughout the valley bottom provides evidence that side channels and complex anastomosing channels were strongly controlled by large log jams development likely going back centuries.

On a smaller scale, natural wood accumulations that develop on gravel bars provide local habitat and are important drivers of lateral channel migration that incorporates standing large trees into the active channel. The trees eroded into the channel during lateral migration either create new habitats on site or are transported downstream into larger deposits (other apex jams or channel spanning jams). Apex wood does not backwater channel segments to the degree that the larger channel spanning log jams do, but are very influential in driving channel migration and providing low and high flow habitat complexity where they exist.

Although much the study area is in very good condition, there has been logging within the valley bottom. The removal of large trees within the meander corridor has taken from the reserve needed to continue future large wood habitat processes in affected parts of the valley bottom. To make up for that loss, there are opportunities to enhance habitat and wood processes by emulating natural apex wood structures, pulling over large trees into the channel and in one instance emulate a large-scale wood deposit to enhance anastomosing channels during high down to base flow discharge. Access to implement potential projects with ground-based equipment varies. In some cases, projects that are not accessible with ground-based equipment but could can be constructed with a heavy lift helicopter. Project opportunities are presented below and are organized within the context of assessment reach breaks presented in previous report segments.

4.2.1 Reach 1

Reach one has no feasible ground-based access due to private property and wetland conditions. However, it would be possible to enhance cover habitat and provide greater structural components to the channel by flying in imported large wood. Greater structural complexity provided by the wood will improve local pool depth and complex cover habitat. The degree of lift within this area would be less than other reaches for two reasons. The first, is because Lake Wenatchee backwaters the majority of this channel segment at all flows so slow water refuge is already very high. Second, the lake backwater has created very slow channel deformation and this has allowed riparian dogwood and willow to overhang the channel margins creating excellent cover habitat. Therefore, most of the helicopter placed habitat enhancement opportunity is in the upstream segment of the reach in a zone of diminished Lake Wenatchee backwater influence.

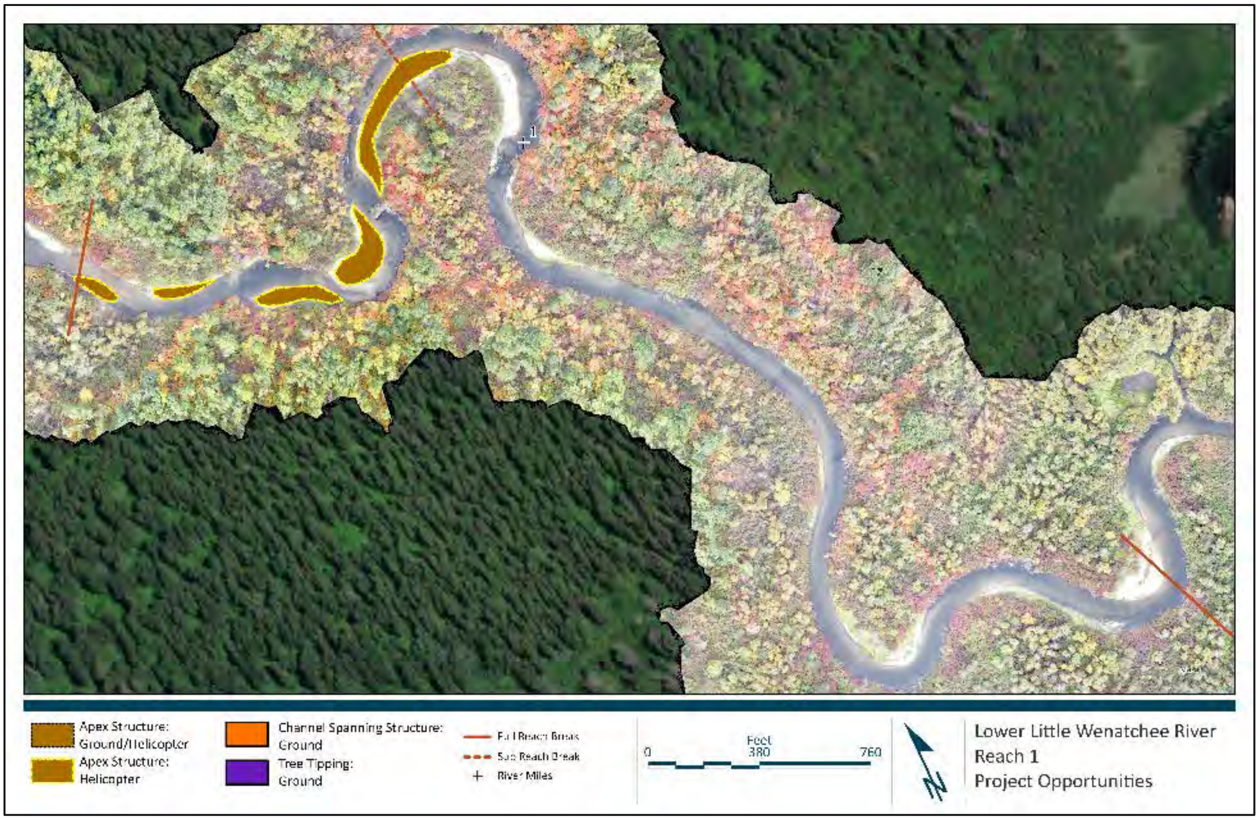

Figure 40. Reach 1 habitat enhancement opportunities.

4.2.2 Reach 2

Reach two is well suited for bar apex large wood structures that would enhance natural wood process. Imported and constructed apex jams would provide cover and channel complexity at high flows and increase lateral bank migration that would incorporate adjacent natural vegetation creating complex pool and cover habitat during both high and low flows. Reach two does not have easy access for ground-based equipment and while access could be constructed, it would require a significant length of vegetative disturbance and some vegetation removal within the valley bottom to allow temporary excavator access. While possible, it would require a greater degree of impact analysis by the United States Forest Service USFS (landowner). As an alternative, it would also be possible to build apex large wood structures using a heavy lift helicopter. While the structures would be mobile, they could be designed to resist movement up to moderate flows (5-year return interval and less). If ground-based equipment access is established, the apex structures could be designed and constructed for stability greater than the 25-year return discharge. Large wood structures are not proposed near or adjacent to the active gravel mine that lies within the reach.

Figure 41. Reach 2 habitat enhancement opportunities.

4.2.3 Reach 3

The opportunities within Reach Three are helicopter based only and are very similar to those in Reach Two. Bar apex wood structures can be helicopter constructed to enhance lateral bank migration, incorporate native trees in the channel and create complex low and high flow fish habitat. Reach 3 is bracketed by large channel spanning log jam complexes at the upstream and downstream terminus of the reach and complex wetland side channels between the valley walls. Due to the complex wetland channels withing this segment of the valley bottom, establishing equipment access is not recommended. Based on our field observations and experience ground-based activity would be very difficult in Reach 3 and cause impacts to wetlands that would likely far exceed justification for them. While the reach is poorly suited for ground-based construction, it is well suited for heavy lift helicopter construction.

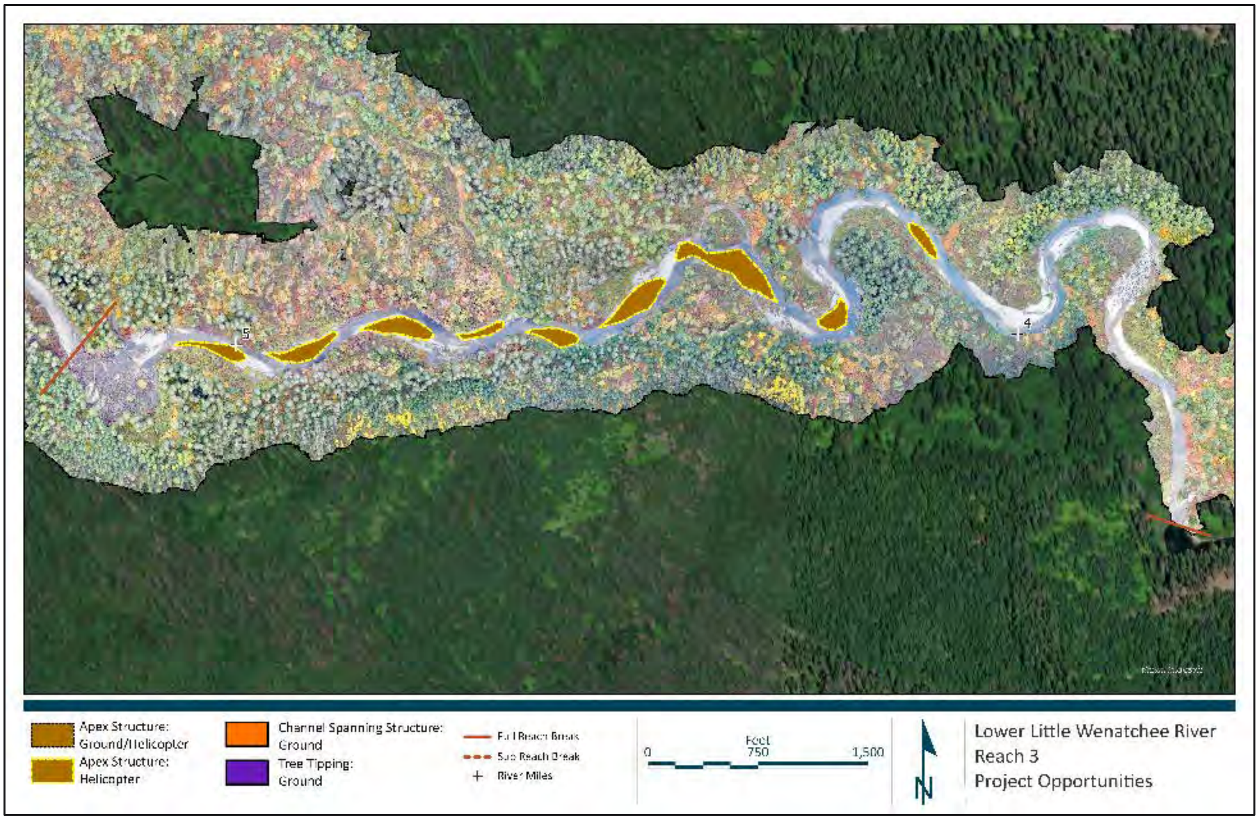

Figure 42. Reach 3 habitat enhancement opportunities.

4.2.4 Reach 4

Reach four opportunities can be organized into three project types. They are bar apex structures, tree pullover and one large-scale large wood structure. The bar apex structure opportunities are similar in scale to those proposed for downstream. Structures would be constructed on existing bar surfaces and provide high flow habitat while enhancing bank migration into forested areas to create natural high and low flow habitat as trees are eroded into the channel. While difficult, it would be possible to establish access into some of the proposed apex structures. Helicopter construction is also possible on all structures.

The second project type in the reach are tree pullover projects. Tree pullover projects use a mobile yarder to tie off and physically pull large diameter trees over using the power of the yarder and leverage created by attaching the yarder cable high in the tree. Access is required to position the yarder close enough to be successful in reaching individual trees. To be viable and function in a river the size of the Little Wenatchee, large diameter trees should be used. Large diameter trees within yarder reach of the USFS 6500 road exist in two locations. Future discussion with USFS will determine whether this type of project type is viable and if so, what trees could be used.

The final project type identified in the reach is a large-scale large wood structure. The structure emulates a large-scale log jam development found within the project reach. In those locations large wood deposits split flow and create anastomosing channel conditions by backwatering flows significant distances upstream. The objective of the project would create a large enough log jam to backwater flows into the inlet of a long anastomosing channel complex. Feeding more water into this segment of floodplain would create better low and moderate flow access for salmonids. A project such as this emulates what has/is occurring within the valley bottom. The inlet to the side channel could be opened up to improve flow or left to function in its current condition. This project type would be best undertaken using ground-based equipment in order to maximize the chance to achieve the objectives previously outline. In order to backwater into the side channel inlet at high flows the structure will likely require extensive piles and be quite high in profile (similar to natural jams downstream). It is possible to place apex bar large wood in the same location with a helicopter, but it is unlikely to meet objectives due to the scale and stability required to improve upstream side channel inlet flows. The challenge using a helicopter is due to the size of wood that can be flown, the scale and stability required of the structure to back flows into the upstream side channel and the river power of the Little Wenatchee (flyable wood mobility is high).

Ground based access is possible but difficult. Access appears best upstream of the project area directly off of the USFS road running along the north side of the valley. The drop down into the valley bottom is significant and will likely require a significant volume of temporary fill and/or side hill cut to ramp down the slope and safely track large excavators downhill to the valley bottom. Once there, access across the river will be required either with a bridge or live water crossing. A combination ground-based construction and access coupled with helicopter large wood delivery could also be employed to minimize impacts.

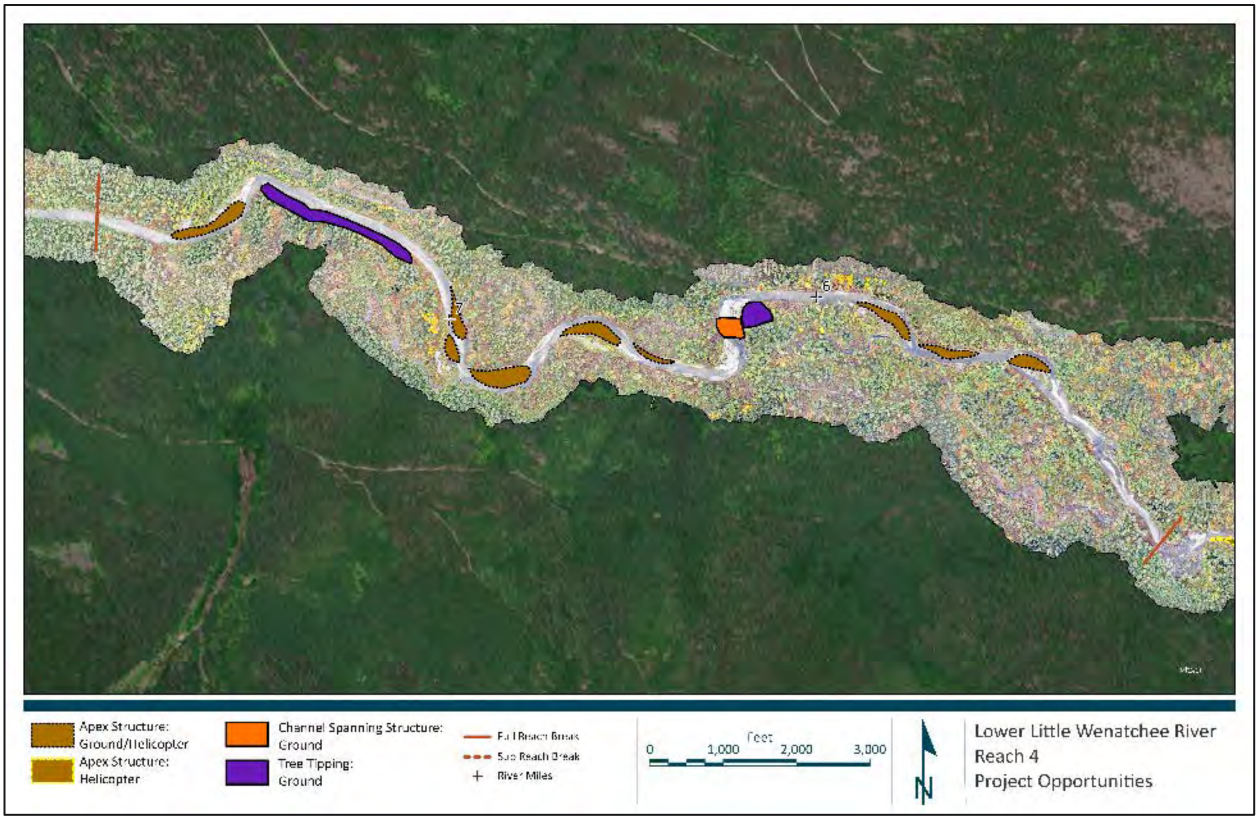

Figure 43. Reach 4 habitat enhancement opportunities.

4.2.5 Reach 5

Based on hydraulic model analysis, most of Reach 5 is a wood transport reach and does not lend itself well to large wood deposition and natural wood-based habitat. However, at the upstream segment of the reach the Little Wenatchee a braided channel type exists and is a naturally large wood depositional area. Here, bar apex structures could be constructed to enhance habitat at all flows. Ground-based access is possible from abandoned but still existing logging road prisms. The site is also well suited to construction using a heavy lift helicopter.

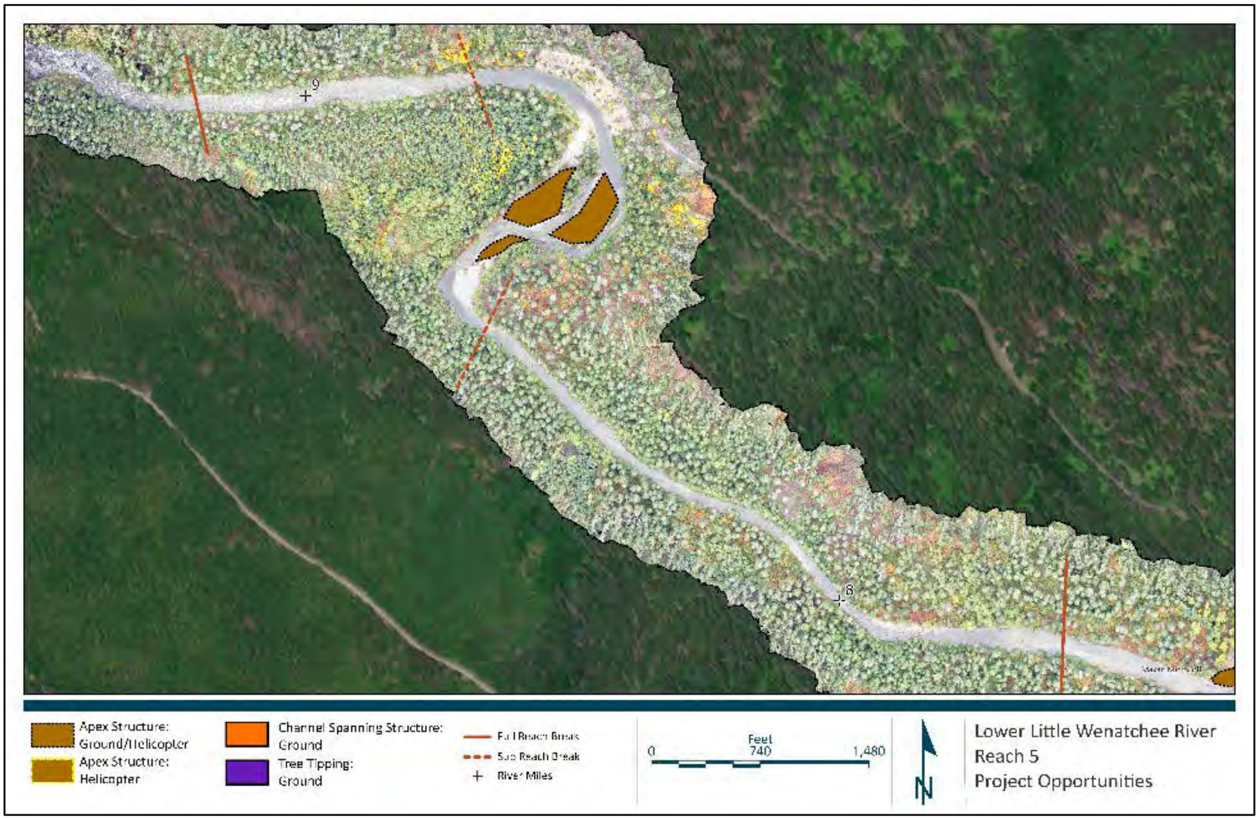

Figure 44. Reach 5 habitat enhancement opportunities.

4.2.6 Reach 6

Reach six is upstream of a waterfall and bedrock cascade that forms an anadromous fish barrier. The channel upstream of the falls and USFS bridge is in very good condition. There are no opportunities to restore or significantly enhance fish and aquatic habitat beyond existing conditions.

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Appendix A| Stream Habitat Assessment

Lower Little Wenatchee River Assessment

Appendix A

Stream Habitat Assessment

Lower Little Wenatchee River Reach Assessment (0.5 – 9.7 RM)

March 2024

Habitat Inventory Survey: *October 8 – 14, 2023*

Table of Contents

1 Introduction & Background

The Little Wenatchee River drains the east side of the Cascade Mountains in central Washington. The Little Wenatchee River flows southeast from its headwaters in the Cascades to its confluence with Lake Wenatchee. The Little Wenatchee River Reach Assessment, and this Habitat Assessment, evaluates the existing aquatic habitat and watershed conditions along the lower nearly 10 miles of river. The assessment was completed on behalf the Columbia-Pacific Northwest Region of the United States Bureau of Reclamation as a part of their efforts to develop Chinook salmon and steelhead habitat rehabilitation projects in the Wenatchee River Sub-basin. As part of the assessment process, Inter-Fluve conducted a salmon habitat survey of the Little Wenatchee River from October 8 – 14, 2023 from River Mile (RM) 0.5 (UCSRB RM 0) at the confluence with Lake Wenatchee, to RM 9.7 (approx. UCSRB RM 8.7), upstream of the Little Wenatchee Falls. It is important to note that the backwater effects of Lake Wenatchee extended up to approximately RM 1.1 (UCSRB RM 0.6). Hereafter in this appendix, USGS river miles are used, which are offset by approximately 0.5–1 miles from the UCSRB river miles used elsewhere in this reporting. The downstream extent of channel habitat unit delineation therefore started at RM 1.1. A flow rate of 37 cfs was measured in the field at the Little Wenatchee Road bridge on October 14, 2023. Insignificant precipitation was received during the survey period and visual estimates of flow did not vary, apart from tributary inputs.

The objective of this Habitat Assessment is the characterize the habitat quantity and quality for salmonid species utilizing the Lower Little Wenatchee River by describing specific in-channel morphological feature types, characterizing riparian conditions, and identifying anthropogenic features influencing aquatic habitat. This information is used to inform potential restoration and conservation actions and will provide a baseline for evaluating future habitat trends and/or measuring the effectiveness of restoration efforts in improve the quantity and quality of available habitat within the study area.

1.1 PREVIOUS SALMON HABITAT ASSESSMENTS IN PROJECT AREA

The Lower Little Wenatchee River appears to have been assessed for instream habitat conditions in the summers of 1997 and 2000, based on references in other reports such as the Okanogan and Wenatchee National Forests Road Analysis Report (USFS 2003) and the Upper Columbia Prioritization Strategy (UCRTT, 2021). The field data collected during the 1997 and 2000 efforts were not available at the time of this report, therefore it is unclear the extent and type of data collected during those efforts. It is also not possible to conduct a specific comparison between the 1997/2000 and 2023 surveys.

2 Methods

In this habitat assessment, the study area (Lower Little Wenatchee River; RM 0.5 – 9.7) was subdivided into six sub-reaches. This survey employed the methods outlined in the US Forest Service Region 6 Level I & II Stream Inventory Handbook, Version 2.16 (USFS, 2016) and the "eastside" protocol was used. All protocols were followed when safe, and most of the suggested forest inventory options were applied in the survey.

The survey protocol adaptations made in the field specifically for this survey are as follows: All reach and habitat unit lengths were measured in GIS from field recorded GPS data collected with a high-accuracy Juniper Systems Geode unit instead of measuring the distance between unit breaks with a tape in the field; stream discharge was measured upstream of the falls near RM 8.5.

The n^{th} channel unit (riffle, pool, glide) measurement frequency applied in the field for data collection was just under 20%, with every 5^{th} unit (one in five) for both slow and fast water units. In total, 18 fast water units and 13 slow water units were sampled, for a total of 31 units measured in Reaches 1-6.

At n^{th} units, the surveyors performed an ocular estimate of the wetted channel width and measured the wetted channel width with a 100-foot tape. Floodprone width was assessed using ArcGIS pro measure tool and orthomosaic drone imagery collected during the habitat assessment. At every channel unit measured, the length of unstable bank was estimated for both the left and right channel banks. Depth of pools, riffles, and glides was measured using a graduated stadia rod carried by the observer. Where water velocity or depth was unsafe for surveying (e.g. excessively deep pools), the observer either estimated depth and/or measured as close to the thalweg as possible.

For the riparian vegetation measurements, it is a "Forest Option" to designate a riparian corridor as either a single 100-ft wide zone or two adjacent riparian zones (inner and outer zones) totaling 100 feet in width (USFS, 2016). For this assessment, one single 100-ft wide riparian zone was designated for the Lower Little Wenatchee River study area. Survey methods dictate defining a dominant size class of vegetation type within the riparian corridor (e.g. small trees, shrubs), then defining the dominant species observed in the overstory and understory. Survey protocol differed from USFS protocol by collecting a dominant overstory and understory size class within the 100-foot-wide riparian zone in addition to species. Six additional riparian vegetation survey measurements were recorded in a few non-n^{th} units throughout the study area where dominant vegetation type changes were noted to support the riparian vegetation assessment.

Nine gravel counts were conducted and were completed by the habitat team to characterize the size distribution of sediment in the system. In total, nine gravel counts were completed, two in Reaches 2, 3, 4, and 5, and one in Reach 6. Criteria for gravel count locations state that they must be representative of the general character of the individual reach and completed at a representative glide to riffle transition point. Due to safety reasons associated with extremely cold water and air temperatures as well as depth of water at the time of the survey, gravel counts were conducted on exposed point bars. This protocol modification provides data that represents the bedload at hydraulically-reduced accumulation zones within the mainstem channel. Mainstem channel substrate composition was characterized with ocular observations provided in Section 4 of the Reach Assessment.

For this habitat survey, we used the USFS protocols (USFS, 2016) to define habitat unit types. Pools are "slow water" units that include dam, scour, or plunge pools. Riffles are "fast water – turbulent" features that are in general relatively shallow and glides are "fast water -nonturbulent" units, which tend to be deeper than riffles. We considered "side-channels" as naturally wetted flow paths connected to the mainstem channel at their upstream and downstream ends at average annual flow. Side channel units were identified when the main channel split to form a stable island with soil or fine sediment accumulations and with establishing vegetation older than 2 to 3 years. Each side channel was determined to be fast or slow, and its average width and length measured. Both total and wetted lengths were recorded using GPS. Wetted lengths are used in this report unless otherwise noted.

Large woody material (LWM) was counted in the mainstem and side channels following the size class characterizations for "eastside" forests. The forest option to count large wood pieces in the small size category was used. Tallies of small (> 6 in. diameter, >20 ft long), medium (>12 in. diameter, > 35 ft long) and large (>20 in. diameter, >35 ft long) pieces of large wood were completed for each reach. For this report, medium and large pieces of LWM will be collectively referred to as "Quality Large Wood." Twenty-four log jams were identified within the study area and are described in more detail in the Stream Reach Reports below. Open-water wetlands on floodplains were not observed, measured, or recorded.

3 Summary of Results

This section summarizes the results of the 6 channel reaches surveyed from October 8-14, 2023 between RM 0.5 and 9.7 on the lower Little Wenatchee River. Detailed descriptions of the survey results from the individual reaches can be found in Section 4 of this report.

3.1 CHANNEL MORPHOLOGY

The surveyed reaches of the Lower Little Wenatchee River are a mix of long glides and riffles, interspersed with short riffles, with more extended riffles in the upper reaches. The channel form is primarily single threaded with several long side channels with decreasing sinuosity moving upstream.

Channel geometry varied within the study area. Mean bankfull depths ranged from 2.8 feet in Reach 6 to 3.7 feet in Reach 2 (Table 1) and widths ranged from 66 feet in Reach 6 to 130 feet in Reach 4 (Table 2). The typical downstream increasing trend in bankfull width/depth is generally observed in the data. Floodprone widths reflect both geomorphic surface changes within the study area and human influenced incision (Table 3). Average floodprone width is greatest in Reaches 1 - 3 and the smallest average floodprone width was recorded in Reach 6.

Table 1. Lower Little Wenatchee bankfull width results from habitat assessment.

	Width (ft)						
Reach	***1***	***2***	***3***	***4***	***5***	***6***	***All Reaches***
Mean	97.00	118.25	113.50	125.00	97.50	66.00	110.00
Median	97.00	121.00	109.50	130.00	97.00	66.00	106.50
St. Dev.	0.00	30.57	23.01	13.04	6.76	0.00	23.00

Table 2. Lower Little Wenatchee bankfull depth results from habitat assessment.

	Average Depth (ft)						
Reach	***1***	***2***	***3***	***4***	***5***	***6***	***All Reaches***
Mean	3.06	3.64	3.34	3.36	3.36	2.86	3.37
Median	3.06	3.77	3.25	3.27	3.40	2.86	3.31
St. Dev.	0.00	0.50	0.67	0.82	0.45	0.00	0.56

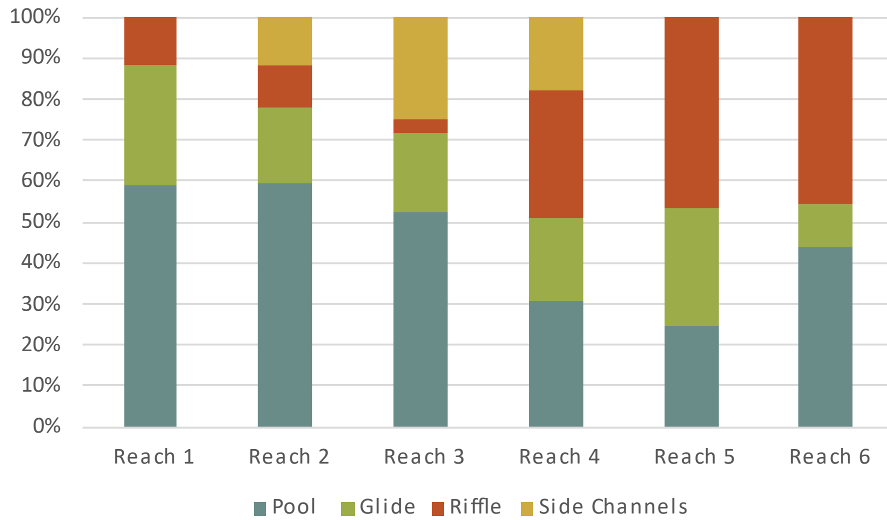
Table 3. Lower Little Wenatchee floodprone widths from habitat assessment.

	Average Depth (ft)						
Reach	***1***	***2***	***3***	***4***	***5***	***6***	***All Reaches***
Mean	6288.00	2904.25	1948.75	1248.00	820.75	98.00	5.23
Median	6288.00	2266.50	2037.00	1048.00	840.50	98.00	5.40
St. Dev.	0.00	1424.88	410.89	521.85	351.27	0.00	0.56

3.2 HABITAT UNIT COMPOSITION

Within the surveyed area, pools are the dominant habitat type, comprising 41% of the total area of the channel. Riffles comprise 23%, and glides 21% of the total channel area. Side channels comprise 14% of the channel area, a substantial proportion (Figure 1). Reaches 1 and 2 maintain the highest percentage of pool habitat at nearly 60%, while Reach 5 is the lowest at 24%. Side channel habitat area highly variable across the study area, with almost a quarter of the channel habitat in Reach 3 consisting of side channels but no side channels connected in Reaches 1, 5 or 6.

The mean residual pool depth for the entire study area was 5.4 feet, while the residual pool depth ranged from a minimum of 1.5 feet in Reaches 3 and 5, to a maximum of 11.3 feet in Reach 2 (Figure 2). On average, pools were greater than 3 feet deep at the time of the survey. Of the 59 pools identified, 75% had residual depths more than 3 feet deep. Reach 5 had the lowest percent of pool habitat with residual depths greater than 3 ft (40%). Average pool spacing throughout the study area was 7.3 channel widths per pool, though there was high variability among the reaches with a generally increasing pattern of pool spacing moving upstream. The mean estimated wetted width of the main channel was 38.4 feet, with pools typically having the greatest wetted widths compared to riffles or glides. Mean riffle depths were fairly uniform throughout the study area ranging from 1.05 feet in Reach 1 to 1.68 feet in Reach 3. In total, 88 fast water units (riffles and glides) were measured. A summary of all data recorded is provided in Section 4.7 Summary Data.



