Nason Creek Reach Assessment

Appendix A | Habitat Assessment

Nason Creek (RM 0-13.55)

January 2026

Table of Contents

1 Introduction & Background 4

2 Methods 4

3 Summary of Results 6

3.1 Channel Morphology 6
3.2 Habitat Unit Composition 8
3.3 Side Channel Habitat 10
3.4 Large Woody Material (LWM) 10
3.5 Bank Instability 11
3.6 Fish Passage Barriers 12
3.7 Riparian Corridor 13

4 Comparison to Past Reach Assessments 16

5 Stream Habitat Reach Reports 20

5.1 Reach 1 20
5.1.1 Habitat Unit Composition 20
5.1.2 Pools 22
5.1.3 Side Channel Habitat 22
5.1.4 Large Woody Material 22
5.1.5 Riparian Corridor 23
5.2 Reach 2 24
5.2.1 Habitat Unit Composition 24
5.2.2 Pools 26
5.2.3 Side Channel Habitat 26
5.2.4 Large Woody Material 27
5.2.5 Riparian Corridor 27
5.3 Reach 3 29
5.3.1 Habitat Unit Composition 29
5.3.2 Pools 31
5.3.3 Side Channel Habitat 31
5.3.4 Large Woody Material 31
5.3.5 Riparian Corridor 32
5.4 Reach 4 34
5.4.1 Habitat Unit Composition 34
5.4.2 Pools 36
5.4.3 Side Channel Habitat 36
5.4.4 Large Woody Material 38
5.4.5 Riparian Corridor 39
5.5 Reach 5 40
5.5.1 Habitat Unit Composition 40

5.5.2 Pools 42
5.5.3 Side Channel Habitat 42
5.5.4 Large Woody Material 42
5.5.5 Riparian Corridor 43
5.6 Reach 6 44
5.6.1 Habitat Unit Composition 44
5.6.2 Pools 46
5.6.3 Side Channel Habitat 46
5.6.4 Large Woody Material 47
5.6.5 Riparian Corridor 47
5.7 Reach 7 49
5.7.1 Habitat Unit Composition 49
5.7.2 Pools 51
5.7.3 Side Channel Habitat 51
5.7.4 Large Woody Material 51
5.7.5 Riparian Corridor 52
5.8 Reach 8 54
5.8.1 Habitat Unit Composition 54
5.8.2 Pools 56
5.8.3 Side Channel Habitat 56
5.8.4 Large Woody Material 56
5.8.5 Riparian Corridor 57
5.9 Reach 9 59
5.9.1 Habitat Unit Composition 59
5.9.2 Pools 61
5.9.3 Side Channel Habitat 61
5.9.4 Large Woody Material 62
5.9.5 Riparian Corridor 63
5.10 Reach 10 65
5.10.1 Habitat Unit Composition 65
5.10.2 Pools 67
5.10.3 Side Channel Habitat 67
5.10.4 Large Woody Material 68
5.10.5 Riparian Corridor 68
5.11 Reach 11 70
5.11.1 Habitat Unit Composition 70
5.11.2 Pools 73
5.11.3 Side Channel Habitat 73
5.11.4 Large Woody Material 73
5.11.5 Riparian Corridor 73
5.12 Reach 12 75
5.12.1 Habitat Unit Composition 75

5.12.2 Pools 77
5.12.3 Side Channel Habitat 78
5.12.4 Large Woody Material 78
5.12.5 Riparian Corridor 79
5.13 Reach 13 81
5.13.1 Habitat Unit Composition 81
5.13.2 Pools 83
5.13.3 Side Channel Habitat 83
5.13.4 Large Woody Material 83
5.13.5 Riparian Corridor 84
5.14 Summary Data 86
6 References 91

1 Introduction & Background

Nason Creek originates in Lake Valhalla, located on the eastern side of the Cascade Mountains in central Washington state. Nason Creek flows approximately 27 miles from the headwaters to its confluence with the Wenatchee River near the town of Plain, WA. River miles (RM) and reach breaks in this document are based on Upper Columbia Salmon Recovery Board (UCSRB) data (UCSRB 2024), with some small modifications described in subsequent sections.

The Nason Creek Reach Assessment and Restoration Strategy evaluates existing aquatic habitat and watershed process conditions along the lower 13.55 miles of Nason Creek and was completed on behalf of the Yakama Nation as part of their efforts to assess and improve Threatened and Endangered salmon and trout habitat within the Columbia River Basin. As part of the assessment process, Inter-Fluve conducted a salmonid habitat survey of Nason Creek between September 9th and September 28th, 2024, from RM 0 (confluence with the Wenatchee River) to RM 13.55 (where White Pine Road crosses Nason Creek). A flow rate of 32 cfs was measured in the field on September 13th, 2024, near RM 4.25, which downstream of where Nason Creek bends northward towards the Wenatchee River. Insignificant precipitation was received over the survey period. Stream flow was not otherwise measured as part of this survey.

The objective of this habitat assessment is to characterize the habitat quantity and quality for salmonid species native to Nason Creek by quantifying in-channel morphologic features, characterizing riparian conditions, and identifying anthropogenic features influencing aquatic habitat. This information is used to inform potential restoration and conservation actions and will provide a baseline for evaluating future habitat trends and measuring the effectiveness of restoration efforts to improve the quantity and quality of available habitat within the assessment area.

2 Methods

Nason Creek was subdivided into 13 distinct channel reaches, between RM 0 – 13.55. These 13 reach delineations are used for both the habitat assessment as well as the Reach-Based Ecosystem Indicators, which can be found in Appendix B. Reach extents used in this assessment were based on the Upper Columbia Salmon Recovery Board reaches in the Entiat River (UCSRB 2024).

The habitat assessment employed the methods outlined in the US Forest Service Stream Inventory Handbook: Level I & II, Pacific Northwest Region. Version 2.20 (USFS 2020). The "Eastside Forest Option" protocol was used. All protocols were followed when safe and most of the suggested forest inventory options were applied in the survey. Adaptions to the USFS Eastside protocol were made for this survey. Those adaptations include:

- All reach and habitat unit lengths were measured in GIS from GPS data recorded in the field. Habitat units were delineated by survey points collected with a Juniper System GNS2 Geode unit (sub-foot accuracy).
- Floodprone width calculated using LiDAR data and 2D hydraulic modeling results

- Bankfull measurements were collected in slow water units when fast water units were not present
- Field data was collected digitally, using an iPad and ESRI Field Maps software
- Dominant riparian vegetation size class and species were recorded for both the understory and overstory within the 100-foot riparian corridor

As per USFS guidelines, n^{th} channel units were a subset of units where additional measurements were taken, at a frequency of every fifth unit (20% of units), for both fast (riffle, glide) and slow (pool) unit types (2020). At all channel units, surveyors recorded an ocular estimate of wetted width and at n^{th} units recorded both an ocular estimate and a measured wetted width. A bankfull measurement was performed at the first three fast water channel units (riffle or glide) per reach, and then at every n^{th} unit after. If fewer than three fast-water units were encountered in a reach, bankfull measurements were collected at slow water units instead. The length of anthropogenically-induced unstable banks was recorded for both the left and right channel banks in all units. Water depths for all habitat units were measured using a graduated stadia rod carried by the surveyor or estimated if depths or velocities exceeded the wading ability of the surveyor.

For the riparian vegetation measurements, the riparian corridor can be defined as either a single 100-ft wide zone or two adjacent riparian zones (inner and outer zones) totaling 100 feet in width (USFS 2020). For this assessment, one single 100-ft wide riparian zone was designated for the Entiat River assessment area. Survey methods dictate defining a dominant size class of vegetation type within the riparian corridor (e.g. small trees, shrubs), then defining the dominant species observed in the overstory and understory. Survey methods for this assessment deviated slightly and included collection of dominant species and size class for both the understory and overstory, as described above.

For this habitat survey, side channels were defined as naturally-wetted flow paths connected to the mainstem channel at their upstream and downstream ends at low flow. Side channel units were identified when the main channel split to form a stable island with soil or fine sediment accumulations and with established vegetation older than 2 to 3 years. Each side channel was determined to be predominately a fast-water or slow-water unit type. The average width of the side channel was recorded based on field observations. Total length of the side channels was recorded using GPS following the same protocols used for main channel unit delineation. In some cases, the side channel was inaccessible to walk to entire length due to beaver dams, dense vegetation, or other obstructions. In these instances, surveyors walked and took data on whatever length was accessible and extrapolated from the portion walked for the rest of the side channel. This report provides data based on total side channel lengths, unless otherwise noted. Several off-channel units were counted in this appendix that were categorized as "other". These were either constructed alcoves or off-channel marshes that were connected to the mainstem of Nason Creek during the time of the survey.

Large woody material (LWM) was counted in the mainstem and side channels following the size class characterizations for "Eastside" forests (USFS 2020) (Tallies of small (> 6 in. diameter, >20 ft long), medium (>12 in. diameter, > 35 ft long) and large (>20 in. diameter, >35 ft long) pieces of LWM were completed for each reach. A log jam was classified as a group of three or more pieces of qualifying size (meets the size requirements above) in contact with one another and with at least one piece within

bankfull. For the log jam count in the habitat survey, both a within bankfull count (number of pieces within bankfull) and total count was performed (number of pieces within and outside of bankfull). The within bankfull count was used for this report.

3 Summary of Results

This section summarizes instream habitat conditions of Nason Creek within the assessment area (RM 0 – 13.55). Reach-scale results are included in Section 4.

3.1 CHANNEL MORPHOLOGY

The Nason Creek channel is naturally unconfined throughout the majority of the assessment area due to its broad glacially carved valley bottom. However, significant human alterations including roads (e.g. Highway 2 and State Route 207), railroads, and other built structures artificially confine the Nason Creek channel, limiting floodplain connectivity and lateral channel migration. The channel in the upstream reaches (Reaches 10-13) has a relatively low slope that is maintained by a valley bottom constriction formed by landslide deposits on river left, and a glacial terrace on river right, from RM 8.6 to 9.1. Downstream of the constriction, channel slope increases significantly, and the valley bottom narrows, resulting in partial lateral confinement of the channel in several locations. Near RM 4.5 the Nason Creek channel bends sharply to the northeast, the valley bottom widens, and the channel returns to a similar gradient as Reaches 10-13 upstream. Channel scars are present throughout the assessment area floodplain, suggesting that Nason Creek has historically migrated across its entire valley bottom.

Table 1. Bankfull and floodprone width results for the entire Nason Creek assessment area.

Bankfull Widths (feet)													
	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**
Min	66	86	70	50	70	72	72	65	85	55	60	60	55
Max	86	102	70	104	100	88	82	85	100	85	80	104	120
Mean	78	94	70	81	82	78	79	74	93	67	68	87	73
St Dev	8	8	n=1	21	16	6	4	8	11	13	10	20	24
Floodprone Widths													
	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**
Min	96	97	366	500	486	100	85	95	90	692	108	99	65
Max	173	273	1371	999	1006	689	441	113	194	1780	794	212	600
Mean	130	157	1014	768	671	361	195	101	127	1372	545	137	409
St Dev	33	100	562	172	291	214	165	8	58	471	379	51	188
Bankfull Depths (feet)													
	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**
Min	0.7	2.0	1.8	0.9	0.8	0.8	1.0	1.2	1.0	1.2	0.8	1.0	1.1
Max	3.5	4.8	3.4	4.7	4.4	4.1	4.3	4.0	3.5	4.4	4.5	5.6	4.5
Mean	2.7	3.7	3.0	3.2	3.1	2.7	2.8	2.8	2.6	3.0	3.3	3.2	3.1
St Dev	0.7	0.7	0.5	0.7	1.0	0.8	0.7	0.5	0.7	0.8	0.9	1.2	0.8

3.2 HABITAT UNIT COMPOSITION

For the Nason Creek assessment area overall, pools were the dominant habitat type, comprising 47% of the total habitat area. Riffles consisted of 26% of the total area, and side channels 17%. Glide units were only 8% of the total habitat area. There were three units recorded in the "other" unit type category (per USFS 2020 protocols), which fell into two main categories: "other" (marsh) and "other" (constructed alcove). Each of the "other" categories comprised of 1% of the total assessment area (Figure 2).

Side channel habitat was found in Reaches 3-4 and Reaches 6-13. See Figure 1 below. The first side channel appeared in Reach 3, where side channel units comprised 16% of the reach area. However, Reach 4 had the most side channel area of all the reaches, at 56% of the reach area.

Pool habitat varied across the assessment area. Reaches 3, 11 and 12 had the highest percentages of pool habitat, with 79%, 77% and 75% pool habitat recorded (respectively). Conversely, Reach 6 had the lowest percentage, with only 18% of the reach area recorded as pool habitat. The mean residual pool depth for Nason Creek ranged from 4.4 feet in Reach 3 to 1.9 feet in Reach 5. Reach 3 and Reach 7 both had the lowest individual residual depth recorded, at 1.2 feet and Reach 3 also had the highest recorded residual depth at 13.5 feet, although it should be noted that the maximum depth in the pool was estimated. Mean residual depth across the 13 reaches was 3.3 feet (Figure 3). Pool frequency was the highest in Reach 3, with 15 pools per mile. Reaches 6-7 and Reach 9 all had the lowest pool frequency, with only five pools per mile.

