Lower & Middle Nason Creek Reach Assessment & Restoration Strategy Update
Final Report

JANUARY 2026

PREPARED FOR
Yakama Nation Fisheries

PREPARED BY
Inter-Fluve

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List of Acronyms

BNSF – Burlington Northern Sante Fe Railroad
BPA – Bonneville Power Administration
CCNRD – Chelan County Natural Resources Department
CDLT – Chelan Douglas Land Trust
CMZ – Channel Migration Zone
CPUD – Chelan Public Utility District
CRITFC – Columbia River Inter-Tribal Fish Commission
DBH – Diameter at Breast Height
DSM – Digital Surface Model
ESA – Endangered Species Act
GIS – Geographic Information System
HCMZ – Historical Channel Migration Zone
LiDAR – Light Detection and Ranging
LWM – Large Woody Material
NMFS – National Marine Fisheries Service
NPCC – Northwest Power and Conservation Council
REI - Reach-Based Ecosystem Indicators
RM – River Mile
UCHRP – Upper Columbia Habitat Restoration Project
UCRTT – Upper Columbia Regional Technical Team
UCSRB – Upper Columbia Salmon Recovery Board
USBR – US Bureau of Reclamation
USFS – US Forest Service
USFWS – US Fish & Wildlife Service
WDFW – Washington Department of Fish & Wildlife
YN – Yakama Nation

1. Introduction

1.1 OVERVIEW

This assessment evaluates aquatic habitat and watershed process conditions for Nason Creek and identifies habitat restoration strategies. The assessment area has been the focus of numerous past assessments, restoration strategies, and implemented restoration projects over at least the past two decades. This current effort summarizes key findings from the previous assessments and collects new data to characterize current conditions, including in areas affected by restoration projects implemented since the original assessments were completed. Based on the findings of this assessment, a new restoration strategy for the study area is provided, which includes updated recommendations for restoration and conservation actions that help achieve the objectives of the Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan (UCSRB 2007) and its associated Biological Strategy (UCRTT 2021).

Nason Creek is a tributary of the Wenatchee River in Chelan County, Washington and is located on the eastern slope of the Cascades Mountains and the western edge of the Columbia River Basin (Figure 2). Nason Creek is northwest of Leavenworth, WA and has its headwaters near Stevens Pass. This Nason Creek Reach Assessment update covers the lower 13.5 river miles (RMs) of Nason Creek, extending from upstream of Merritt, WA to the confluence with the Wenatchee River. The assessment area encompasses the areas commonly referred to as the Upper White Pine, Lower White Pine, Kahler, and Lower Nason segments.

This reach assessment provides a technical foundation for understanding the existing conditions of Nason Creek and for identifying areas that would benefit most from restoration strategies to improve aquatic habitat and stream ecological functions. Conditions are assessed at multiple scales, ranging from the habitat unit scale (e.g. habitat assessment) to the reach-scale (e.g. REI analysis) to the study area scale (e.g. hydraulic modeling). The aim of this assessment is to identify areas for restoration actions that address factors limiting the productivity of native salmonids and to ensure that the identified actions fit within the appropriate geomorphic and ecological 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. Additionally, areas of minimal human impact, or areas at particular risk of further degradation, are identified to promote conservation of ecological processes. Although the proposed restoration and conservation 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 Bull Trout (*Salvelinus confluentus*).

The report includes the following components:

- Assessment Area Summary (Section 2): Description of the assessment area, fish use, and geophysical setting based on previous assessments.

- Hydrology and Hydraulic Modeling (Section 2.4): 2-dimensional hydraulic modeling of the study area, and related hydrologic summary. Detailed methods and results provided Appendix D.
- Habitat Assessment Summary (Section 4): Aquatic habitat inventory at the reach scale. Detailed methods and results provided in Appendix A.
- Reach-based Ecosystem Indicators (REI) Summary (Section 5): Comparison of habitat conditions to established functional thresholds. Detailed methods and results provided in Appendix B.
- Channel Segment Conditions (Section 6): Inventory and analysis of habitat and geomorphic conditions at the reach and sub-reach scales.
- Restoration Strategy (Appendix C): 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.

December 2025 Flooding:

As this assessment report was being finalized in December 2025, significant flooding occurred on Nason Creek as a result of an atmospheric river event that delivered high rainfall amounts to parts of the Pacific Northwest. Area rivers peaked on December 11, 2025. Preliminary data from the nearby Wenatchee River at Plain gage (USGS 12457000) suggests the upper Wenatchee experienced greater than a 1% annual exceedance probability (AEP) event (100-yr recurrence interval) and Icicle Creek likely experienced at least a 2% AEP (50-year) event based on data from the Icicle above Snow Creek gage (USGS 12458000). In contrast, rivers just to the north, including the nearby Chiwawa and Entiat Rivers, had lower intensity floods, with a 50-20% AEP (2- to 5-yr) event on the Chiwawa (USGS 12456500) and less than a 50% AEP (2-yr) event on the Entiat (USGS 12452800), revealing the strong north-to-south gradient in rainfall intensity. Gage data from this event is unavailable for Nason Creek. However, observations, including drone imagery collected by the Yakama Nation (Figure 1), suggest considerable flooding occurred. Initial comparison of the imagery with the hydraulic model indicates that the flooding could be in the range of a ~1% AEP (100-yr) event.

Events of this magnitude have the potential to significantly alter channel, floodplain, habitat, and infrastructure conditions. For these reasons, it is important for the reader to understand there may be changes within the Nason Creek reach assessment area compared to the conditions documented in this report, which are based on pre-flood field surveys from the summers of 2024 and 2025. Regardless of potential changes, preliminary observations suggest the effects of the flood are unlikely to alter the overall habitat condition/REI analysis, restoration recommendations, or other broad conclusions made in the assessment.

Figure 1. Flooding within the Nason Creek confluence area, view looking south, showing water over State Route 207. Note that this area is also influenced by flows in the Wenatchee River. Drone imagery from Yakama Nation, December 11, 2025.

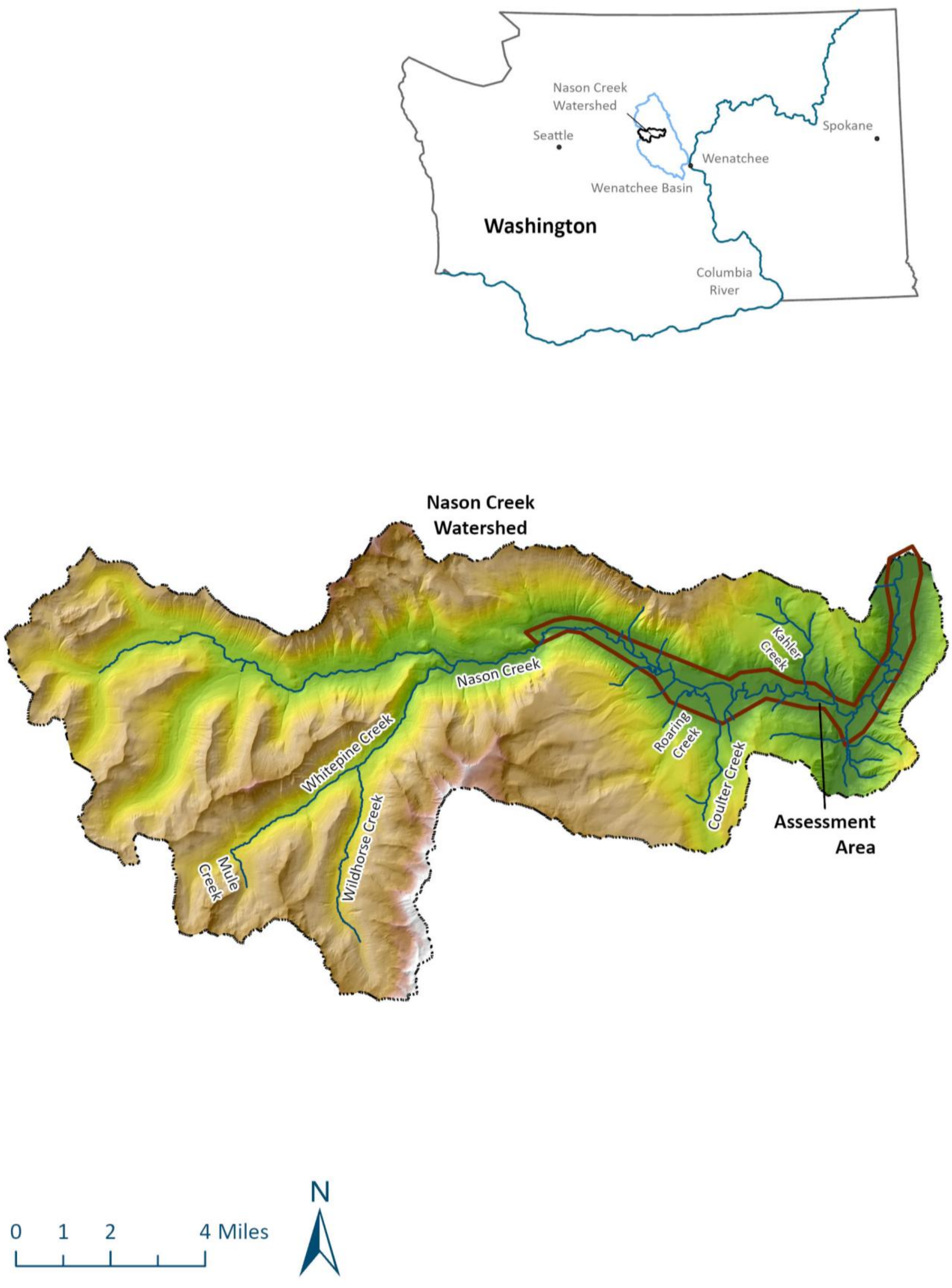


Figure 2. Locator map of assessment area.

1.2 PURPOSE AND APPROACH

This project was completed on behalf of the Yakama Nation as a part of their efforts to improve native aquatic fisheries within the Columbia River Basin through their Upper Columbia Habitat Restoration Project (UCHRP). The UCHRP works to achieve the objectives of the Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan (UCSRB 2007) and its associated Biological Strategy (UCRTT 2021).

This assessment involves collecting field data of the study area and combining it with existing available information. Various assessments, including past watershed assessments and reach-scale assessments, have been completed for the study area. These assessments are summarized in Section 2.2. This current reach assessment relies heavily on past work to inform certain basin- and reach-scale conditions that would be relatively unchanged since the previous assessments, such as geophysical setting, hydrologic setting, and past human impacts. New data collection and analysis only occur for elements that are likely to have changed. New data collection and analysis include new habitat surveys, new hydraulic modeling, new vegetation characterization, and a new Reach-Based Ecosystem Indicators (REI) analysis. In this regard, this current reach assessment differs somewhat from typical reach assessments. The emphasis is on providing an update to reflect current conditions, understanding how these have changed, and using this information to develop an updated habitat restoration strategy. The presence of past restoration projects is also taken into consideration. Over the past 20+ years, there have been many restoration projects implemented in the assessment area. The location of these projects is documented in this assessment. The restoration strategy evaluates potential adaptive management of these projects, additional potential work in existing project areas, and opportunities to address areas that have not been previous targets for restoration.

The purpose of this assessment is to:

- Summarize watershed- and reach-scale conditions that have been characterized as part of previous assessments.
- Perform updated field data collection and technical analyses to document current conditions, including an aquatic habitat inventory, hydraulic modeling, vegetation characterization, and an REI analysis.
- Document the location of past restoration projects within the study area and discuss their observed influence on existing conditions.
- Develop an updated habitat restoration strategy that identifies and prioritizes actions for aquatic habitat improvement.
- Act as a resource for coordinating efforts with local landowners, resource managers, and other stakeholders to establish collaborative efforts that contribute to the success of restoration strategies.

2. Assessment Area Overview

This section includes a brief overview and description of the assessment area, including orientation to the geography of the assessment area, a summary of past assessments and projects, overview of fish use, and a description of the geophysical setting. Detailed information on basin history, geography, geology, ecologic setting, and geomorphic setting is well-covered in other sources, including the past assessments described below in Section 2.2. As described previously, this report is not intended to re-state this information, but rather to build upon and update information as it relates to specific habitat and river process conditions at the reach-scale. To that end, this section (Section 2) is mostly a summary of existing relevant information provided for context. The sections that follow (Sections 2.4 through 5, plus relevant appendices) describe the data that were collected and analyzed as part of this current effort to provide an updated reach assessment and restoration strategy. This includes a hydrology and hydraulics analysis, habitat assessment, and the REI analysis. Section 6 describes specific conditions at the reach-scale (grouped into segments) and the restoration strategy is included in Appendix C.

2.1 ASSESSMENT AREA DESCRIPTION

The assessment area includes the Nason Creek channel and floodplain from the confluence with the Wenatchee River to RM 13.5 (at the railroad bridge). A map of the assessment area is included in Figure 3. The reach breaks and river miles used in this assessment generally adhere to those used by the Upper Columbia Salmon Recovery Board (UCSRB) and vary slightly by those used in other past assessments, including past reach and tributary assessments by the U.S. Bureau of Reclamation.

There are numerous transportation and utility corridors within the assessment area that impact channel and floodplain processes. U.S. Highway 2 parallels Nason Creek from RM 5 near Coles Corner to the upstream end of the assessment area. State Highway 207 follows Nason Creek from Coles Corner to the mouth. Improvements to Hwy 2 in 1960 and Hwy 207 in 1943 relocated both highways closer to the river. A railroad line parallels Nason Creek through the study area upstream of RM 9.2 and cuts off significant portions of former channel and floodplain. There is a Chelan PUD (CPUD) powerline along the river and floodplain upstream of RM 7.5. A BPA transmission line crosses the river in numerous locations. There are numerous other roads, housing developments, bridges, campgrounds, and a golf course that either lie along the river or are within the floodplain.

The Nason Creek watershed is 78% federally owned, with most of that managed by the U.S. Forest Service. Of this, 51% is non-designated recreational forest, 21% is in the Alpine Lakes Wilderness, and 3% is in the Henry M. Jackson Wilderness (U.S. Bureau of Reclamation 2008). Private land makes up 22%, mostly along the lower 15 miles and along Kahler and Coulter Creeks. Private lands include residential lands, a golf course, corporate timber land, and small businesses. Within the assessment area, 35% is private, 36% is state, federal, or tribe-owned, and 29% is conservation lands, county, or CPUD. A landownership map of the assessment area is provided in Figure 4.

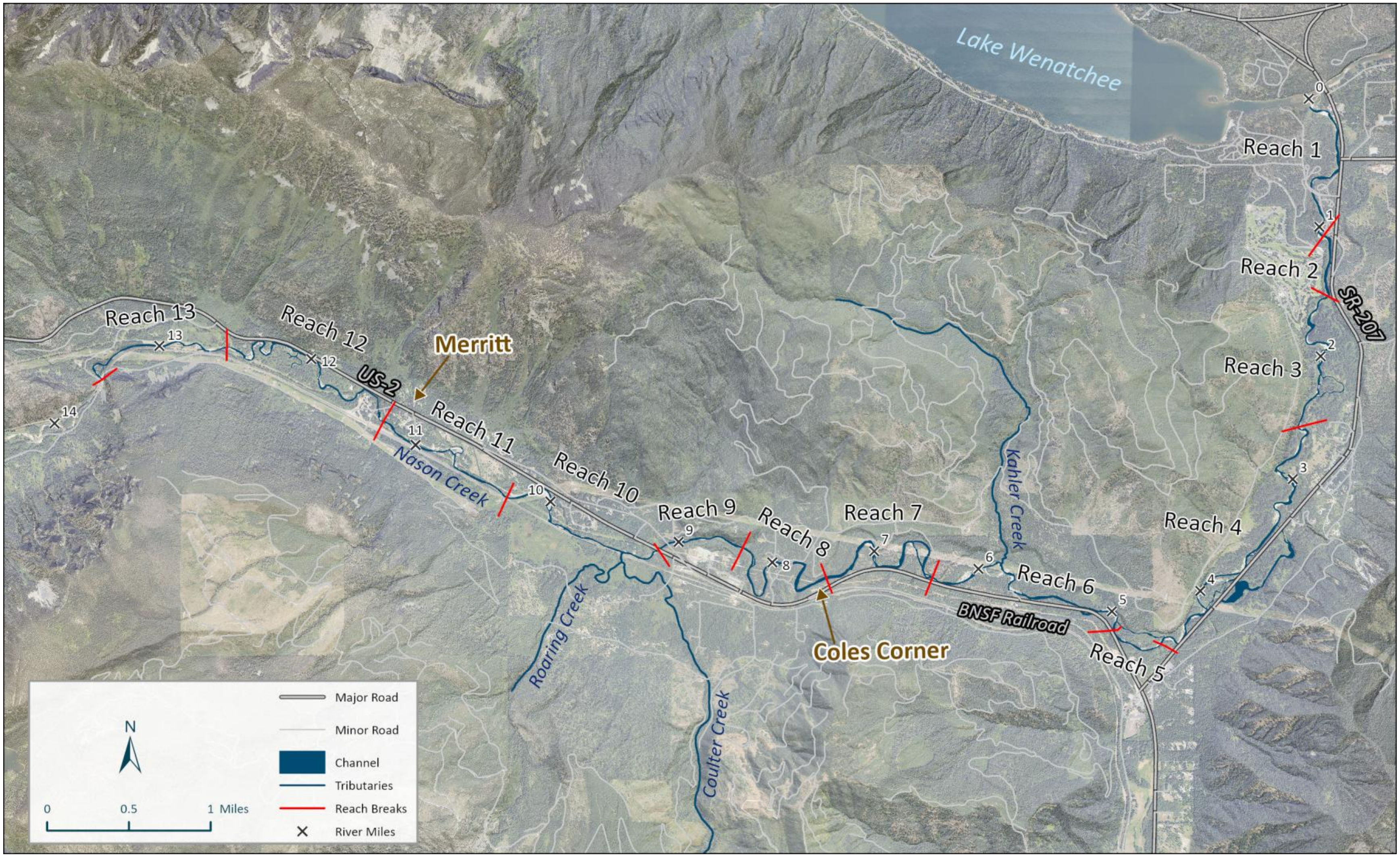


Figure 3. Overview of the Nason Creek assessment area.

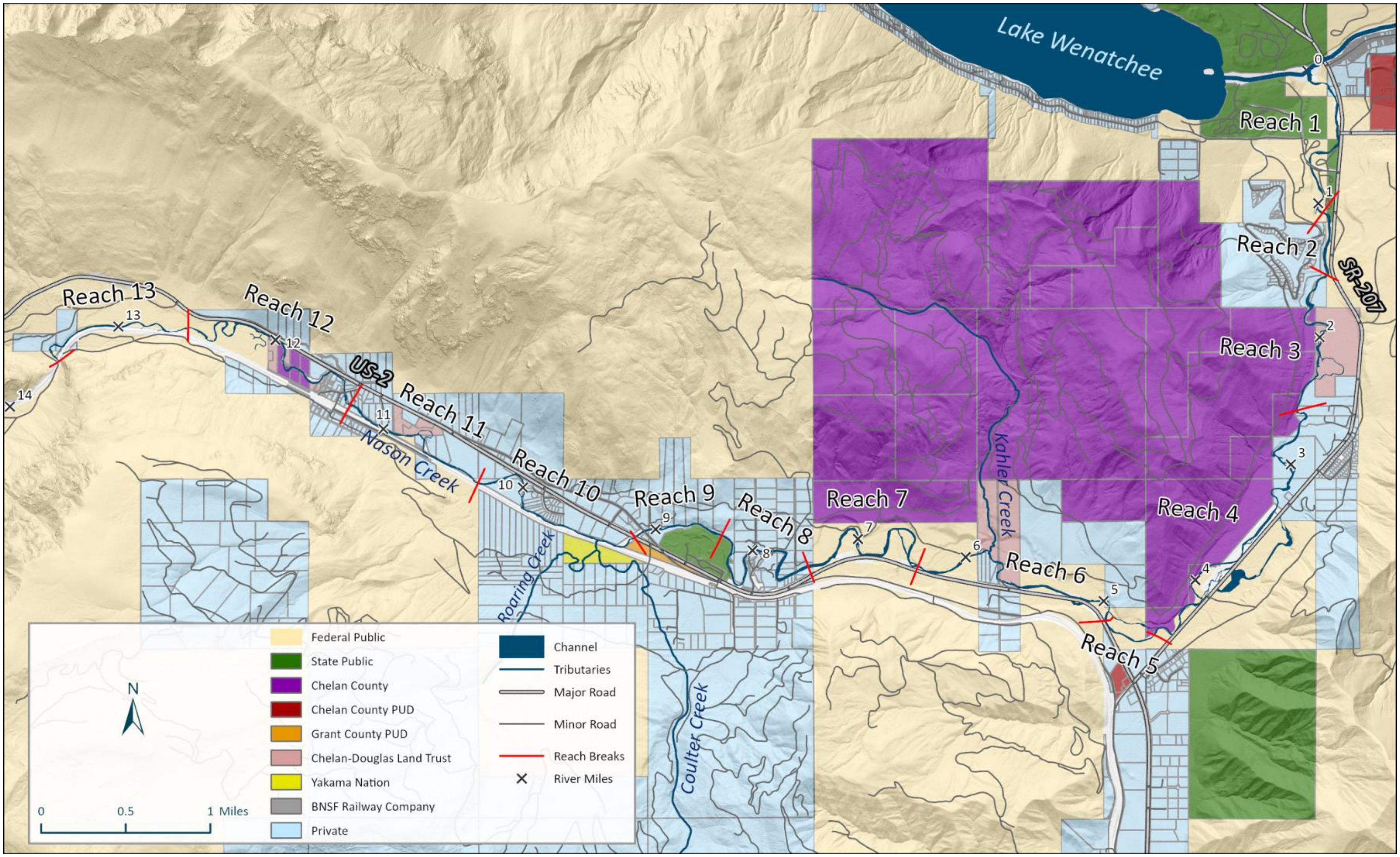


Figure 4. Landownership in and around the assessment area.

2.2 PAST ASSESSMENTS AND PROJECTS

There have been multiple past reach assessments and other relevant studies within the assessment area and contributing basin. Studies with particular relevance to this assessment are listed in Table 1. The Nason Creek Tributary Assessment (U.S. Bureau of Reclamation 2008) constituted an in-depth early look at the assessment area and provided useful information that was subsequently used in the reach-specific ‘reach assessments’ that followed. The past reach assessments that specifically cover the study area include the Lower Nason Assessment of Geomorphic and Ecologic Indicators (USBR 2011), the Kahler Reach Assessment (U.S. Bureau of Reclamation 2009), the Lower White Pine Reach Assessment (USBR 2009a), and the Upper White Pine Reach Assessment (USBR 2009b). There are a few other relevant reports and studies that are included in the table. This current assessment builds upon these past efforts. Relevant past information was reviewed, summarized, and used to inform components of the current assessment. The many habitat restoration projects that have been implemented in the assessment area over the past 15 years were in many cases a result of the findings and recommendations from these past assessments.

Table 1. Past assessments within the Nason Creek assessment area. Listed in chronological order.

Year	Name	Agency	Area of coverage	Description
2008	Nason Creek Tributary Assessment	US Bureau of Reclamation	The 27 miles of the Nason Creek Tributary between RM 4.6 and RM 14.3 (Coles Corner to the White Pine Railroad Bridge).	Geomorphic Assessment, Reach-Based Restoration Opportunities and Priorities, Hydrologic Analysis, Hydraulic Analysis, and Vegetation Assessment
2009	Upper White Pine Reach Assessment	US Bureau of Reclamation	The Upper White Pine from RM 12 and 14.25 between Highway 2 to the north and the railroad grade to the south.	Water quality assessment, Reach-Based Indicator reach characterization, Habitat assessment, Geomorphic assessment, Hydraulic Analysis, and Vegetation assessment.
2009	Lower White Pine Reach Assessment	US Bureau of Reclamation	Lower White Pine Reach is located between river mile (RM) 9.45 and 11.55 on Nason Creek	Water quality assessment, Reach-Based Indicator reach characterization, Habitat assessment, Geomorphic assessment, Hydraulic Analysis, and Vegetation assessment.
2009	Kahler Reach Assessment	US Bureau of Reclamation	The Kahler reach is between RM 4.65 and 8.9.	Reach-Based Indicator reach characterization, Habitat assessment, Geomorphic assessment, Hydraulic Analysis, and Vegetation assessment.
2011	Lower Nason Assessment of Geomorphic and Ecologic Indicators	US Bureau of Reclamation	The lower 4.6 miles of the Nason Creek.	Habitat assessment, Reach-Based Indicator reach characterization, Geomorphic assessment, Hydraulic Analysis, and Vegetation assessment.
2011	Lower White Pine Inner-Zone	Yakama Nation	Lower White Pine Segment. RM 9.1 – 11.	Project opportunity identification.

Year	Name	Agency	Area of coverage	Description
	Project Identification			
2013	Nason Creek: Upper White Pine Reach Restoration Plan	US Bureau of Reclamation	The Upper White Pine from RM 12 and 14.25	Restoration project planning and Wetland determination
2016	Geomorphic and Hydraulic Assessment Nason Creek RM 6.0 – 7.6	Chelan County Natural Resources Department	Nason Creek RM 6.0 – 7.6	Geomorphic characterization, Hydraulic analysis, and habitat assessment.
2019	Upper Nason Creek Reach Assessment	Yakama Nation Fisheries	The Upper Nason Creek extends from RM 13.7 (at the train bridge over Nason Creek) to RM 16.2 (0.07 miles above the confluence with Whitepine Creek).	Habitat conditions assessment and restoration identification, Geomorphic assessment, Reach-Based Ecosystem Indicator characterization, and Hydraulic analysis

The previous, current, and potential habitat restoration projects in the assessment area have been performed by multiple entities over the past two decades. Past projects since 2007 are listed in Table 2. Information about these projects was obtained from a combination of sources including personal knowledge, communication with sponsor entities (or their design consultants), available web-based knowledge (i.e. WA Recreation and Conservation Office database, Salmon Recovery Portal), and field-based observations during the surveys. Overview maps of the projects are included in the more detailed maps in the Channel Segment Condition chapters (Section 6). These chapters also describe the influence that project elements are having on river processes and habitat conditions.

Table 2. Past restoration projects within the Nason Creek assessment area. Listed in chronological order.

Year	Name	Sponsor	Area of Coverage	Project Components
2007-8	Nason Oxbow Reconnection	Chelan County	RM 3.4 to 3.7	Improve fish access to the historical “oxbow” side channel via culverts through State Route 207; protect floodplain and riparian habitat; Install large wood structures; Regrade of surfaces; Revegetation; Bank protection
2009	Unknown	Chelan County	RM 1.15 to 1.25	Culvert connections through State Route 207 to reconnect historical channel segment as a side-channel with fish access.
2012	Nason Creek Lower White Pine Habitat Reconnection Project	Chelan County	2.1 mile of the Lower White Pine between RM 9.45 and 11.55	Off-channel habitat restoration for juvenile salmonids; Increase floodplain connectivity; Reconnect creek basins; Create flow-through habitat; Maintain summer low flows; Protect existing spawning habitat
2013	Nason Lower White Pine – First Bend	Yakama Nation	RM 10.6 to 10.8	Controlled meander cut-off to prevent avulsion and additional straightening along the railroad; Wetland and off-channel habitat enhancement using large wood; Mainstem

Year	Name	Sponsor	Area of Coverage	Project Components
				large wood jams for complexity; Riparian reforestation.
2013	Nason Lower White Pine Floodplain Reconnection	Chelan County	RM 9.4	Creation of a connection point to the disconnected channel across the railroad via a railroad bridge.
2014?	Bank revetment	Unknown	RM 9.2 (river-right)	Bank stabilization and erosion control; Riparian revegetation. Potentially related to protection of the Grant PUD Hatchery facility.
2014	Nason Creek RM 4.7 – RM 3.3 Restoration Project	Chelan County	RM 4.7 to 3.3	Regrading surfaces; Abutment removal; Install habitat structures; Erosion control; Install large wood structures; Floodplain excavation
2015	Nason Upper White Pine - Lower	Yakama Nation	RM 12 to 12.5	Mainstem large wood structures; Creation of alcove habitat with extensive placement of large wood habitat.
2015	Bridge abutment removal and floodplain enhancement	Chelan County	RM 4.4 to 4.5	Old bridge crossing abutment fill removal; Removal of parking lot from river-right floodplain and revegetation.
2016	Nason Lower White Pine – Groups 2 & 3	Yakama Nation	RM 10.1 to 10.5	Large wood enhancement; Revegetation; Bank treatment
2018	Nason Upper White Pine - Upstream	Chelan County	RM 12.5 to 13.4	Channel relocation, lifting, and meandering. Removal of bank armoring; Filling old ditched channel; Levee removal; Creation of new floodplain areas; Large wood installation; Wetland and off-channel enhancement; Floodplain and riparian revegetation.
2018	Nason Creek RM 2.3 Side Channel Reconnection	Chelan County	RM 2.3	Large wood structures; Revegetation; Improve side and in-channel channel habitat; Increase wetland; Stabilize streambanks; increase floodplain connectivity
2019	Nason Kahler Stream and Floodplain Enhancement	Yakama Nation	RM 8 to 8.5	Mainstem large wood placement; Off-channel enhancement; Avulsion abatement; Revegetation
2021	Nason Confluence Side Channel	Yakama Nation	RM 0 to 0.1	Create side channel; Install large woody material; Revegetation
2022	Nason Merritt Oxbow Reconnection	Cascade Fisheries	RM 10.8 to 11	Create side channels and reconnect relic oxbow channels; increase floodplain connectivity; Increase in-stream habitat and large woody structures; Maintain and create side channels; Revegetation
2022	Kahler Reach Habitat Improvement – Site 1	Chelan County	RM 6.8 to 7.3	Side channel connection grading; Installation of large wood structures; Revegetation; Road decommissioning.
2024	Kahler Reach Habitat	Chelan County	RM 5.7 to 6.3	Installation of large wood structures; Revegetation

Year	Name	Sponsor	Area of Coverage	Project Components
	Improvement – Site 2			
Planned	Nason RM 12 Floodplain Reconnection	Chelan County	RM 11.8 to 12	Excavate pilot channel; Increase floodplain connectivity; Bank enhancement; Increase side channel activation
Planned	Nason Creek RM 6 Thermal Refuge Project	Chelan County	RM 6.3 to 6.7	Mainstem and side-channel large wood habitat structure placements
Planned	Nason Floodplain – Highway 207 (RM 3.2 – 4.6)	Yakama Nation	RM 3.2 to 4.6	Partial relocation of State Route 207; Mainstem large wood jams: Side-channel habitat enhancement; Riparian and floodplain revegetation
Planned	Thermal refugia and bridge abutment removal	Chelan County	RM 9.1	Abandoned bridge abutment removal; Large wood and boulder habitat placements; Riparian planting

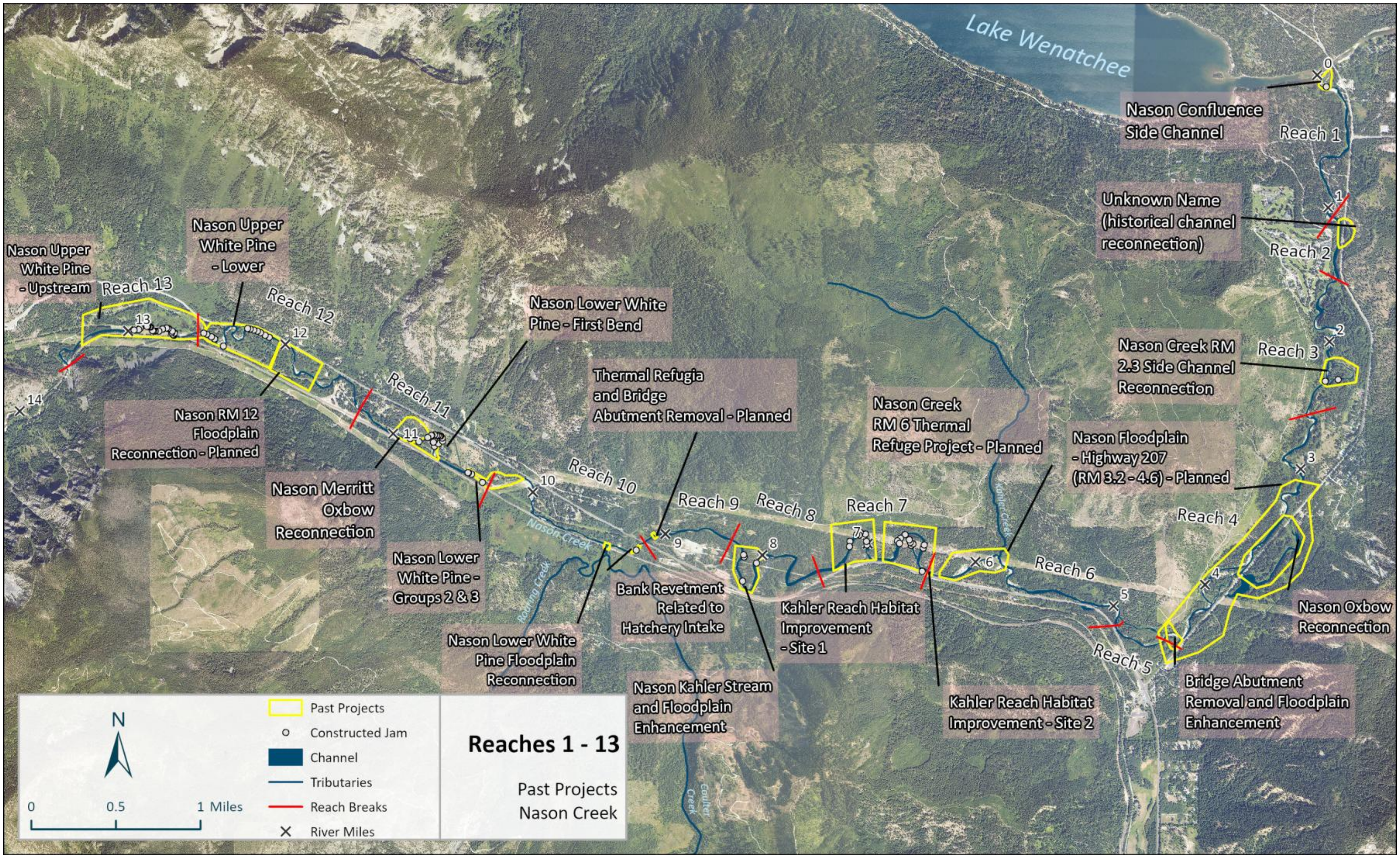


Figure 5. Past and planned restoration projects in the assessment area.

2.3 FISH USE

The Nason Creek assessment area provides migrating, spawning, and rearing habitat for Upper Columbia River (UCR) spring Chinook Salmon (*Oncorhynchus tschawytscha*), UCR steelhead trout (*O. mykiss*), and Bull Trout (*Salvelinus confluentus*). Historically, Nason Creek supported abundant populations of these species. However, populations declined significantly in Nason Creek and the greater Columbia River basin due to historical and legacy impacts, such as overfishing, hydropower development, and widespread habitat degradation. In response, UCR spring Chinook were listed as endangered under the Endangered Species Act (ESA) in 1999, UCR steelhead as endangered in 1997 (later reclassified as threatened), and CR Bull Trout as threatened in 1998 (NMFS 1997; USFS 1998; USFWS 1999).

Regional objectives for salmonid habitat protection and restoration in the Upper Columbia Region have been evaluated and summarized in the UCSRB RTT's Biological Strategy (UCRTT 2021), which recommends region-wide biological considerations and approaches for salmonid habitat restoration and protection actions. The RTT guides the development and evaluation of salmonid recovery projects within the Upper Columbia region.

This Nason Creek Reach Assessment project area falls entirely within the UCRTT's Lower Nason Creek Assessment Unit (AU). The Biological Strategy has identified the Lower Nason Creek AU as the highest priority (Tier 1) for restoration and protection of spring Chinook and steelhead. For Bull Trout, the Lower Nason Creek AU is designated as Tier 1 for restoration and Tier 3 for protection. Upstream reaches within the Lower Nason Creek AU are generally higher priority for restoration than lower reaches (UCRTT 2023). For spring Chinook, priority life stages within the Lower Nason Creek AU include adult holding, spawning, and year-round juvenile rearing. For steelhead, winter rearing is a high priority life stage in Lower Nason Creek. For Bull Trout, adult holding, spawning, and rearing are the highest priority life stages in the AU.

According to the Biological Strategy, restoration actions should aim to address limiting factors in Lower Nason Creek wherever possible, including improving channel habitat complexity and quality, reconnecting floodplain and off-channel habitats, restoring riparian condition, improving water quality and temperature for spawning and rearing life stages, improving bank conditions to manage fine sediments, and limiting brook trout interactions (UCRTT 2023).

2.3.1 Spring Chinook

Adult spring Chinook typically enter the Wenatchee River around May, passing Tumwater Dam in June and July on their way to spawning grounds (Hillman et al. 2021). Adults hold in deep pools with overhanging cover until spawning (Figure 6). Spawning typically occurs from mid-August through September, with most spawning in early September (Graf et al. 2023). From 2002 to 2018, there were an average of 172 spring Chinook redds per year counted in Nason Creek, with a range of 68 to 413 per year (Hillman et al. 2021).The average annual spawning escapement from 1989 to 2020 was 309 fish, ranging from 18 to 702 per year (Hillman et al. 2021). Eggs incubate for several weeks, and fry live in the interstitial spaces between gravels and cobbles prior to emergence in June and July. Fry are generally poor swimmers when they first emerge, and emergence often coincides with the rising hydrograph in Nason Creek, forcing juveniles to seek out backwater or margin areas with lower velocities, dense cover from overhanging banks or large wood, and abundant food (Healy 1991; Quinn 2005; Hillman et al. 2011). As they increase in size, juvenile Chinook begin to select for deeper and faster moving water, particularly areas with overhanging cover (Moyle 2002). Juvenile electrofishing shows that most juvenile Chinook in Nason Creek are found between RM 3.75 and 10.5 (Hillman et al. 2021).

Spring Chinook in the Upper Columbia Basin typically express a stream-type life history, rearing in freshwater for a year before outmigrating as yearlings, though some may migrate downstream to larger river systems or the estuary in the fall as Age-0 outmigrants (for instance, see Hillman et al. 2021). Age-1 smolts begin migrating downstream from their natal rearing areas around March (NWPCC 2004). Smolt trapping using a rotary screw trap occurs annually near the mouth of Nason Creek. Data from 2002 to 2018 shows an average of 24,491 juvenile spring Chinook emigrants annually, 81% subyearlings and 19% smolts (yearlings) (Hillman et al. 2021).

Hatchery spring Chinook are released into Nason Creek. The Nason Creek Acclimation Facility is located near RM 9.2, upstream of the Highway 2 crossing. The Nason Creek hatchery program began producing adult returns in 2016. Prior to this, any hatchery-origin spring Chinook were strays, mainly from the Chiwawa hatchery program (Graf et al. 2023). Monitoring shows that the percentage of hatchery-origin spawners within Nason Creek exceeds 30% in the 4 surveyed reaches (mouth to RM 15.4) and was highest in the lower 4 miles (79%), followed by the next 4.3 miles (61%). Above RM 8.3 to RM 15.4, the proportions of hatchery-origin and natural-origin fish were close to equal (ranged from 46% – 54% by sample reach) (Graf et al. 2023).

2.3.2 Summer Steelhead

Summer steelhead typically begin returning to the Wenatchee River as early as July (Figure 6). Adult migration past Tumwater Dam is bimodal, with most fish passing from July to November and a second, smaller pulse March to May (Hillman et al. 2021). Over the fall and winter, adult steelhead will hold in deep pools of larger rivers before finishing their migration to spawning areas the following spring. Spawning typically peaks in May (UCSRB 2007). Monitoring from 2005 to 2018 in Nason Creek showed that approximately 80% of the steelhead spawning in Nason Creek occurred from the third week in March through the first 2 weeks of May (Shelby et al. 2023). Steelhead redd counts from 2001 to 2013, during which consistent redd surveys were conducted throughout Nason Creek, averaged 149 redds per year, ranging from 27 to 412 (Hillman et al. 2021). Steelhead fry emerge 6-10 weeks after spawning (Peven 2003), usually on the descending limb of the hydrograph after snowmelt runoff has peaked.

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, USFWS 1996). Older juveniles prefer faster moving water including deep pools and runs over cobble and boulder substrate (USFWS 1996). Juveniles typically outmigrate between ages one and three, though some may remain in freshwater longer or exhibit a resident life history form as rainbow trout. Steelhead juveniles may redistribute to larger rivers downstream of natal areas in the winter and fall, and smolt migration to the ocean typically occurs between March and June (NWPCC 2004; ICF International 2012a). Smolt trapping near the mouth of Nason Creek from 2003 to 2020 shows an average annual steelhead count of 43,300 fish, with 97% of them being hatchery-origin fish that are released as part of a supplementation program (Hillman et al. 2021). Rainbow trout, the non-anadromous life history variant of steelhead, are also present and overlap spatially and temporally with their anadromous counterparts (Hillman & Miller 1989; Moyle 2002).

2.3.3 Bull Trout

Bull Trout may exhibit both resident and migratory life history strategies (Rieman and McIntyre 1993). Resident Bull Trout remain in tributary streams throughout their entire life cycle. Migratory Bull Trout spawn in tributary streams, with juveniles completing a portion of their rearing in those natal tributaries before migrating to a lake or other river. The greater Wenatchee watershed is recognized as one of three core areas in the Upper Columbia Critical Habitat Unit for Bull Trout (USFWS 2010). Seven local populations comprise the Wenatchee core area, including populations within the Peshastin, Icicle, Chiwaukum, Nason, Chiwawa, Little Wenatchee, and White subbasins. Bull Trout within the Wenatchee River core area exhibit multiple life history strategies, and Nason Creek is used for spawning and rearing, as well as foraging, migration and overwintering (NWPCC 2004; USFWS 2015). Bull Trout can pass Gaynor Falls (RM 17.2, upstream of the assessment area), but are unable to pass a natural bedrock falls near RM 20.9 (Andonaegui 2001). Redd count data between 1995 – 2019 in Nason Creek range from 0 – 17 redds observed in a given year. Comparatively, the Chiwawa River regularly documents hundreds of redds each year (Mayfield et al. 2022).

Bull Trout have very specific habitat requirements that influence their distribution and abundance. Critical parameters include cold water temperatures, available cover, complex channel forms, suitable spawning and rearing substrates, and availability of migratory corridors (USFWS 1999). Bull Trout normally reach sexual maturity in 4 to 7 years and can live 12 or more years. Bull Trout typically spawn from August to November during periods of decreasing water temperatures (Figure 6). Eggs incubate through the winter and spring, with fry typically emerging in April and May. Juveniles select for margin habitat with overhanging cover, feeding primarily on aquatic insects until they grow larger and shift towards feeding on fish. Juveniles may remain in natal tributaries for up to four years prior to commencing any downstream migrations, which can occur in both spring and fall (McPhail, J. D. and Baxter 1996; NPCC 2004; USFWS 2010).

2.3.4 Other Species of Interest

Coho Salmon were extirpated from the Upper Columbia River due to a suite of anthropogenic impacts, such as overfishing, construction of dams and hydropower facilities, and loss of high-quality aquatic habitats and floodplains. In 1999, the Yakama Nation initiated a reintroduction program for Coho Salmon in the Upper Columbia. Nason Creek is now identified as a "stronghold" with the highest potential in the Wenatchee Basin to support self-sustaining Coho populations (CRITFC 2012; UCRTT 2021).

Sockeye Salmon, and the non-anadromous life history variant kokanee, are present in the Wenatchee River basin, including nearby Lake Wenatchee. Sockeye and kokanee may use Nason Creek and its tributaries for spawning, rearing, and migration. Sockeye and kokanee are not listed under the ESA.

Brook Trout, introduced as a game species to west coast waterbodies, are presumed to be present in the Nason Creek system. Although their current distribution and abundance are not well documented, Brook Trout are known to hybridize with and compete against Bull Trout, potentially exacerbating declines in native populations (NPCC 2004; USFWS 2010)

Although data on Pacific lamprey (*Entosphenus tridentatus*) is limited, historical records and habitat suitability suggest that Pacific Lamprey were once widespread throughout the Wenatchee Basin, including Nason Creek. Reintroduction efforts by the Yakama Nation are underway, and larvae may now be present upstream of Tumwater Dam (Bioanalysts Inc. 2000; Grote & Lampman 2024).

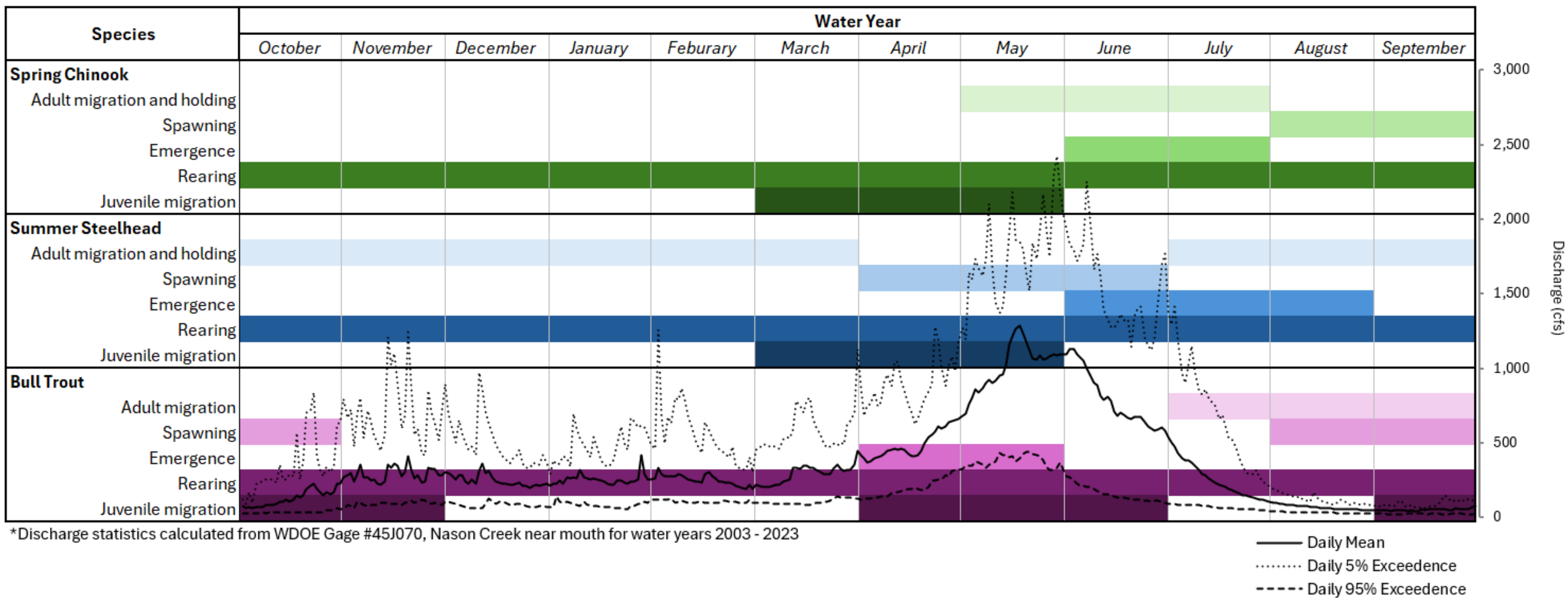


Figure 6. Summary of the life history timing of Spring Chinook, summer steelhead, and Bull Trout in Nason Creek, overlaid on an annual hydrograph depicting daily mean discharge as well as the daily 5% and 95% exceedance discharges in Nason Creek for water years 2003 through 2023 (WDOE Station 45J070). Life history references are cited in the species description sections above.

2.4 STREAM TEMPERATURE

2.4.1 Nason Creek Stream Temperatures

Stream temperatures are important for salmonid growth and survival and are impaired in lower Nason Creek. The majority of the assessment area is listed as a Category 4a impaired waterbody for temperature on the Washington State 303(d) list. A temperature Total Maximum Daily Load (TMDL) technical study was completed by the Washington Department of Ecology in 2005 for the Upper Wenatchee watershed, including Nason Creek (Cristea & Pelletier, 2005); a temperature TMDL Water Quality Improvement Report was completed in 2007 (Anderson 2007). Other temperature studies and temperature data collection efforts have been performed in Nason Creek over the years, some of which are summarized here to provide context for the reach assessment and restoration strategy.

Stream temperatures in Nason Creek regularly exceed spawning and rearing thresholds and have approached salmonid lethal limits in some cases. Salmonids require stream temperatures within certain ranges depending on life stage (Richter and Kolmes 2005). Temperatures that exceed those ranges can inhibit growth and survival. A threshold of 13°C for spawning and 15°C for rearing, holding, and migration are commonly used to assess impacts, and are what was used in the REI analysis as part of this assessment (see Appendix B for more details). Data reported by Richter and Kolmes (2005) suggest the lethal limit for salmonids is near 26°C, but above 24°C, mortality can occur with sufficient duration of exposure. The longest temperature record for Nason Creek is from the WDOE gage (#45J070) located near the Cedar Brae Road bridge crossing at the downstream end of the assessment area. This gage has recorded stream temperatures for the past 23 years, from 2002 to 2025. The 7-day rolling average of the daily maximum temperature (7DAD-Max), which is a common metric for assessing stream temperature, was calculated from the data. The 7DAD-Max temperatures surpassed spawning (13°C) and rearing, holding, and migration (15°C) thresholds every year during the summer months (2016 had a data gap during the hottest months of the year). In 2015, the 7DAD-Max temperatures neared the critical 24°C threshold for several days in early July. See Figure 7 below.