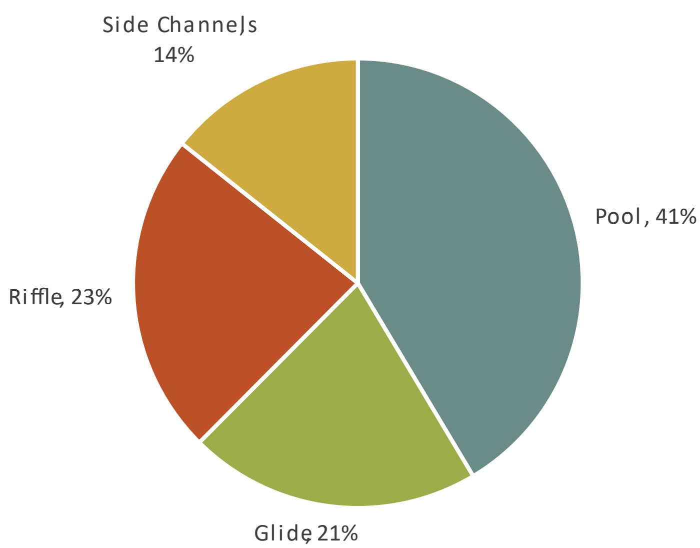


Figure 1. Top chart illustrates the habitat unit composition of the 6 reaches of the survey area. The bottom chart illustrates the habitat unit area composition of the entire survey area.

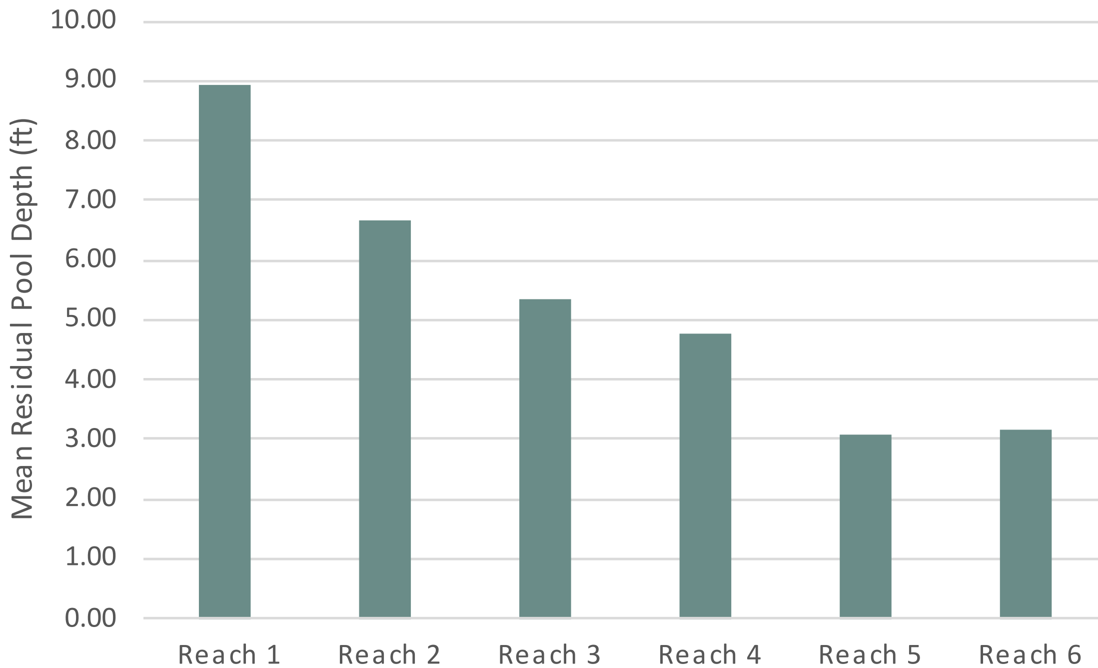


Figure 2. Mean residual pool depth by reach.

3.3 SIDE CHANNEL HABITAT

Side channel habitat was primarily confined to the middle of the survey area in Reaches 2, 3, and 4 and accounted for 15% of the habitat unit area in the surveyed system. There were 23 side channel units observed in total, with an average length of 668 feet and an average wetted width of 13.26 ft. Figure 3 is a photo of a slow-water side channel in Reach 2 containing some large wood. Side channels contained similar loads of large woody material as the main channel, with a total of 293 pieces, 168 small, 55 medium, and 70 large across the 23 mapped side channels.

Figure 3. Side channel observed in Reach 2 with large woody material.

3.4 LARGE WOODY MATERIAL

On average, the survey area contained 152.44 pieces of large woody material per mile. Of the large woody material in the system, 60% were "small" pieces with diameters between 6 and 12 inches and lengths greater than 20 feet, 23% were "medium" pieces with diameters between 12 and 20 inches and lengths over 35 feet, and 17% were 17% "large" pieces with diameters over 20 inches and lengths over 35 feet (Figure 4). Reach 2 contained the most pieces of large wood, 410 pieces, but Reach 3 contained the most pieces per mile, at 300.59 pieces / mile. Reach 6 had the lowest load of LWM, with only 24 total pieces of LWM and only 2% of the wood in the system. There were 24 log jams identified in the survey area. Reach 2 had the most jams, 10 total, and Reach 1 had no jams at all.

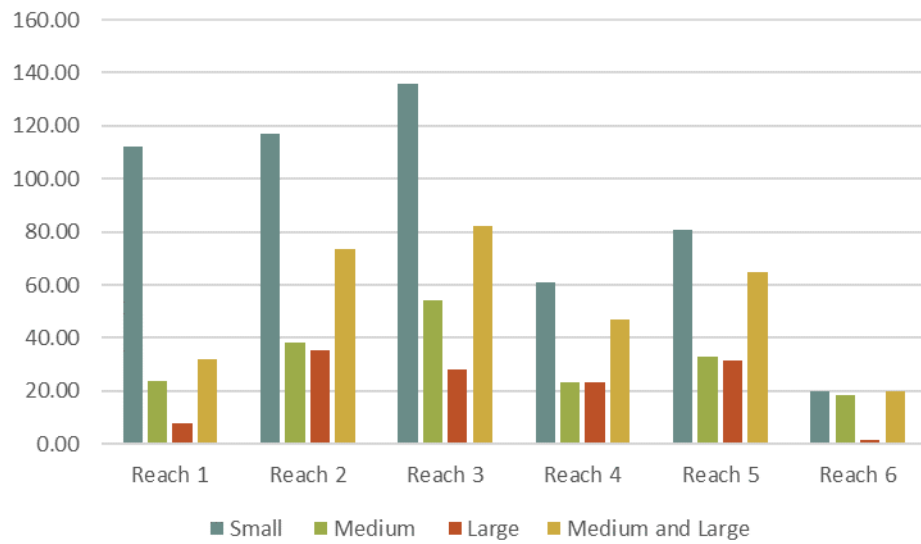
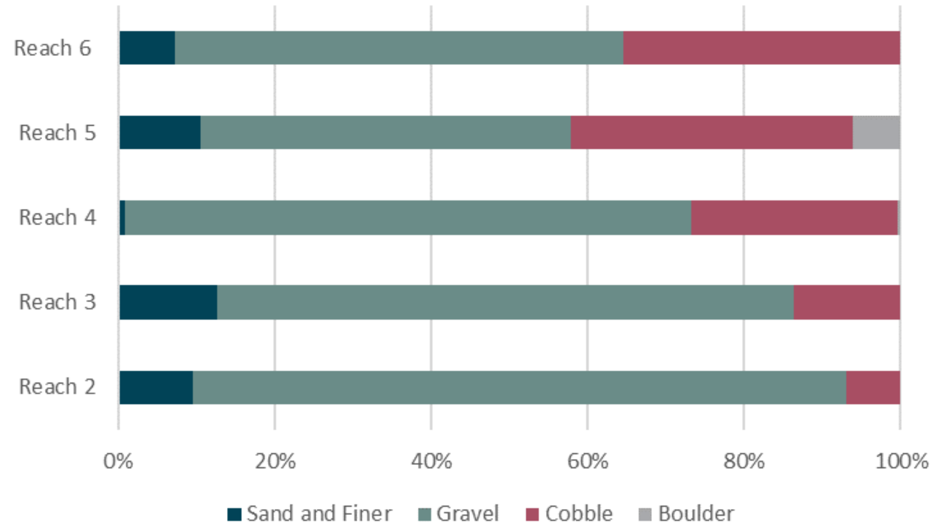


Figure 4. Pieces of large wood per river mile for the Lower Little Wenatchee River, Reaches 1 – 6.

Based on thresholds established by Fox & Bolton (2007) for Eastside forests, the "adequate" threshold for LWM is >32 pieces per mile of quality – medium and large size class – wood, with additional woody debris available for short and long-term recruitment. There were 60.93 pieces of quality LWM per mile across the system. Reach 6 was the only reach that was below the adequate threshold for quality large wood, with only 20 pieces per mile.

3.5 SUBSTRATE & FINE SEDIMENT

Bedload characterization is based on 9 gravel counts in Reaches 2-6 of the survey area. Sediment type is classified by the B-axis diameter of the clasts sampled (sand = < 2mm, gravel = 2.1-64 mm, cobble = 64.1-256 mm, boulder = >256.1mm). Gravel counts were conducted in all reaches except Reach 1 and were all on exposed gravel bars. Overall, the sediment composition was similar between the reaches of the survey area, with gravel being the dominant substrate and increasing proportions of larger cobble and boulder material in more upstream reaches (Figure 5).



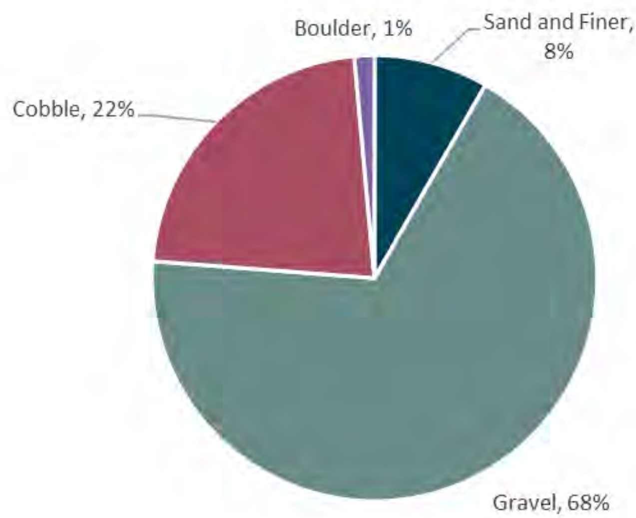


Figure 5. Gravel count classification for reaches where gravel counts were conducted (2-6) in the Lower Little Wenatchee River. Reaches 2-5 had two gravel counts conducted and the data illustrated above is the average of the two counts, Reach 6 had only one gravel count conducted.

3.6 BANK INSTABILITY

Reach 2 had the most human imposed impacts to the floodplain due to the gravel mine located on river-left, including levees, road building, and gravel pit excavation or other associated development, which has resulted in some geomorphic simplification of the channel and floodplain morphology. The Little Wenatchee River Road is immediately adjacent to the channel in several locations in Reaches 4, 5 and 6. Reach 5 was the only reach in which bank instability and erosion from anthropogenic causes was noted, however. In Reach 6, the road crosses the channel and adjacent to the bridge and on the river-river bank upstream of the bridge riprap has been placed along the bank (Figure 6), potentially as a result of prior erosion or bank instability. Minimal other modifications to the banks resulting in anthropogenically-induced bank instability were observed by the habitat team.

Figure 6. Left: Riprap material around the Little Wenatchee Road bridge crossing in Reach 6. Right: Riprap bank on river-left upstream of the bridge crossing in Reach 6.

3.7 FISH PASSAGE BARRIERS

No anthropogenic fish passage barriers were observed in the mainstem channel during the habitat assessment. A natural waterfall was observed near RM 9.2 in Reach 6 that is assumed to be a barrier to fish migration.

3.8 RIPARIAN CORRIDOR

Of the 31 n^{th} units measured in Reaches 1-6, the dominant (49%) riparian vegetation size class was designated as large tree (21 – 31.9-inch diameter at breast height (dbh). Small tree (9.0 – 20.9-inch dbh) was the second most dominant class (27%). Reaches 3 and 5 had some units with mature trees (> 32-inch dbh) as the dominant class of overstory within the riparian corridor. Sapling/pole (5 – 8.9-inch dbh) was recorded as the dominant size class in 15% of the riparian corridor overstory units across all six reaches (Figure 7).

The overall dominant overstory species was Western red cedar (38%), followed by 25% of units composed primarily of a cottonwood-dominant overstory. Additional species in the overstory in a handful of habitat units included alder (20%) or Western hemlock (17%) (Figure 8).

The dominant understory size classes were sapling/pole (5 – 8.9-inch dbh) (45%), shrub/seedling (52%), and small tree (3%) (Figure 9). Alder was the most dominant riparian understory observed, accounting for 33% of the understory. Additional dominant riparian understory species included redosier dogwood (27%); vine maple (15%); willow (14%); and cottonwood (12%) (Figure 10).

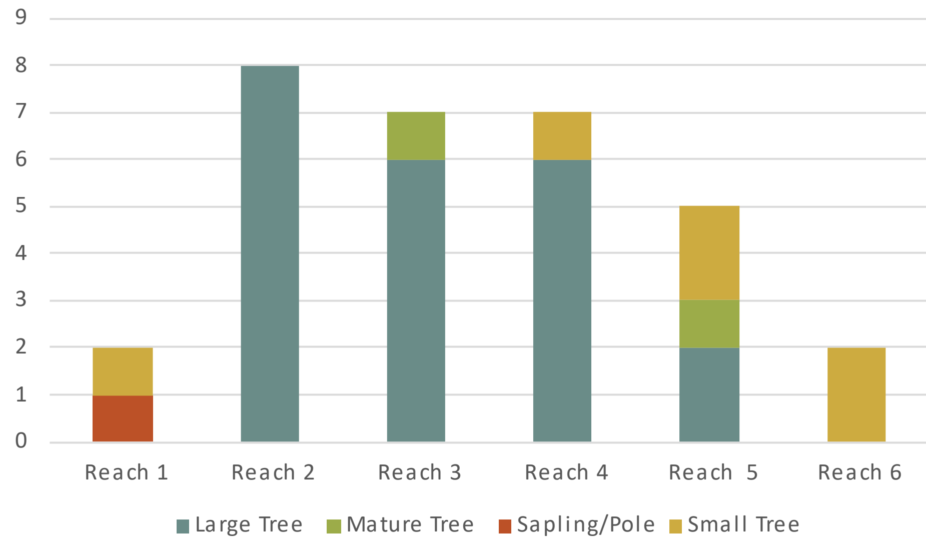


Figure 7. Distribution of dominant overstory size class category for the riparian zones, based on nth unit measurements from Reaches 1-6.

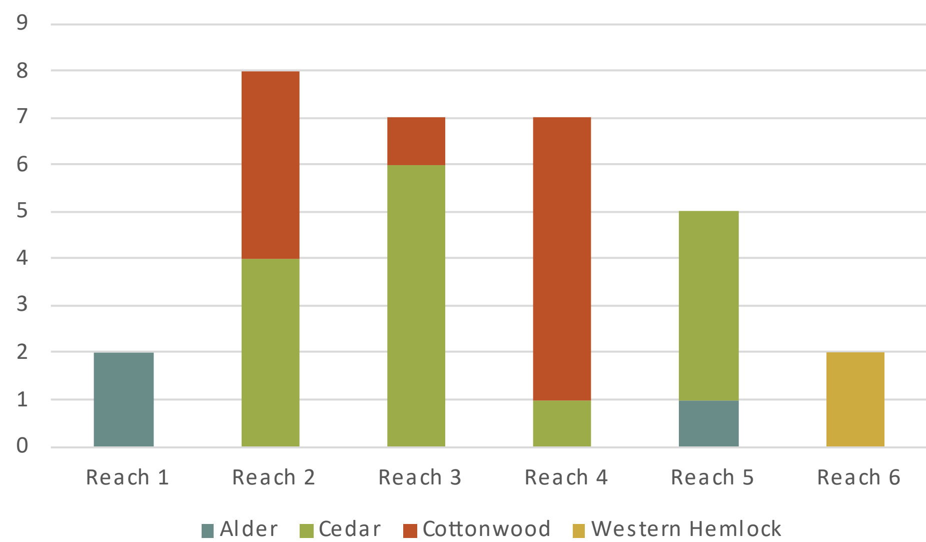


Figure 8. Distribution of dominant overstory species in the riparian zone, based on nth unit measurements from Reaches 1-6.

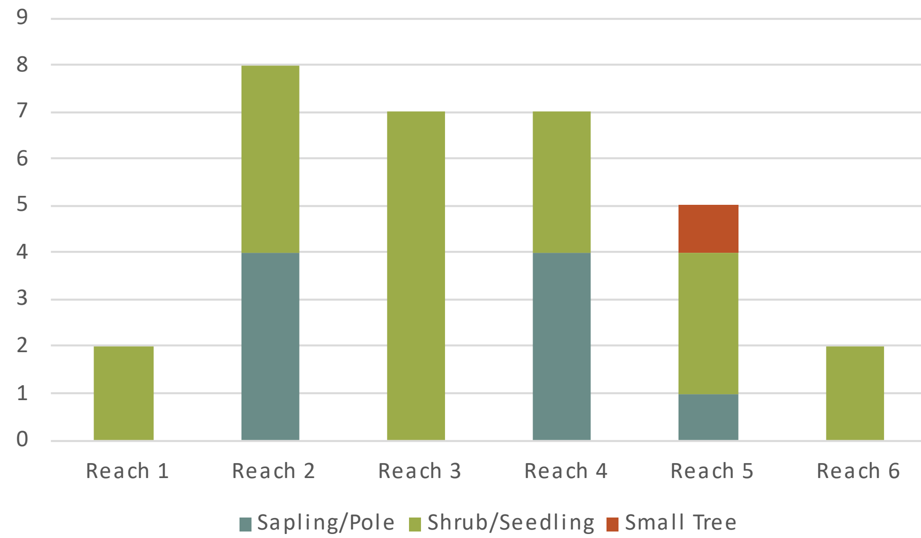


Figure 9. Distribution of dominant understory class category for the riparian zone, based on nth unit measurements from Reaches 1-6.

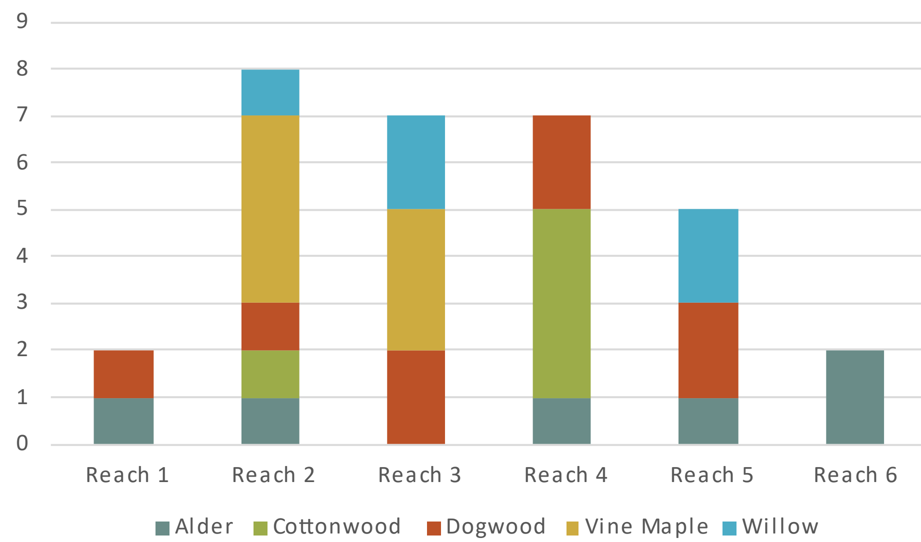


Figure 10. Distribution of dominant understory species for the riparian zone, based on nth unit measurements for Reaches 1-6.

4 Stream Habitat Reach Reports

4.1 REACH 1

Location: River mile 0.5 – 1.35 (surveyed RM 1.1 – 1.35)
Total length: 0.85 miles (surveyed 0.25 miles)
Survey date: October 9th, 2023

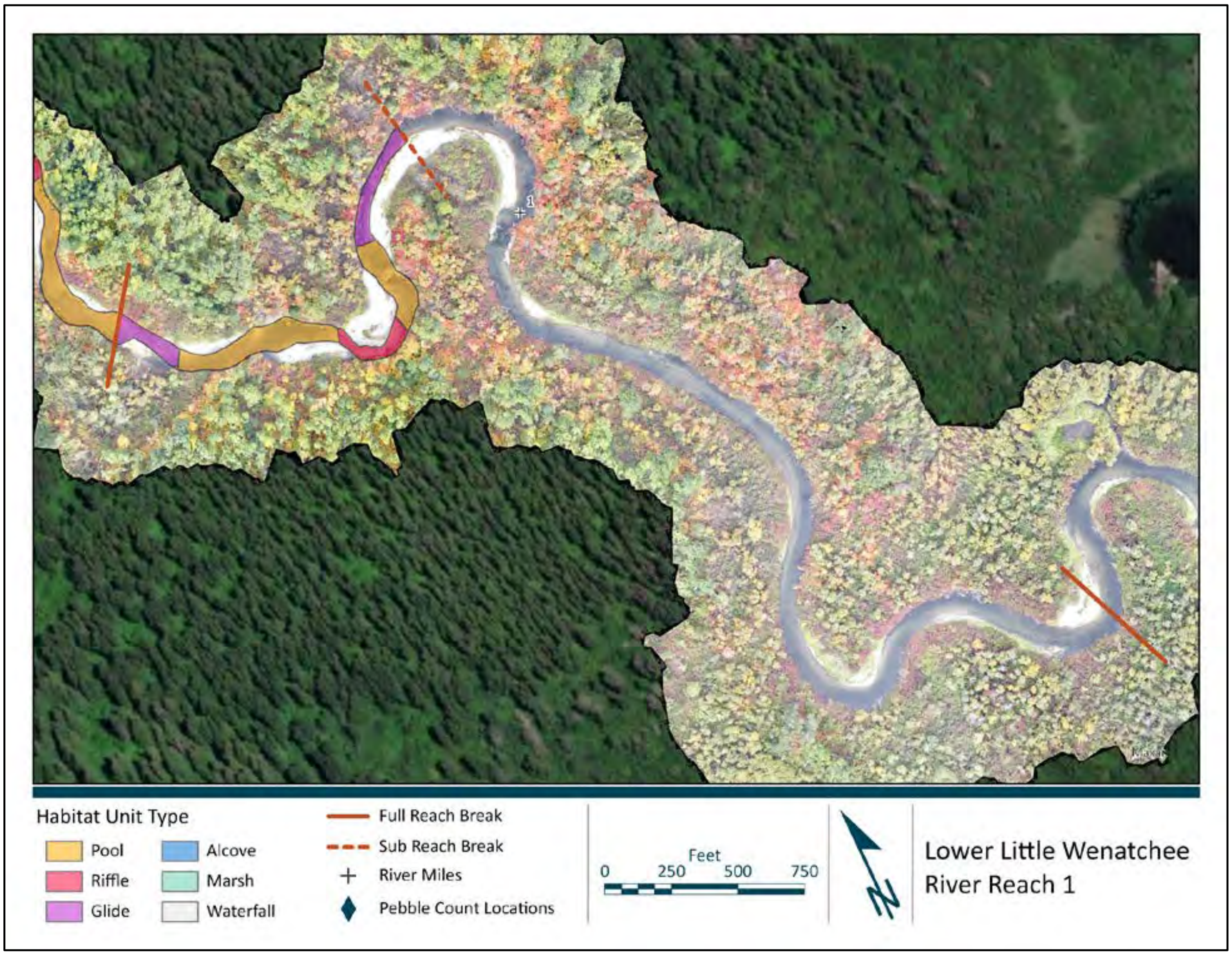


Figure 11. Lower Little Wenatchee River, Reach 1, habitat units and pebble count locations.

4.1.1 Habitat Unit Composition

Reach 1 begins at RM 0.5, but is backwatered by Lake Wenatchee up to RM 1.1. Channel habitat units were delineated beginning at the upstream extent of the backwater. Based on channel habitat units recorded between RM 1.1 and 1.35, the habitat in Reach 1 is dominated by smooth water habitat, with 59% of the area surveyed as pools and 29% as glide, with only the remaining 12% of area categorized as riffle habitat (Figure 12). There were no connected side channels observed in Reach 1.

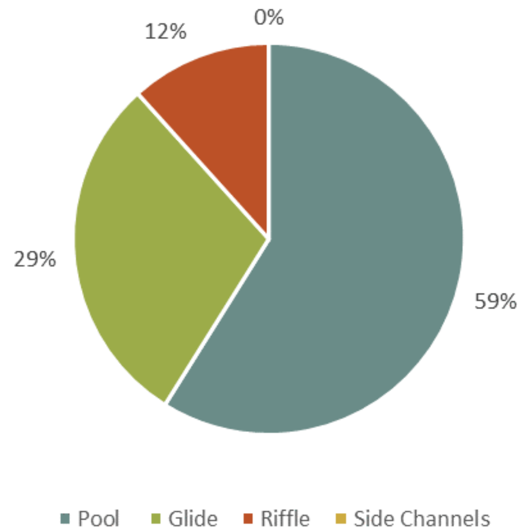


Figure 12. Habitat unit composition for Reach 1 of the Lower Little Wenatchee River.

4.1.2 Pools

Pools were the most common habitat type in Reach 1, with 59% of the area categorized as pools. A total of two pools were counted in Reach 1, averaging 8 pools per mile. Pools had an average maximum depth of 10.0 ft, with a maximum of 10.0 ft and a minimum of 8.0 ft. Residual pool depth averaged 8.95 ft. Both pools had a residual depth greater than 3.0 ft. Mean pool spacing for Reach 1 was 19.7 channel wetted widths per pool, compared to an average of 17.7 channel wetted widths per pool across the entire survey area.

Figure 13. Representative pool observed in Reach 1.

4.1.3 Side Channel Habitat

No side channels were identified in Reach 1.

4.1.4 Large Woody Material

Reach 1 had a total of 36 pieces of LWM (Table 4). Of the large wood recorded, there were 28 small, 6 medium, and 2 large pieces, for a total of 8 quality pieces of LWM and an average of 176 pieces of LWM per mile. No log jams were identified in Reach 1.

Table 4. Large woody material quantities in Reach 1.

	Small (6 in X 20 ft)	Medium (12 in x 35 ft)	Large (20 in x 35 ft)	Total
Number of Pieces	28	6	2	36
Number of Pieces / Mile	112	24	8	176
Number of Jams		-		0
Number of Jams / Mile		-		0

4.1.5 Substrate & Fine Sediment

No gravel counts were conducted in Reach 1.

4.1.6 Riparian Corridor

Two nth units were evaluated in Reach 1. The dominant observed overstory size classes in Reach 1 were split between small trees (50%) and sapling/pole (50%), and the dominant over story species was alder throughout Reach 1 (Figure 14). The dominant observed understory class in Reach 1 was sapling/pole (100%) and the dominant observed understory species were alder (50%) and dogwood (50%) (Figure 15).

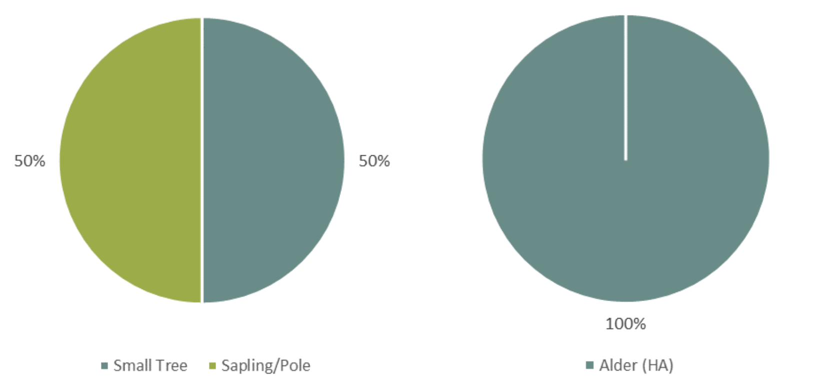


Figure 14. Dominant overstory size class (left) and dominant overstory species (right) for Reach 1.

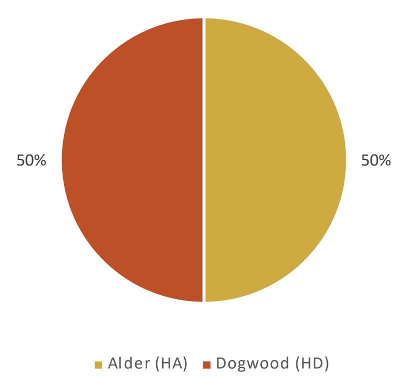


Figure 15. Dominant understory size class (left) and dominant understory species (right).

4.2 REACH 2

Location: River mile 1.35 – 3.5
Total length: 2.15 miles
Survey date: October 10th – 11th, 2024

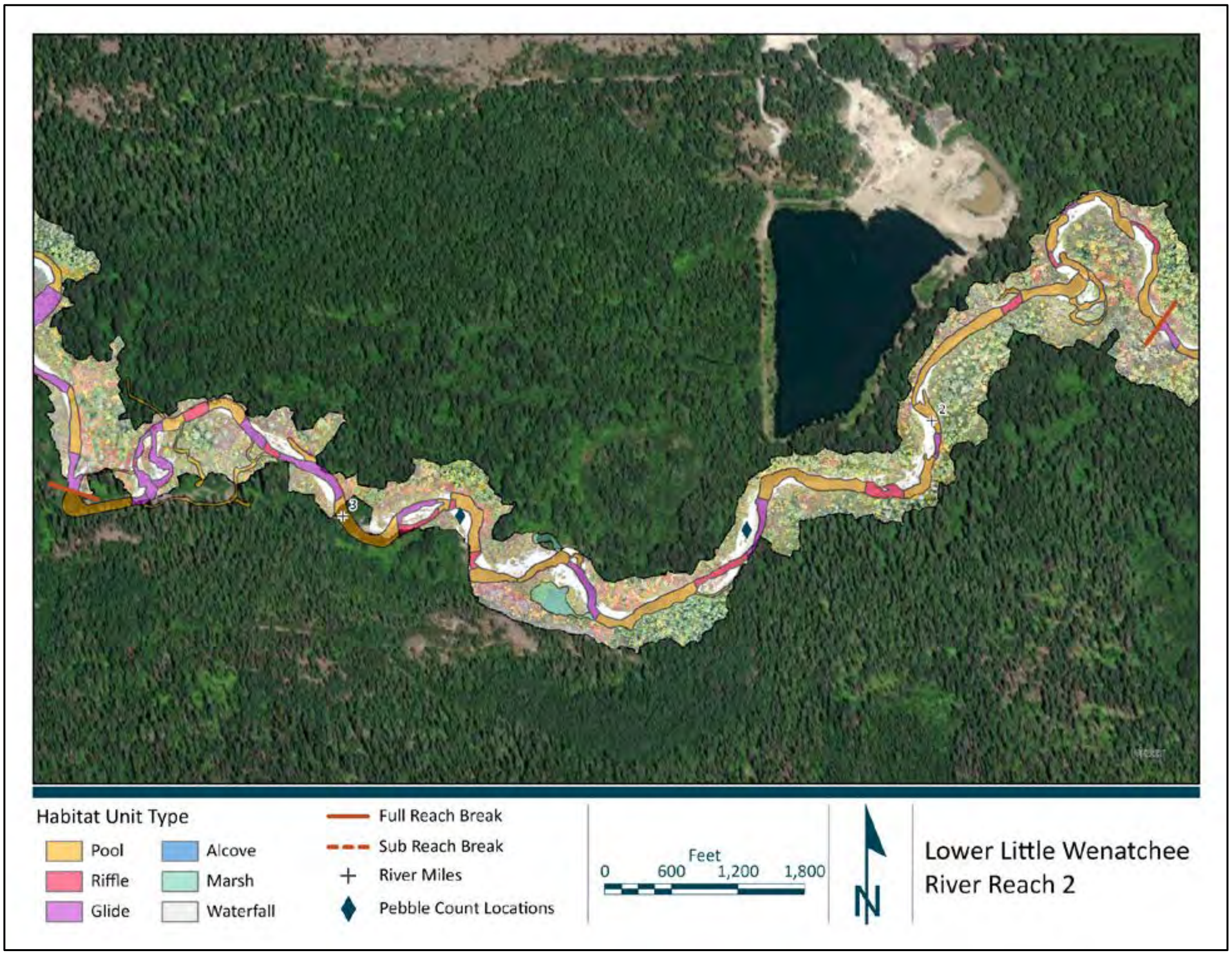


Figure 16. Lower Little Wenatchee River, Reach 2, habitat units and pebble count locations.