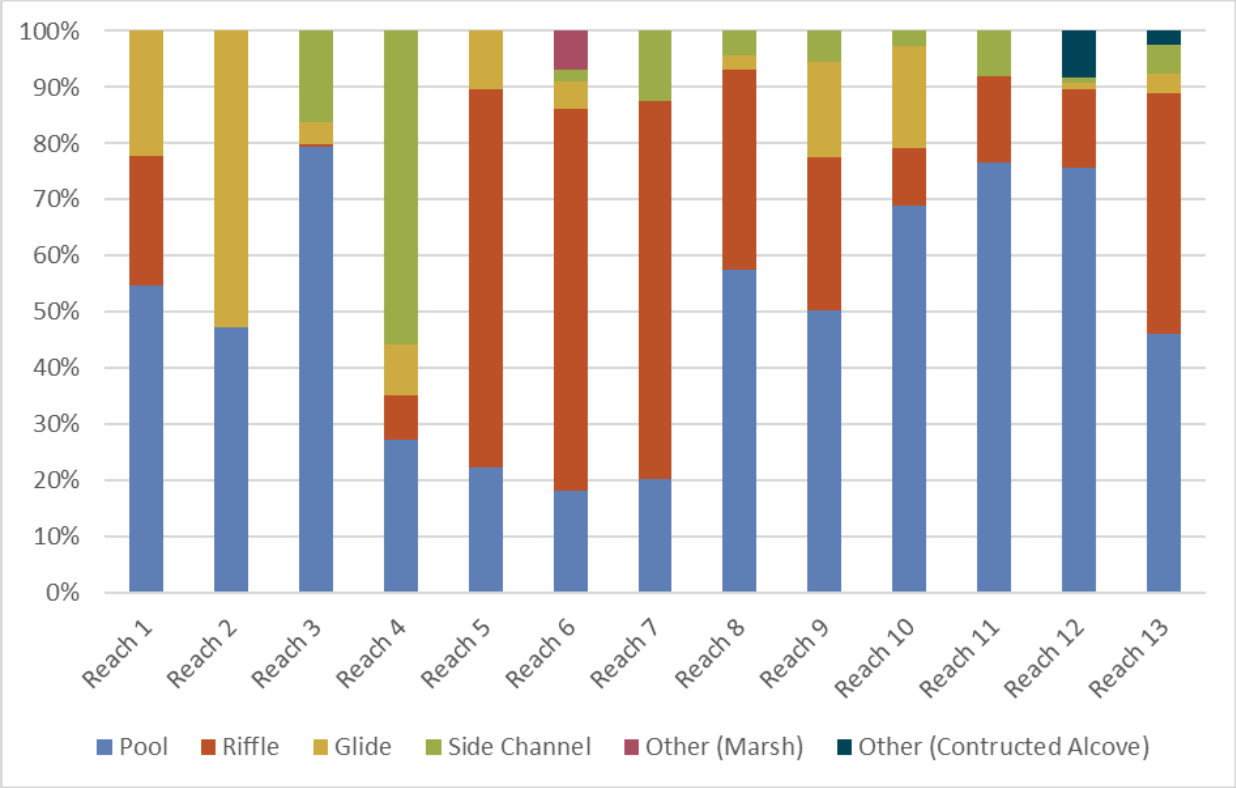


Figure 1. Habitat unit composition per reach (as a percent of total reach area) for each of the 13 surveyed reaches.

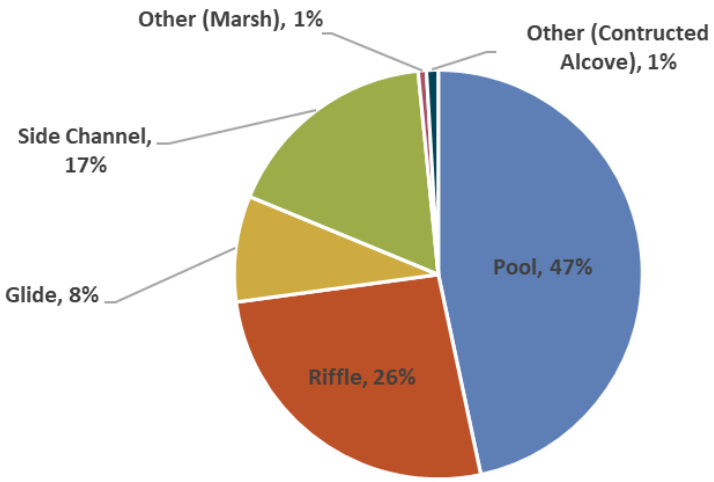


Figure 2. Habitat unit composition across the entire assessment area.

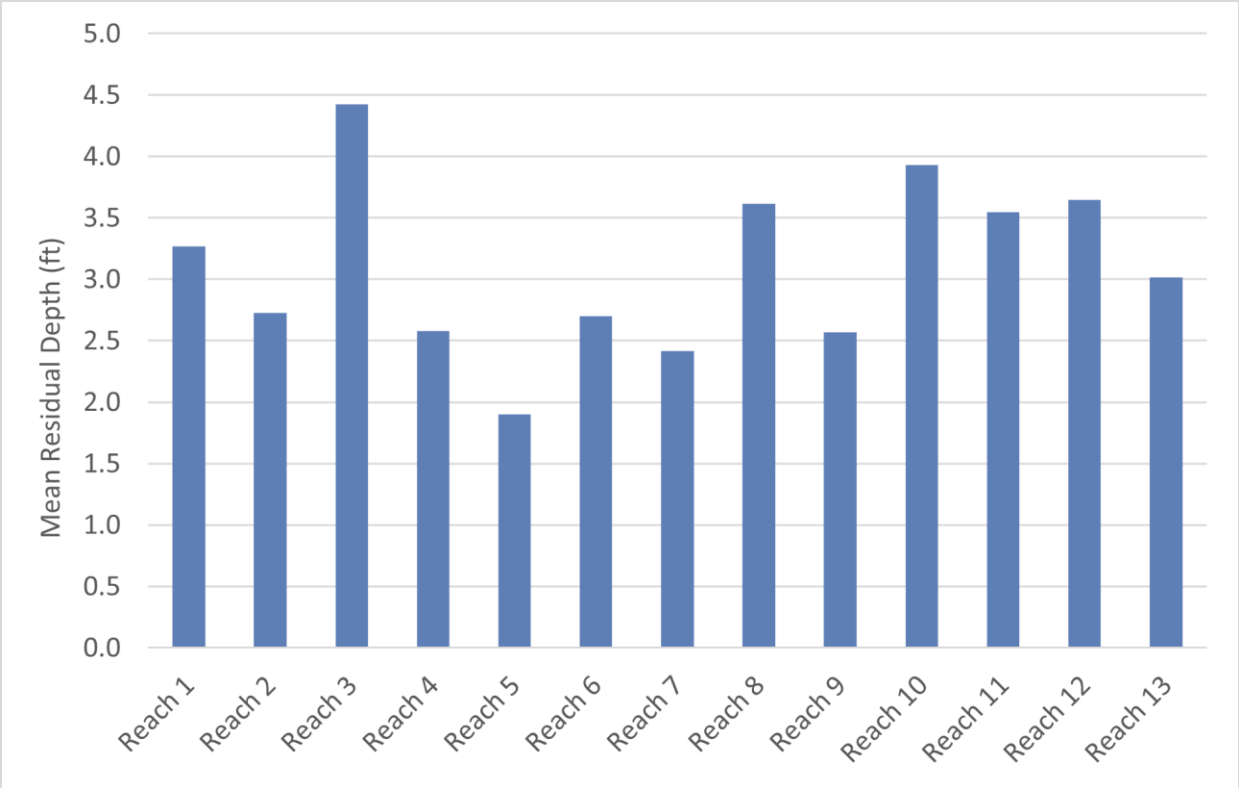


Figure 3. Average residual pool depth per reach.

3.3 SIDE CHANNEL HABITAT

Side channel habitat throughout the assessment area made up 17% of the total area. A total of 27 side channels were observed in the assessment area, four of which were constructed. Twenty-two were predominantly slow water (pool-type) habitat and five were predominantly fast water (riffle-glide type) habitat. Reach 4 had the most side channel by area (56% of the reach area) and in total number of side channels (n=10). Reach four also had both the longest and shortest side channels of the assessment area, at 5,033 feet and 79 feet, respectively.

3.4 LARGE WOODY MATERIAL (LWM)

There were 4,180 pieces of LWM observed in the assessment area in total, averaging 309 pieces per mile and 183 medium and large (M+L) LWM pieces per mile. This count includes individual pieces recorded as well as the number of pieces estimated in jams. Over half of all the LWM observed in the assessment area was positioned in jams (58%), while 42% were recorded as individual pieces of LWM. A total of 161 jams (12 jams per mile) were counted in the assessment area. LWM was counted in three size classes: small (diameter >6 inches and length >20 feet), medium (diameter >12 inches and length >35 feet), and large (diameter >20 inches and length >35 feet). Small LWM pieces made up 41% of all wood recorded in the assessment area, while 33% was recorded as medium and 26% was classified as large. Reach 12 had the most LWM, both in the number of M+L LWM pieces per mile (n=588) and in the total pieces per mile (n=704). There was a large, constructed alcove (near RM 12.1) that contained 63% of the wood found in Reach 12. Reach 7 had the second highest amount of LWM observed, with 593 total pieces per mile (244 M+L per mile and 349 small pieces per mile) recorded. Reach 5 had the lowest number of pieces per mile,

with only 17 M+L pieces and 37 total pieces per mile recorded (Figure 4). These quantities include the wood found in jams, as well as individual pieces.

Fox and Bolton (Fox and Bolton 2007) conducted instream large wood surveys in unmanaged streams across Washington state to help understand natural wood loading conditions. As part of their study, they compared their data to the National Marine Fisheries Service (NMFS) properly functioning conditions threshold (NMFS 1996) that are based on sizes exceeding the "medium" size class used by the USFS in the Level 2 survey protocols (2020; ≥12 in diameter and at least 35 ft long). The Fox and Bolton (2007) 75th percentile of wood loading was 67.45 pieces per mile for unmanaged streams in eastside forests. For this Nason Creek reach assessment, we chose the 75th percentile value to use as a comparison to observed conditions in Nason Creek, since this is believed to be a reasonable target for restoration of natural wood loading ranges across the landscape by Fox and Bolton (2007). Therefore, the "adequate" threshold for LWM in Nason Creek is > 67.45 pieces per mile of M+L size class wood, with additional woody debris available for long-term recruitment. Reaches 1-4, Reaches 7-8, and Reaches 10-13 all met the minimum number of pieces per mile for the "adequate" threshold however, none of them met the criteria for LWM recruitment. The remaining reaches met neither the M+L criteria per mile nor the recruitment potential.

The LWM reported in this habitat assessment is based on USFS criteria (2020). Additional information on LWM, including LWM that doesn't meet USFS criteria (2020) but provides geomorphic function to the Nason Creek, is discussed in Section 6 of the main report.

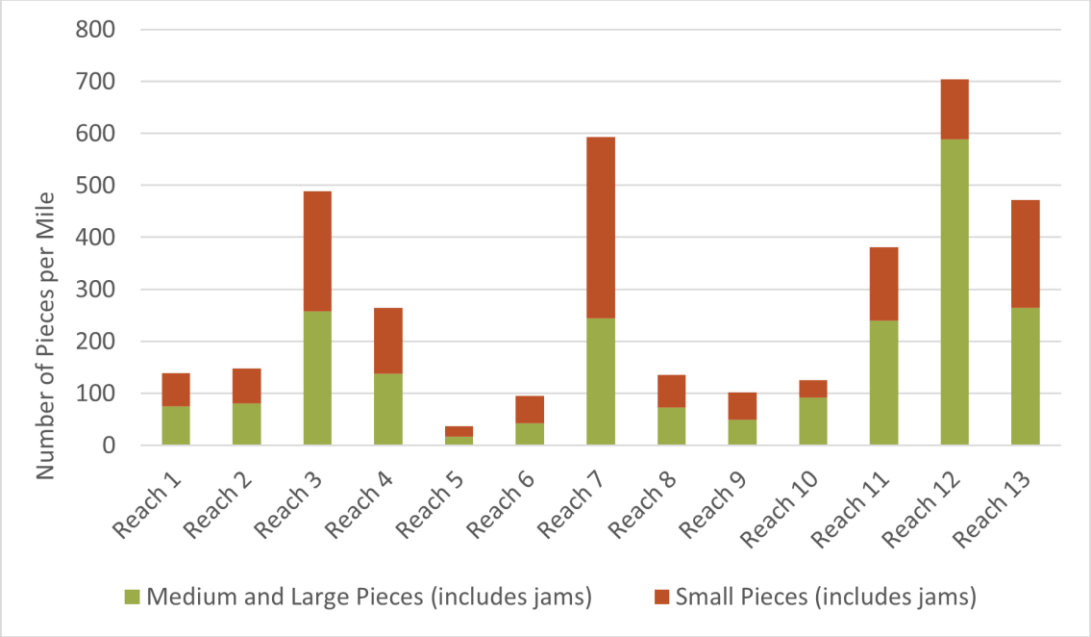


Figure 4. Number of LWM pieces per mile for each reach, organized by small and M+L pieces.

3.5 BANK INSTABILITY

Throughout the assessment area, human-caused bank instability was low, making up 4% of the total bank length. The total bank length throughout the assessment area was calculated by doubling the length of the reach to account for unstable banks on both river left and river right. Surveyors recorded anthropogenically-caused bank instability, where human actions were leading to increased levels of

erosion or where stability/reinforcement features were located. The primary causes of unstable banks were riprap along the banks near roads and railroads or underneath bridges (Figure 5).

Reach 13 had the highest percentage of unstable banks, with 17% of the total bank length (i.e., both sides) recorded as unstable. There was a 0.4-mile stretch of Reach 13 (42% of the reach length) near RM 12.9-13.3 where both banks had been armored with riprap. Reach 1 and Reach 10 also had relatively high percentages of unstable banks, with 12% of the total bank length recorded in each reach. Anthropogenically-caused bank instability was largely a result of State Route 207 and Nason Creek Campground adjacent to the channel in Reach 1. Highway 2 crosses the Nason Creek channel in Reach 10, and the BNSF railroad is adjacent to the channel for almost the entirety of the reach. Residential and recreational uses also contributed to the human-caused bank erosion in both Reaches 1 and 10.