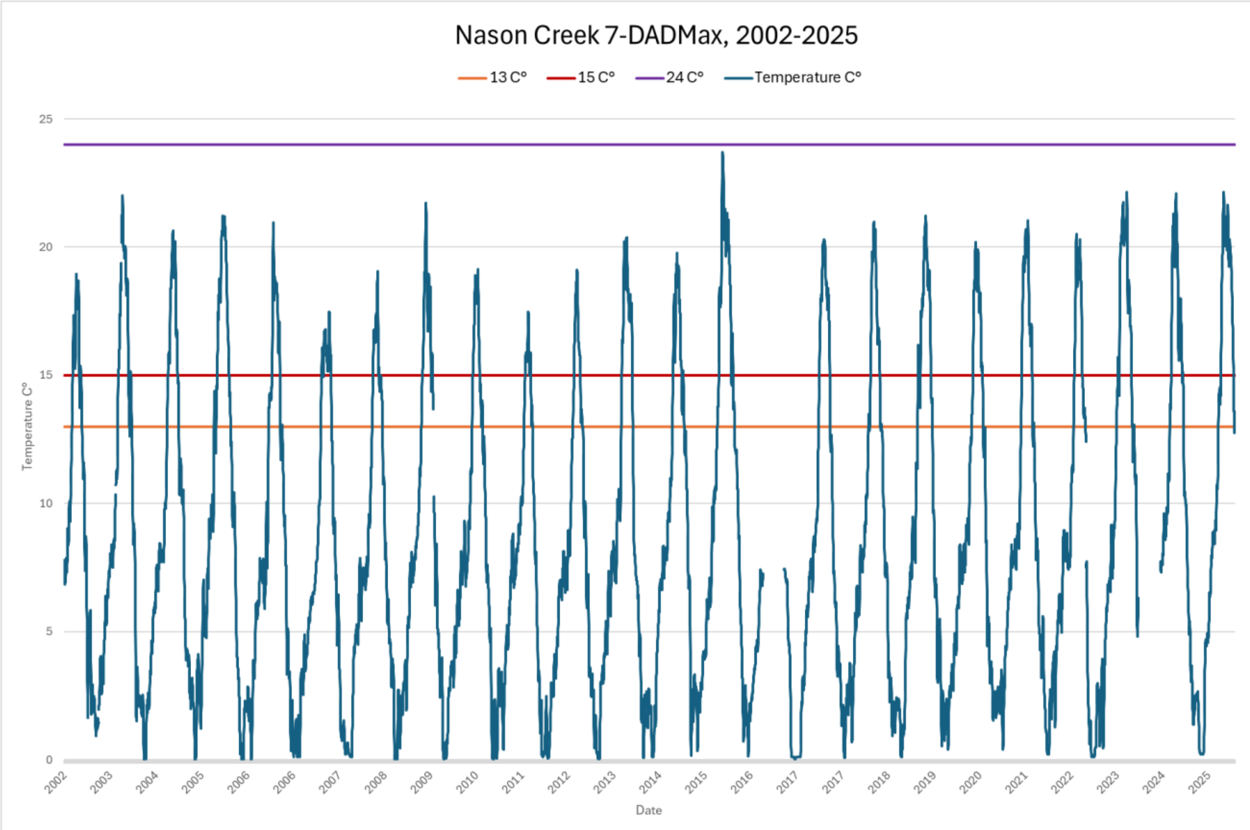


Figure 7. Graph shows the 7DAD-Max from WDOE gage #45J070 (at the downstream end of the assessment area) from 2002-2025. The spawning threshold (13°C) and the rearing, holding, and migration threshold (15°C) are exceeded every year during the summer months that data was recorded. In 2015 stream temperatures neared the lethal limit (24-26 C°) for several days in July.

The data from the downstream gage presented above likely represent the warmest zone in the assessment area given the longitudinal temperature patterns observed in other studies. In support of the TMDL assessment, the Washington Department of Ecology collected aerial-based thermal infrared radiation (TIR) data for lower Nason Creek in the summers of 2001 and 2003. Longitudinal temperature profiles from these efforts reveal overall trends of downstream warming, with some areas of cooling and re-warming. The absolute temperatures were higher in 2001 compared to 2003 but the temperature trends showed similar patterns between the two years (Figure 8). Viewing the entire TIR profile reveals that summer temperatures at RM 26 are considerably cooler (by approximately 8°C) than the temperatures at the mouth. Within the assessment area of this reach assessment, temperatures fluctuated by approximately 4°C. The overall trend in downstream warming is governed primarily by stream size and elevation, with more localized variation likely a result of channel confinement, tributary inputs, and stream shading.

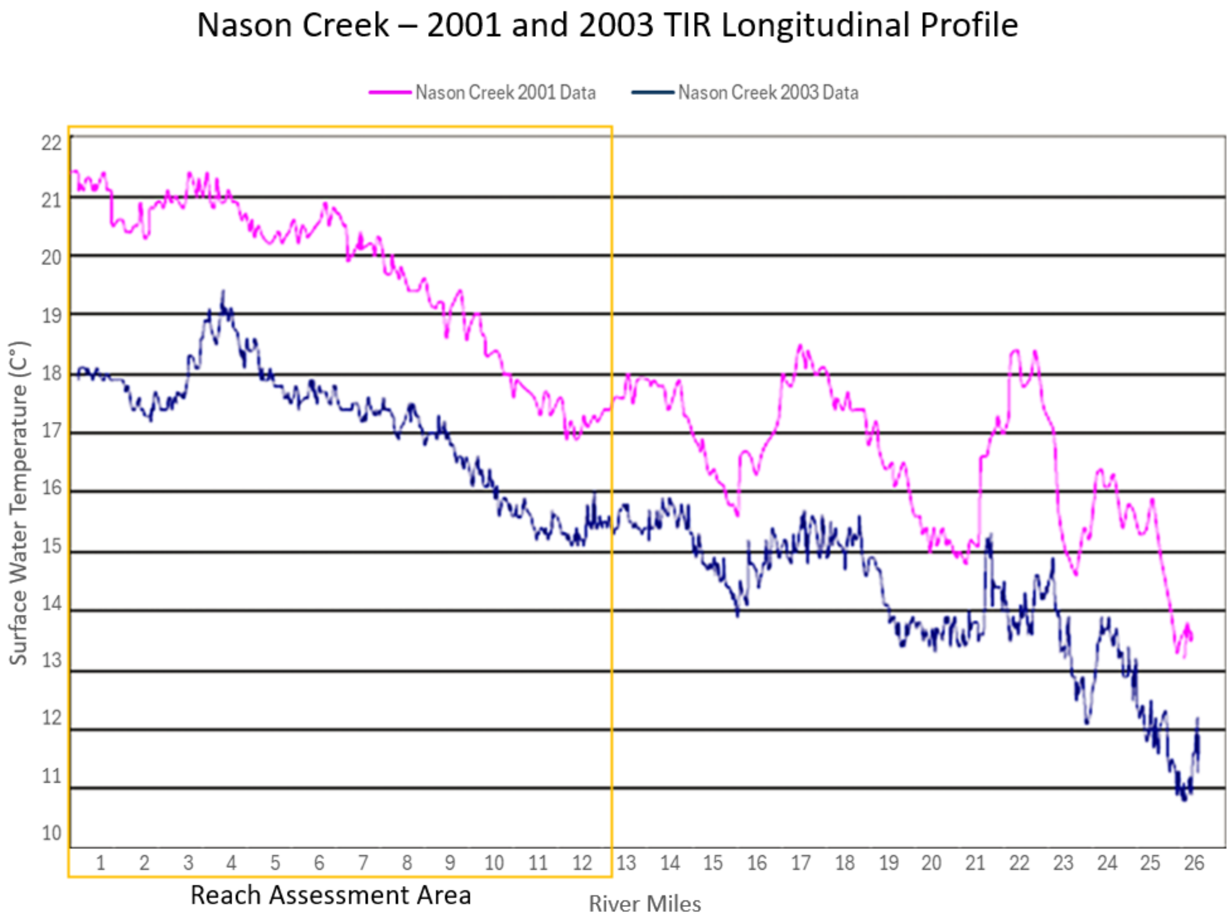


Figure 8. Longitudinal profiles of the 2001 and 2003 TIR data. The assessment area for this reach assessment is shown in yellow. This is a modification of figure 6 in Appendix F of the Nason Creek Tributary Assessment (U.S. Bureau of Reclamation 2008).

2.4.2 Cold Water Refugia

The availability of cold water refugia is an important consideration for fish use, and the location of potential thermal refuge areas helps to inform restoration actions. The Upper Wenatchee Thermal Refuge Assessment (UWTRA) was performed by Chelan County in 2020 (Roumasset et al. 2020). This study analyzed a variety of temperature data that were collected on Nason Creek over the past two decades and assessed streams in the upper Wenatchee basin for the presence of cold-water refugia. The study looked at the 2001 and 2003 TIR aerial imagery described previously as well as temperature logger data from multiple locations for the years 2018 and 2019 (provided by various partners). The study also involved hand sampling temperature data during the summers of 2015 and 2018 to create a longitudinal temperature profile. Hand sampled data were also collected in the summer of 2019 to ground truth cold-water features observed in the TIR data. Additional cold features were encountered during the longitudinal float. Cold features were binned into surface water features (tributaries or springs) and groundwater features (seeps) and had to be a minimum of 1°C colder than the upstream ambient temperature to be considered potential cold water refuge areas.

Similar to the TIR data, the longitudinal temperature profile from the UWTRA hand sampling revealed a typical warming trend moving downstream, although only by a couple of degrees when adjusted for diurnal variations. During the longitudinal collection, warm spots were observed to correlate with openings in the riparian corridor (e.g. residential areas or BPA powerline clearings). Data from three fixed location temperature loggers located at RM 0.5, 7, and 12 (from summer 2018 and 2019) showed a similar trend, but again the variations moving downstream were minimal.

The UWTRA analysis found a total of 14 cold water features within the lower 14 miles of Nason Creek, all of which were upstream of RM 4.5 (Coles Corner). The cold water features were found in reaches, 4, 6, and 8 through 12. Nine of those were groundwater features and five were surface water features (Roumasset et al. 2020). See Figure 9 below. Groundwater features tended to occur in clusters within reaches 4, 6, and 11. The two downstream-most groundwater features (in Reach 4) are directly downstream of a side channel with beaver activity, possibly contributing to the cold seeps. Moving upstream, the next cluster of groundwater features was near the Kahler Creek confluence in Reach 6. Note that two of the cold-water features in this cluster were dry during the summer 2024 habitat survey performed as part of this reach assessment. The third and final cluster of groundwater features was near RM 10.75 (Roumasset et al. 2020). The surface water features were associated with tributaries or springs. One of the cold water tributaries identified in the UWTRA was Butcher Creek; however, the TIR data showed Butcher Creek warmer than the mainstem in 2001 (though slightly cooler in 2003). These differences may be due to temperatures taken at lower depths during the UWTRA longitudinal sampling (Roumasset et al. 2020).

The 2024 habitat survey for this reach assessment also included samples of stream temperatures at tributaries. Two temperatures were collected at each tributary, one in the tributary and one upstream in the mainstem, to provide a comparative sample. In contrast to the UWTRA study, the 2024 habitat survey found Butcher Creek to be about 1°C warmer than the mainstem. Kahler Creek was identified as a cold-water input in both the 2024 survey and the UWTRA. Additional tributaries were sampled in the 2024 survey, but no others overlapped with the identified cold surface water features in the UWTRA. The 2024 survey found five out of the eight tributaries sampled were colder than the mainstem (Table 3). All UWTRA-identified cold water features and the tributaries sampled in the 2024 survey (as part of this reach assessment) are shown in Figure 9.

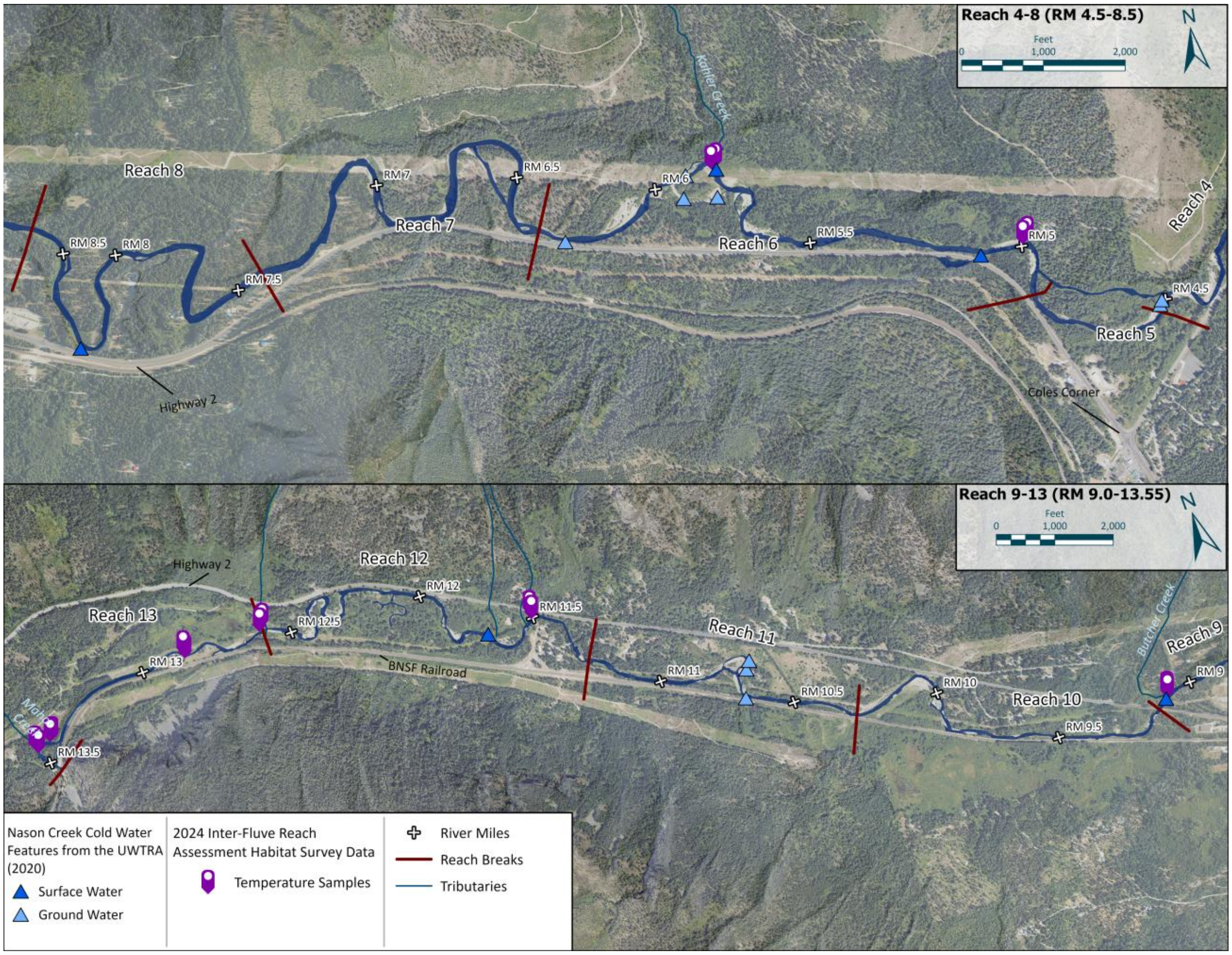


Figure 9. Map showing the ground-verified cold-water features from the UWTRA study (Roumasset et al. 2020) along with the tributaries sampled during the 2024 habitat survey.

Table 3. Data from the 2024 habitat survey temperature samples. Nason Creek temperatures were taken upstream of the tributary confluence and at the same depth as the corresponding tributary sample.

Tributary	RM	Nason Creek Temperature	Tributary Temp	Tributary Differential
Unnamed	5	15.8	15.1	-0.7
Kahler	5.9	14.5	12.8	-1.7
Butcher	9.1	12.3	13.2	0.9
Unnamed	11.5	10.4	8.6	-1.8
Unnamed	12.6	10.3	10.6	0.3
Unnamed	12.85	11.1	11.9	0.8
Mahar	13.4	12.7	11.4	-1.3
Unnamed	13.45	12.6	12.4	-0.2

2.4.3 Factors Affecting Stream Temperatures

Since the early 1900s, land use changes along Nason Creek have affected the conditions necessary to maintain cool summertime stream temperatures that support salmonid use. These land use changes are well-documented elsewhere in this report. In particular, the development of Highway 2, State Route 207, and the BNSF railroad have simplified channels and impaired the geomorphic processes that are known to maintain cool temperatures and temperature refuge areas. Impaired processes have increased channel widths; have reduced the creation of deep pools; have reduced the availability of cool-water off-channel habitat areas (and fish access to them); have severed connections to cool-water tributary habitat; and have altered the channel complexity necessary to drive exchanges between surface water and cool groundwater. Numerous stream-adjacent transportation and utility corridors, plus residential land uses, have resulted in cleared riparian zones, reducing shade from canopy cover. In addition, the impacts of historical logging continue to affect the amount of riparian canopy cover (Andonaegui 2001; U.S. Bureau of Reclamation 2008).

2.4.4 Climate Change Effects on Stream Temperature

Based on climate change modeling, the risk of elevated summer stream temperatures continues to increase into the future. Climate models predict an increase in precipitation falling as rain, resulting in a decreased snowpack and earlier spring runoff timing. An earlier spring runoff leads to lower summer base flows, which are more prone to heating. Cristea and Burges (2010) modeled scenarios for predicted stream temperature warming in relation to multiple emission scenarios combined with shade potentials for the Wenatchee River, Icicle Creek, and Nason Creek. The study found that Nason Creek had the highest potential reduction in stream temperatures from riparian vegetation shading of all three rivers assessed. This was based off width/discharge relationships and shade potential. The discharge and ecological conditions of Nason are favorable for stream temperatures to be affected by shading, emphasizing the importance of preserving and enhancing the riparian vegetation along Nason Creek in the face of climate change (Cristea and Burges 2010). See Section 3.2.5 for more information on climate change within the Nason Creek basin.

2.4.5 Implications for Restoration

The TMDL Water Quality Improvement Report (Anderson 2007) identifies 17 implementation strategies for addressing stream temperature impairments. These include relying on ongoing, planned, or new actions to improve stream temperatures. Recommended actions include restoration of riparian vegetation/shade, increased instream flows, reducing channel width and sediment runoff, increasing hyphoreic exchange and surface-groundwater recharge, and consideration of highway re-alignments away from streams. There are also numerous monitoring, funding, and coordination strategies. The restoration strategy (Appendix C) supports several of these recommendations, in particular riparian revegetation, reducing channel widths, increasing hyphoreic/groundwater exchange, and highway re-alignments.

Although the TMDL studies speak little of thermal refugia, there may be opportunities to enhance thermal refugia in Nason Creek to support salmonid growth and survival. Cold-water features offer thermal refugia for fish to wait out periods of severe temperature until conditions return to suitable levels. Restoration actions in these areas should look for opportunities to enhance the function and access to the cold-water features, and/or implement conservation measures for these areas if warranted. Improved conditions in these areas, especially in the form of habitat complexity (e.g.

large wood) and improved connectivity, can increase access to cold-water features and provide cover for fish while utilizing thermal refugia.

2.5 GEOPHYSICAL SETTING

2.5.1 Geology

The Nason Creek watershed is located in the North Cascade Mountains in the portion known as the Cascade Sierra Mountains physiographic province. The Nason Creek Watershed is geologically complex, shaped by tectonic activity, glaciation, and fluvial processes. It consists of three tectono-stratigraphic terranes (fault-bounded geologic blocks that are substantially different from each other). These terranes include the Nason Terrane, Ingalls Tectonic Complex, and the Chiwaukum Graben. The Nason Terrane and Ingalls Tectonic Complex are comprised of predominantly metamorphic rocks, and the Chiwaukum consists of sedimentary rocks of the Chumstick Formation (Gresens et al. 1978). The upper watershed is underlain by the Nason Terrane, primarily composed of Late Cretaceous metamorphic rocks such as Chiwaukum Schist and gneiss, which originated as fine-grained sedimentary rocks before undergoing regional metamorphism (Tabor et al. 1987). Bedrock in this terrane forms steep mountain slopes with over-steepened valley walls and talus slopes, particularly upstream of White Pine Campground (U.S. Bureau of Reclamation 2008). A geologic map is included in Figure 10.

Southwest of the Nason Terrane lies the Chumstick Formation, a softer, more erodible sedimentary unit forming subdued hills in the lower drainage. Nason Creek crosses this geologic boundary as it transitions from a bedrock-confined upper valley to a broader, glacially scoured valley bottom downstream. The valley exhibits deposits from multiple Pleistocene glacial episodes, including terminal and recessional moraines, glacial outwash, and flood deposits, with visible features from the Salmon Springs and Fraser Glaciations (Nimick 1977; Porter 1976; Waitt 1979).

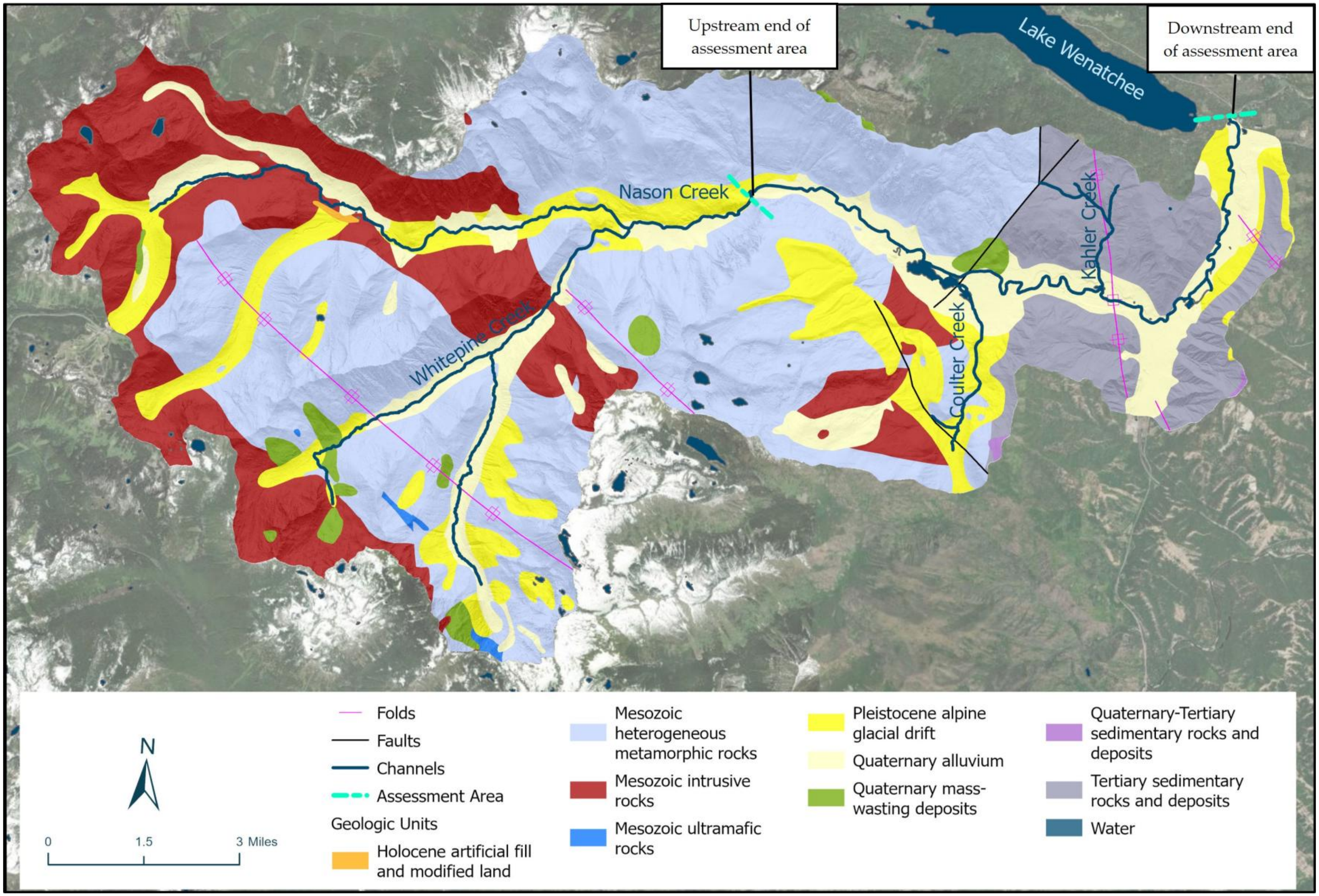


Figure 10. Geology of the Nason Creek Watershed (Derived from Tabor et al., 1987). Date ranges of geologic time periods listed are as follows: Quaternary (2.5 Ma – Present), Pleistocene (2.6 Ma – 11 Ka), Tertiary (66 – 2.6 Ma), Miocene (23 – 5.3 MA), Mesozoic (252 – 66 Ma), Precambrian (4.6 Ga – 540 Ma).

2.5.2 Geomorphologic Conditions

The reaches within the assessment area vary in their natural geomorphologic setting as well as the degree of anthropogenic impacts to channel form and processes. Most of the assessment area lies within a naturally unconfined alluvial valley shaped by glacial processes. There are, however, a few sections with natural confinement and numerous sections that are heavily impacted by artificial confinement and direct human impacts to channel location and form. In many locations, human infrastructure and past land use practices have had a significant impact on floodplain inundation extents and channel migration zone connectivity and have reduced (or completely severed) the natural geomorphic processes that existed historically. Natural sediment sourcing and transport processes have been severely altered. In some areas, past restoration work over the past 20 years has removed, set back, or breached confining infrastructure. Although these efforts have meaningfully improved geomorphologic and habitat conditions in specific areas, the overall dominant influence of the infrastructure nevertheless remains a limiting factor to naturally functioning conditions in the assessment area as a whole.

Starting at the upstream end, the Upper and Lower White Pine reaches (RM 9.1–13.5) mostly lie within a wide and low-gradient (Figure 11) U-shaped valley that is underlain by glacial and alluvial deposits. Bed material is dominated by gravels and cobbles. There is a short section of channel confinement near the community of Merritt (RM 11.4-11.5), where the channel is bounded by terrace deposits on the south (augmented by anthropogenic fill) and the hillslope on the north. Throughout the White Pine sections, the channel has been significantly altered by human infrastructure. This includes the Burlington Northern Santa Fe (BNSF) railroad, Highway 2, and their associated fill prisms, which have disconnected approximately one-third of the historical floodplain and altered geomorphic processes (U.S. Bureau of Reclamation 2008; Inter-Fluve and U.S. Forest Service 2013). Geomorphic mapping by Reclamation (U.S. Bureau of Reclamation 2008) and others indicates that the current channel has been substantially straightened during construction of the railroad and highway. The railroad and highway embankments also prevent connectivity between the main channel and the adjoining hillslopes, floodplains, and tributaries. From RM 9.2 to 13.5, nearly all tributaries and hillslope runoff are partially or fully disconnected by railroad embankments on the southwest side of the valley and by U.S. Highway 2 on the northeast side of the valley. In some cases, tributary water ponds up behind the railroad and highway embankments. There are also numerous powerline corridor crossings in the White Pine segments, including the Chelan PUD powerlines and BPA powerlines, which affect riparian, habitat, and geomorphologic conditions.

From RM 9 down to approximately RM 8.6 (Reach 9, "rest stop" area), the channel is mostly confined by landslide and glacial outwash deposits. Below RM 8.6, in the Kahler Reach (Reaches 5-8), the valley opens back up, but the modern floodplain is set slightly lower than adjacent sequences of glacial terraces that influence channel position and migration rates. This segment, down to Coles Corner near RM 4, is steeper than upstream and downstream reaches (Figure 11). Dominant substrate ranges from large gravels to small boulders. The planform is sinuous but lateral adjustment is partially constrained by the glacial terraces. Channel type is mostly pool-riffle with some long plane-bed sections dominated by cobbles. Floodplain terraces and alluvial fans provide key vertical and lateral controls (U.S. Bureau of Reclamation 2008). Short sections of channel have been cut off and shortened by Highway 2 and there is lateral confinement from the bridge crossing and floodplain fill from RM 8 down to 7.8. The BPA powerlines, with a 200+ foot cleared corridor, cross the river in numerous locations in this section, with significant impacts on riparian (e.g., stream shade), habitat (e.g., margin complexity), and geomorphologic (e.g., large wood recruitment) conditions.

Downstream of Coles Corner (~RM 4) to RM 1.5 (Reaches 3 and 4), the active channel migration zone and floodplain are wider and gradient is lower. Bed substrates are dominated by gravels. There are hillslope and some bedrock (Chumstick Formation) contacts on the river-left side. The natural channel form is meandering with some sections of anabranching; however, infrastructure constraints have resulted in channel straightening and loss of secondary channel segments. Channel type is pool-riffle. State Highway 207 on the east (river-right) side has cut off numerous sections of former channel and has severed portions of the channel migration zone, reducing lateral connectivity and floodplain inundation processes. Past restoration work has reconnected flow and fish access to some of the cut off channel segments but has not addressed channel migration impacts. Sediment recruitment via bank erosion has been reduced by the channel cut offs and bank armoring along the roadway, likely resulting in channel incision and further disconnection of the floodplain.

Downstream of RM 1.5, there is a short section of natural confinement (Reach 2) from glacial deposits, and the channel here is dominated by cobble and small boulders. Gradient increases slightly from upstream, which continues down to the mouth. The Nason Creek Campground, Cedar Brae Road bridge crossing, and State Route 207 provide significant sources of artificial confinement and floodplain fill in Reach 1. Much of this lower reach has riprap bank armoring. Bed substrates are dominated by gravels and cobbles. Channel type is mostly pool-riffle in these lower reaches. Below RM 0.6 on the river-left side, there is a wide vegetated floodplain that remains partially connected to the channel. The river-right side, which was historically connected to the expansive Nason Creek alluvial delta at the confluence, has been disconnected by State Route 207.

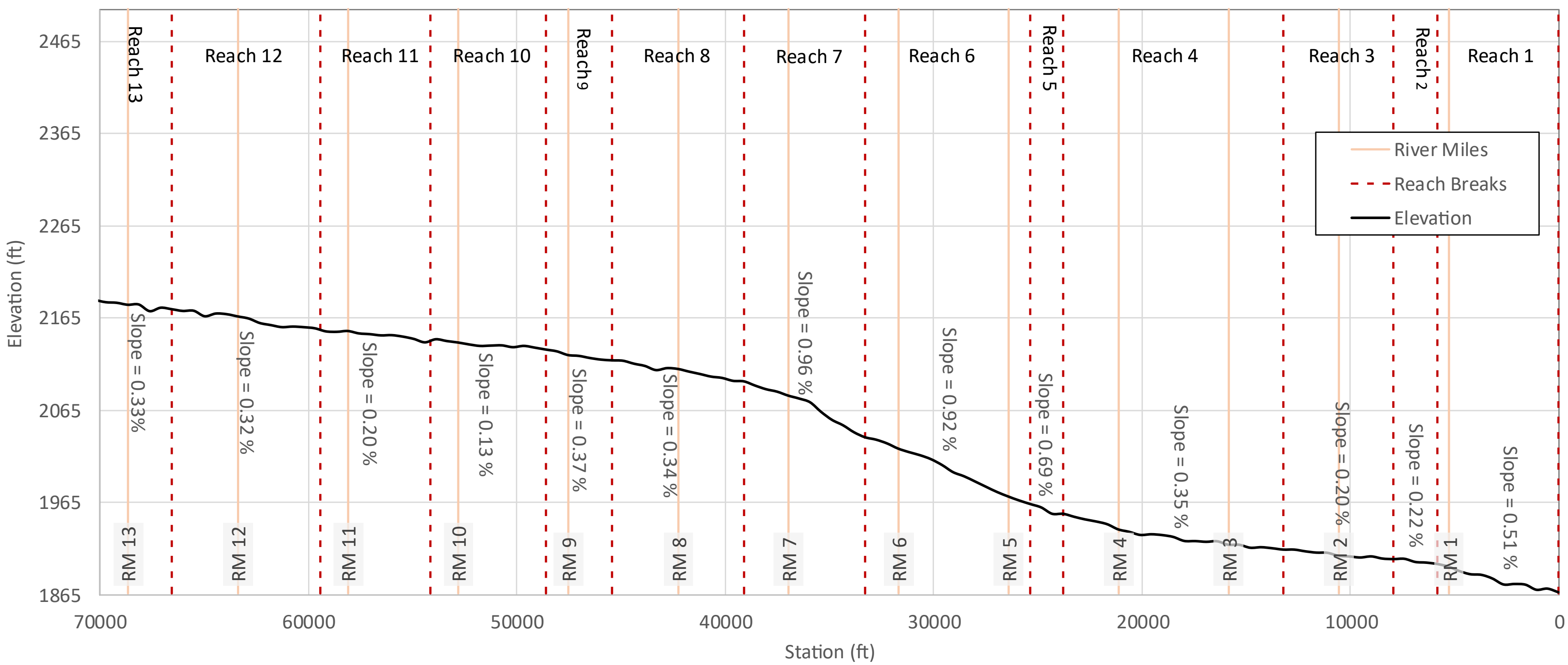


Figure 11. Longitudinal profile for Nason Creek within the assessment area.

2.5.1 Channel Migration Zones

Previously delineated channel migration zones were reviewed in consideration of updated data (e.g., newer LiDAR), new analysis (e.g., modeling), and channel changes that have occurred since the previous studies. There have been two channel migration zone analyses for the Nason Creek assessment area. This includes one that was performed in 2003/4 (Jones and Stokes 2004) for the lower 5 miles (mouth to Coles Corner) and one that was performed for RM 4.4 to 13.5 as part of the 2008 Tributary Assessment (USBR 2008). The data from both of these prior analyses were obtained and reviewed as part of the reach assessment to compare to current observations and conditions. The data from the downstream study was observed to have limited utility due to CMZ boundaries that in many places do not appear to track well with topographic features readily visible in the LiDAR (e.g., former channel scars, terrace boundaries). These data may lack accuracy due to lack of the detailed topographic information provided by LiDAR, which to our knowledge was not available for Nason Creek at the time of the 2003 assessment. Evaluating these data was also challenging as the final study report did not include methods. For these reasons, the CMZ study was not reviewed as part of this reach assessment.

For the upstream portion of the assessment area (RM 4.4 to 13.5), the 2008 Tributary Assessment delineated the Historical Channel Migration Zone (HCMZ), defined as the “areas that have evidence of channel migration for a period of at least the last 100 years and probably several hundred years” (USBR 2008). USBR performed this analysis using LiDAR, field observations, and historical maps and aerial photos. The GIS data of the HCMZ from the Tributary Assessment matches the extents of the “Geologic” and “Impacted” zones included in the maps below, with the “Geologic” zones representing those areas of the HCMZ that have been disconnected from the current CMZ due to anthropogenic changes. In most cases, the HCMZ data appear to match the field observations and modeling performed as part of this reach assessment. A few areas where conditions have changed, or where our assessment suggests different boundaries, are included in the figures below (Figure 12).

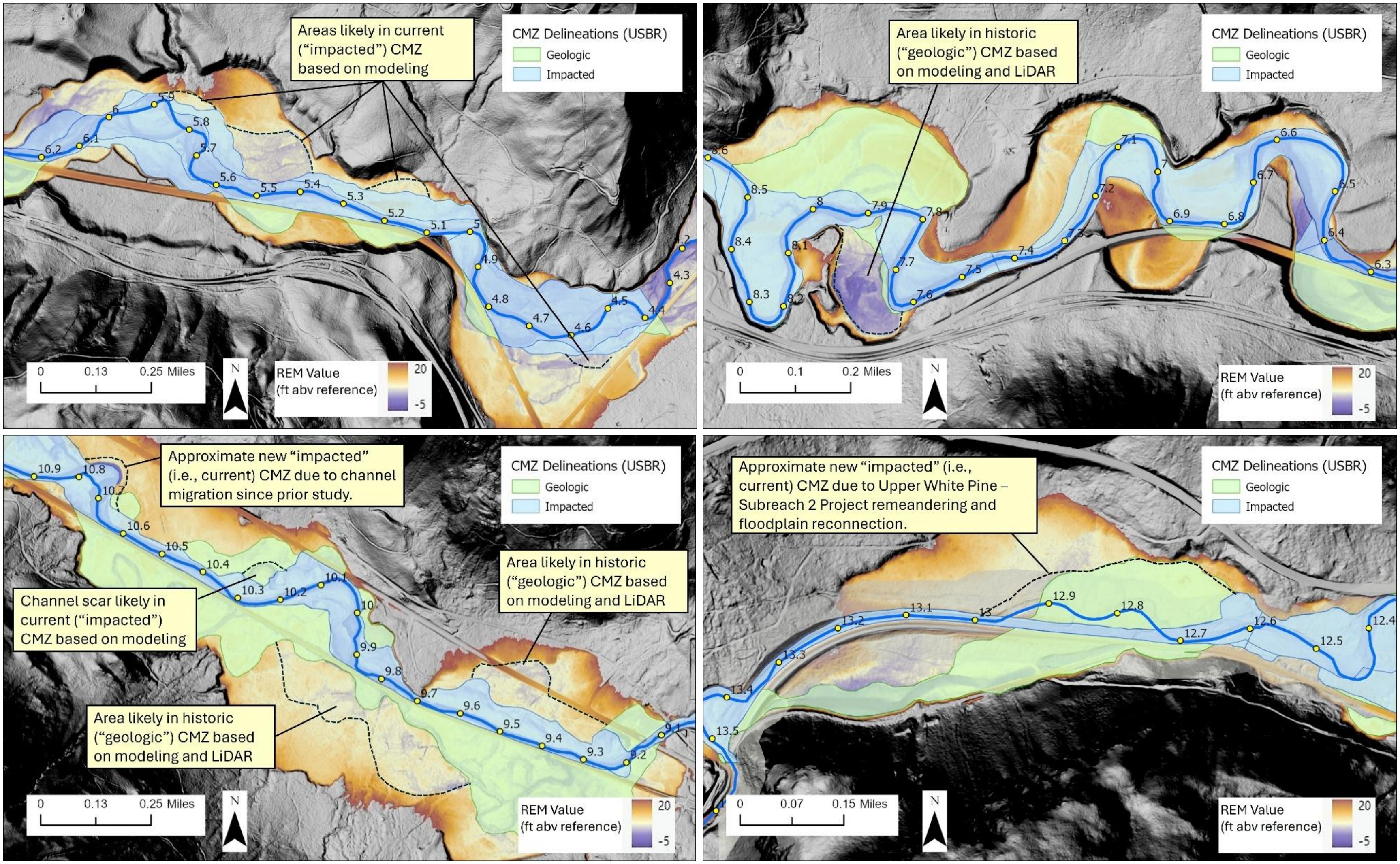


Figure 12. Notes of potential changes in channel migration zone delineations (from those delineated in USBR Tributary Assessment 2008) due to: 1) channel adjustments since the previous study or 2) from new data (e.g. newer LiDAR), new hydraulic modeling, and field observations performed as part of this reach assessment.

3. Hydrology and Hydraulic Modeling

3.1 INTRODUCTION

A hydraulic analysis of the study area was conducted to support the ecological and geomorphological interpretations of the site and to inform restoration strategies and project identification within the study area. This hydraulic analysis consisted of a preliminary-level 2-dimensional (2-D) hydraulic model of peak flood events for of Reaches 1-13 of Nason Creek, which was developed using elevation data from LiDAR available at the time of the analysis, and a flood frequency analysis of stream flows in and adjacent to the study area to estimate peak flood event discharges. Section 3.2 describes the hydrology and flood frequency analysis used to support this hydraulic analysis, and section 3.3 provides a brief overview of the hydraulic model and its results (see Appendix D for more detailed information on the hydraulic model).

3.2 HYDROLOGY

Nason Creek is a snowmelt-dominated hydrologic system and has a complex precipitation pattern (USGS 2019). The western slopes are dominated by heavy precipitation caused by prevailing westerly winds that move moist air from the Pacific Ocean over the Cascade Mountains. The eastern side of the Cascades is in a rain shadow. The annual precipitation in the Nason Creek watershed ranges from approximately 90 inches at the cascade crest to 30 inches at the mouth (Andonaegui 2001), with average precipitation of 63 inches per year. Most precipitation falls from late fall through the winter, and in the winter, precipitation typically falls as snow. Nason Creek has consistently high flows from late spring through early summer as snowpack melts. This is followed by seasonal drought and persistent low flows in late summer. There are periodic rain-on-snow events in the fall and winter, most typically from October through November. Nason Creek accounts for approximately 18% of the total low flow in the Wenatchee River (Andonaegui, 2001).

3.2.1 Basin Characteristics

Nason Creek flows approximately 27 miles from Stevens Pass, WA to its confluence with the Wenatchee River just downstream of Lake Wenatchee at Lake Wenatchee State Park. The drainage area of the Nason Creek watershed is approximately 109 square miles, much of it within the Wenatchee National Forest. Elevations range from 1,870 to 8,040 feet above sea level with a mean basin elevation of 4,110 ft (USGS 2022). Figure 13 provides a map of the Nason Creek watershed, its primary tributaries, and the reach assessment area (RM 0 – 13.5). Within the assessment area, there are six perennial tributaries that enter Nason Creek: Manhar Creek, Gill Creek, Roaring Creek, Coulter Creek, Butcher Creek, and Kahler Creek. The original Gill Creek confluence has been disconnected from Nason Creek by a perched culvert under the BNSF railroad. At most flows, Gill Creek currently flows down the west side of the railroad prism and enters Nason Creek at the confluence of Roaring and Coulter Creeks. Hydraulic modeling suggests that at the 2-year recurrence interval flood and greater, the perched culvert is activated.

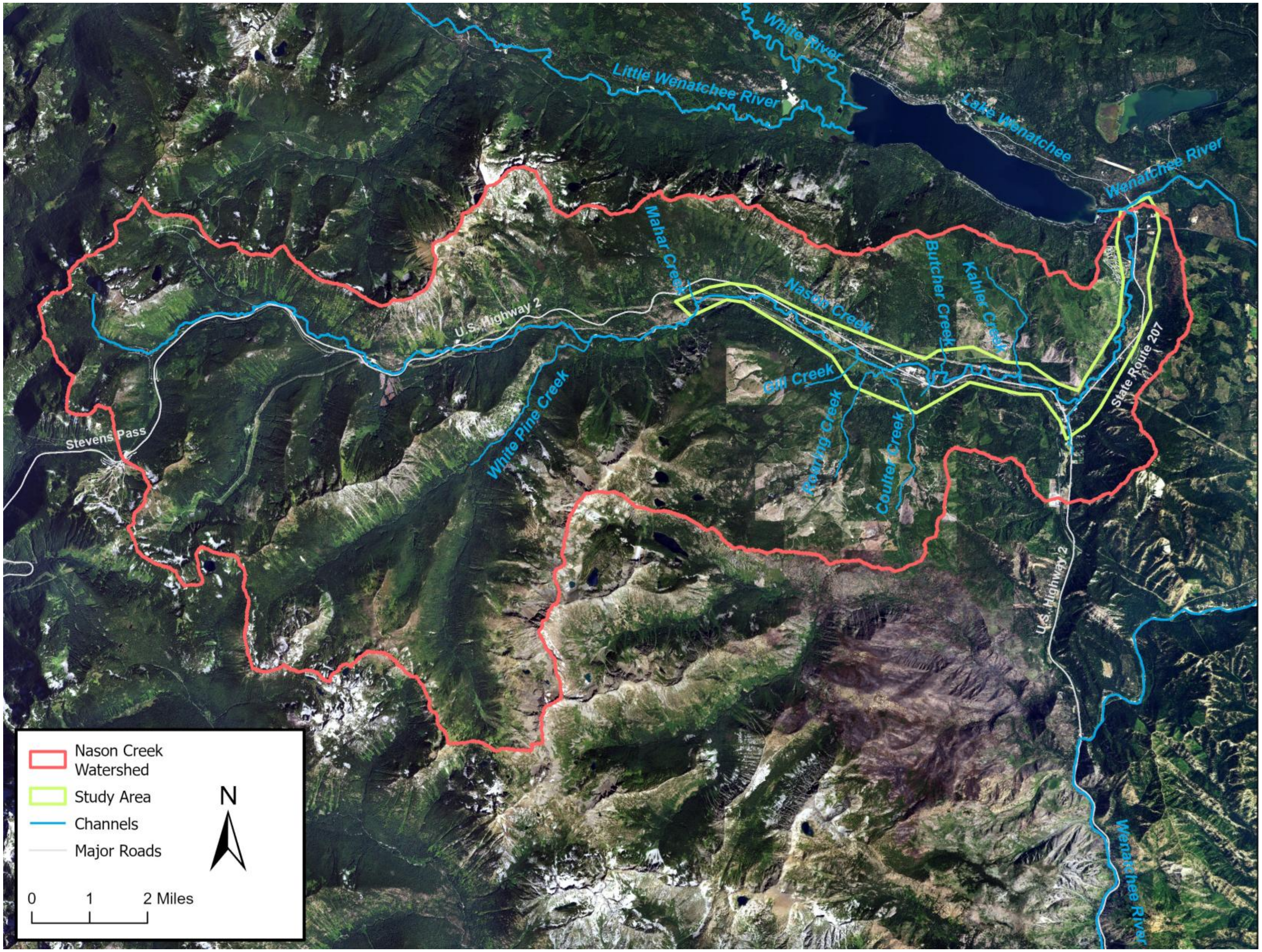


Figure 13. Map of the Nason Creek watershed in the context of the surrounding area with its major tributaries and the reach assessment study area.

3.2.2 Available Streamflow Data

Limited stream discharge data is available for Nason Creek. USGS gage 12455550, Nason Creek Near Plain, WA, has no recorded data, and USGS gage 12455500, Nason Creek Near Nason, WA, only has sporadic stream flow measurements from 1912, 1913, 1958, 1967, and 1970, but neither of these gages provide peak flow information or continuous flow or stage data. The Washington Department of Ecology (WDOE) operates a streamflow monitoring station below Cedar Brae Rd bridge near RM 0.2, Nason Cr. nr mouth (Sation 45J070) (WDOE 2025). This gage has a period of record from May of 2002 to present. While this gage provides useful seasonal flow information, its proximity to the confluence with the Wenatchee River results in peak flow measurements often being impacted by backwatering from the Wenatchee River, limiting the use of these data. A detailed analysis of Nason Creek's hydrology was conducted by the U.S. Bureau of Reclamation in 2008 as part of the Nason Creek Tributary Assessment, which used flood frequency analysis of several USGS gages to estimate peak flows at ungagged locations in the Wenatchee Basin (U.S. Bureau of Reclamation 2008). This analysis used data from the Icicle Creek Above Snow Creek gage (12458000) and preliminary data from the Nason Creek WDOE gage to estimate peak flows for Nason Creek between RM 0 to RM 14. However, as the WDOE gage has since been found to be backwatered by the Wenatchee River at high flows, and as it is missing more recent flow data from the last 17 years, this analysis was not directly used for the reach assessment.

3.2.3 Seasonal Flows

Nason Creek's annual hydrograph follows a typical pattern for east-slope Cascade Mountain streams, with greatest discharges in the late spring to early summer from snowmelt runoff and smaller precipitation-driven peaks throughout fall and winter. The WDOE gage shows a relatively constant baseflow from late August through September, with discharge increasing October to November as fall rains increase flows (Figure 14). These flows remain fairly constant in the winter from December through early March, while some precipitation falls as both rain and snow, and before snowmelt begins in spring. Figure 14 shows the daily flow statistics for the period of record, including the daily mean, 5% exceedance, and 95% exceedance as well as a monthly flow mean based on the last 20 years of flow data.

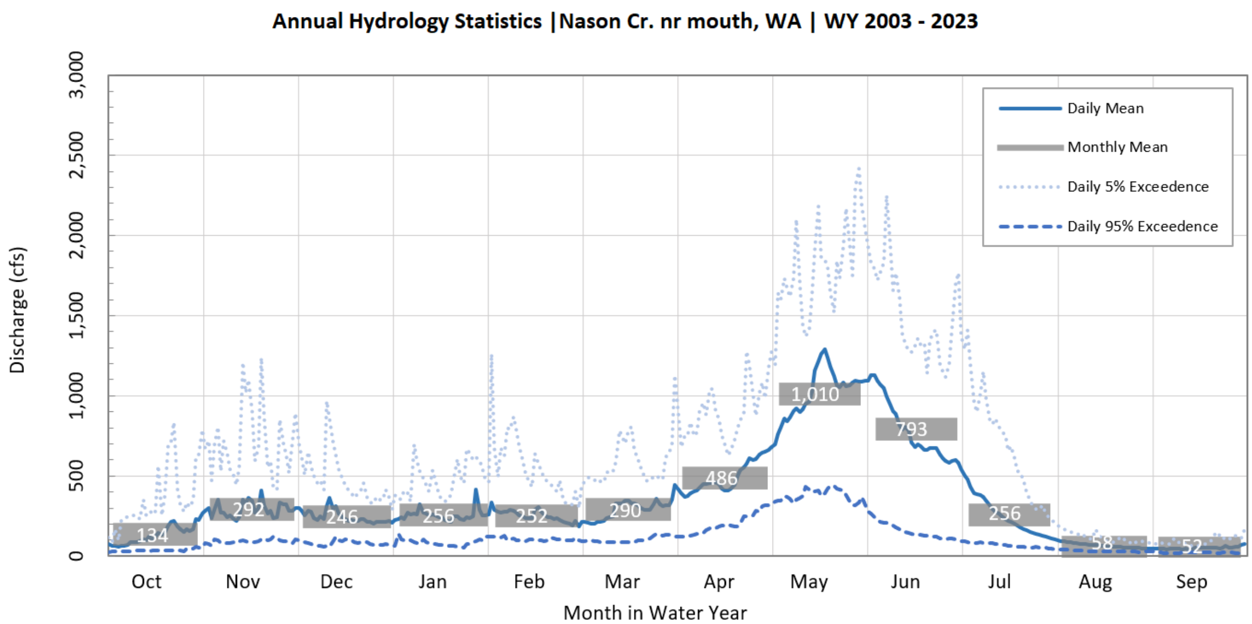


Figure 14. Daily flow statistics at the Nason Creek Near Mouth gage (WDOE Station 45J070), for water years 2003 through 2023 showing the daily average, 5% exceedance, and 95% exceedance discharge and monthly average discharge for the period of record.

3.2.4 Peak Flows

As previously mentioned, reliable peak flow data for Nason Creek is not readily available. Because of this, peak flows for this analysis were estimated using a combination of several surrounding gages, similar to the methods used in the ungagged Wenatchee Basin location analysis laid out in the Nason Creek Tributary Assessment (U.S. Bureau of Reclamation 2008). Peaks flows for several nearby gages were basin area-corrected for the project area's drainage area and then averaged to estimate peak flows for Nason Creek. Data used in this analysis included USGS gage data for the Stehekin River at Stehekin (12451000), Railroad Creek at Lucerne (12451500), Icicle above Snow Creek (12458000), Chiwawa River Near Plain (12456500), Wenatchee at Plain (12457000), and Entiat River Near Ardenvoir (12452990) gages, as well as the Washington Department of Ecology gage for White River Near Plain (Station 45K090) (USGS 1957, 2024a, 2024b, 2025a, 2025b, 2025c; WDOE 2024). Peak flow analyses were performed using the Bulletin 17C flood frequency analysis methods with the HEC-SSP software, using a weighted skew with a regional skew of -0.07 and a regional skew MSE of 0.18, following the guidelines in Mastin et al. (Table 1) (Mastin et al. 2017; USACE 2023). All available peak flow data for each gage were used to complete the analysis. Using the HEC-SSP results, the Mastin et al. (2017) equation 11 was used to weight peak flow results for each gage by the drainage area of the top of the project area (RM 14.9) and the bottom of the project area (RM 0), all of which were then averaged to estimate flows within the project area (Table 5). Project drainage areas were interpolated using the USGS Streamstats Program.