4.2.1 Habitat Unit Composition

Reach 2 has the highest proportion of pools across the survey area, with 60% of the total area classified as a pool unit. Glide habitat units accounted for the next highest proportion in Reach 2 (18%) with side channel units following at 12% of the survey area and riffle units only 10% (Figure 17).

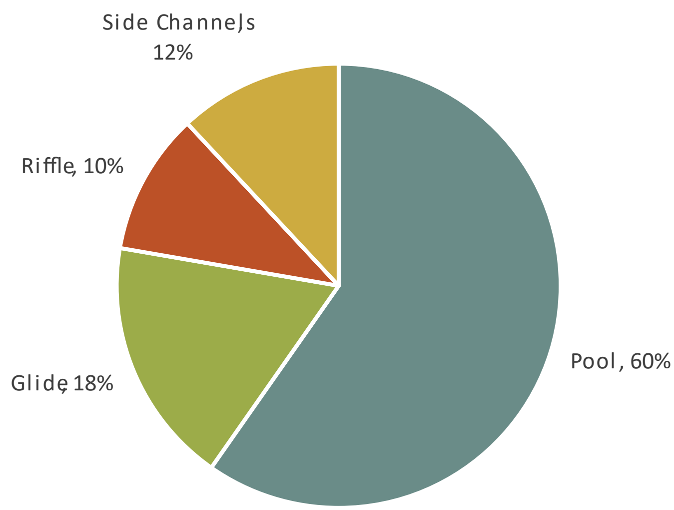


Figure 17. Habitat area breakdown for Lower Little Wenatchee Reach 2.

4.2.2 Pools

Pools were the most common habitat type in Reach 2, with 60% of the area categorized as pools. A total of 18 pools were counted in Reach 2, averaging 8.4 pools per mile. Pools had an average maximum depth of 7.62 ft, with a maximum of 12.00 ft and a minimum of 3.0 ft. Residual pool depth averaged 6.66 ft. Of the 18 pools identified, 16 had a residual depth greater than 3 ft (89%), and only 2 (11%) had residual depths less than 3ft. Mean pool spacing for Reach 2 was 15.44 channel wetted widths per pool, compared to an average of 17.7 channel wetted widths per pool across the entire survey area.

4.2.3 Side Channel Habitat

Side channels in Reach 2 account for 12% of the area, have an average wetted width of 10.9 ft, and an average length of 768 ft (0.46 miles). All side channels identified in Reach 2 were classified as slow water units. There were 156 total pieces of large woody material counted in the side channels of Reach 2, 87 small, 29 medium, and 40 large.

4.2.4 Large Woody Material

Reach 2 contained the greatest number of LWM pieces in the assessment area with 410 pieces, which account for 31% of the system total (Table 5). These counts equate to roughly 264 pieces per mile. There were 252 small, 82 medium, and 76 large pieces of wood. Medium and large combined total to 158 pieces of quality LWM.

Table 5. Large woody material quantities in Reach 2.

	Small (6 in X 20 ft)	Medium (12 in x 35 ft)	Large (20 in x 35 ft)	Total
Number of Pieces	252	82	76	410
Number of Pieces / Mile	117	38	35	264
Number of Jams	10			
Number of Jams / Mile	4.65			

4.2.5 Substrate & Fine Sediment

Two pebble counts were conducted in Reach 2, both on exposed bars. The material composition from the gravel counts in Reach 2 combined was primarily gravel (83%), with nearly equal parts sand and finer material (10%) and cobble (7%) (Figure 18). No boulders were observed in the pebble counts in Reach 2.

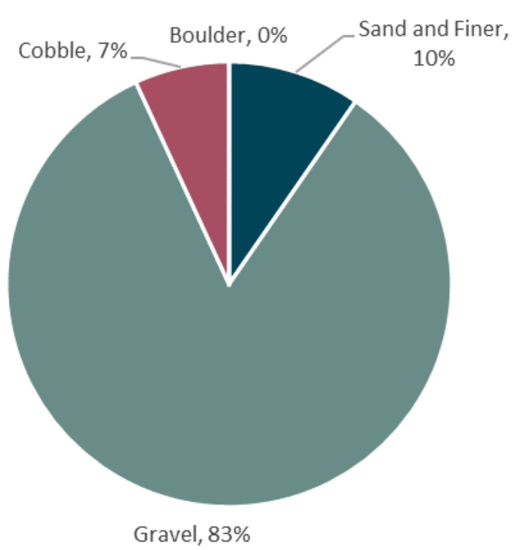


Figure 18. Combined percent composition sediment size type from two gravel counts in Reach 2.

4.2.6 Riparian Corridor

A total of 7 nth units were surveyed in Reach 2. The dominant overstory class in Reach 2 was exclusively classified as large trees, 50% of which were recorded as Western red cedar and 50% as cottonwood (Figure 19). The dominant understory in Reach 2 was comprised of 50% sapling/pole and 50% shrub/seedling, with a wide variety of understory species (Figure 20). Vine maple accounted for 50% of understory species, and willow, dogwood, cottonwood, and alder each made up 13% of the dominant understory species.

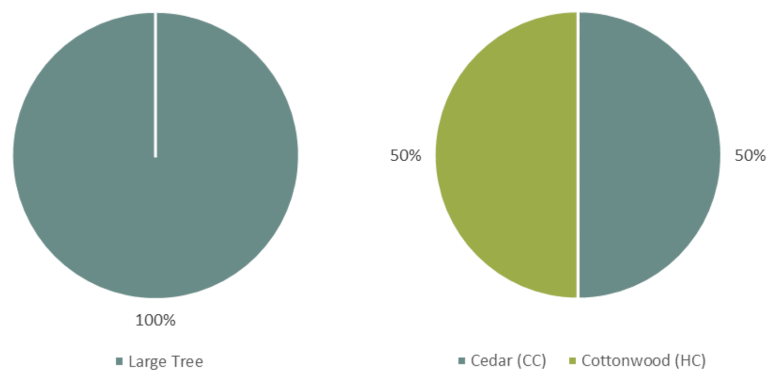


Figure 19. Dominant overstory size class (left) and dominant overstory species (right) for Reach 2.

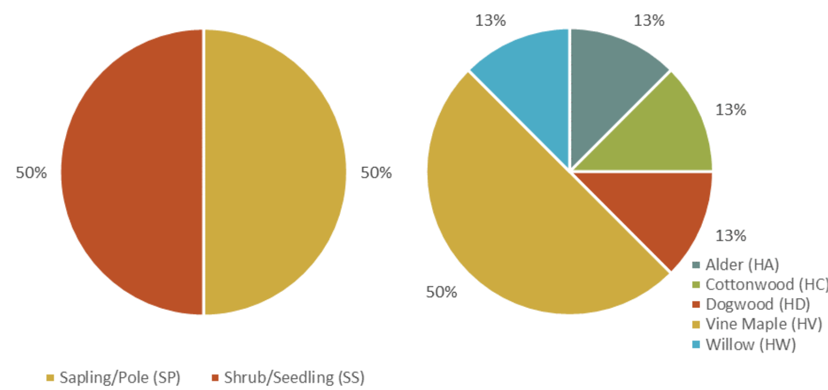


Figure 20. Dominant understory size class (left) and dominant understory species (right) for Reach.

4.3 REACH 3

Location: River mile 3.5 – 5.2
Total length: 1.7 miles
Survey date: October 11th, 2023

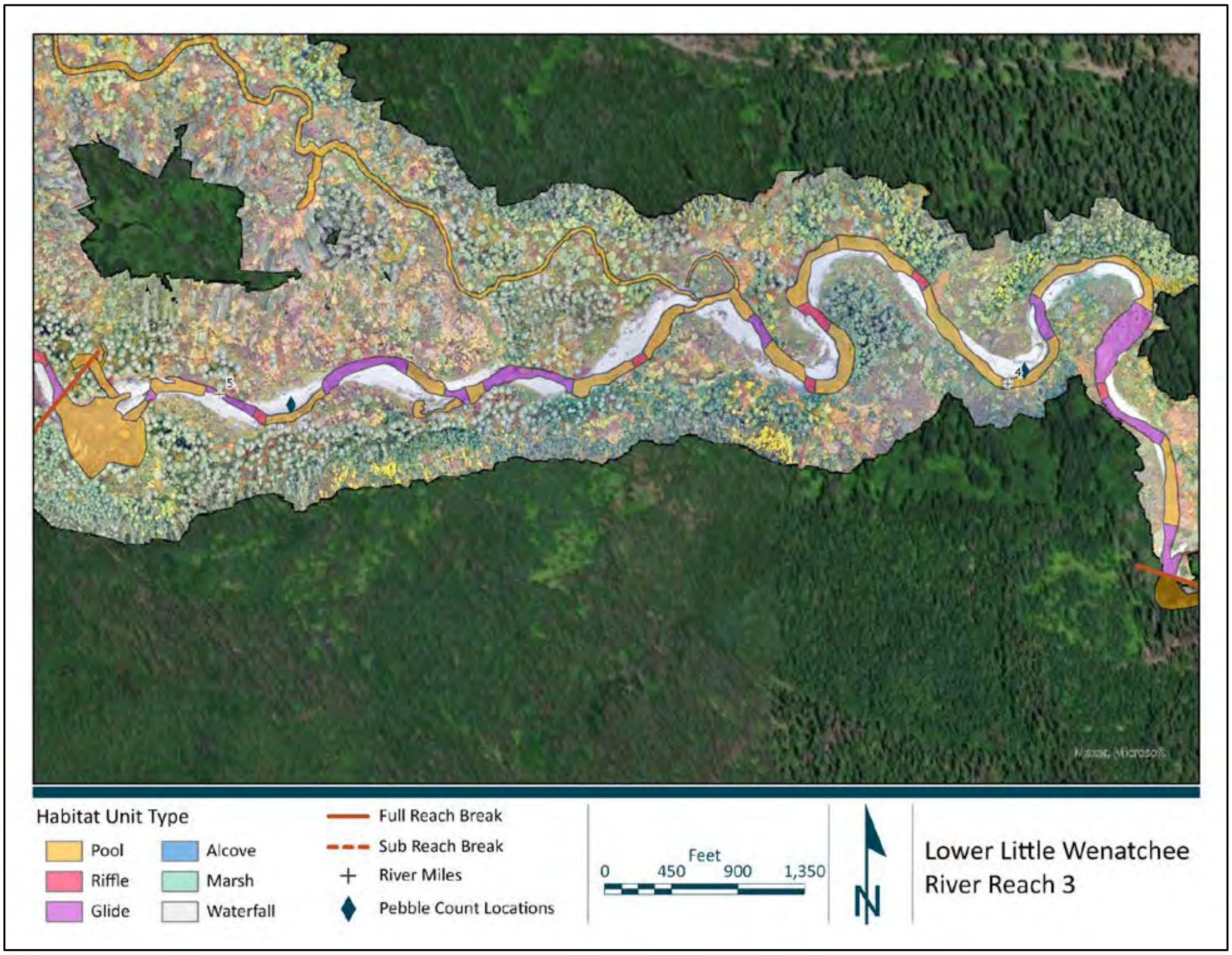


Figure 21. Lower Little Wenatchee River, Reach 3, habitat units and pebble count locations.

4.3.1 Habitat Unit Composition

Side channels accounted for 25% of the surface area in Reach 3, making it the reach with the highest proportion of off-channel area connected at low flows. Pools accounted for the vast majority of main channel habitat in Reach 3 (52%) with glides (19%) and riffles (3%) representing a much lower proportion of in-channel habitat (Figure 21).

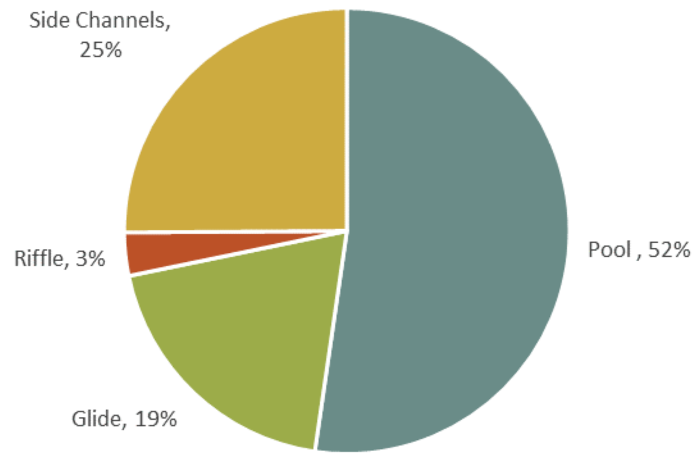


Figure 22. Habitat area breakdown for Lower Little Wenatchee Reach 3.

4.3.2 Pools

Pools were the most common habitat type in the main channel of Reach 3, with 52% of the area categorized as pools (Figure 22). A total of 17 pools were counted in Reach 3, averaging 10 pools per mile. Pools had an average maximum depth of 6.6 ft, with a maximum of 12 ft and a minimum of 4 ft. Residual pool depth averaged 5.4 ft. Of the 17 pools identified, 13 had a residual depth greater than 3 ft (76%), and 4 (24%) had residual depths less than 3 ft. Mean pool spacing for Reach 3 was 11.8 channel wetted widths per pool, compared to an average of 17.7 channel wetted widths per pool across the entire survey area.

4.3.3 Side Channel Habitat

Side channel habitat accounted for a quarter (25%) of the area in Reach 3, the most of all reaches in the assessment area (Figure 22) and had an average length of 2410 ft (0.46 miles). All side channels were categorized as slow water units and had the greatest wetted width, at an average of 16.50 ft, of all side channel habitat in the assessment area. There were a total of 93 pieces of large wood in Reach 3 side channels; 55 small, 21 medium and 17 large pieces.

4.3.4 Large Woody Material

Reach 3 contained the highest volume of LWM per mile in the assessment area with 301 pieces per mile (Table 6). There were 231 small, 92 medium, and 48 large pieces of wood. Medium and large pieces totaled to 140 pieces of quality LWM. There were 4 log jams identified in Reach 3, or approximately 2.35 per mile.

Table 6. Large woody material quantities in Reach 3.

	Small (6 in X 20 ft)	Medium (12 in x 35 ft)	Large (20 in x 35 ft)	Total
Number of Pieces	231	92	48	371
Number of Pieces / Mile	136	54	28	301
Number of Jams	4			
Number of Jams / Mile	2.35			

4.3.5 Substrate & Fine Sediment

Two pebble counts were conducted in Reach 3, both on exposed bars (Figure 23). The material composition from the gravel counts in Reach 3 combined was primarily gravel (74%), with nearly equal parts sand and finer material (13%) and cobble (14%).

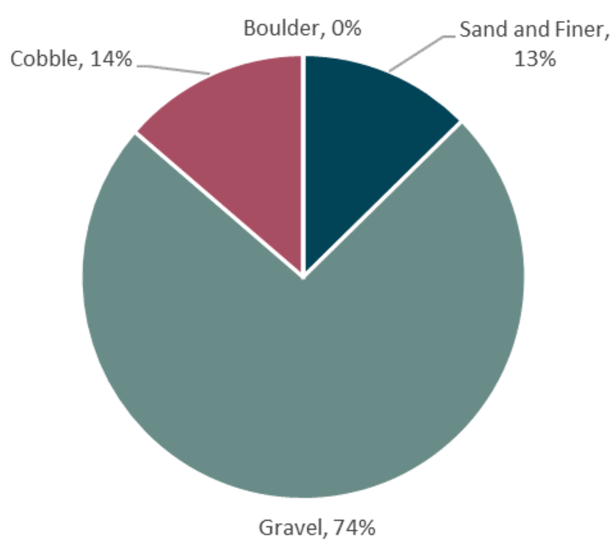


Figure 23. Combined percent composition sediment size type from two gravel counts on exposed bars in Reach 3.

4.3.6 Riparian Corridor

Seven nth units were evaluated in Reach 3. The dominant observed overstory size classes in Reach 3 were large trees (86%) and mature trees (14%) (Figure 24). Cottonwoods accounted for 86% of overstory species in Reach 3, with Western red cedar assigned to the remaining 14% of observations in this reach. Shrub/seedlings were the dominant understory class throughout Reach 3, and were primarily vine maples (43%), dogwood (29%), and willow (29%) (Figure 25).

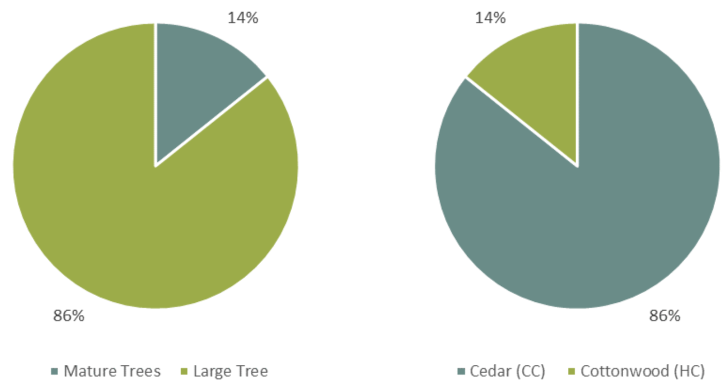


Figure 24. Dominant overstory size class (left) and dominant overstory species (right) for Reach 3.

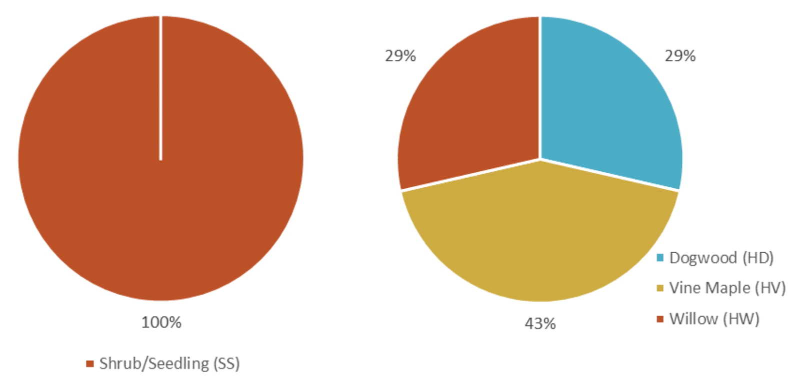


Figure 25. Dominant understory size class (left) and dominant understory species (right) for Reach 3.

4.4 REACH 4

Location: River mile 5.2 – 7.8
Total length: 2.6 miles
Survey date: October 12th, 2023

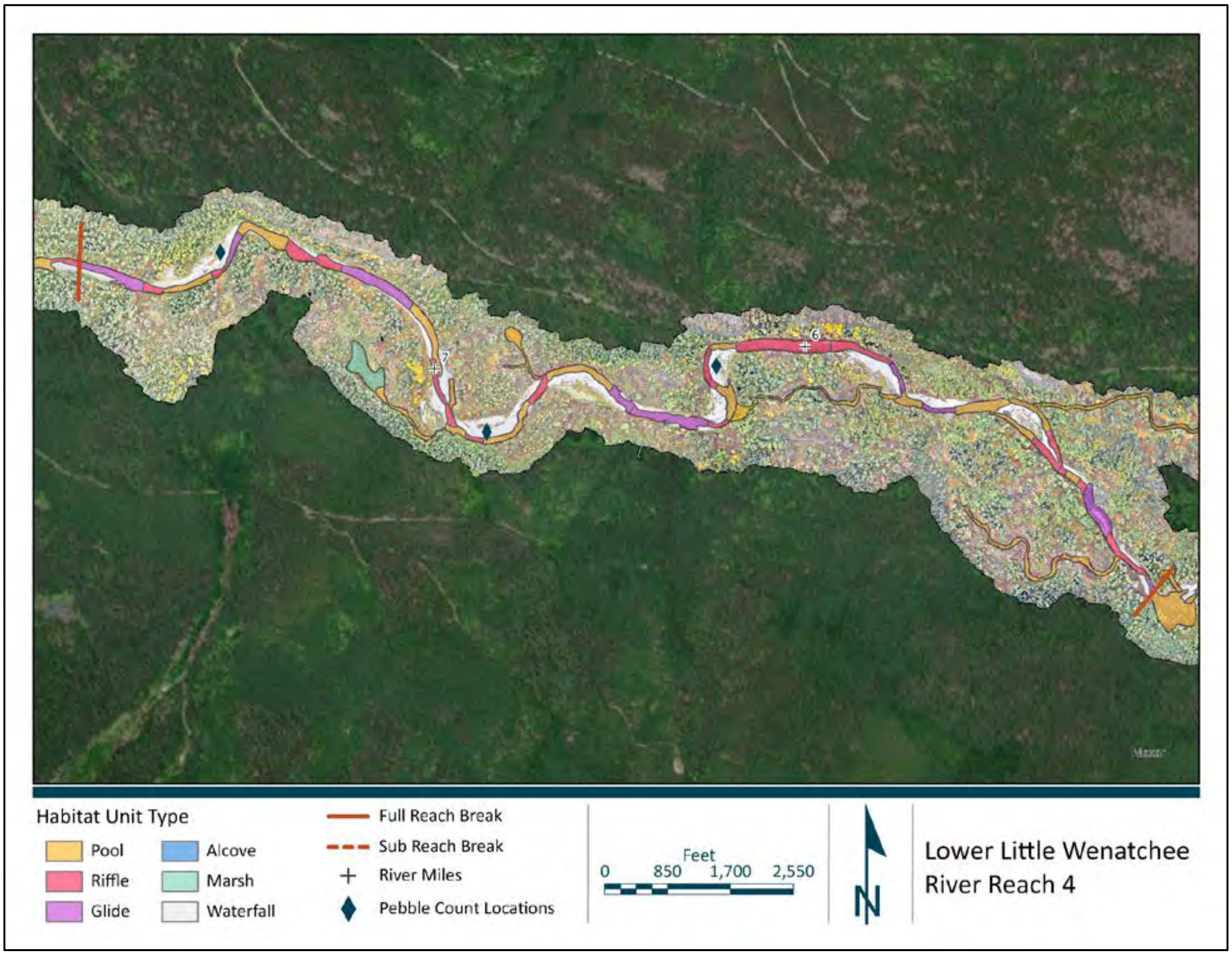


Figure 26. Lower Little Wenatchee River, Reach 1, habitat units and pebble count locations.

4.4.1 Habitat Unit Composition

The habitat area in Reach 4 was nearly evenly split between fast and slow water habitat types. Riffles and glides accounted for 51% of habitat area in Reach 4, 31% and 20% respectively. Pools and side channel habitats that were predominately slow-moving made up the remaining 49% of habitat area, 31% and 18% respectively (Figure 26).

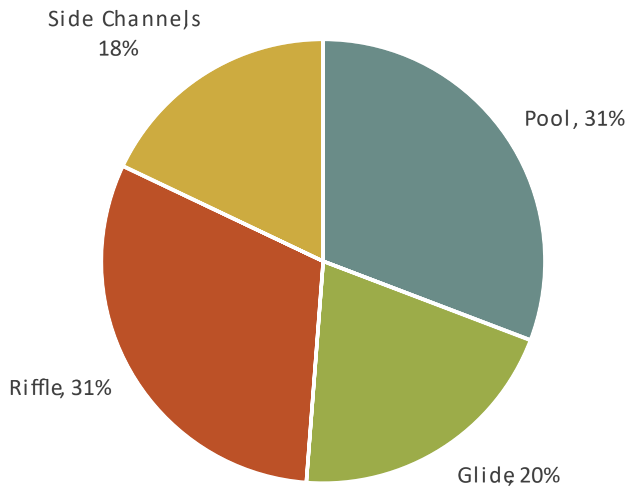


Figure 27. Habitat area breakdown for Lower Little Wenatchee Reach 3.

4.4.2 Pools

Pools accounted for 39% of Reach 4 habitat area (Figure 27). A total of 13 pools were counted in Reach 4, averaging 5 pools per mile. Pools had an average maximum depth of 5.7 ft, with a maximum of 10.00 ft and a minimum of 3.0 ft. Residual pool depth averaged 4.8 ft. Of the 17 pools identified, 9 had a residual depth greater than 3 ft (69%), and 4 (31%) had residual depths less than 3ft. Mean pool spacing for Reach 4 was 25.2 channel wetted widths per pool, compared to an average of 17.7 channel wetted widths per pool across the entire survey area.

4.4.3 Side Channel Habitat

Side channel habitat accounted for 18% of the area (Figure 27) in Reach 4 and all of them were categorized as slow water units. Reach 4 side channels had an average length of 2602 ft (0.49 miles). The average wetted width for Reach 4 side channels was 15 ft. There were a total of 44 pieces of large wood in Reach 4 side channels; 26 small, 5 medium and 13 large pieces.

4.4.4 Large Woody Material

Reach 4 contained 281 pieces of large woody material (Table 7); 159 small, 61 medium, and 61 large pieces of wood, for 155 pieces of LWM per mile. There were 8 log jams identified in Reach 4.

Table 7. Large woody material quantities in Reach 4.

	Small (6 in X 20 ft)	Medium (12 in x 35 ft)	Large (20 in x 35 ft)	Total
Number of Pieces	159	61	61	281
Number of Pieces / Mile	61	23	23	155
Number of Jams	8			
Number of Jams / Mile	3.07			

4.4.5 Substrate & Fine Sediment

Two pebble counts were conducted in Reach 4, both on exposed bars (Figure 28). The material composition from the gravel counts in Reach 4 combined was nearly three quarters gravel (72%), and quarter cobble (26%) and only 1% classified as sand and finer material.

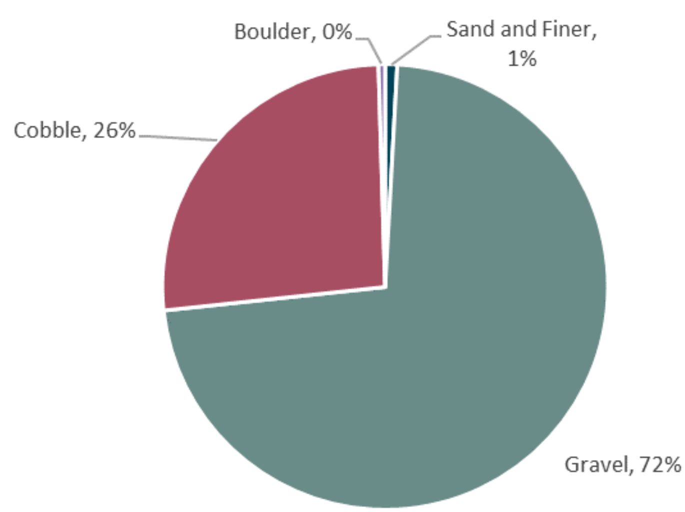


Figure 28. Combined percent composition sediment size type from two gravel counts on exposed bars in Reach 4.

4.4.6 Riparian Corridor

Seven nth units were evaluated in Reach 4. The dominant observed overstory size classes in Reach 4 were large trees (86%) and small trees (14%) (Figure 29). Cottonwoods accounted for 86% of overstory species in Reach 4, with Western red cedar accounting for the remaining 14% of overstory observations. Shrub/seedlings accounted for 57% of the dominant understory class, with sapling/pole size class making up the remaining 43% (Figure 30). Cottonwoods made up 57% of the dominant understory species recorded in the reach, with dogwood accounting for 29%, and alder making up the remaining 14%.

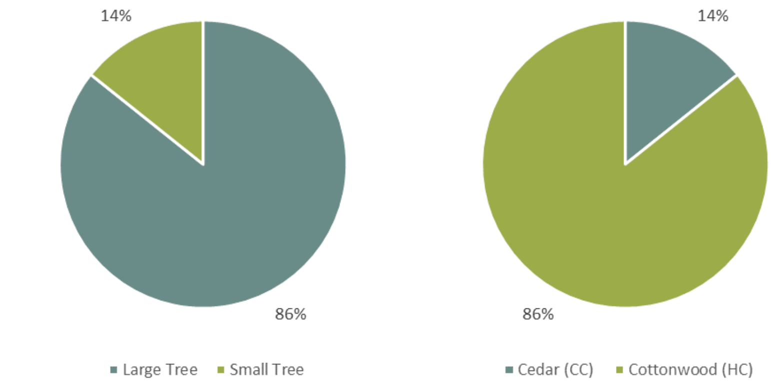


Figure 29. Dominant overstory size class (left) and dominant overstory species (right) for Reach 4.

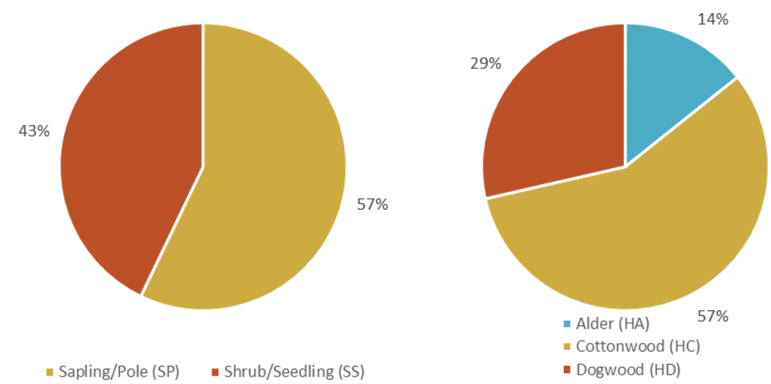


Figure 30. Dominant understory size class (left) and dominant understory species (right) for Reach 4.