Figure 5. The BNSF railroad and riprap placed along the bank in Reach 10.

3.6 FISH PASSAGE BARRIERS

No full fish passage barriers were observed in the main channel of Nason Creek within the assessment area. There were several man-made rock dams near the Nason Creek Campground in Reach 1 (between RM 0 - 1.1). None of them were channel-spanning or full fish passage barriers at the time of survey, but they all had the potential to impede fish passage. An in-channel water intake structure was observed in Reach 10 near RM 9.25 (Figure 6). The intake structure was approximately 4x4 feet, with a vertical pipe

extending from the riverbed. Just upstream of the in-channel structure was a channel-spanning, anthropogenic rock weir. At the time of the survey the thalweg depth through the rock weir was 0.4 ft.

Figure 6. In-stream water intake structure and associated rock weir in Reach 10.

3.7 RIPARIAN CORRIDOR

Riparian conditions within 100 feet of the channel on both banks were recorded at a subset of channel units, including n^{th} units or where surveyors noticed significant changes in riparian conditions. Of the 95 units where vegetation conditions were recorded in the assessment area (Figure 7), the dominant (75%) overstory riparian vegetation size was large tree (21.0-31.9-inch diameter at breast height [dbh]). Small trees (9.0-20.9-inch dbh) were the second most frequent overstory size class in the assessment area (found in 15% of units), followed by no vegetation (9%) and shrub/seedling (1-4.9-inch dbh; 1%). The most common overstory species recorded was cottonwood (31%), followed closely by grand fir (28%) and ponderosa pine (25%). Douglas fir (3%), alder (2%), and quaking aspen (1%) were also reported as overstory species in the assessment area (Figure 8). In the 9% of surveyed units with no overstory, the lack of vegetation was typically caused from transmission lines, the BNSF railroad, or recent restoration projects where the overstory had yet to be established.

The dominant understory in the assessment area was recorded as 88% in the shrub/seedling (1.0 -4.9-inch dbh) size class. Grassland/forb was the second most prevalent class (5%), followed by "other" , sapling/pole (5-8.9-inch dbh), and no vegetation, all of which were found in 2% of units surveyed (Figure 9). The units with "other" as the understory were areas with landscaped yards containing a variety of ornamental vegetation. Understory species were frequently observed to be dogwood (40%), alder (27%) and willow (14%). "Other"/unknown species, usually an unknown species of grass or ornamental species

in landscaped residential areas, consisted of 7% of the observations in the assessment area. Vine maple (6%), cottonwood (5%), and no vegetation (2%) were also present (Figure 10).

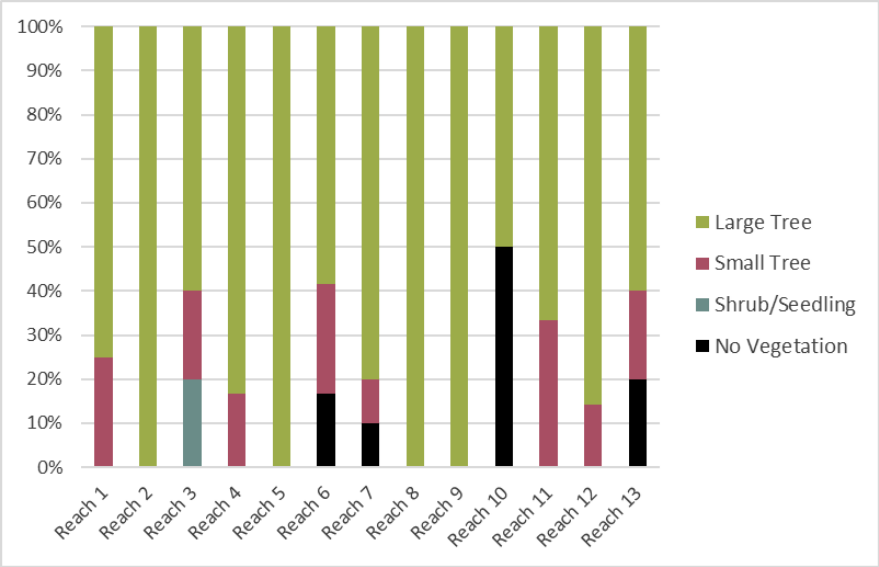


Figure 7. Percent composition of the dominant overstory size class for all units in which vegetation surveys were performed.

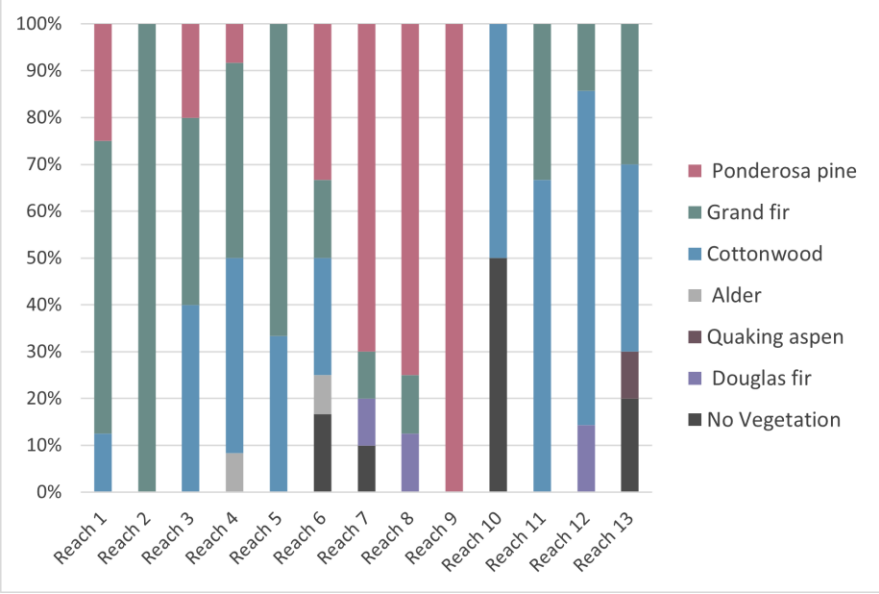


Figure 8. Percent composition of the dominant overstory species for all units in which vegetation surveys were performed.

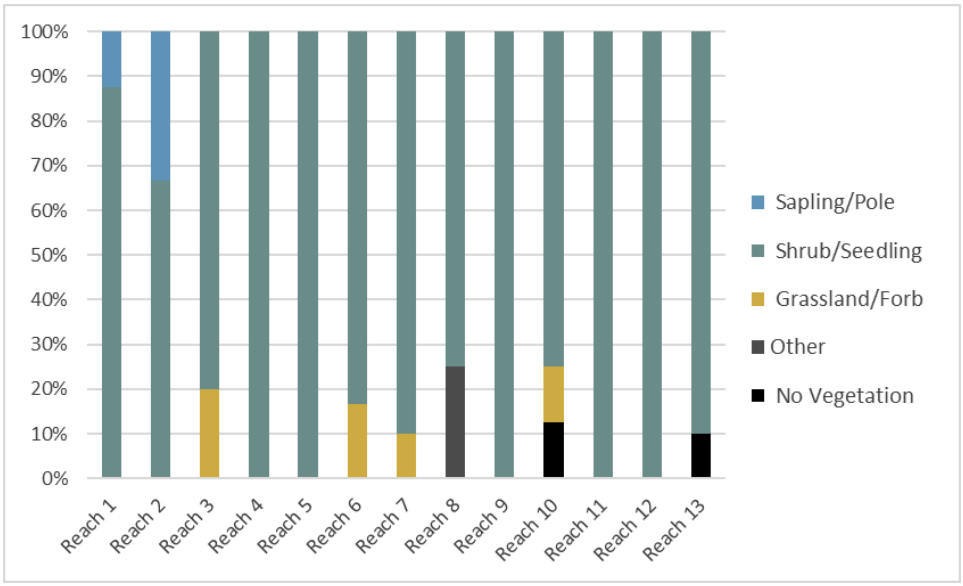


Figure 9. Percent composition of the dominant understory size class for all units in which vegetation surveys were performed.

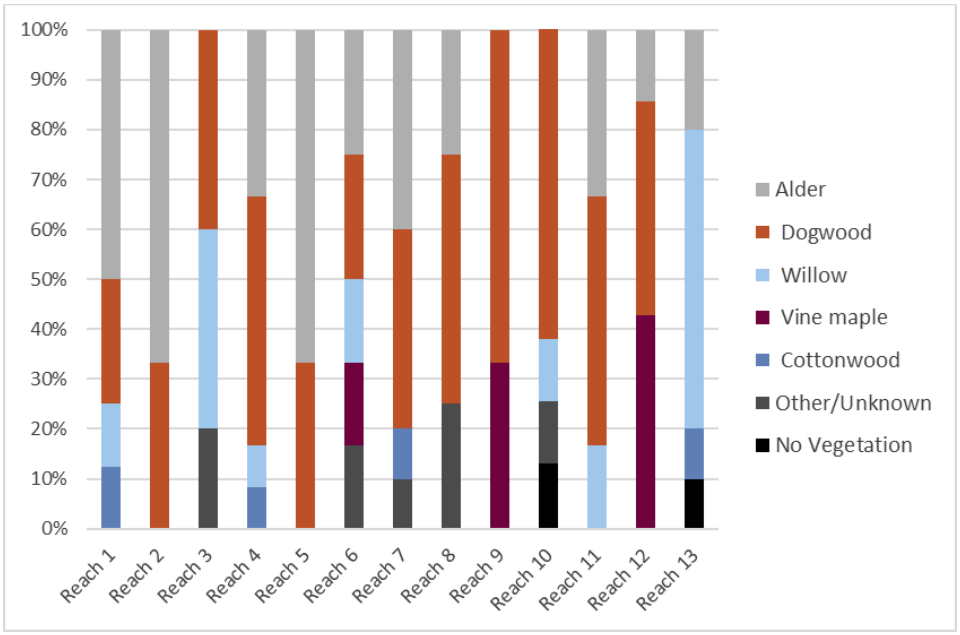


Figure 10. Percent composition of the dominant understory species for all units in which vegetation surveys were performed.

4 Comparison to Past Reach Assessments

Two stream habitat assessments covering this Nason Creek assessment area (RM 0 – 13.55) have been previously conducted, and include:

- 2010 Lower Nason Assessment of Geomorphic and Ecologic Indicators, which documented the results of two separate habitat assessments by USBR and by USFS, RM 0-4.4 (USBR 2011)
- 2007 Nason Creek Habitat Assessment, RM 4.4-13.55 (USBR 2009)

Data from the equivalent stretch of Nason Creek from this 2024 assessment was compared to the corresponding previous reach assessment extents (Table 2). In the Lower Nason Assessment of Geomorphic and Ecologic Indicators (RM 0-4.4) there were two stream habitat surveys reported, one by USBR and one by USFS (USBR 2011). The 2010 USBR Survey (RM 0-4.4) reported habitat unit composition by channel segments that roughly align with the reach breaks of this 2024 assessment. It should be noted that the side channel definition in the 2010 USBR Survey (RM 0-4.4) included ephemeral secondary channels, whereas in this 2024 assessment only side channels wetted at low flow were included, as outlined in the USFS (2020) habitat inventory protocols. The 2010 USFS Survey (RM 0-4.4) reported habitat unit composition data, LWM counts, and the number of side channels. The 2007 Nason Creek Habitat Assessment (RM 4.4-13.55) reach breaks largely correspond to the reach breaks used in this 2024 assessment. Data reported in the 2007 Assessment included habitat unit composition and LWM counts. All assessments used the same size criteria for LWM, as defined by USFS (2020).

Table 2. Table showing crosswalk of the location of reaches between the 2024 Assessment and previous assessments.

2010 USBR Survey (Lower Nason Assessment of Geomorphic and Ecologic Indicators), RM 0-4.4	**2024 Assessment, RM 0-4.4**
Segment D (RM 0-0.9)	Lower Portion of Reach 1 (RM 0-0.9)
Segment C (RM 0.9-1.5)	Upper Portion of Reach 1-Reach 2 (RM 0.9-1.5)
Segment B (RM 1.5-2.5)	Reach 3 (RM 1.5-2.5)
Segment A (RM 2.5-4.4)	Lower Portion of Reach 4 (RM 2.5-4.4)
2010 USFS Stream Survey (Lower Nason Assessment of Geomorphic and Ecologic Indicators), RM 0-4.4	**2024 Assessment, RM 0-4.4**
2007 Nason Creek Habitat Assessment, RM 4.4-13.55	**2024 Assessment, RM 4.4-13.55**
Reach 1 (RM 4.4-8.6)	Upper Portion of Reach 4-Reach 8 (RM 4.4-8.6)
Reach 2 (RM 8.6-9.15)	Reach 9 (RM 8.6-9.15)
Reach 3 (RM 9.15-11.25)	Reach 10-11 (RM 9.15-11.25)
Reach 4 (RM 11.25-12.6)	Reach 12 (RM 11.25-12.6)
Reach 5 (RM 12.6-13.55)	Reach 13 (RM 12.6-13.55)

Between the 2010 USBR Survey (RM 0-4.4) and this 2024 assessment the habitat unit composition has shifted markedly. All segments have increased in the proportion of pool habitat, typically with corresponding decreases in the riffle/glide habitat percentages (Table 3). The side channel habitat in the two most downstream of the compared segments (Segment D-C vs Reaches 1-2) decreased over time, though this difference may be attributed to ephemeral side channels being included in the USBR survey.

Notably however, given this difference in definitions, the percentage of side channel habitat increased over time in the two upstream most compared segments (Segment B-A vs. Reach 3-4).

Between the 2010 USFS Survey (RM 0-4.4) and this 2024 assessment, pool habitat has decreased while side channel habitat area has increased substantially (Table 3). Fast water (riffle/glide) habitat remained roughly equivalent between the 2010 and 2024 surveys. Despite the increase in proportion of side channel habitat in this 2024 assessment, the number of side channels only increased by one, and the LWM (M+L) pieces per mile increased by 60% between 2010 and 2024.