Table 4. Flood frequency analysis results (in cfs) for the USGS gages used to estimate peak flows in Nason Creek** (USGS 1957, 2024a, 2024b, 2025a, 2025b, 2025c; WDOE 2024)**.

Recurrence Interval	White River (WDOE)	Stehekin River	Railroad	Entiat near Ardenvoir	Icicle above snow creek	Chiwawa	Wenatchee at Plain
2	5,970	9,590	1,310	2,700	4,540	3,220	11,690
5	7,300	12,770	1,880	3,630	6,670	4,350	15,590
10	8,110	14,850	2,290	4,220	8,290	5,070	18,310
25	9,080	17,430	2,840	4,940	10,600	5,950	21,930
50	9,760	19,340	3,290	5,460	12,510	6,580	24,760
100	10,420	21,240	3,750	5,980	14,600	7,210	27,700

Table 5. Nason Creek project area estimated peak flood events based on weighted and averaged flood frequency analysis results for surrounding gages.

Flood Return Interval	Nason Creek Peak Discharge at RM 14.9 (cfs)	Nason Creek Peak Discharge at RM 0 (cfs)
2-Year	1,760	2,780
5-Year	2,410	3,770
10-Year	2,870	4,450
25-Year	3,470	5,350
50-Year	3,940	6,050
100-Year	4,430	6,770

3.2.5 Climate Change

Climate modeling in the Pacific Northwest predicts potential changes to streamflow as a result of temperature changes and shifts in the seasonal precipitation pattern. Climate change models have predicted a 3.2°F increase in annual temperature by the 2040s, and a 5.3°F increase by the 2080s (Mote and Salathé 2010). Predicted changes in precipitation vary by model but generally show trends towards wetter fall and winter seasons and drier summers (Mote and Salathé 2010).

Seasonal shifts caused by overall warmer and drier conditions are expected to shift transitional (mixed rain and snow) and snow-dominated basins towards a rain-dominated regime. Tohver et al. (2014) used the Variable Infiltration Capacity hydrological model to simulate basin hydrological regimes under the A1B medium emissions and the B1 low emissions climate scenarios. Under these scenarios, the Wenatchee basin is predicted to remain a snow-dominated hydrological regime through the 2020s but then transition into a transitional basin starting in the 2040s (Tohver et al., 2014). Transitional basins typically have elevated flows in the winter with peak rainfall and again in the spring with peak snowmelt, representing systems with mixed rain and snow dominance. These basins are projected to be the most sensitive to warming from climate change. Projected increases in winter precipitation are expected to cause more extensive flooding in basins such as the Wenatchee through the 2080s (Tohver et al. 2014). Warmer air temperatures combined with shifts in seasonal precipitation are predicted to result in earlier snowmelts, lower summer baseflows, and earlier peak flow timing. Warmer winter temperatures will result in more precipitation falling as rain instead of snow, lessening snowpacks that are essential for moderating stream temperature and regulating flow in spring and summer.

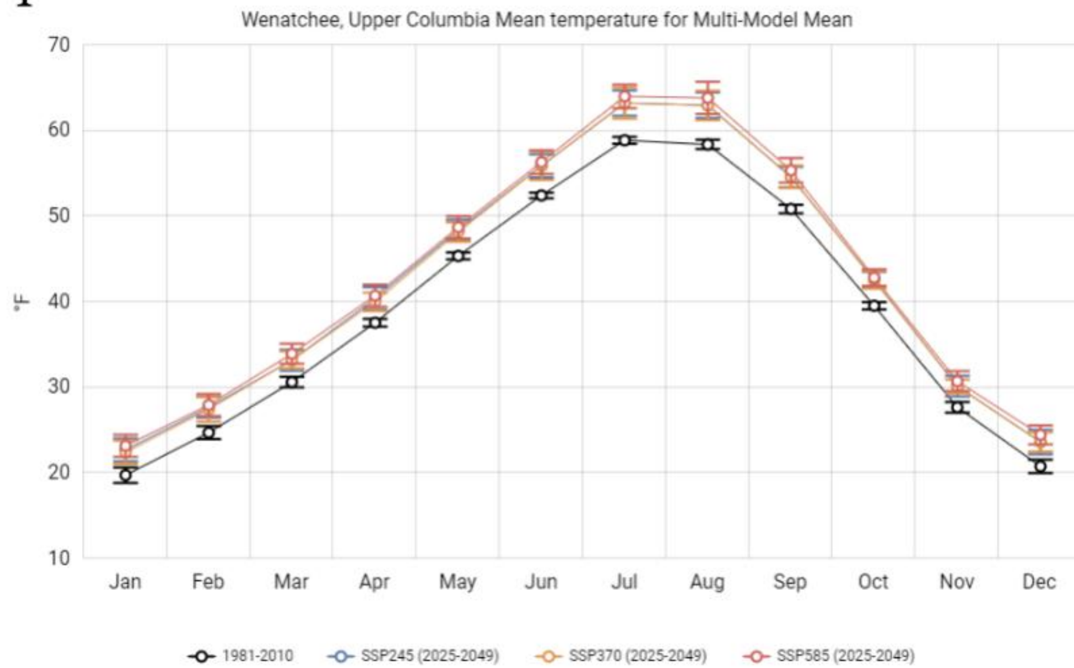
The National Climate Change Viewer (NCCV) is a USGS tool developed by Alder & Hostetler (2013) for visualizing and graphing projected climate change impacts from the Climate Model Intercomparison Program (CMIP) across the conterminous United States. This tool downscales projections from 27 Global Climate Models (GCMs) to 6km spatial resolution that can be used to visualize specific climate change impacts in watersheds. The climate change impacts are organized by Shared Socioeconomic Pathways (SSPs). SSPs represent various human development potentials and their impact on the amount of radiative forcing, or warming, that is projected to occur. Radiative forcing occurs when the amount of energy entering our atmosphere is larger than the energy exiting our atmosphere. A larger, positive radiative forcing value signals more warming. The SSP scenarios serve as a baseline to compare how the climate is predicted to change based on various social, economic, and policy factors.

In the Wenatchee basin between 2025 - 2099, the climate models show an increase in mean temperature, a decrease in the amount of snow received, and an increase in late fall and winter precipitation in all Shared Socioeconomic Pathways (SSPs) (Figure 15, Figure 16, and Figure 17). The total amount of annual precipitation the basin receives is projected to change very little in the 2025 – 2099 timeframe, emphasizing seasonal and precipitation-type changes as the basin transitions from a snow-dominated to a transitional basin.

The climate change predictions from the modeling described above may already be occurring in the upper basin tributaries to the Wenatchee River. Other drainages that have long periods of gaging records, including the nearby White River and Icicle Creek, show shifts in runoff timing (earlier snowmelt runoff), a slightly shorter runoff duration, and lower summer base flows (Inter-Fluve 2025a, 2025b). Peak flows occurring in the fall also appear to be more common over the last 2 decades compared to the older data. These shifts may be evidence of a transition from snow-dominated systems to transient systems, a change predicted for the Wenatchee basin based on the modeling by Tohver et al. (2014).

Changes to the dominant hydrological regime could have impacts on habitat conditions and seasonal impacts on stream temperatures. A reduction in the snowmelt runoff duration has the potential to diminish channel dynamism and related stream habitat complexity. Lower summer baseflows may increase the risk for summer water temperature exceedances for the salmonid and trout species that reside in Nason Creek and its tributaries. Changes in runoff timing and magnitude also have the potential to affect fish life history patterns, including run timing. The hydrological and habitat changes are crucial to consider as the climate continues to change in and around the upper Wenatchee River basin.

1



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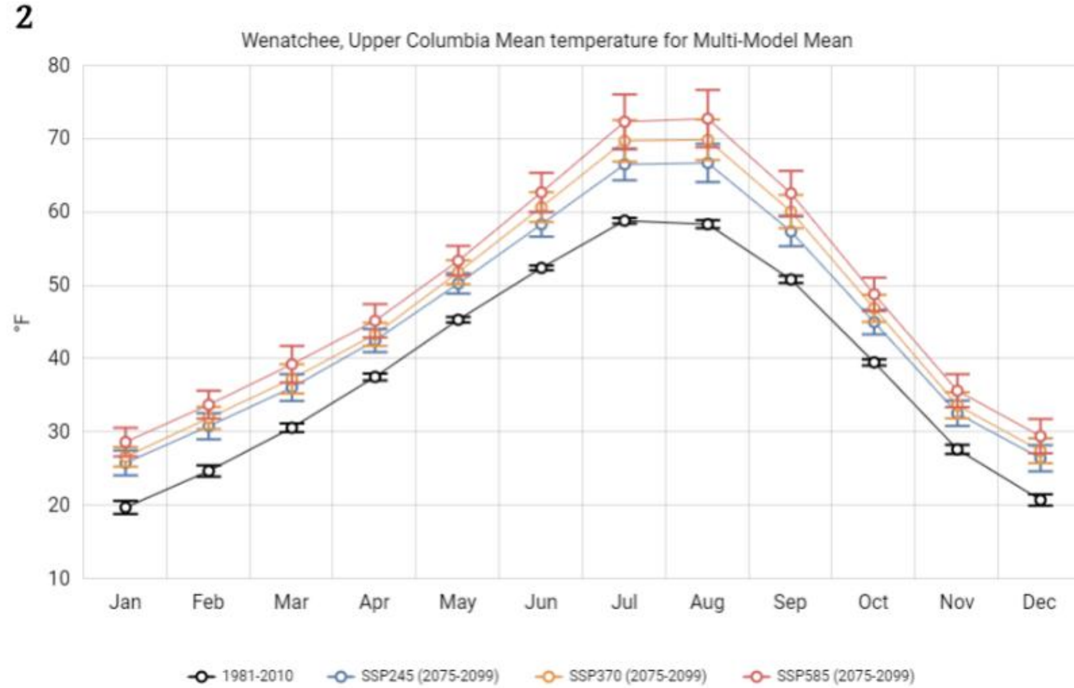
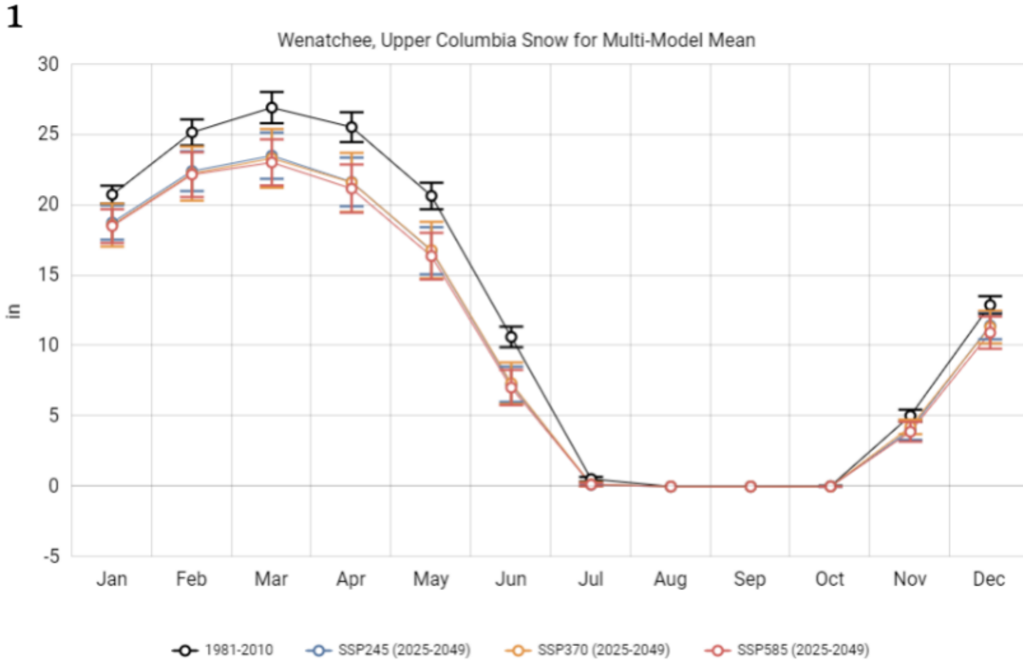


Figure 15. Climate change scenario graphs for the Wenatchee mean temperature. Source: *Alder & Hostetler (2021)****, generated via USGS NCCV. The multi-model mean for mean temperature in the Wenatchee basin from 1) 2025 – 2049 and 2) 2075 – 2099. The three scenarios are the 3 Shared Socioeconomic Pathways. SSP245 represents a 'middle of the road' scenario with an additional 4.5W/m^2 of radiative forcing by 2100. SSP 370 represents an upper-middle scenario with an additional 7.0W/m^2 of radiative forcing by 2100. SSP585 represents the worst-case scenario akin to RCP 8.5 with an additional radiative forcing 8.5W/m^2 by 2100.***



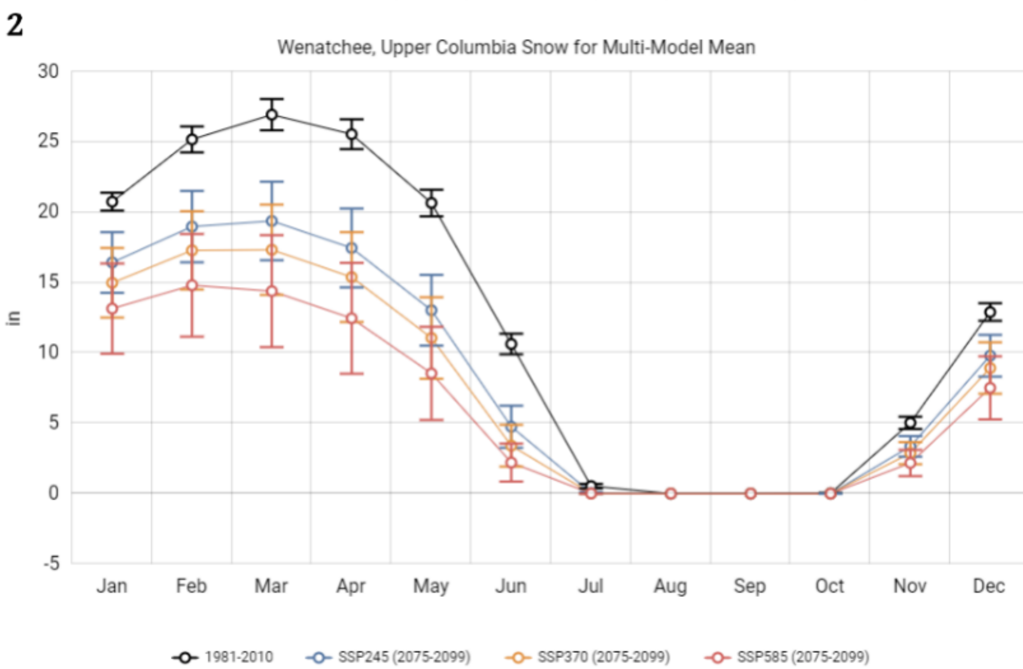


Figure 16. Climate change scenario graphs for the Wenatchee snow fall. Source: *Alder & Hostetler (2021)****, generated via USGS NCCV. The multi-model mean for snow amount in the Wenatchee basin from 1) 2025 – 2049 and 2) 2075 – 2099. The three scenarios are the 3 Shared Socioeconomic Pathways. SSP245 represents a 'middle of the road' scenario with an additional 4.5W/m² of radiative forcing by 2100. SSP 370 represents an upper-middle scenario with an additional 7.0W/m² of radiative forcing by 2100. SSP585 represents the worst-case scenario akin to RCP 8.5 with an additional radiative forcing 8.5W/m² by 2100.***

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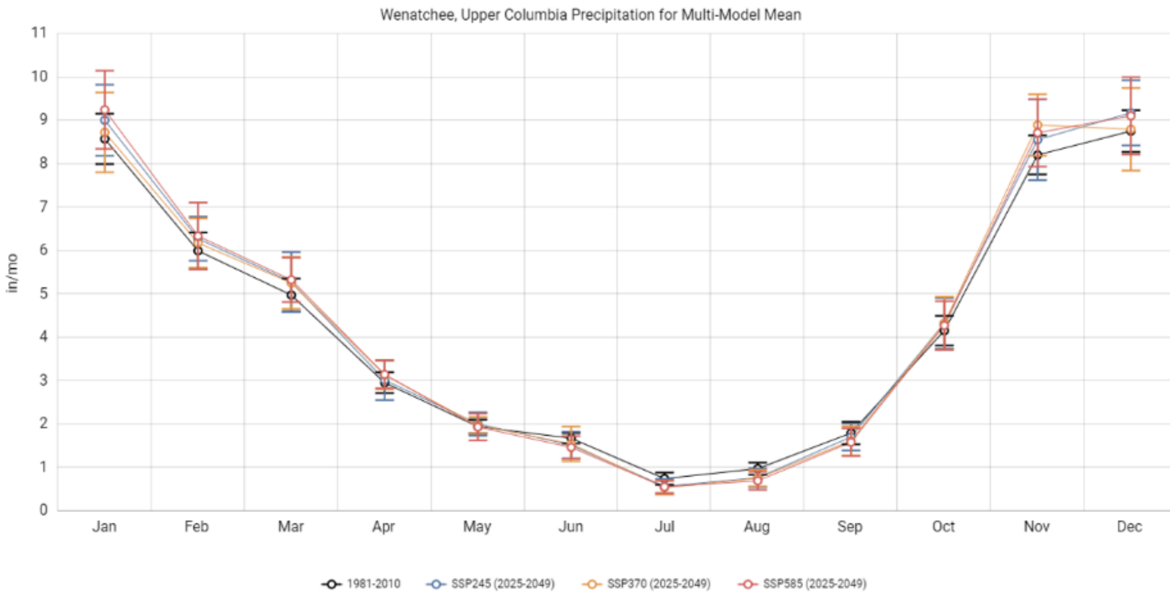

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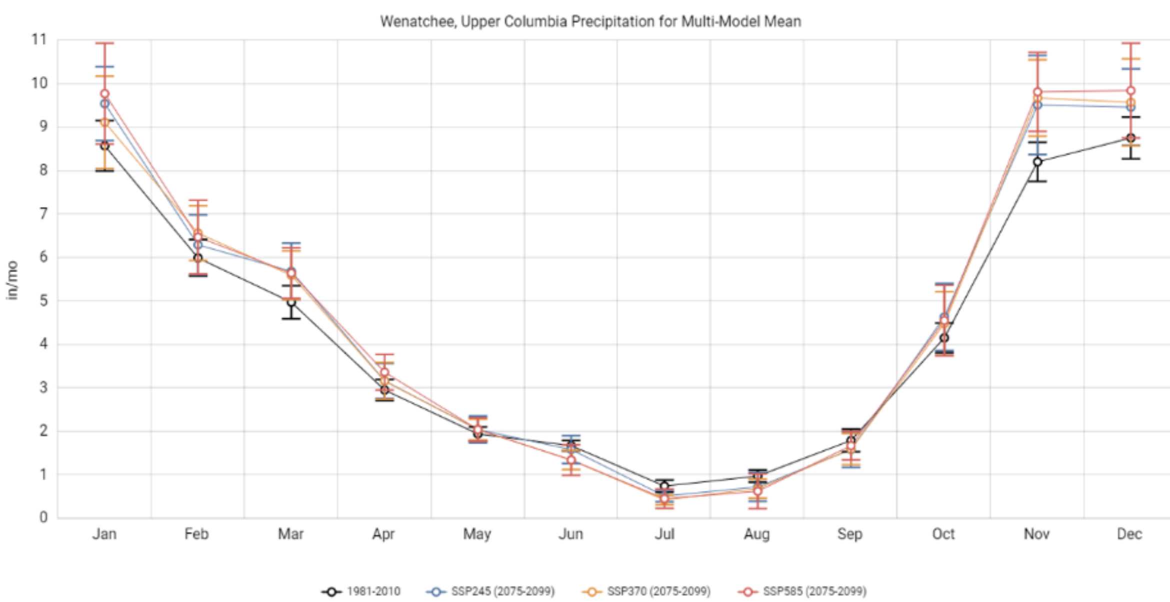

Figure 17. Climate change scenario graphs for the Wenatchee precipitation. Source: *Alder & Hostetler (2021)****, generated via USGS NCCV. The multi-model mean for precipitation amount in the Wenatchee basin from 1) 2025 – 2049 and 2) 2075 – 2099. The three scenarios are the 3 Shared Socioeconomic Pathways. SSP245 represents a 'middle of the road' scenario with an additional 4.5W/m^2 of radiative forcing by 2100. SSP 370 represents an upper-middle scenario with an additional 7.0W/m^2 of radiative forcing by 2100. SSP585 represents the worst-case scenario akin to RCP 8.5 with an additional radiative forcing 8.5W/m^2 by 2100.***

3.3 HYDRAULIC MODEL OVERVIEW

3.3.1 2-D Hydraulic Modeling

A preliminary-level 2-D hydraulic model of Nason Creek was developed for existing conditions for the study area using the estimated flood discharges described in Section 3.2.4. The hydraulic model was developed in the U.S. Army Corps of Engineers HEC-RAS 6.6 software (USACE 2024), which computes hydraulic properties related to the physical processes governing water flow through natural rivers and other channels. Existing conditions were based on the most recent available LiDAR data, including topographic and bathymetric data from 2020 and 2022 (NV5 Geospatial 2022; WGS 2023). The goal of this preliminary model is to assess the current channel and floodplain dynamics, as well as assess the impacts of flood flows on the existing landscape.

3.3.2 Model Results

Model result figures can be seen in figures 5 to 8 of Appendix D and in segment-scale figures in Section 6. Modeled velocities and depths for the 2-year and 100-year flood events show trends across the study area. Floodplain inundations and connectivity vary throughout the study area, activating floodplains in less than half of the reaches during the 2-year flood, but with increased floodplain and side channel activation, velocities, and depths across the study area at the 100-year flood. Some reaches in the study area experience high main channel velocities, exceeding 10 feet per second at the 100-year flood. 100-year flow results indicate inundation south of State Route 207 in the confluence area, as well as flooding of small rural roads and structures in numerous upstream reaches, including in reaches 4, 6, 8, 10, 11, and 12.

3.3.3 Model Considerations

While this preliminary model was built using readily available and informative data, it lacks the detail to be used to design restoration projects. Further surveys of the river and the surrounding landscape and infrastructure are needed to confirm the accuracy of the topobathymetric LiDAR and represent key features such as bridges, culverts, and other floodplain structures in a hydraulic model. Additionally, flow inputs from groundwater or small tributaries not included in this analysis need to be investigated to inform more detailed model development and better support restoration design.

4. Habitat Assessment Summary

Habitat surveys using the US Forest Service Region 6 Level 2 protocols were performed in the assessment area from September 9 – 28, 2024. This section provides a summary of the findings, including a summary data table below (Table 6). The full Nason Creek Habitat Assessment is included in Appendix A, which provides the detailed methods, results, and mapping for the habitat assessment. The appendix also includes a comparison of habitat survey results to previous habitat surveys performed on Nason Creek.

Pool habitat was the most prevalent habitat unit type through the lower Nason Creek assessment area, making up about half of the total area recorded. Reaches with relatively high gradients were typically dominated (>70% by area) by riffle habitat (reaches 5-7). Side channels were observed in reaches 3-4 and reaches 6-13. Reach 4 had the most side channel by area (56%) and in total number of side channels (n=10).

There were a total of 4,180 pieces of LWM observed in the assessment area, which equates to 309 pieces per mile. There were 183 medium and large (M+L) pieces per mile (used for comparison to regional standards). Medium pieces are defined as greater than 12 inches in diameter and 35 feet in length, whereas large pieces are defined as greater than 20 inches in diameter and 35 feet in length. There were a total of 161 log jams within the assessment area, averaging 12 jams per mile. Jams contained 58% of the LWM observed during the habitat assessment, and about half (49%, n = 78) of the jams were constructed (not naturally established). Reach 12 had the most LWM of any reach, with 588 M+L pieces per mile, largely due to a constructed alcove which contained 63% of the wood in the reach. Reach 5 had the lowest amount of LWM of any reach, with 17 pieces of M+L per mile. Although certain reaches have high amounts of LWM, those pieces are frequently concentrated in constructed jams that are partially bank-buried or in off-channel habitat. LWM that is well distributed, and with a strong influence on channel dynamics or geomorphic function, is generally lacking throughout the assessment area.

The habitat survey recorded riparian vegetation conditions in a subset of habitat units, as per survey protocols, including overstory and understory dominant size classes and species. The dominant overstory size class was large tree (21-31.9-inch dbh), which was the dominant class in 75% of surveyed units. The most prevalent overstory species were cottonwood, grand fir, and ponderosa pine. The dominant (dominant in 88% of surveyed units) understory size class was shrub/seedling (1.0-4.9-inch dbh). Dogwood and Alder spp. were the most frequently observed dominant understory species (dominant in 40% and 27%, respectively, of surveyed units). Large swaths of vegetation within the riparian corridor had been cleared throughout the assessment area, related to the BNSF railroad, Highway 2, State Route 207, other local roads, or utility transmission lines. Riparian vegetation clearing was most pronounced in reaches 6-7, Reach 10, and Reach 13.

Table 6. Summary of the results from the Habitat Assessment. The full assessment is included as Appendix A of this report.

Habitat Metric	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Reach 7	Reach 8	Reach 9	Reach 10	Reach 11	Reach 12	Reach 13
Unit Composition (percent of total area)													
Pool	55%	47%	79%	27%	22%	18%	20%	57%	50%	69%	77%	75%	46%
Riffle	23%	0%	1%	8%	67%	68%	67%	36%	27%	10%	15%	14%	43%
Glide	22%	53%	4%	9%	10%	5%	0%	3%	17%	18%	0%	1%	3%
Side Channel	0%	0%	16%	56%	0%	2%	12%	4%	5%	3%	8%	1%	5%
Marsh	0%	0%	0%	0%	0%	7%	0%	0%	0%	0%	0%	0%	0%
Alcove (constructed)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	8%	2%
Medium & Large LWM/mile (includes jams)	75	80	257	137	17	42	244	73	48	91	239	588	264
Pools/mile	9	10	15	11	7	5	5	6	5	12	11	13	7
No. of Pools with Residual Depth D≥3ft	5	1	13	5	0	4	1	6	1	7	6	13	4
No. of Side Channels	0	0	2	10	0	2	3	2	1	1	2	1	3
Riparian Conditions													
Large Tree	75%	100%	60%	83%	100%	58%	80%	100%	100%	50%	67%	86%	60%
Small Tree	25%	0%	20%	17%	0%	25%	10%	0%	0%	0%	33%	14%	20%
Shrub/Seedling	0%	0%	20%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
No Vegetation	0%	0%	0%	0%	0%	17%	10%	0%	0%	50%	0%	0%	20%

5. REI Summary

A Reach-Based Ecosystem Indicators (REI) analysis was performed to support the reach assessment. The REI evaluates biological and physical conditions of a watershed in relation to regional standards and known habitat requirements for aquatic biota. The REI results include functional ratings for a range of attributes at the reach- and watershed-scales. 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. The full REI analysis methods and results are provided in Appendix B. A summary of the reach-scale results for Nason Creek is included in Table 7.

At the watershed scale, REI ratings for Nason Creek ranged from At Risk to Unacceptable. Watershed-scale impairments are primarily related to historical or ongoing anthropogenic disturbance to the watershed, particularly road development and the resulting floodplain disconnection that has occurred. Reach-scale metrics ranged from Adequate to Unacceptable. Across all reaches, the most impaired indicators occurred in the Floodplain Connectivity and Bank Stability/Channel Migration categories. Nason Creek does not have any full fish passage barriers. However, altered geomorphic processes and riparian clearing from human development alongside Nason Creek has resulted in degraded habitat quality, riparian vegetation, and channel dynamics across all the surveyed reaches. Reach 10 and Reach 11 were the most impaired across all indicators.

Table 7. Summary of the REI ratings for the Nason Creek assessment area. REI ratings are color-coded, with green shading for Adequate condition, yellow for At Risk condition, and red for Unacceptable condition.

Pathway	General Indicators	Specific Indicators	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Reach 7	Reach 8	Reach 9	Reach 10	Reach 11	Reach 12	Reach 13
Habitat Access	Physical Barriers	Main Channel Barriers	At Risk	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate	At Risk	Adequate	Adequate	Adequate
Habitat Quality	Substrate	Dominant Substrate/ Fine Sediment	Unacceptable	At Risk	At Risk	At Risk	At Risk	At Risk	At Risk	Adequate	At Risk	Unacceptable	Unacceptable	Unacceptable	Unacceptable
	LWM	Pieces per Mile at Bankfull	At Risk	At Risk	At Risk	At Risk	Unacceptable	Unacceptable	At Risk*	At Risk*	Unacceptable	At Risk	At Risk*	At Risk	At Risk*
	Pools	Pool Frequency and Quality, Presence of	Unacceptable	Unacceptable	At Risk	At Risk	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	At Risk	At Risk	At Risk	At Risk
	Off-Channel Habitat	Connectivity with Main Channel	Unacceptable	Unacceptable	At Risk	At Risk	Unacceptable	At Risk	At Risk	At Risk	At Risk	Unacceptable	Unacceptable	At Risk	At Risk
Riparian Vegetation	Condition	Structure	At Risk	At Risk	At Risk	At Risk	At Risk	Unacceptable	At Risk	At Risk	At Risk	Unacceptable	Unacceptable	At Risk	Unacceptable
		Disturbance (Human)	Unacceptable	Unacceptable	Adequate	At Risk	At Risk	At Risk	Unacceptable	At Risk	At Risk	At Risk	Unacceptable	At Risk	Unacceptable
		Canopy Cover	At Risk	Adequate	At Risk	At Risk	At Risk	At Risk	At Risk	Adequate	At Risk	Unacceptable	Unacceptable	At Risk	At Risk
Channel	Dynamics	Floodplain Connectivity	Unacceptable	At Risk	At Risk	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	At Risk	Unacceptable	Unacceptable	Unacceptable	Unacceptable
		Bank Stability/ Channel Migration	Unacceptable	At Risk	At Risk	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	At Risk	Unacceptable	Unacceptable	Unacceptable	Unacceptable
		Vertical Channel Stability	At Risk	At Risk	Adequate	Unacceptable	Unacceptable	Unacceptable	Unacceptable	At Risk	At Risk	Unacceptable	Unacceptable	Unacceptable	Unacceptable

*Without restoration efforts, this reach would be rated Unacceptable.

6. Channel Segment Conditions

6.1 SEGMENT 1 – LOWER LOWER NASON (REACHES 1-2)

6.1.1 Overview

The Lower Lower Nason segment includes reaches 1 and 2 and extends from the confluence with the Wenatchee River up to RM 1.5. Reach 2 is mostly naturally confined except for the downstream third of the reach where State Route 207 cut off a former channel segment. Reach 1 lies within an unconfined valley but is heavily artificially confined by armoring at the Nason Creek Campground, the Cedar Brae Road bridge crossing, and State Route 207 downstream. A large portion of the historical floodplain and river delta at the confluence area was cut off by State Route 207 and fill associated with residential and commercial development in the area. Representative photos of the segment are included in Figure 18, Figure 19, Figure 20, and Figure 21.

Table 8. Key segment metrics. Metrics collected during the Habitat Assessment are discussed in Appendix A.

	Length (miles)	River Mile	Stream Gradient (%)	Sinuosity	Dominant Habitat Unit Type	Average Bankfull Width (ft)	Confinement	Dominant Substrate	% Pool Habitat	% Glide Habitat	% Riffle Habitat	% Side Channel	% Other Habitat
Reach 1	1.1	0-1.1	0.51%	0.57	Pool	78	Unconfined	Boulders/ Cobbles/ Gravel/Sand	55%	22%	23%	0%	0%
Reach 2	0.4	1.1-1.5	0.22%	1.06	Glide	94	Confined	Boulders	47%	53%	0%	0%	0%

Figure 18. View upstream near RM 1.4 of confined segment in Reach 2.

Figure 19. View upstream near RM 1.0 with campground and hard armoring on river-right.

Figure 20. View upstream at highly simplified channel near RM 0.3.

Figure 21. View downstream at the confluence with the Wenatchee River.

River process and habitat conditions are highly degraded in this segment. Although there is decent percentage of pool habitat (Table 8), pool frequency is low and the pools that do exist have low quality (depth and cover). Side-channel habitat is nearly non-existent. There is one side-channel (constructed) at the confluence but it did not qualify in the habitat assessment because its outlet is on the Wenatchee River. Although large wood quantities barely meet standards for properly functioning, the wood does not contribute a strong geomorphic influence due to its small size and scarcity. Large wood recruitment potential is very low due to natural confinement in Reach 2, abundant artificial confinement/armoring, and young or cleared riparian forests. There is only one known past restoration project in this segment, which includes creation/enhancement of a side-channel at the confluence and large wood placements. There remain significant opportunities for restoration, some of which may require infrastructure modifications to realize meaningful improvements.

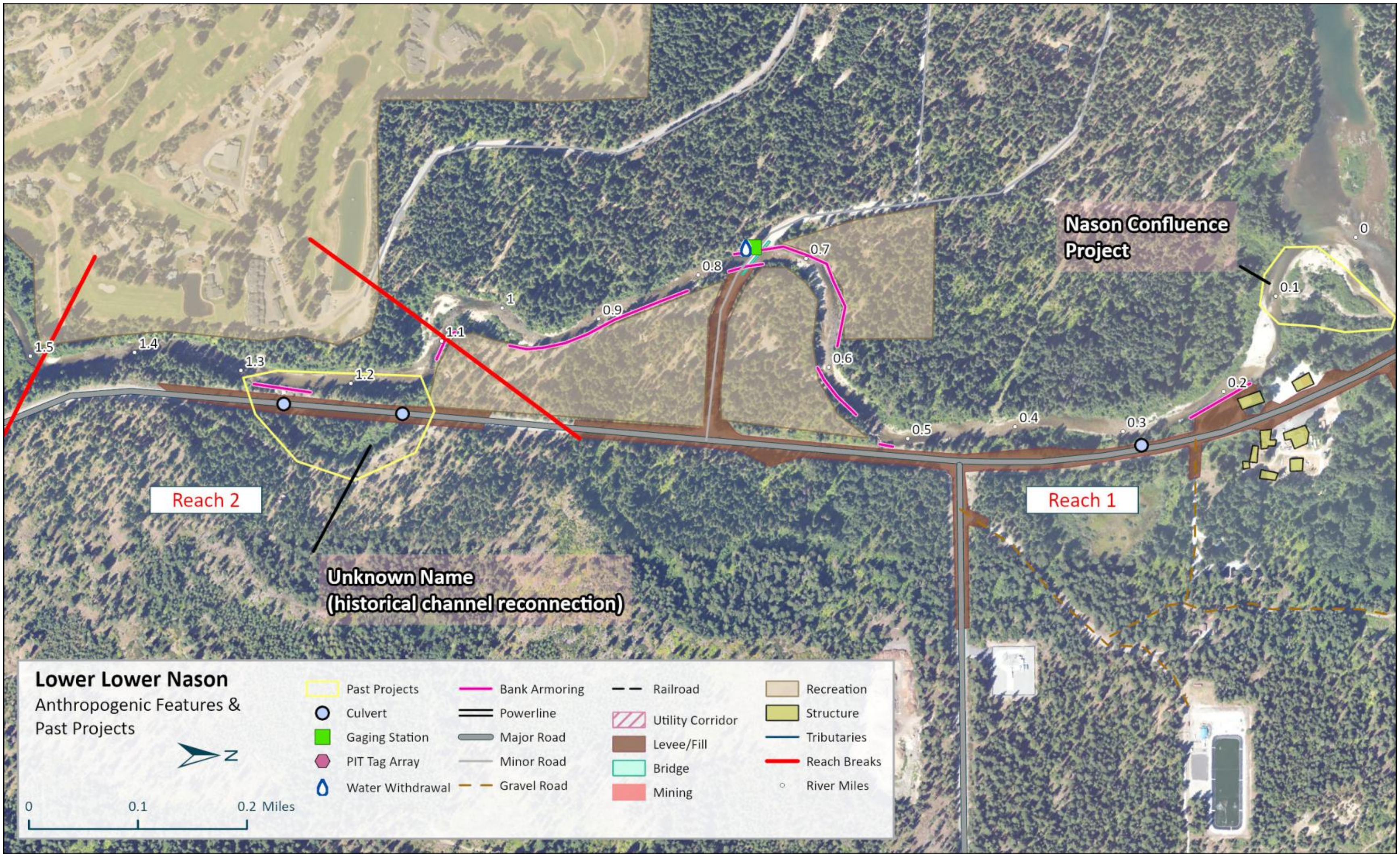

Figure 22. Mapped anthropogenic features and past projects in Segment 1.

6.1.2 Channel and Floodplain Geomorphology

This segment begins at the upstream end with a short (~500 ft) channel segment confined by high glacial deposits on both sides (Figure 23). The valley then gradually opens into the broad Wenatchee River valley. Glacial deposits and terraces of different elevations bound the valley (U.S. Bureau of Reclamation 2008). Some of these deposits are part of the terminal moraine that created Lake Wenatchee. Channel scars indicate significant past channel adjustment as Nason Creek has historically worked and re-worked the glacial material. The location of the confluence with the Wenatchee River has likely changed over time.

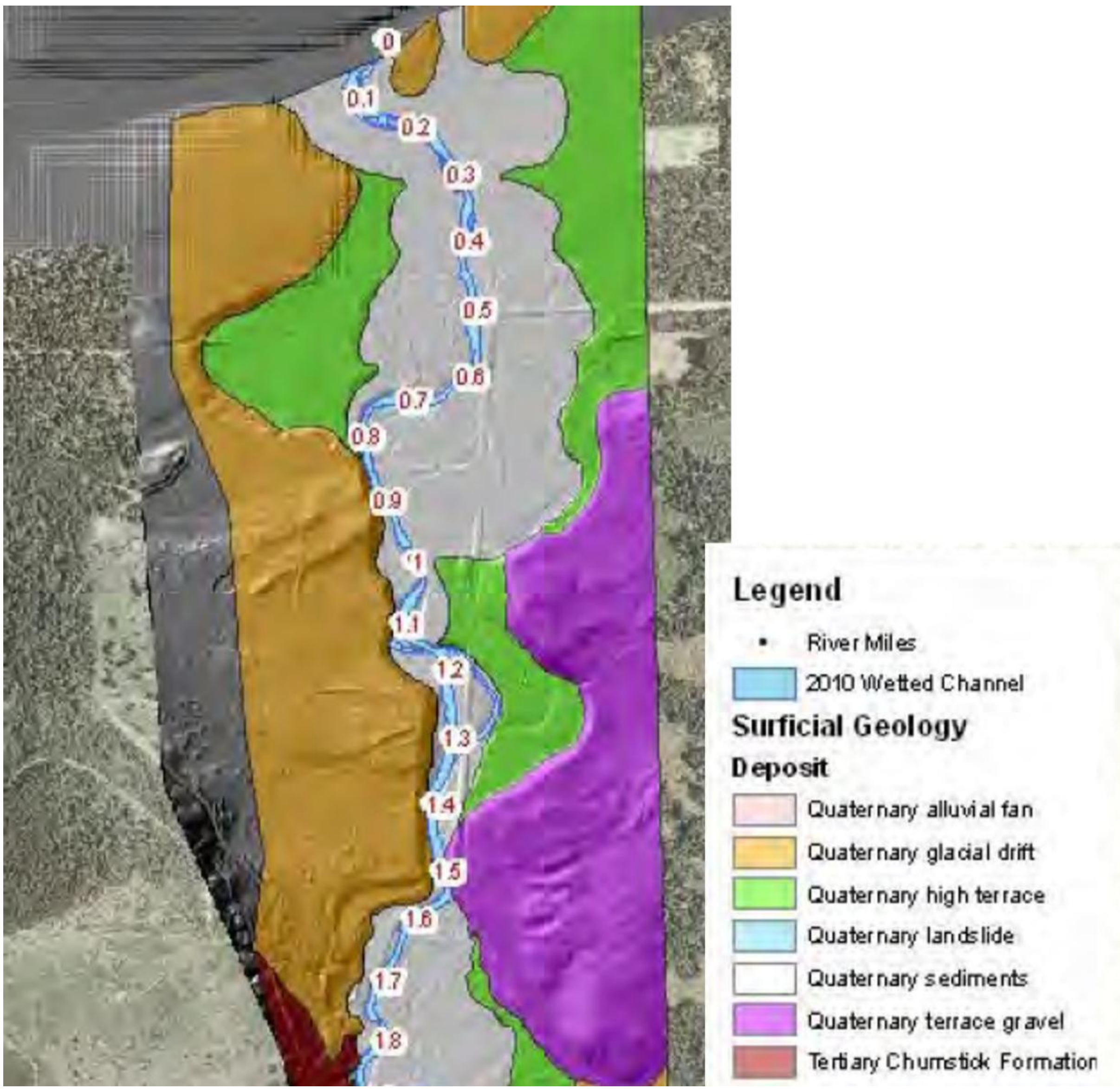

Figure 23. Copy of surficial geology map of the valley floor in Segment 1, obtained from the Lower Nason Assessment of Geomorphic and Ecologic Indicators report (Reach Assessment,** (USBR 2011)**. Gray (non-color) areas are Quaternary Sediments, with the exception of anthropogenic fill that is not mapped. Note that river miles are slightly different than other river miles used in this report. Segment 1 extends up to near RM 1.5 on this map.

Segment 1 has been heavily impacted by past and ongoing human alterations including road construction, residential and commercial development, and recreation infrastructure. One of the most significant influences on channel and floodplain function is State Route 207, which has cut off at least three former main channel segments and portions of floodplain. These include an approximately 900-ft section from RM 1.1 to 1.3, a >3,000-ft section from RM 0.5 to 0.9, and an approximately 1,200-ft section from RM 0.3 to 0.4. These can be seen in the Relative Elevation Map (REM) in Figure 28. Portions of the channel are now armored with riprap where they abut the highway embankment. The cut off section in Reach 2 is connected as a side-channel via culverts at both ends designed for fish passage (Figure 24). The other cutoff segments only have drainage culverts.

Figure 24. View of river-right bank near RM 1.3 at historical channel cutoff point that is now connected via a culvert under State Route 207.

The Nason Creek Campground and Cedar Brae Road and bridge provide other major sources of impairment to channel and floodplain processes. The bridge and bank armoring along the campground has locked the channel in place and prevents channel migration (Figure 25). Approximately 2,500 feet of channel through the campground is armored. There has also likely been floodplain fill associated with the campground, but the specific extent is unknown and so it was not mapped as part of this effort. Downstream of the campground, there are a few areas of bank armoring on river-right (Figure 26) and also areas of fill associated with development to the east of the confluence area.

Figure 25. View upstream near RM 0.7 at river-left riprap and Cedar Brae Rd bridge in background.

Figure 26. View upstream near RM 0.2 at simplified channel and bank armor on the river-right bank.

Bed material in Reach 2 is dominated by boulders, likely sourced from the adjacent glacial deposits. Human alterations have changed the bed material composition and sources of bed material in Reach 1. Reach 1 has approximately equal amounts of cobbles, small boulders, gravels, and sand/fines. Large boulder riprap constitutes a fairly significant portion of channel bed material along the campground. It is assumed that prior to human alterations, bed material in Reach 1 would have been dominated by gravels, given the lower stream energy prior to artificial confinement. The sourcing of bed material from streambanks has been severely diminished due to channel cut-offs, bank armoring, and confinement from the bridge, all of which have reduced channel migration potential. There are only a few places where material is being recruited, including from glacial deposits on river-left at RM 1.05 (Figure 27) and from fairly short areas of lateral migration still occurring at the most downstream outside bends at the confluence area.

Figure 27. View toward river-left bank near RM 1.05 where material is being recruited from glacial deposits.

Overall, channel conditions in Segment 1 are very uniform and simplified, with very few pieces of large wood and low channel complexity. From RM 0.5 to 1.3, LiDAR analysis suggests that the current channel is likely 1-3 feet lower in elevation than the historical channel based on the elevation of the cutoff channels. Modeling shows that significant portions of the modern (Holocene) floodplain, even portions not cut off by the highway, are not inundated at the 100-year flood, likely a result of both base lowering of the channel and floodplain fill (Figure 29). Despite a reduction to the historical extent of flooding in this segment, there are nevertheless structures that appear to be well within the 100-year floodplain. Modeling also shows very high stream energy through the artificially confined campground section (Figure 30), which could contribute to continued channel incision; however, base level control from the downstream Wenatchee River will likely limit significant channel profile adjustment.

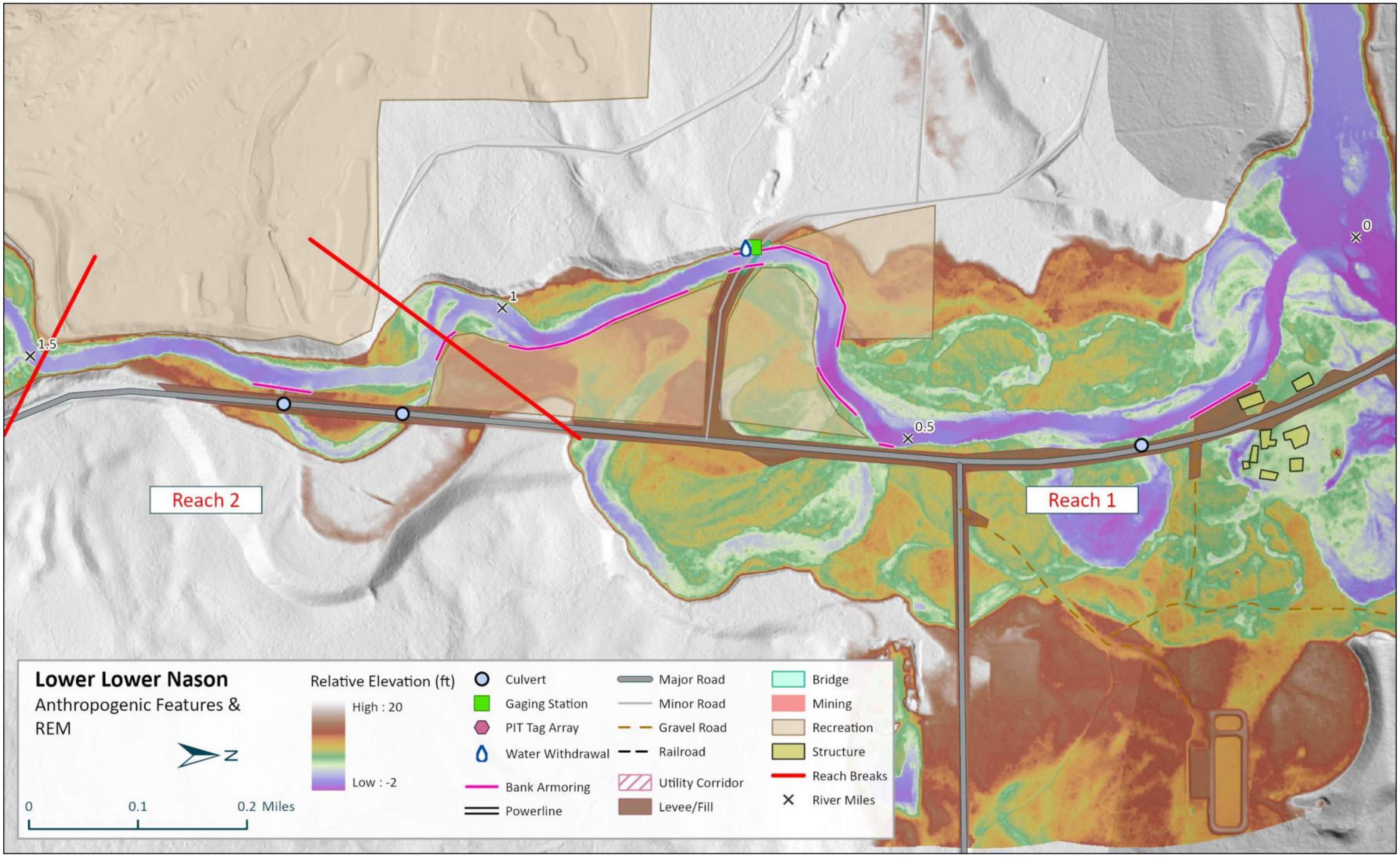

Figure 28. Mapped anthropogenic features and relative elevation map for Segment 1.

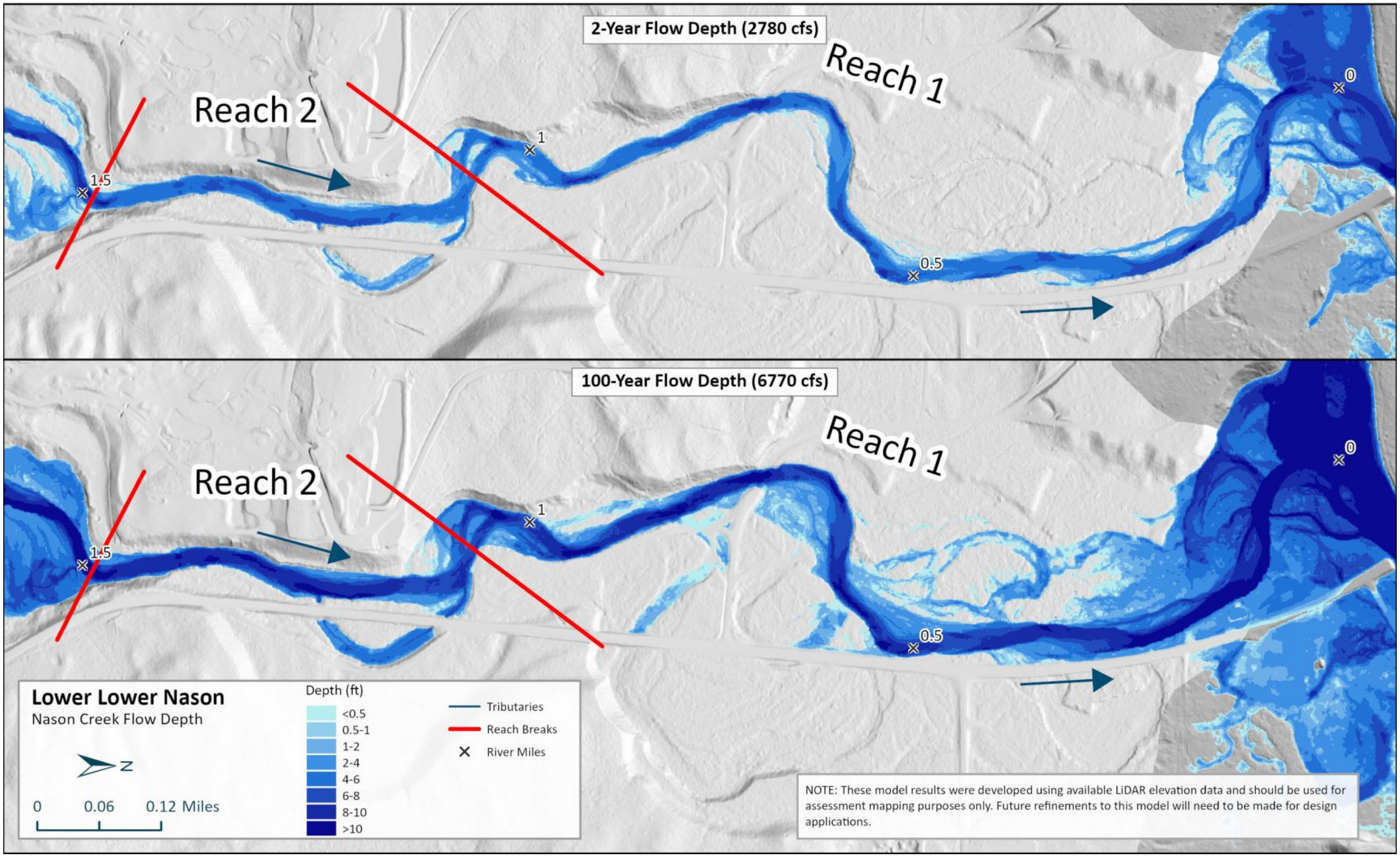

Figure 29. Modeled depth results for Segment 1.