4.5 REACH 5

Location: River mile 7.8 – 9.1
Total length: 1.3 miles
Survey date: October 13th, 2023

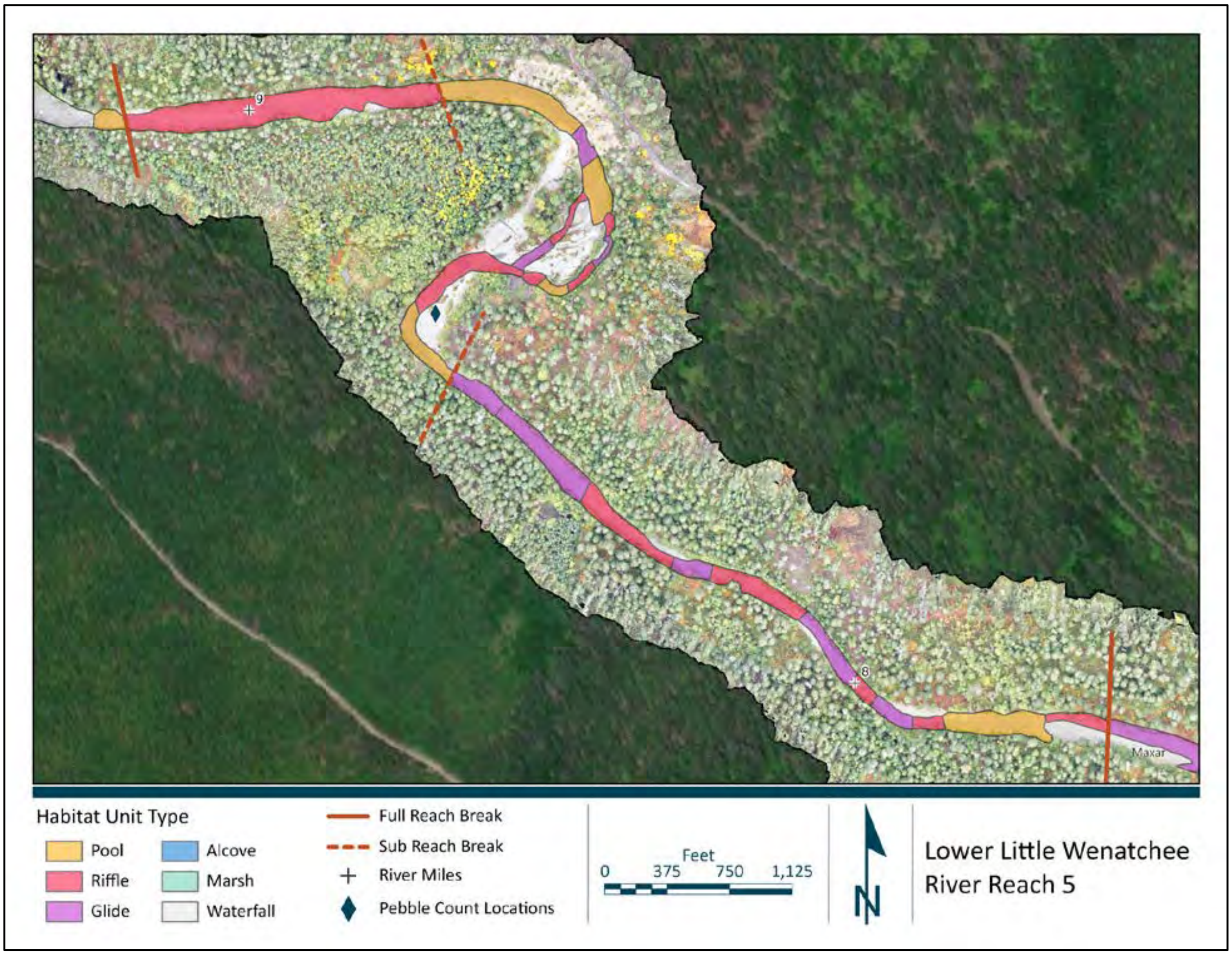


Figure 31. Lower Little Wenatchee River, Reach 1, habitat units and pebble count locations.

4.5.1 Habitat Unit Composition

The habitat area in Reach 5 is dominated by fast water habitat, with 46% of the area surveyed as riffles and 29% as glides, with only 24% categorized as pools. No side channels were identified in Reach 5 (Figure 31).

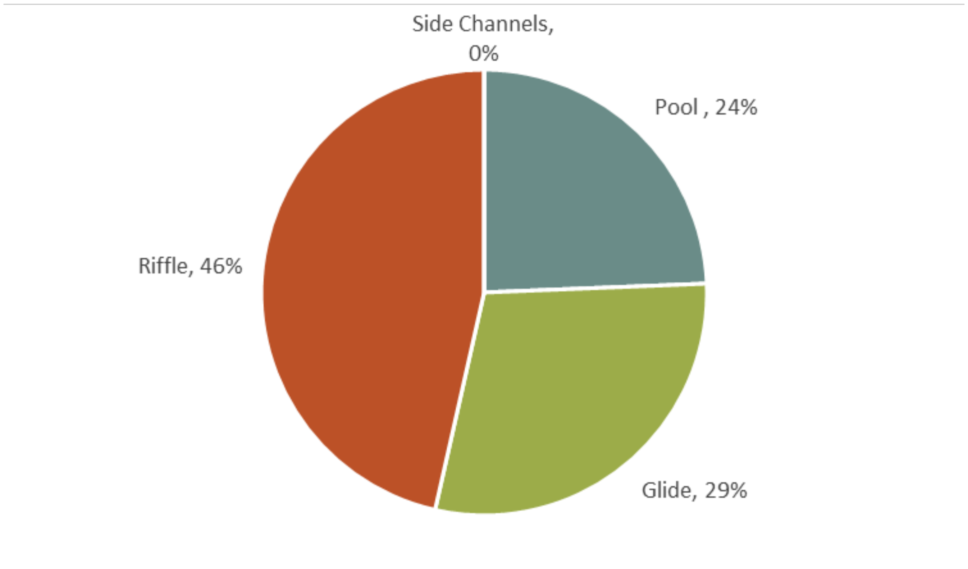


Figure 32. Habitat area breakdown for Lower Little Wenatchee Reach 5.

4.5.2 Pools

Pools accounted for 24% of Reach 5 habitat area (Figure 32). A total of 5 pools were counted in Reach 5, averaging 3.9 pools per mile. Pools had an average maximum depth of 4.1 ft, with a maximum of 6 ft and a minimum of 2.3 ft. Residual pool depth averaged 3.1 ft. Of the 5 pools identified, 2 had a residual depth greater than 3 ft (40%), and 3 (60%) had residual depths less than 3ft. Mean pool spacing for Reach 5 was 48.5 channel wetted widths per pool, compared to an average of 17.7 channel wetted widths per pool across the entire survey area.

4.5.3 Side Channel Habitat

No side channels were identified in Reach 5 (Figure 32).

4.5.4 Large Woody Material

Reach 5 contained 189 pieces of large woody material (Table 8); 105 small, 43 medium, and 41 large pieces of wood, for 145 pieces of total LWM per mile. There was one log jam identified in Reach 5.

Table 8. Large woody material quantities in Reach 5

	Small (6 in X 20 ft)	Medium (12 in x 35 ft)	Large (20 in x 35 ft)	Total
Number of Pieces	105	43	41	189
Number of Pieces / Mile	81	33	32	145
Number of Jams	1			
Number of Jams / Mile	0.76			

4.5.5 Substrate & Fine Sediment

Two pebble counts were conducted in Reach 5, both on exposed bars (Figure 33). The material composition from the gravel counts in Reach 5 combined was more mixed than the other reaches, with gravel accounting for 47%, cobble for 36%, and sand and finer accounting for 11%. Reach 5 had the highest proportion of boulders, at 6% of the combined percent composition of sediment size.

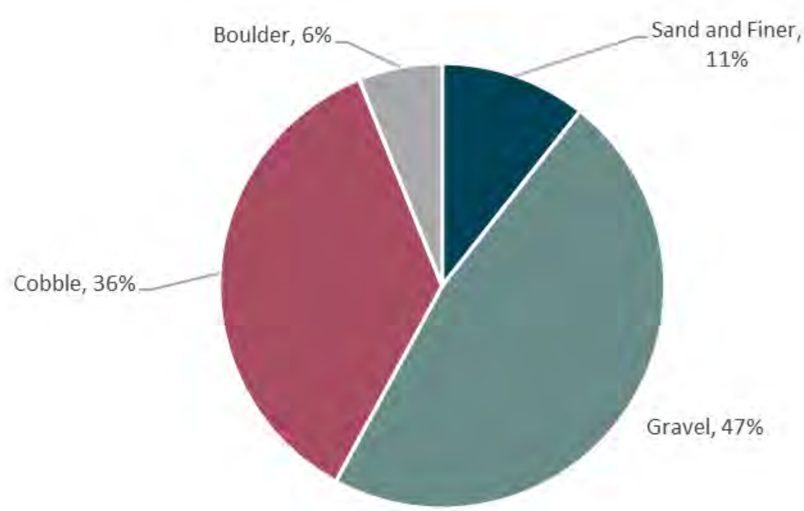


Figure 33. Combined percent composition sediment size type from two gravel counts on exposed bars in Reach 5.

4.5.6 Riparian Corridor

Five nth units were evaluated in Reach 5. The overstory class in Reach 5 were a mix of mature trees (40%), sapling/poles (40%), large trees (20%). Cedars and alders were the primary species in the overstory, 80% and 20% respectively (Figure 34). The understory was primarily sapling/poles (60%), with shrub/seedlings (20%) and small trees (20%) accounting for the remaining understory. Dominant understory species were dogwood (40%), willow (40%) and alder (20%) (Figure 35).

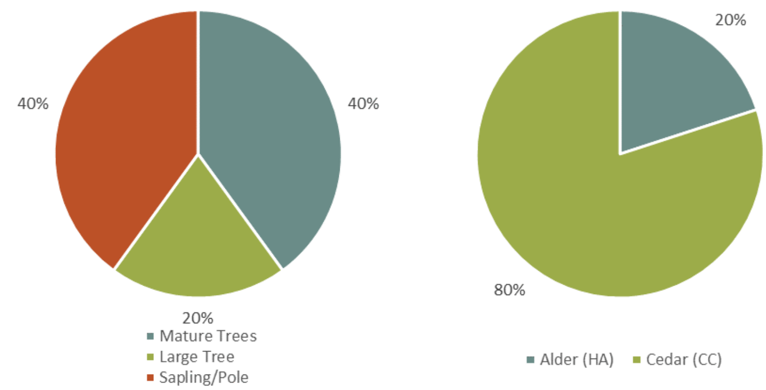


Figure 34. Dominant overstory size class (left) and dominant overstory species (right) for Reach 5.

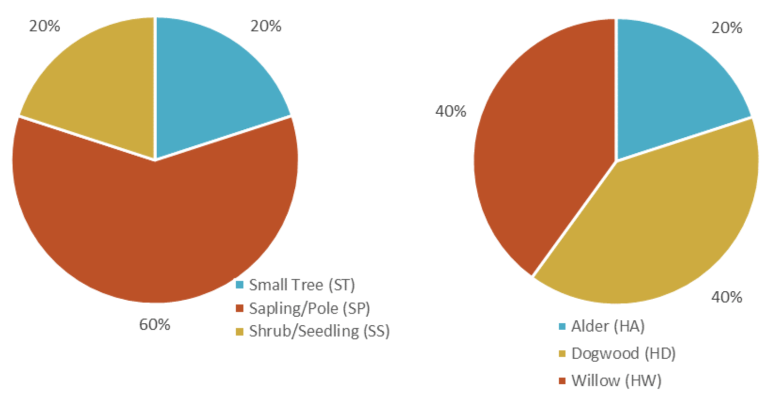


Figure 35. Dominant understory size class (left) and dominant understory species (right) for Reach 5.

4.6 REACH 6

Location: River mile 9.1 -9.7
Total length: 0.6 miles
Survey date: October 13th, 2023

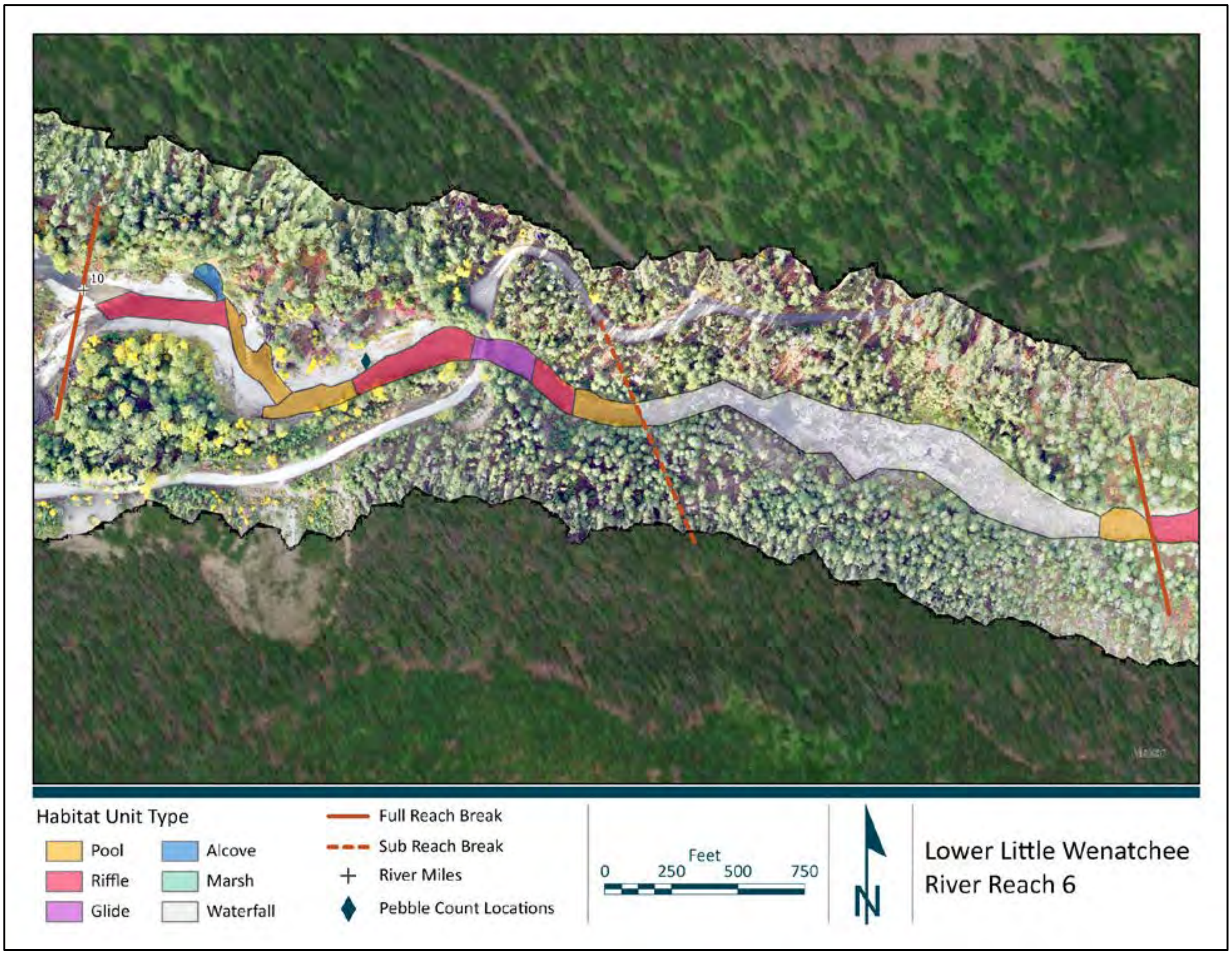


Figure 36. Lower Little Wenatchee River, Reach 1, habitat units and pebble count locations.

4.6.1 Habitat Unit Composition

The habitat area in Reach 6 was split between fast and slow water habitat types (Figure 36). Riffles and glides accounted for 56% of habitat area, 46% and 10% respectively. Pools comprised the remaining 44% of habitat area (44%).

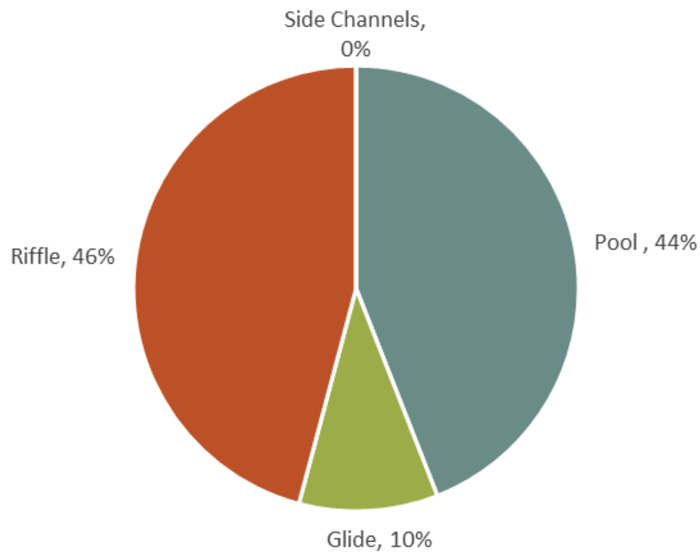


Figure 37. Habitat area breakdown for Lower Little Wenatchee Reach 6.

4.6.2 Pools

Pools accounted for 44% of Reach 6 habitat area (Figure 37). A total of 4 pools were counted in Reach 6, averaging 3.85 pools per mile. Pools had an average maximum depth of 4.7 ft, with a maximum of 6 ft and a minimum of 3.5 ft. Residual pool depth averaged 3.2 ft. Of the 4 pools identified, 2 had a residual depth greater than 3 ft (50%), and 2 (50%) had residual depths less than 3ft. Mean pool spacing for Reach 6 was 15.2 channel wetted widths per pool, compared to an average of 17.7 channel wetted widths per pool across the entire survey area.

4.6.3 Side Channel Habitat

No side channels were identified in Reach 6.

4.6.4 Large Woody Material

Reach 6 contained 24 pieces of large woody material (Table 9); 12 small, 11 medium, and 1 large pieces of wood, for 60 pieces of LWM per mile. There was 1 log jam identified in Reach 6.

Table 9. Large woody material in Reach 6.

	Small (6 in X 20 ft)	Medium (12 in x 35 ft)	Large (20 in x 35 ft)	Total
Number of Pieces	12	11	1	24
Number of Pieces / Mile	20	18	2	60
Number of Jams	1			
Number of Jams / Mile	1.67			

4.6.5 Substrate & Fine Sediment

One pebble count was conducted in Reach 6 on an exposed bar (Figure 38). The material composition from the gravel count in Reach 6 consisted of predominately gravels (57%), followed by cobble (35%), and sand and finer material accounting for only 7%.

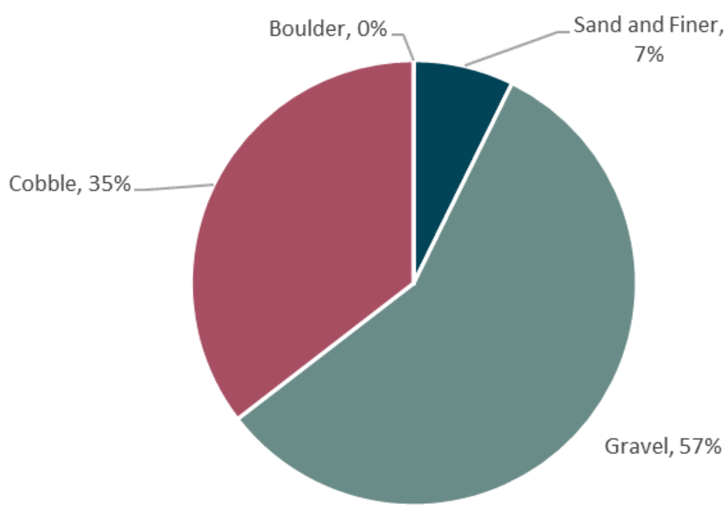


Figure 38. Combined percent composition sediment size type from two gravel counts on exposed bars in Reach 6.

4.6.6 Riparian Corridor

Two nth units were evaluated in Reach 6. The overstory was entirely comprised small western hemlocks (Figure 39) and the understory was comprised of entirely alder shrub seedlings (Figure 40).

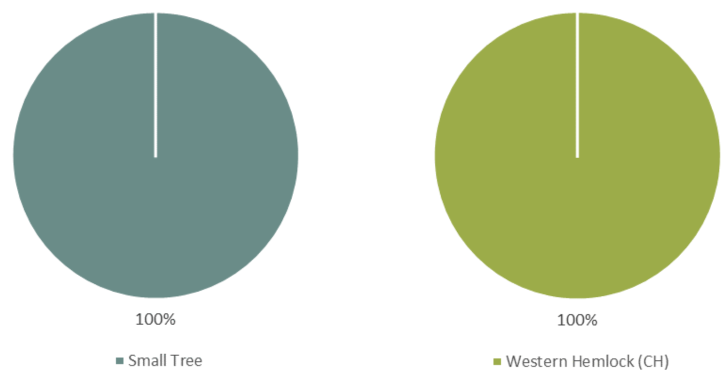


Figure 39. Dominant overstory size class (left) and dominant overstory species (right) for Reach 6.

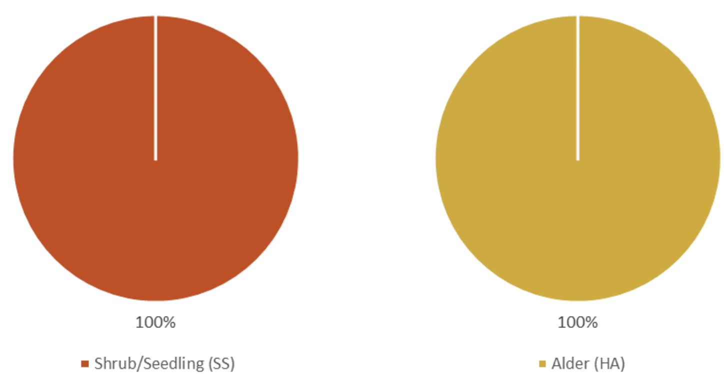


Figure 40. Dominant understory size class (left) and dominant understory species (right) for Reach 6.

4.7 SUMMARY DATA

Table 10 provides a list of the data and metrics presented in this habitat assessment for the Lower Little Wenatchee River (RM 0.5-9.7).

Table 10. Summary of all data collected for Reaches 1-6 of the Lower Little Wenatchee River Habitat Assessment.

Reach	*1*	*2*	*3*	*4*	*5*	*6*	*All Reaches*
Reach Mileage Boundaries	0.5 - 1.35	1.35 - 3.5	3.5 - 5.2	5.2 - 7.8	7.8 - 9.1	9.1 - 9.7	0.5 - 9.7
River Miles Surveyed	0.25	2.15	1.7	2.6	1.3	0.6	8.6
Average Wetted Width							
Pool							
Mean	47.50	56.39	53.24	51.92	64.00	37.50	53.56
Median	47.50	60.00	50.00	50.00	60.00	37.50	50.00
St. Dev.	3.54	12.46	35.04	11.64	34.89	11.90	23.14
Glide							
Mean	27.50	34.62	30.00	47.86	51.67	55.00	41.14
Median	27.50	30.00	30.00	45.00	45.00	55.00	40.00
St. Dev.	3.54	12.49	7.75	18.22	24.75	55.00	17.47
Riffle							
Mean	20.00	30.00	29.00	41.67	49.55	38.33	39.00
Median	20.00	25.00	25.00	40.00	35.00	40.00	35.00
St. Dev.	0.00	12.75	8.22	16.65	32.28	7.64	20.74
Side Channel							
Mean	N/A	10.92	16.50	15.00	N/A	N/A	13.26
Median	N/A	11.00	15.00	20.00	N/A	N/A	12.00
St. Dev.	N/A	4.87	9.40	7.07	N/A	N/A	6.90
Water Depth (ft)							
Pool Maximum Depth							
Mean	10.00	7.62	6.63	5.71	4.08	4.68	6.49
Median	10.00	8.00	5.75	6.00	4.40	4.60	6.00
St. Dev.	2.83	2.84	2.48	2.26	1.79	1.08	2.69
Pool Residual Depth							
Mean	8.95	6.66	5.36	4.75	3.1	3.18	5.41
Median	8.95	6.85	4.80	4.80	2.3	3.15	4.85
St. Dev.	2.05	2.87	1.64	2.32	1.7	1.40	2.71
Riffle/Glide Average Depth							
Mean	1.13	1.30	1.68	1.14	1.25	1.05	1.28
Median	1.00	1.30	1.60	1.00	2.00	1.10	1.20
St. Dev.	0.42	0.48	0.73	0.43	0.68	0.48	0.55

Reach	*1*	*2*	*3*	*4*	*5*	*6*	*All Reaches*
Bankfull Characteristics							
Width (ft)							
Mean	97.00	118.25	113.50	125.00	97.50	66.00	110.00
Median	97.00	121.00	109.50	130.00	97.00	66.00	106.50
St. Dev.	0.00	30.57	23.01	13.04	6.76	0.00	23.00
Average Depth (ft)							
Mean	3.06	3.64	3.34	3.36	3.36	2.86	3.37
Median	3.06	3.77	3.25	3.27	3.40	2.86	3.31
St. Dev.	0.00	0.50	0.67	0.82	0.45	0.00	0.56
Maximum Depth (ft)							
Mean	5.50	5.55	5.55	5.03	5.03	4.00	5.23
Median	5.50	5.60	5.90	5.05	5.05	4.00	5.40
St. Dev.	0.00	0.95	1.06	1.11	0.46	0.00	0.56
Width:Depth Ratio							
Mean	31.70	32.46	33.96	37.23	29.02	23.08	32.60
Floodprone Width							
Mean	6288.00	2904.25	1948.75	1248.00	820.75	98.00	5.23
Median	6288.00	2266.50	2037.00	1048.00	840.50	98.00	5.40
St. Dev.	0.00	1424.88	410.89	521.85	351.27	0.00	0.56
Habitat Percent Areas							
Pool	59%	60%	52%	31%	24%	44%	41%
Glide	29%	18%	19%	20%	29%	10%	21%
Riffle	12%	10%	3%	31%	46%	46%	23%
Side Channels	0%	12%	25%	18%	0%	0%	14%
Pools							
Pools Per Mile	8.00	8.37	10.00	5.00	3.85	6.67	6.86
Residual Depth							
Percent >/=3	100%	89%	76%	69%	40%	50%	75%
Percent < 3	0%	11%	24%	31%	60%	50%	25%
Riffle:Pool Ratio	5.05	6.27	16.72	1.00	0.52	0.96	1.83
Mean Pool Spacing (bankfull channel widths per pool)	6.91	5.66	4.62	8.60	16.34	11.27	7.28
Large Woody Material							
Total Number of Pieces							
Small	28	252	231	159	105	12	787
Medium	6	82	92	61	43	11	295
Large	2	76	48	61	41	1	229
Medium and Large (Quality LW)	8	158	140	122	84	12	524
Total	36	410	371	281	189	24	1311

Reach	*1*	*2*	*3*	*4*	*5*	*6*	*All Reaches*
Number of Pieces/Mile							
Small	112.00	117.21	135.88	61.15	80.77	20.00	712.69
Medium	24.00	38.14	54.12	23.46	33.08	18.33	269.39
Large	8.00	35.35	28.24	23.46	31.54	1.67	188.71
Medium and Large	32.00	73.49	82.35	46.92	64.62	20.00	458.10
Total	176.00	264.19	300.59	155.00	145.38	60.00	1628.89
Jams							
Total Jam / Reach							
Total Jams	0	10	4	8	1	1	24
Average LWM Pieces	0	79.88889	449.25	190.5	68	32	
Unstable Banks							
Total Unstable Banks (Percent of Total Bank)	0%	0%	0%	0%	10%	0%	10%
Substrate							
Total							
% Sand	N/A	10%	13%	1%	11%	7%	8%
% Gravel	N/A	83%	74%	72%	47%	57%	68%
% Cobble	N/A	7%	14%	26%	36%	35%	22%
% Boulder	N/A	0%	0%	0%	6%	0%	1%
% Bedrock	N/A	0%	0%	0%	0%	0%	0%
Vegetation							
Dominant Overstory Size Class							**Percent of System**
Mature Trees	0%	0%	14%	0%	40%	0%	71%
Large Tree	0%	100%	86%	86%	20%	0%	6%
Small Tree	50%	0%	0%	14%	0%	100%	3%
Sapling Pole	50%	0%	0%	0%	40%	0%	19%
Dominant Overstory Species Composition							
Alder (HA)	100%	0%	0%	0%	20%	0%	10%
Cedar (CC)	0%	50%	86%	14%	80%	0%	48%
Cottonwood (HC)	0%	50%	14%	86%	0%	0%	35%
Western Hemlock (CH)	0%	0%	0%	0%	0%	100%	6%
Dominant Understory Size Class							
Small Tree (ST)	0%	0%	0%	0%	20%	0%	29%
Sapling/Pole (SP)	100%	50%	0%	57%	60%	0%	68%
Shrub/Seedling (SS)	0%	50%	100%	43%	20%	100%	3%
Dominant Understory Species Composition							
Alder (HA)	50%	13%	0%	14%	20%	100%	19%
Cottonwood (HC)	0%	13%	0%	57%	0%	0%	16%
Dogwood (HD)	50%	13%	29%	29%	40%	0%	26%
Vine Maple (HV)	0%	50%	43%	0%	0%	0%	23%
Willow (HW)	0%	13%	29%	0%	40%	0%	16%

5 References

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Appendix B| Reach-Based Ecosystem Indicators (REI)

Lower Little Wenatchee River Assessment

Appendix B

Reach-Based Ecosystem Indicators (REI)

Lower Little Wenatchee River Reach Assessment (RM 0.5 – 9.7)

March 2024

Contents

1 Introduction

1.1 BACKGROUND

The Reach-based Ecosystem Indicators (REI) provides a consistent means of evaluating biological and physical conditions of a watershed in relation to regional standards and known habitat requirements for aquatic biota. These indicators, along with other scientific evaluations, are used to describe the current quality of stream biophysical conditions and to help inform restoration targets and actions. The REI indicators used in this assessment are adaptations from previous efforts including the National Marine Fisheries Service (NMFS) matrix of pathways and indicators (NMFS 1996) and the United States Fish and Wildlife (USFWS) (1998). With a few exceptions, the REI are based on the United States Bureau of Reclamation's (USBR) latest adaptations and use of these indicators (USBR 2012).

The REI evaluation for the Lower Little Wenatchee was conducted using field data, observations, previous studies, and available data for the study area. In particular, the rankings were developed based on quantitative inventory information from: 1) Habitat Assessment (Appendix A) performed as part of the Reach Assessment using United States Forest Service (USFS) (2016) protocols, 2) assessment of geomorphic patterns and processes and how they have deviated, if at all, from historical conditions, and 3) analysis of existing watershed assessments and data (e.g. available ArcGIS layers and shapefiles etc.). Functional ratings include **Adequate**, **At Risk**, or **Unacceptable**. The REI analysis helps to summarize habitat impairments and to distill the impairments down to a consistent value that can be compared among reaches.

1.2 SUMMARY OF RESULTS

At the watershed-scale, the Little Wenatchee River was rated **At Risk** for the Drainage Network and Hydrologically Impaired Surfaces indicator and the Disturbance Regime indicator, due to the number of roads and residential/agricultural clearing, particularly in the lower basin. The Streamflow indicator was also rated **At Risk** for the Little Wenatchee, while Water Quality – including water temperature and contaminants – was rated as **Unacceptable**.

At the reach-scale, Reaches 5 and 6 of the Lower Little Wenatchee River had the highest number of **Unacceptable** ratings. Reach 2, though it had fewer **Unacceptable** ratings, still had a high number of **At Risk** ratings, largely due to the gravel mine impacting floodplain connection and increasing channel confinement. Reaches 3 and 4 showed the greatest number of adequately functioning ecosystem metrics.

The ratings relating to salmonid habitat ranged from Adequate to Unacceptable across the study area. All six reaches were given **Adequate** ratings for the Habitat Access Pathway- Main Channel Barriers indicator since there were no anthropogenic barriers within the main channel that completely excluded fish passage. A natural waterfall that is assumed to act as at least a partial barrier to fish migration was observed in Reach 6, however, the REI ratings are based on non-natural barriers present in the main channel, of which there were none in the assessment area.

For the Dominant Substrate/Fine Sediment indicator, Reach 3 was rated **At Risk** due to the relatively high proportion of fine sands and silt sediments present in the substrate. All other reaches had high proportions of gravels and cobbles appropriate for salmonid spawning and rearing with low amounts of fine sediments, and therefore given **Adequate** ratings.