Between the 2007 Nason Creek Reach Assessment (RM 4.4-13.55) and this 2024 assessment, habitat unit compositions were fairly similar, except for notable increases in side/off-channel habitats observed across all reach comparisons (Table 4). The number of LWM (M+L) per mile was also much higher, ranging from increases of 350% all the way up to 2,000% more in 2024 than in 2007.

The changes across all of the compared assessments are presumably related to the roughly 21 restoration projects implemented in the Nason Creek over the decade and a half. Though additional metrics were surveyed in all the assessments, these key metrics were selected for comparison due to the high likelihood of change as a result of restoration actions.

Table 3. Comparative data from the equivalent sections of the 2024 Assessment as the 2010 USBR Survey (RM 0-4.4) and 2010 USFS Stream Survey (RM 0-4.4). It should be noted that the 2010 USBR Survey included ephemeral side channels while the 2024 Assessment only included side channels that were wet at low flow. In the 2010 USFS Stream Survey (RM 0-4.4) the side channel percentage was calculated as a percentage of main channel area, rather than total area (as was done in the 2024 Assessment). LWM size criteria were consistent between the compared assessments and both included wood in jams.

2010 USBR Survey (Lower Nason Assessment of Geomorphic and Ecologic Indicators), RM 0-4.4		**2024 Assessment (RM 0-4.4)**	
Segment D (RM 0-0.9)		Lower Portion of Reach 1 (RM 0-0.9)	
Pool	19%	Pool	60%
Fast Water (riffle/ glide)	74%	Fast Water (riffle/glide)	40%
Side Channel	19%	Side Channel	0%
Segment C (RM 0.9-1.5)		Upper Portion of Reach 1-Reach 2 (RM 0.9-1.5)	
Pool	14%	Pool	45%
Fast Water (riffle/ glide)	66%	Fast Water (riffle/glide)	55%
Side Channel	20%	Side Channel	0%
Segment B (RM 1.5-2.5)		Reach 3 (RM 1.5-2.5)	
Pool	51%	Pool	79%
Fast Water (riffle/glide)	44%	Fast Water (riffle/glide)	5%
Side Channel	5%	Side Channel	16%
Segment A (RM 2.5-4.4)		Lower Portion of Reach 4 (RM 2.5-4.4)	
Pool	22%	Pool	27%
Fast Water (riffle/ glide)	32%	Fast Water (riffle/glide)	16%
Side Channel	46%	Side Channel	57%
2010 USFS Stream Survey (Lower Nason Assessment of Geomorphic and Ecologic Indicators), RM 0-4.4		**2024 Assessment (RM 0-4.4)**	
Habitat Unit Composition (percent of total area)		Habitat Unit Composition (percent of total area)	
Pool	72%	Pool	41%
Fast Water (riffle/glide)	28%	Fast Water (riffle/glide)	21%
Side Channel (as a % of main channel area)	10%	Side Channel	38%
Number of Side Channels	10	Number of Side Channels	11
LWM (M+L) per mile	88	LWM (M+L) per mile	141

Table 4. Comparative data from the equivalent section of the 2024 Assessment as the 2007 Nason Creek Habitat Assessment area. Both assessments used the same LWM size criteria, as outlined by the USFS (2020) habitat inventory protocols.

2007 Nason Creek Habitat Assessment (Appendix C), RM 4.4-13.55		**2024 Assessment (RM 4.4-13.55)**	
Reach 1 (RM 4.4-8.6)		Upper Portion of Reach 4-Reach 8 (RM 4.4-8.6)	
Habitat Unit Composition (percent of total area)		Habitat Unit Composition (percent of total area)	
Pool	28.6%	Pool	31%
Riffle	57.5%	Riffle	60%
Glide	12.4%	Glide	3%
Side Channel	1.5%	Side Channel	6%
LWM (M+L) per mile)	10.5	LWM (M+L) per mile)	95
Reach 2 (RM 8.6-9.15)		Reach 9 (RM 8.6-9.15)	
Habitat Unit Composition (percent of total area)		Habitat Unit Composition (percent of total area)	
Pool	54.3%	Pool	50%
Riffle	35.1%	Riffle	27%
Glide	10.6%	Glide	17%
Side Channel	0.0%	Side Channel	5%
LWM (M+L) per mile)	10.6	LWM (M+L) per mile)	48
Reach 3 (RM 9.15-11.25)		Reach 10-Reach 11 (RM 9.15-11.25)	
Habitat Unit Composition (percent of total area)		Habitat Unit Composition (percent of total area)	
Pool	69.8%	Pool	73%
Riffle	21.6%	Riffle	13%
Glide	7.4%	Glide	9%
Side Channel	1.2%	Side Channel	5%
LWM (M+L) per mile)	15.7	LWM (M+L) per mile)	163
Reach 4 (RM 11.25-12.6)		Reach 12 (RM 11.25-12.6)	
Habitat Unit Composition (percent of total area)		Habitat Unit Composition (percent of total area)	
Pool	72.6%	Pool	76%
Riffle	22.3%	Riffle	14%
Glide	4.6%	Glide	1%
Side Channel	0.5%	Side/Off-Channel	9%
LWM (M+L) per mile)	25.8	LWM (M+L) per mile)	588
Reach 5 (RM 12.6-13.55)		Reach 13 (RM 12.6-13.55)	
Habitat Unit Composition (percent of total area)		Habitat Unit Composition (percent of total area)	
Pool	36.0%	Pool	46%
Riffle	48.8%	Riffle	43%
Glide	13.8%	Glide	3%
Side Channel	1.4%	Side/Off-Channel	7%
LWM (M+L) per mile)	14.8	LWM (M+L) per mile)	264

5 Stream Habitat Reach Reports

5.1 REACH 1

Location: River mile 0 – 1.1
Total length: 1.1 miles
Survey date: September 9th, 2024

Figure 11. Representative photo of Reach 1. Habitat units were dominated by pools.

5.1.1 Habitat Unit Composition

Reach 1 was 1.1 miles long with a channel gradient of 0.51%. This reach was a majority (55%) pool habitat units (Figure 13). Riffles and glides made up the remaining habitat types, with 23% and 22%, respectively. There were no actively flowing side channels at the time of the survey. State Route 207 and Nason Creek campground are present on the banks throughout a majority of the reach, with riprap, small rock dams, and recreational footpaths apparent throughout the in-stream and riparian zones.

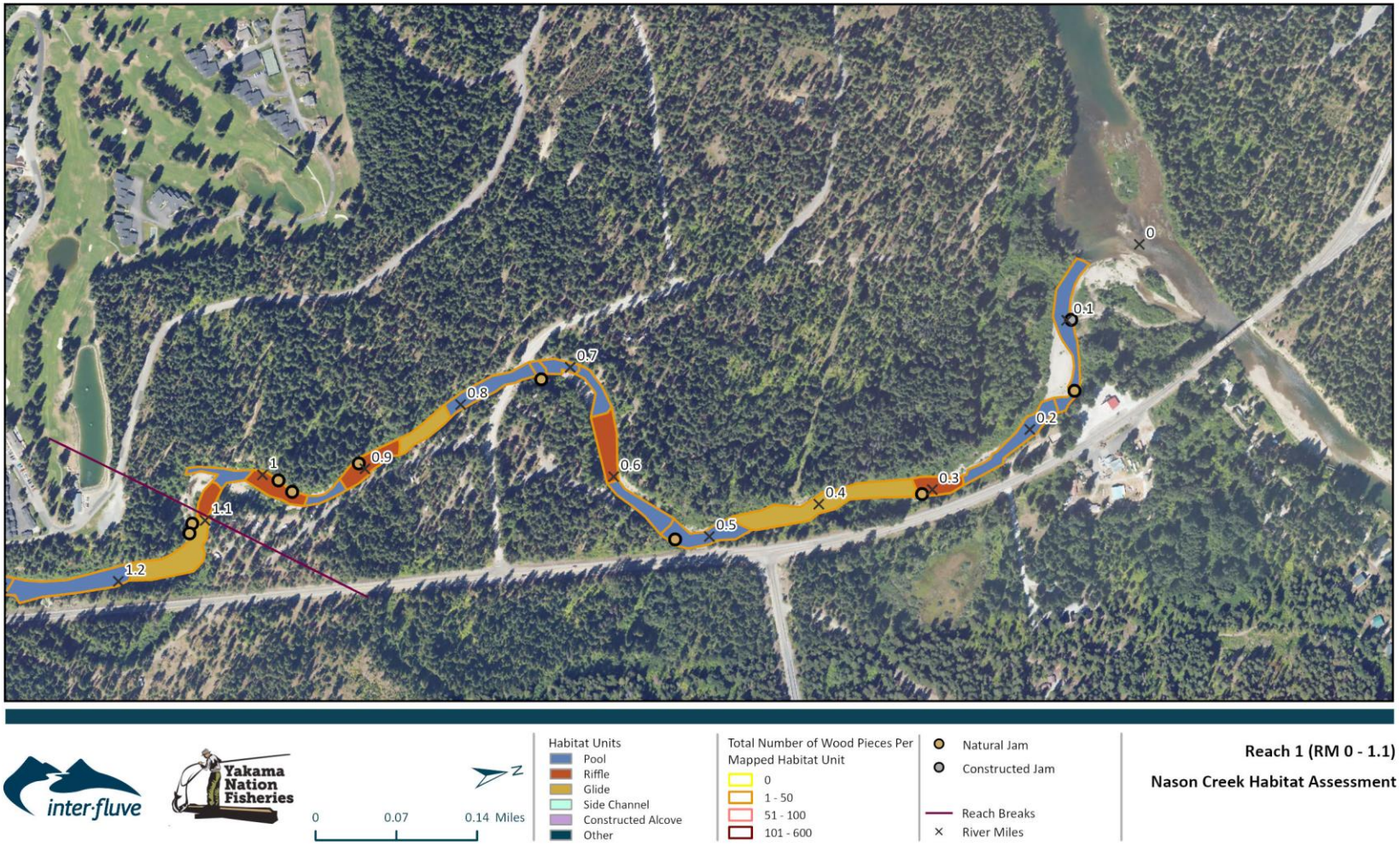


Figure 12. Map of the habitat unit composition and LWM in Reach 1 of Nason Creek. LWM count includes pieces in jams.

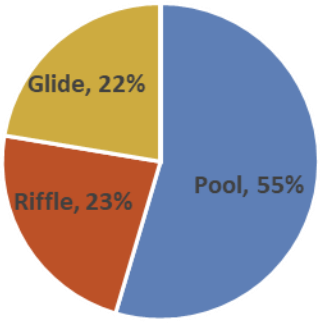


Figure 13. Stream habitat unit area composition of Reach 1.

5.1.2 Pools

Pool habitat was the most prevalent habitat type found in Reach 1, with 10 pool units recorded and a reach average of nine pools per mile. The assessment area average was also nine pools per mile. Reach 1 had an average residual depth of 3.3 feet, the same as the assessment area average of 3.3 feet. Half of the pools in Reach 1 had residual depths greater than or equal to 3 feet. The range of residual depths was from 1.7 to 5 feet deep.

5.1.3 Side Channel Habitat

No side channels were observed in Reach 1. A high-flow side channel was observed at the mouth of Nason Creek. The side channel was located on river right, with an inlet near RM 0.1 and flowed into the mainstem Wenatchee River. The channel was dry at the time of survey and was not recorded as a part of this habitat assessment, per USFS methods (2020).

5.1.4 Large Woody Material

Reach 1 had 152 total pieces of LWM, including wood counted in jams, which equates to 138 pieces per mile. There were 75 (54%) pieces of M+L wood (combined) per mile. Eight jams were counted, containing 29% (n = 44) of the total number of LWM pieces observed in the reach (Table 5).

Table 5. Large woody material quantities in Reach 1.

	Small (6 in x 20 ft)	Medium (12 in x 35 ft)	Large (20 in x 35 ft)	Total
Number of individual LWM pieces	46	35	27	108
Number of individual LWM pieces per mile	42	56		98
Number of pieces per mile (including pieces in jams)	64	75		138
Number of jams	8			
Number of jams per mile	7			
Estimated Wood Count in Jams	44			

5.1.5 Riparian Corridor

Eight channel units in Reach 1 included ocular assessments of riparian vegetation. The overstory was primarily grand fir and Ponderosa pine in the large tree (21 - 31.9-inch dbh) size class. Cottonwood and grand fir in the small tree (9.0-20.9-inch dbh) size class were also observed (Figure 14). The understory was primarily alder, followed by dogwood and willow, in the shrub/seedling (1.0 -4.9-inch dbh) size class. Cottonwood in the sapling/pole (5-8.9-inch dbh) size class was also observed in the understory (Figure 15).

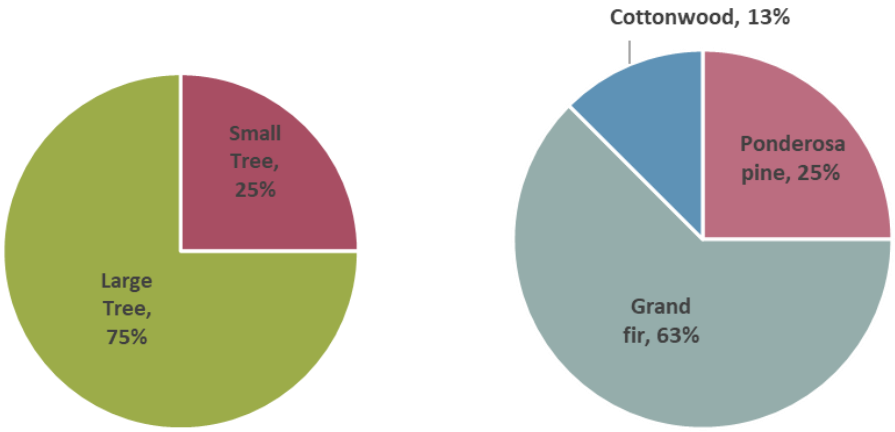


Figure 14. Dominant overstory riparian vegetation class and species, based on eight units surveyed, within 100 feet of Nason Creek by ocular estimate.