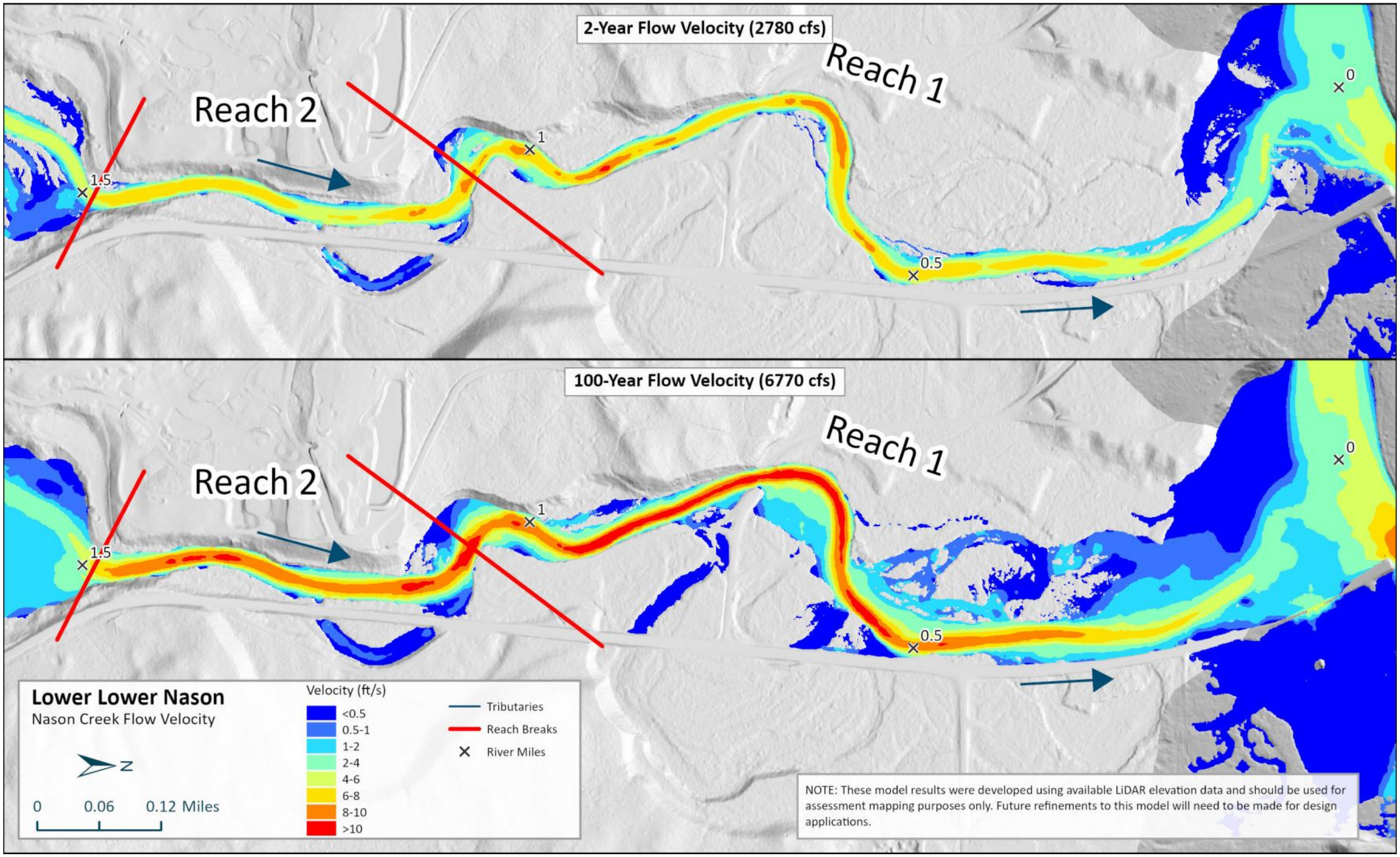

Figure 30. Modeled velocity results for Segment 1.

6.1.3 Large Wood Material

Large wood processes are impaired in this segment. Piece frequency barely meets standards for properly functioning, but recruitment and retention processes have been severely altered in many locations. Most of the wood is located near the confluence (including a constructed log jam that accounts for a significant portion of the count) or around the bend at the campground near RM 1.0 where it is mostly located in a side-channel and alcove area on river-left (Figure 31). Wood in this side-channel area is causing split flows, gravel capture, and hydraulic complexity, but the area is limited in size and most of the other wood in the segment is not providing significant geomorphic processes. Past restoration work has increased large wood numbers but not by a large amount and primarily only at the confluence and at one additional jam downstream of the bridge along the campground (Figure 32). Note that the Nason Confluence Project included a constructed side-channel that has its inlet on Nason Creek and its outlet on the Wenatchee River. For this reason, it was not included in the habitat survey or wood counts, even though it has abundant large wood.

Figure 31. Log jam at head of left-bank side-channel near RM 1.1.

Figure 32. Log cabled to a boulder near RM 0.75.

The abundance of riprap, channel confinement, and denuded or young riparian vegetation severely limits large wood recruitment potential (e.g. Figure 33). Furthermore, when wood is recruited, the wood size and the high energy confined channel makes it difficult for wood to be retained in the channel. The only area where channel migration processes are intact is at the confluence, where wood recruitment would most likely result in the wood readily moving out of Nason Creek. Due to constraints on lateral migration, tree recruitment primarily happens only via natural tree fall (i.e. not bank erosion), which occurs seldomly due to the relatively young riparian stands or narrow or non-existent buffers. The few areas where there are large trees include atop the river-left terrace near RM 1 (fig), the downstream river-left floodplain (up to RM 0.7), and in portions of the campground. Tree fall from the campground would likely be prevented or trees would be readily removed from the river. Tree fall from the river-left RM 1 terrace may also be removed as they could provide a hazard for campground users. The mature stand of trees in the downstream river-left floodplain do provide a potential source for recruitment, if the river could be re-located or induced to scroll into that area.

Figure 33. Tree recruitment potential halted by bank armor at campground near RM 1.1.

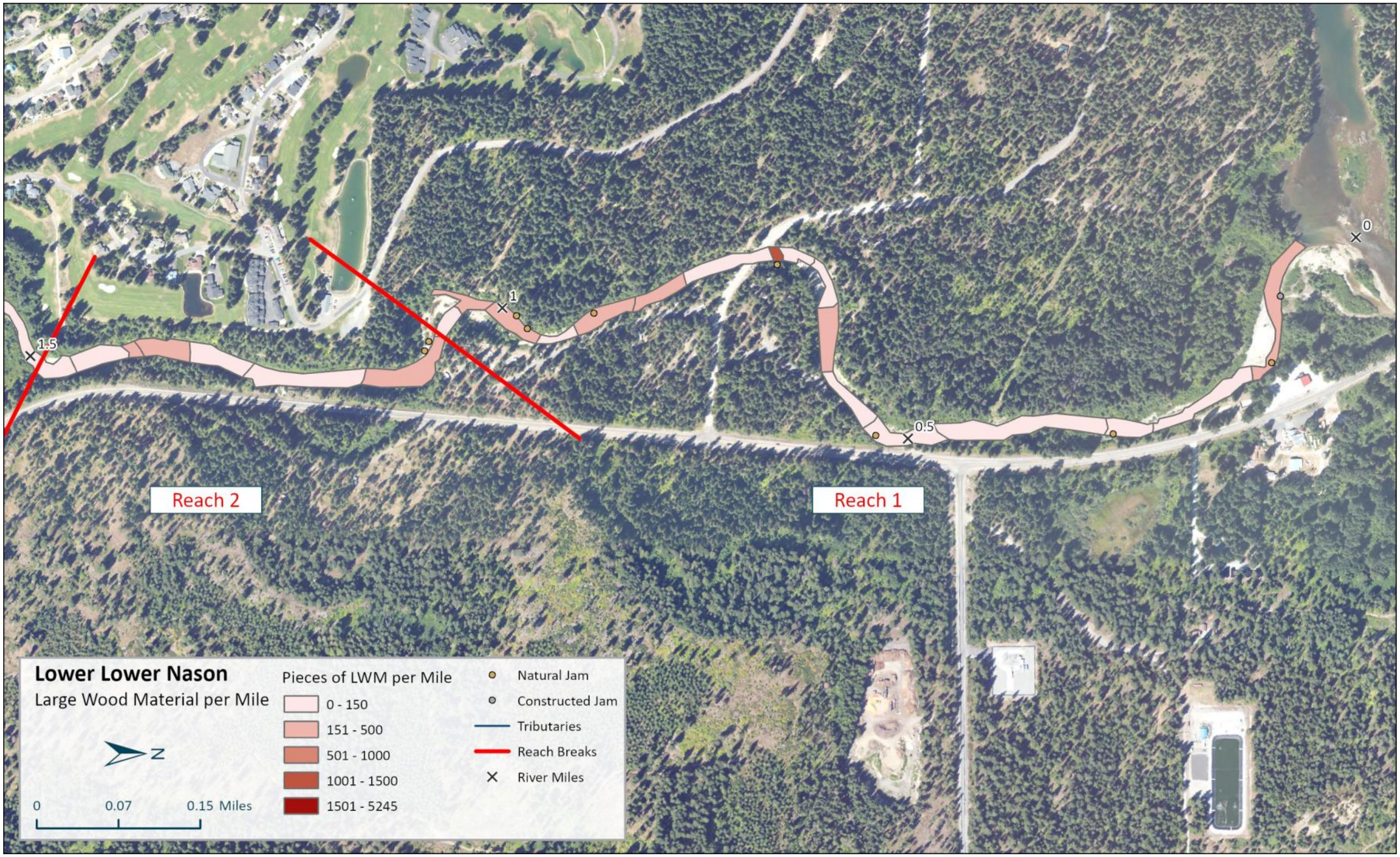

Figure 34. Large wood frequency and jams in Segment 1.

6.1.4 Vegetation

Vegetation in Segment 1 consists of riparian areas and lower floodplain surfaces dominated by cottonwood, dogwood, alder, willow, cedar, and reed canary grass. The higher floodplain and terrace surfaces are dominated by ponderosa pine and fir. At the confluence, there is sparse and mostly young riparian vegetation. In the river-left floodplain between the confluence and RM 0.7, there is a mature forest with some trees over 150 tall. There is also an aspen stand in the river-left floodplain at the confluence area. Most of the remaining overstory is dominated by mixed-age cottonwoods, with young cottonwoods, willows, dogwoods, and alder in the understory and along the channel banks in most locations. Overall, the vegetation in Segment 1 is highly disturbed, with few larger mature trees, low canopy cover, and low large wood recruitment potential for the reasons described previously in the Large Wood Material section. Past timber harvest, plus on-going impacts including the campground, State Route 207, a powerline corridor crossing, and the golf course all contribute to impaired riparian vegetation conditions. The highway and the golf course, in particular, result in persistent narrow riparian buffers, or no buffer at all in some locations. Invasive reed canary grass dominates most of the channel bars and banks and low surfaces. Abundant filamentous algae was observed in the channel in Reach 2, possibly due to the south-facing exposure of the channel and large substrate (Figure 36). A vegetation height map is included for reference in Figure 37.

Figure 35.Large trees on the river-left glacial terrace near RM 1.0.

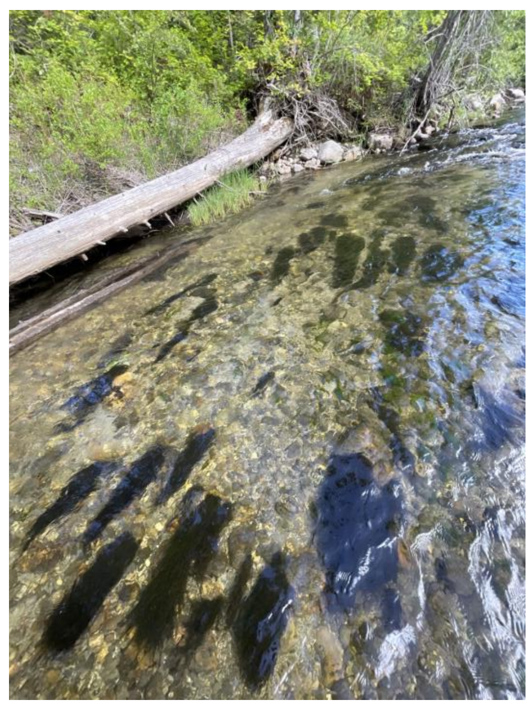

Figure 36. Algae in channel near RM 1.4.

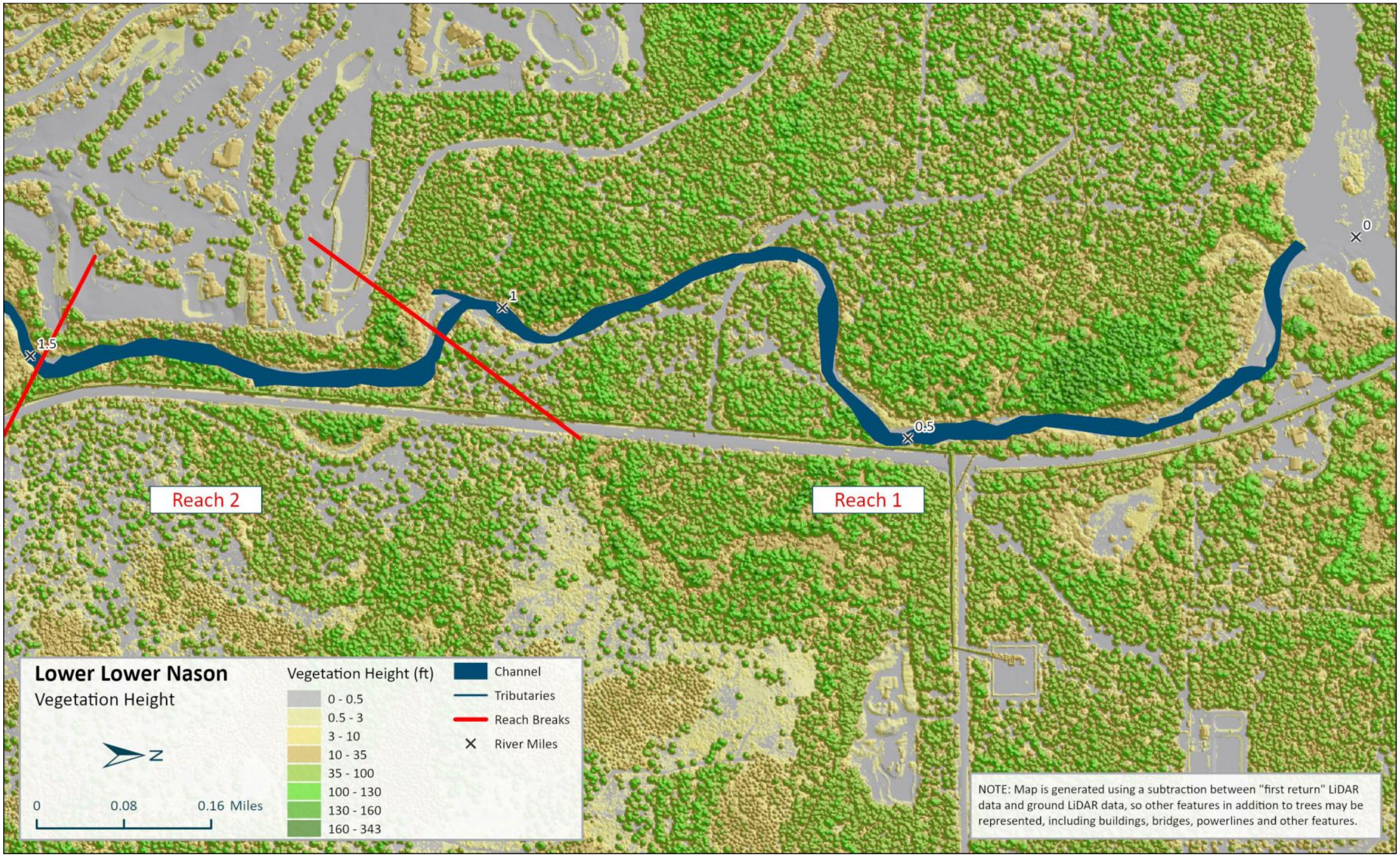

Figure 37. Vegetation heights along Segment 1 of Nason Creek.

6.1.5 Past Restoration Projects

There have been at least two past restoration projects in Segment 1 (Figure 40). The Nason Confluence Project (Yakama Nation) was constructed in 2021 and included construction of a side-channel that has its inlet on Nason Creek (Figure 38) and its outlet on the Wenatchee River. Large wood was also placed throughout the side-channel. At the time of the early July 2025 survey, the channel was flowing with water, deep and complex pools were observed to be associated with the log jams, and riparian vegetation was healthy. A Yakama Nation crew was onsite removing invasive vegetation in the area, indicating that long-term maintenance of planted vegetation is occurring.

Figure 38. Inlet of constructed side-channel and wood placements on river-right as part of Nason Confluence Project near RM 0.1.

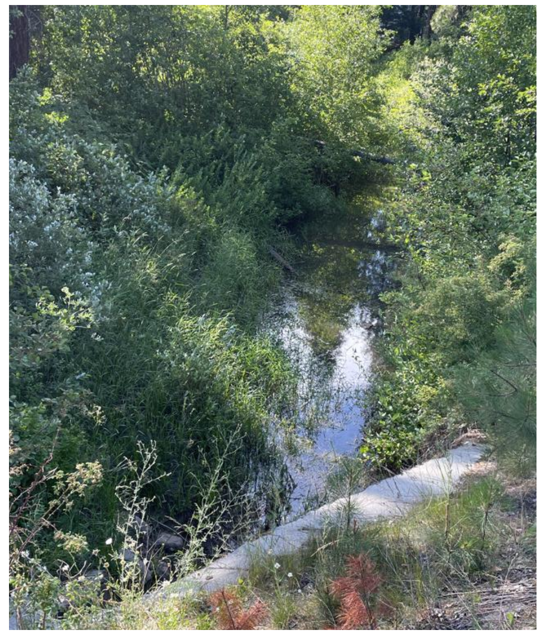

Figure 39. View toward the river from State Route 207 at the outlet of the reconnected channel near RM 1.15.

In 2009, the disconnected main channel segment in Reach 2 was reconnected as a side-channel with culverts placed under State Route 207 (Chelan County project). Culverts were placed at the upstream (RM 1.3) and downstream (RM 1.15) ends to provide fish passage. Survey of the culverts was not performed during the field survey although standing water was observed on both sides of both culverts, even though the side-channel did not have any discernable flow (Figure 39).

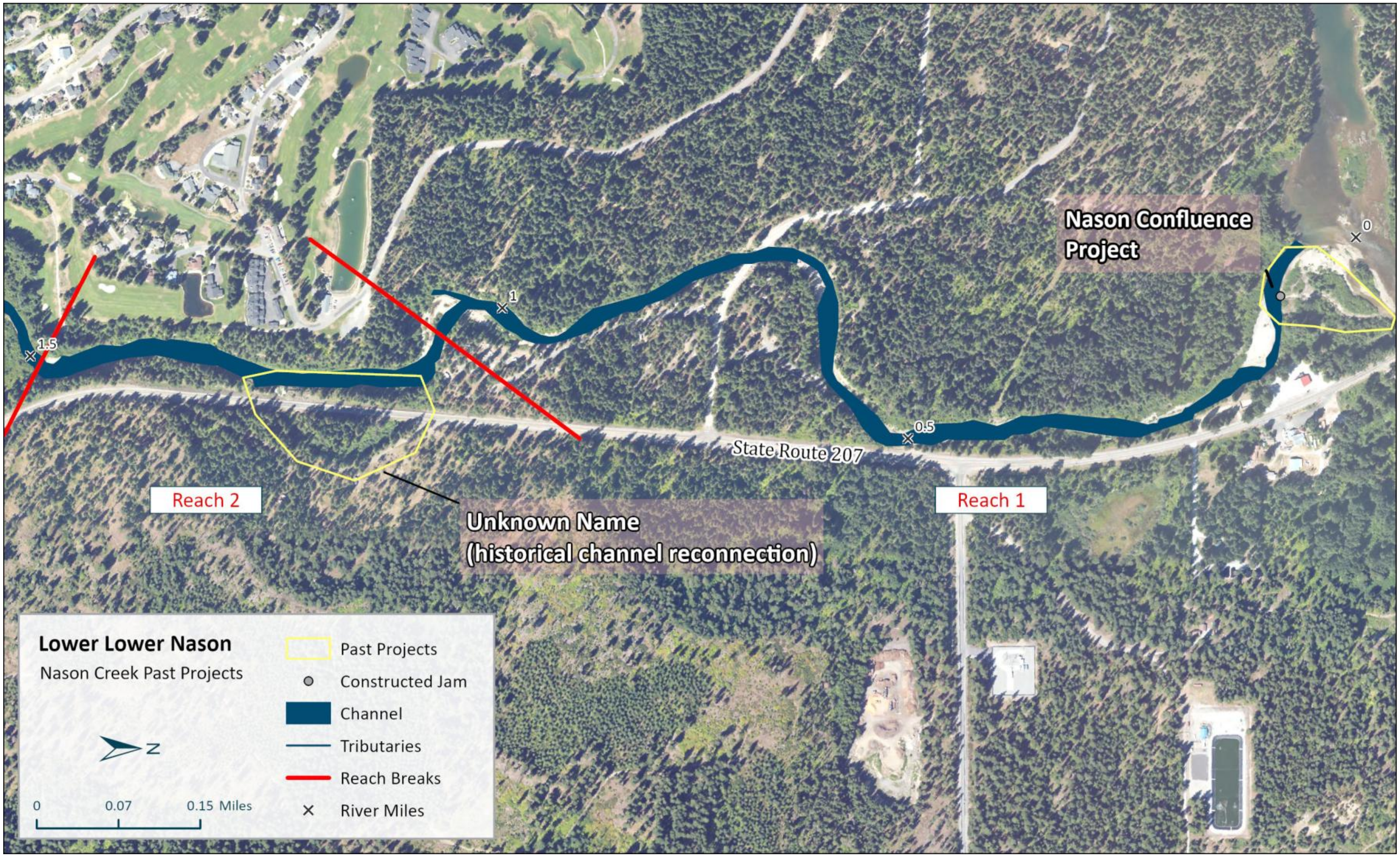

Figure 40. Past projects within Segment 1.

6.1.6 Project Opportunity Summary

Two projects have been identified in this segment. The Confluence Project area would build off of past project work to reconnect side-channels, floodplains, and add large wood complexity to the channel. There is especially opportunity in the river-left floodplain extending up to near the campground. There are large trees in this area and based on the elevations, it is possible it would be viable for side-channel connections. There may be larger reconnection scenarios in this project area that would require modifications of infrastructure, such as relocating State Route 207 or relocating the channel away from the highway. These would have high costs and the potential benefits would need to be weighed accordingly.

The second identified project is the Campground Project. Potential actions here are severely limited by the proximity of the campground, most of the banks of which are armored to protect the campground. There also may be recreational and safety considerations. The only real viable options for work are in a couple of alcoves and the left-bank side-channel area near RM 1.1. There is also opportunity for some main channel complexity in the simplified section of channel upstream of the campground.

6.2 SEGMENT 2 – UPPER LOWER NASON (REACHES 3-4)

6.2.1 Overview

The Upper Lower Nason segment includes reaches 3 and 4 and extends from RM 1.5 to 4.55. The upstream end is just downstream of Coles Corner and the downstream end is located at a valley constriction near the upper end of the Kahler Glen Golf Course. Landownership is dominated by Chelan County on the west side of Nason Creek, with a combination of ownership to the east including private, CDLT conservation lands, and National Forest. Both sides are private at the very downstream portion of the segment. The upstream half of this segment has been significantly impacted by road fill associated with construction of State Route 207, which has disconnected portions of the channel and floodplain. Bank armoring is located at these locations. The 300-ft wide BPA powerline corridor crosses the channel at the upstream portion of the segment in Reach 4, with severe impacts to riparian vegetation. Floodplain clearing and development associated with residential uses occurs on private lands on the east side midway through the segment, mostly in Reach 4. Representative photos of the segment are included in Figure 41, Figure 42, and Figure 43.

Table 9. Key segment metrics. Metrics collected during the Habitat Assessment are discussed in Appendix A.

	Length (miles)	River Mile	Stream Gradient (%)	Sinuosity	Dominant Habitat Unit Type	Average Bankfull Width (ft)	Confinement	Dominant Substrate	% Pool Habitat	% Glide Habitat	% Riffle Habitat	% Side Channel	% Other Habitat
Reach 3	1	1.5-2.5	0.20%	1.25	Pool	70	Unconfined	Gravels	79%	4%	1%	16%	0%
Reach 4	2.05	2.5-4.55	0.35%	1.28	Side Channel	81	Unconfined	Gravels/Cobble	27%	9%	8%	56%	0%

Figure 41. View downstream near RM.4.2. Typical conditions for Reach 4 (Inter-Fluve photo July 2025).

Figure 42. View upstream at typical Reach 4 conditions near RM 3.5 (Inter-Fluve photo July 2025).

Figure 43. View downstream at typical Reach 4 conditions near RM 2.7.

Figure 44. Upstream view into outlet of "oxbow" side-channel from State Route 207 near RM 3.3 (Inter-Fluve photo July 2025).

River process and habitat conditions are degraded in this segment due to past and ongoing anthropogenic impacts including channel cut-offs, straightening, bank armoring, the transmission line corridor, and clearing and development in the floodplain. Although Reach 3 is dominated by pool habitat (Table 9), pool frequency is low in both reaches, and pool quality is low especially in Reach 4. There are, however, some very complex pools with abundant large wood in a couple of locations in Reach 3 (Figure 45). Side channel habitat is relatively high, especially in Reach 4, but this is mostly due to the culverted reconnection of the "oxbow" channel across the highway, a past restoration project that reconnected the formerly cut-off main channel feature as a side-channel (Figure 44). Historically, much more abundant side-channel habitat would have been expected in these low gradient reaches with historical channel migration across the valley floor. Large wood quantities meet standards, but recruitment potential is impacted due to channel cut-offs, bank armoring, and young or cleared vegetation, especially at the powerline crossing and at the private lands midway through the segment.

Figure 45. View downstream near RM 2.1 at area of high channel complexity in Reach 3.

Past restoration work primarily includes two side-channel projects, including the "oxbow" reconnection project across State Route 207. These projects have improved the quantity of accessible off-channel habitat. Not much work has been done in the mainstem, only a few log structures, but one that has collected additional wood and has become channel-spanning. There remain significant opportunities for restoration, some of which may require infrastructure modifications to realize meaningful improvements. There are also significant opportunities for increasing mainstem complexity using log jams and creation/activation of off-channel and side-channel habitats. There are also riparian restoration opportunities and conservation priorities.

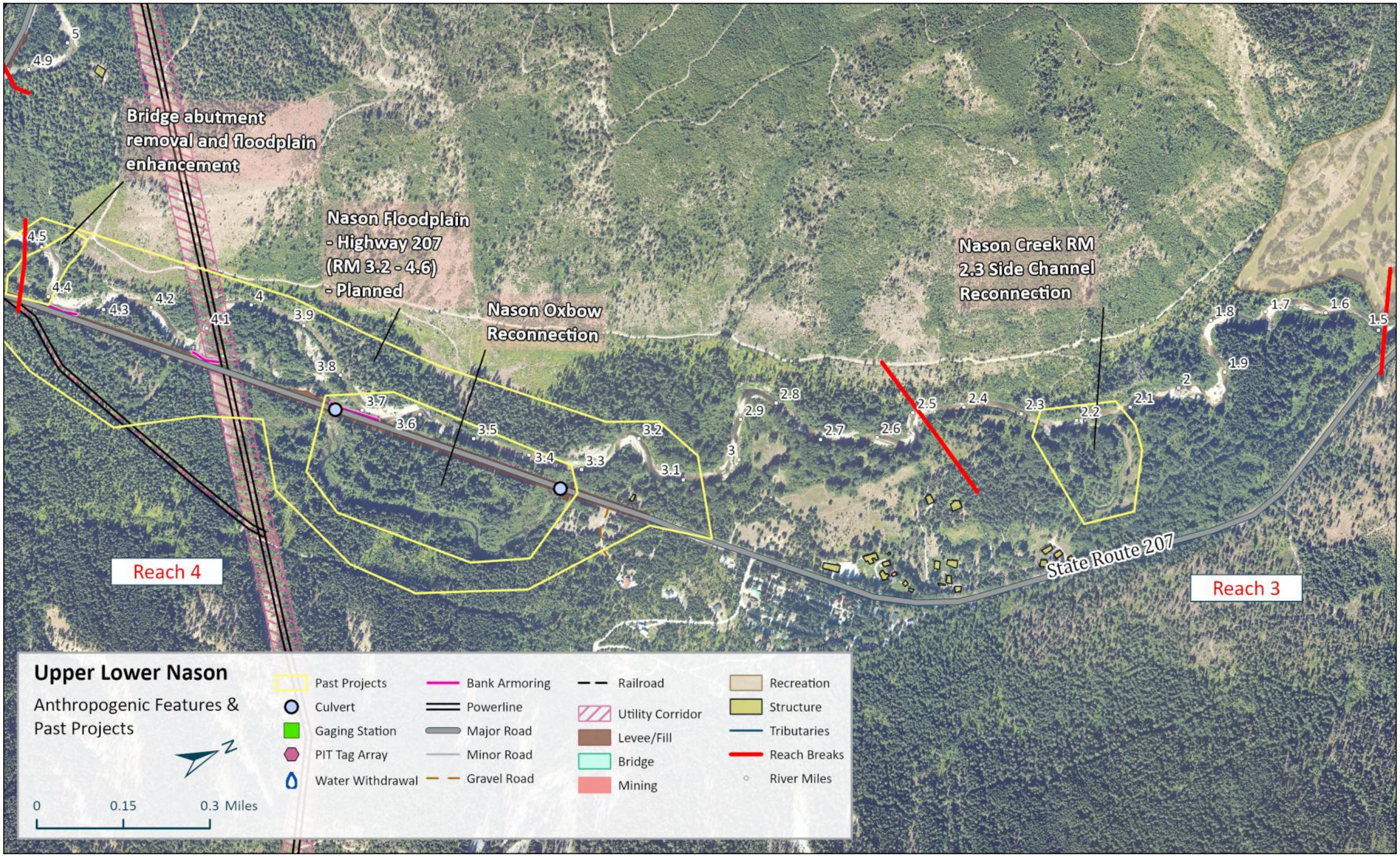

Figure 46. Mapped anthropogenic features and past projects in Segment 2.

6.2.2 Channel and Floodplain Geomorphology

Segment 2 flows within a naturally unconfined glacially-carved valley bounded by glacial terraces, alluvial fans, and outcrops of the Chumstick Formation on the west side of the valley (Figure 47) (USBR 2011). Average valley width is approximately 1,000 ft. This segment has a wider valley and lower gradient (<0.4%) than the upstream Kahler segments. A glacial outwash terrace extending out from the east side of the valley around RM 2.5 (Figure 47) keeps the channel position to the west side of the valley, but this surface is still mostly inundated during large floods (Figure 52). There is a valley constriction at the downstream end of the segment at RM 1.5 caused by glacial deposits. Bedrock (Chumstick Formation) is located at numerous locations where the channel abuts the left valley wall. Channel type is pool-riffle.

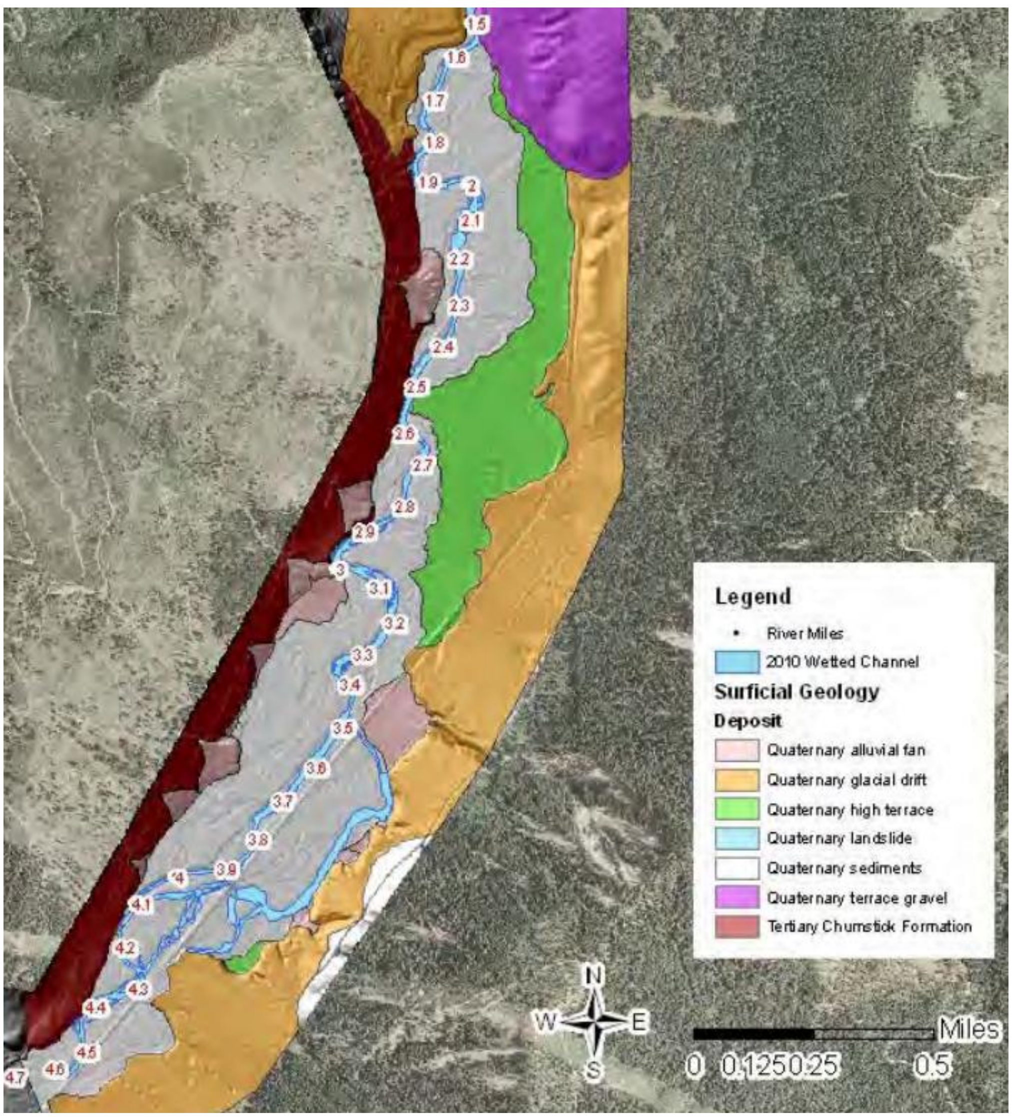

Figure 47. Copy of surficial geology map of the valley floor in Segment 2, obtained from the Lower Nason Assessment of Geomorphic and Ecologic Indicators report** (USBR 2011)**. Gray (non-color) areas are Quaternary Sediments, with the exception of anthropogenic fill that is not mapped. Note that river miles are slightly different than other river miles used in this report. Segment 2 extends from the valley constriction near RM 1.5 on this map upstream to the extent of mapped surfaces.

There have been significant impacts to channel and floodplain processes in this segment, primarily in the upstream portion of the segment in Reach 4. The primary impacts are channel and floodplain disconnections that occurred with the construction of State Route 207 on the east side of the valley. This includes an approximately 2,000 ft section of channel between RM 4.2 and 4.4. and a 4,400 ft section of channel between RM 3.3 and 4.0. Analysis performed as part of Reclamation's Lower Nason Assessment (USBR 2011) showed that in the lower 4.6 miles of Nason Creek, channel cutoffs due to the highway reduced sinuosity from ~1.45 to ~1.2 and increased channel slope from ~0.30% to ~0.37%. Although disconnections in Segment 1 also contribute to these changes, the most disconnection has occurred in Segment 2. Past restoration efforts have reconnected a portion of the historical channel as a side-channel connected via culverts through the highway. Bank armoring is located in a few locations where the channel abuts State Route 207 (Figure 48). There is a total of approximately 1,100 feet of riprap. There are some areas of likely floodplain fill midway through the segment in the river-right floodplain near RM 2.5 associated with private residential development. These were not mapped as fill as the specific locations and extents could not be readily verified due to private lands.

Figure 48. View downstream at bank armor along State Route 207 near RM 4.4 (Inter-Fluve photo July 2005).

The downstream portion of the segment (Reach 3) has experienced fewer manipulations to channel and floodplain processes than the upstream portion (Reach 4). This can at least be partially attributed to landownership. Much of the large east-side floodplain is currently held in private conservation ownership (CDLT), with Chelan County land to the west. Primary impacts to this section of stream are past harvest of riparian and floodplain forests and reduced instream wood quantities. There are a few sections, however, that still contain significant amounts of large wood, which is having a positive effect on channel complexity and habitat in these locations. This is discussed further in the large wood section below.

Bed substrate is dominated by gravels, with some cobble-dominated sections in the upstream portion of the segment. Bedrock was observed extending across the channel bed during the field surveys at RM 3.97, 4.03, 4.24, and 4.27 (Figure 49). Bed material sourcing primarily occurs from lateral erosion into modern floodplain deposits and also from erosion into alluvial fan deposits and outcrops of the Chumstick Formation, both of which occur primarily where the channel abuts the west valley wall (Figure 50). Bed material sourcing has been affected by channel cutoffs that have reduced sinuosity, lateral erosion potential, and contacts with the east valley wall sediments at the upstream end of the segment.

Figure 49. Bedrock in the channel bed near RM 4.

Figure 50. View downstream near RM 4.25. An outcrop of the Chumstick Formation can be seen on the left side of the photo.

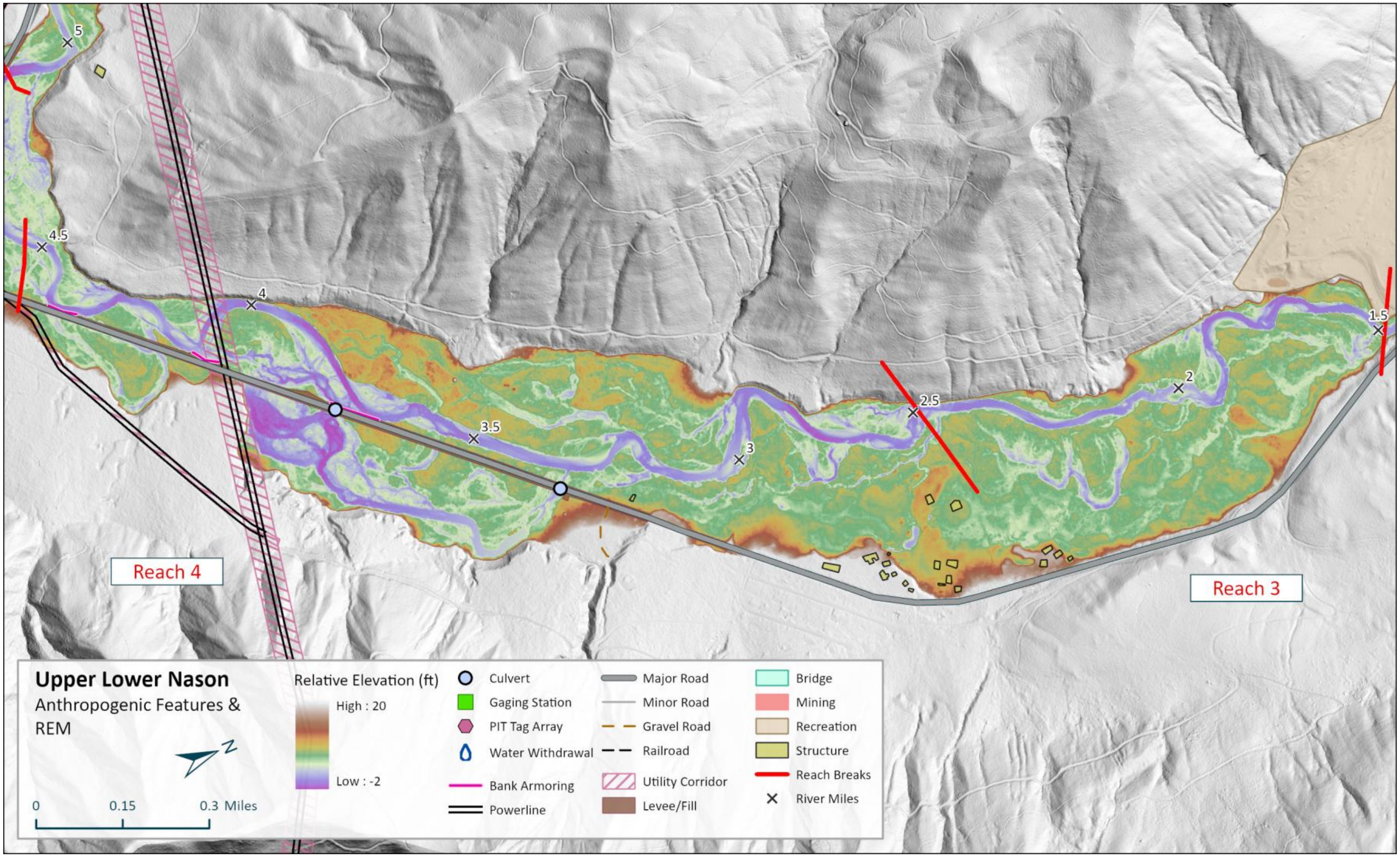

Figure 51. Mapped anthropogenic features and relative elevation map for Segment 2.

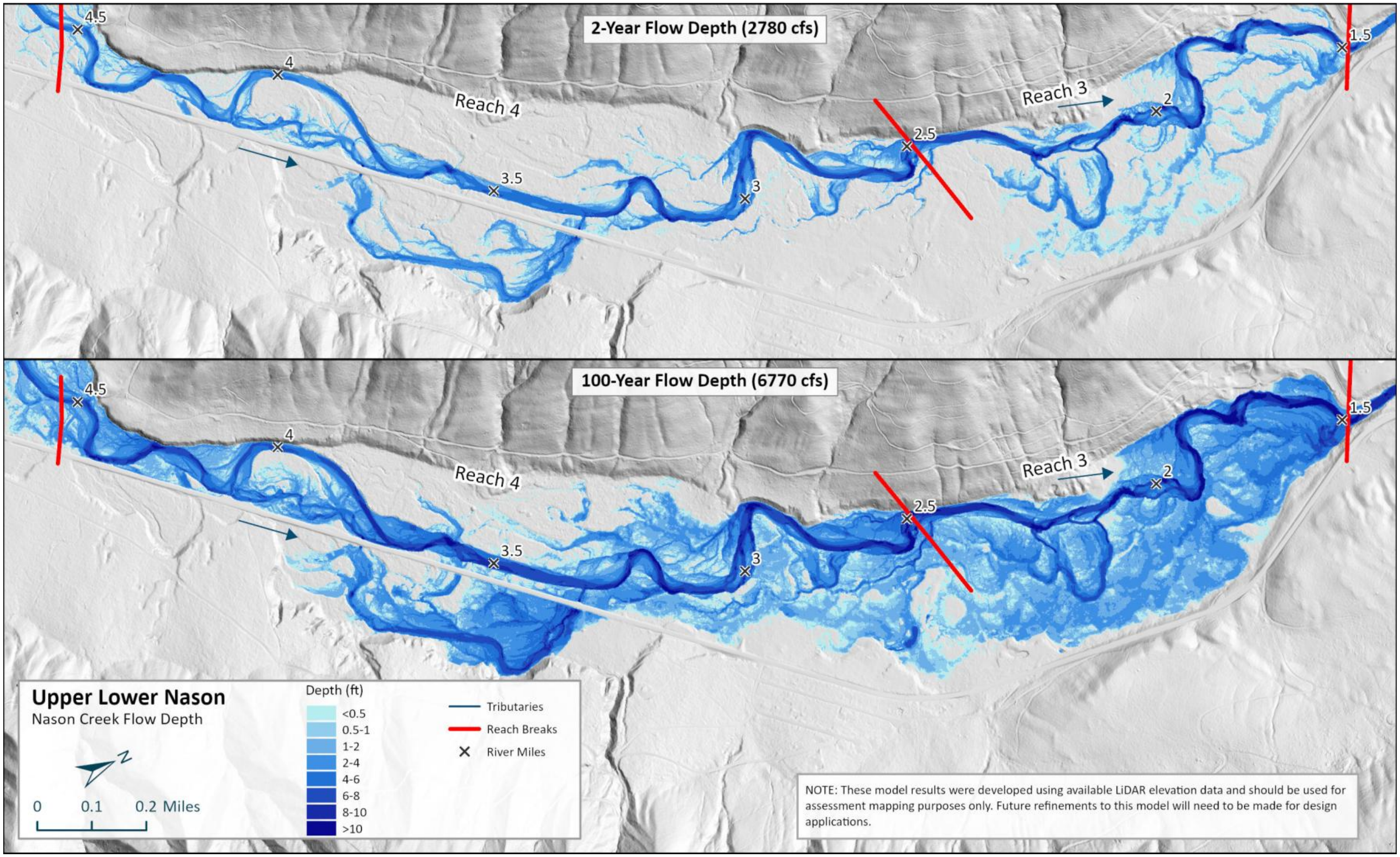

Figure 52. Modeled depth results for Segment 2.

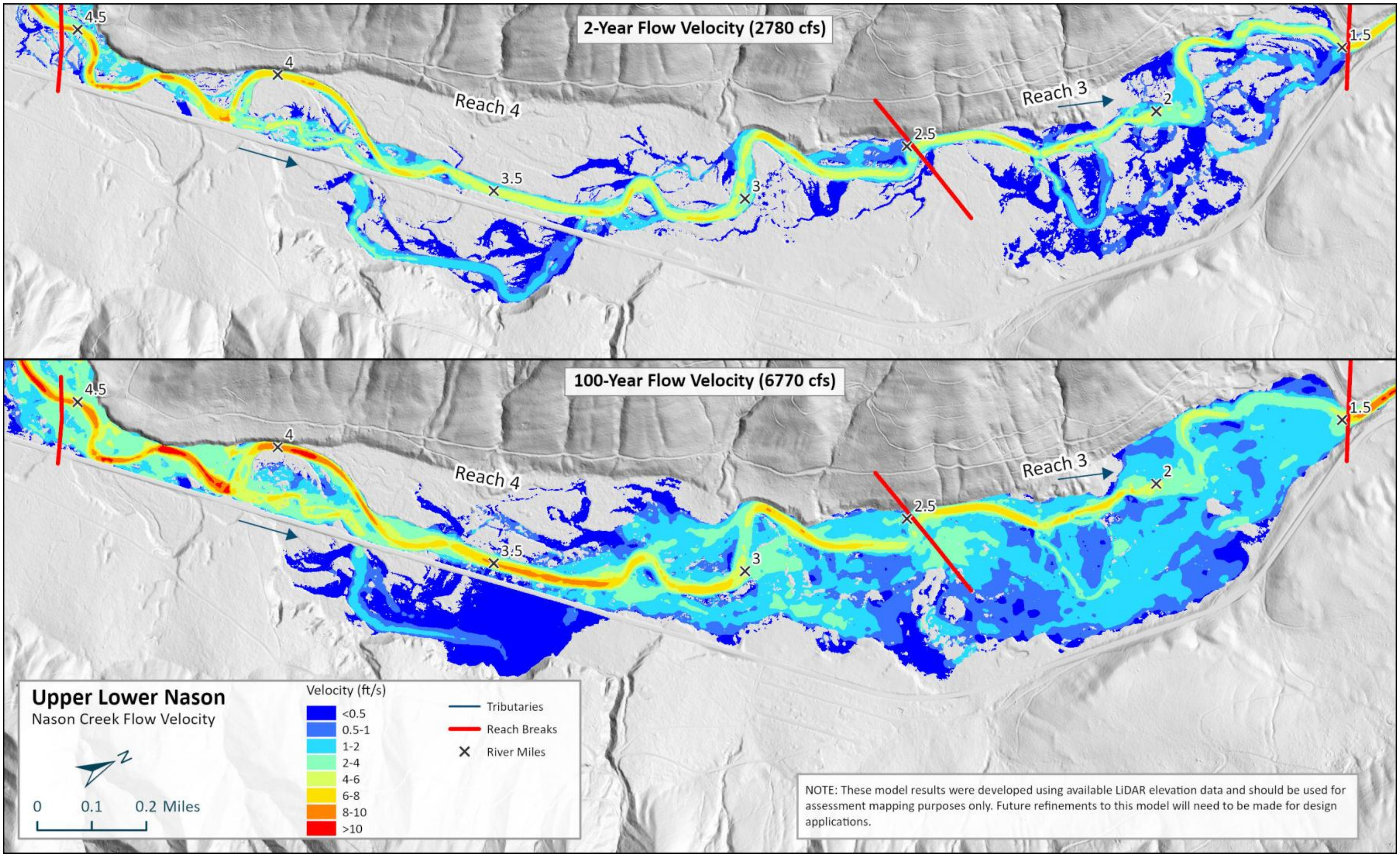

Figure 53. Modeled velocity results for Segment 2.

6.2.3 Large Wood Material

Large wood processes are impaired in this segment. Wood counts are relatively high, especially for Reach 3, which far exceeds the standard for properly functioning (see REI analysis, Section 5). However, recruitment and retention processes are impaired, with the greatest impacts in Reach 4. Most of the natural wood (i.e. not placed as part of a project) is located in a couple of mainstem sections in Reach 3 or in side-channels in Reach 4 (Figure 60). In Reach 3 at RM 1.7, wood is being recruited by lateral processes and is driving geomorphic complexity (Figure 54). The channel here has migrated to the east into some relatively large trees, recruiting wood that has then collected additional fluvially-transported wood to create a dynamic and complex section with deep scour pools and barform development/ protection. The wood was not channel-spanning at the time of the early July 2025 survey, but has been in the recent past based on aerial photography.