Large Woody Material (LWM) ratings varied between **Adequate** in Reaches 2, 3, and 5 and **At Risk** in Reaches 1 and 4. Only Reach 6 had low numbers of large wood pieces present in the channel and lacked potential for future large wood recruitment, earning a rating of **Unacceptable**. Pool frequency was rated **At Risk** or **Unacceptable** in all reaches due to the very low pool frequency and, in the case of Reaches 5 and 6, somewhat low quality of the pools (low residual depths and minimal/no large wood cover or habitat). The Off-channel Habitat indicator was rated as **Unacceptable** for Reaches 1 and 5 and **At Risk** for all other reaches, due to either the complete lack or very infrequent occurrence of alcoves and side channels connected at baseflows.

Riparian vegetation condition indicators – Structure and Disturbance – are functioning relatively well across all reaches due to minimal roads and development located within the riparian zone of these reaches. Reaches 2, 4, and 6 received **At Risk** ratings for Riparian Vegetation Structure, while Reaches 1, 3, and 5 received **Adequate** ratings. For Riparian Vegetation Disturbance, Reaches 1, 2, 4, and 6 are functioning in an **At Risk** condition, while reaches 3 and 5 were rated as **Adequate**. At Risk ratings for riparian vegetation condition indictors were largely due to the relatively young seral stage of the overstory in those reaches where historically a more complex mosaic of mature overstory would have been expected. Canopy Cover was rated as **Unacceptable** for all reaches since a majority of the low-flow wetted channel is not shaded by adjacent riparian trees.

Channel dynamics for Reaches 1 and 2 are mostly functioning well. Floodplain connectivity was rated **At Risk** for all reaches except Reach 4. Reach 2 was the only reach that received **At Risk** ratings for Bank Stability/Channel Migration and Vertical Channel Stability. All other reaches were rated as Adequate for the Bank Stability/Channel Migration and Vertical Channel Stability indicators.

For the study area as a whole, **Adequate** was the most common reach-scale rating (30), followed by **At Risk** (25), then **Unacceptable** (11).

2 Metrics & Indicators

2.1 WATERSHED-SCALE METRICS

Pathway	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Watershed Scale					
Watershed Condition	Drainage Network and Hydrologically Impaired Surfaces	Increase in Drainage Network/ Hydrologically Impaired Surfaces	Zero or minimal increases in the drainage network that is correlated with human caused disturbances. Hydrologically impaired surfaces in watershed total < 8%. Road density <1 mile/miles^2.	Low to moderate increase in the drainage network correlated with human caused disturbances. Hydrologically impaired surfaces in watershed total between 8 and 14.9%. Road density 1-2.4 miles/miles^2.	Substantial increase in the drainage network correlated with human caused disturbances. Hydrologically impaired surfaces in watershed total > 15%. Road density >2.4 miles/miles^2.
	Disturbance Regime	Natural/Human Caused	Environmental disturbance is short-lived; predictable hydrograph, high quality habitat and watershed complexity providing refuge and rearing space for all life stages or multiple life-history forms. Natural processes are stable.	Localized events of hillslope contributions, avulsion, lateral migrations, minor bed incision, or wildfires. Resiliency of habitat to recover from environmental disturbances is moderate.	Frequent flood or drought producing highly variable and unpredictable flows, hillslope contributions, avulsion, lateral migrations, minor to major bed incision (head cuts), or wildfires throughout a majority of the watershed. The channel is simplified, providing little hydraulic complexity in the form of pools or side channels. Natural processes are unstable.
Flow/Hydrology	Streamflow	Alterations to Peak/Base Flows	Magnitude, timing, duration, and frequency of peak flows within a watershed are not altered relative to natural conditions of an undisturbed watershed of similar size, geology, and geography.	Some evidence of altered magnitude, timing, duration and/or frequency of peak flows relative to natural conditions of an undisturbed watershed of similar size, geology, and geography.	Pronounced changes in magnitude, timing, duration and/or frequency of peak flows relative to natural conditions of an undisturbed watershed of similar size, geology, and geography.
Water Quality	Temperature	(1) Maximum Weekly Temperature or (2) 7-day average daily maximum temperatures	(1) Bull Trout: incubation 2 - 5°C, rearing 4 - 10°C, spawning 1 - 9°C; Other salmonids: Spawning (June-Sept) <15°C and (Sept-May) <12°C, rearing <15°C, holding and migration <15°C; Lamprey: rearing 10 – 18 °C, migration <18°C (2) Salmonids: spawning <13°C, rearing and migration <17.5°C	(1) Bull trout and other salmonids: Incubation <2°C or ≥6°C, rearing <4°C or ≥13-15°C, spawning <4°C to ≥10°C; temperatures in areas used by adults during the local spawning migration sometimes exceed 15°C. Lamprey: rearing 18 – 22 °C, migration 18 - 22°C (2) 7-day average daily maximum temperature standards are exceeded by ≤15%	(1) Bull trout and other salmonids: Incubation <1°C or >6°C; rearing >15°C; spawning <4°C or >10°C; temperatures in areas used by adults during the local spawning migration regularly exceed 15°C. Lamprey: rearing >22 °C, migration >22°C (2) 7-day average daily maximum temperature standards are exceeded by ≥15%

2.2 REACH-SCALE METRICS

Pathway	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Reach Scale					
Habitat Access	Physical Barriers	Main Channel Barriers	No man-made barriers present in the mainstem that limit upstream or downstream migration at any flow.	Man-made barriers are present in the mainstem that have the potential to prevent or inhibit upstream or downstream migration at a subset of flows.	Man-made barriers present in the mainstem that prevent upstream or downstream migration at multiple or all flows.
Habitat Quality	Substrate	Dominant Substrate/Fine Sediment	Gravels or small cobbles make up >50% of the bed materials in spawning areas. ≤12%fines/sand (<2 mm) in spawning gravel.	Gravels or small cobbles make up 30-50% of the bed materials in spawning areas. 12-17% fines (<2 mm) in spawning gravel.	Gravels or small cobbles make up <30% of the bed materials in spawning areas. >17% fines (<2 mm) in spawning gravel.
	LWM	Pieces per Mile at Bankfull	Quantities of LWM in the reach exceed both Eastside and Westside criteria for the 75th percentile of large wood loading in Fox and Bolton (2007). The Westside criteria is 64 pieces/mile of qualifying large wood. The Eastside criteria is 32 pieces/mile of qualifying large wood. Qualifying pieces are those classified as Medium or Large in the USFS Stream Inventory protocol (2016), under the Eastside Forests criteria: Medium = diameter > 12 in, length > 35 ft; and Large = diameter > 20 in, length > 35 ft In addition to a minimum of 64 pieces of qualifying large wood/mile, an adequate rating also indicates there are sources of woody debris available for both long- and short-term recruitment within the reach.	Quantities of LWM in the reach range from 32 pieces/mile to <64 pieces/mile, thereby meeting the Eastside criteria for the 75th percentile of large wood loading in Fox and Bolton (2007) but not exceeding the Westside criteria for qualifying pieces. Qualifying pieces are those classified as Medium or Large in the USFS Stream Inventory protocol (2016), under Eastside Forests. In addition to a minimum of 32 pieces of large wood/mile, an at risk rating also indicates that the potential source for large woody debris recruitment in the short and/or long term is lacking.	Current levels are not meeting the minimum requirements for an "at-risk" rating, and potential source of woody debris for short- and/or long-term recruitment are lacking as well.
	Pools	Pool Frequency and Quality; presence of large pools.	Pool frequency: Number of pools/mile for a given channel width. Channel widths were variable throughout the study area, therefore the following channel width metrics for minimum pool frequencies will be used to determine adequate conditions based on average bankfull widths for each reach: Reaches 1, 2, 3, 4, and 6: 25-50 feet = 26 pools/mile Reach 5: 50-75 feet = 23 pools/mile To be considered adequate, at least 50% of the total pools are large pools >1 m (3 ft) deep. Pools must also have good fish cover (as determined by riparian vegetation and canopy cover metrics) and cool water with only a minor reduction in pool volume from fine sediment.	Pool frequency meets the values for the "adequate" rating, but pools have inadequate cover/temperature and/or there has been a moderate reduction of pool volume by fine sediment. Reaches have between 20 – 50% large pools (>1 m deep) present with good fish cover.	Pool frequency does not meet the pools/mile metric given in the "adequate" rating. Pools also have inadequate cover/temperature and/or there has been a major reduction of pool volume by fine sediment. Reaches have <20% large pools (>1 m deep).

Pathway	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
	Off-Channel Habitat and Refugia	Connectivity with Main Channel	Reach has side channels and/or groundwater fed tributaries. Aquatic refugia such as backwaters, alcoves, large boulder eddies exist within the channel. Well-vegetated floodplains with healthy riparian community are inundated on a 1--2-year recurrence frequency. No man-made barriers along the mainstem that prevent access to off-channel areas.	Reach provides some aquatic off-channel and refugia features but access varies or is at risk of disconnection due to human impacts or man-made barriers. Floodplains along the off-channel habitat are well-vegetated with inundation recurrence of 2—5-years.	Reach provides no or only minimal off-channel or in-channel refugia. Floodplains are disconnected by processes of incision and/or human structures (levee, bridges, etc.) and riparian vegetation has been altered.
Riparian Vegetation	Condition	Structure	>80% large trees (>21" DBH; USFS 2016) in the riparian buffer zone (defined as a 200ft buffer along each bank) based on habitat assessment data.	50-80% large trees (>21" DBH; USFS 2013) in the riparian buffer zone (defined as a 200ft buffer along each bank) based on habitat assessment data.	<50% large trees (>21" DBH; USFS 2013) in the riparian buffer zone (defined as a 200ft buffer along each bank) based on habitat assessment data.
		Disturbance (Human)	<20% disturbance in the 200-foot riparian buffer zone (e.g. agriculture and grazing, residential, roads, etc.) and <1 mile/miles^2 road density in the 200-foot riparian buffer zone.	20-50% disturbance in the 200-foot riparian buffer zone (e.g. agriculture and grazing, residential, roads, etc.) and 1-2.4 miles/miles^2 road density in the 200-foot riparian buffer zone.	>50% disturbance in the 200-foot riparian buffer zone (e.g. agriculture and grazing, residential, roads, etc.) and >2.4 miles/miles^2 road density in the 200-foot riparian buffer zone.
		Canopy Cover	Trees and shrubs within one site potential tree height distance (~100 feet) have >80% canopy cover that provides thermal shading to the river.	Trees and shrubs within one site potential tree height distance have 50-80% canopy cover that provides thermal shading to the river.	Trees and shrubs within one site potential tree height distance have <50% canopy cover that provides thermal shading to the river.
Channel	Dynamics	Floodplain Connectivity	Floodplain areas are hydrologically linked to main channel within the context of the local process domain; overbank flows occur and maintain wetland functions, and riparian vegetation. Naturally confined channels are considered adequate.	Reduced linkage of floodplains and riparian areas to main channel in reaches with historically strong connectivity; overbank flows are reduced relative to historic frequency, as evidenced by moderate degradation of floodplain soil accumulations and riparian vegetation/succession.	Severe reduction in hydrologic connectivity between off-channel, floodplain, and riparian areas relative to historical connectivity; riparian vegetation/succession is altered significantly.
		Bank Stability/Channel Migration	Channel is migrating at or near natural rates within the geomorphic construct of the reach.	Channel migration is occurring at a faster or slower rate relative to natural rates, but significant change in channel width or planform is not detectable; large woody debris is still being recruited.	Little or no channel migration is occurring because of human actions preventing reworking of the floodplain and large woody debris recruitment; or channel migration is occurring at an accelerated rate such that channel width has at least doubled, possibly resulting in a channel planform change, and sediment supply has noticeably increased from bank erosion.
		Vertical Channel Stability	No measurable trend of aggradation or incision beyond the natural geomorphic processes of the reach.	Measurable trend of aggradation or incision that has the potential to, but has not yet caused, disconnection of the floodplain or a visible change in channel planform (e.g. single thread to braided.)	Enough incision or human infrastructure has occurred that the floodplain and off-channel habitat areas have been disconnected from the main channel; or enough aggradation has occurred to create a visible change in channel planform (e.g. single thread to braided.)

3 REI Ratings

This section discusses the results for each indicator, rated at either the reach-scale or watershed-scale for all four reaches.

3.1 WATERSHED-SCALE RATINGS

General Characteristics	General Indicators	Specific Indicators	Rating	Discussion
Watershed Scale				
Watershed Condition	Drainage Network and Hydrologically Impaired Surfaces	Increase in Drainage Network/ Hydrologically Impaired Surfaces	At Risk Condition	Watershed hydrologically impaired surfaces (roads, parking lots, and buildings) were calculated based on WADNR Roads from Washington State Geospatial Open Data Portal and from aerial imagery using to delineate areas that show signs of hydrologic impairment. To determine the surface area of roads within the watershed, road lines were buffered to 20 ft and clipped to the Little Wenatchee watershed, as determined using USGS Streamstats (2023). The total area of roads and manually delineated hydrologically impaired surfaces were summed and divided by the total watershed area to determine that 0.96% of the contributing Little Wenatchee watershed is hydrologically impaired. Road density was calculated using the WADNR Roads and dividing the length of the roads in the watershed, giving an overall road density of 1.2 miles of road per square mile. Although total area of hydrologically impaired surfaces is well below the threshold required to be deemed in adequate condition (<8%), the road density is above the threshold of <1 mile per square mile, and the proximity of roads to the active channel places this indicator in the At Risk Category.
	Disturbance Regime	Natural/Human Caused	At Risk Condition	This disturbance history rating reflects historical and ongoing riparian and hillslope timber harvest and mining activities in the watershed but relatively limited road or residential development. Some public land use development, such as trailheads, campgrounds, are present throughout the watershed. Timber harvest and mining activities have likely had significant direct and indirect effects on riparian vegetation age and structure, and have been shown to create channel instability and decrease the ability of the system to respond to natural disturbance regimes such as fire or flood. The watershed has annual spring flooding and frequent rain-on-snow floods. It is possible that channel-clearing activities were undertaken historically to transport logs or to minimize flooding or debris flow impacts, as has occurred throughout many Pacific Northwest watersheds. Currently only a small portion of the lower watershed is within private ownership and used for gravel mining. A majority of the watershed is within public (federal/state) ownership, including campground and trails. It is likely that some timber harvest will continue in the upper reaches, but any additional disturbance potential other than from natural causes is minor throughout the watershed. However, alterations from past human disturbance are still influencing the Little Wenatchee River (such as the lag between riparian timber harvest/clearing and in-stream LWD removal that takes many years for new trees to mature and fall into the river). The system is still recovering from these disturbances that have a persistent and long-lasting impact. Based on this information, the Lower Little Wenatchee River receives a rating of At Risk.
Flow/Hydrology	Streamflow	Alternations to Peak/Base Flows	At Risk Condition	The hydrology of the watershed contributing to the Lower Little Wenatchee River is driven by a combination of precipitation and snowmelt. Annual snowmelt flooding in the spring with infrequent rain-on-snow floods dominate the seasonal streamflow pattern in the basin. Snowmelt runoff is primarily driven by changes in ambient air temperature, snowpack mass, and the elevation of the season's snowpack. Peak runoff usually occurs in May and June, typically returning to baseflow by late summer. Timber harvest activities are the dominant historical and current land use in the Little Wenatchee watershed, and have been shown to change one or all of the above-mentioned attributes of peak flows in other basins. Climate change models indicate that winter precipitation is expected to increasingly fall as rain in the Cascade Mountains (Mote and Salanthe 2009) and likely result in an increase in winter stream flows, earlier and lower peak runoff, and lower summer baseflows. These analyses suggest that human-induced climate change is likely to have an effect on the magnitude, timing, duration, and frequency of stream flows in the Lower Little Wenatchee River. Based on the effects of past watershed management, and the potential effects of climate change, this indicator is rated At Risk.
Water Quality	Temperature	Daily maximum and 7-day mean daily maximum temperatures	Unacceptable Condition	Water temperatures in the Little Wenatchee River can exceed Washington State water quality standards for salmonids and Class AA streams and criteria set by the Wenatchee Forest Plan (<60.8 and 61°F, respectively) for several weeks during the summer (typically mid-July through the end of August; Roumasset 2020; Whiley and Cleland 2003). Harsh winter conditions, such as icing, may be equally problematic for juvenile salmonids overwintering in the project area. The Little Wenatchee River is generally cooler than the Wenatchee River downstream of Wenatchee Lake the summer and several cool-water seeps have been documented in the Lower Little Wenatchee project reach. Though relatively low amounts of anthropogenic disturbance have occurred in the watershed compared to other systems, Whiley and Cleland (2003) suggest that there have been channel morphological changes (channels that have widened and become shallower) due to high sediment loading combined with low shade levels, which have contributed to elevated water temperatures. For this reason, the Lower Little Wenatchee River is rated as Unacceptable.

3.2 REACH-SCALE RATINGS

Pathway	General Indicators	Specific Indicators	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6
Habitat Access	Physical Barriers	Main Channel Barriers	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate
			There are no anthropogenic barriers in the main channel.	There are no anthropogenic barriers in the main channel.	There are no anthropogenic barriers in the main channel.	There are no anthropogenic barriers in the main channel.	There are no anthropogenic barriers in the main channel.	There are no anthropogenic barriers in the main channel.
Habitat Quality	Substrate	Dominant Substrate/ Fine Sediment	Adequate	Adequate	At Risk	Adequate	Adequate	Adequate
			No pebble counts were conducted in Reach 1. Visual observations suggest small gravels and sands/silts dominate in this reach. Much of the reach is influenced by backwatering from Lake Wenatchee. The relatively higher percentage of fine material found in this reach would be expected as a natural depositional reach.	Two pebble counts. Averages: Fines & Sand: 10% Gravel: 83% Cobble: 7% Gravels dominate with some cobbles. Coarse sand is present in eddies and pool tail-outs.	Two pebble counts. Averages: Fines & Sand: 13% Gravel: 74% Cobble: 14% Gravels and cobbles dominate in Reach 3. Sand is present in along margins, in eddies, pool tail-outs, and on small bars.	Two pebble counts. Averages: Fines & Sand: 1% Gravel: 72% Cobble: 26% Plentiful gravels and cobbles on bars, pool tail-outs, and behind log jams. Fine material is very limited in this reach owing to the increasing valley confinement of the upper portion of the reach.	Two pebble counts. Averages: Fines & Sand: 11% Gravel: 47% Cobble: 36% Boulder: 6% Cobble, gravel, boulder substrate are present. Plentiful gravels and small cobbles on bars, pool tail-outs, and behind log jams and boulder steps.	One pebble count. Fines & Sand: 7% Gravel: 57% Cobble: 35% Cobble and gravel substrates dominate, with some smaller gravels and fines present behind large wood pieces and boulders, or along stream margins.
	LWM	Pieces per Mile at Bankfull	At Risk	Adequate	Adequate	At Risk	Adequate	Unacceptable
			M+L pieces/mi = 32 Meets the criteria of 32 M+L pieces/mile for Eastside forests, but does not meet the criteria for Westside forests (64 pieces/mi). Reach has moderate availability of large wood for future recruitment.	M+L pieces/mi = 73.5 Exceeds criteria of 64 M+L pieces/mile for Westside forests, with moderate availability of large wood for future recruitment.	M+L pieces/mi = 82.4 Exceeds criteria of 64 M+L pieces/mile for Westside forests, with good availability of large wood for future recruitment.	M+L pieces/mi = 47 Meets the criteria of 32 M+L pieces/mile for Eastside forests, but does not meet the criteria for Westside forests (64 pieces/mi). Reach has good availability of large wood for future recruitment.	M+L pieces/mi = 64.6 Exceeds criteria of 64 M+L pieces/mile for Westside forests, with good availability of large wood for future recruitment.	M+L pieces/mi = 20 Does not meet criteria for either Eastside or Westside forests (32 or 64 M+L pieces/mile, respectively). Reach has moderate availability of large wood for future recruitment.
	Pools	Pool Frequency and Quality; presence of large pools.	At Risk	At Risk	At Risk	At Risk	Unacceptable	Unacceptable
			Total Pools = 2 Pools/mi = 8 Pools ≥ 3 ft = 2 (100%) Average residual pool depth: 8.9 ft Low pool shading. Some cover from overhanging	Total Pools = 18 Pools/mi = 8.4 Pools ≥ 3 ft = 16 (89%) Average residual pool depth: 6.7 ft Low pool shading and cover from riparian vegetation. There is	Total Pools = 17 Pools/mi = 10 Pools ≥ 3 ft = 13 (76%) Average residual pool depth: 5.3 ft Low pool shading and cover from riparian vegetation. There is	Total Pools = 13 Pools/mi = 5 Pools ≥ 3 ft = 9 (69%) Average residual pool depth: 4.7 ft Low pool shading and cover from riparian vegetation. There is very	Total Pools = 5 Pools/mi = 3.9 Pools ≥ 3 ft = 2 (40%) Average residual pool depth: 2.8 ft Less pool habitat, and much shallower pool habitat, is present in this	Total Pools = 4 Pools/mi = 6.7 Pools ≥ 3 ft = 2 (50%) Average residual pool depth: 3.22 ft Less pool habitat, and much shallower pool habitat, is present in this

Pathway	General Indicators	Specific Indicators	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6
			riparian vegetation and large wood.	some large wood providing cover, including one large jam near the upstream reach break.	some large wood providing cover, including two large jams within the reach.	little large wood providing cover over pools at lower flows in this reach.	reach than in downstream reaches. Very little cover and complexity is available from riparian vegetation or large wood.	reach than in downstream reaches. Very little cover and complexity is available from riparian vegetation or large wood.
	Off-Channel Habitat and Refugia Condition	Connectivity with Main Channel	Unacceptable	At Risk	At Risk	At Risk	Unacceptable	At Risk
			Total SC = 0 Lacking off-channel habitats that are connected at a higher range of flows. Channel scars exist on the floodplain and may have been disconnected due to human alternation in the river-left floodplain.	Total SC = 12 Fast water = 0 Slow water = 12 Cover = low Off-channel habitats that are connected at low flows are relatively short and lack substantial riparian cover or large wood, particularly in the lower portion of the reach. A portion of off-channel features on the river-left floodplain were disconnected as a result of human alterations.	Total SC = 6 Fast water = 0 Slow water = 6 Cover = high Several long off-channel complexes are present in this reach, with varying levels of hydraulic connectivity. Few of the off-channel features provide year-round access from the mainstem, however. Off-channel features have relatively good cover from riparian vegetation and large wood.	Total SC = 5 Fast water = 0 Slow water =5 Cover = moderate The lower portion of this reach provides several long, off-channel complexes with varying levels of hydraulic connectivity. Few off-channel features that offer year-round access are present, particularly in the upper portion of the reach where the valley is more naturally confined.	Total SC = 0 The valley and channel are more naturally confined in this reach, limiting available off-channel and floodplain areas. However, where relatively low surfaces exist, there is not significant off-channel habitat available. This reach is lacking off-channel habitats that are connected at a range of flows.	Total SC = 0 The valley and channel are more naturally confined in this reach (which contains the falls), limiting available off-channel and floodplain areas. However, where relatively low surfaces exist, such as upstream of the falls, there is not significant off-channel habitat available. Anthropogenic modifications to the channel and floodplain, such as riprap or roads, likely further limit availability of off-channel habitats that are connected at a range of flows.
Riparian Vegetation	Off-Channel Habitat and Refugia Condition Dynamics Dynamics	Structure	Adequate	At Risk	Adequate	At Risk	Adequate	At Risk
			The riparian canopy overstory composition within the 200-foot riparian buffer was recorded as 50% small tree and 50% sapling/pole. Floodplain surfaces throughout a majority of the reach may receive regular inundation due to backwatering from Lake Wenatchee, limiting the	The riparian canopy overstory composition within the 200-foot riparian buffer was recorded as 100% large tree. Human disturbance in this reach has impacted stand age and structural complexity, as historically more patches of mature trees would have been present. Riparian canopy is limited in the lower	The riparian canopy overstory composition within the 200-foot riparian buffer was recorded as 14% mature trees and 86% large trees. The wide floodplains and off-channel complexes present in this reach support a complex stand age and structure. It is likely that some human disturbance in this reach	The riparian canopy overstory composition within the 200-foot riparian buffer was recorded as 86% large tree and 14% small tree. Human disturbance in this reach, particularly as a result of road building, has impacted stand age and structural complexity, as historically more patches of mature trees	The riparian canopy overstory composition within the 200-foot riparian buffer was recorded as 40% mature tree, 20% large tree and 40% sapling/pole. Evidence of historical timber harvest activities on the river-right floodplain in the upper portion of the reach, and hillslopes surrounding this reach	The riparian canopy overstory composition within the 200-foot riparian buffer was recorded 100% small tree. Human disturbance in this reach, including recreational use, roads, and historical timber harvesting, in assumed to have impacted stand age and structural complexity, as historically more

Pathway	General Indicators	Specific Indicators	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6
			production of larger trees.	portion of the reach on river-left as a result of anthropogenic land uses.	(e.g., previous timber harvesting) has moderately impacted stand age and structural complexity, as historically larger patches of mature trees would have been present.	would have been present.	are assumed to have moderately impacted the overall stand age and structural complexity, despite local zones of high quality, large mature trees.	patches of mature trees would have been present.
		Disturbance (Human)	At Risk	At Risk	Adequate	At Risk	Adequate	At Risk
			0.03% disturbance in the 200-foot buffer zone (e.g. residential, roads, etc.) and 11.12 miles / mile^2 road density in the 200-foot riparian buffer zone.	Though there was only 0.19% disturbance (e.g. residential, roads, etc.) identified within the 200-foot buffer zone and 0.97 miles/miles^2 road density in the 200-foot riparian buffer zone, the presence of the gravel pit in the river-left floodplain does appear to have modified and impacted riparian process within the reach.	0% disturbance in the 200-foot buffer zone (e.g. residential, roads, etc.) and 0.00 miles/miles^2 road density in the 200-foot riparian buffer zone.	0.54% disturbance in the 200-foot buffer zone (e.g. residential, roads, etc.) and 5.16 miles/miles^2 road density in the 200-foot riparian buffer zone.	0.11% disturbance in the 200-foot buffer zone (e.g. residential, roads, etc.) and 7.72 miles/miles^2 road density in the 200-foot riparian buffer zone.	0.34% disturbance in the 200-foot buffer zone (e.g. residential, roads, etc.) and 18.70 miles/miles^2 road density in the 200-foot riparian buffer zone.
		Canopy Cover	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable
			Canopy Cover = 10%, Stream and banks highly visible at most portions of the reach. Approximately 30% of the trees within the 100 – foot riparian buffer are 100 feet or taller, offering some thermal protection to the channel at portions of the day.	Canopy Cover = 10%, Stream and banks highly visible at most portions of the reach. Approximately 25% of the trees within the 100 – foot riparian buffer are 100 feet or taller, offering some thermal protection to the channel at portions of the day.	Canopy Cover = 10%, Stream and banks highly visible at most portions of the reach. Approximately 30% of the trees within the 100 – foot riparian buffer are 100 feet or taller, offering some thermal protection to the channel at portions of the day.	Canopy Cover = 5%, Stream and banks highly visible at most portions of the reach. Approximately 20% of the trees within the 100 – foot riparian buffer are 100 feet or taller, offering some thermal protection to the channel at portions of the day.	Canopy Cover = 5%, Stream and banks highly visible at most portions of the reach. Approximately 25% of the trees within the 100 – foot riparian buffer are 100 feet or taller, offering some thermal protection to the channel at portions of the day.	Canopy Cover = 5%, Stream and banks highly visible at most portions of the reach. Approximately 15% of the trees within the 100 – foot riparian buffer are 100 feet or taller, offering some thermal protection to the channel at portions of the day.
Channel	Dynamics Dynamics	Floodplain Connectivity	At Risk	At Risk	At Risk	Adequate	At Risk	At Risk
			The channel is moderately entrenched in this reach due to the influence of the Lake Wenatchee backwater effect and human land	Land uses and channel confinement have reduced hydraulic connection to the available valley floor, particularly in the lower	Road confinement reduces available valley floor. Existing small floodplain pockets are regularly connected.	Where valley width allows floodplains occur. Connectivity is adequate overall.	Where valley width allows floodplains occur and inundation is present at the annual event and above. Connectivity is	Land uses and channel confinement have reduced hydraulic connection to the available valley floor, particularly in in the

Pathway	General Indicators	Specific Indicators	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6
			uses in Reach 2 disconnecting available low floodplain surfaces.	portion of the reach. Existing floodplain pockets are regularly connected above the annual event.			somewhat limited in the upper portions of the reach where increasing natural confinement and possible historic human disturbance has increased floodplain disconnection.	vicinity of the bridge. Existing floodplain pockets appear regularly connected.
		Bank Stability/ Channel Migration	Adequate	At Risk	Adequate	Adequate	Adequate	Adequate
			Channel migration can occur freely onto wide surrounding floodplain. No instances of unstable banks were identified in this reach.	Channel has moderate ability to migrate; river left is confined by the presence of the mine tailings pond, but river right is freely able to migrate on to the floodplain. No instances of unstable banks were identified in this reach.	Channel migration can occur freely onto surrounding floodplain. No instances of unstable banks were identified in this reach.	Channel migration can occur freely onto surrounding floodplain. No instances of unstable banks were identified in this reach.	Where floodplain allows, channel can migrate freely in this naturally confined portion of channel. Approximately 10% of reach identified as unstable.	Where floodplain allows, channel can migrate freely in this naturally confined portion of channel. No instances of unstable banks were identified in this reach.
		Vertical Channel Stability	Adequate	At Risk	Adequate	Adequate	Adequate	Adequate
			Vertical channel stability in Reach 1 is largely controlled by Lake Wenatchee. Connectivity is adequate overall.	Vertical channel stability is functioning according to natural geomorphic processes under current conditions. However, the meander corridor has been impinged and severely degraded due to the gravel mining land use in the majority of the river-left floodplain. Should the channel capture the floodplain within the footprint of the gravel mine, adjustments to the vertical channel stability may push the reach out of its natural condition.	Functioning as normal. Long term reservoir of large wood available for recruitment has been lost due to floodplain logging, impacts the reach and downstream reaches	Functioning adequately.	Where valley width allows floodplains occur. Connectivity is adequate overall.	Where valley width allows floodplains occur. Connectivity is adequate overall.