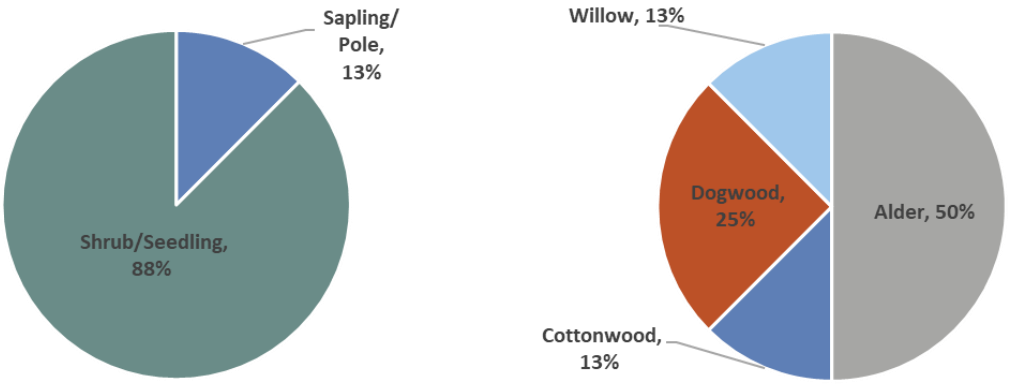


Figure 15. Dominant understory riparian vegetation class and species, based on eight units surveyed, within 100 feet of Nason Creek by ocular estimate.

5.2 REACH 2

Location: River mile 1.1-1.4
Total length: 0.4 miles
Survey Date: September 10th, 2024

Figure 16. Representative photo of Reach 2. Habitat units were a mix of glide and pool units.

5.2.1 Habitat Unit Composition

Reach 2 channel habitat consisted of a roughly equal mix of glide and pool units, where glide habitat made up 53% of the reach and pool habitat the remaining 47% (Figure 18). The reach was only 0.4 miles long, the second shortest of the survey, and had a stream gradient of 0.22%. Kahler Glen Golf Course on river left and State Route 207 on river right abuts the reach, resulting in a relatively straight, single threaded, and confined reach.

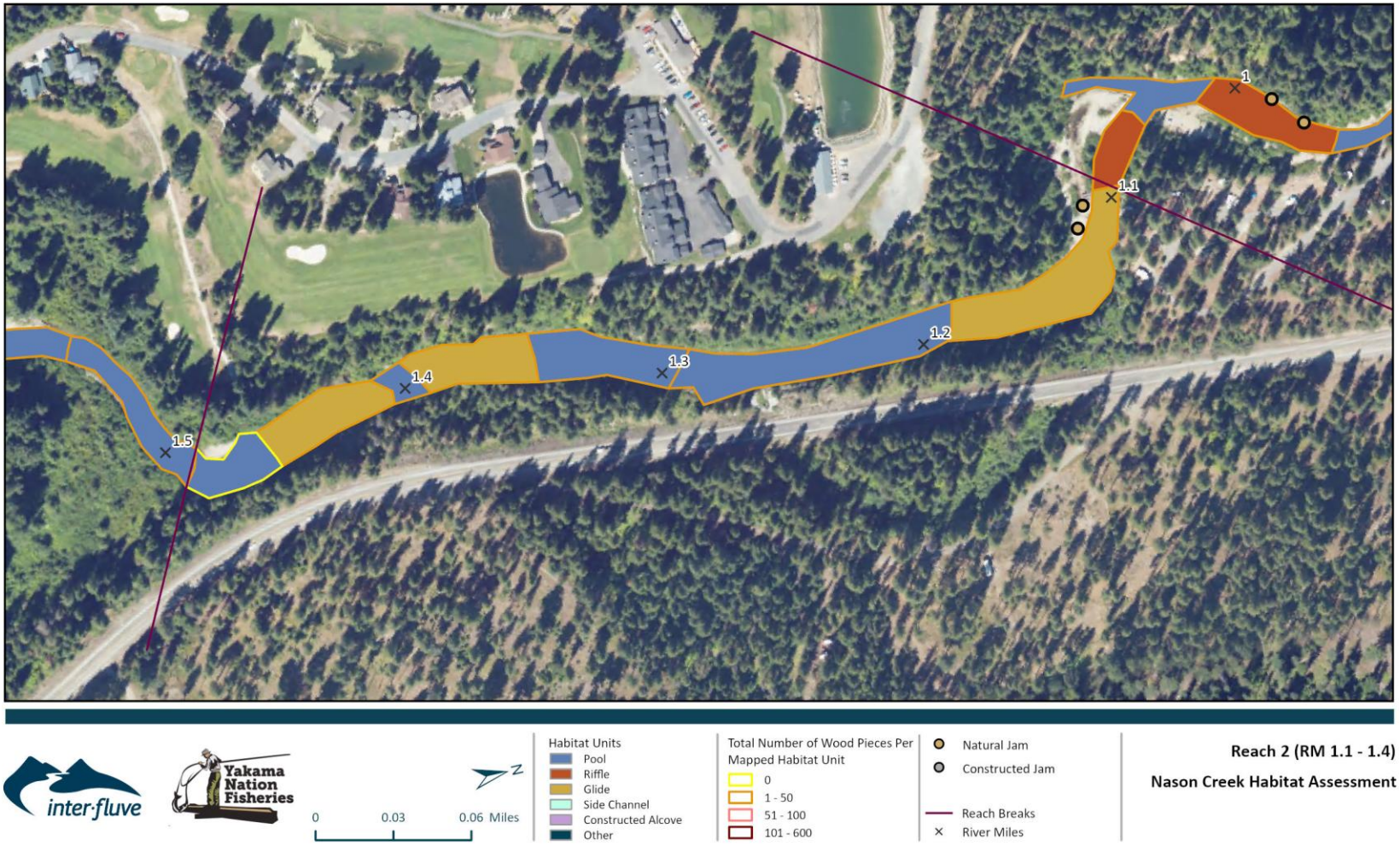


Figure 17. Map of the habitat unit composition and LWM in Reach 2 of Nason Creek. LWM count includes pieces in jams.

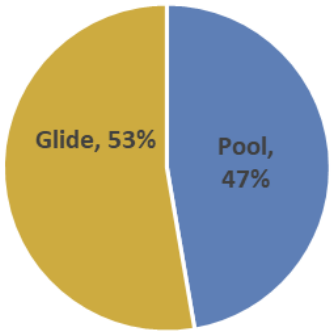


Figure 18. Stream habitat unit area composition of Reach 2.

5.2.2 Pools

A total of four pools were observed in 0.4-mile-long Reach 2. This results in a reach average of 10 pools per mile, slightly higher than the assessment area average of nine pools per mile. The average residual depth in Reach 2 was lower than the assessment area average (3.3 feet) and the residual depths ranged from 1.9 to 4.6 feet deep. Only 25% of the pools had a residual depth greater than or equal to three feet deep.

5.2.3 Side Channel Habitat

No actively flowing side channels were observed in Reach 2. There is a high-flow side channel at the downstream end on river right, that runs under State Route 207 via two large culverts. However, most of the side channel was dry at the time of the survey, including the inlet, and dense vegetation in the side channel suggests it is not wetted often. There was a small amount of back watering occurring at the outlet of the side channel, creating a small amount of off-channel habitat. However, the off-channel habitat had minimal surface flow and was therefore excluded from the habitat survey. See below.

Figure 19. Outlet of the high flow side channel in Reach 2, with minimal backwatering from Nason Creek. The side channel was excluded from the habitat survey.

5.2.4 Large Woody Material

Reach 2 had 59 pieces of LWM total, which averages to 100 pieces per mile. This total includes individual pieces and pieces recorded in jams. Of the 100 pieces per mile of LWM, 80 pieces per mile were M+L (combined). Two jams were observed in Reach 2, or five jams per mile, containing an estimated 32% (19 pieces) of the total number of LWM recorded in the reach (Table 6).

Table 6. Large woody material quantities in Reach 2.

	Small (6 in x 20 ft)	Medium (12 in x 35 ft)	Large (20 in x 35 ft)	Total
Number of individual pieces	19	10	11	40
Number of individual pieces per mile	48	53		100
Number of pieces per mile (including pieces in jams)	68	80		148
Number of jams	2			
Number of jams per mile	5			
Estimated Wood Count in Jams	19			

5.2.5 Riparian Corridor

Three channel units in Reach 2 included ocular assessments of riparian vegetation. The overstory size class in the riparian zone was entirely composed of grand fir in the large tree (21.0 - 31.9-inch dbh) size class (Figure 20). The understory consisted of alder and dogwood in the shrub/seedling (1.0 -4.9-inch dbh) or sapling/pole (5-8.9-inch dbh) size class (Figure 21).

Figure 20. Dominant overstory riparian vegetation class and species, based on three units surveyed, within 100 feet of Nason Creek by ocular estimate.

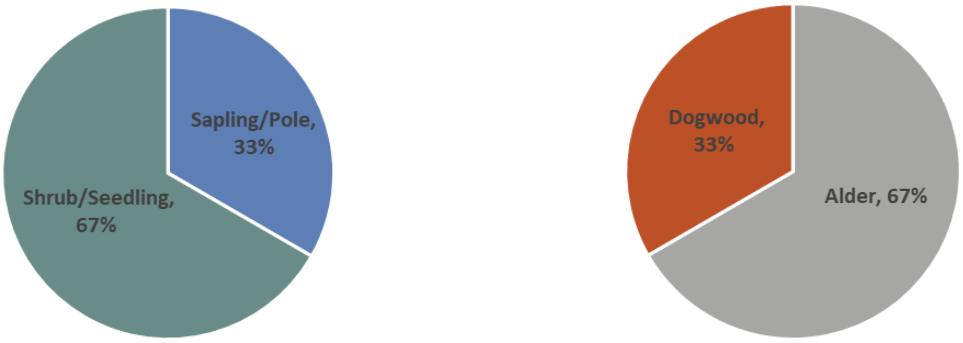


Figure 21. Dominant understory riparian vegetation class and species, based on three units surveyed, within 100 feet of Nason Creek by ocular estimate.

5.3 REACH 3

Location: River mile 1.4-2.5
Total length: 1.0 miles
Survey Date: September 11th, 2024

Figure 22. Representative photo of Reach 3. Habitat units were dominated by pools.

5.3.1 Habitat Unit Composition

Reach 3 had the most pool habitat by area of any reach in the assessment area at 79%. Side channel habitat was also present in this reach (16%), followed by relatively small proportions of fast-water habitats – glide habitat made up 4% and riffle habitat only 0.6% of the habitat units by area (Figure 24). Reach 3 was less confined by anthropogenic features and more sinuous than the previous two reaches, with a stream gradient of 0.20%.

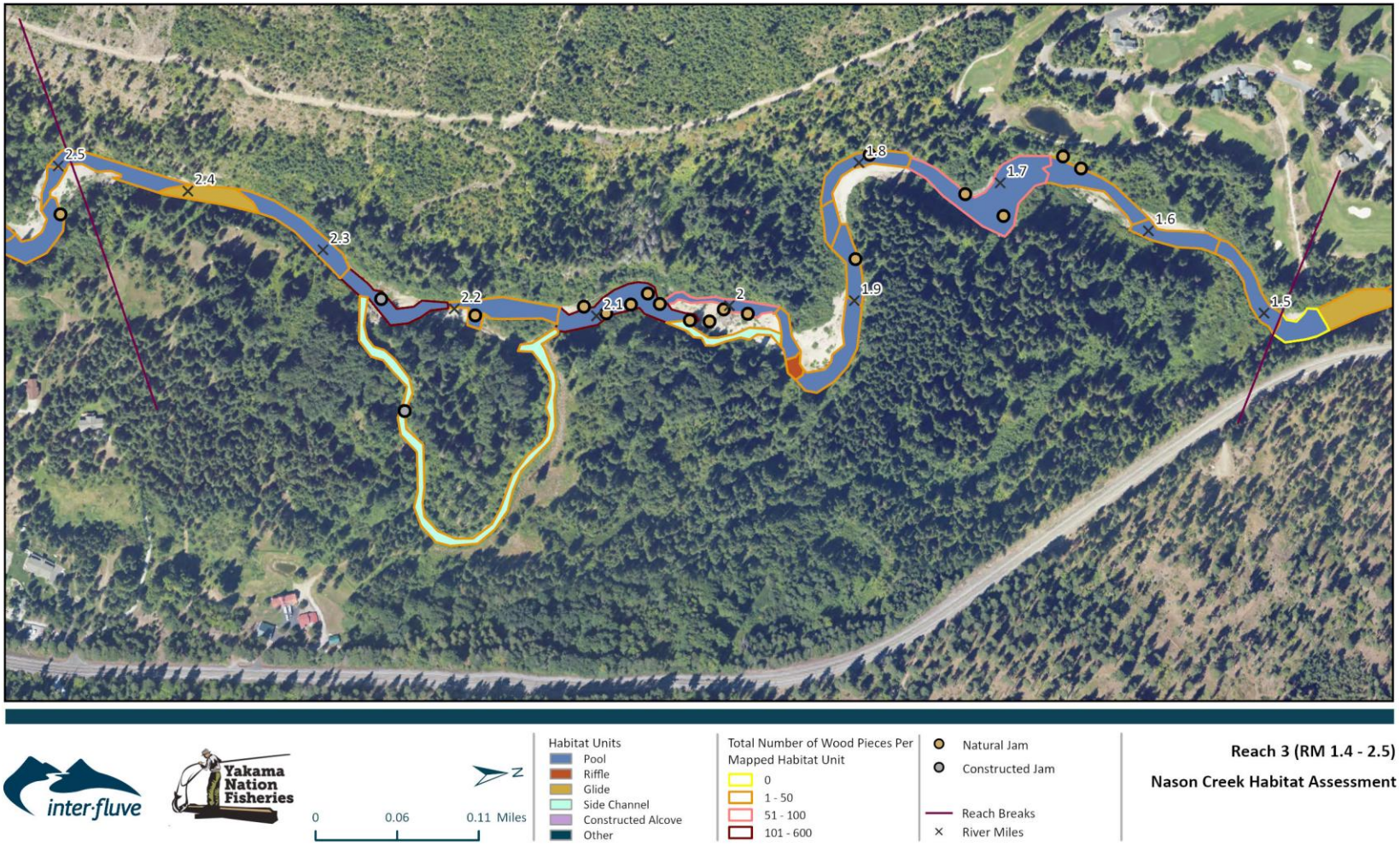


Figure 23. Map of the habitat unit composition and LWM in Reach 3 of Nason Creek. LWM count includes pieces in jams.