Figure 54. View downstream near RM 1.7.

The most complex area of Reach 3, however, is from RM 1.9 to 2.3. The highly complex section with abundant large wood was the location of a prior channel-spanning log jam that was documented in the 2011 Lower Nason Reach Assessment (USBR 2011). Based on the reach assessment and older aerial photos, the channel-spanning jam was likely present from at least 1998 to 2013. Much of the wood from the jam on river-left has been colonized by vegetation and has essentially been incorporated into the left-bank as the channel has shifted right over the years (Figure 55). This demonstrates an important function that large wood can provide in the system; not only providing instream habitat complexity but also serving as substrate for new vegetation growth and comprising a portion of the streambank and floodplain structure. Photos of the remnants of the jam from the early July 2025 field survey are included in Figure 56 and Figure 57.

Figure 55. Evolution of channel-spanning log jam near RM 2. Photos series obtained from Google Earth imagery.

Figure 56. Jam on left-bank near RM 2.05 at location of older channel-spanning jam.

Figure 57. Large wood jam at RM 2.1.

Just upstream of this, at RM 2.25, there was a channel-spanning jam at the time of the early July 2025 survey (Figure 58, and photo of jam in Figure 65). A river-left jam was constructed here as part of the 2018 side-channel project, which then collected more wood to become channel-spanning. It is now providing significant influence on the channel and is helping to maintain activation of the constructed/enhanced river-right side-channel. This jam, combined with another constructed jam just downstream, constitutes a significant portion of the total wood count for this reach.

Figure 58. Channel-spanning jam (partly constructed) at RM 2.25 and constructed apex jam downstream. Spanning jam is helping to keep the river-right side-channel active (Google Earth 2024 image).

The other area of high wood complexity is in Reach 4 at the top end of the river-right side-channel near RM 4.1 (Figure 59). Abundant wood carries through the top half of this side-channel (Figure 60). Apart from these and some other localized areas with wood, most of Segment 2 is lacking in large wood, and where it does exist, it is not providing significant geomorphic influence on the channel. In addition, recruitment processes are impaired in Reach 4 due to the channel cutoffs and bank armoring described previously. One of the largest stands of mature trees is located in the cutoff portion of floodplain east of the highway near RM 3.5 (see Vegetation section below and Figure 63). The riparian vegetation is also very young or absent in many locations, so even if recruitment processes (e.g. lateral migration) are intact, there are not trees of adequate size to serve as key pieces in the main channel. Young or absent woody riparian vegetation is especially concentrated in sections abutting the highway and within private lands.

Figure 59. Log jam at entrance to river-right side-channel complex near RM 4.1.

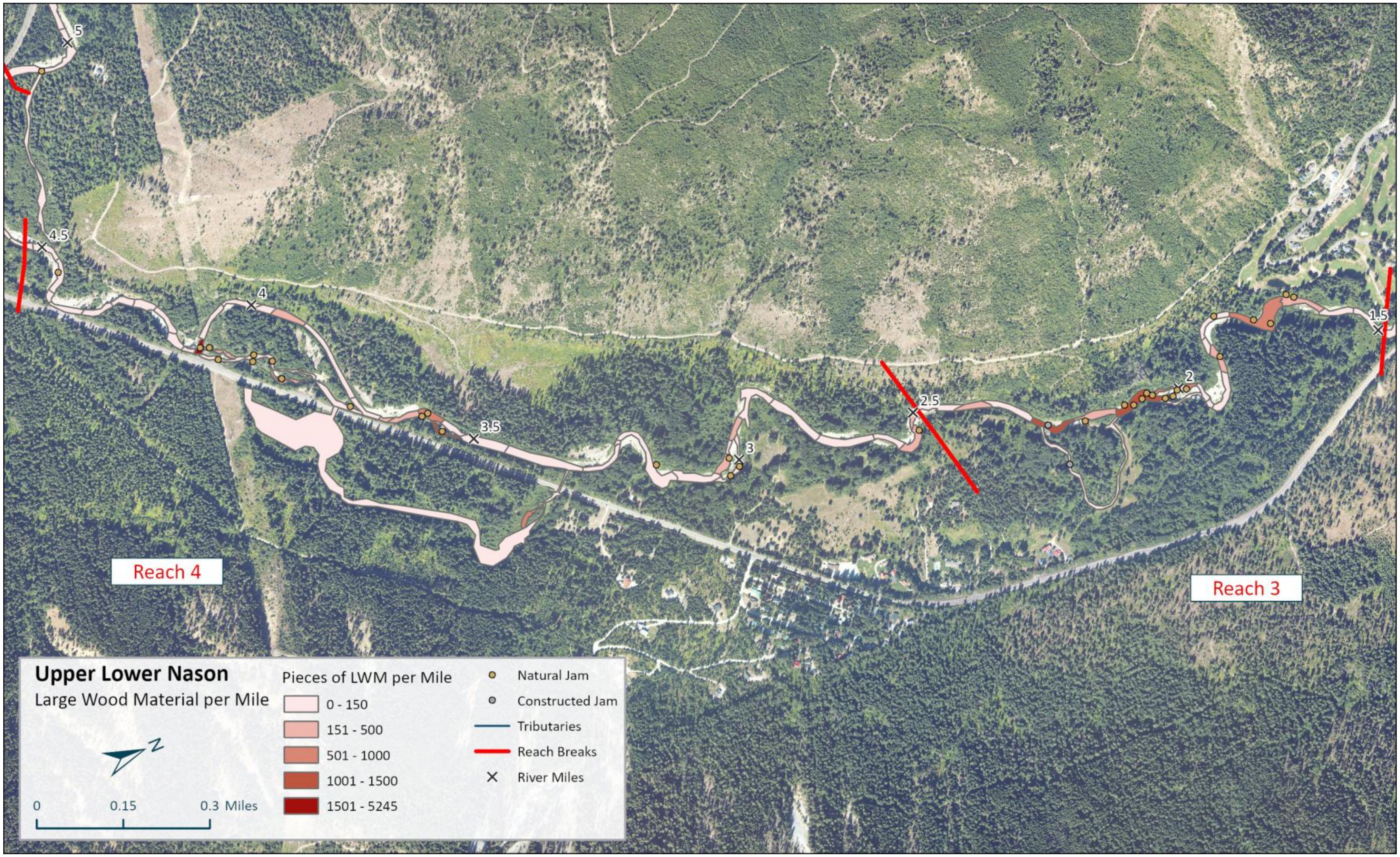

Figure 60. Large wood frequency and jams in Segment 2.

6.2.4 Vegetation

Vegetation types in Segment 2 are similar to Segment 1, with cottonwood, fir, and cedar in the overstory and cottonwood, dogwood, alder, and willow dominating the understory (Figure 61). Understory areas along channel banks also have lessor amounts of spirea, rose, and hawthorn. There is abundant reed canary grass on low surfaces within and just above the active channel margin. Knapweed was observed on gravel bars in a few locations. Vegetation is frequently young in a narrow band along the channel, with a variety of forest types and ages deeper into the floodplain (Figure 63). There are stands with trees over 150 feet tall in a few locations, including at the downstream end of Reach 3 from RM 1.5 to 2.1, in the river-left floodplain from RM 3.1 to 3.4, and in a few other scattered locations upstream. One of the largest stands of large trees is located in the disconnected floodplain across the highway at RM 3.5. Many locations along the left-bank (west side) have experienced timber harvest with sometimes narrow riparian buffers. These areas are also where the stream abuts the steeper west hillslope (Chumstick Formation bedrock), where the vegetation tends to be comprised of drier, more upland species with the overstory dominated by ponderosa pine (Figure 62). In these areas, the left bank of the channel is dominated by shrubs and is less vegetated than the right bank. There are a few other areas where riparian and floodplain clearing has occurred, including along private properties on river-right from RM 2.4 to 3 and within the BPA powerline crossing at RM 4.1, where a 300+-ft swath of riparian zone is routinely cleared.

Overall, as described previously in the Large Wood Material section, large wood recruitment processes have been disrupted. There is recruitment happening but it is mainly of young or medium-aged trees. There is also relatively little shade being provided by the canopy. A vegetation height map is included for reference in Figure 63.

Figure 61. This photo captures the typical variety of riparian vegetation in the lower end of Reach 3 and in other areas of the segment. This photo is a view upstream near RM 1.9.

Figure 62. View upstream at RM 2.8 of drier, more upland forest affected by past harvest.

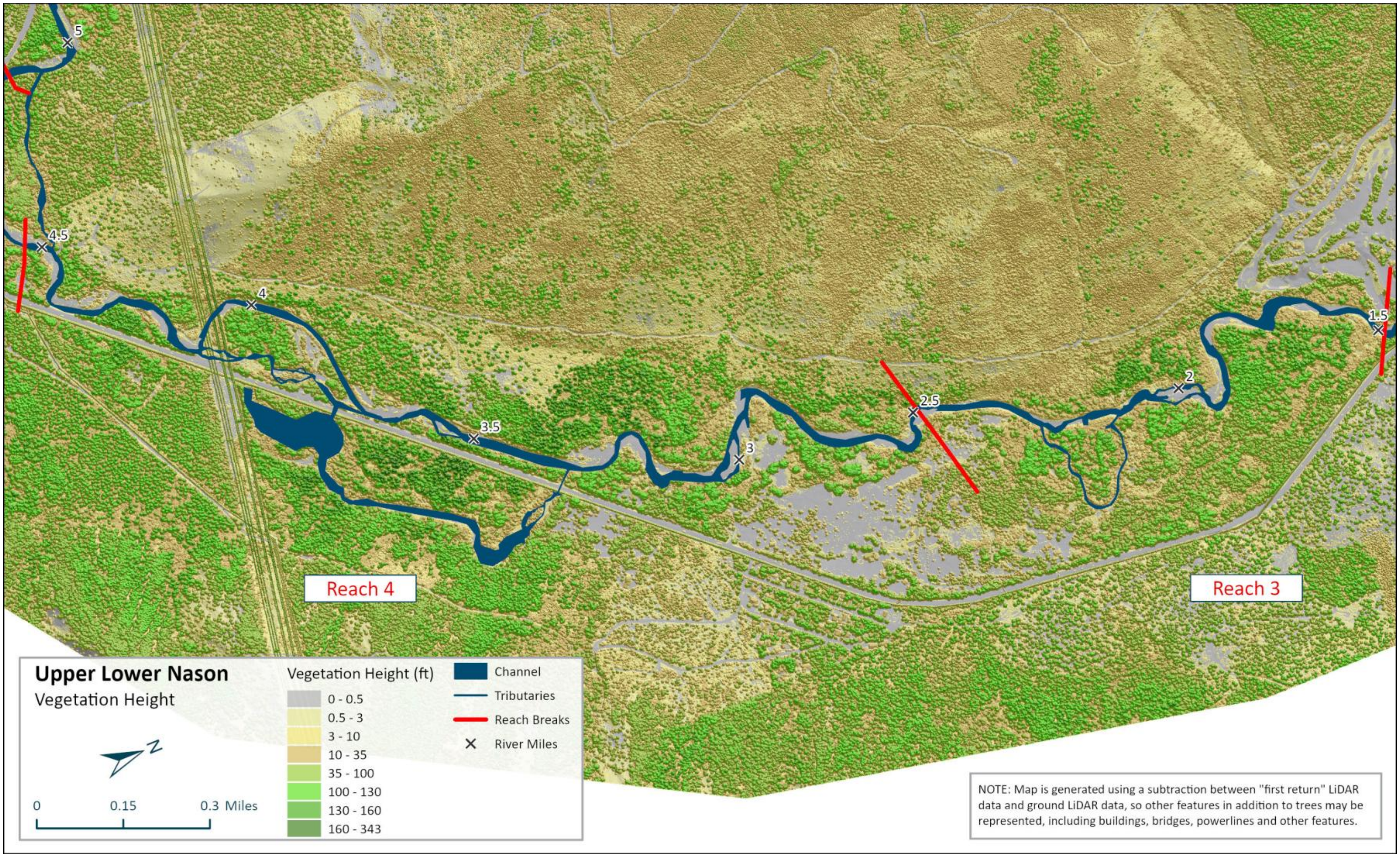

Figure 63. Vegetation heights along Segment 2 of Nason Creek.

6.2.5 Past Restoration Projects

There have been at least three restoration projects in this segment and a couple more are being planned (Figure 66).

In 2008, the Nason Oxbow Reconnection Project (Chelan County) was constructed from RM 3.4 to 3.7 and included improvement of fish access to the historical "oxbow" channel via culverts through State Route 207 and placement of large wood habitat (Figure 64). At the time of the early July 2025 field survey, there was good connectivity through the culvert connections.

Figure 64. View of culvert under State Route 207 near RM 3.75 (inlet to reconnected 'oxbow' side-channel).

In 2015, Chelan County removed floodplain fill associated with an old bridge crossing at RM 4.5 and also removed a parking lot from the river-right floodplain between RM 4.4 and 4.5. This area has regrown significantly from planted and volunteer vegetation and the footprint of work along the channel is difficult to see.

The Nason Creek RM 2.3 Side Channel Reconnection Project (Chelan County) was constructed in 2018 and included two mainstem log jams and reconnection/enhancement of an approximately 1,800-ft long side-channel via excavation and wood placements. The upstream jam was located across from the side-channel inlet and subsequently racked wood and at the time of the early July 2025 field survey was a channel-spanning jam helping to keep the side-channel open, creating a deep and complex mainstem pool, and providing gravel sorting. This is currently a highly complex section of channel (Figure 65).

Figure 65. Channel-spanning jam at RM 2.25. Aerial photos suggest that this Jam was originally constructed as a left-bank jam that collected additional wood and became channel-spanning. The jam is very effective at keeping the right-bank side-channel active. The inlet is at the right side of the jam in the photo (Inter-Fluve photo July 2025).

The Nason Floodplain – Highway 207 (RM 3.2 – 4.6) Project (Yakama Nation) is currently in the planning and design phase. The current plan is that this project will extend from RM 3.2 to 4.6 and will include partial relocation of State Route 207, mainstem large wood jams, side-channel habitat enhancement, and riparian and floodplain revegetation. The "Nason Ridge Project" described in the section below and in Appendix C reflects some of the planned elements of this project.

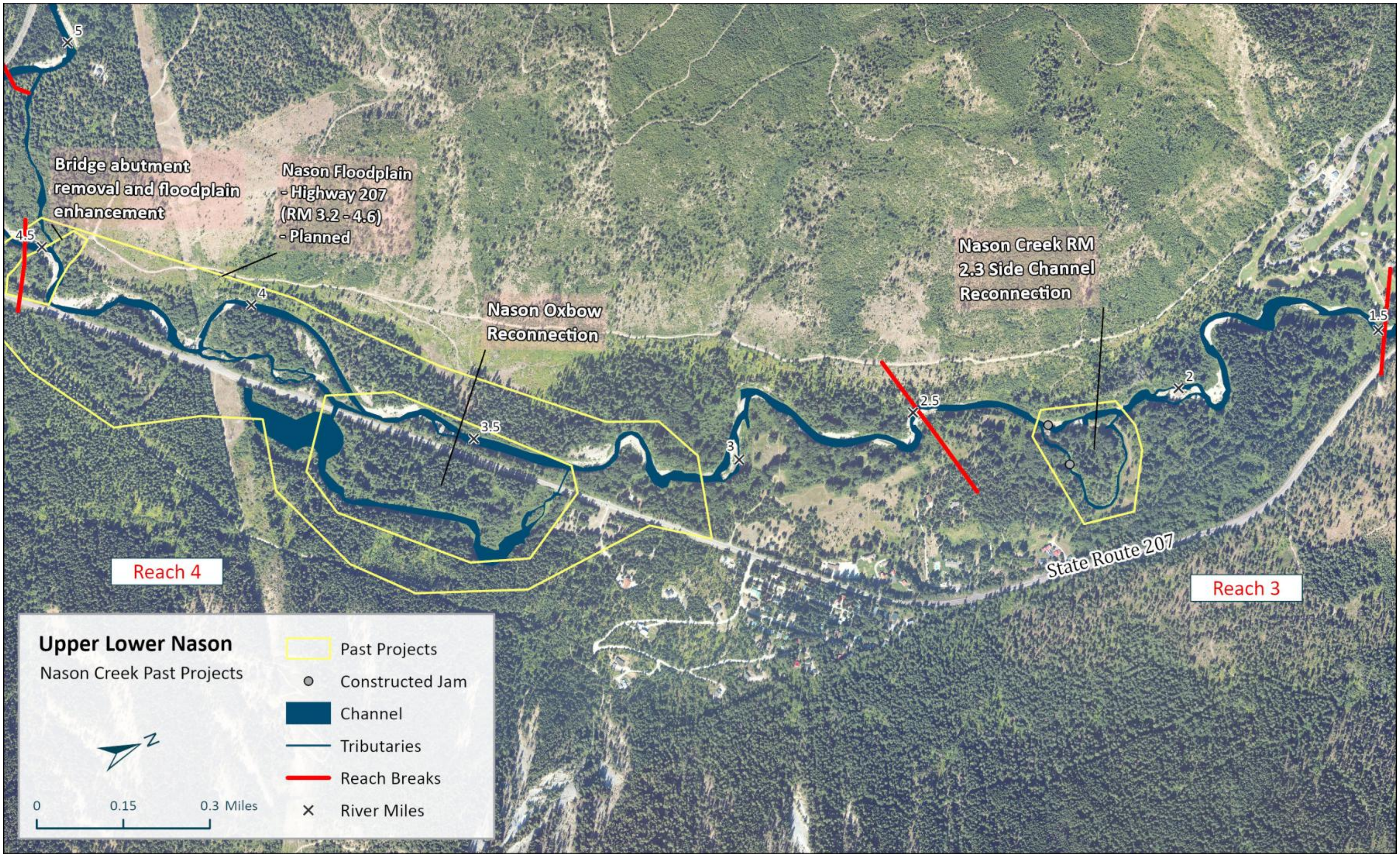

Figure 66. Past and planned projects within Segment 2.

6.2.6 Project Opportunity Summary

Two projects have been identified in this segment. The Miracle Mile project area spans the entirety of Reach 3 and a portion of Reach 4. This section of channel has had past project work that is providing good habitat and also some high complexity from natural log jams. Additional work could build on these conditions to enhance habitat complexity and floodplain connectivity in the many remaining areas that have very simplified habitat conditions. There is abundant opportunity for main channel log structures to create flow-splits, encourage lateral process, capture and sort bed material, and provide complex cover. There are also numerous locations for creation, activation, or enhancement of side- and off-channel habitat. Areas of cleared or young vegetation could be targeted for reforestation efforts. Cooperation with willing landowners will be required for portions of this project area at the upstream end. This is also an area of conservation priority, where conserving lands would prevent potential future development and may allow for greater opportunities for restoration work.

The second identified project area is the Nason Ridge project area, which comprises the remainder of Reach 4. This project area includes the elements that are currently in the planning and design stage as part of the Nason Floodplain – Highway 207 (RM 3.2 – 4.6) Project described in the previous section. This includes partial relocation of State Route 207, mainstem large wood jams, side-channel habitat enhancement, and riparian and floodplain revegetation. Additional potential elements for future consideration are also described, including additional highway set-backs and similar mainstem and side-channel actions expanding into other areas.

6.3 SEGMENT 3 – LOWER KAHLER (REACHES 5-6)

6.3.1 Overview

The Lower Kahler segment includes reaches 5 and 6 and extends from RM 4.55 to 6.3. The upstream end is located at a point where the highway directly abuts the channel and the downstream end is just downstream of Coles Corner. Landownership is primarily National Forest, with private parcels at the downstream end around Coles Corner and midway through the segment in Reach 6. CDLT conservation lands are also located to the north of the channel midway in Reach 6. The segment has been significantly impacted by road fill associated with construction of Highway 2, which has disconnected portions of the channel and floodplain in three to four locations. Bank armoring is located at these locations. The 300-ft wide BPA powerline corridor crosses the channel at the upstream portion of the segment in Reach 6, with severe impacts to riparian vegetation. Development around Coles Corner, including old floodplain grading and fill, impacts floodplain processes and vegetation. Representative photos of the segment are included in Figure 67 and Figure 68.

Table 10. Key segment metrics. Metrics collected during the Habitat Assessment are discussed in Appendix A.

	Length (miles)	River Mile	Stream Gradient (%)	Sinuosity	Dominant Habitat Unit Type	Average Bankfull Width (ft)	Confinement	Dominant Substrate	% Pool Habitat	% Glide Habitat	% Riffle Habitat	% Side Channel	% Other Habitat
Reach 5	0.25	4.55-4.8	0.69%	0.81	Riffle	82	Unconfined	Cobbles/Boulders	22%	10%	67%	0%	0%
Reach 6	1.5	4.8-6.3	0.92%	1.28	Riffle	78	Unconfined	Cobbles	18%	5%	68%	2%	7%

Figure 67. View downstream approaching bend with powerline crossing near RM 6 (Inter-Fluve photo July 2025).

Figure 68. View downstream near RM 5.3 at steep uniform boulder-bed channel segment typical of this section of Reach 6 (Inter-Fluve photo July 2025).

River process and habitat conditions are degraded in this segment due to past and ongoing anthropogenic impacts including channel cut-offs, straightening, bank armoring, the transmission line corridor, and development in the floodplain. Pool quantity and frequency is severely lacking (Table 10). The lack of pools may be somewhat natural given the steeper slope of these reaches; however, channel straightening and lack of large wood has likely exacerbated the paucity of pools, and has impaired the depth and quality (cover and complexity) of the pools that do exist. There is also very low incidence of side-channel habitat, which would have been expected to be more prevalent in historical conditions prior to channel and floodplain cut-offs. Reach 5, however, does contain one of the highest functioning natural side-channels in the entire reach assessment area (Figure 69). Large wood abundance is very low, below properly functioning standards, and the wood that is present has limited overall geomorphic influence due to its size and scarcity. Large wood recruitment potential has been impacted by bank armoring, the adjacent highway, riparian clearing under the powerlines, and past timber harvest.

There has not been any significant past restoration work in this segment, although there are a couple of projects in the planning stages. There are significant opportunities for restoration, some of which may require infrastructure modifications to realize meaningful improvements.

Figure 69. Upstream end of river-left side-channel in Reach 5 near RM 4.9 (Inter-Fluve photo July 2005).

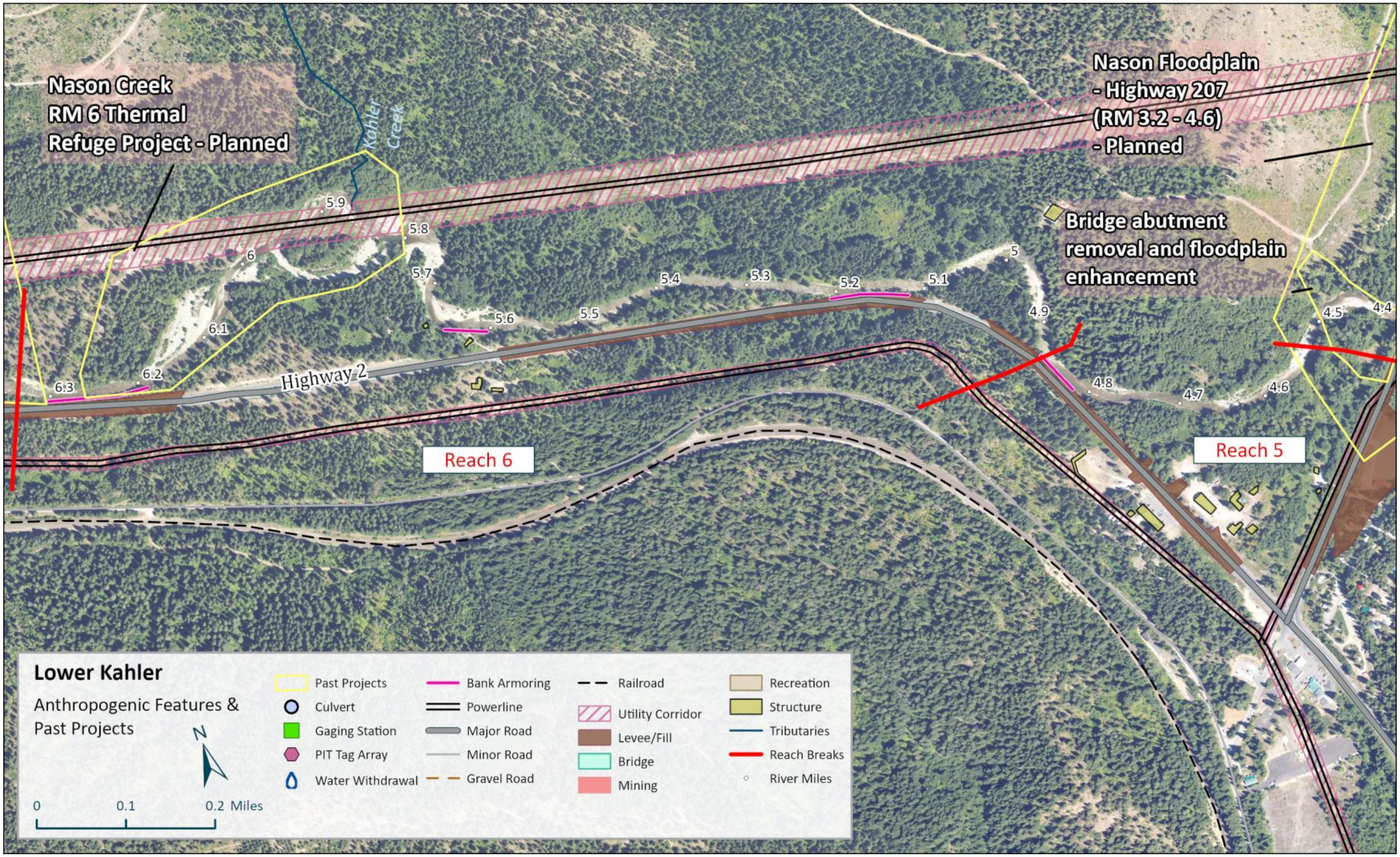

Figure 70. Mapped anthropogenic features and past projects in Segment 3.

6.3.2 Channel and Floodplain Geomorphology

This segment, along with Reach 7 upstream, has higher slope than upstream and downstream segments (Figure 11). These reaches are working through glacial material resulting from the multiple alpine glaciers that advanced and retreated in the valley (U.S. Bureau of Reclamation 2008). The Holocene floodplain and active channel migration zone width averages approximately 800 feet, with a narrow ~400-ft wide section near RM 5. Floodplain channel scars indicate abundant past scrolling within the modern floodplain. This modern floodplain is bounded by sets of glacial terraces of different ages, plus older and younger tributary alluvial fan deposits (Figure 71) (U.S. Bureau of Reclamation 2008), the largest of which is the Kahler Creek alluvial fan, which enters from the north near RM 5.9. Channel type is pool-riffle.

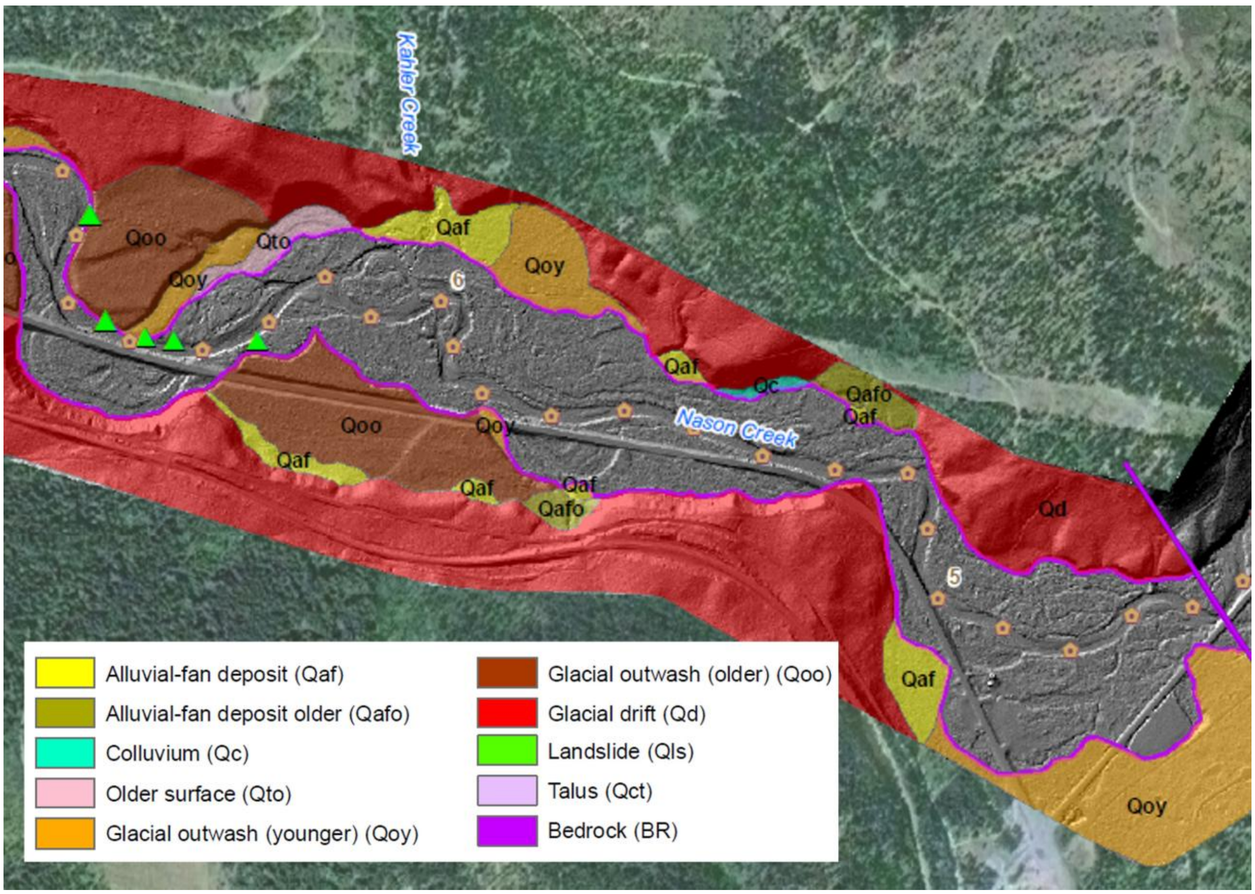

Figure 71. Copy of surficial geology map of the valley floor in Segment 3, reproduced from the Nason Creek Tributary Assessment – Map Atlas** (U.S. Bureau of Reclamation 2008)**. Gray (non-color) areas are Quaternary Sediments, with the exception of anthropogenic fill that is not mapped. Note that river miles are slightly different than other river miles used in this report.

Landownership is mostly National Forest, and so there is less residential development compared to up- and downstream areas. However, there have nevertheless been significant past and ongoing impacts to channel and floodplain processes. One of the biggest impacts has been the construction of the modern location of Highway 2, which has cut off 4 sections of channel and associated floodplain areas. The greatest disconnected zone is at the upstream end of the segment in Reach 6, where an approximately 1,000 ft section of channel (spanning reaches 6 and 7) was cut off (Figure 76). This relocation resulted in the current channel being artificially confined between the highway embankment and a glacial terrace to the north. This has resulted in confinement of the channel to essentially one channel-width wide. The bed of the channel also appears to be significantly lower than the historical channel. LiDAR analysis indicates that the current channel could be greater than 5 feet lower than the historical channel, which may have occurred at the time of highway construction and/or from channel incision over time in what is now a very high energy section of channel (Figure 78). Other points of disconnection due to the highway occurred at RMs 5.5, 5.2, and 4.8. These sections now lie adjacent to the highway embankment, with riprap armoring (Figure 72). The BPA powerline corridor crossing also has an impact on floodplain and channel migration zone connectivity, with transmission towers located within the river-left floodplain near RM 5.95 and RM 5.85 (see Figure 83). The other major impact has been the development and fill around Coles Corner, which has disconnected a portion of the south floodplain in Reach 5. There are also other areas of floodplain fill of unknown origin. Several of these are scattered in the river-left and river-right floodplain near RM 4.7 in Reach 5 (Figure 73). These are now forested and on National Forest land. Modeling shows that the disconnections due to Highway 2 have the largest reductions in floodplain inundation, followed by fill at Coles Corner and then what is likely incision related to highway disconnections (Figure 77 and Figure 78).

Figure 72. View downstream near RM 6.3.

Figure 73. Floodplain fill mounds in river-right floodplain near RM 4.75.

Large cobbles are the dominant bed and bank sediments in the segment. There are many long cobble or small boulder-dominated riffles, although gravel and cobble dominated riffles are also common. Sources of bed material vary throughout the segment but primarily include erosion into modern floodplain surfaces. Much of this occurs in the sinuous section in Reach 6 from RM 5.6 to 6.2, especially where banks lack mature woody vegetation due to the powerline corridor crossing (Figure 74) and are eroding at more rapid rates than would be expected under forested conditions. There is one notable location where material is being sourced from older glacial drift material where the modern floodplain narrows at RM 5. The river here is eroding into the high river-left bank and is recruiting a range of material sizes (Figure 75). With respect to vertical bed stability and trends in slope, geologic assessments and interpretations suggest that the underlying geology exerts a strong influence and stability on the channel profile, despite the significant human alterations including channel shortening due to the highway (U.S. Bureau of Reclamation 2008).

Figure 74. View upstream near RM 5.95 showing bank erosion on river-left bank.

Figure 75. View of river-left bank near RM 5.0 where the channel is eroding into glacial deposits (Inter-Fluve photo July 2025).

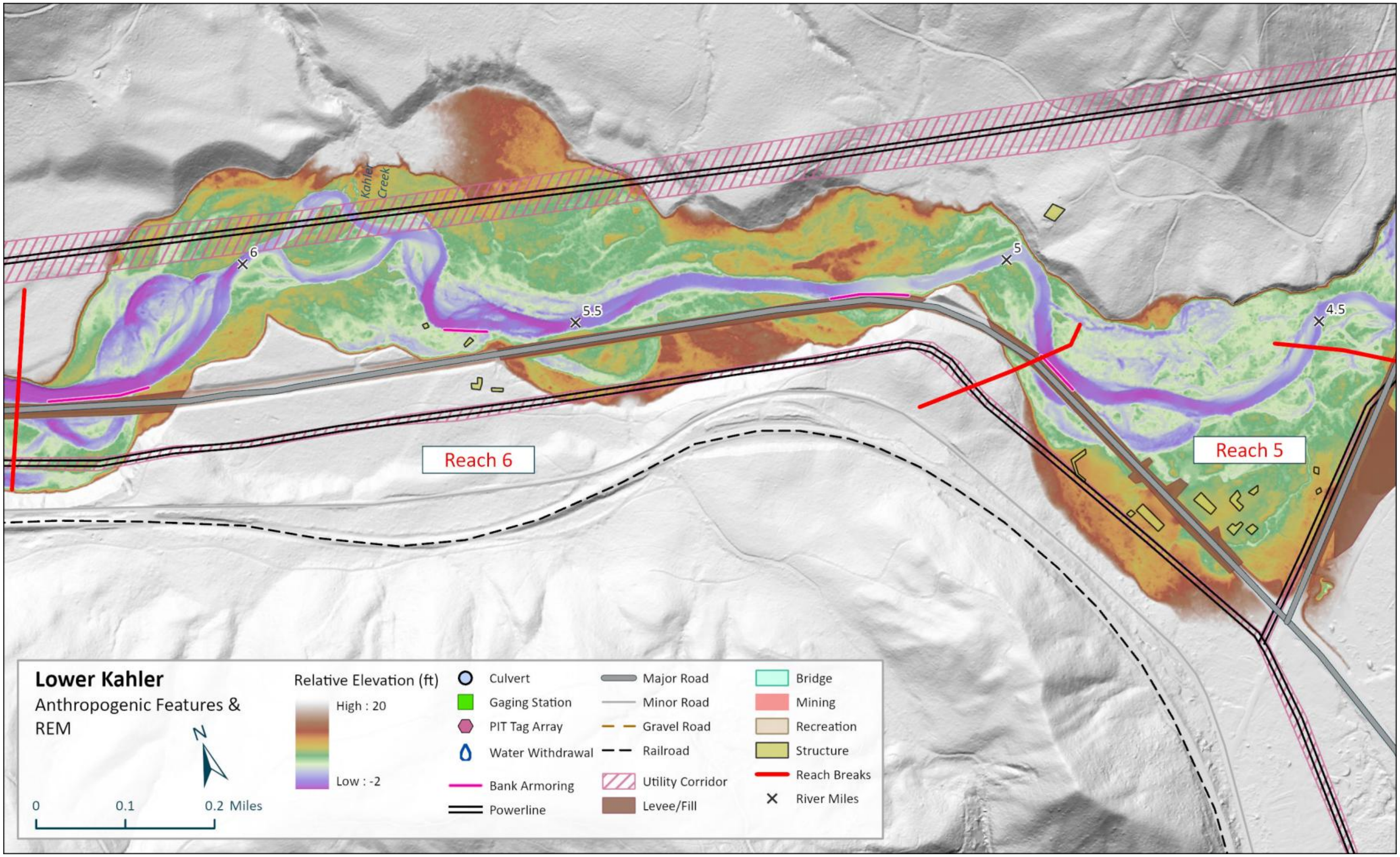

Figure 76. Mapped anthropogenic features and relative elevation map for Segment 3.

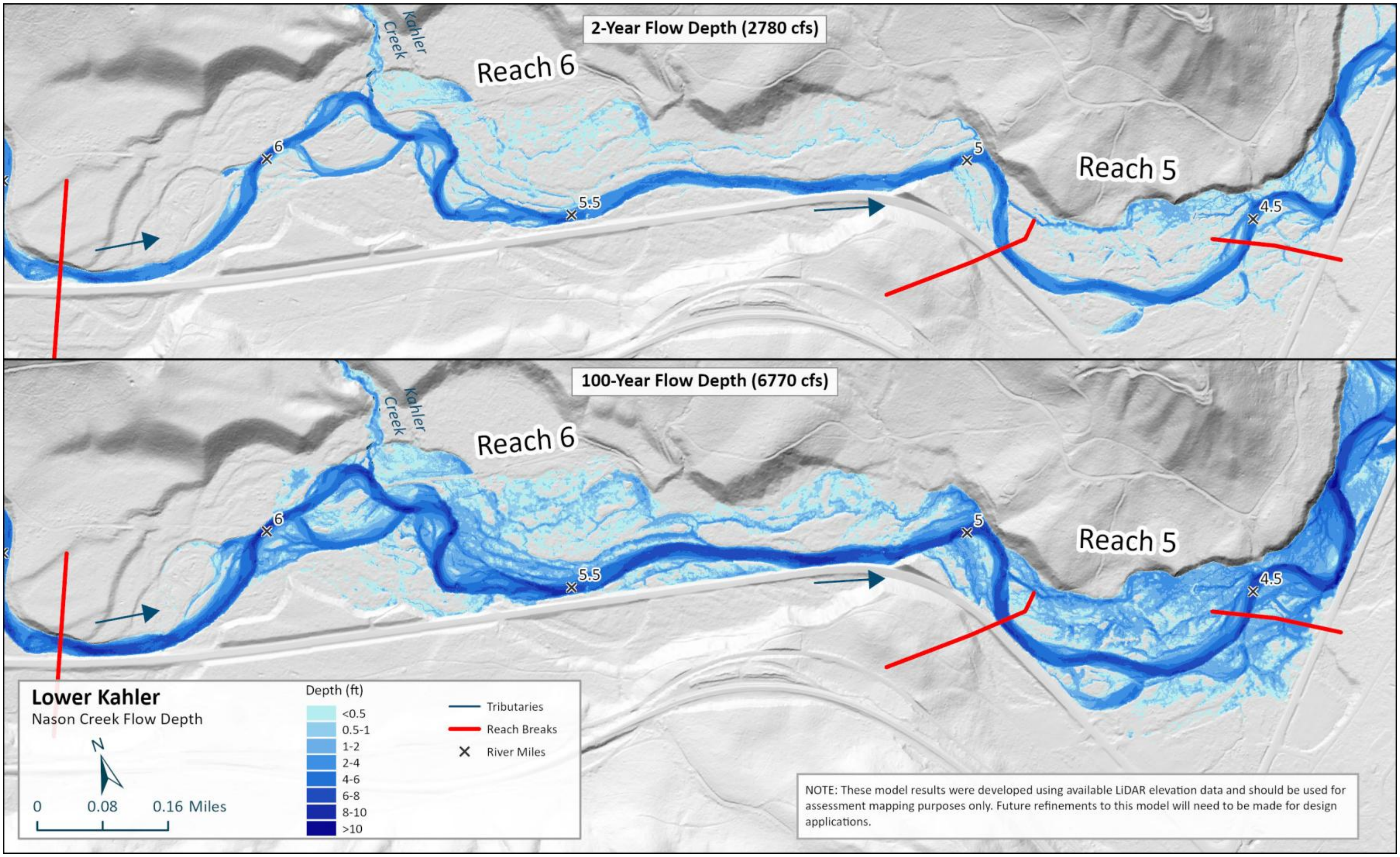

Figure 77. Modeled depth results for Segment 3.

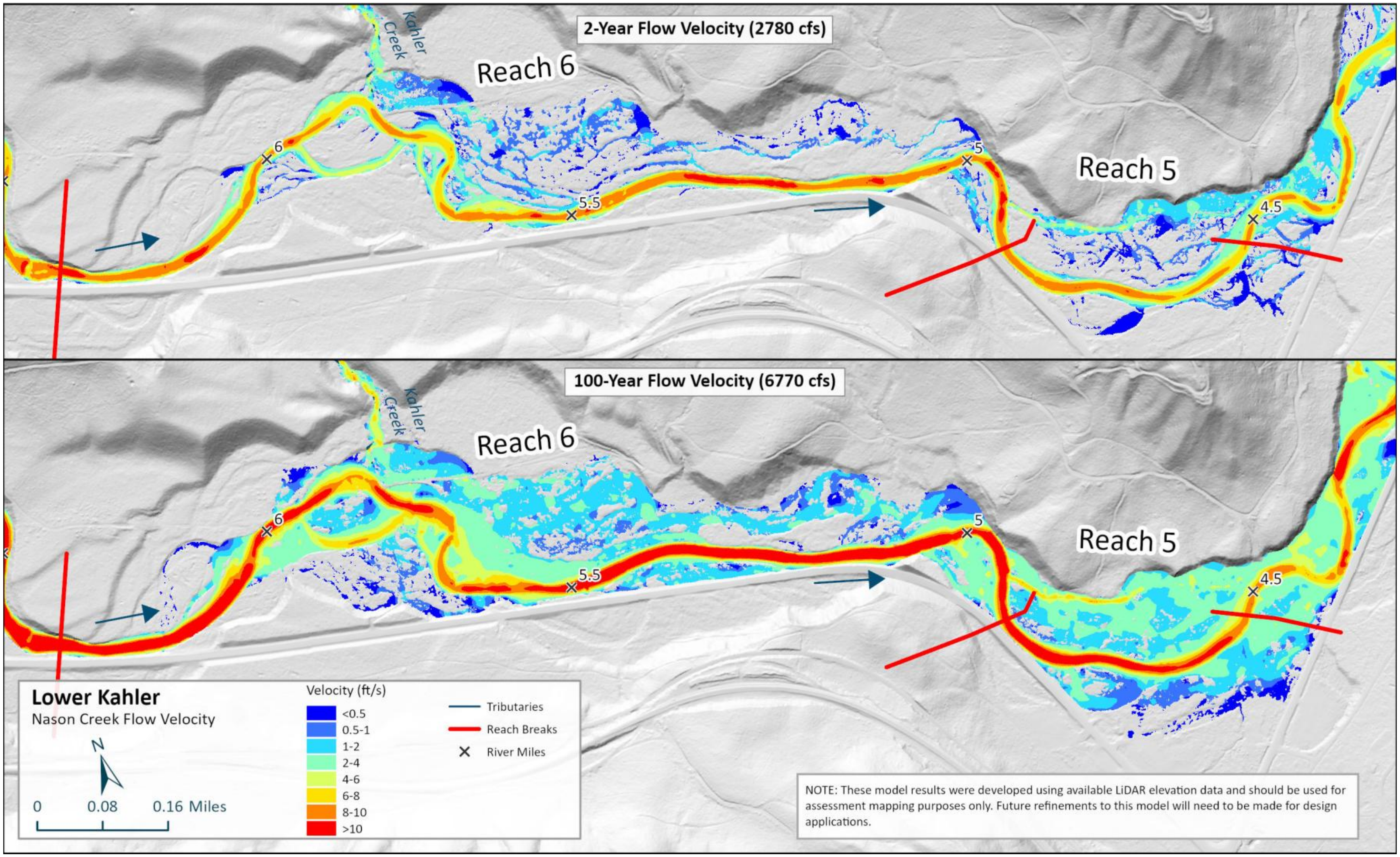

Figure 78. Modeled velocity results for Segment 3

6.3.3 Large Wood Material

Large wood processes are impaired in this segment. Piece numbers are very low and do not meet standards (see REI, Section 5). Recruitment and retention processes are also impaired due to past channel manipulations and young or absent woody vegetation. There is very little wood in Reach 5 and none of it is providing any significant geomorphic influence on the channel. Much of the wood in this reach is associated with the river-left side-channel that runs through most of this reach. Reach 6 has slightly more wood than Reach 5 but still very little, and the wood that does exist is not proving much geomorphic function. It often consists of single pieces or small jams that are along the banks, outside of the active channel, or located in off-channel areas (Figure 79 and Figure 80).

The channel cutoffs from the highway, vegetation clearing at the BPA powerline corridor, residential uses, and past timber harvest have severely impaired large wood numbers, recruitment, and retention. A few areas where natural channel scrolling and recruitment would naturally occur are either cut off due to the highway and/or are armored with riprap. The greatest amount of lateral migration is currently occurring from RM 5.7 to 6.2. However, much of this segment is within the BPA powerline corridor and so there are no available trees to recruit. Even areas not within the corridor have very young vegetation.

Figure 79. Small log jams tight against bank on river-left near RM 5.8.

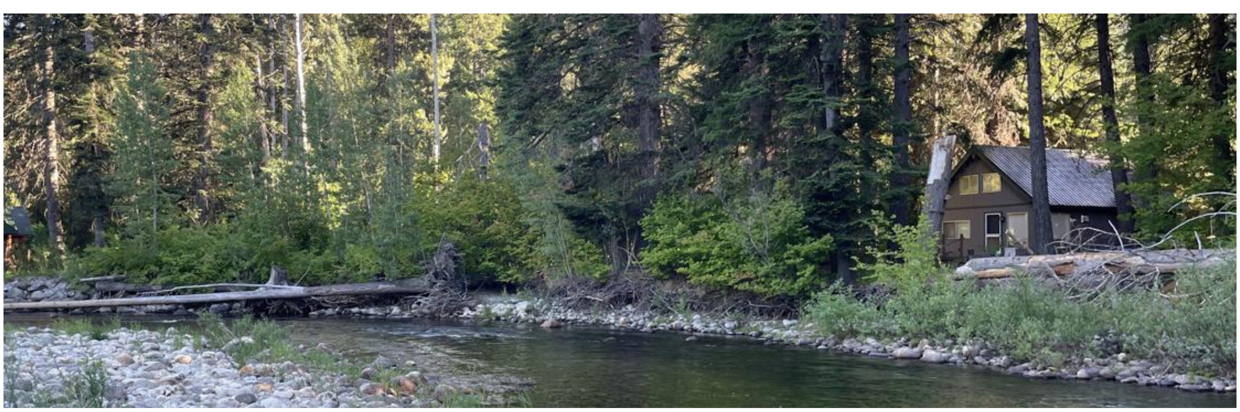

Figure 80. View downstream near RM 5.65. Single large wood pieces can be seen downstream along bank and one piece on the right extending above the channel.

Figure 81. Large wood frequency and jams in Segment 3.

6.3.4 Vegetation

Vegetation in Segment 3 varies along the segment and is highly affected by past clearing and ongoing human alterations and infrastructure. The overstory, where it exists, tends to be dominated by cottonwood, fir, western red cedar, and ponderosa pine, with the understory comprised of alder, maple, cottonwood, willow, and dogwood. Reed canary grass occupies some lower surfaces and wet off-channel areas but is not as prevalent as it is downstream. Along the highway sections is mostly unvegetated with some narrow buffers of young cottonwood, pine, and fir. The largest stands (with trees >150-ft tall) are located across the river-right bend at RM 5 and in the river-right floodplain from RM 5.7 to 6.0 (Figure 82). The entire segment has been impacted by past harvest of riparian and floodplain trees. Modern riparian clearing continues to occur in a few locations with the largest impact being the clearing within the BPA powerline corridor crossing from RM 5.8 to 6.0 (Figure 83). Large wood recruitment processes are impaired as described in the previous section. Shading from canopy cover is much less than would have been expected historically with larger trees. Lack of canopy due to the highway being located to the south of the channel through much of Reach 6 also affects shading. A vegetation height map is included for reference in Figure 84.

Figure 82. Large pine and fir on river-right. View is looking downstream from RM 5.7.

Figure 83. View looking downstream near RM 5.9 at area of channel with denuded riparian vegetation within the BPA powerline corridor (Inter-Fluve photo July 2025).