4 References

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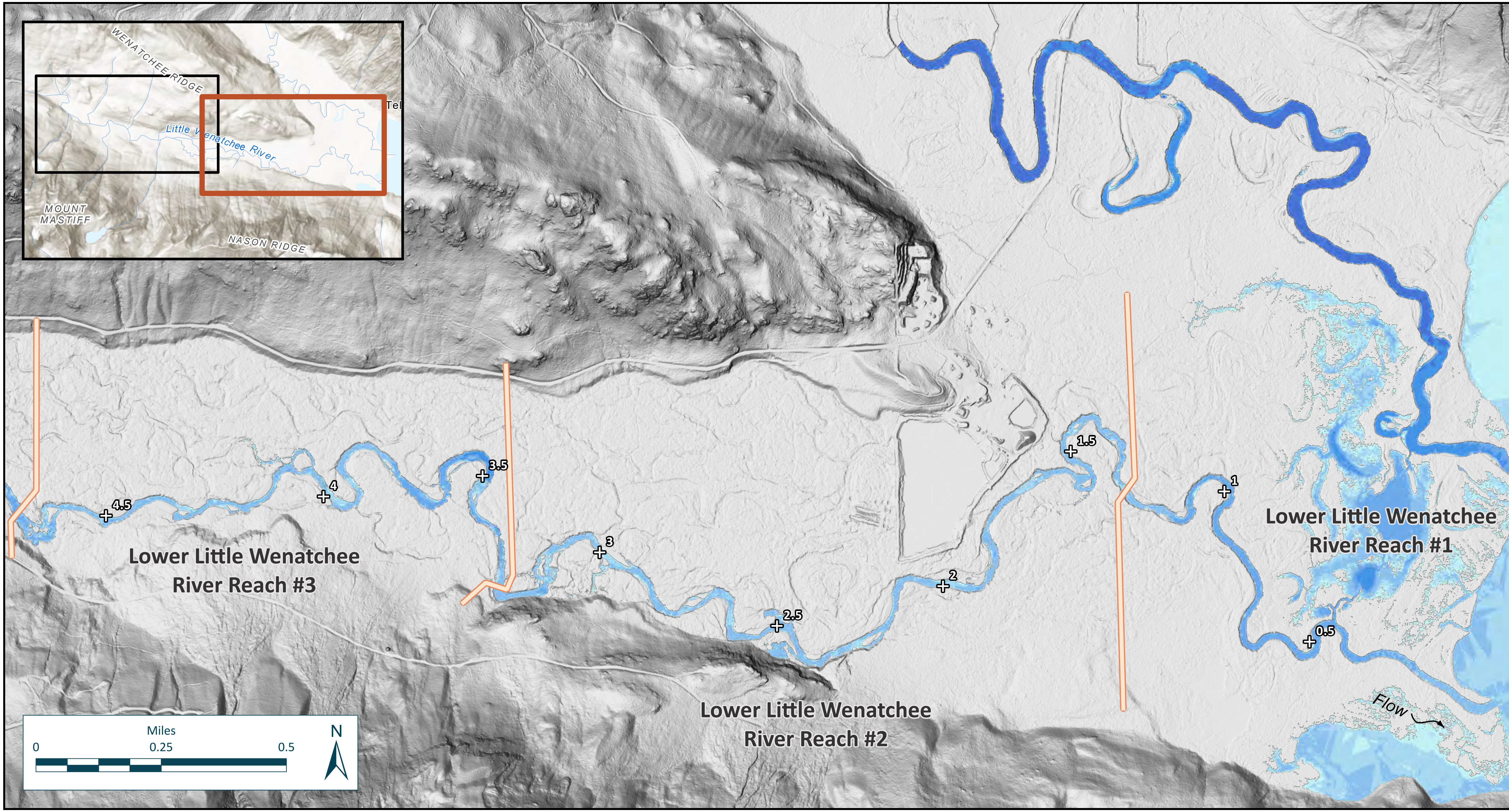
Appendix C| Existing Conditions Hydraulic Model Results

Lower Little Wenatchee River Assessment



River Miles

Reach Breaks

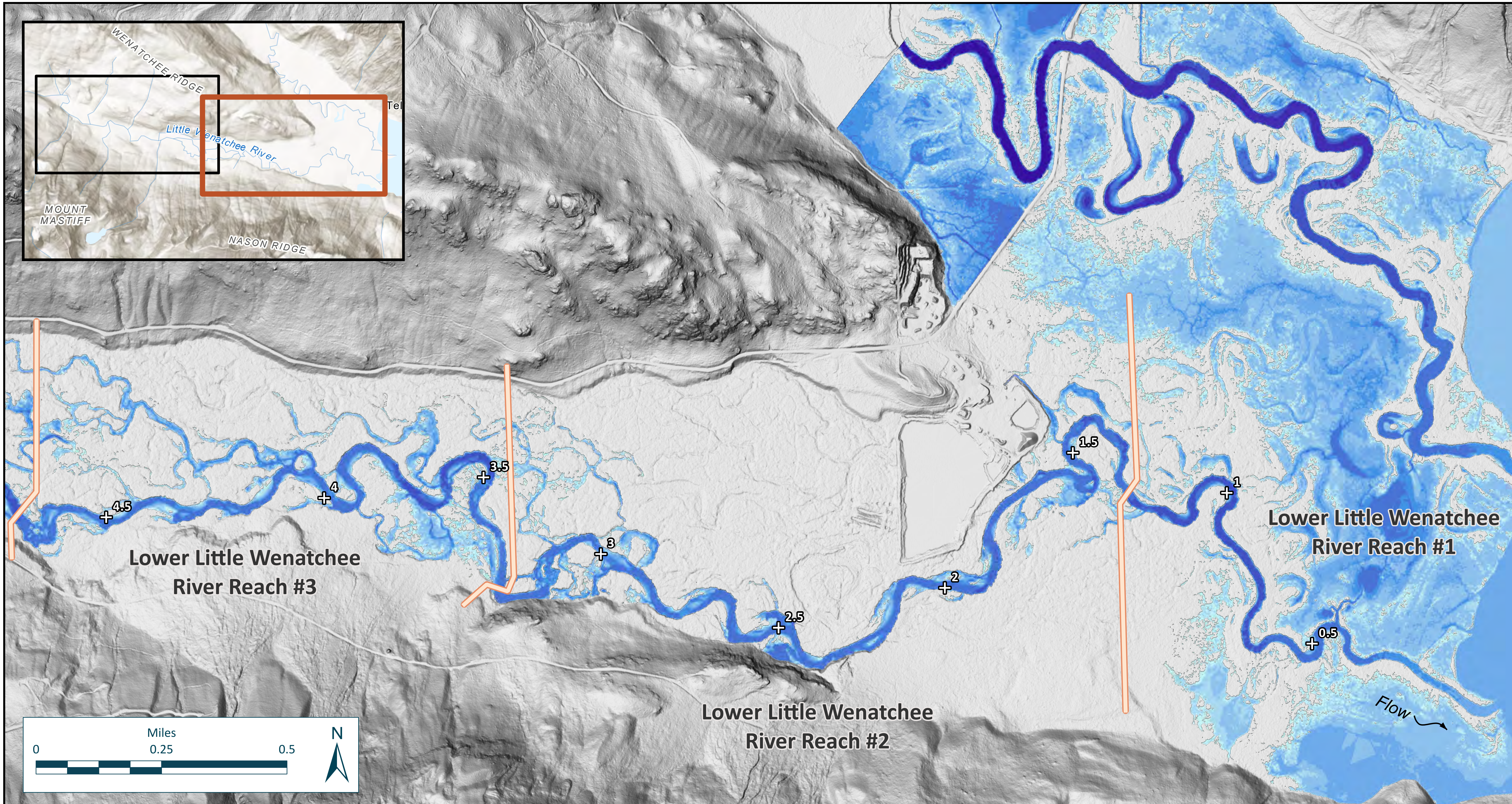
September Avg. Flow (81 cfs) -- Depth (ft):

<0.5 | <1 | <2 | <3 | <4 | <6 | <8 | <10 | 10+

Lower Little Wenatchee River Habitat Assessment
Existing Conditions Hydraulic Model Results

Downstream Assessment Area (RM 0–4.5)

Upper Wenatchee River Basin, WA



River Miles

Reach Breaks

June Avg. Flow (1131 cfs) -- Depth (ft):

<0.5	<1	<2	<3	<4	<6	<8	<10	10+

inter·fluve

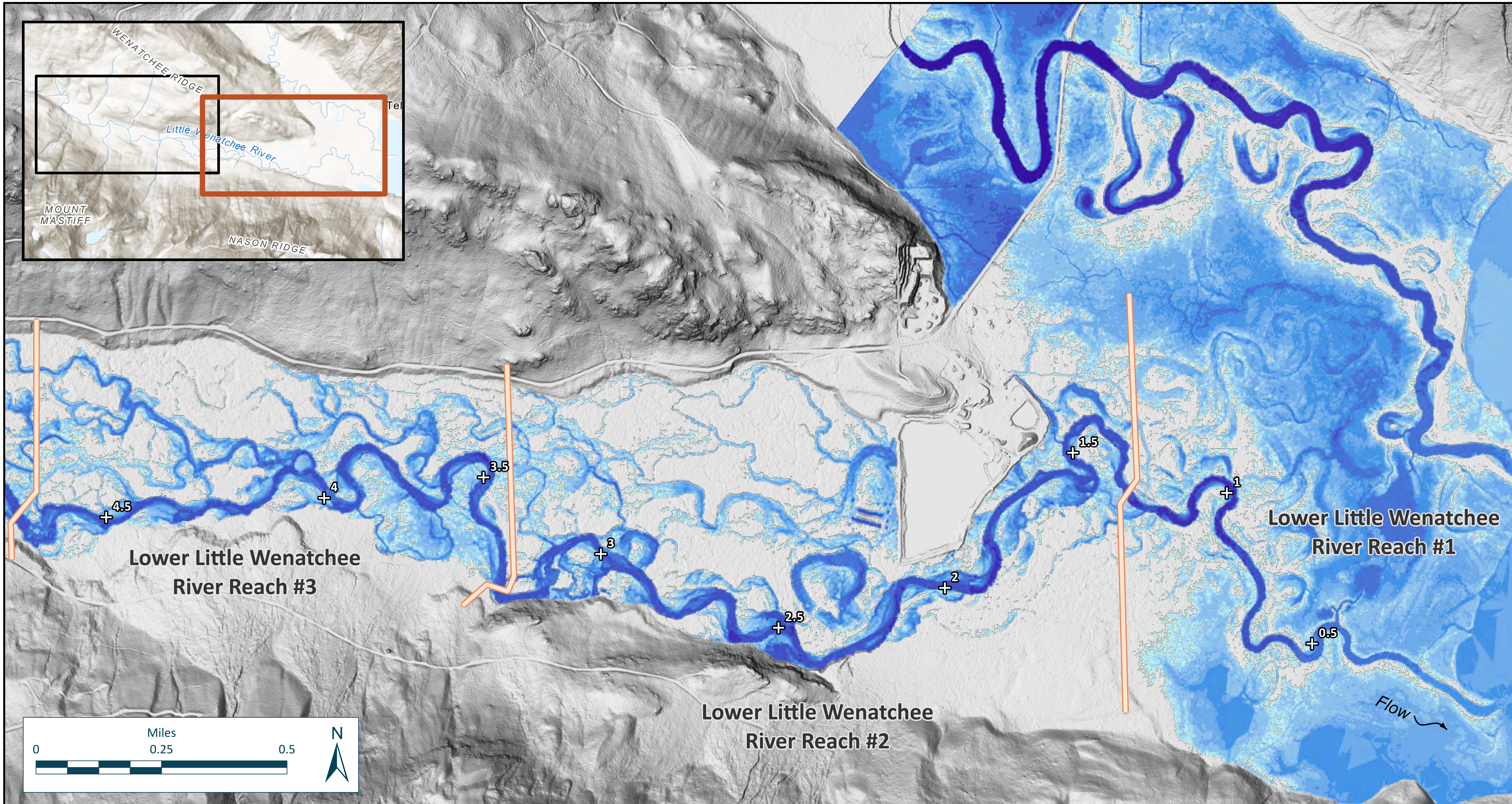
Fish & Wildlife Department Colville Tribes

BUREAU OF RECLAMATION

Lower Little Wenatchee River Habitat Assessment
Existing Conditions Hydraulic Model Results

Downstream Assessment Area (RM 0–4.5)

Upper Wenatchee River Basin, WA



Lower Little Wenatchee River Habitat Assessment
Existing Conditions Hydraulic Model Results

Downstream Assessment Area (RM 0–4.5)

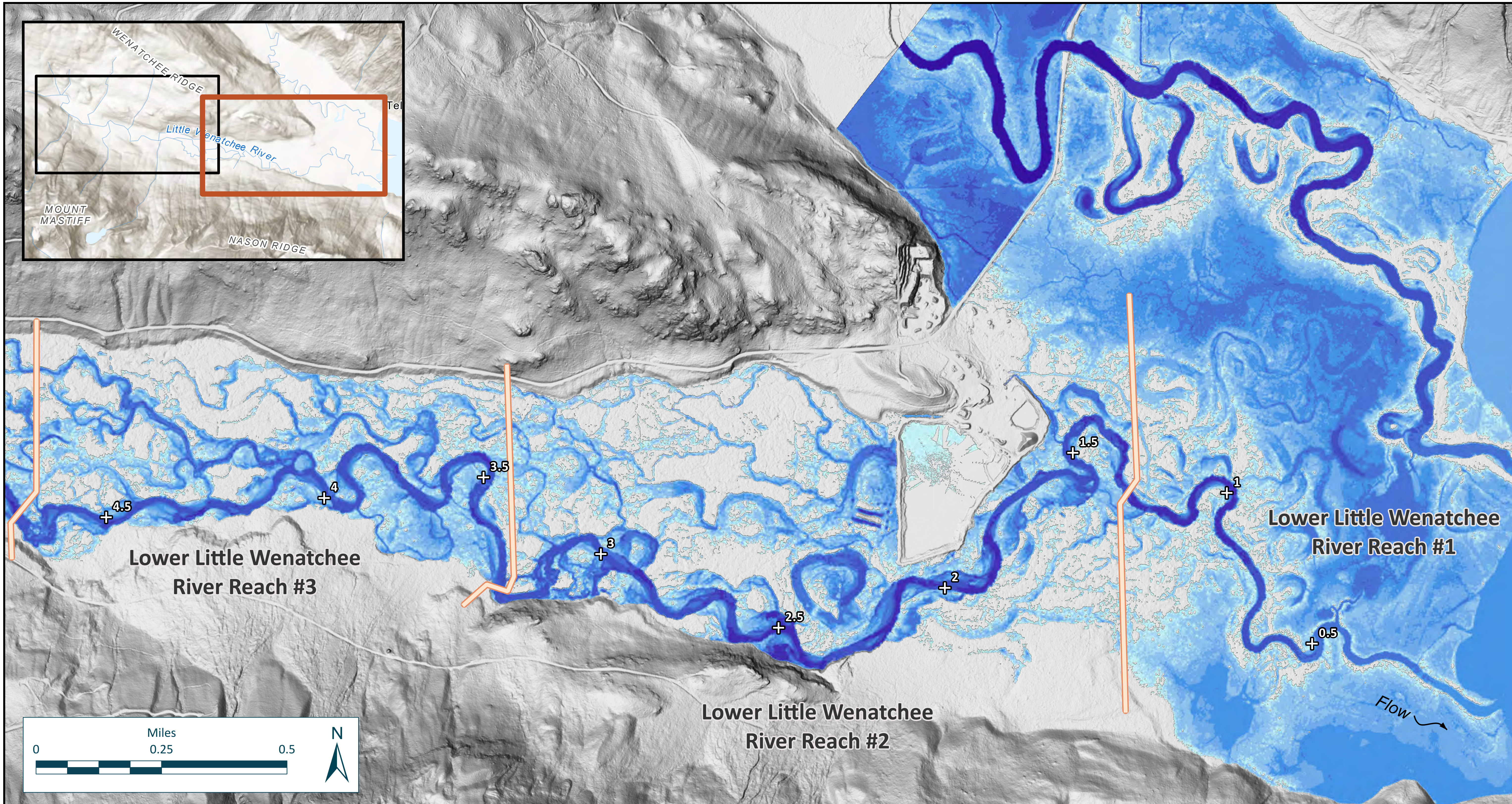
Upper Wenatchee River Basin, WA

River Miles
Reach Breaks

2-Year Peak Flow (2738 cfs) -- Depth (ft):

<0.5, <1, <2, <3, <4, <6, <8, <10, 10+

inter·fluve
BUREAU OF RECLAMATION



inter-fluve

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River Miles

Reach Breaks

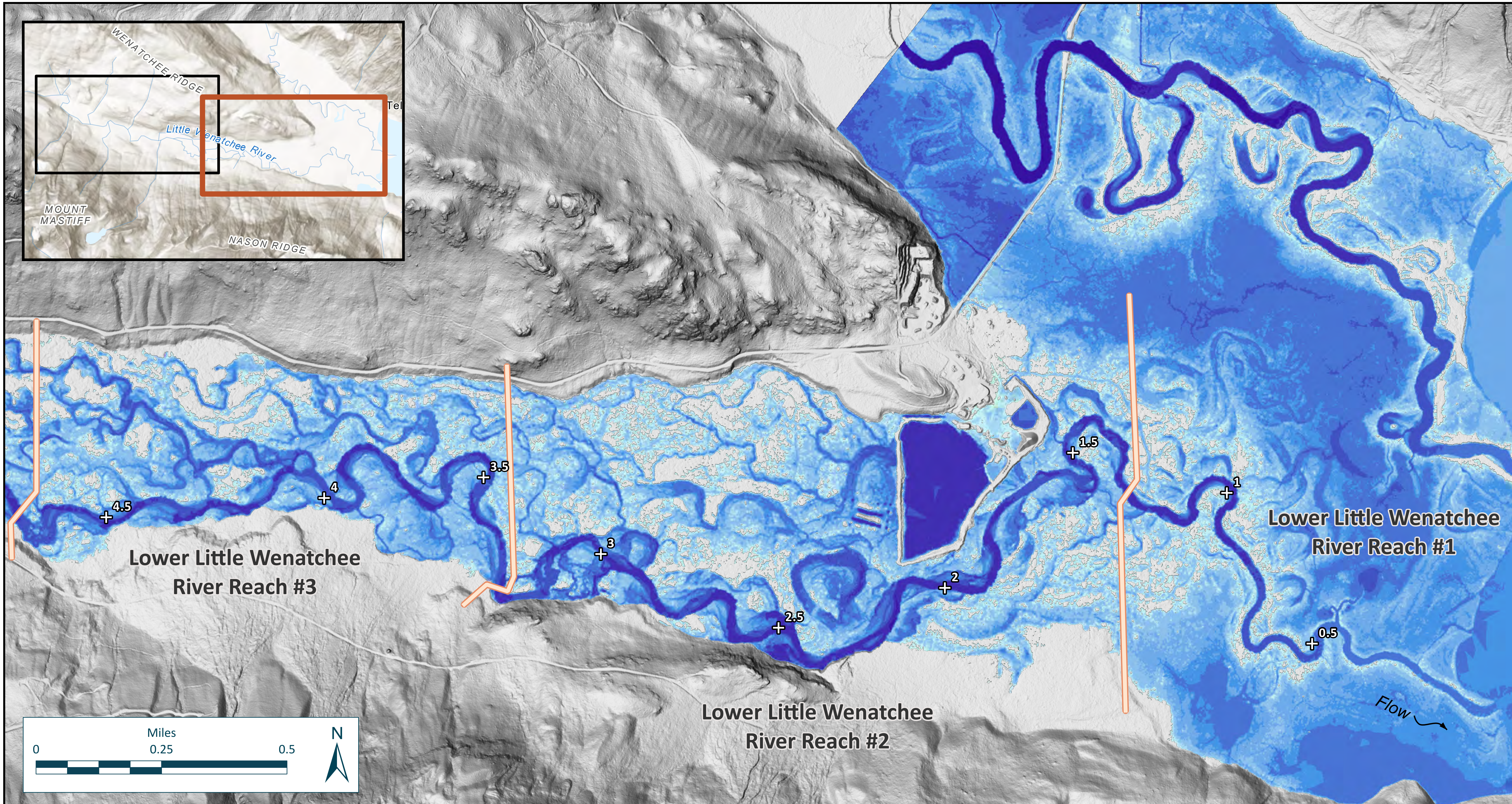
5-Year Peak Flow (3612 cfs) -- Depth (ft):

<0.5, <1, <2, <3, <4, <6, <8, <10, 10+

Lower Little Wenatchee River Habitat Assessment
Existing Conditions Hydraulic Model Results

Downstream Assessment Area (RM 0–4.5)

Upper Wenatchee River Basin, WA



BUREAU OF RECLAMATION

River Miles
Reach Breaks

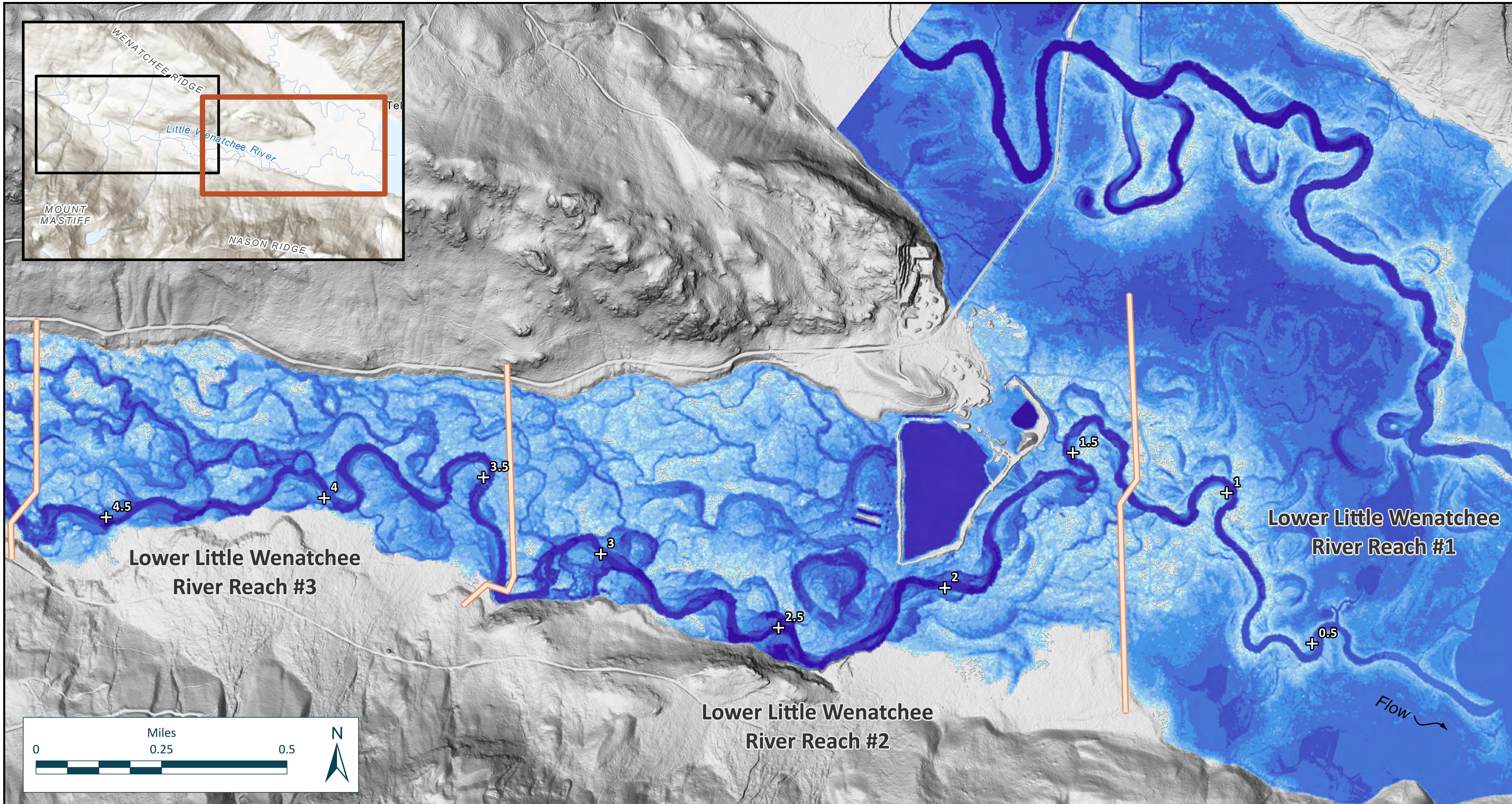
25-Year Peak Flow (5876 cfs) -- Depth (ft):

<0.5 | <1 | <2 | <3 | <4 | <6 | <8 | <10 | 10+

Lower Little Wenatchee River Habitat Assessment
Existing Conditions Hydraulic Model Results

Downstream Assessment Area (RM 0–4.5)

Upper Wenatchee River Basin, WA



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BUREAU OF RECLAMATION

River Miles

Reach Breaks

100-Year Peak Flow (10757 cfs) -- Depth (ft):

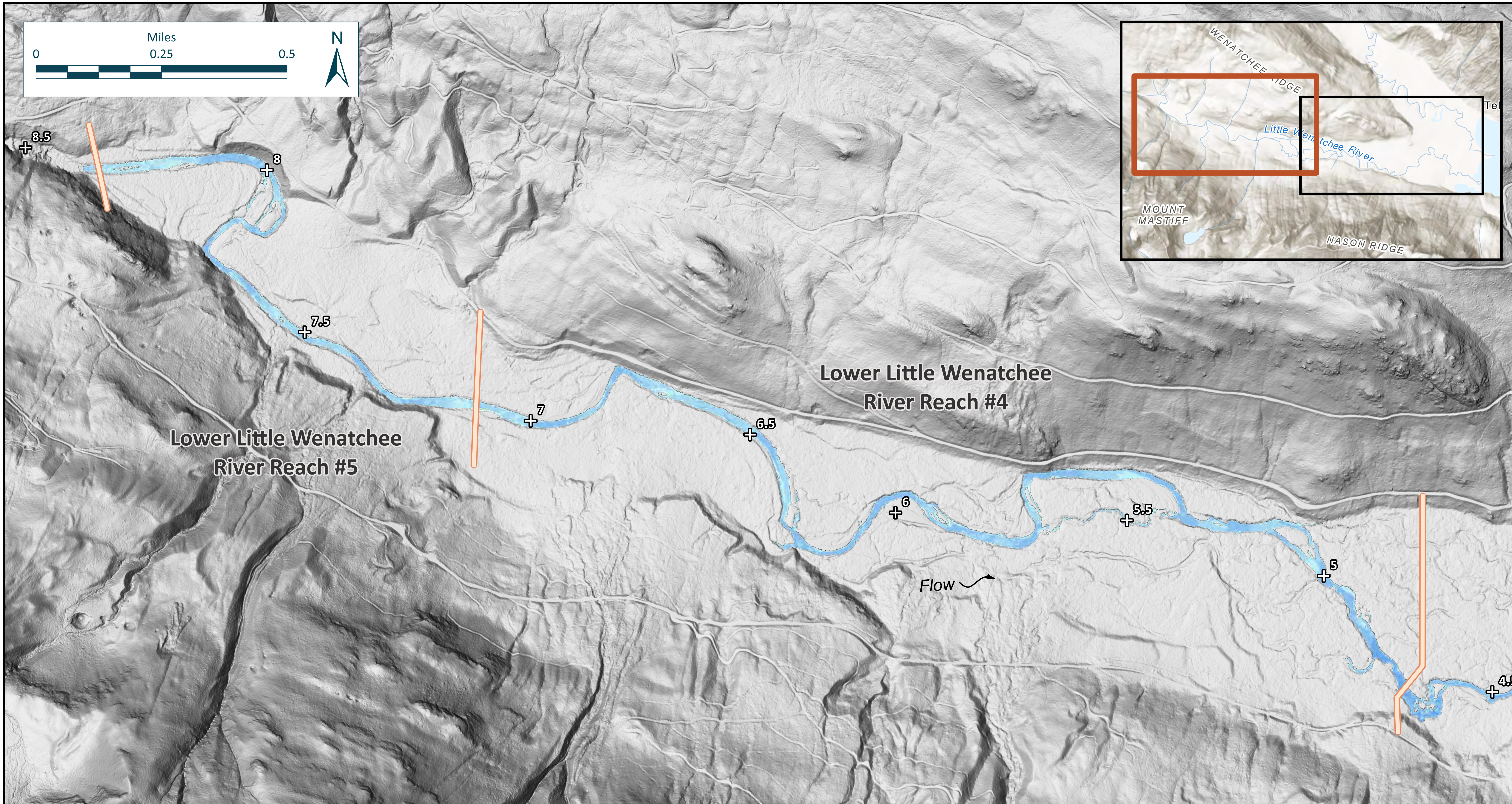
<0.5, <1, <2, <3, <4, <6, <8, <10, 10+

Lower Little Wenatchee River Habitat Assessment

Existing Conditions Hydraulic Model Results

Downstream Assessment Area (RM 0–4.5)

Upper Wenatchee River Basin, WA



River Miles

Reach Breaks

September Avg. Flow (81 cfs) -- Depth (ft):

<0.5 | <1 | <2 | <3 | <4 | <6 | <8 | <10 | 10+

Lower Little Wenatchee River Habitat Assessment
Existing Conditions Hydraulic Model Results

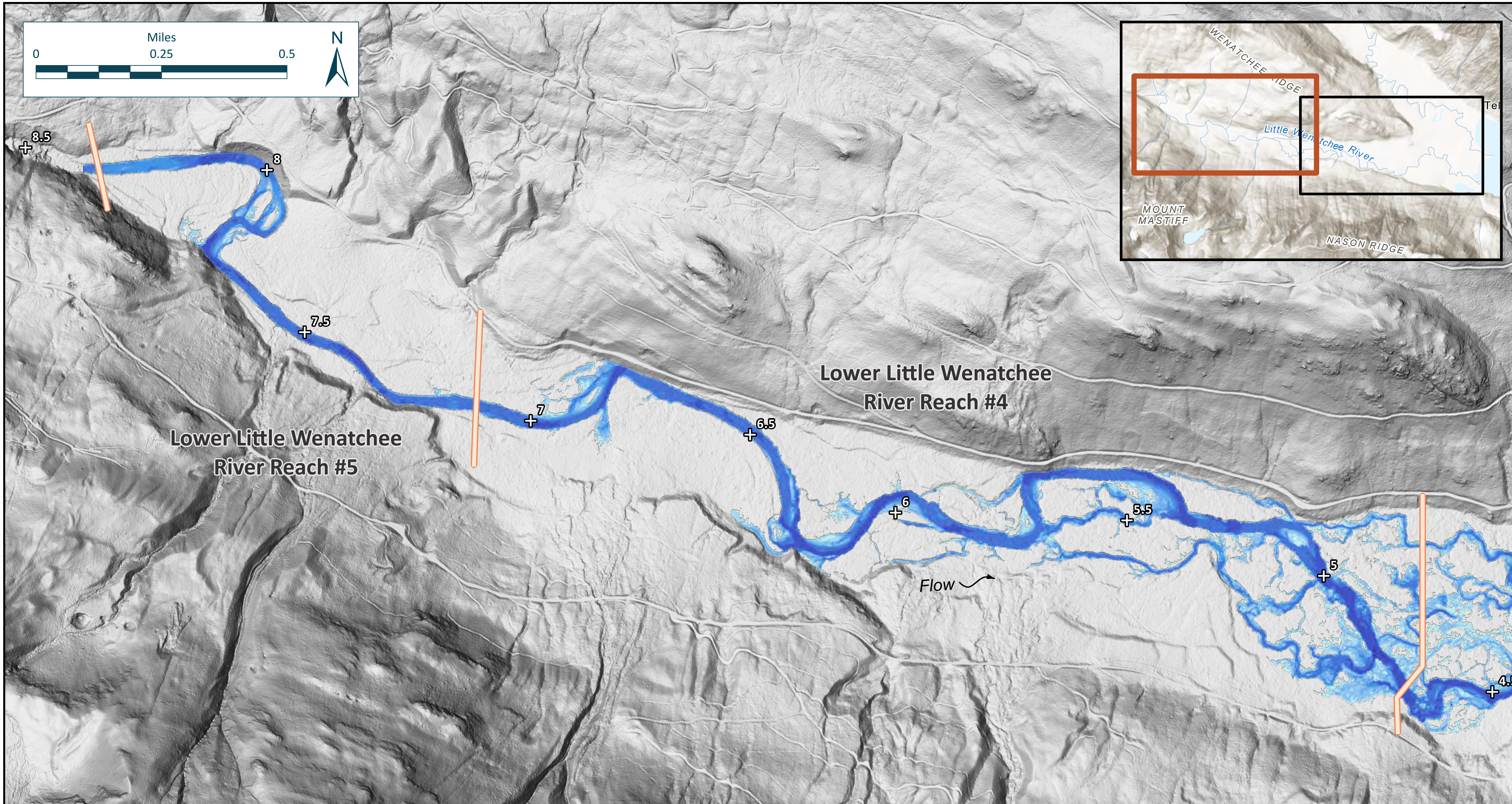
Upstream Assessment Area (RM 4.5–8.5)

Upper Wenatchee River Basin, WA

Lower Little Wenatchee River Habitat Assessment
Existing Conditions Hydraulic Model Results

Upstream Assessment Area (RM 4.5–8.5)