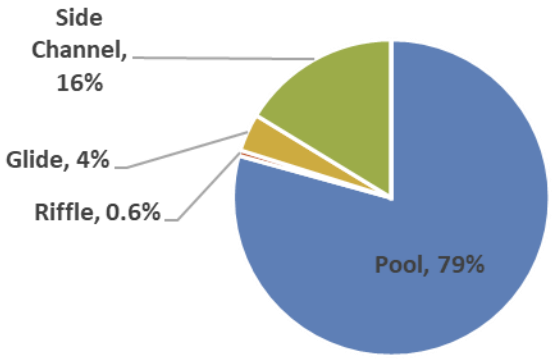


Figure 24. Stream habitat unit area composition of Reach 3.

5.3.2 Pools

Reach 3 had the deepest pools and the most pool habitat by area. Fifteen pools were observed (for a frequency of 15 pools per mile), which exceeds the nine pools per mile average for the entire assessment area. The average residual pool depth was 4.4 feet deep, higher than the assessment area average of 3.3 feet. Reach 3 also had the widest range of residual pool depths in the assessment area, ranging from 1.2 - 13.5 feet deep. A majority (87%) of the pools had residual depths of three feet or more.

5.3.3 Side Channel Habitat

Two side channels were observed in Reach 3, with a total combined length of 2,867 feet (Table 7). Both side channels were primarily slow water (pool-type) habitat at the time of the survey. A total of 25 individual pieces of LWM, plus one jam that contained three pieces of LWM, were observed in the two side channels. Side 2 was constructed and included instream habitat restoration.

Table 7. Summary of the side channel habitat observed in Reach 3.

Location	Length (ft)	Dominant unit type	Wood count	Jam Count	Wood Count in Jams
Side 1	407	Side Slow	10	0	0
Side 2	2,460	Side Slow	15	1	3
Total	*2,867*		*25*	*1*	*3*

5.3.4 Large Woody Material

Reach 3 had 489 total pieces of LWM, including individual pieces of LWM and pieces counted in jams (Table 8). Since the reach was one mile long, there were 489 piece per mile, of which 257 were M+L (combined) pieces per mile. A total of 18 jams were recorded (also 18 jams per mile) containing an estimated 341 pieces (70%) of the LWM in Reach 3.

Table 8. Large woody material quantities in Reach 3.

	Small (6 in x 20 ft)	Medium (12 in x 35 ft)	Large (20 in x 35 ft)	Total
Number of pieces	78	44	26	148
Number of pieces per mile	78	70		148
Number of pieces per mile (including pieces in jams)	232	257		489
Number of jams	18			
Number of jams per mile	18			
Estimated Wood Count in Jams	341			

5.3.5 Riparian Corridor

Five channel units in Reach 3 included ocular assessments of riparian vegetation. The overstory in Reach 3 was mainly grand fir or cottonwood in the large tree (21-31.9-inch dbh) and grand fir in the small tree (9-20.9-inch dbh) size class. Near RM 2.1 was a constructed side channel where the overstory was Ponderosa pines in the shrub/seedling (1-4.9-inch dbh) size class (

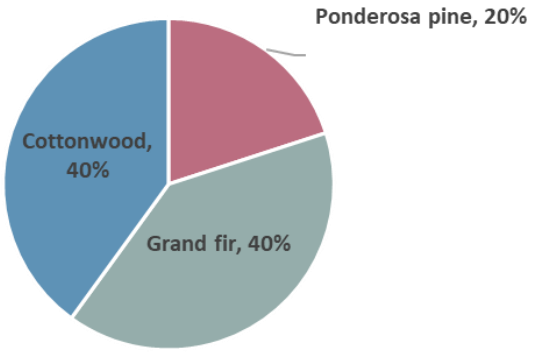


Figure ***25***). The understory was primarily dogwood or willow in the shrub seedling (1-4.9-inch dbh) size class. The understory near the constructed side channel (RM 2.1) was an unknown species of grass (Figure 26).

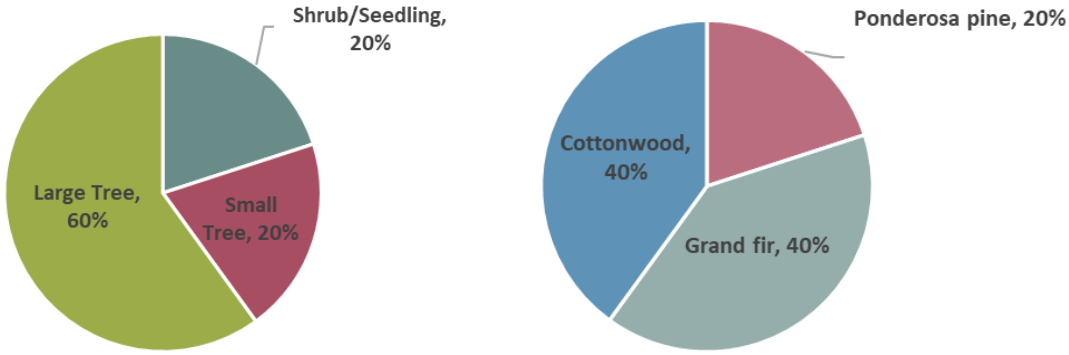


Figure 25. Dominant overstory riparian vegetation class and species, based on five surveyed units, within 100 feet of Nason Creek by ocular estimate.

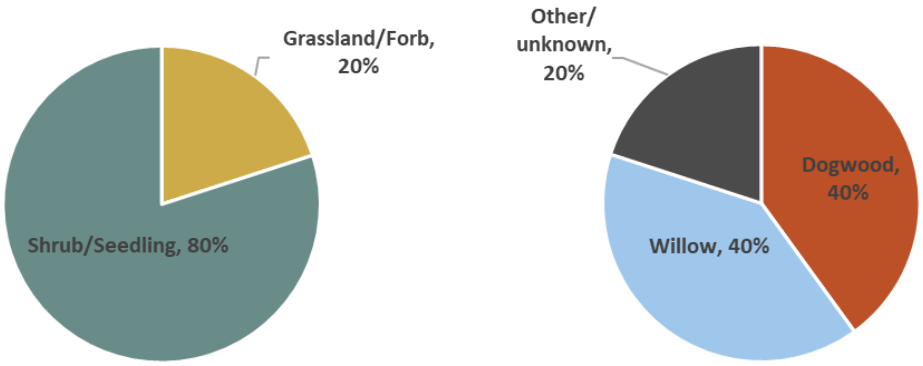


Figure 26. Dominant understory riparian vegetation class and species, based on five surveyed units, within 100 feet of Nason Creek by ocular estimate.

5.4 REACH 4

Location: River mile 2.5-4.55
Total length: 2.05 miles
Survey Date: September 12th, 2024

Figure 27. Representative photo of Reach 4. Photo shows the inlet of one of the side channels as it passes through a culvert in State Route 207. Habitat units in this reach were dominated by side channels.

5.4.1 Habitat Unit Composition

Reach 4 was the longest reach at 2.05 miles long and had the most side channel habitat of any reach, with 56% of the habitat type being side channel habitat. There was a large side channel that passed under State Route 207 along this reach that contributed to the large composition of side channel habitat. Pool was the second most prominent habitat type at 27%, followed by glide (9%) and riffle (8%). See Figure 29 below. The stream gradient was 0.35% and it was relatively sinuous compared to other reaches.

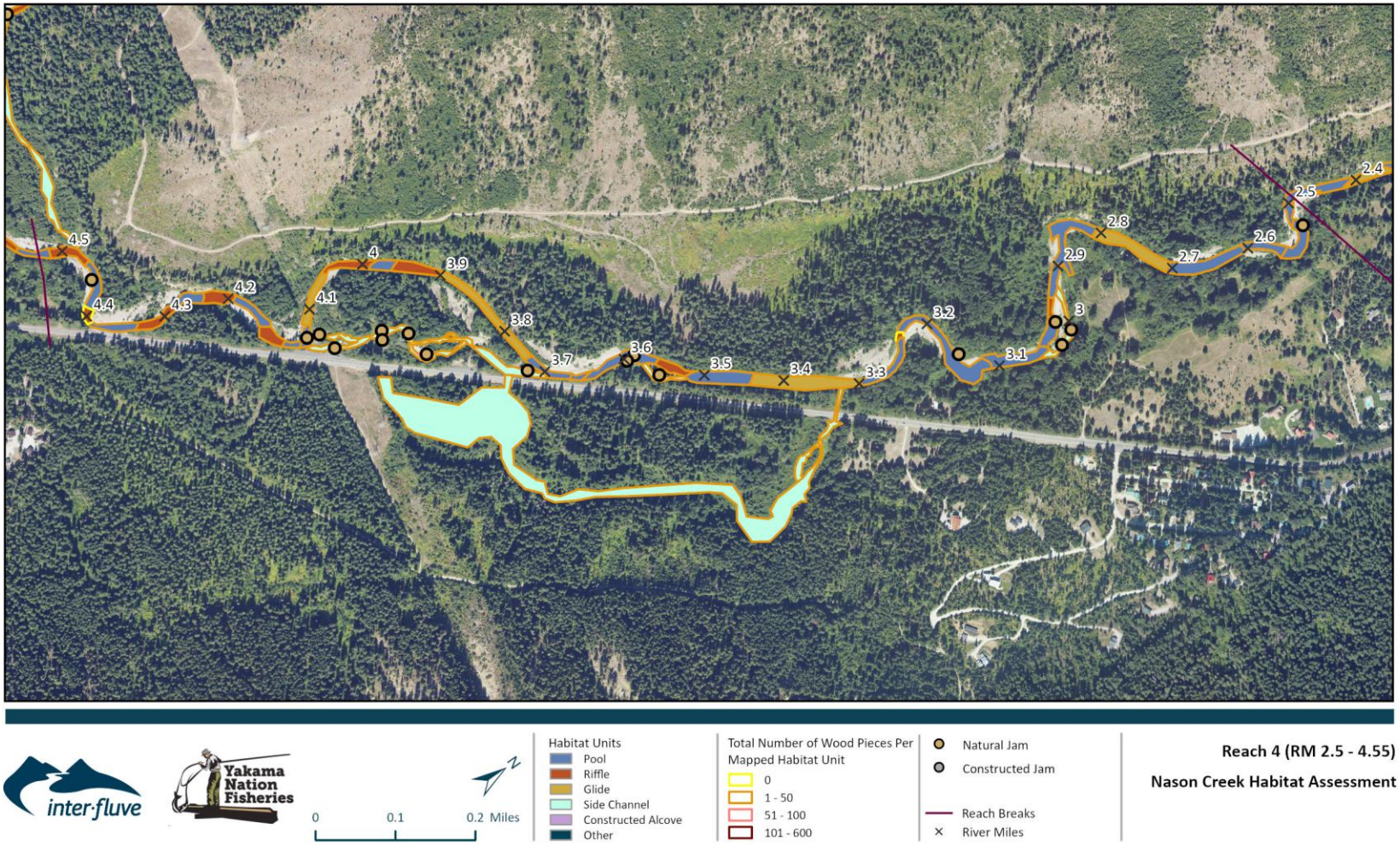


Figure 28. Map of the habitat unit composition and LWM in Reach 4 of Nason Creek. LWM count includes pieces in jams.

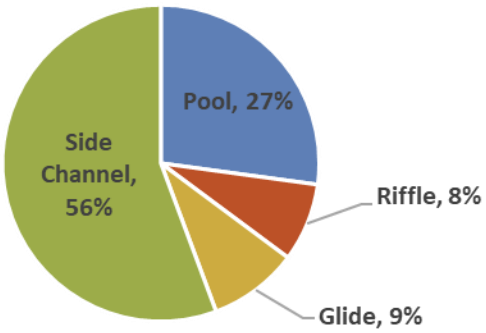


Figure 29. Stream habitat unit area composition of Reach 4.

5.4.2 Pools

With 22 pool units observed, Reach 4 had the highest total number of pools observed. This equates to 11 pools per mile, slightly higher than the nine pools per mile for the entire assessment area. Only 23% of the pools had a residual depth greater than 3 feet, and the depths ranged from 1.5-4.9 feet deep. The average residual depth was 2.6 feet deep, compared to the assessment area average of 3.3 feet.

5.4.3 Side Channel Habitat

Side channels were the dominant habitat type in this unit, with a combined total length of 10,327 feet. A total of 112 individual pieces of LWM were observed, in addition to 10 jams with a total of 153 pieces of LWM. All 10 of the side channels were predominantly slow water (pool habitat). See Figure 30 and Table 9 below. The fourth side channel encountered in the survey (Side 4) was the largest side channel throughout the assessment area. It spanned across State Route 207 on the river right side, connected by two large culverts, and had extensive beaver activity (Figure 31). The final side channel in Reach 4 (Side 12), had an outlet in Reach 4 but the inlet was in Reach 6.