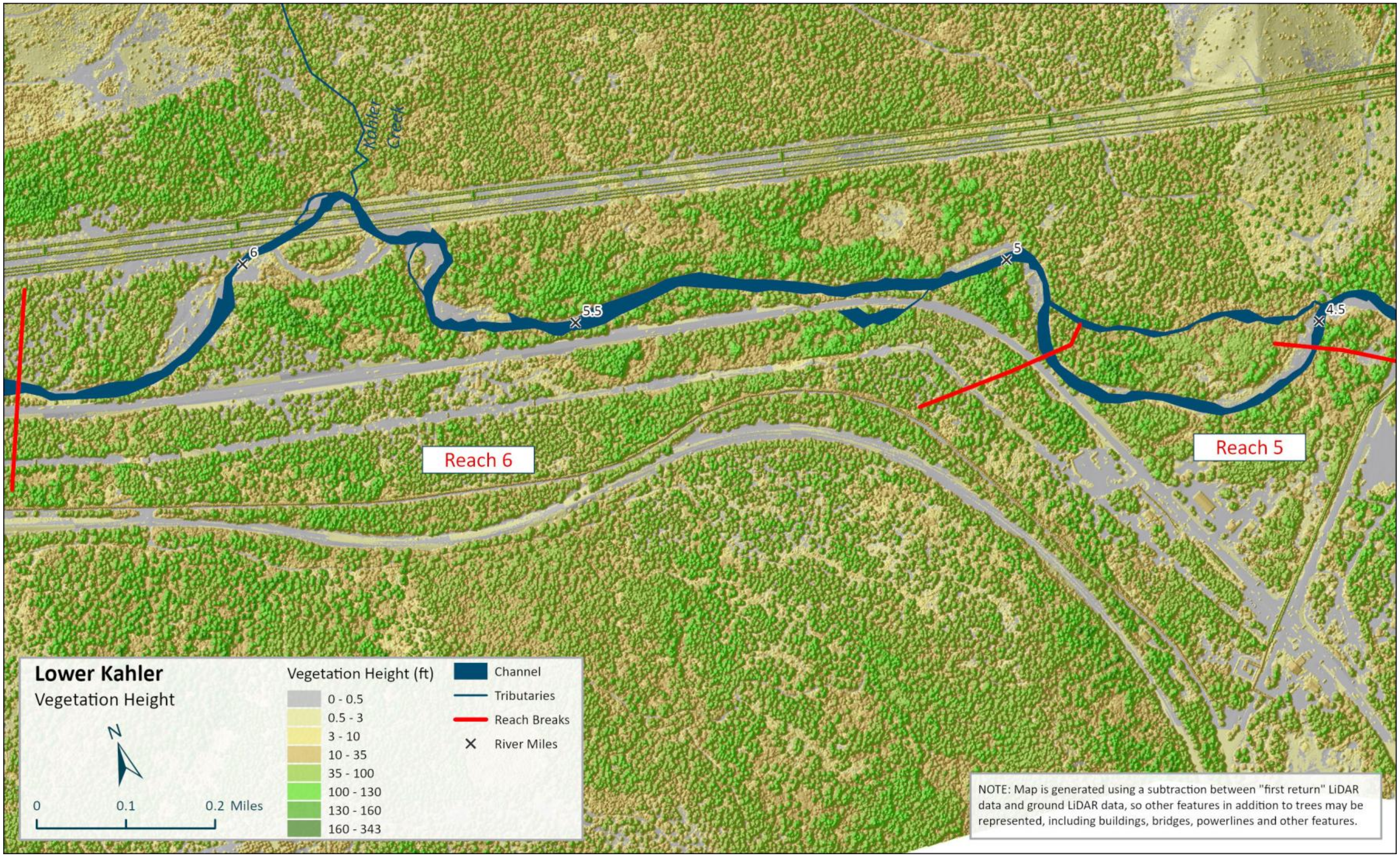

Figure 84. Vegetation heights along Segment 3 of Nason Creek.

6.3.5 Past Restoration Projects

There has not been any significant past restoration work in this segment. There is one project that is in the planning and design stage in this section (Figure 85). This is the Nason Creek RM 6 Thermal Refuge Project (Chelan County) from RM 6.3 to 6.7 around the Kahler Creek confluence. Preliminary plans for this project include mainstem and side-channel log jams, some of which are designed to enhance habitat conditions at cold water input areas including at the mouth of Kahler Creek.

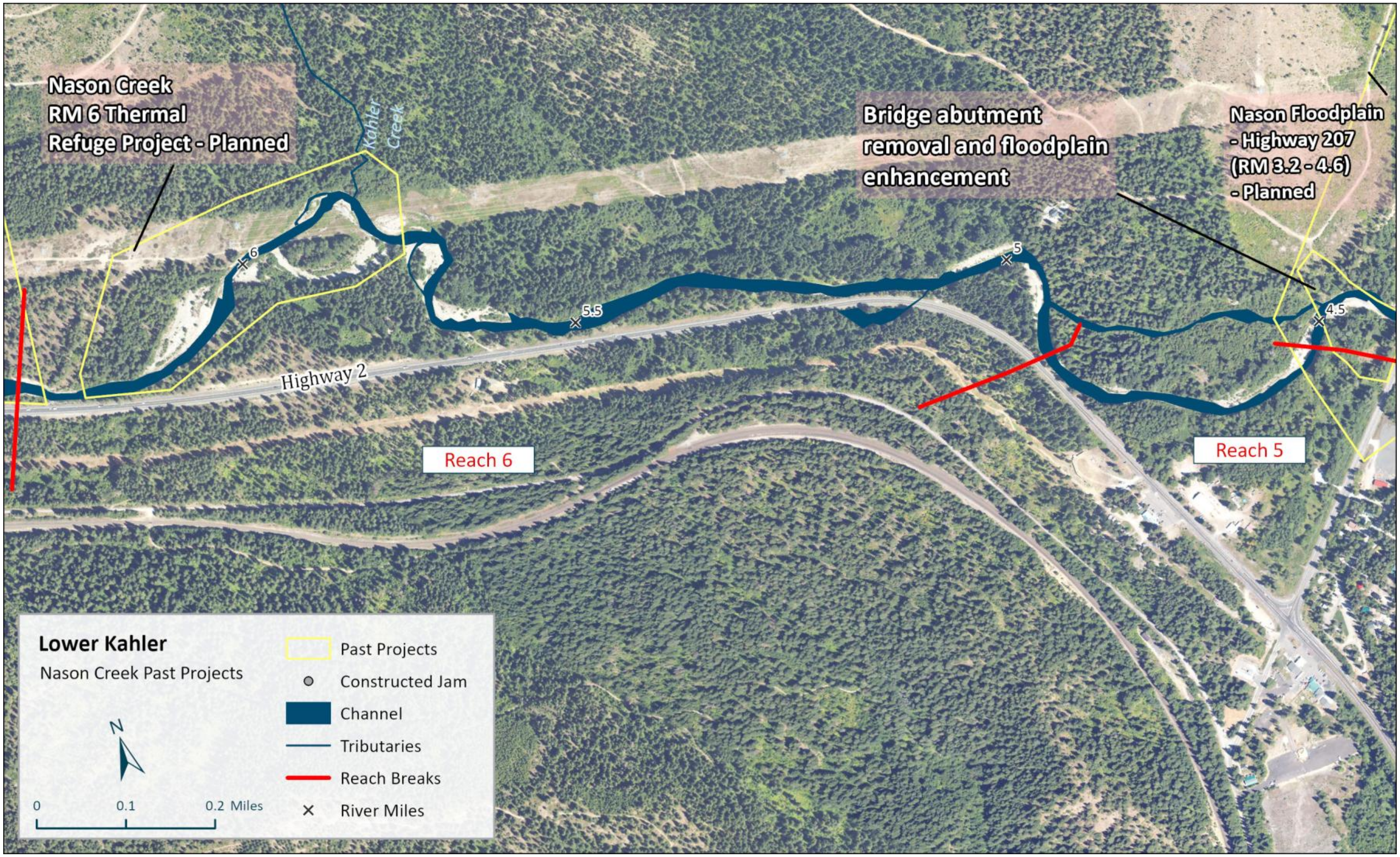

Figure 85. Past and planned projects within Segment 3.

6.3.6 Project Opportunity Summary

Two projects have been identified in this segment. The Coles project area incorporates all of Reach 5 and a portion of Reach 6. This project includes main channel log structures to create flow-splits, encourage lateral process, capture and sort bed material, and provide complex cover. There are also a few locations for creation, activation, or enhancement of side- and off-channel habitat, including potentially some long side-channel activation in the river-left floodplain from RM 5 to 5.4. There is floodplain fill that could be removed near Coles Corner, mainly in the river-right floodplain but also likely some in the river-left floodplain. A larger infrastructure modification to consider is the re-alignment of Highway 2 along the old Merritt-Winton road adjacent to the railroad. This would allow for the reconnection and restoration of areas formerly cut off by highway fill.

The Kahler Project area encompasses the remainder of Reach 6 plus Reach 7 and therefore extends into Segment 4. This area has been the site of extensive past recent restoration work and future planned work. Most of the past work has included main channel log jams, with some limited side-channel activation and some side-channel log structure placement. Future planned work includes work around the Kahler Creek confluence to enhance thermal refuge habitat. This work is reflected in the recommended project actions. Additional main channel complexity work using log jams is included throughout the project area to create flow-splits, encourage lateral process, capture and sort bed material, and provide complex cover. There are also a few locations for creation, activation, or enhancement of side- and off-channel habitat. Jams that would serve to aggrade the main channel and thereby reduce past incision would help to reconnect floodplains, but the proximity of the highway and some residences provide challenges. A larger infrastructure modification to consider is the re-alignment of Highway 2 along the old Merritt-Winton road adjacent to the railroad. This would allow for the reconnection and restoration of areas formerly cut off by highway fill. Other more localized modifications include shifting the river away from the highway where the channel directly abuts the highway embankment with hard armoring. This could either be a very local shift to create a forested buffer between the channel and highway or could be a more aggressive shift into existing floodplain channel scars, such as at the bend from RM 6.8 to 6.9. These actions would remove the direct influence of the highway but would not necessarily address channel incision and the more fundamental floodplain disconnections created by the highway fill.

6.4 SEGMENT 4 – UPPER KAHLER (REACHES 7-9)

6.4.1 Overview

The Upper Kahler segment includes reaches 7-9 and extends from RM 6.3 to 9.2. The upstream boundary of the segment is the Highway 2 crossing and the downstream boundary is located at a point where the highway directly abuts the channel at RM 6.3. Landownership is mostly private, with National Forest dominating the downstream portion (Reach 7) and Washington State land in the rest stop area in Reach 9. The segment has been significantly impacted by road fill associated with construction of Highway 2, which has disconnected portions of the channel and floodplain in two locations. Bank armoring is located at these and other locations. The 300-ft wide BPA powerline corridor crosses the channel in the downstream portion of the segment in Reach 7, with severe impacts to riparian vegetation. The CPUD powerlines, and its narrower ~50-ft cleared corridor, also cross the channel in multiple locations. Floodplain fill, the Gill Creek Road bridge (and associated approach fills), and residential development provide additional impairments to channels, riparian zones, and floodplain connectivity. Representative photos of the segment are included in Figure 86, Figure 87, and Figure 88.

Table 11. Key segment metrics. Metrics collected during the Habitat Assessment are discussed in Appendix A.

	Length (miles)	River Mile	Stream Gradient (%)	Sinuosity	Dominant Habitat Unit Type	Average Bankfull Width (ft)	Confinement	Dominant Substrate	% Pool Habitat	% Glide Habitat	% Riffle Habitat	% Side Channel	% Other Habitat
Reach 7	1.1	6.3-7.4	0.96%	1.70	Riffle	79	Confined	Boulders	20%	0%	67%	12%	0%
Reach 8	1.2	7.4-8.6	0.34%	2.23	Pool	74	Confined	Gravels/Cobble	57%	3%	36%	4%	0%
Reach 9	0.6	8.6-9.2	0.37%	1.15	Pool	93	Confined	Gravels	50%	14%	27%	5%	0%

Figure 86. View downstream near RM 8.7 (Reach 9) where the channel is naturally confined, steeper than up- and downstream reaches, and boulder-bed (Inter-Fluve photo July 2025).

Figure 87. View upstream from the Butcher Creek Rd bridge at RM 7.9. Residential impacts can be seen to the left. Low surfaces are dominated by reed canary grass (Inter-Fluve photo July 2025).

Figure 88. View upstream at steep boulder-bed channel looking upstream toward powerline crossing at RM 6.5 (Inter-Fluve photo July 2025).

River process and habitat conditions are degraded in this segment due to past and ongoing anthropogenic impacts including channel cut-offs, straightening, bank armoring, transmission line corridors, and residential development in the riparian area and floodplain. Pool frequency and quality is lacking, despite reaches 8 and 9 having significant total percentage pools (Table 11). Pools are long and lack cover and complexity. A lack of natural large wood contributes to the lack of pools and lack of complexity overall. Large wood abundance is relatively high in Reach 7, but this is nearly entirely due to past restoration work, and this wood is concentrated into constructed log jams or is placed in side-channel habitat with limited overall geomorphic influence at the reach-scale. LW in Reach 8 barely meets standards, and only because of past restoration work. LW in Reach 9 does not meet standards. Large wood recruitment processes are severely limited due to bank armoring and cleared or young riparian vegetation. Except for Reach 7, side channel habitat is lacking and overall is lower than would have been expected historically prior to channel cut-offs, floodplain constrictions, and floodplain fill.

Past restoration work has improved conditions in some areas, including improvements to mainstem and side-channel complexity and cover from large wood placements. A lot of this work has occurred under the BPA powerlines, which helps to improve habitat in these otherwise denuded segments. However, there remain significant opportunities for restoration, some of which may require infrastructure modifications to realize meaningful improvements.

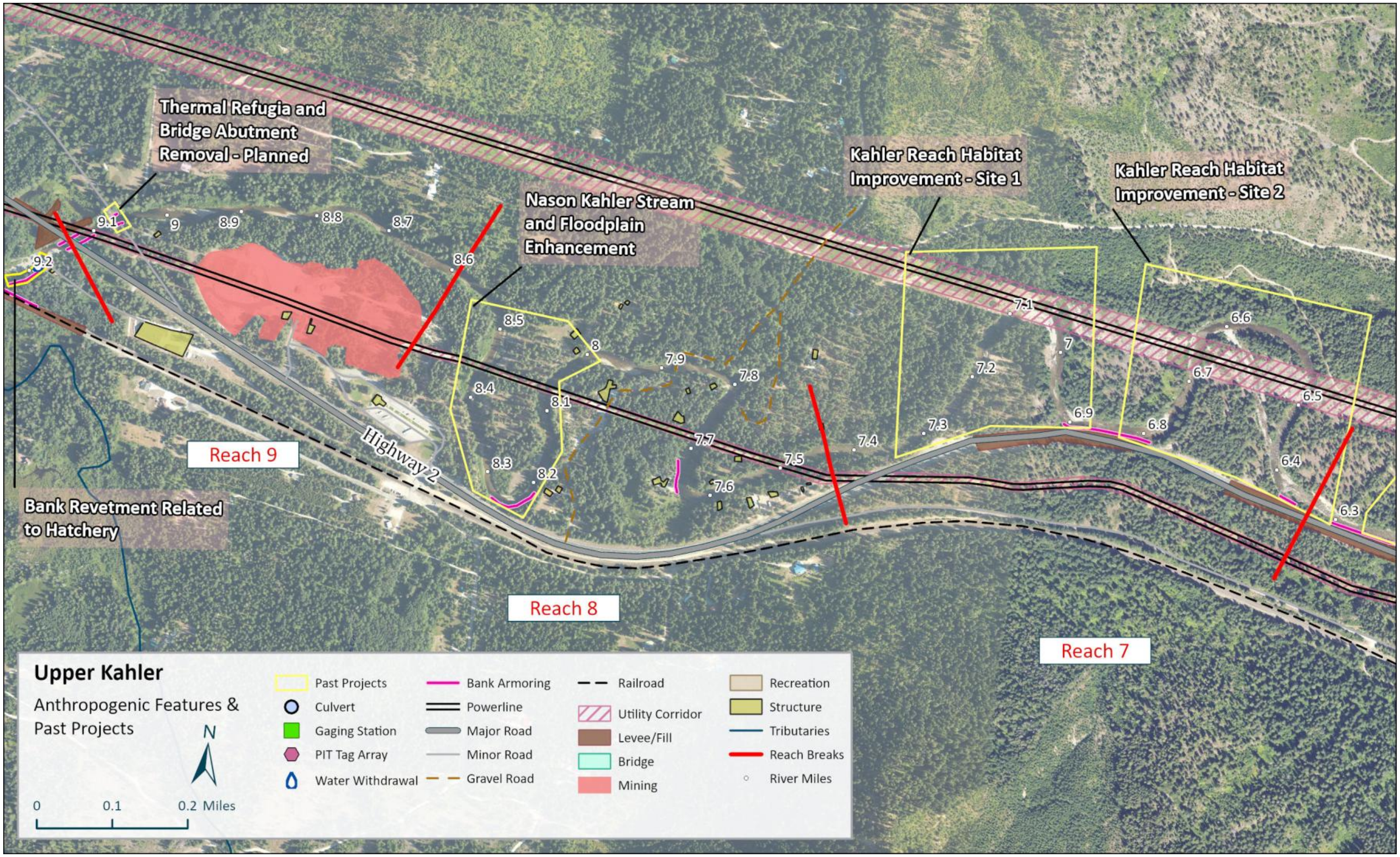

Figure 89. Mapped anthropogenic features and past projects in Segment 4.

6.4.2 Channel and Floodplain Geomorphology

This segment ranges from confined to unconfined (under historical conditions) and is steeper, overall, than upstream reaches. It marks a transition from the low gradient reaches upstream to steeper downstream channels including reaches 6 and 7. The upper portion of this segment (Reach 9) is a confined reach, where the valley is confined by glacial deposits to the south and landslide deposits to the north. Reach 9 has a slope of 0.37% and is characterized by low gradient pools and glides with some long and steep boulder riffles (Figure 86). Due to natural confinement, there are no significant human constraints on channel function in Reach 9 except for a reduction in large wood.

Moving downstream, reaches 7 and 8 are less confined than Reach 9. Channel type is pool-riffle. Similar to the Lower Kahler Segment, these reaches are laterally bounded by sets of terraces of glacial origin resulting from the multiple alpine glaciers that advanced and retreated in the valley (Figure 90) (U.S. Bureau of Reclamation 2008). Floodplain channel scars indicate past scrolling within the modern floodplain. Glacial terraces and alluvial fans limit the extent of the natural floodplain and active channel migration zone within the valley bottom. The maximum width of the Holocene alluvium is approximately 1,100 feet, which occurs in Reach 8. The width is narrower in Reach 7, where it is closer to 600 feet, on average. Reach 7 is the steepest of the three reaches in this segment, with almost a 1.0% slope and channels dominated by large cobble / small boulder riffles (67% riffle habitat).

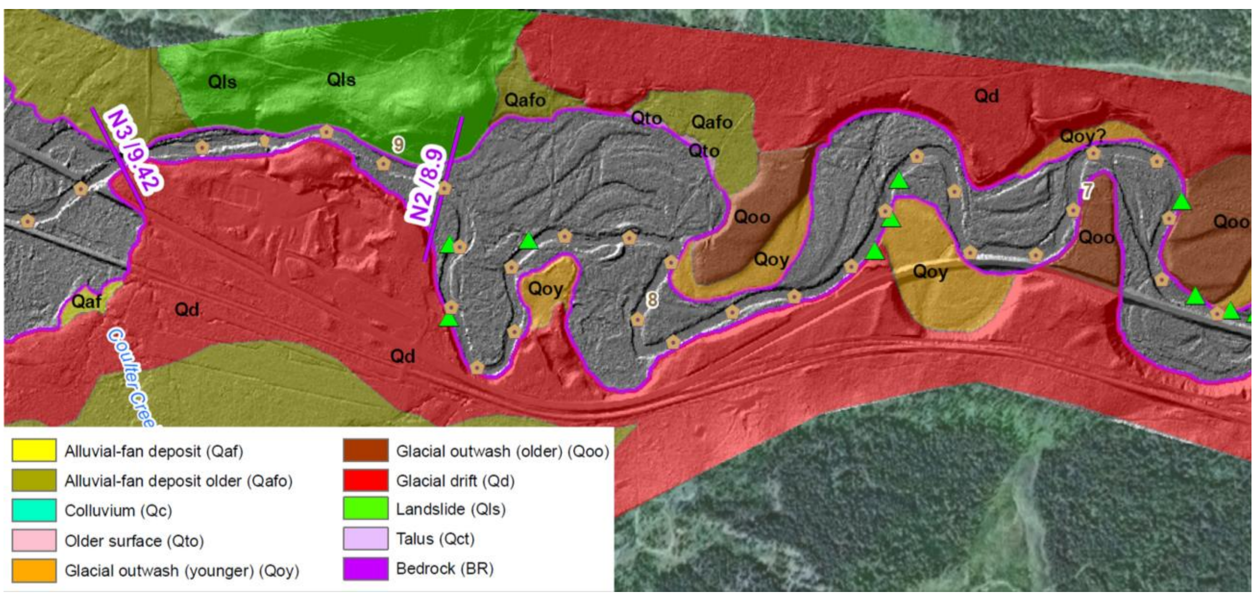

Figure 90. Copy of surficial geology map of the valley floor in Segment 4, reproduced from the Nason Creek Tributary Assessment – Map Atlas** (U.S. Bureau of Reclamation 2008)**. Gray (non-color) areas are Quaternary Sediments, with the exception of anthropogenic fill that is not mapped. Note that river miles are slightly different than other river miles used in this report.

Past human alterations and infrastructure have had a significant impact on channel and floodplain processes in reaches 7 and 8. In Reach 8, the primary impacts are floodplain fill associated with residential development and the Butcher Creek Road bridge crossing at RM 7.9. The bridge and the approach fills confine the channel in its current location and impact the natural floodplain inundation patterns and extents. There is currently a large portion of the historical floodplain to the north that is not inundated at the 100-year flood (Figure 97 and Figure 98), which is assumed to be reduced inundation compared to historical conditions prior to channel confinement and floodplain fill. Channel scars to the north of the bridge crossing are 4-5 feet higher than the mainstem based on LiDAR analysis. Continuing downstream into Reach 7, there is less floodplain filling from residential development due to National Forest lands. The greatest impacts to channel function in Reach 7 have been sections of former main channel and floodplain that were cut off from the construction of Highway 2 (Figure 91). This occurred on the south side of the channel around RM 6.3 and 6.9. Based on elevations, the downstream disconnection likely involved the shifting of the main channel to the north against the highway, whereas the upstream disconnection likely disconnected a historical channel scar and floodplain area, with only a minor shift in active channel location (though also now against the highway embankment). Modeling indicates that the 100-year flood currently occupies only a fraction of the historical floodplain, which may be related to these cut-offs and associated channel incision. As described in Segment 3, due to the glacial terrace to the north, the channel relocation at RM 6.3 narrowly confined the channel to essentially one channel-width wide, and included a significant lowering of the base level of the channel, which may have been worsened over time due to incision in what is now a very high energy section of channel (Figure 98).

Figure 91. View downstream at riprap along the road fill on river-right near RM 6.9.

Dominant bed and bank sediments in the segment range from gravels to boulders, with large gravel dominant in Reach 9, gravels and cobbles codominant in Reach 8, and small boulders dominant in Reach 7. All reaches have long boulder-dominated riffles, although gravel and cobble dominated riffles are also common in reaches 8 and 9. Sources of bed material vary throughout the segment. In Reach 9, a range of material sizes are sourced from the glacial and landslide deposits, with a section contributing significant amounts of boulders near RM 8.8 (Figure 92). Most of the material sourced to the channel in reaches 7 and 8 comes from erosion into glacial deposits. This is especially prevalent at the outside of the bends near RM 6.5 and 7.0 (Figure 93). There are also some areas of erosion into the more modern floodplain surface, such as on river-right near RM 6.4 (Figure 94). Recruitment of bank material has been reduced due to the confinement of the channel midway through Reach 8, which has reduced lateral scrolling. Bank armoring has eliminated recruitment of material from the banks in several locations, including at RM 7.65 (Figure 95) and where the channel abuts the highway fill (e.g. Figure 91). In some cases, constructed large wood structures have also reduced recruitment of bank sediments, at least for the near-term. With respect to vertical bed stability and trends in slope, geologic assessments and interpretations suggest that the underlying geology exerts a strong influence and stability on the channel profile, despite the significant human alterations including channel shortening due to the highway (U.S. Bureau of Reclamation 2008).

Figure 92. Boulders sourced from river-right bank near RM 8.8.

Figure 93. View downstream near RM 6.5 where the river is eroding into glacial deposits on the river-left bank.

Figure 94. Bank material being recruited on river-right bank near RM 6.4.

Figure 95. Bank armoring on river-right bank near RM 7.65.

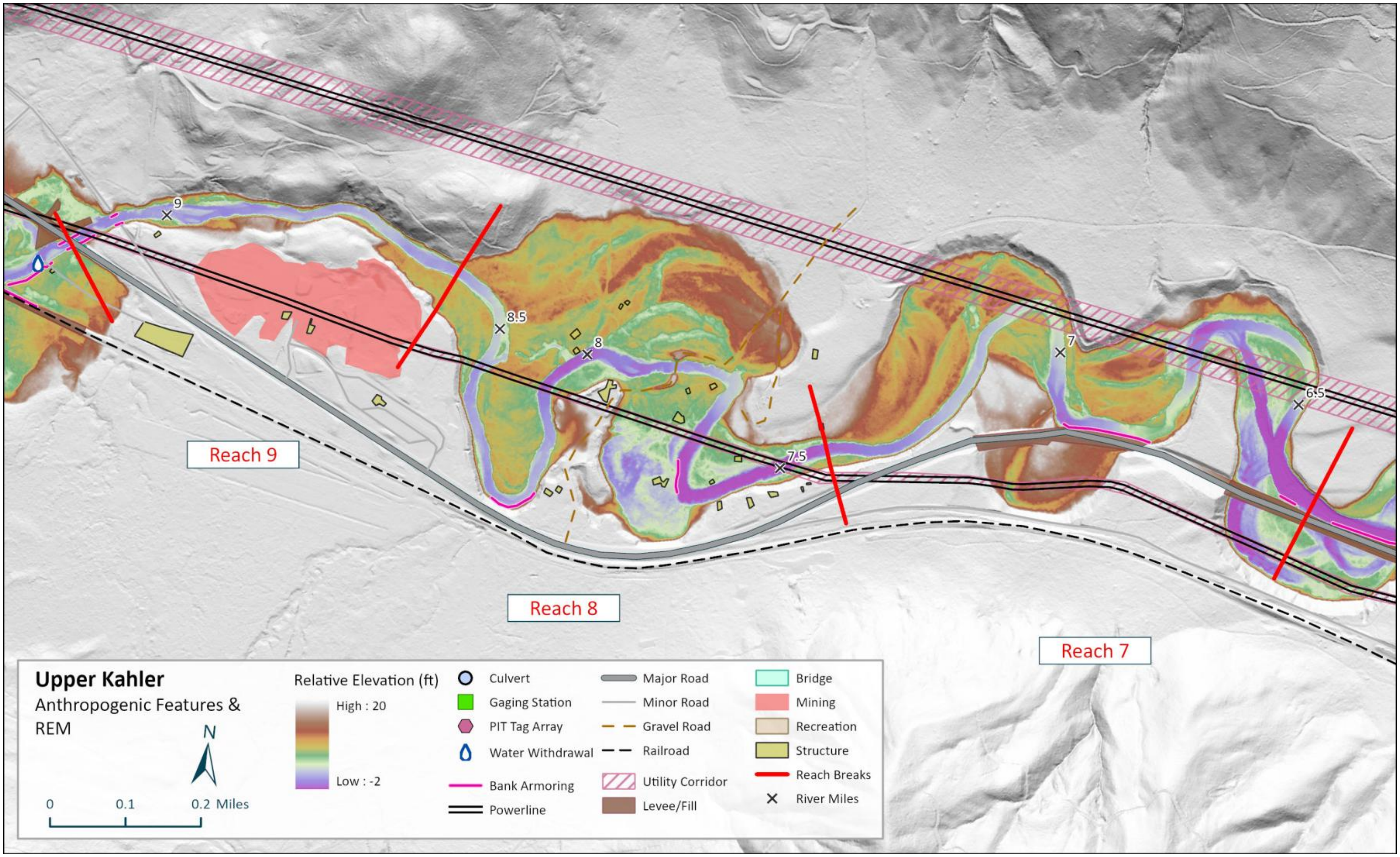

Figure 96. Mapped anthropogenic features and relative elevation map for Segment 4.

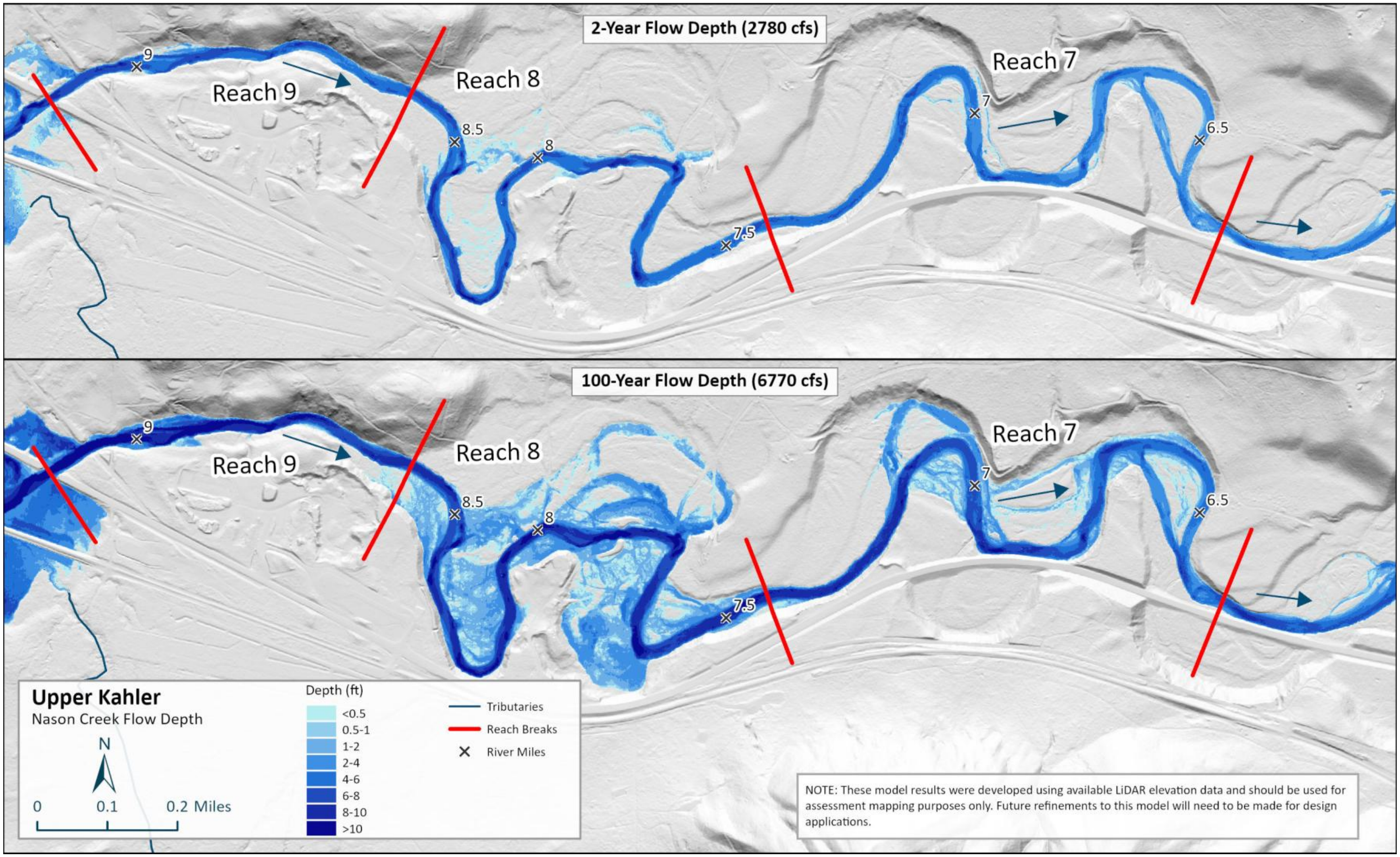

Figure 97. Modeled depth results for Segment 4.

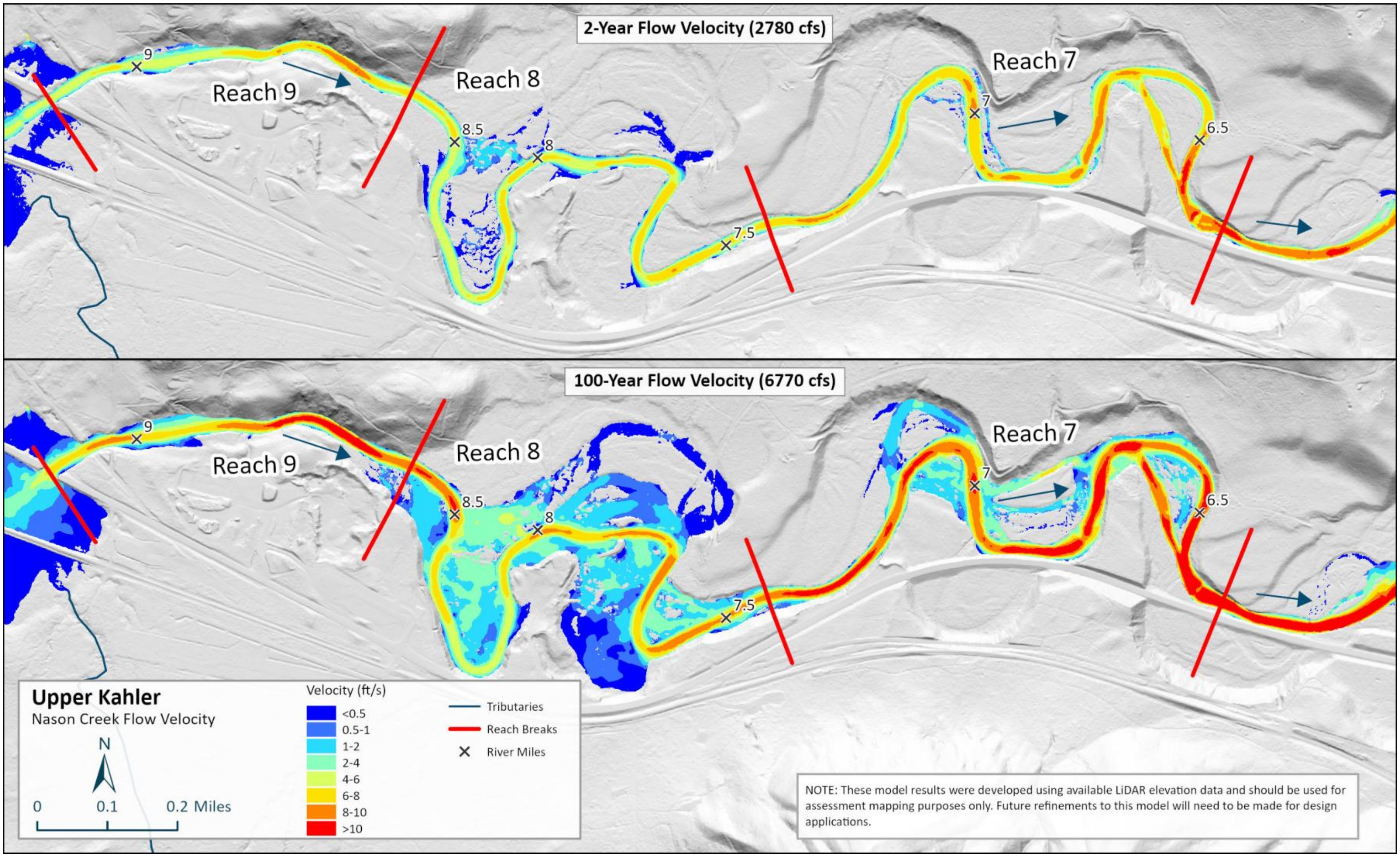

Figure 98. Modeled velocity results for Segment 4.

6.4.3 Large Wood Material

Large wood processes are impaired in Segment 4, with large wood conditions very similar to those in Segment 3. The one exception is that Segment 4 has had more restoration project work that has added large wood, significantly increasing piece numbers in those locations. Reach 7 has had the most placement of large wood, and piece numbers are accordingly very high (see REI, Section 5) (Figure 102). Reach 8 has received less wood placements but enough to bring the piece numbers above the threshold for properly functioning (Figure 106). Reach 9 does not meet standards. In all reaches, despite some high localized piece counts, large wood is lacking in many areas and recruitment and retention processes are impaired.

Most of the wood in Reach 7 is located from RM 6.4 – 7.2 and is concentrated in jams placed as part of restoration project work (Figure 99). These jams are relatively new and are providing some geomorphic functions including flow-splitting, pool scour, and sediment sorting/capture. Other, non-placed, wood is fairly scarce in the reach and is not providing any significant geomorphic influence. The total piece count for medium and large pieces in Reach 7 is 244; however, without the placed wood, there would only be 36 pieces, well below the standard of 67 pieces per mile. In Reach 8, nearly all the wood is placed wood, with only 10 of the 73 medium or large pieces being natural, and none of these are providing any significant geomorphic influence on the channel. Reach 9 has low wood overall. The wood that does exist is not providing strong geomorphic influence on the channel and is mostly along the banks (Figure 100) or in backbar channels.

Figure 99. Constructed large wood structures near RM 7.1.

Figure 100. Wood along bank near RM 8.9.

The channel cutoffs from the highway, vegetation clearing at the BPA powerlines, residential uses, and past timber harvest have severely impaired large wood numbers, recruitment, and in-channel retention. A few areas where natural channel scrolling and recruitment would naturally occur are either cut off due to the highway and/or are armored with riprap. The greatest amount of recent lateral migration has occurred at the RM 6.6 and 7.1 bends. However, much of this segment is within the BPA powerline corridor and so there are no available trees to recruit. The placed wood from the restoration work may slow recruitment in some areas but may increase it in others. There was some recruitment of large trees observed from toe erosion of the landslide deposits in Reach 9 on the river-left bank near RM 8.7 (Figure 101). Overall, however, there is young vegetation throughout the segment (see Vegetation section below and Figure 105) that would typically not yield large enough trees to be able to be retained in the channel and serve as key pieces.

Figure 101. View of left bank near RM 8.7. Wood recruitment from mass wasting.

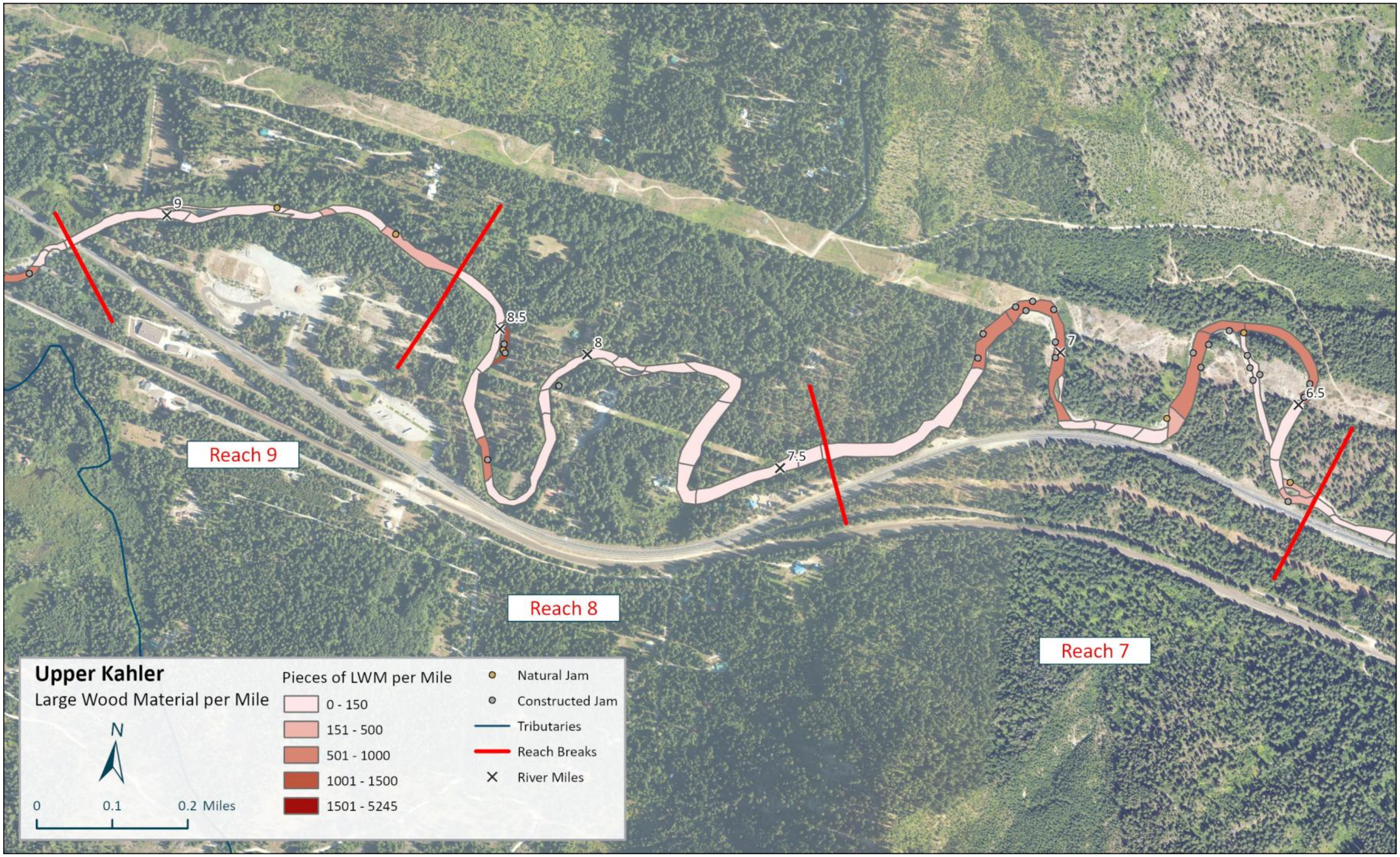

Figure 102. Large wood frequency and jams in Segment 4.

6.4.4 Vegetation

Vegetation in Segment 4 is similar to Segment 3, especially given the similar impacts from the powerline crossing (Figure 103). However, there are fewer areas of large trees >150 ft tall and more areas of riparian clearing, possibly due to more private landownership. As in downstream areas, the overstory tends to be dominated by a combination of cottonwood, fir, and ponderosa pine, but there is less cedar in this segment. The understory is typically comprised of young cottonwood, alder, willow, maple, and dogwood, with lessor amounts of hawthorn, spirea, Pacific ninebark, rose, Oregon grape, and possibly cascara. The entire segment has been impacted by past harvest of riparian and floodplain trees. Apart from the highway and powerlines, recent riparian clearing has occurred in a few locations related to residential uses and other forest management. Clearing has occurred associated with homes from RM 7.5 to 8.5. The floodplain across the bend on river-left between RM 6.8 to 6.9 is sparsely vegetated, with widely-spaced pines (Figure 104). This is common in a few other areas, and may be related to drier conditions on higher glacial outwash surfaces that are not that well-connected to flood flows. Overall, as described previously in the Large Wood Material section, large wood recruitment processes have been disrupted. There is recruitment happening but it is mainly of young or medium-aged trees. There is also relatively little shade being provided by the canopy. A vegetation height map is included for reference in Figure 105.

Figure 103. View form terrace looking upstream near RM 7 at section of denuded riparian vegetation within the BPA powerline corridor (Inter-Fluve photo July 2005).

Figure 104. Sparsely vegetated floodplain river-left at RM 6.85.

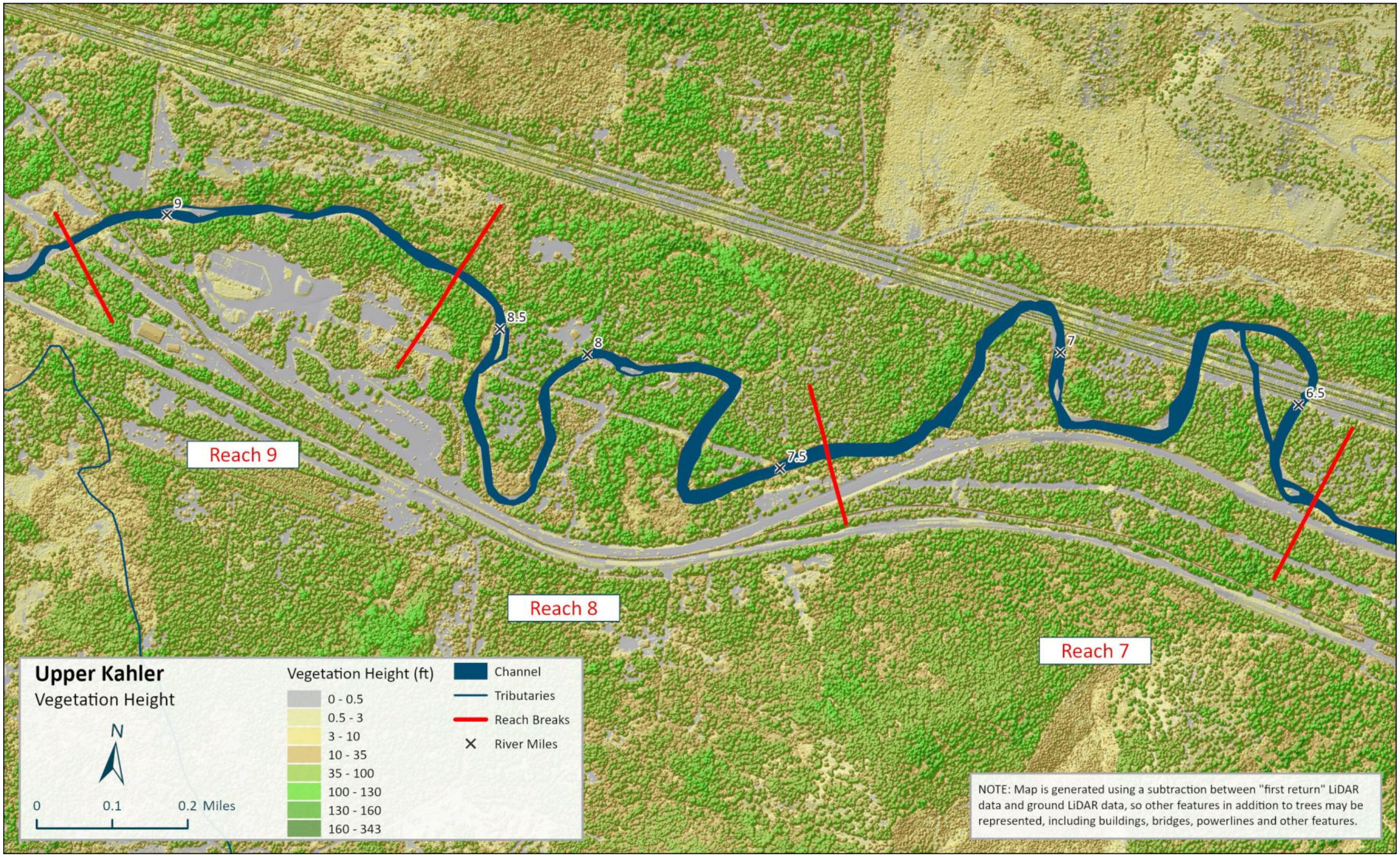

Figure 105. Vegetation heights along Segment 4 of Nason Creek.

6.4.5 Past Restoration Projects

There have been three constructed projects and there is one planned project in this segment (Figure 110). In 2019, the Nason Kahler Stream and Floodplain Enhancement Project (Yakama Nation) was constructed from RM 8.0 to 8.5. This project included mainstem large wood placements, off-channel enhancement using large wood, avulsion abatement, and revegetation. The mainstem log jams were observed during the early July 2025 field surveys and were helping to maintain deep and complex scour pools (Figure 106). The enhanced side-channel near RM 8.5 was active and very complex with abundant large wood cover (Figure 107).

Figure 106.Nason Kahler project constructed log jam near RM 8.35.

Figure 107. Enhanced side-channel with large wood complexity on river-left near RM 8.5.

The Kahler Reach Habitat Improvement Project (Chelan County) was constructed in two phases with Site 1 (RM 6.8 to 7.3) completed in 2022 and Site 2 (RM 5.7 to 6.3) completed in 2024. The project mostly occurred within the BPA powerline corridor and consisted of installation of large wood structures, side-channel connection grading, road decommissioning, and revegetation. At Site 2, large wood jams were placed in the mainstem and also in the side-channel that extends across the river-right bar from RM 6.6 to 6.4 (Figure 108). Site 1 mainly consists of bank-attached log jams, with one apex jam near RM 7 (Figure 109). During the early July 2025 field survey, the jams at both sites appeared to be providing localized pool scour, collecting small wood debris, and providing some sediment sorting. The project is fairly new and may take some time to initiate channel responses. The site will continue to be challenged by the vegetation clearing within the powerline corridor.

There is one planned project in this segment, the Nason Creek Thermal Refugia and Bridge Abutment Removal Project (Chelan County). This project includes removal of abandoned wooden bridge abutments and former road fill, large wood and boulder habitat placements, and riparian revegetation. The project is located at a former road/bridge crossing at RM 9.06.

Figure 108. Constructed large wood structures in river-right side-channel near RM 6.6.

Figure 109. Constructed jam splitting flow along river-right bank near RM 7.0.

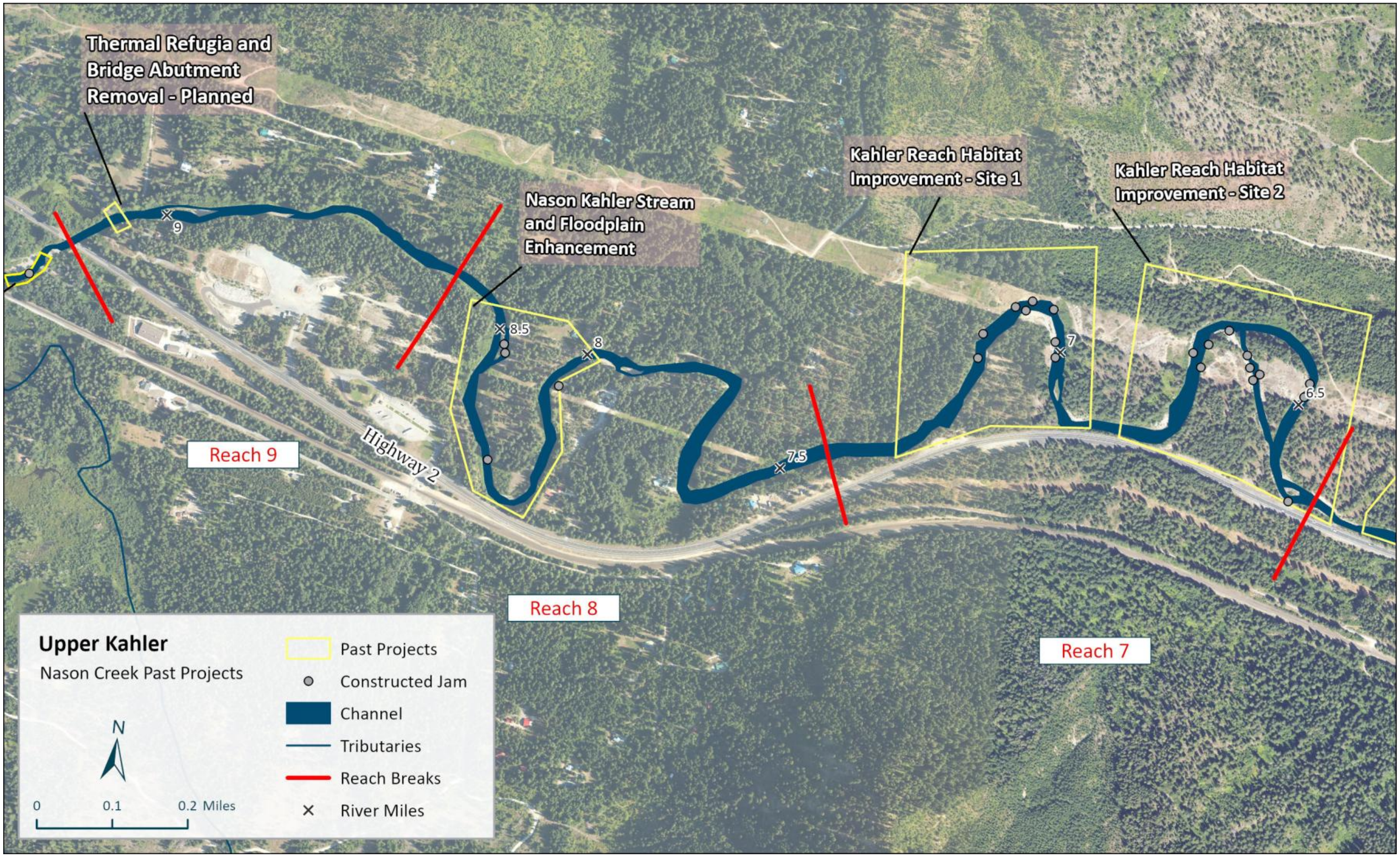

Figure 110. Past and planned projects within Segment 4.