Upper Wenatchee River Basin, WA



inter·fluve

BUREAU OF RECLAMATION

River Miles

Reach Breaks

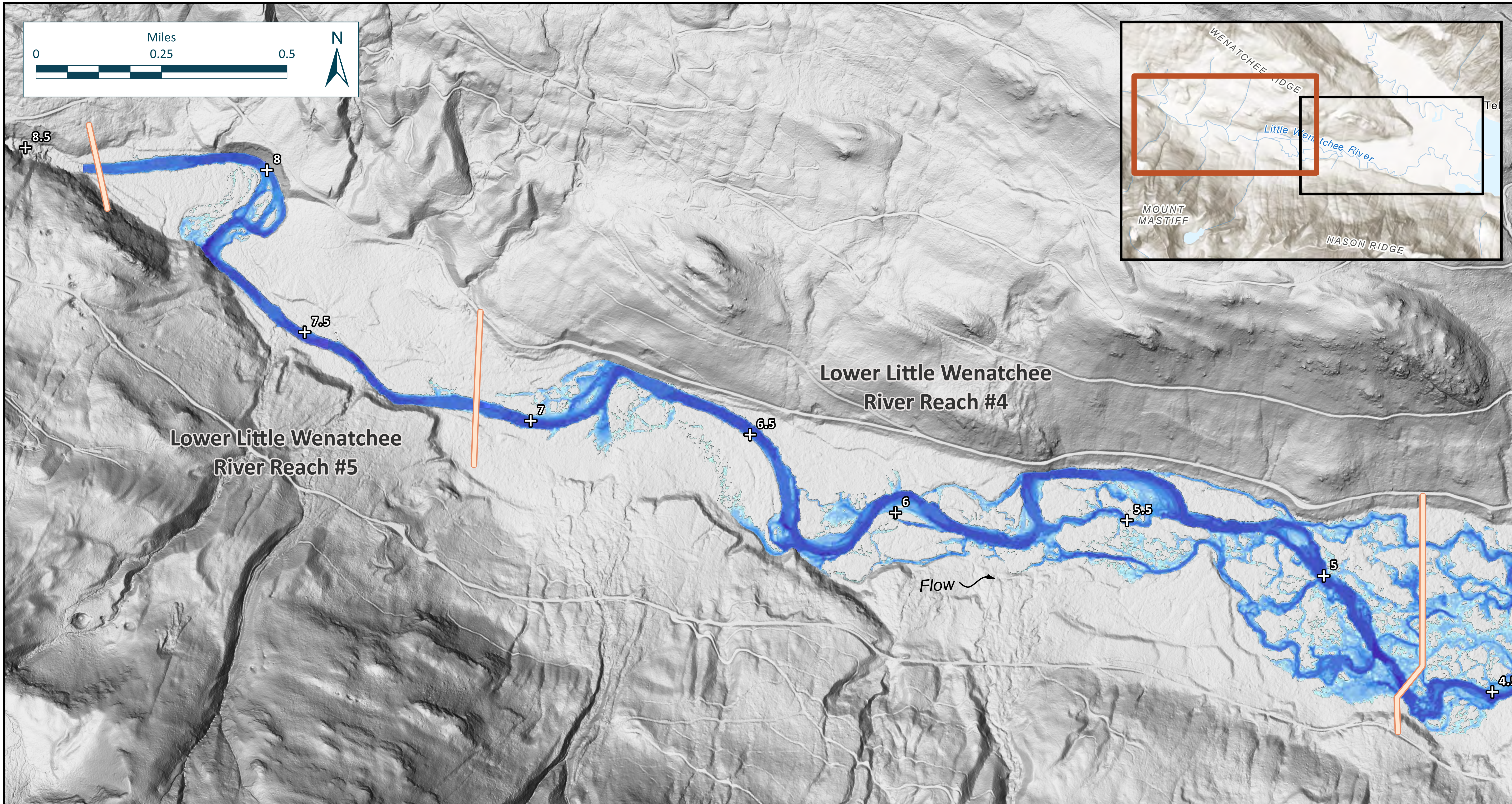
2-Year Peak Flow (2738 cfs) -- Depth (ft):

<0.5 | <1 | <2 | <3 | <4 | <6 | <8 | <10 | 10+

Lower Little Wenatchee River Habitat Assessment
Existing Conditions Hydraulic Model Results

Upstream Assessment Area (RM 4.5–8.5)

Upper Wenatchee River Basin, WA



River Miles
Reach Breaks

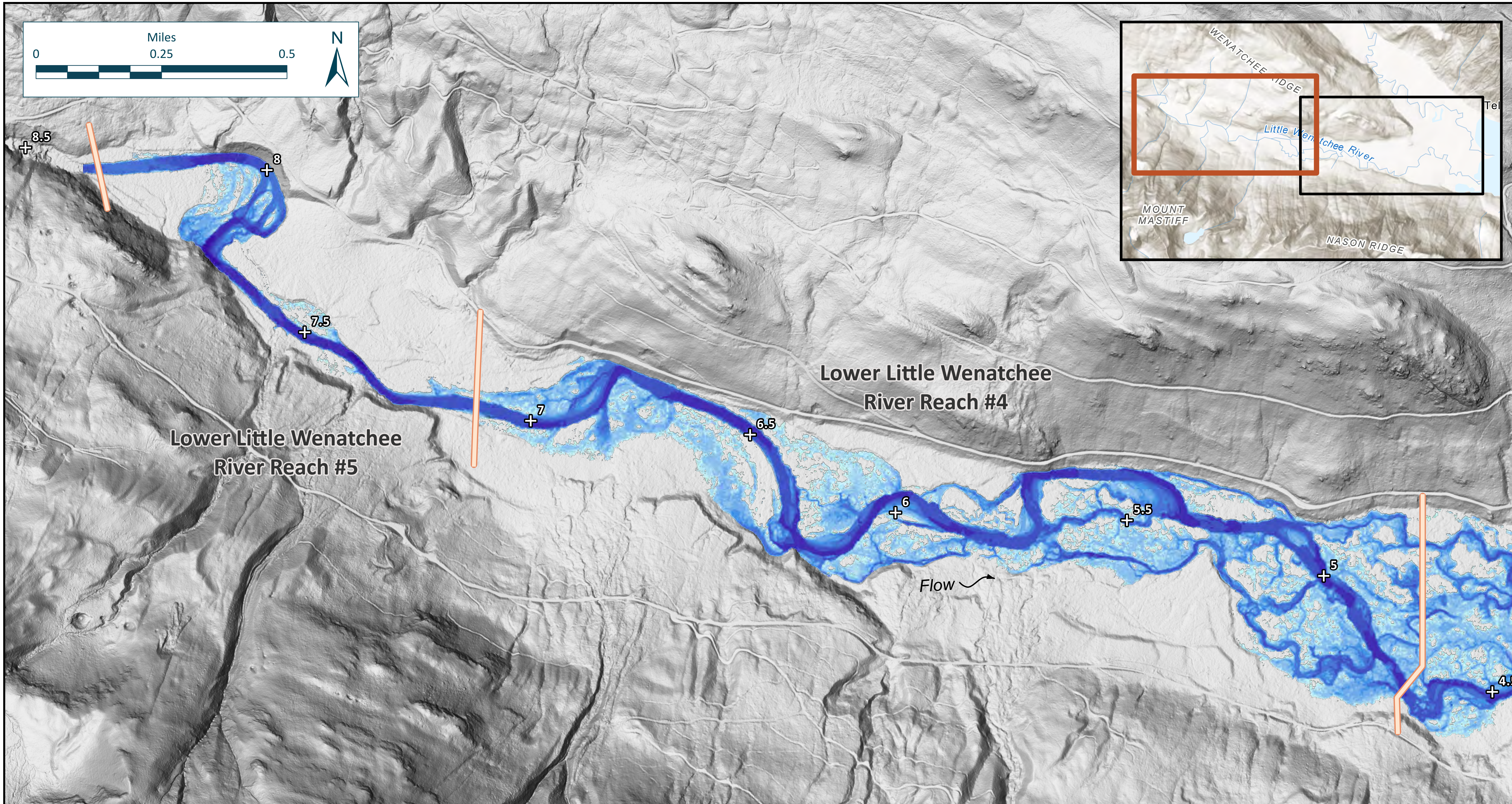
5-Year Peak Flow (3612 cfs) -- Depth (ft):

<0.5 | <1 | <2 | <3 | <4 | <6 | <8 | <10 | 10+

Lower Little Wenatchee River Habitat Assessment
Existing Conditions Hydraulic Model Results

Upstream Assessment Area (RM 4.5–8.5)

Upper Wenatchee River Basin, WA



inter·fluve

BUREAU OF RECLAMATION

River Miles

Reach Breaks

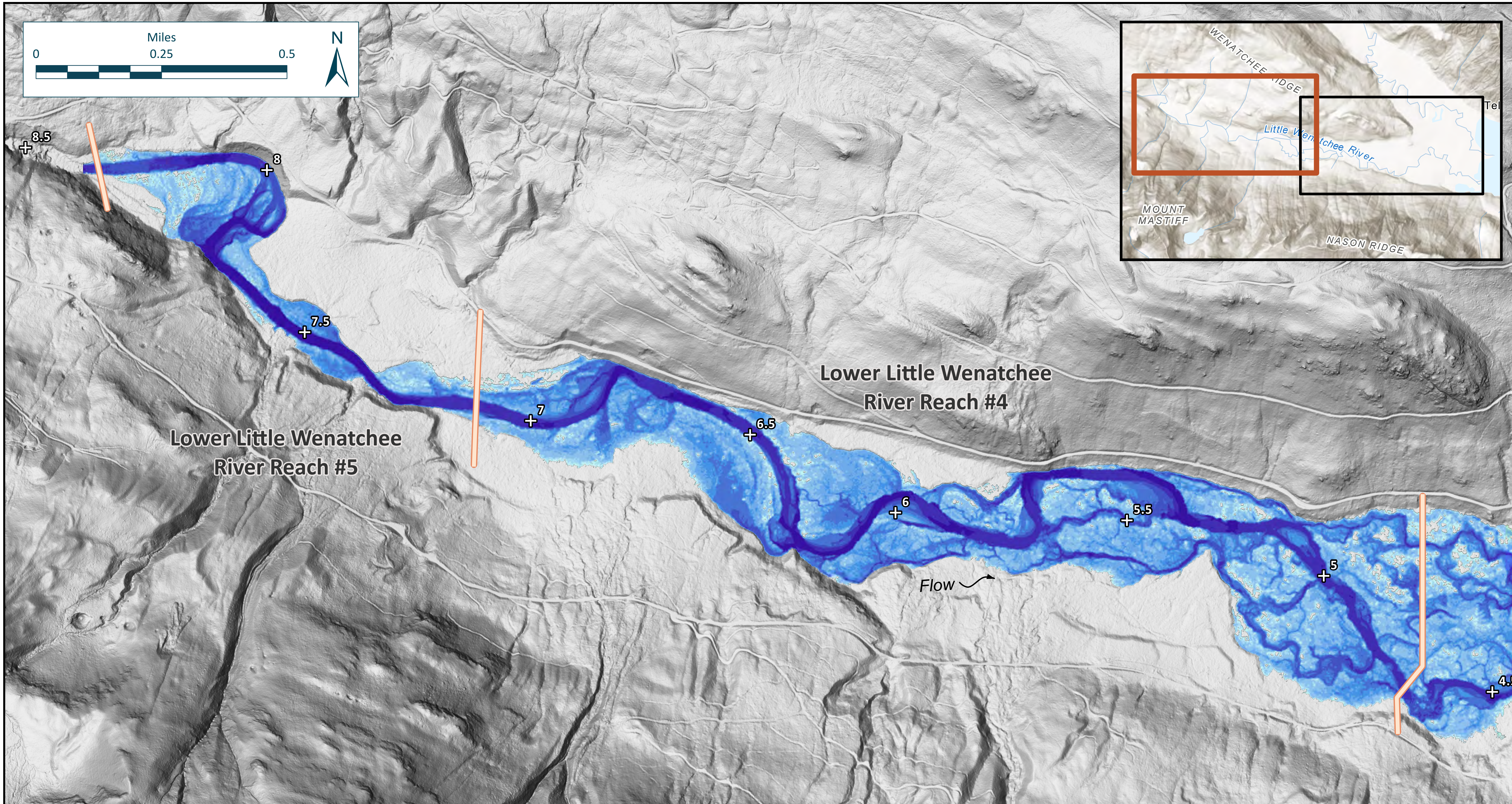
25-Year Peak Flow (5876 cfs) -- Depth (ft):

<0.5 | <1 | <2 | <3 | <4 | <6 | <8 | <10 | 10+

Lower Little Wenatchee River Habitat Assessment
Existing Conditions Hydraulic Model Results

Upstream Assessment Area (RM 4.5–8.5)

Upper Wenatchee River Basin, WA



inter·fluve

BUREAU OF RECLAMATION

River Miles

Reach Breaks

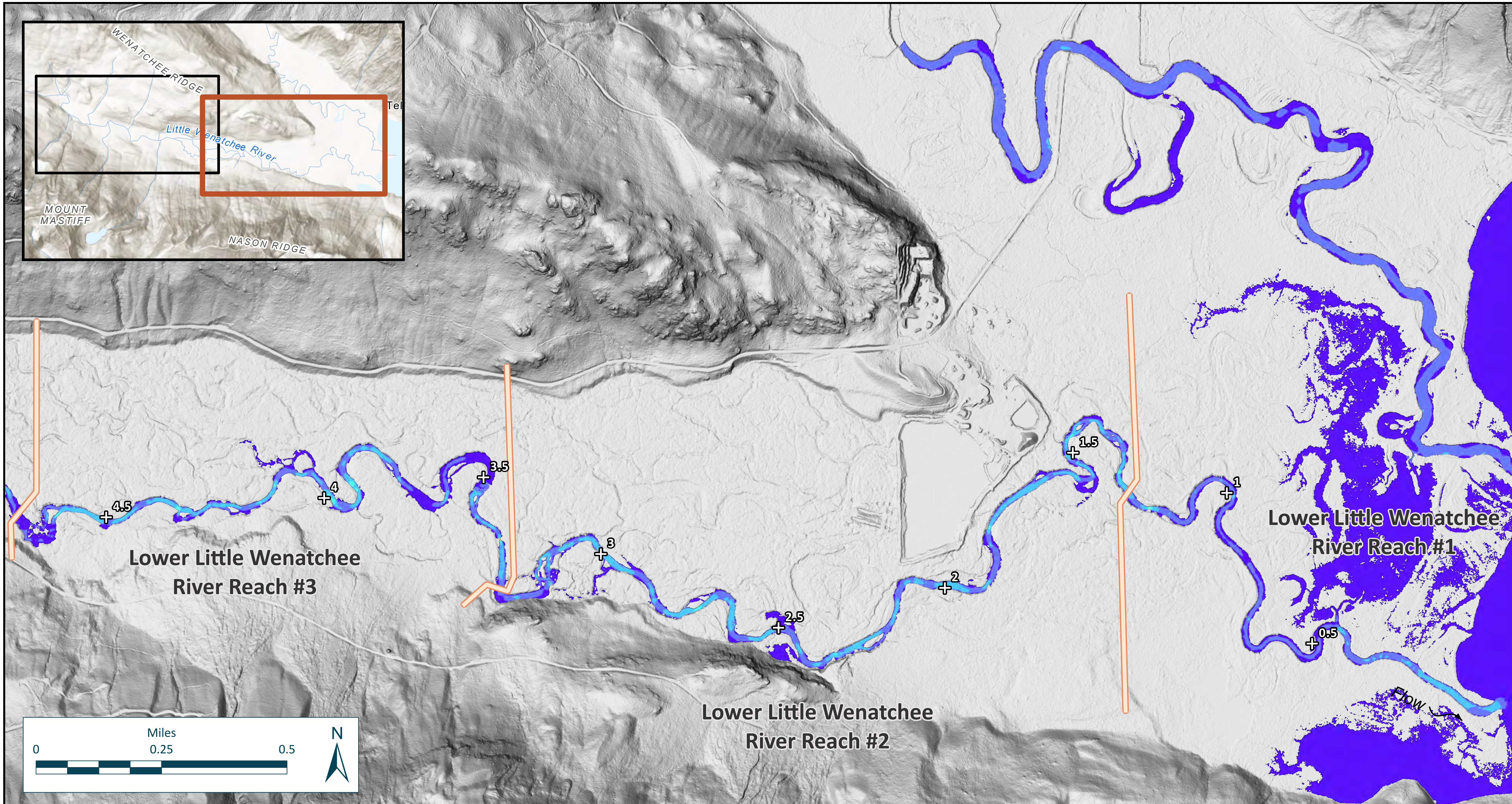
100-Year Peak Flow (10757 cfs) -- Depth (ft):

<0.5 | <1 | <2 | <3 | <4 | <6 | <8 | <10 | 10+

Lower Little Wenatchee River Habitat Assessment
Existing Conditions Hydraulic Model Results

Upstream Assessment Area (RM 4.5–8.5)

Upper Wenatchee River Basin, WA



River Miles
Reach Breaks

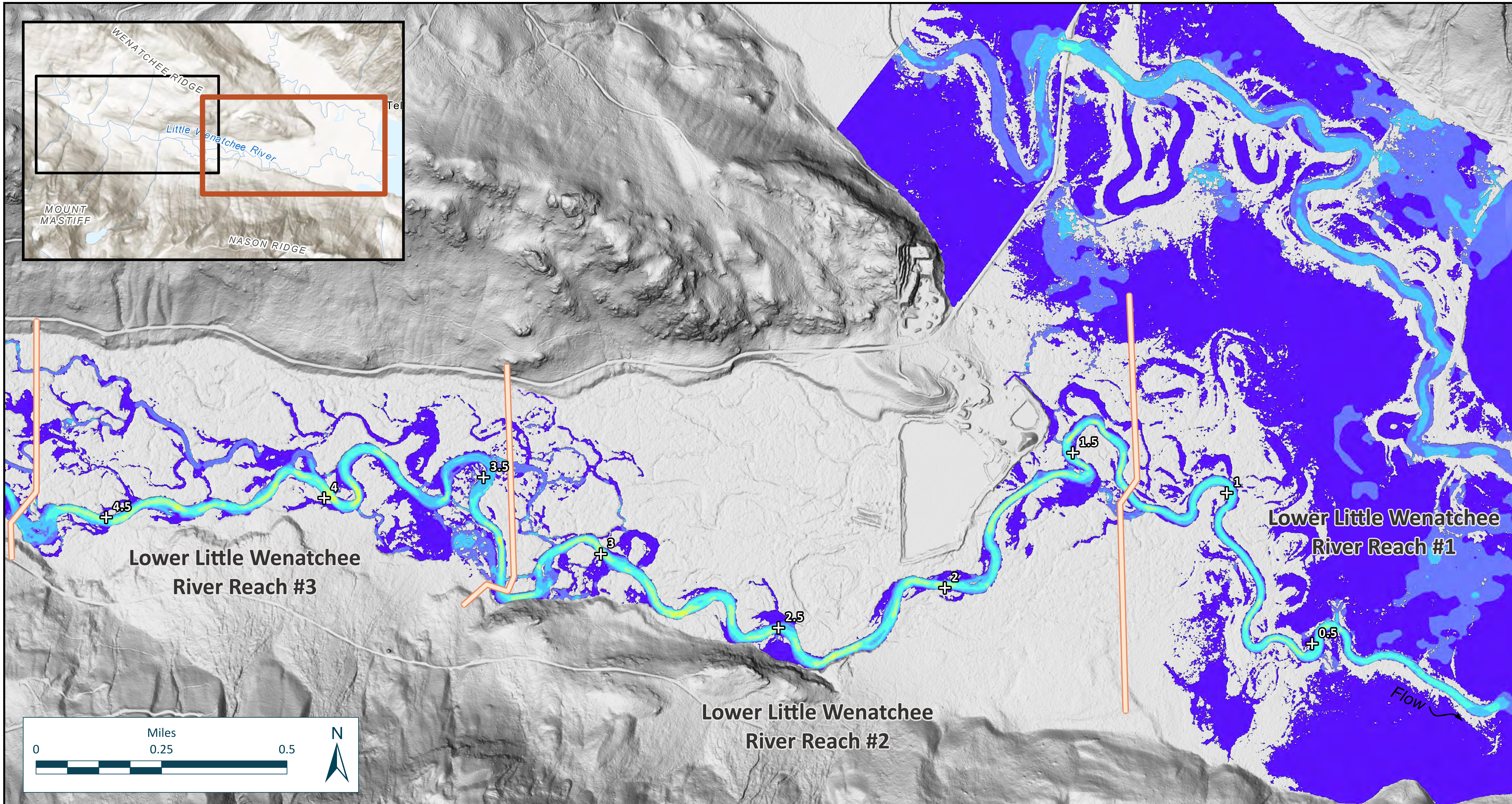
September Avg. Flow (81 cfs) -- Velocity (ft/s):

<0.5 <1 <2 <3 <4 <6 <8 <10 10+

Lower Little Wenatchee River Habitat Assessment
Existing Conditions Hydraulic Model Results

Downstream Assessment Area (RM 0–4.5)

Upper Wenatchee River Basin, WA



inter·fluve

BUREAU OF RECLAMATION

River Miles

Reach Breaks

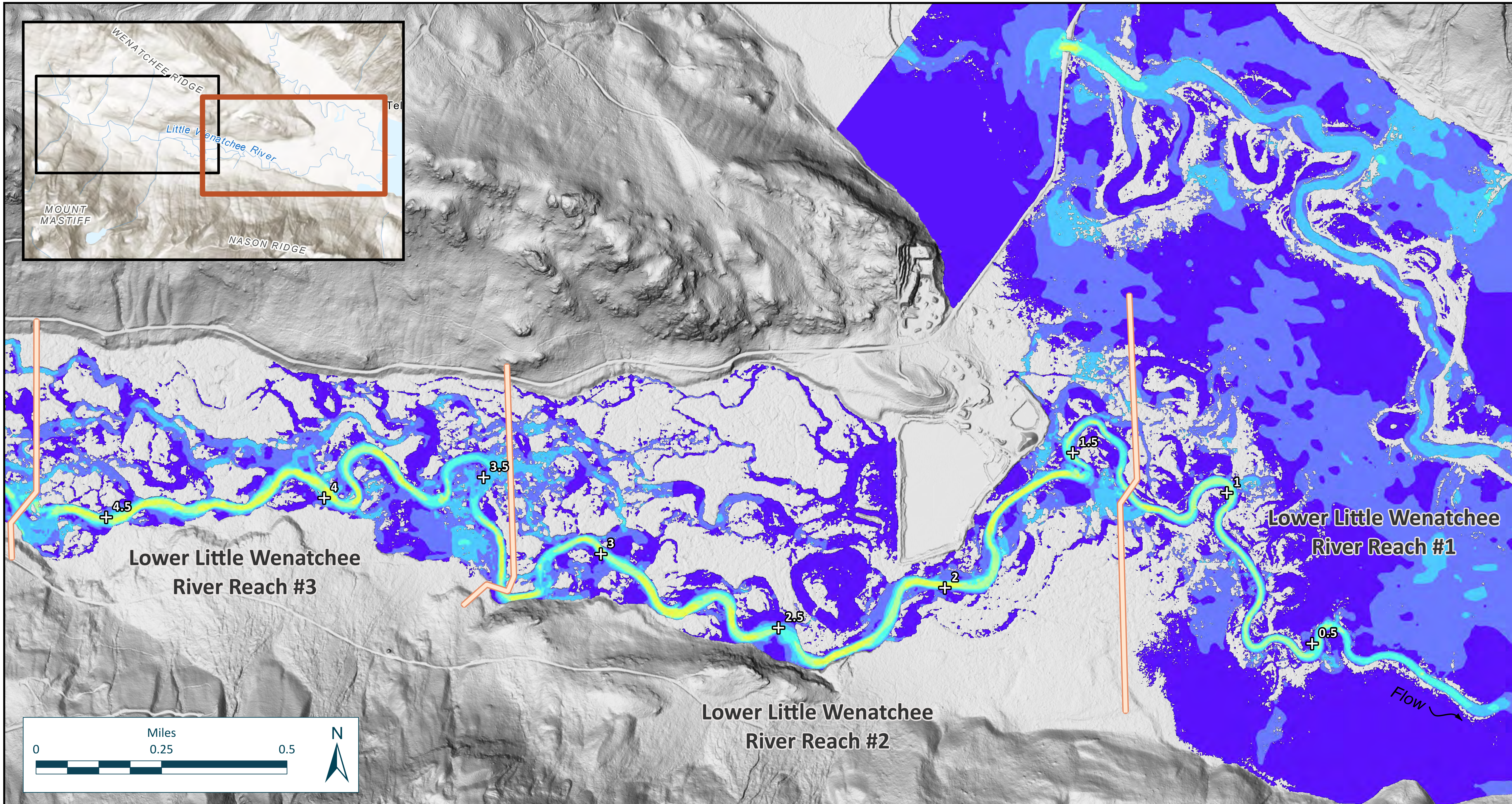
June Avg. Flow (1131 cfs) -- Velocity (ft/s):

<0.5 | <1 | <2 | <3 | <4 | <6 | <8 | <10 | 10+

Lower Little Wenatchee River Habitat Assessment
Existing Conditions Hydraulic Model Results

<u>Downstream Assessment Area (RM 0–4.5)</u>

Upper Wenatchee River Basin, WA



River Miles
Reach Breaks

2-Year Peak Flow (2738 cfs) -- Velocity (ft/s):

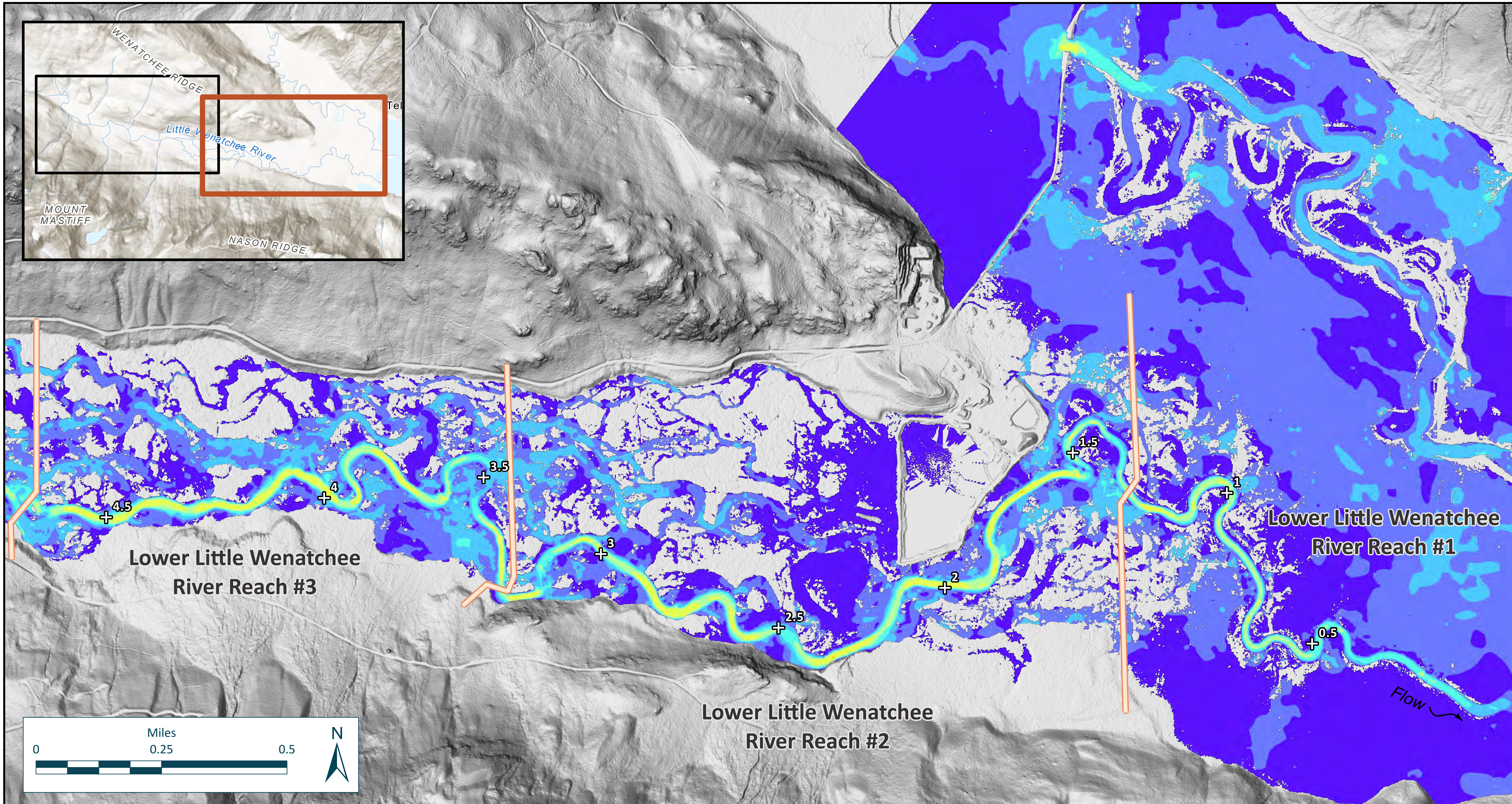
<0.5 | <1 | <2 | <3 | <4 | <6 | <8 | <10 | 10+

inter·fluve — Fish & Wildlife Department, Colville Tribes — Bureau of Reclamation

Lower Little Wenatchee River Habitat Assessment
Existing Conditions Hydraulic Model Results

Downstream Assessment Area (RM 0–4.5)

Upper Wenatchee River Basin, WA



River Miles

Reach Breaks

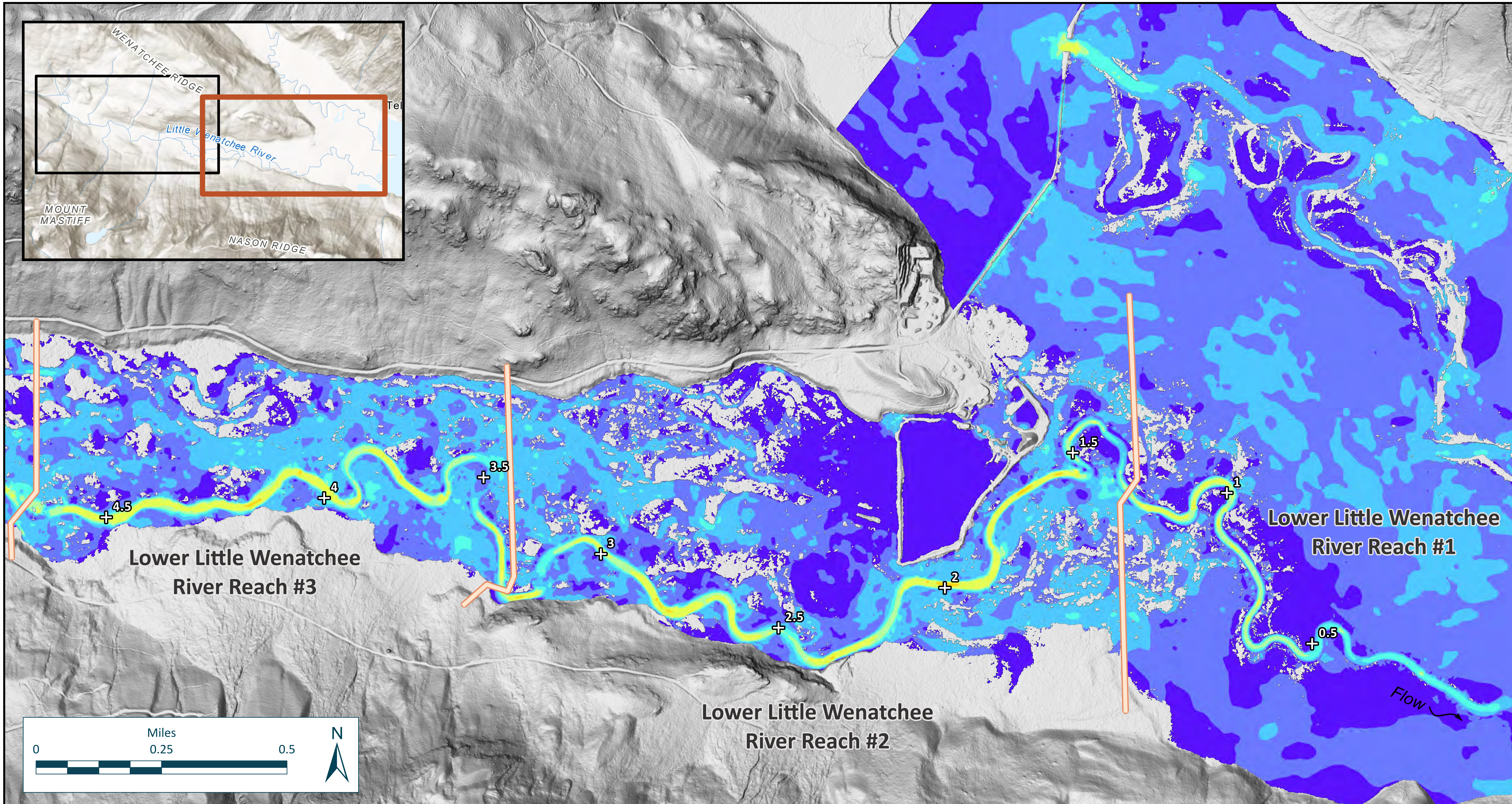
5-Year Peak Flow (3612 cfs) -- Velocity (ft/s):