Table 9. Summary of the side channel habitat observed in Reach 4.

Location	Length (ft)	Dominant unit type	Wood count	Jam Count	Wood Count in Jams
Side 3	451	Side Slow	10	2	32
Side 4	5033	Side Slow	11	0	0
Side 5	295	Side Slow	29	0	0
Side 6	137	Side Slow	3	1	24
Side 7	1734	Side Slow	17	1	4
Side 8	475	Side Slow	1	1	33
Side 9	98	Side Slow	3	0	0
Side 10	79	Side Slow	19	4	54
Side 11	314	Side Slow	8	1	6
Side 12	1711	Side Slow	11	0	0
Total	*10,327*		*112*	*10*	*153*

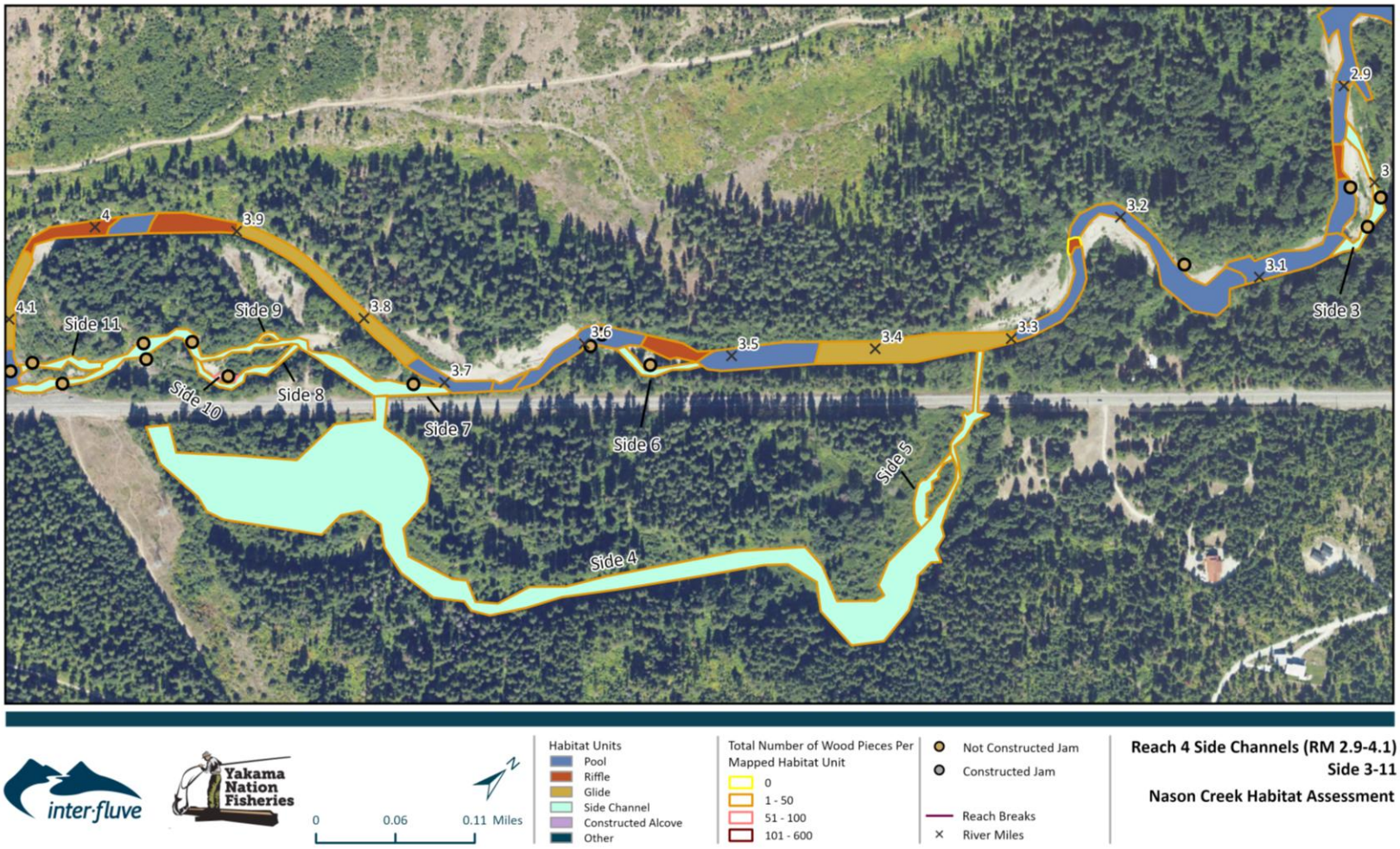


Figure 30. Side channel detail map for Reach 4. Side 12 was recorded near the upstream extent of Reach 4, and is not pictured here.

Figure 31. One of many large beaver dams constructed in Side 4 in Reach 4.

5.4.4 Large Woody Material

A total of 542 pieces of LWM, equating to 264 pieces of LWM per mile, were observed in Reach 4. This count includes both individual pieces of LWM and pieces observed in jams. Of that total, 137 pieces per mile were M+L (combined) in size. Seventeen jams (eight jams per mile) were observed, containing 50% (n = 269) of the total LWM recorded. See Table 10 below.

Table 10. Large woody material quantities in Reach 4.

	Small (6 in x 20 ft)	Medium (12 in x 35 ft)	Large (20 in x 35 ft)	Total
Number of pieces	138	72	63	273
Number of pieces per mile	67	66		133
Number of pieces per mile (including pieces in jams)	127	137		264
Number of jams	17			
Number of jams per mile	8			
Estimated Wood Count in Jams	269			

5.4.5 Riparian Corridor

Twelve units in Reach 4 included ocular estimates of riparian vegetation. The overstory in Reach 4 was primarily cottonwood and grand fir, with a smaller percentage of alder and Ponderosa pine, in the large (21.0 - 31.9-inch dbh) and small tree (9-20.19 dbh) size classes (Figure 33). The understory consisted of dogwood, alder, cottonwood, and willow in the shrub/seedling size class (1.0 - 4.9 inch dbh). See Figure 32 and Figure 33 below.

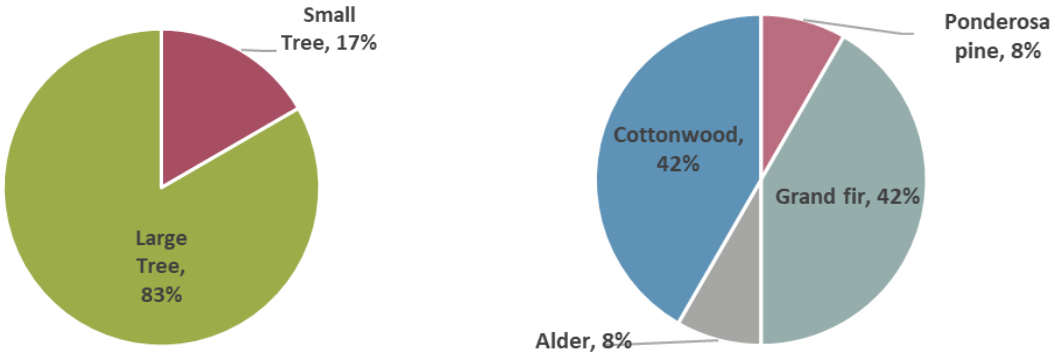


Figure 32. Dominant overstory riparian vegetation class and species, based on 12 surveyed units, within 100 feet of Nason Creek by ocular estimate.

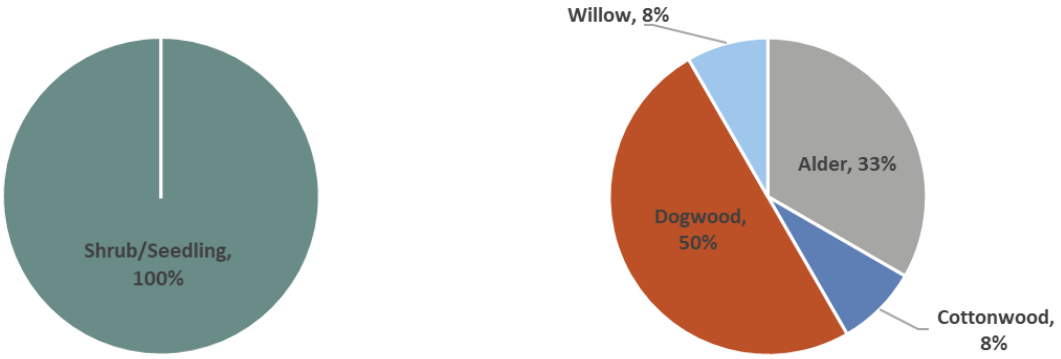


Figure 33. Dominant understory riparian vegetation class and species, based on 12 surveyed units, within 100 feet of Nason Creek by ocular estimate.

5.5 REACH 5

Location: River mile 4.55-4.8
Total length: 0.3 miles
Survey Date: September 13th, 2024

Figure 34. Representative photo of Reach 5. Habitat units were dominated by riffles.

5.5.1 Habitat Unit Composition

Reach 5 was the shortest reach at 0.30 miles long. It was dominated by riffle (67%), followed by pool (22%) and glide habitat (10%). See Figure 36 below. Channel gradient in this reach was 0.69%. There were no actively flowing side channels at the time of the survey.

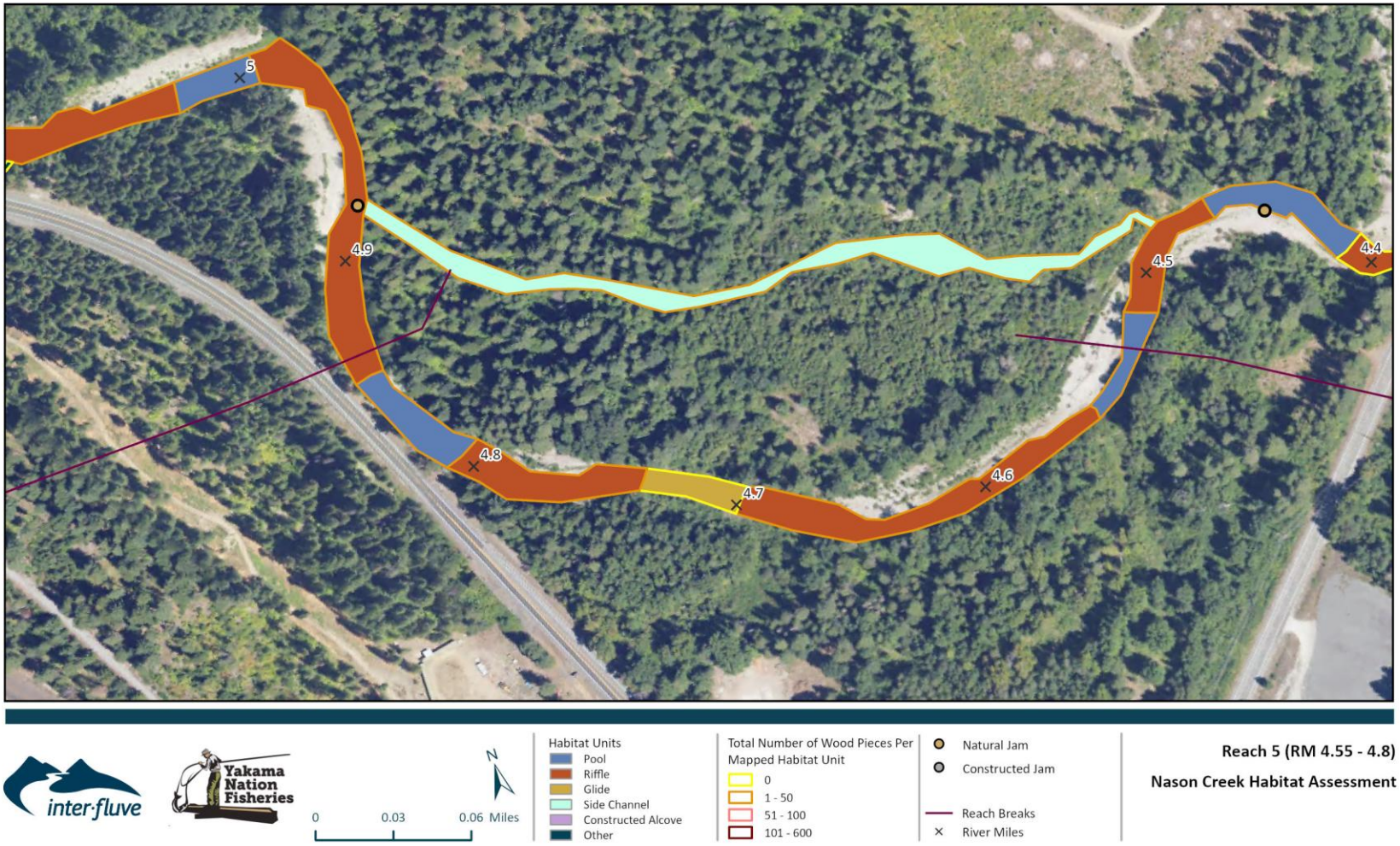


Figure 35. Map of the habitat unit composition and LWM in Reach 5 of Nason Creek. LWM count includes pieces in jams.

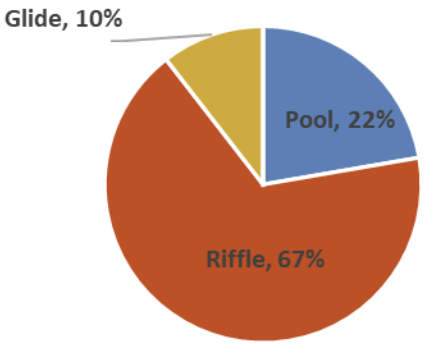


Figure 36. Stream habitat unit area composition of Reach 5.