6.4.6 Project Opportunity Summary

Two projects have been identified in this segment. The Kahler Project area encompasses all of Reach 7 and a portion of Reach 6 and therefore extends downstream into Segment 3. Because this project spans two segments, the same project description is included from the Segment 3 Project Opportunity Summary section above (Section 6.3.6). This project area has been the site of extensive past recent restoration work and future planned work. Most of the past work has included main channel log jams, with some limited side-channel activation and some side-channel log structure placement. Future planned work includes work around the Kahler Creek confluence to enhance thermal refuge habitat. This work is reflected in the recommended project actions. Additional main channel complexity work using log jams is included throughout the project area to create flow-splits, encourage lateral process, capture and sort bed material, and provide complex cover. There are also a few locations for creation, activation, or enhancement of side- and off-channel habitat. Jams that would serve to aggrade the main channel and thereby reduce past incision would help to reconnect floodplains, but the proximity of the highway and some residences provide challenges. A larger infrastructure modification to consider is the re-alignment of Highway 2 along the old Merritt-Winton road adjacent to the railroad. This would allow for the reconnection and restoration of areas formerly cut off by highway fill. Other more localized modifications include shifting the river away from the highway where the channel directly abuts the highway embankment with hard armoring. This could either be a very local shift to create a forested buffer between the channel and highway or could be a more aggressive shift into existing floodplain channel scars, such as at the bend from RM 6.8 to 6.9. These actions would remove the direct influence of the highway but would not necessarily address channel incision and the more fundamental floodplain disconnections created by the highway fill.

The Rest Stop project area has relatively little opportunity for restoration actions due to a combination of natural and artificial confinement. The upstream portion, in Reach 9, is naturally confined. There are opportunities for enhancing large wood complexity here, and possibly some minor side-channel enhancements, but opportunities are generally limited. In the downstream portion of the project area, there is good opportunity for mainstem log structures to create flow-splits, encourage lateral process, capture and sort bed material, and provide complex cover, building off of past work. However, adjacent residential uses, the highway, and the Gill Creek Road crossing will limit the intensity of the approach. There may be opportunity for a few side-channel connections, including on river-left near the Gill Creek Road bridge. These would require excavation and a culvert or bridge under the road to the north. As with the Kahler Project downstream, a potential infrastructure modification to consider is to shift the channel away from the highway at the bend at RM 8.25 to create a forested buffer and improve channel margin habitat conditions. There are riparian reforestation opportunities in this area where private residential uses have resulted in vegetation impacts. There are also conservation opportunities in this project area, to prevent additional future impairments and to allow for future restoration work.

6.5 SEGMENT 5 – LOWER WHITE PINE (REACHES 10-11)

6.5.1 Overview

The Lower White Pine segment includes reaches 10 and 11 and extends from RM 9.2 to 11.25. The upstream end of the segment is just downstream of Merritt and the downstream end is at the Highway 2 bridge that crosses the river. Landownership is mostly private, with some CDLT conservation lands in Reach 11 and some Yakama Nation and National Forest lands in the former (now disconnected) floodplain across the railroad embankment. These reaches were severely altered with construction of the railroad in the late 1800s, which cut off portions of the channel and associated floodplain for nearly all of Reach 10 and nearly half of Reach 11. The channel was relocated into a straightened and ditched segment along the railroad embankment for much of the length of this segment. Highway 2 further severed floodplain connections at the downstream end of Reach 10. Residential development, floodplain fill, bank armoring, and transmission lines create additional impacts to the channel and floodplain. The 300-ft wide cleared BPA powerline corridor crosses the floodplain in Reach 11 and the CPUD powerlines run parallel and close to the channel through most of the segment. Representative photos of the segment are included in Figure 111, Figure 112, and Figure 113.

Table 12. Key segment metrics. Metrics collected during the Habitat Assessment are discussed in Appendix A.

	Length (miles)	River Mile	Stream Gradient (%)	Sinuosity	Dominant Habitat Unit Type	Average Bankfull Width (ft)	Confinement	Dominant Substrate	% Pool Habitat	% Glide Habitat	% Riffle Habitat	% Side Channel	% Other Habitat
Reach 10	1.05	9.2-10.25	0.13%	1.07	Pool	67	Confined	Gravels	69%	18%	10%	3%	0%
Reach 11	1	10.25-11.25	0.20%	1.10	Pool	68	Unconfined	Gravels	77%	0%	15%	8%	0%

Figure 111. View downstream near RM 10.6 showing typical simplified conditions in straightened reach long railroad embankment (right side of photo) (Inter-Fluve photo June 2025).

Figure 112. View downstream near RM 10.2 showing highly impacted channel and riparian conditions within the BPA powerline corridor (Inter-Fluve photo June 2025).

Figure 113. View downstream near RM 9.4 showing straightened section along railroad embankment (right side) (Inter-Fluve photo July 2025).

River process and habitat conditions are highly degraded in this segment due to past and ongoing anthropogenic impacts including channel relocation, straightening, incision, bank armoring, and residential development in the riparian area and floodplain. Although the reaches are dominated by pool habitat (Table 12), pool frequency is low and side channel habitat is much lower than would have been expected historically when the channel had more access to the full valley floor floodplain. Large wood pieces per mile are relatively high in Reach 11; however, most of this wood is concentrated in constructed jams or is within constructed off-channel habitat and does not have a strong geomorphic influence on the segment as a whole. Large wood pieces per mile barely meets standards for Reach 10. Large wood recruitment processes are severely limited due to bank armoring, levees, and cleared or young riparian vegetation. Riparian vegetation is highly affected by the highway, railroad, and transmission lines in places.

Past restoration work has improved conditions in some areas, and has prevented further degradation in the case of the Nason LWP First Bend Project. The largest improvements have been to off-channel habitat. However, there remain significant opportunities for restoration, some of which may require infrastructure modifications to realize meaningful improvements.

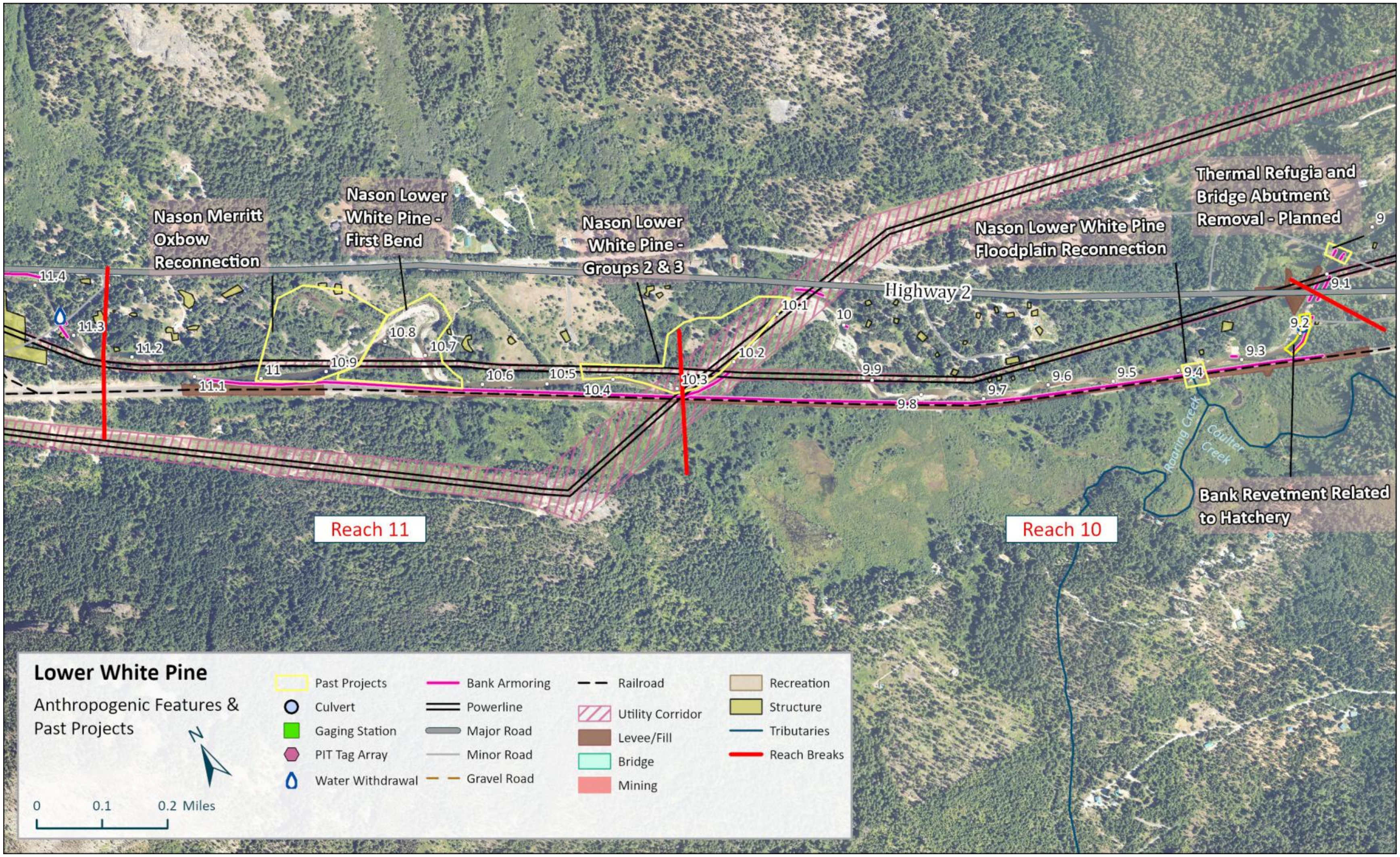

Figure 114. Mapped anthropogenic features and past projects in Segment 5.

6.5.2 Channel and Floodplain Geomorphology

The Lower White Pine segment is low gradient (<0.2%) and flows within a wide valley that was historically unconfined. There is a natural valley confinement at the downstream end of the segment created by glacial terrace deposits on the south and landslide deposits on the north. The historical floodplain and channel migration zone is bounded by alluvial fan, glacial deposits, and bedrock in at least one location (Figure 115). The channel is mostly pool-riffle.

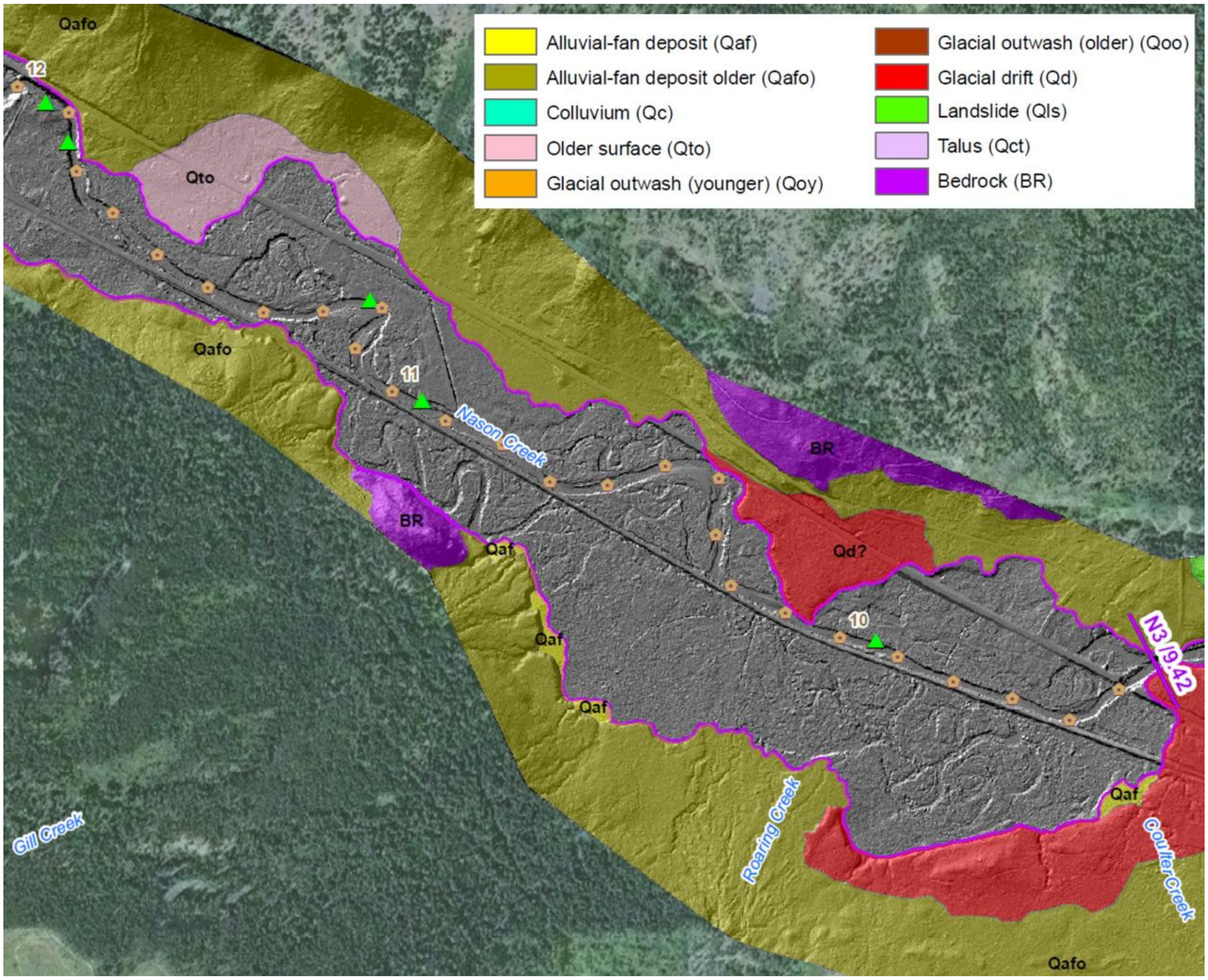

Figure 115. Copy of surficial geology map of the valley floor in Segment 5, reproduced from the Nason Creek Tributary Assessment – Map Atlas** (U.S. Bureau of Reclamation 2008)**. Gray (non-color) areas are Quaternary Sediments, with the exception of anthropogenic fill that is not mapped. Note that river miles are slightly different than other river miles used in this report.

This segment has been severely altered by past channel relocations due to infrastructure. The primary impact was the construction of the railroad embankment (originally the Great Northern Railway and now Burlington Northern Sante Fe), which cut off approximately 0.95 miles in Reach 10 and 0.85 miles in Reach 11, for a total of approximately 60% of the total historical channel length of the segment. The disconnected portions of the channel can be seen in Figure 116. The relocated portions of the channel are now located directly adjacent to the railroad embankment that is lined with riprap, with either a non-existent or only a very narrow vegetated riparian buffer (Figure 113). The section of disconnected channel in Reach 10 was reconnected at the downstream end via creation of an enlarged perforation (bridge) through the railroad embankment in 2013, which allows for hydrologic connection of surface water and fish access into this disconnected segment. The upstream disconnected segment in Reach 11 remains fully disconnected with only small culverts for drainage of tributary inflows. Gill Creek and Roaring Creek, which both enter Nason Creek from the south in this segment, first connect into the cut-off portions of the original Nason Creek channel across the railroad embankment. An additional impact to the segment includes the construction of Highway 2, which has filled and cut off portions of the historical floodplain and channel migration zone, with bank armoring along the highway near RM 10.1. The BPA powerlines and the CPUD powerlines also contribute to limited channel migration potential within the segment. Lastly, floodplain fill and armoring for residential development has further disconnected the floodplain and limited channel migration potential.

The relocation and straightening of the former channel has resulted in an incised and over-widened channel that has a lower base elevation than the former channel (Figure 116). The elevation difference is at least 3 feet based on analysis of LiDAR data. This has also been documented in past assessments, including the analysis to support the Nason Creek Lower White Pine Habitat Reconnection Project (perforation through railroad embankment near RM 9.4) in 2012 (ICF International 2012b). The confinement, incision, and widening, along with some areas of floodplain fill, have disconnected the channel from accessing its historical floodplain and channel migration zone. Modeling indicates that the 100-year flood continues to inundate a significant portion of the valley bottom in the disconnected area (Figure 120 and Figure 121); however, this is due to tributary inflows into the disconnected zone and not from connectivity to Nason Creek. In the model, this flow backs up as it enters Nason Creek through the reconnection point near RM 9.4. We recognize there are culverts under the railroad embankment (U.S. Bureau of Reclamation 2008) that would limit the extent of inundation in the disconnected zone, but these are not represented in the model, which is based on LiDAR data. Despite the broad inundation shown in the modeling, the natural exchange and flow of water between the floodplain and Nason Creek is severed and channel migration into this zone is prevented.

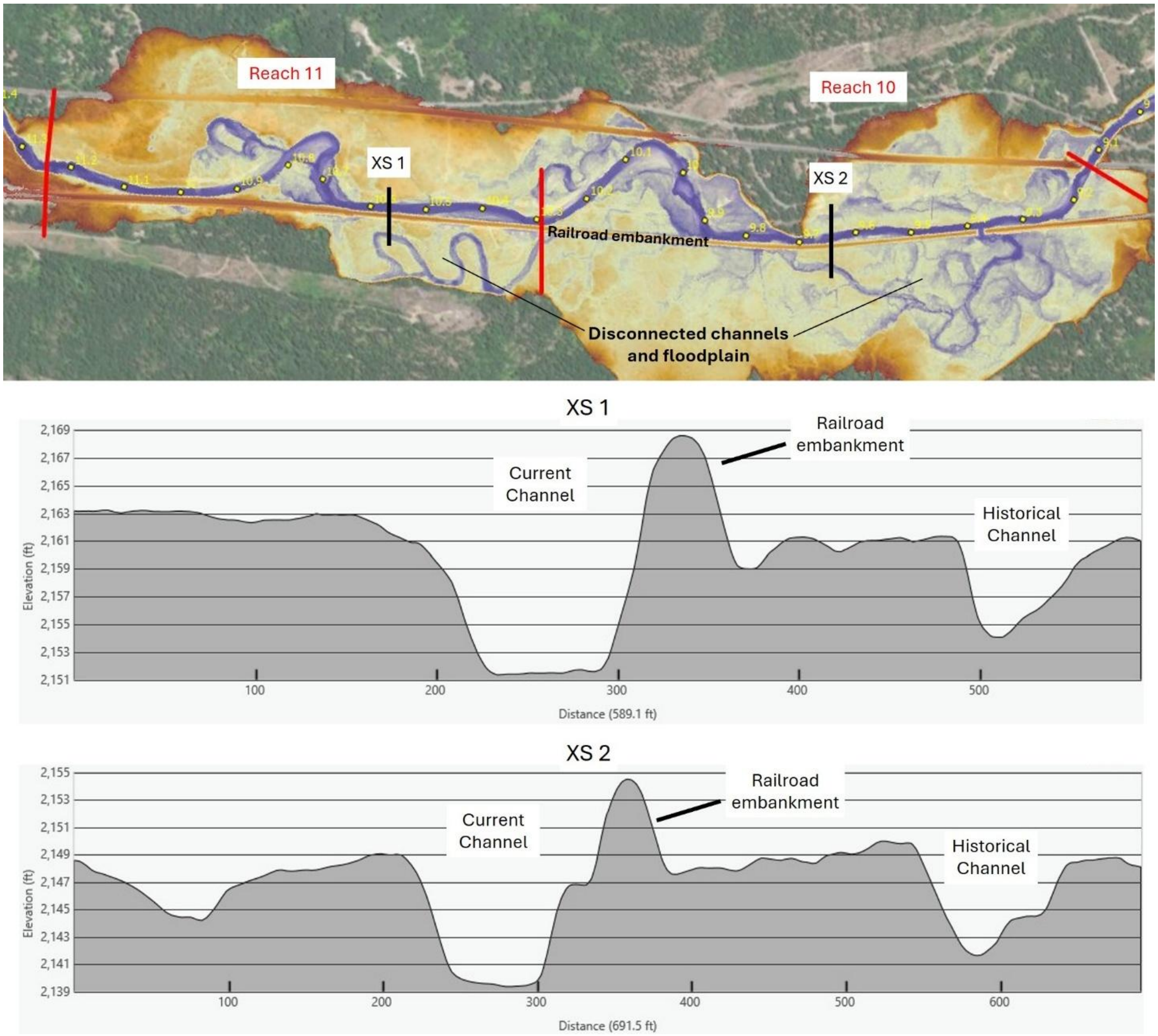

Figure 116. Cross-sections showing differences in channel elevation and geometry between historical cut-off channel segments and current channel segments in reaches 10 and 11.

The historical sediment transport processes in this segment have been severely disrupted, with less opportunity for bank material recruitment than would have occurred historically via lateral scrolling; and high energy and scour of bed sediments due to confinement. Bed and bank sediments in the segment overall are dominated by gravels, with small cobble subdominant and a considerable contribution of boulders due to the extensive riprap making up the banks and portions of the bed along the railroad. Sediment sources within the reach are highly impacted by confinement and the abundance of bank armoring, which limits lateral processes of cut and fill alluviation. There are only three areas where lateral processes are still occurring to any meaningful degree, at RM 11.2, at the 'First Bend' site near RM 10.8, and at the 'Second Bend' site near RM 10.0. On river-left at RM 11.2, the approximately 8-ft tall bank has eroded 30+ feet since 2006, based on aerial photo analysis and conversations with the landowner during the field survey (Figure 117).

Figure 117. View upstream at eroding river-left bank near RM 11.2 (Inter-Fluve photo June 2025).

At the First Bend site, prior to restoration work in 2013, the outside bend was rapidly eroding due to a lack of riparian forest. The controlled meander cut-off, wood placements, and riparian reforestation work (2013 and 2022 projects) have reduced rapid scrolling, but this area nevertheless remains a source of material through localized bank erosion and scour of bar features. There are also lateral dynamics, including bank erosion, bar scouring, and bedload deposition occurring at Second Bend (Figure 118).

Figure 118. View toward river-right bank near RM 10 showing area of gravel recruitment from bank (Inter-Fluve photo July 2025).

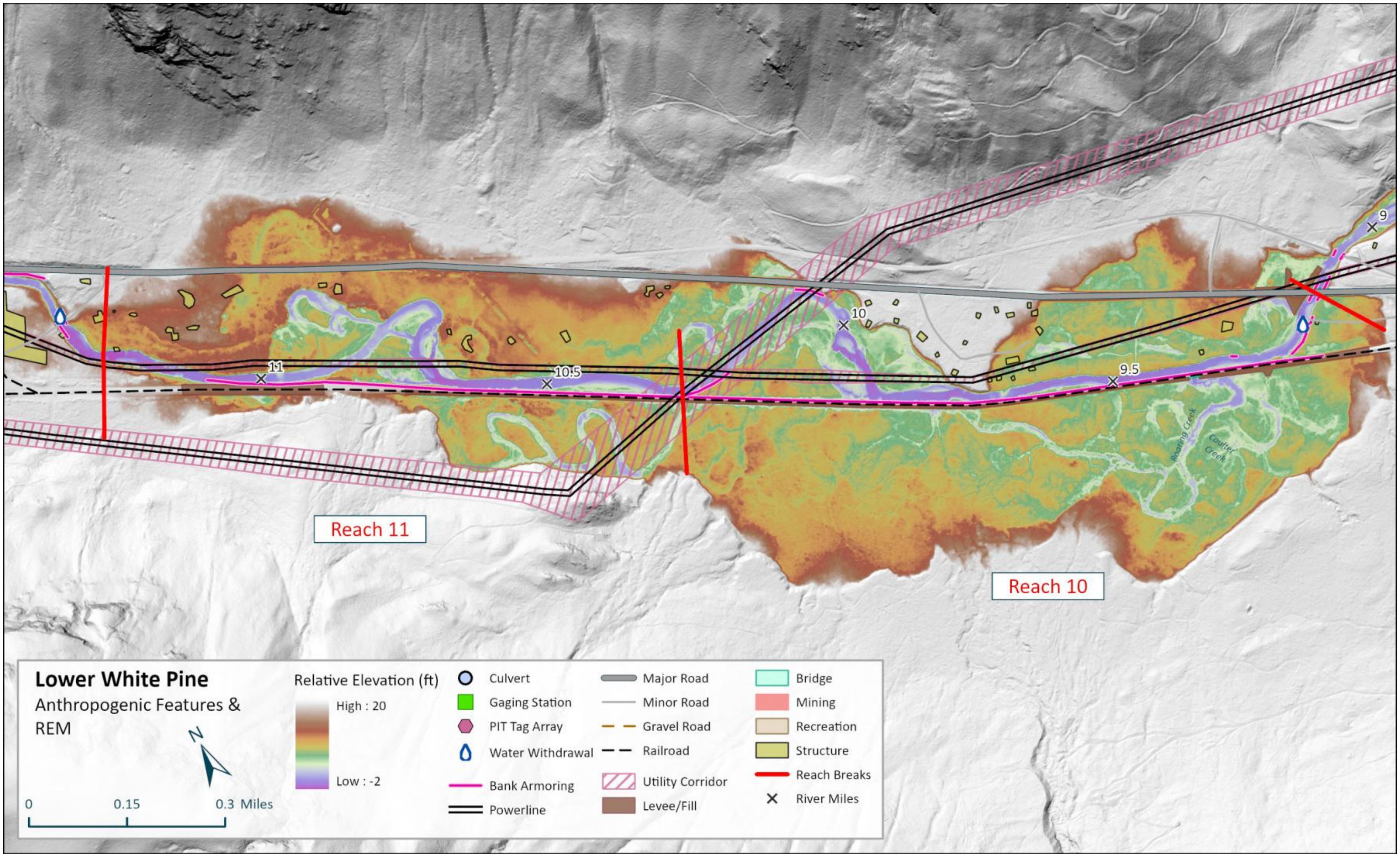

Figure 119. Mapped anthropogenic features and relative elevation map for Segment 5.

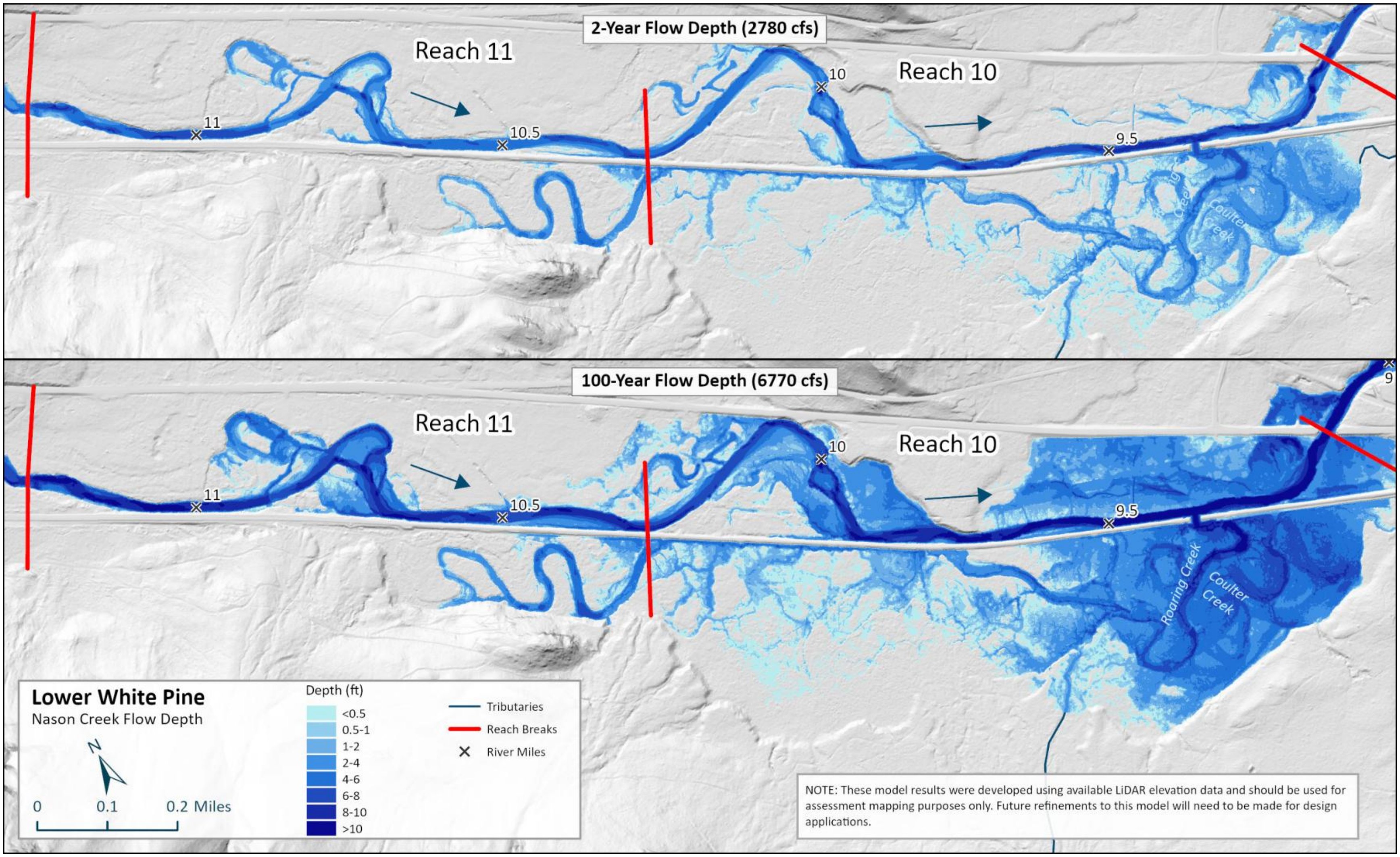

Figure 120. Modeled depth results for Segment 5.

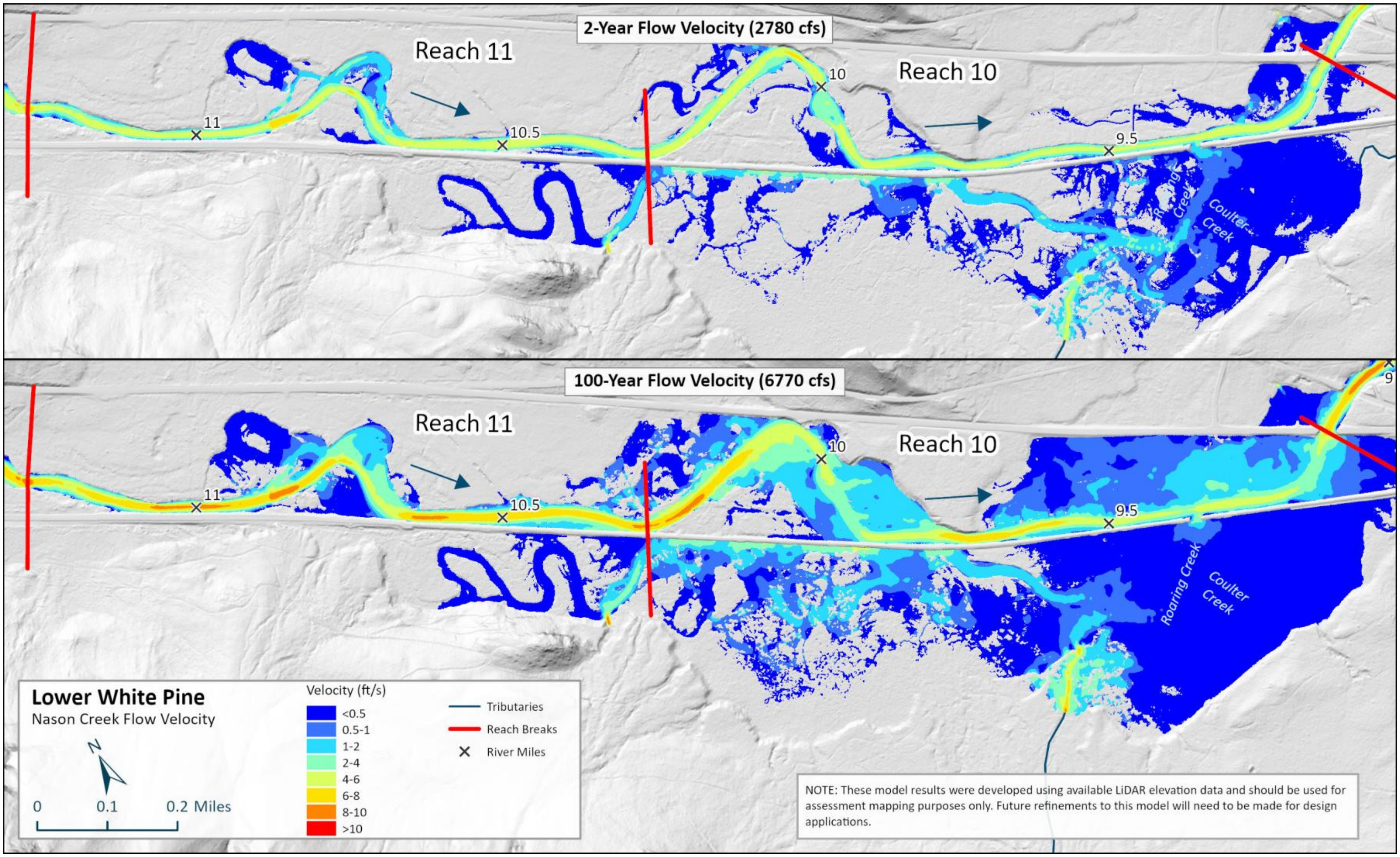

Figure 121. Modeled velocity results for Segment 5.

6.5.3 Large Wood Material

Large wood recruitment and retention processes are highly impaired in this segment. Although total wood counts meet standards (see REI, Appendix B), most of this wood is concentrated in constructed jams or in constructed off-channel habitats. The abundance of riprap, channel confinement, and denuded or young riparian vegetation severely limits large wood recruitment and retention potential (Figure 122). There are only a couple of areas where active lateral adjustment and wood recruitment is occurring. The main one is between RM 9.9 and 10.0 where there is a mid-channel bar, split flows, and some active bank erosion toward river-right. The bank vegetation here, however, is young so there is no recruitment of large wood that would serve as key pieces in the channel (Figure 123). The other area where recruitment is occurring is on river-left at RM 11.2, where the approximately 8-ft tall bank has eroded 30+ feet since 2006 as described previously (Figure 117). The recruitment here is also of relatively young and small trees, but could eventually recruit larger trees if erosion continues to the north. Lateral adjustment and large wood recruitment is not occurring to a meaningful extent anywhere else in this segment. Recruitment in most areas happens only through natural tree fall (i.e. not bank erosion), which occurs seldomly due to the absent or young riparian stands; and furthermore, trees that are recruited do not function as key pieces that can self-stabilize in the channel due to small sizes and simplified/straightened channels.

Figure 122. Example of complete loss of large wood recruitment potential due to bank armoring and clearing under the BPA powerlines. View upstream near RM 10.2.

Figure 123. Bank erosion and recruitment occurring into a young and medium-aged stand of cottonwoods at flow-split near RM 10.0. View of river-right bank (Inter-Fluve photo July 2025).

Past restoration work has significantly increased large wood numbers in the segment, particularly in Reach 11, which has numbers (239 qualifying pieces) that well exceed standards (see REI, Section 5). Without restoration work, numbers would fall below the standard. The placed wood in Reach 11 has improved habitat cover and complexity in the project locations, including main channel and off-channel locations. In particular, there is high complexity due to project actions including abundant placed wood around the 'First Bend' site and just upstream (RM 10.7 – 10.9). Wood in this segment is providing geomorphic influence on the channel, including maintaining deep scour pools and supporting split flow conditions. There is also abundant wood in the constructed backwater alcove on river-left at 'Second Bend' near RM 10.1 – 10.2. Wood in the alcove is proving abundant cover and complexity. Main channel wood around this location is mostly buried tight against the bank and is not having a strong geomorphic influence on the channel.

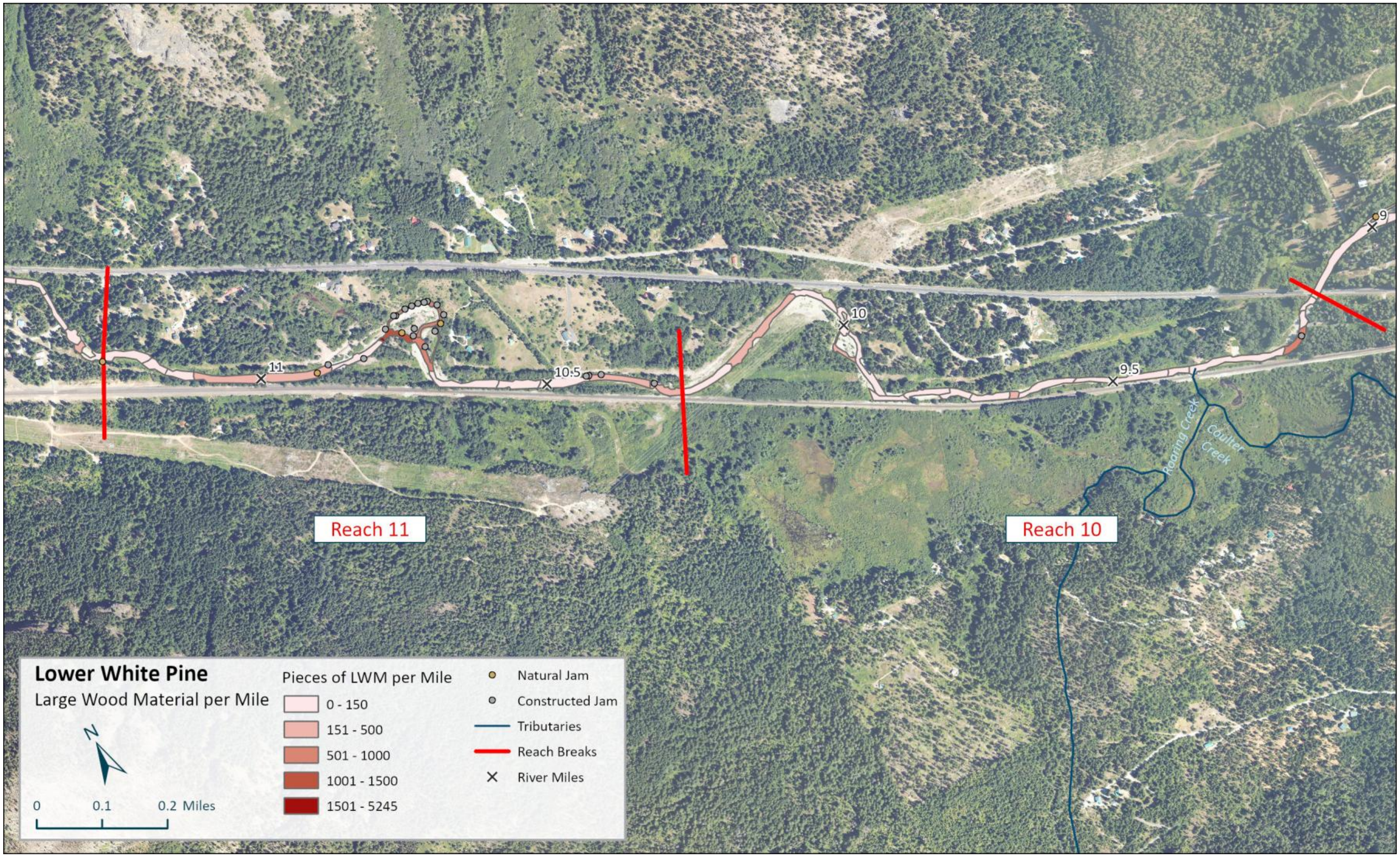

Figure 124. Large wood frequency and jams in Segment 5.

6.5.4 Vegetation

Vegetation conditions in Segment 5 are highly impacted by past and ongoing uses and infrastructure. Conditions degrade markedly from downstream conditions, as there is substantial human disturbance and clearing of the riparian vegetation. A significant portion of the segment has very narrow riparian buffers on one or both sides of the channel due to the railroad and/or the CPUD powerlines. The BPA powerlines follow along approximately 0.3 miles of channel midway through the segment, with vegetation regularly cleared along the riparian zones on both sides of the channel (see Figure 112 and Figure 122). Private residential uses and contacts with Highway 2 further the amount of clearing in this segment. There are very few, if any, trees that exceed 150 feet height, and many areas are dominated by shrubs, grass, or are completely devoid of vegetation altogether. There is a discontinuous mature overstory dominated by young to medium-aged cottonwood and fir. The understory is dominated by willow, alder, dogwood, and maple, with lesser amounts of hawthorn, Indian plum, and rose. Many areas only have shrub-dominated stands with only occasional larger trees. Large wood recruitment potential is described in the previous section and is very low overall. There is very little stream shading provided by canopy cover in this section. This is especially the case due to the railroad paralleling the southern side of the channel for much of the segment. A vegetation height map is included for reference in Figure 125.

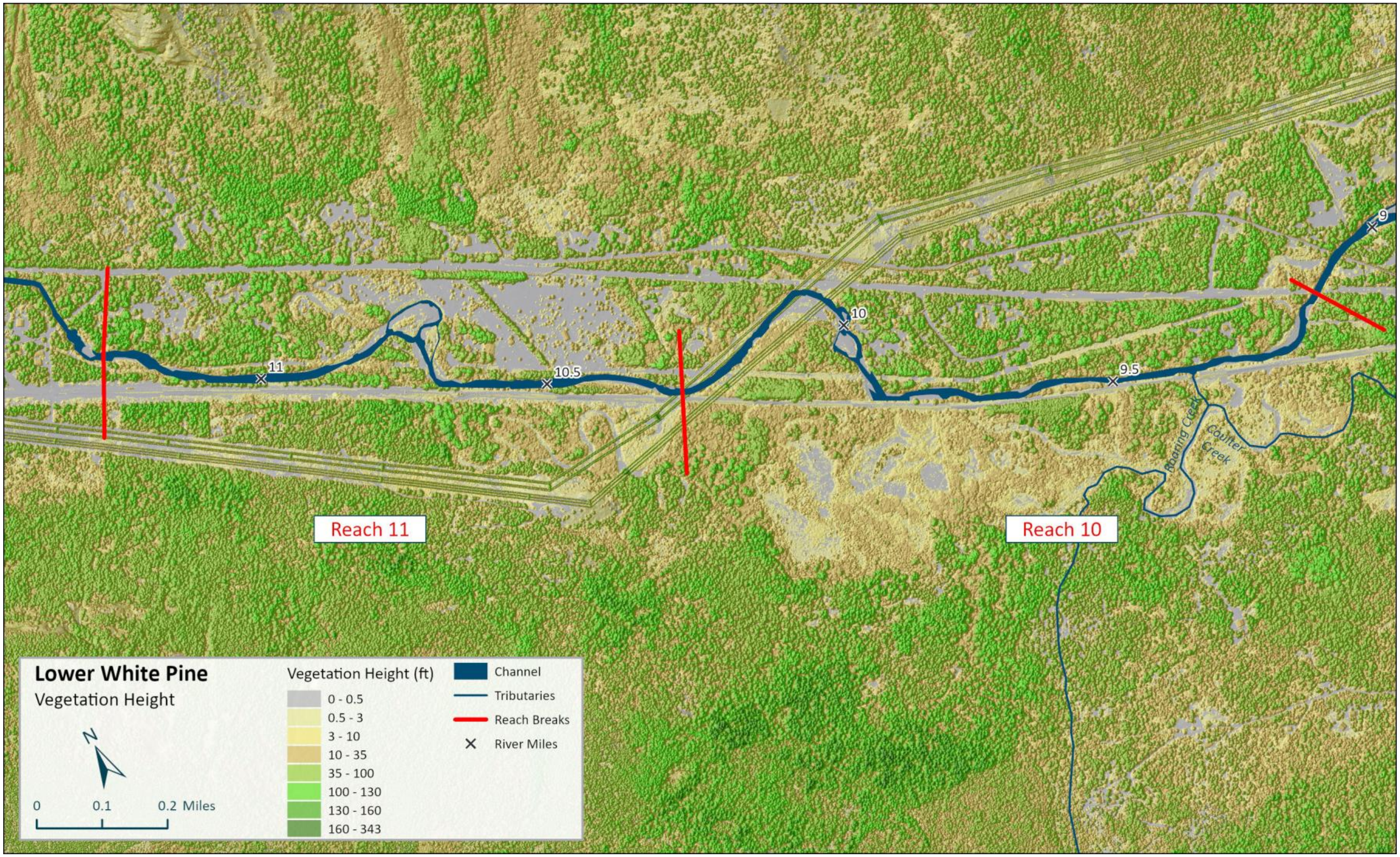

Figure 125. Vegetation heights along Segment 5 of Nason Creek.

6.5.5 Past Restoration Projects

There have been at least five past projects in this segment (Figure 133). The First Bend project (Yakama Nation) was constructed in 2013 and included a controlled meander cut-off and other treatments (Figure 126). The controlled cut-off was to avert an impending avulsion across the inside of the river-right bar (where an advancing headcut was located), which would have resulted in a straightened channel along the railroad embankment, loss of the existing complexity at the bend, and contributing even further to the straightened and armored condition of the greater reach. The controlled cut-off 'dialed back the clock', so to speak, on the evolutionary trajectory of the bend, maintaining complexity and promoting the evolution of the abandoned channel section into an off-channel wetland complex. Project implementation in 2013 included the following: construction of a pilot channel across the bend; large wood structures along the pilot channel; layback, large wood placement, and planting of the vertical bank at the outside of the bend; large wood placement downstream in the mainstem; placement of vertical members to help retain an existing log jam; and riparian reforestation (Inter-Fluve 2013). The pilot channel was successful in 'capturing' the main channel after 3-4 years, and over the past 12 years the abandoned channel has slowly been filling with sediments and converting to high quality off-channel habitat (Figure 127). This channel, however, remains active as a split-flow condition during high flows each year.

In 2022, the Nason Merritt Oxbow Reconnection Project (Cascade Fisheries) occurred just upstream and partially within the First Bend project site. This project involved the following: construction of a river-left side-channel that connects into floodplain wetlands and the abandoned First Bend channel downstream; construction of a log jam on the upstream river-right bank; construction of a roughened channel (constructed riffle) in the mainstem; and riparian revegetation (RIO Applied Science and Engineering 2022). The roughened channel (constructed riffle) prevents channel headcutting from continuing upstream from the cut-off channel, and thereby helps to keep the left-bank side-channel active (Figure 128). These features complement the First Bend project elements. At the time of the late June 2025 field survey, the side-channel had a small amount of flowing water, but is possibly not active at lowest base flows. Planted revegetation along the sides of the side-channel appeared to have mixed success, with some significant mortality.

Figure 126. View downstream into cut-off channel at First Bend project site. Photo taken from RM 10.8 (Inter-Fluve photo June 2025).

Figure 127. Upstream end of abandoned channel at First Bend project showing wetland development and good riparian regrowth on river-left (Inter-Fluve photo June 2025).

Figure 128. View downstream near RM 10.9 of constructed side-channel inlet (river-left) and constructed riffle (in main channel) at the Merritt Oxbow Reconnection Project (Inter-Fluve photo June 2025).

The LWP Groups 2 & 3 Project (Yakama Nation) occurred in 2016 between RM 10.1 and 10.45 and included large wood placements in the mainstem, backwater channel and alcove creation with large wood, reconnection of a floodplain wetland pond complex, and riparian revegetation. During the late June 2025 field survey, the mainstem log jams were observed to be tightly tucked to the bank and not interacting much with flow. The alcove/backwater complex had high quality habitat (wetted, highly complex), but it was not connected via surface flow with the mainstem, possibly due to beaver activity, with the alcove water surface approximately 1 foot higher than the mainstem water surface.

Figure 129. Large wood structure installed on river-left bank as part of LWP Groups 2&3 Project near RM 10.45 (Inter-Fluve photo June 2025).

Figure 130. Constructed backwater alcove in river-left floodplain as part of LWP Groups 2&3 Project near RM 10.15 (Inter-Fluve photo June 2025).

The Nason Creek Lower White Pine Habitat Reconnection Project (Chelan County) was constructed in 2012 and included a breach, via a bridge, through the railroad embankment to connect Nason Creek to the large disconnected historical channel segment to the south of the railroad. Site observations during the early July 2025 field survey showed continued good connectivity through the breach between Nason Creek and the downstream end of the disconnected channel across the railroad (Figure 131).

There is a large wood bank revetment on river-right at the bend at RM 9.2. This was presumably placed to protect the Grant PUD hatchery facility (Figure 132). Observations during the field survey indicated that erosion of the upper portion of this bank is potentially putting the structure at risk of failure.

Figure 131. View from opposite side of the railroad at the historical channel reconnection near RM 9 (Inter-Fluve photo July 2025).

Figure 132. Large wood bank revetment on the river-right bank at RM 9.2 (Inter-Fluve photo July 2025).