<0.5 | <1 | <2 | <3 | <4 | <6 | <8 | <10 | 10+

Lower Little Wenatchee River Habitat Assessment
Existing Conditions Hydraulic Model Results

Downstream Assessment Area (RM 0–4.5)

Upper Wenatchee River Basin, WA



River Miles
Reach Breaks

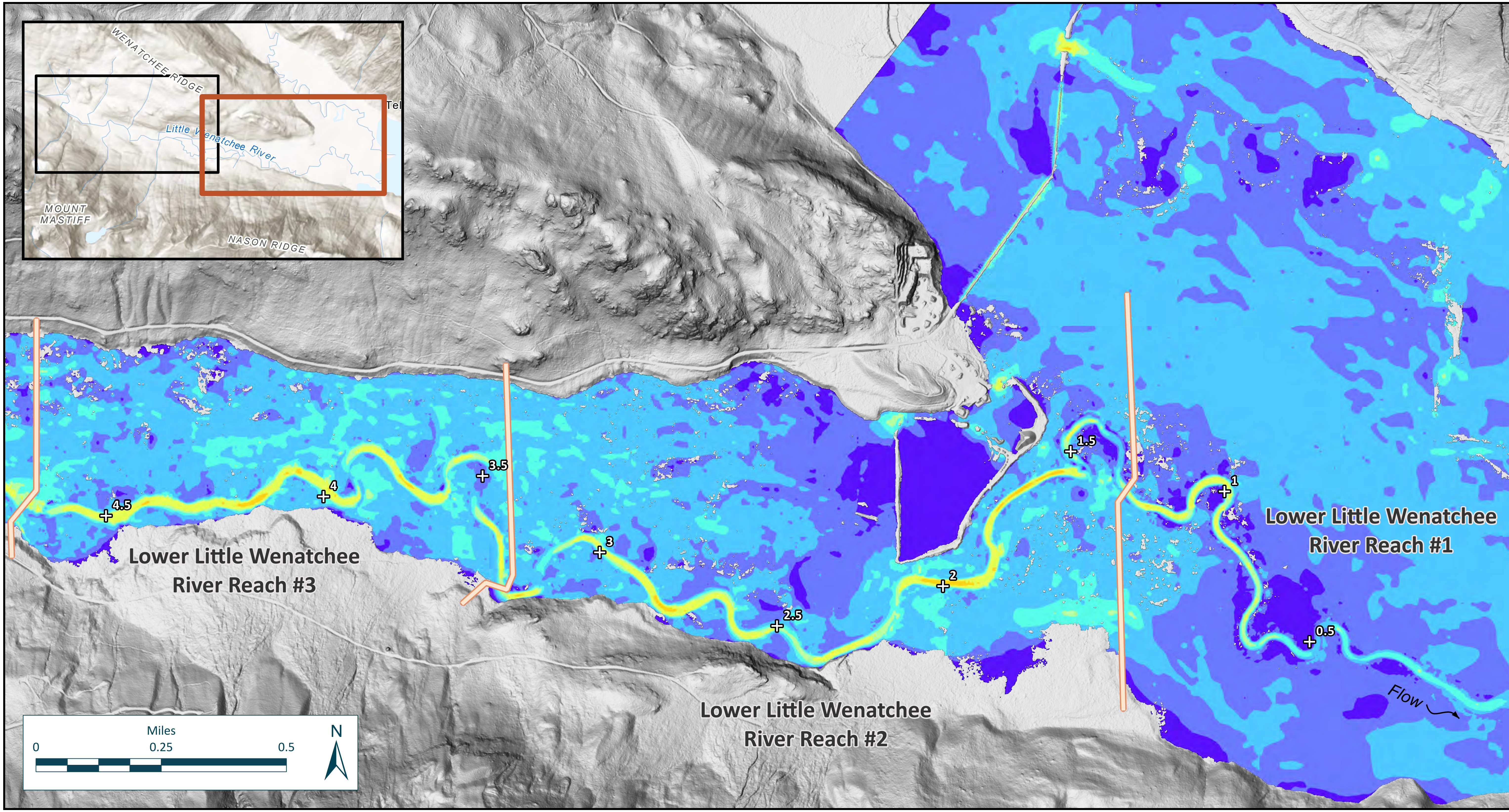
25-Year Peak Flow (5876 cfs) -- Velocity (ft/s):

<0.5 | <1 | <2 | <3 | <4 | <6 | <8 | <10 | 10+

Lower Little Wenatchee River Habitat Assessment
Existing Conditions Hydraulic Model Results

Downstream Assessment Area (RM 0–4.5)

Upper Wenatchee River Basin, WA



inter·fluve

Fish & Wildlife Department Colville Tribes

Bureau of Reclamation

River Miles

Reach Breaks

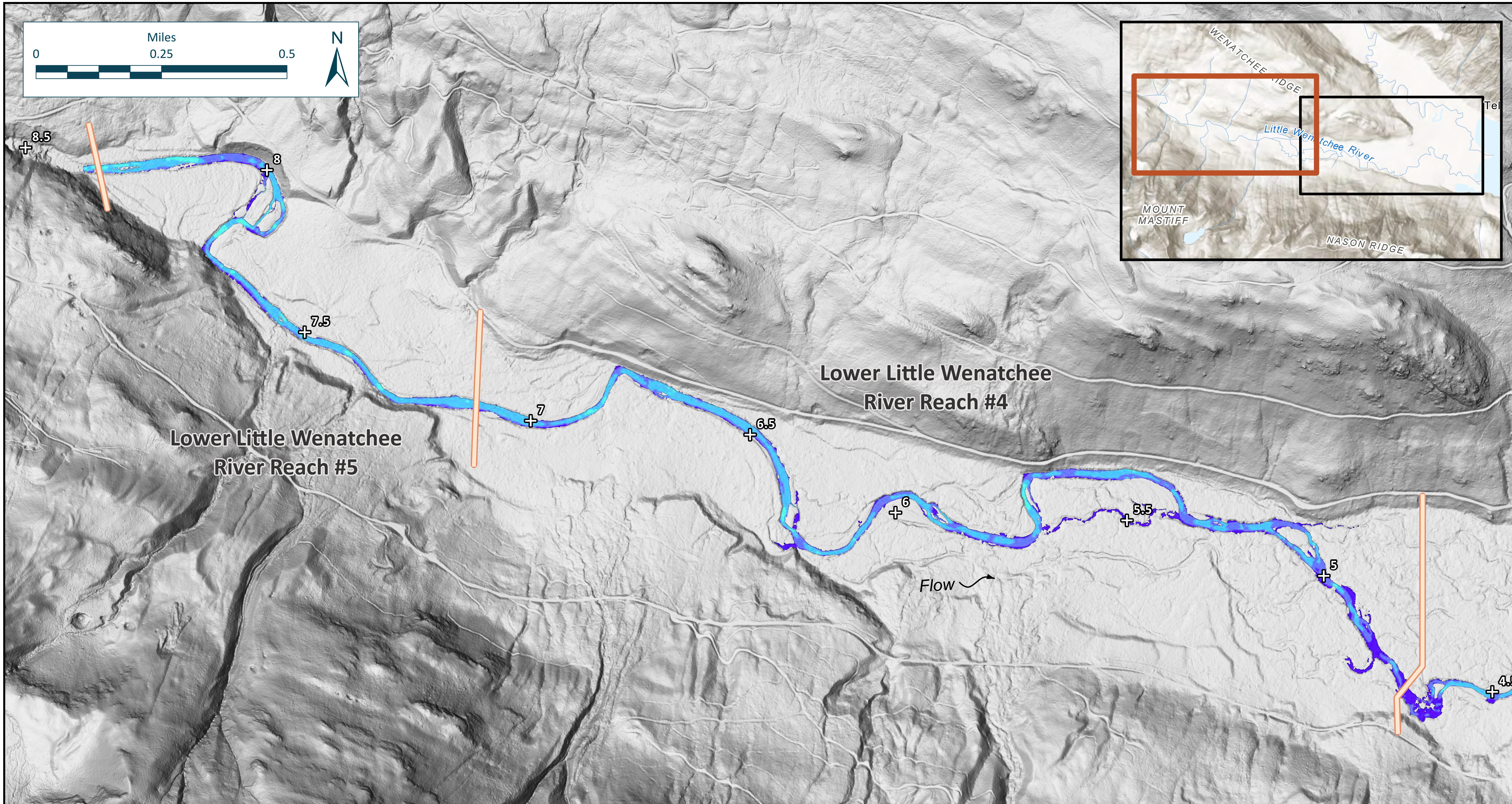
100-Year Peak Flow (10757 cfs) -- Velocity (ft/s):

<0.5, <1, <2, <3, <4, <6, <8, <10, 10+

Lower Little Wenatchee River Habitat Assessment
Existing Conditions Hydraulic Model Results

Downstream Assessment Area (RM 0–4.5)

Upper Wenatchee River Basin, WA



inter·fluve

BUREAU OF RECLAMATION

River Miles

Reach Breaks

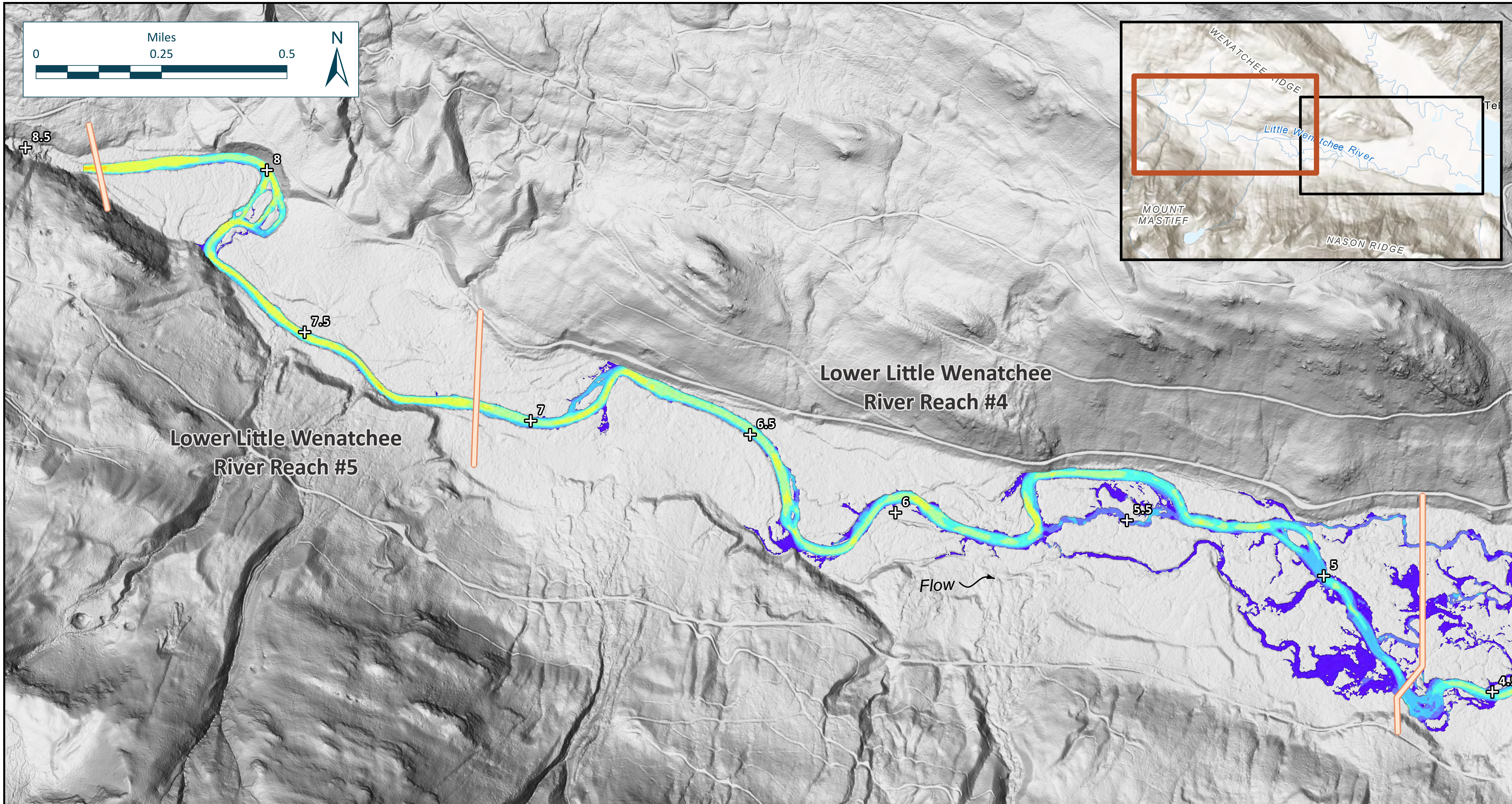
September Avg. Flow (81 cfs) -- Velocity (ft/s):

<0.5 | <1 | <2 | <3 | <4 | <6 | <8 | <10 | 10+

Lower Little Wenatchee River Habitat Assessment
Existing Conditions Hydraulic Model Results

Upstream Assessment Area (RM 4.5–8.5)

Upper Wenatchee River Basin, WA



River Miles

Reach Breaks

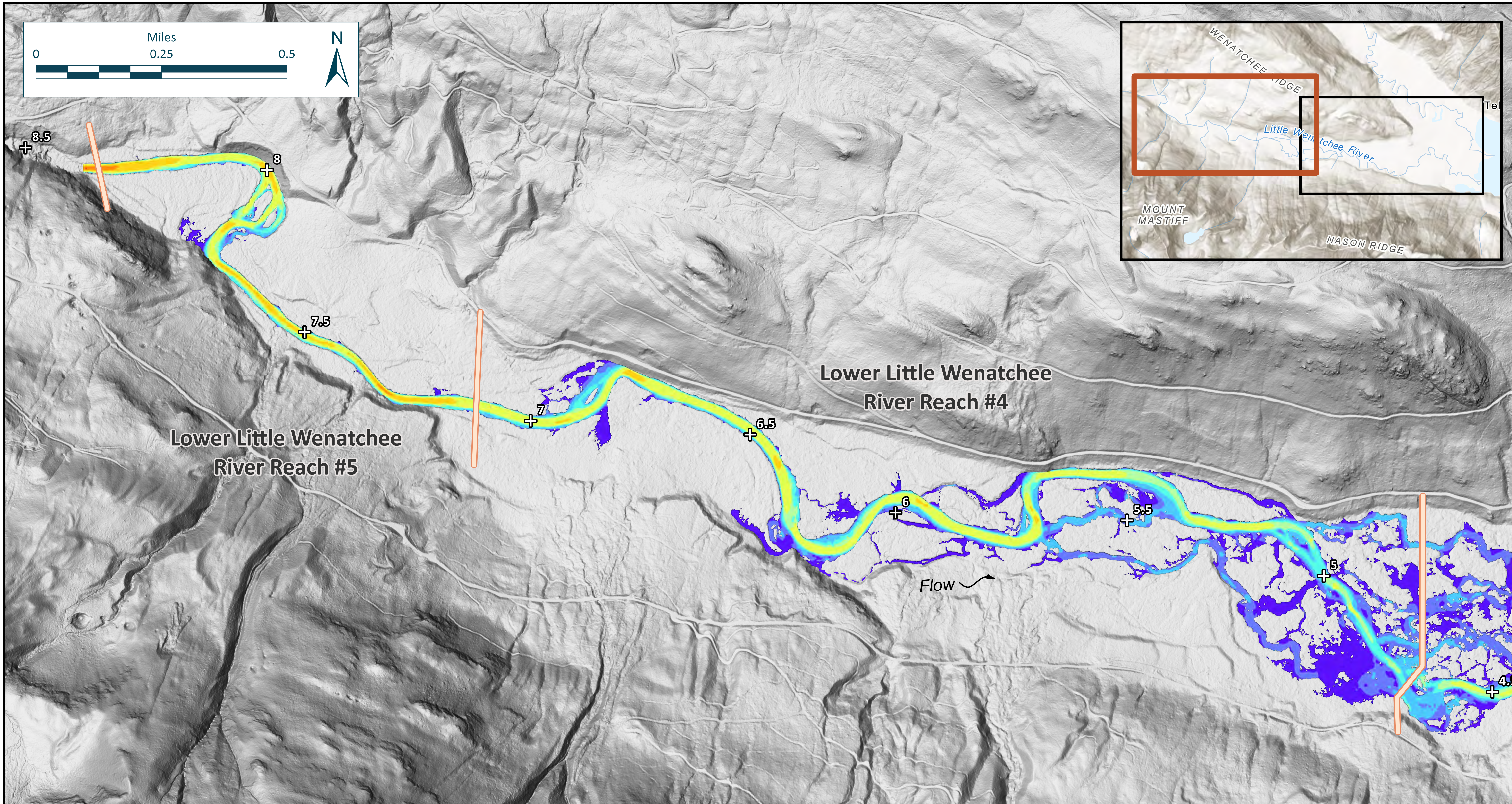
June Avg. Flow (1131 cfs) -- Velocity (ft/s):

<0.5 | <1 | <2 | <3 | <4 | <6 | <8 | <10 | 10+

Lower Little Wenatchee River Habitat Assessment
Existing Conditions Hydraulic Model Results

Upstream Assessment Area (RM 4.5–8.5)

Upper Wenatchee River Basin, WA



inter·fluve

BUREAU OF RECLAMATION

River Miles

Reach Breaks

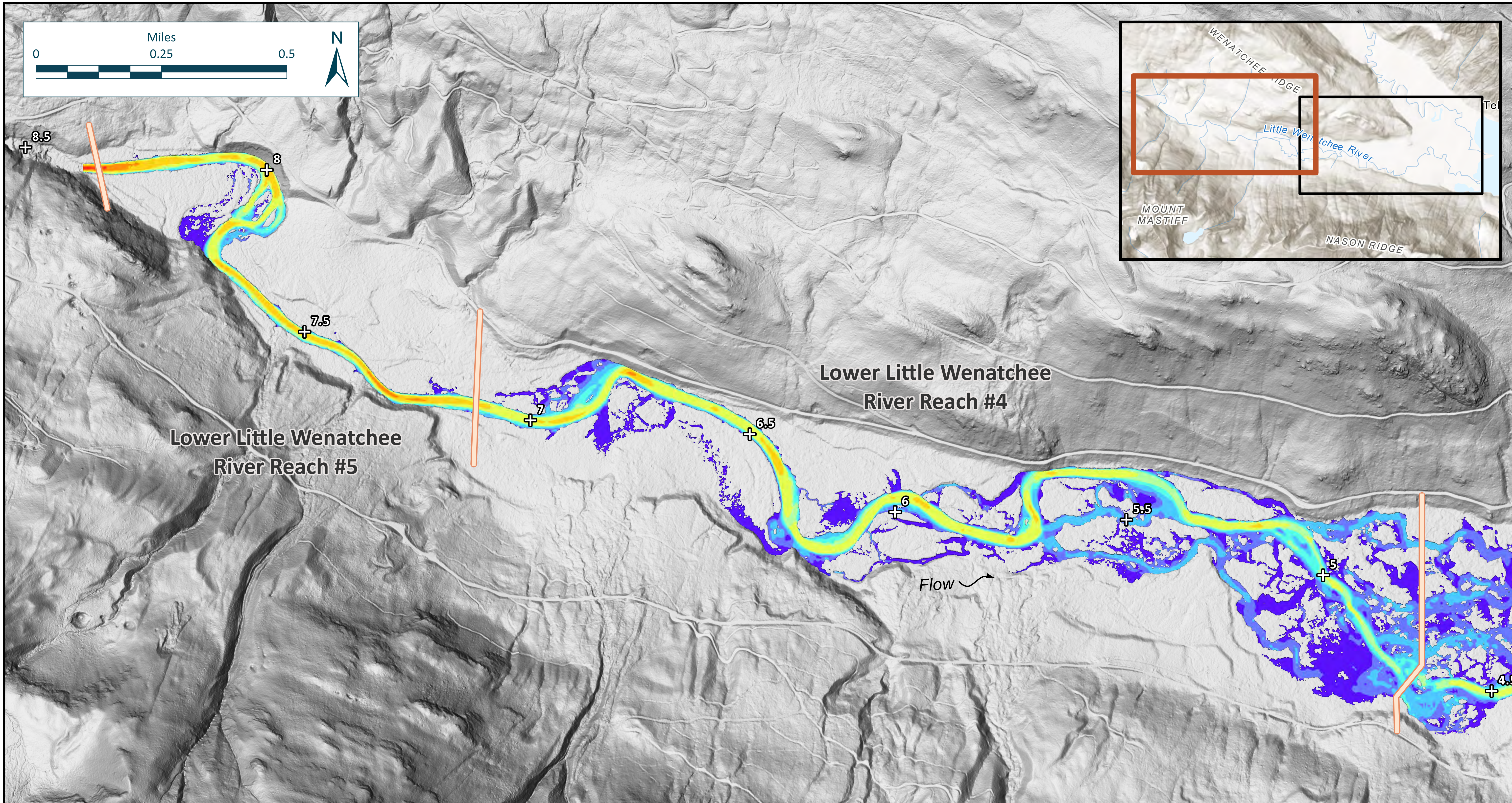
2-Year Peak Flow (2738 cfs) -- Velocity (ft/s):

<0.5 | <1 | <2 | <3 | <4 | <6 | <8 | <10 | 10+

Lower Little Wenatchee River Habitat Assessment
Existing Conditions Hydraulic Model Results

Upstream Assessment Area (RM 4.5–8.5)

Upper Wenatchee River Basin, WA



River Miles

Reach Breaks

5-Year Peak Flow (3612 cfs) -- Velocity (ft/s):

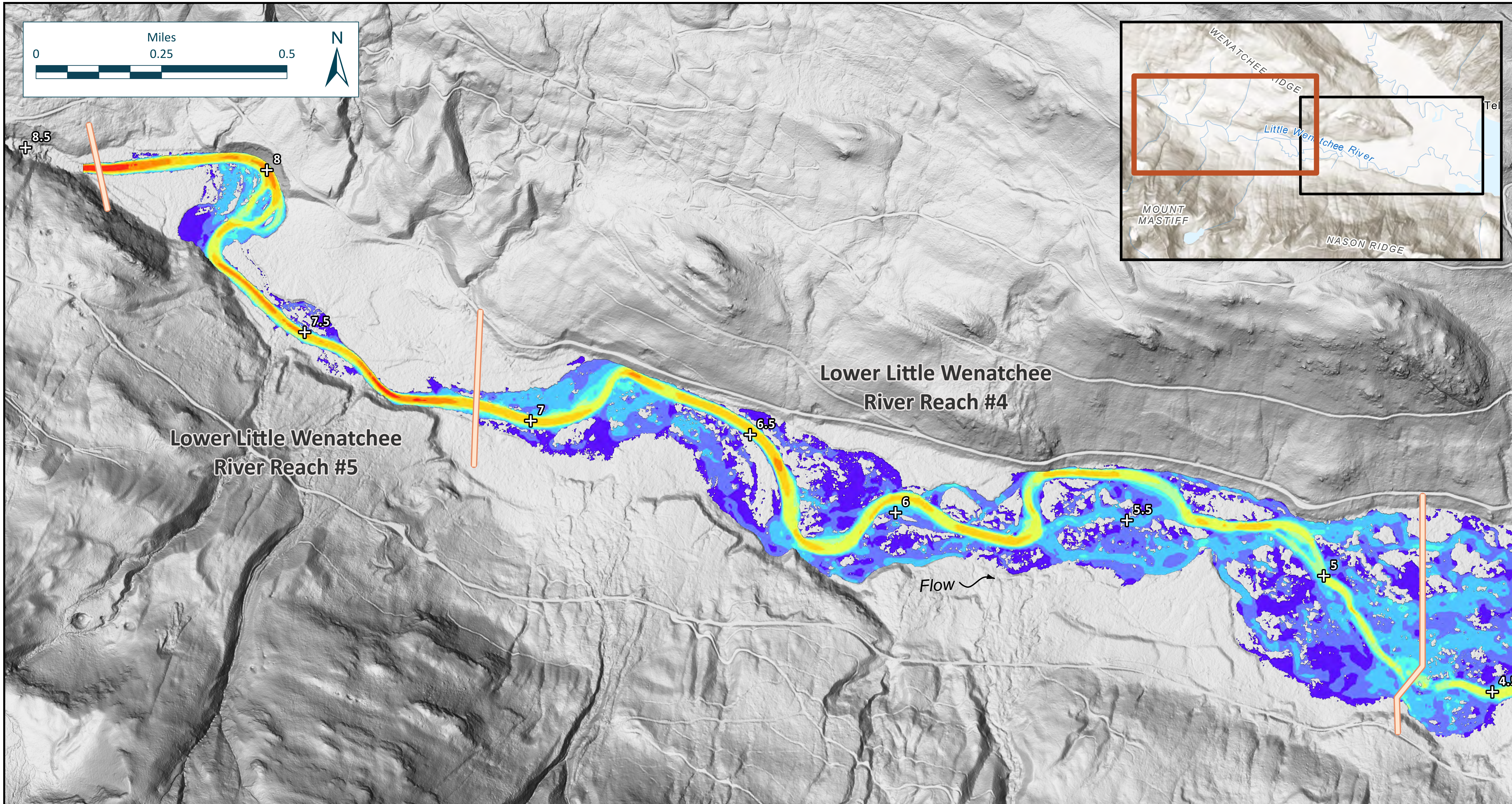
<0.5 <1 <2 <3 <4 <6 <8 <10 10+

Lower Little Wenatchee River Habitat Assessment

Existing Conditions Hydraulic Model Results

Upstream Assessment Area (RM 4.5–8.5)

Upper Wenatchee River Basin, WA



inter·fluve

BUREAU OF RECLAMATION

River Miles

Reach Breaks

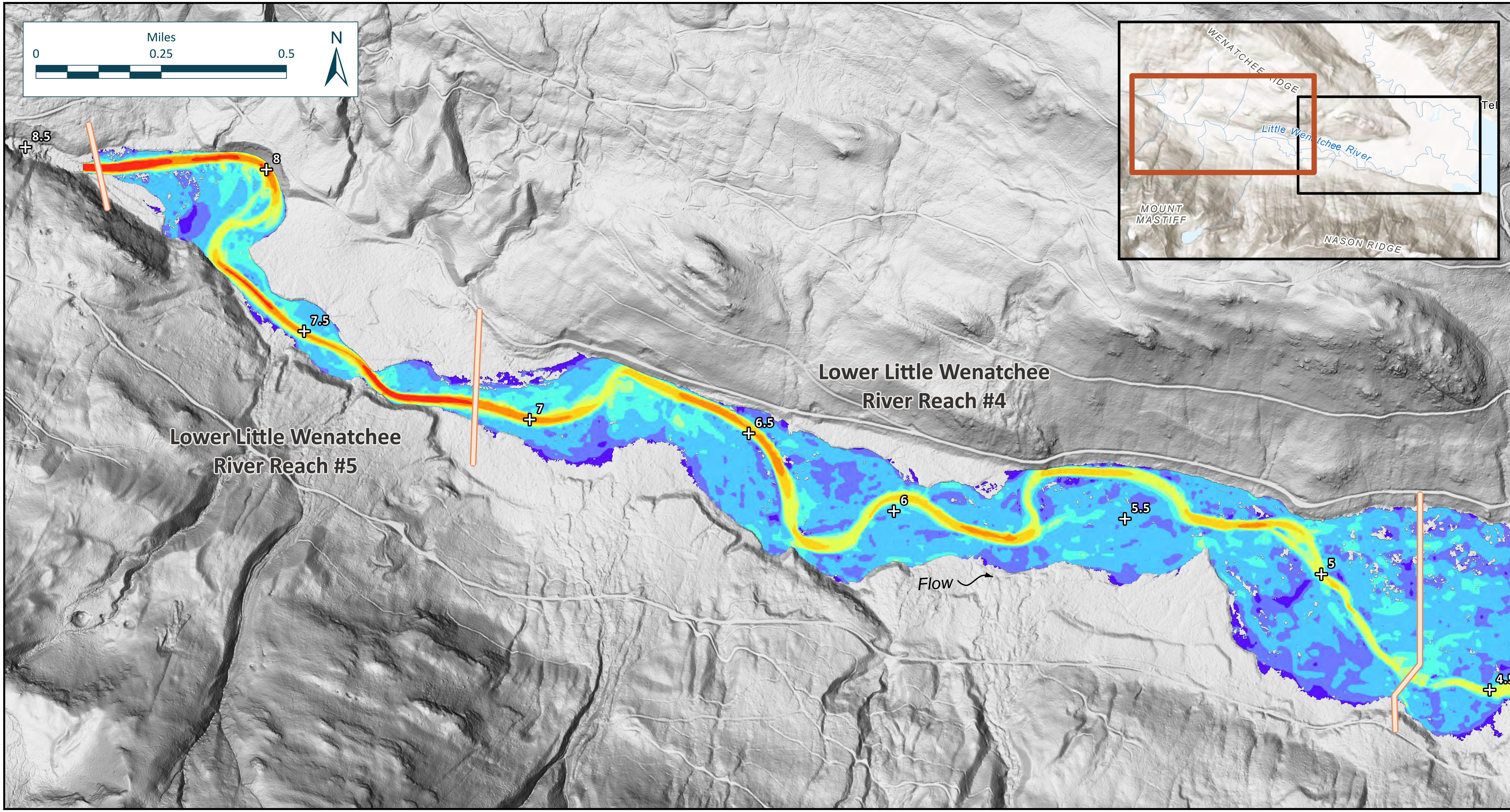
25-Year Peak Flow (5876 cfs) -- Velocity (ft/s):

<0.5 <1 <2 <3 <4 <6 <8 <10 10+

Lower Little Wenatchee River Habitat Assessment
Existing Conditions Hydraulic Model Results

Upstream Assessment Area (RM 4.5–8.5)

Upper Wenatchee River Basin, WA



inter·fluve

FISH & WILDLIFE DEPARTMENT COLVILLE TRIBES

BUREAU OF RECLAMATION

Lower Little Wenatchee River Habitat Assessment
Existing Conditions Hydraulic Model Results

Upstream Assessment Area (RM 4.5–8.5)

Upper Wenatchee River Basin, WA