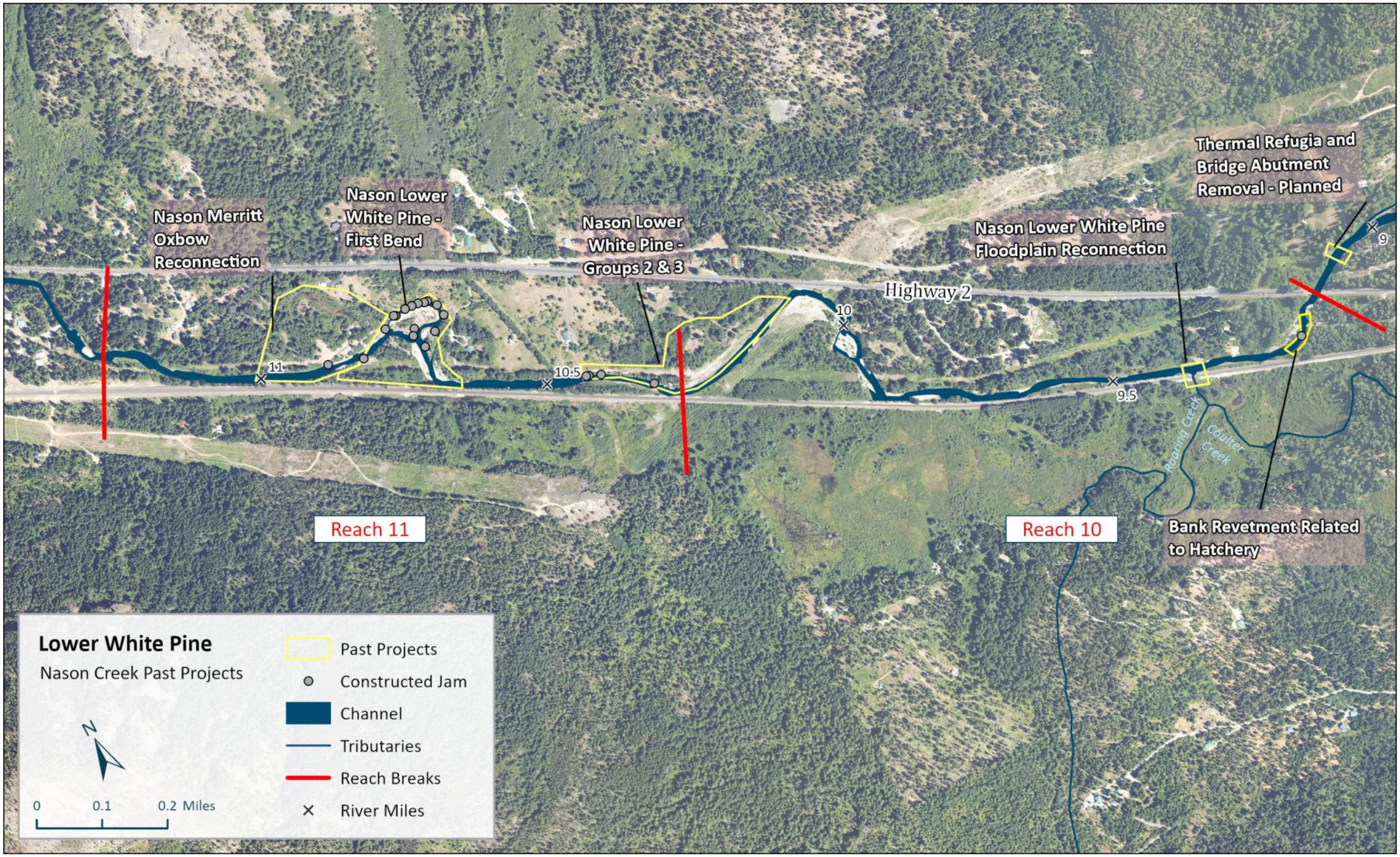

Figure 133. Past projects within Segment 5.

6.5.6 Project Opportunity Summary

Three projects have been identified in this segment. The LWP Sunland project encompasses the lower 0.7 miles of Reach 10 and is located where the channel is confined along the BNSF railroad embankment. Actions are limited by the proximity of the railroad to the south and private residences to the north. Work could nevertheless occur within the channel by adding large wood to enhance cover and complexity in this highly degraded and simplified stretch of channel. Jams that would initiate strong lateral processes or increase floodplain inundation may be challenging given adjacent land uses. There may be some, albeit limited, opportunity for engagement of the river-left floodplain, including off-channel work or slight increases in main channel sinuosity, but again, with challenges. Private lands in the river-left floodplain are a potential conservation opportunity if there are willing landowners. A large-scale re-route of the CPUD powerlines should be considered. This could potentially encompass all of the LWP and portions of the UWP segments. One potential scenario is the relocation of the powerlines along Highway 2. It is understood that some consideration has been given to this in the past, and there are certainly logistical challenges and expense; but moving the lines would improve habitat conditions, provide greater restoration potential, and would reduce flood and erosion risk to the lines. The potential reconnection of the former channels and floodplain to the south of the railroad has been investigated by others in the past, and a reconnection point via a bridge was implemented at RM 9.4. It is recognized that there would be considerable challenges and expenses with a larger reconnection scenario, not the least of which are elevational differences due to the incised condition of the current channel and the partially silted in condition of the former channel. Potential future reconnection scenarios (flow-through or simple passage improvement) should nevertheless continue to be investigated given the large amount of potential habitat that could be reconnected.

The LWP Second Bend project encompasses portions of reaches 10 and 11 and includes the broad 'Second bend' where the river bends to the north. There has been past project work in this area, including main channel log jams and off-channel creation/enhancement. There is significant opportunity for additional main channel complexity work, including more aggressive log jams to create flow-splits, encourage lateral process, capture and sort bed material, and provide complex cover. There may also be opportunities to create additional flow-through side channels including in the vicinity of the former LWP Groups 2&3 Project. Due to the severe impairment caused by the BPA powerline crossing, highway, and railroad, consideration should be given to a re-route of the main channel that would move it away from the railroad and highway and would cross the powerline corridor more perpendicular, which would reduce the length of riparian impairment. There are also opportunities for riparian restoration and land conservation in this project area. A large-scale re-route of the CPUD powerlines, as described previously, should be considered. As described above for the LWP Sunland project, consideration should be given to scenarios that would reconnect the extensive disconnected former channel south of the railroad, despite potential challenges. Strong consideration should at the least be given to a perforation through the railroad embankment near RM 10.3 for fish passage, similar to the prior work downstream at RM 9.4.

The LWP First Bend project includes a few actions that would further complement the past restoration work that has been done in this area. This includes creation of a second side-channel on river-left upstream of the bend that would connect into floodplain wetlands and previously constructed off-channel habitat. There is also a need to enhance vegetation growth of the point bar at the bend at RM 10.75. Additional work could occur in the mainstem to enhance complexity and cover, but the intensity of the actions will be limited by private parcels, the railroad, and the CPUD powerlines. A large-scale re-route of the CPUD powerlines, as described previously, should be considered.

6.6 SEGMENT 6 – UPPER WHITE PINE (REACHES 12-13)

6.6.1 Overview

The Upper White Pine segment includes reaches 12 and 13 and extends from RM 11.25 to 13.55. The BNSF railroad crosses Nason Creek at the upstream end of the segment and the downstream end of the segment is located just downstream of the Gill Creek Road Bridge crossing downstream of Merritt. Most of the segment lies within the Wenatchee National Forest. There are a few private parcels at the upstream end. The downstream half of reach 12 is within private lands, with some Chelan County land and CDLT conservation lands. Much of the upstream portion of the segment (Reach 13) lies adjacent to the BNSF railway. Past relocation of the channel (associated with railroad relocation) has resulted in a highly degraded and confined channel through much of the length of Reach 13, a condition that has been improved by past restoration project work in the reach. A significant portion of Reach 12 is straightened and directly abuts Highway 2. Natural confinement plus historical fill at Merritt impacts channel conditions at the downstream portion of the reach. The CPUD powerlines are located within the floodplain through much of this segment and affect channel migration potential and restoration feasibility. Representative photos of the segment are included in Figure 134, Figure 135, and Figure 136.

Table 13. Key segment metrics. Metrics collected during the Habitat Assessment are discussed in Appendix A.

	Length (miles)	River Mile	Stream Gradient (%)	Sinuosity	Dominant Habitat Unit Type	Average Bankfull Width (ft)	Confinement	Dominant Substrate	% Pool Habitat	% Glide Habitat	% Riffle Habitat	% Side Channel	% Other Habitat
Reach 12	1.35	11.25-12.6	0.32%	1.27	Pool	87	Unconfined	Gravels	75%	1%	14%	1%	8%
Reach 13	0.96	12.6-13.55	0.33%	1.22	Pool	73	Unconfined	Cobbles	46%	3%	43%	5%	2%

River process and habitat conditions are highly degraded in this segment due to past and ongoing anthropogenic impacts including channel relocation, straightening, and incision. Although the reaches are dominated by pool habitat (Table 13), pool frequency is low and side channel habitat is lower than would have been expected historically when the channel had more access to the full valley floor floodplain. Large wood pieces per mile are high; however, most of this wood is concentrated in constructed jams or off-channel habitat created from past restoration work. Riparian vegetation is highly affected by the highway, railroad, and transmission lines in places. However, most of the floodplain is vegetated with medium-aged vegetation, with some areas of young vegetation from past replanting efforts. Past restoration work has improved conditions in some areas but there remain significant opportunities for restoration, some of which may require infrastructure modifications to realize meaningful improvements.

Figure 134. Steep boulder-bed channel at upstream end of segment near RM 13.4 (Inter-Fluve photo June 2025).

Figure 135. Area of relative complexity (large wood, channel migration) near RM 11.8 (Inter-Fluve photo June 2025).

Figure 136. View looking upstream near RM 13 showing riprap along both sides of the channel. This is the historically relocated and ditched channel segment. The railroad is on the left. The right side is just upstream of the prior UWP (upper) project where a levee was removed and riparian/floodplain revegetated, but riprap was left in place (Inter-Fluve photo June 2025).

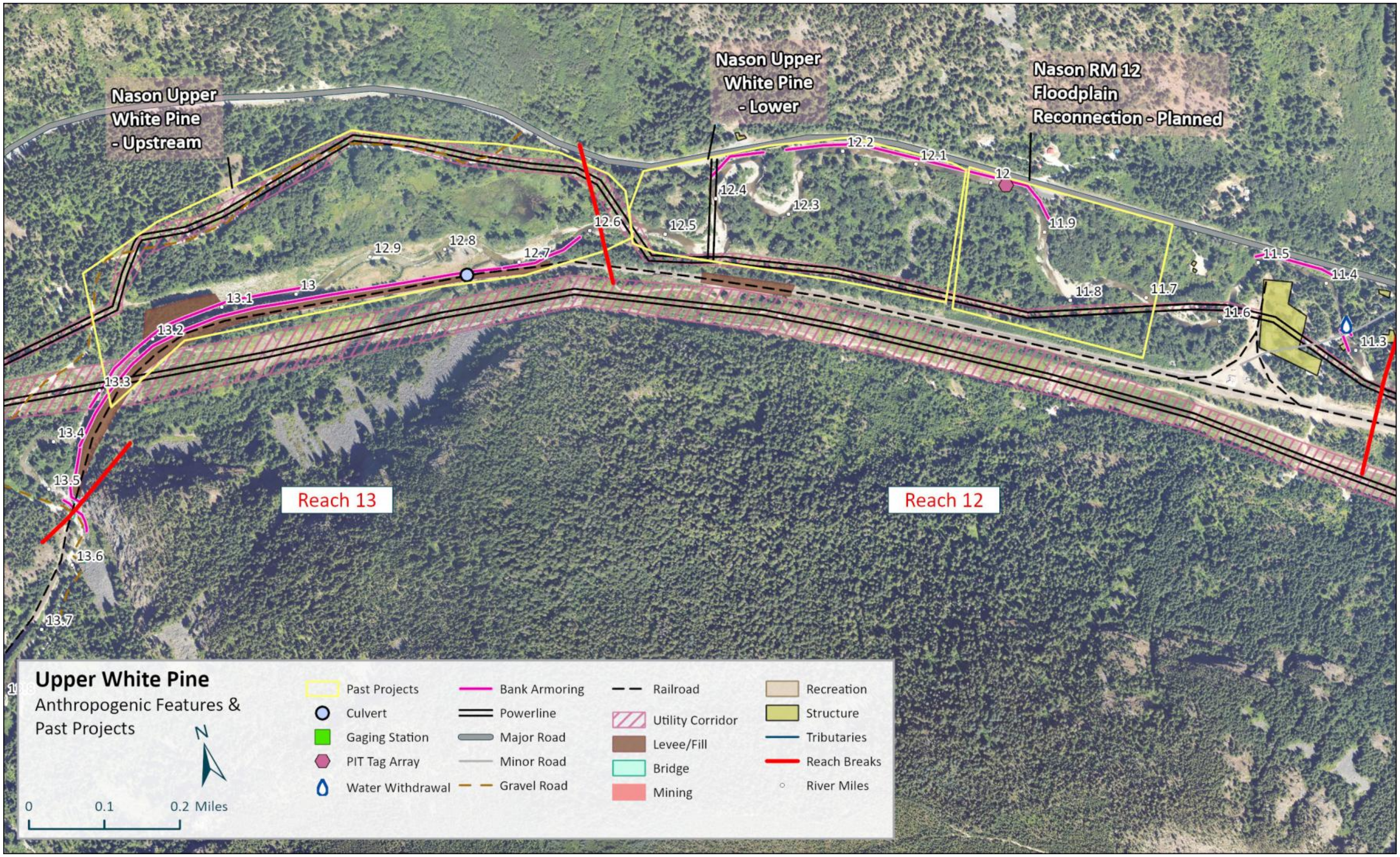

Figure 137. Mapped anthropogenic features and past projects in Segment 6.

6.6.2 Channel and Floodplain Geomorphology

The Upper White Pine segment begins at the upstream end at a valley constriction and is a steep boulder-bed channel for the first 0.3 miles before the gradient reduces and the valley opens. The remainder of the segment lies within a low gradient, unconfined valley where the channel has been artificially confined for much of its length by numerous pieces of infrastructure including the BNSF railway, Highway 2, transmission lines, bank armoring, and floodplain fill. The downstream end of the segment is naturally confined by a valley constriction at Merritt, which has likely experienced an increase in confinement due to fill when the original railway, and the settlement of Merritt, was constructed (late 1800s). The modern (Holocene) floodplain is naturally bounded by bedrock, alluvial fans, colluvium, and glacial terrace deposits (Figure 138), and is now further constrained by human infrastructure. Most of the channel through this segment is pool-riffle, with some planebed channel conditions in the uppermost portion of the segment.

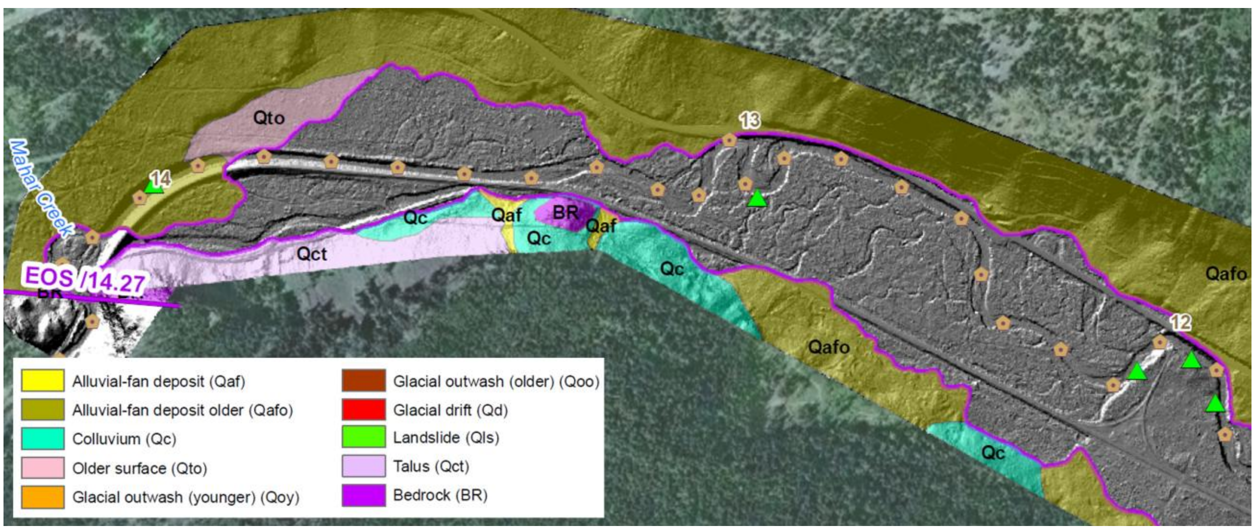

Figure 138. Copy of surficial geology map of the valley floor in Segment 6, reproduced from the Nason Creek Tributary Assessment – Map Atlas** (U.S. Bureau of Reclamation 2008)**. Gray (non-color) areas are Quaternary Sediments, with the exception of anthropogenic fill that is not mapped. Note that river miles are slightly different than other river miles used in this report.

In Reach 13, approximately 3,500 feet of the mainstem was relocated associated with railroad re-alignment in the late 1950s/early 1960s, creating a ditched channel and severing nearly all floodplain connections and halting lateral migration. The former channel location can be seen in the REM in Figure 142 south of the railroad in the upper portion of the reach. Figure 139 shows the change in channel elevation due to this relocation. Restoration work completed in 2018 reconnected significant portions of the floodplain in Reach 13 by lifting and re-meandering the channel and relocating the CPUD powerlines out of the floodplain, but the reach is still highly incised and disconnected overall compared to historical conditions. The entire historical floodplain across the railroad remains disconnected, with only limited backwatering from a culvert connection at RM 12.75.

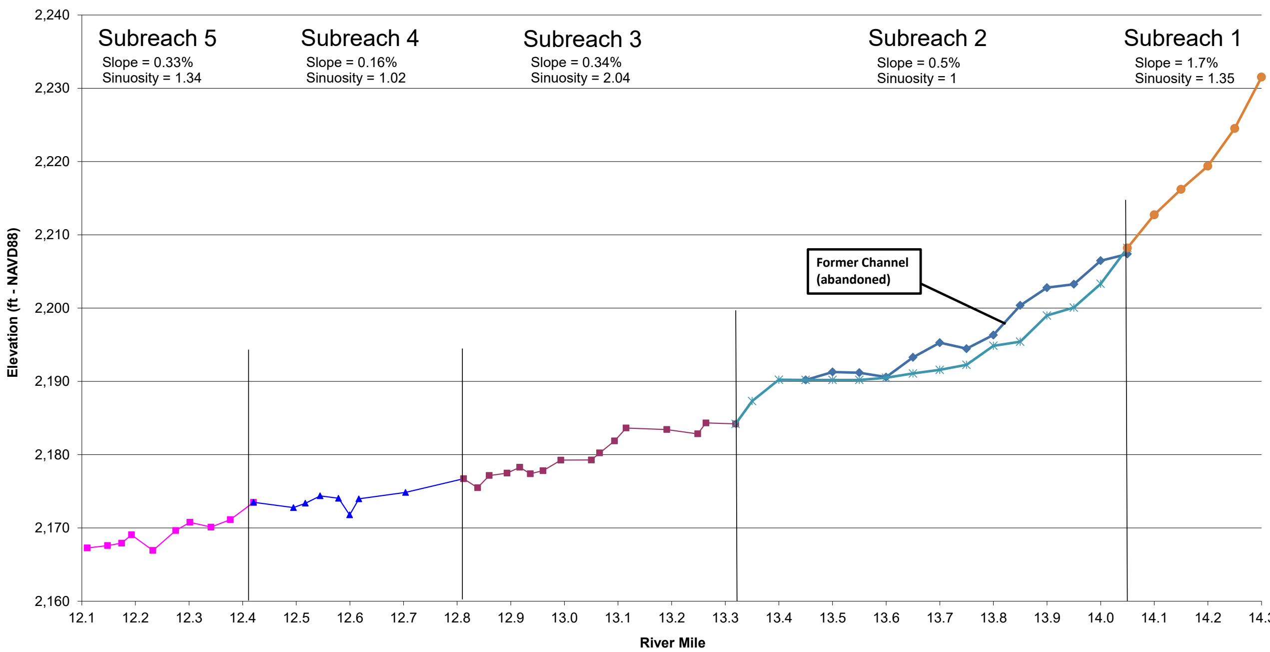

Figure 139. Longitudinal profile of Segment 6 from the UWP Restoration Plan *(Inter-Fluve and U.S. Forest Service 2013)(Inter-Fluve and U.S. Forest Service 2013)(Inter-Fluve and U.S. Forest Service 2013)*. ***Data is combination of LiDAR and survey. The higher elevation of the former channel is shown for comparison in "Subreach 2". These data were prior to the UWP (Upper) Project completed in 2018 that lifted the downstream portion of the relocated channel. Note: river miles are different than those used in this assessment (add 0.5 miles for a correction).***

In Reach 12, much of the channel is straightened and confined along the highway and at Merritt. This results in greater than 40% of the valley length of Reach 12 with the channel confined along the highway, reducing floodplain inundation and the rate of lateral channel adjustment. The 100-year flood currently inundates only a portion (roughly half) of the valley bottom of Reach 12 (Figure 143 and Figure 144), whereas historically it would likely have completely inundated the valley bottom. The flood inundation patterns and straightening of the channel along the highway suggest past channel incision, even despite what appears to be existing vertical bed stability. Between RM 12.2 and 12.5 (area known as the "knife shop bends") is one of the most dynamic and complex portions of this segment, where high sinuosity, active channel scrolling, and natural large wood accumulations create habitat heterogeneity and complexity (Figure 140 and Figure 145). This is despite the presence of riprap and denuded riparian vegetation along the highway embankment.

Figure 140. View downstream near RM 12.3 (knife shop bends). Active bank erosion and some large wood recruitment is occurring on river-right (Inter-Fluve photo June 2025).

Bed and bank sediments in the segment overall are dominated by gravels and cobbles. The exceptions are: 1) the uppermost 0.3 miles, which is a steep boulder-bed channel, and 2) the downstream section around Merritt, where boulders are more prevalent, and appear to be from a combination of glacial lag and anthropogenic fill. Sediment sources within the reach are highly impacted by the abundance of bank armoring, which limits bank erosion. The Mahar Creek tributary alluvial fan on river-left at the upstream end provides a source of some material, but it is limited due to riprap along the river-left bank that starts under the BPA powerline corridor and extends downstream to the top of the re-meandered channel segment at the prior restoration project (Figure 141). The top riffle at the re-meandered section provides a grade control that backwaters upriver approximately 950 feet at low flows. This backwater has created a depositional zone for bed sediments and is expected to continue to fill over time until bed aggradation restores a more equilibrium sediment transport condition. In the meantime, bedload transport into the UWP (upper) project area may be limited; however, incision of the project reach is not expected given the cobble material size of the constructed meanders. Bank stability provided by the jams at the prior UWP (upper) project area will limit bank material recruitment within the project area for a period until the jams deteriorate, at which point planted riparian vegetation is expected to provide natural rates of channel adjustment, and will re-initiate recruitment of material from the banks. The greatest amount of material recruitment is occurring downstream of the prior UWP (upper) project and through the knife shop bends. Below this, recruitment is again limited in the straightened reach along the highway, and then picks back up again in the bends upstream of Merritt.

Figure 141. View downstream near RM 13.8. Riprap from the railroad embankment can be seen on river-right and bed material sourced from the Mahar Creek alluvial fan can seen on river-left. BPA powerline crossing and related vegetation impacts can be seen in the background on river-left.

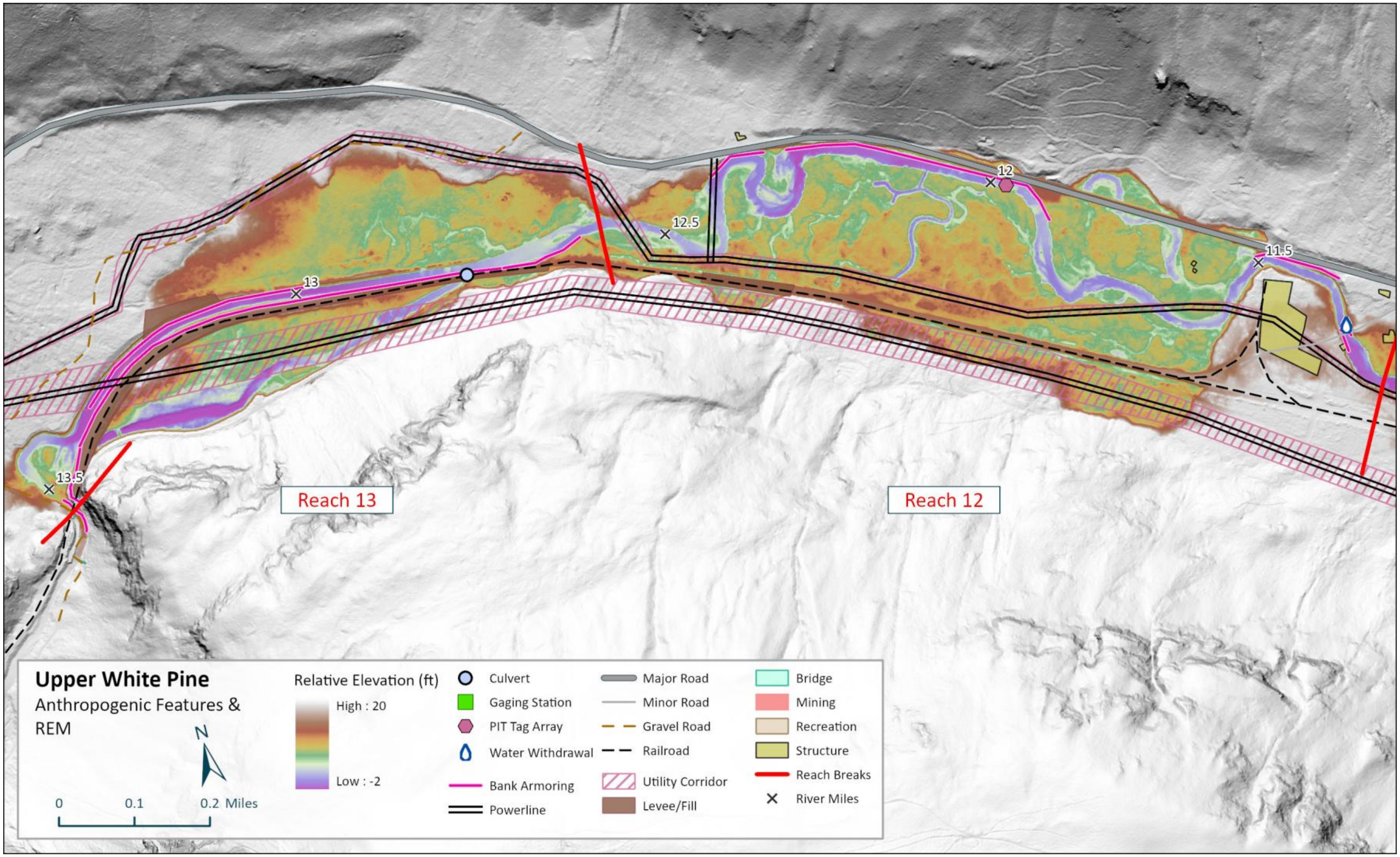

Figure 142. Mapped anthropogenic features and relative elevation map for Segment 6.

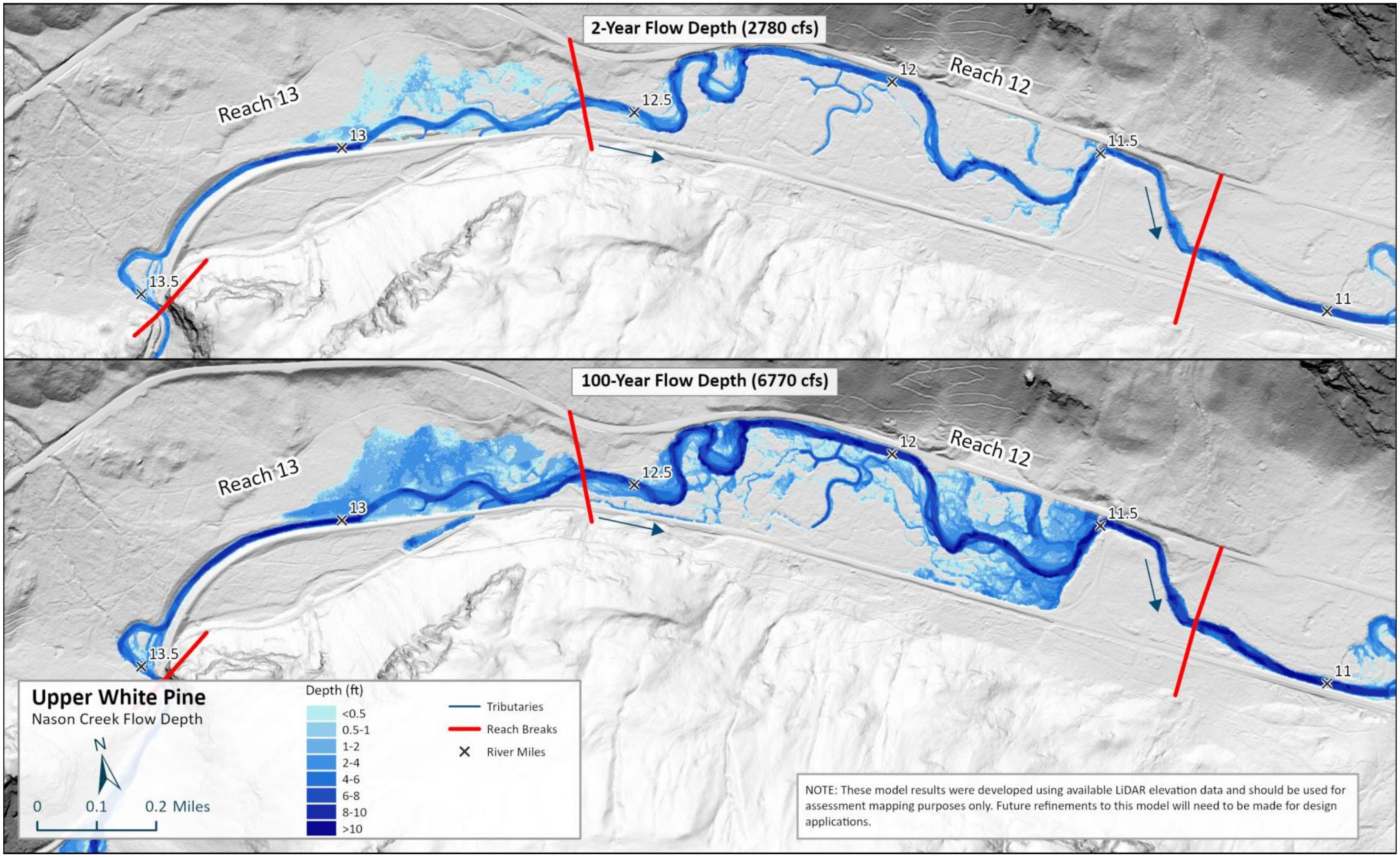

Figure 143. Modeled depth results for Segment 6.

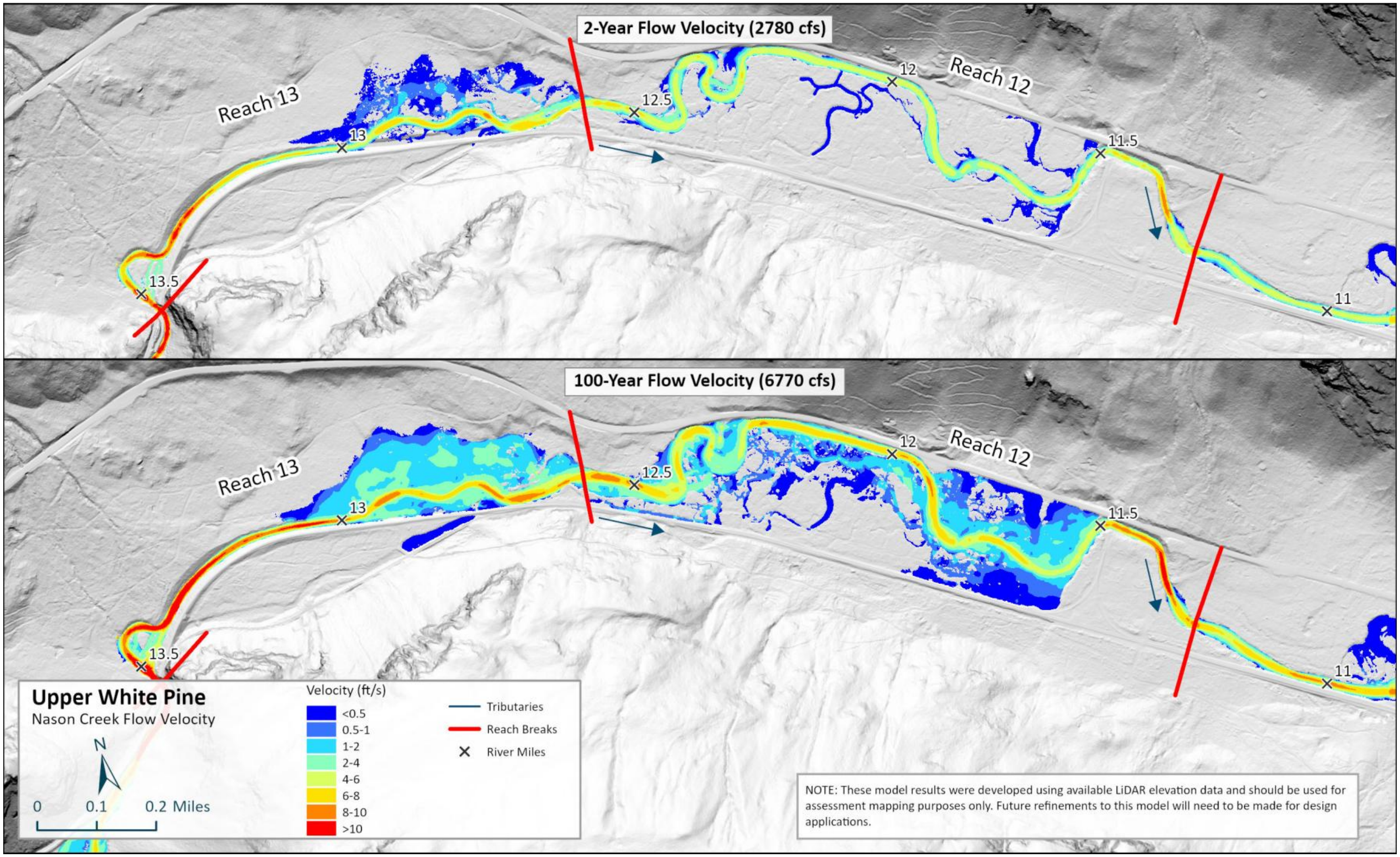

Figure 144. Modeled velocity results for Segment 6.

6.6.3 Large Wood Material

Large wood recruitment and retention processes are highly impaired in this segment. Although total wood counts are high by regional standards (see REI, Appendix B), most of this wood is concentrated in constructed jams or in constructed off-channel habitats. The abundance of riprap, channel confinement, and denuded or young riparian vegetation severely limits large wood recruitment potential. In the couple of areas where channel migration processes are intact (knife shop bends and upstream of Merritt), there is wood recruitment and retention due to channel complexity, high sinuosity, and some larger trees (Figure 145 and Figure 146). However, the remainder of the segment has very little recruitment potential due to bank armoring and lacks the complexity necessary to retain wood in the channel even if it is recruited. Recruitment in these areas happens only through natural tree fall (i.e. not bank erosion), which occurs seldomly due to the relatively young riparian stands; and furthermore, trees that are recruited do not function as key pieces that can self-stabilize in the channel due to simplified and straightened channels.

Past restoration work has significantly increased large wood numbers and has improved habitat cover and complexity in the project locations, including main channel and off-channel locations. The constructed alcove at RM 12.1 has very abundant large wood that is assumed to provide significant juvenile salmonid rearing cover, especially at higher flows when the alcove is active and well-connected. Most of the large wood placements in the mainstem are bank-buried jams, and some are not engaged with the channel at low flows. These jams provide important functions in some locations (e.g. interim bank stability until planted riparian vegetation can mature) but in many cases don’t have a lot of influence on geomorphologic processes including sediment sorting/capture, flow splitting, and deep pool scour.

Figure 145. View looking upstream toward river-left bank near RM 12.35 at actively eroding and relatively complex section within the ‘knife shop bends’ (Inter-Fluve photo June 2025).

Figure 146. Large cottonwood tree soon to be recruited via a beaver chew near RM 11.7 (Inter-Fluve photo June 2025).

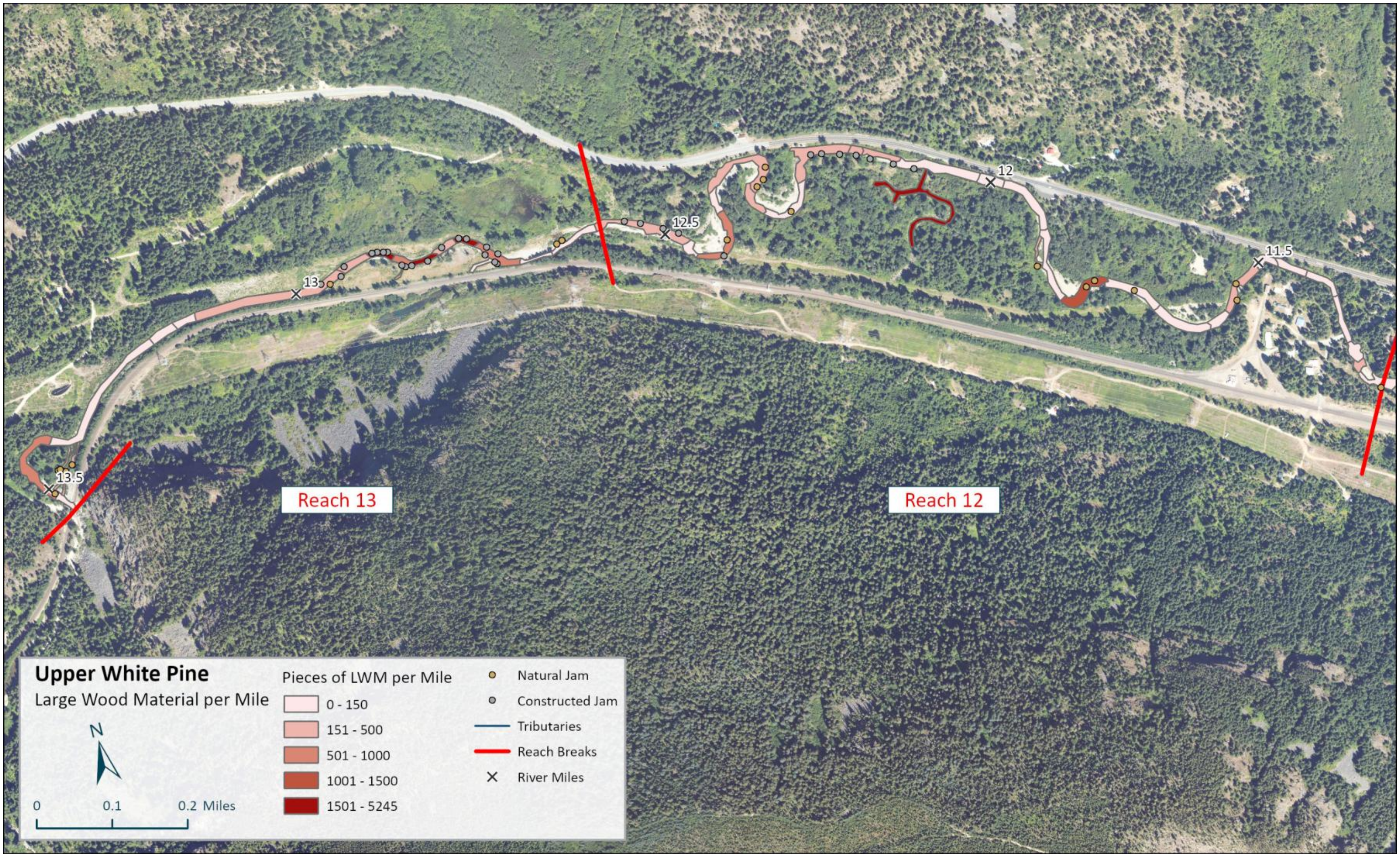

Figure 147. Large wood frequency and jams in Segment 6.

6.6.4 Vegetation

Vegetation conditions in Segment 6 are highly impacted by past and ongoing uses and infrastructure. The vegetation in Reach 12 is highly affected by the adjacent Highway 2 (Figure 148) and vegetation in Reach 13 is highly affected by the railroad embankment (see Figure 141). These pieces of infrastructure have resulted in considerable lengths of channel with narrow riparian buffers on at least one side of the channel. The CPUD powerlines also affect riparian conditions in a few areas where they cross the channel, including near RM 11.7 and RM 12.55. Residential uses and clearing at Merritt also contribute to impaired riparian vegetation conditions in the downstream portion of the segment. There are very few trees that exceed 150 feet height, and many areas are dominated by shrubs, grass, or are completely devoid of vegetation altogether. The areas with the most mature stands are located in the river-right floodplain from 11.6 to 11.8 and in the river-left floodplain on the inside of the bend from RM 12.4 to 12.6. There are some large cottonwoods, up to 4-5 feet diameter, near RM 11.7. The overstory typically consists of fir, western red cedar, cottonwood, or ponderosa pine. The understory is typically comprised of alder, willow, dogwood, or maple. The overstory is discontinuous and many areas only have shrub-dominated stands with only occasional larger trees. Large wood recruitment potential is described in the previous section and is very low overall. There is moderate stream shading provided by canopy cover in this section. A vegetation height map is included for reference in Figure 149.

Figure 148. View upstream near RM 12 .1 showing nearly non-existent riparian buffer along Highway 2.

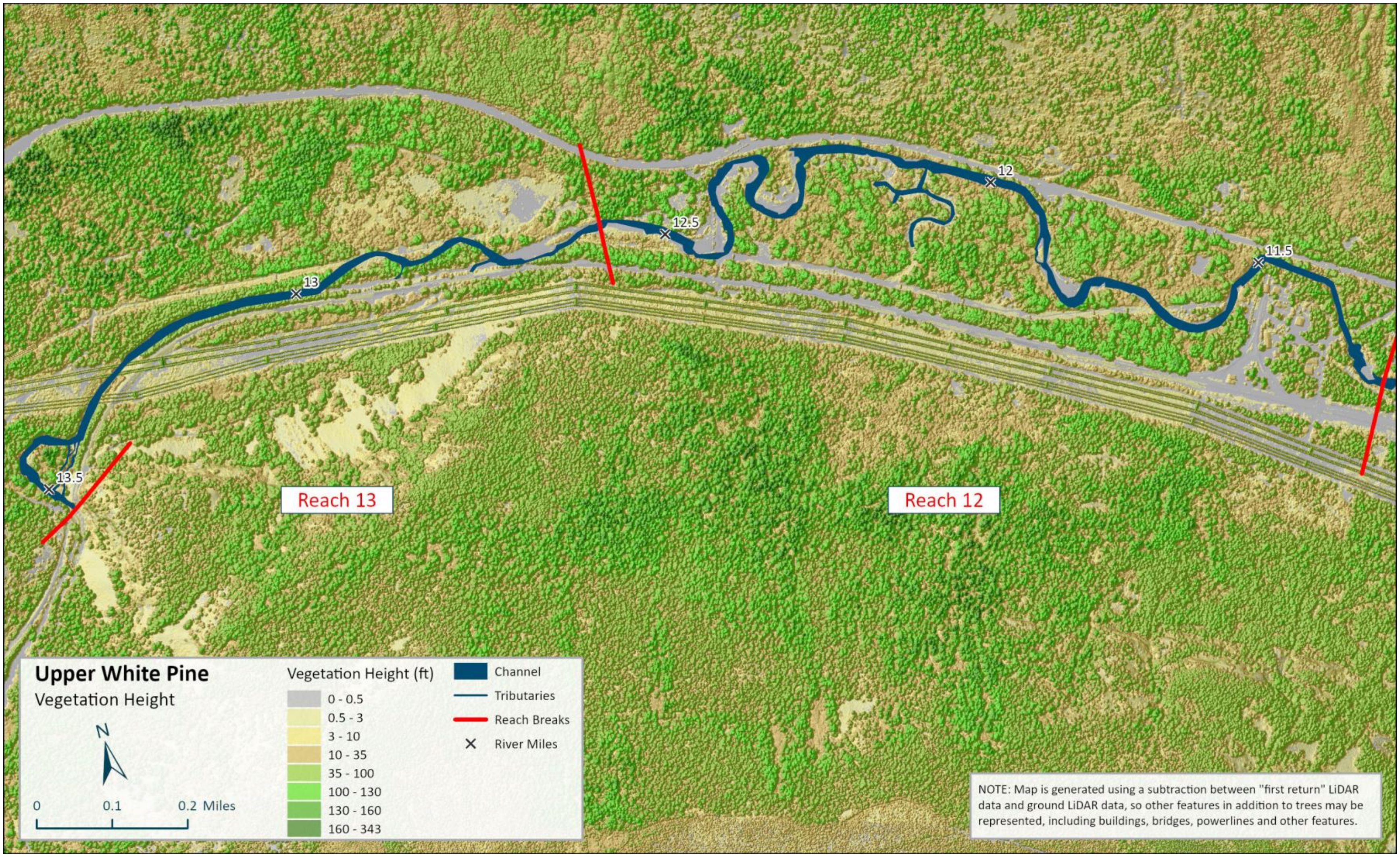

Figure 149. Vegetation heights along Segment 6 of Nason Creek.

6.6.5 Past Restoration Projects

There are two past restoration projects and one planned project in the Upper White Pine segment (Figure 153). The two past projects include the UWP (upper) Project and the UWP (lower) Project; these are also known as UWP Subreach 2 and UWP Subreaches 3 and 4 projects, respectively.

The UWP (upper) project was led by Chelan County and was constructed from 2016 to 2018 in multiple phases (Figure 150). This project included relocation of the CPUD powerlines to the north out of the floodplain, removal of a river-left levee/armoring, lifting and re-meandering of a 1,400-ft long previously ditched portion of the mainstem, creation of connected alcove habitat, addition of large wood, placement of floodplain roughness large wood, and revegetation (Inter-Fluve 2017)(Inter-Fluve 2017)(Inter-Fluve 2017). During the June 2025 field survey, no major changes had appeared to occur since construction, except for significant growth of planted riparian vegetation on the left bank, especially upstream of the re-meander portion. Riparian vegetation on the right bank is still relatively sparse and very young. This area was not planted to the same degree as the left bank due to agreement with the railroad (based on the author's personal knowledge of the project). Vegetation success on the river-left bank along the re-meandered portion is high; however, vegetation growth further back from the bank on the left bank is more sparse. The large wood jams are engaged with the river at low flows and in most cases are maintaining pool scour. There did not appear to be significant changes in substrate conditions (e.g. scour or aggradation) in the re-meandered section. As described previously, the channel upstream of the re-meandered portion is backwatered. There appeared to be some sign of gravel and sand deposition on the bed at the upstream end of the backwatered section.

Figure 150. View downstream near RM 12.9 of UWP (upper) project, within the re-meandered section (Inter-Fluve photo June 2025).

The UWP (lower) project was led by Yakama Nation and was constructed in 2015 (Figure 151 and Figure 152). This project included mainstem bank-buried jams, construction of an extensive alcove complex with large wood, and riparian revegetation (Inter-Fluve 2014)(Inter-Fluve 2014)(Inter-Fluve 2014). The mainstem jams extended from RM 12.1 to 12.6 and consisted of approximately 12 jams. The largest jam is located at the 'powerline bend' on river-right at RM 12.45. This jam was intended to provide habitat complexity to an area of rapidly eroding streambank within the CPUD powerline corridor where riparian vegetation clearing (powerline corridor maintenance) had prevented mature riparian forests from being able to provide natural bank stability. During the June 2025 field surveys, this jam was observed to have some deterioration, including some erosion and possibly loss of large wood members at the downstream end and erosion of the upper bank in some locations. Much of the planted shrub vegetation was no longer present, and may have been cleared by poweline maintenance. Some of the other smaller bank-buried jams were providing good margin complexity and maintaining pool scour; however, a few of them were tight against the banks and not engaging with flow at the low flows during the field survey, and were not associated with scour pools. The created alcove habitat, which connects to the channel near RM 12.1, had abundant large wood, and likely provides critical salmonid rearing cover as described previously. However, the alcove was not connected to surface flow in the mainstem at the time of the survey, which was also likely related to a beaver dam in the alcove just above the mainstem connection point. The alcove did have standing water, but the alcove did not appear accessible to fish at the low flows during the survey. Planted vegetation along the alcove looked to be robust and thriving.

Figure 151. View downstream of 'powerline bend' jam at RM 12.45. Some erosion can be seen at the downstream portion of the jam (Inter-Fluve photo June 2025).

Figure 152. Constructed alcove with large wood placements near RM 12.1 (Inter-Fluve photo June 2025).

There is a planned project, the Nason RM 12 Floodplain Reconnection Project (Chelan County), from RM 11.8 to 12. Preliminary designs from 2023 include mainstem log jams and side-channel enhancement (Natural Systems Design 2023)(Natural Systems Design 2023)(Natural Systems Design 2023).

Figure 153. Past and planned projects within Segment 6.

6.6.6 Project Opportunity Summary

Two projects have been identified in this segment. The UWP Lower project area comprises the portion of Reach 12 upstream of Merritt. This area includes past work and future planned work currently in design. There is potential main channel wood complexity work throughout the project area, including log jams to create flow-splits, encourage lateral process, capture and sort bed material, and provide complex cover. There are also opportunities for creation, activation, or enhancement of side- and off-channel habitat, building off of past work in some locations. The large alcove that was created in the river-right floodplain that connects to Nason Creek at RM 12.1 could be partially incorporated into a flow-through side-channel. There are also side- and off-channel enhancement opportunities in the downstream section on the left and right sides from RM 12 downstream to Merritt. There is another opportunity of side-channel creation across the river-left bend from RM 12.4 to 12.5. Due to the severe impairment caused by the confined section along the highway, consideration should be given to a re-route of the main channel that would move it away from the highway and into the river-left floodplain. Alternatively, the general current alignment could be maintained but sinuosity increased by forcing lateral erosion away from the highway at a few targeted locations. A large-scale re-route of the CPUD powerlines, as described previously for LWP projects (Segment 5), should be considered. There are also land conservation opportunities river-left at the downstream end where private parcels occupy floodplain areas that could be areas for future reconnection work.

The UWP Upper project area has opportunities that would build off and complement past work. One of the primary recommendations is the removal of additional riprap along the river-left bank upstream of the prior channel re-meander and extending up to the BPA powerline crossing. Removal of the remaining fill/levee from RM 13.1 – 13.2 could also occur, though impacts to large trees on the fill should be considered. Removal of the riprap would help to restore lateral processes, bank material recruitment, and sediment transport dynamics in the reach. Creation of a side-channel could be considered in river-left that would connect into existing tributary-fed wetlands. Additional log jams could be placed throughout the main channel in the project area, including within the previously re-meandered section. The jams would be designed to create flow-splits, encourage lateral process, capture and sort bed material, and provide complex cover. Vegetation recovery on river-right between the re-meandered section and the railroad has been poor. This area should be a renewed focus for reforestation. The Whitepine Fire in the summer of 2025 affected vegetation and potentially soil erosion conditions at the upstream end of the project area, mostly in the area of the BPA powerline crossing. The geomorphology and project identification field surveys occurred just prior to the fire so post-fire conditions are not captured in this reach assessment and could affect the characterization of existing conditions and recommended restoration actions.

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