5.5.2 Pools

Only two pools were observed in Reach 5, which equates to seven pools per mile. There was an average of nine pools per mile for the entire assessment area. The average residual depth was 1.9 feet deep, the shallowest of any reach. The average residual depth across all reaches was 3.3 feet. Residual depths in this reach ranged from 1.5-2.3 feet deep. None of the pools had a residual depth greater than or equal to 3 feet.

5.5.3 Side Channel Habitat

No actively-flowing side channels were recorded in Reach 5. However, Side 12 flows throughout the river left floodplain of Reach 5, beginning in Reach 6 upstream and reconnecting with the mainstem Nason Creek in Reach 4. Side 12 is therefore quantified in the Reach 4 metrics per USFS (2020) methods (see Section **Error! Reference source not found.**).

5.5.4 Large Woody Material

Reach 5 had the lowest quantity of LWM of any reach, with 11 total pieces of LWM or 37 pieces per mile. There were 17 (45%) pieces of M+L wood (combined) per mile. There were no jams in Reach 5 (Table 11).

Table 11. Large woody material quantities in Reach 5.

	Small (6 in x 20 ft)	Medium (12 in x 35 ft)	Large (20 in x 35 ft)	Total
Number of pieces	6	2	3	11
Number of pieces per mile	20	17		37
Number of pieces per mile (including pieces in jams)	20	17		37
Number of jams	0			
Number of jams per mile	0			
Estimated Wood Count in Jams	0			

5.5.5 Riparian Corridor

Three units in Reach 5 included ocular estimates of riparian vegetation. The overstory composed of grand fir and cottonwood in the large tree (21.0 - 31.9-inch dbh) size class (Figure 37). The understory was composed of alder and dogwood in the shrub/seedling (1.0 -4.9-inch dbh) size class (Figure 38).

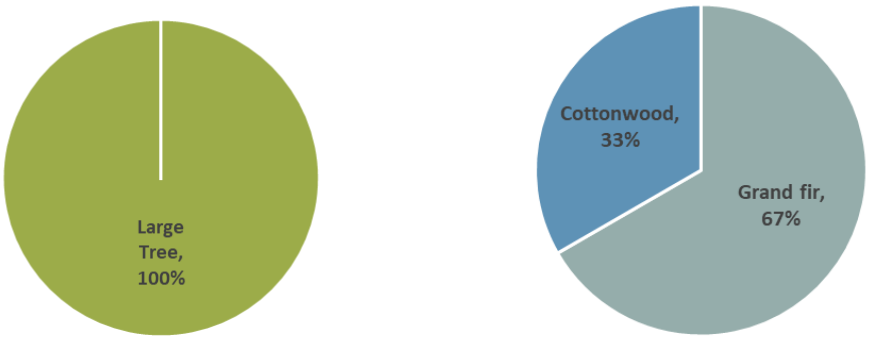


Figure 37. Dominant overstory riparian vegetation class and species, based on three surveyed units, within 100 feet of Nason Creek by ocular estimate.

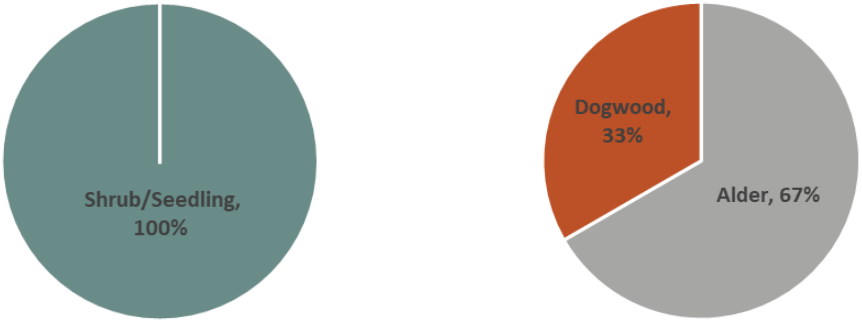


Figure 38. Dominant overstory riparian vegetation class and species, based on three surveyed units, within 100 feet of Nason Creek by ocular estimate.

5.6 REACH 6

Location: River mile 4.8-6.3
Total length: 1.5 miles
Survey Date: September 13-14th, 2024

Figure 39. Representative photo of Reach 6. Habitat units were dominated by riffle.

5.6.1 Habitat Unit Composition

Reach 6 was 1.5 miles long and had the most riffle habitat of any reach, making up 68% of the reach area. Pools were the second most dominant habitat type at 18%, this was followed by "other" (a naturally-occurring marsh in this instance) at 7%. Glide (5%) and side channel (2%) habitat were also observed. The marsh was located on river right, near RM 5.1, where it came under Highway 2 through a culvert. Figure 41 below shows the habitat composition. There was a portion of this reach, between RM 5.75 – RM 6, that ran under a transmission line, where the riparian corridor had been cleared for the transmission right-of-way. Channel gradient in Reach 6 was 0.92%.

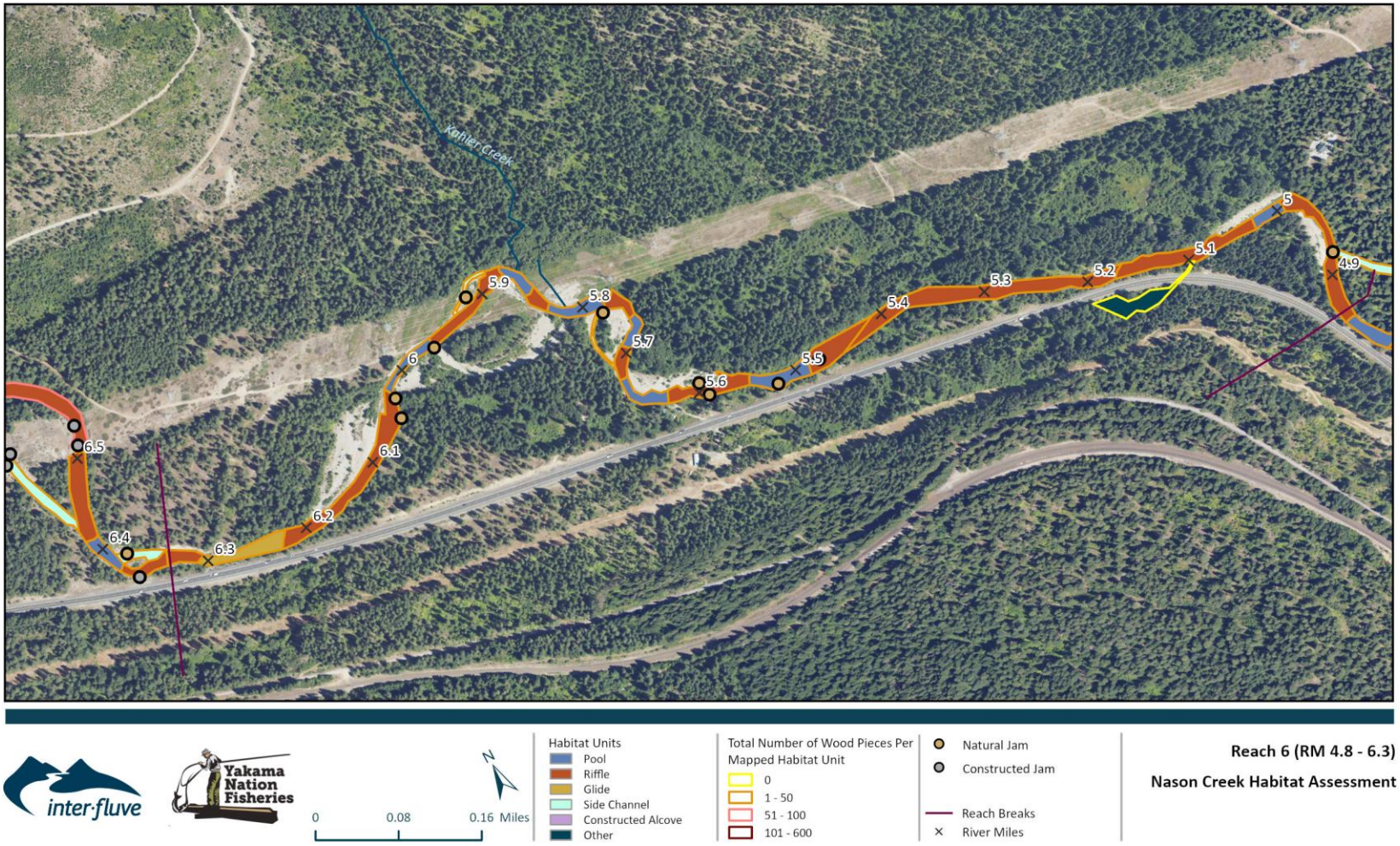


Figure 40. Map of the habitat unit composition and LWM in Reach 6 of Nason Creek. LWM count includes pieces in jams.

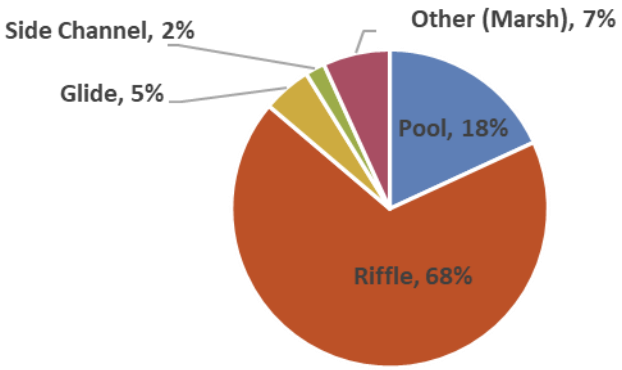


Figure 41. Stream habitat unit area composition of Reach 6.

5.6.2 Pools

Reach 6 had the least pool habitat by area of any reach, and one of the lowest pool counts of any reach with only five pools per mile (seven total in the reach). The assessment area average was nine pools per mile. The residual depths ranged from 1.9-3.9 feet deep with a reach average of 2.7 feet deep. The average residual depth for all the reaches was 3.3 feet deep. More than half (57%) of the pools had a residual depth greater than or equal to 3 feet deep.

5.6.3 Side Channel Habitat

Two side channels were observed in Reach 6, both were predominantly slow water at the time of survey. Six individual pieces of LWM were observed in the two side channels, as well as one jam containing four pieces of LWM. The combined total length of the two side channels was 639 feet. See Table 12 below. The inlet of Side 12 was located at the downstream end of Reach 6, however, since the outlet was in Reach 4, it is reported in Section 5.4.3. There was an off-channel marsh that crossed under Highway 2 via an estimated 16-inch diameter culvert and entered the mainstem of Nason Creek near RM 5.1 (Figure 42).

Table 12. Summary of the side channel habitat observed in Reach 6.

Location	Length (ft)	Dominant unit type	Wood count	Jam Count	Wood Count in Jams
Side 13	348	Side Slow	5	0	0
Side 14	291	Side Slow	1	1	4
Total	*639*		*6*	*1*	*4*

Figure 42. Left: photo facing upstream at the off-channel marsh observed on the south side of Highway 2. Right: marsh connection with the mainstem of Nason Creek. The marsh flowed through a 16-inch culvert beneath Highway 2.

5.6.4 Large Woody Material

A total of 142 pieces of LWM, equating to 95 pieces of LWM per mile, were observed in Reach 6. This total includes individual pieces and pieces recorded in jams. Of the total number of pieces, there were 42 M+L (combined) pieces per mile. Ten jams were observed, containing 44% (n=62) of the total LWM recorded (Table 13).

Table 13. Large woody material quantities in Reach 6.

	Small (6 in x 20 ft)	Medium (12 in x 35 ft)	Large (20 in x 35 ft)	Total
Number of pieces	48	16	16	80
Number of pieces per mile	32	21		53
Number of pieces per mile (including pieces in jams)	53	42		95
Number of jams	10			
Number of jams per mile	7			
Estimated Wood Count in Jams	62			

5.6.5 Riparian Corridor

Twelve channel units in Reach 6 included ocular assessments of riparian vegetation. The overstory consisted of Ponderosa pine, cottonwood, grand fir, and alder in the large (21.0 - 31.9 inch dbh) and small tree (9.0 - 20.9 inch dbh) size classes. Near RM 5.8, a transmission line right-of-way ran adjacent to Nason Creek, resulting in no vegetation in the overstory. The understory was primarily alder, dogwood, willow and vine maple, all in the shrub/seedling (1.0 - 4.9 inch) size class, except below the transmission lines, where there was an unknown species of grass in the understory. See Figure 44 and Figure 44 below.

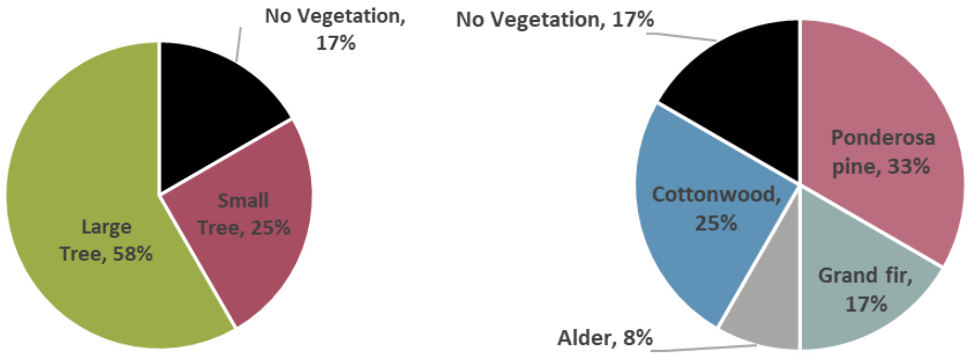


Figure 43. Dominant overstory riparian vegetation class and species, based on 12 surveyed units, within 100 feet of Nason Creek by ocular estimate.

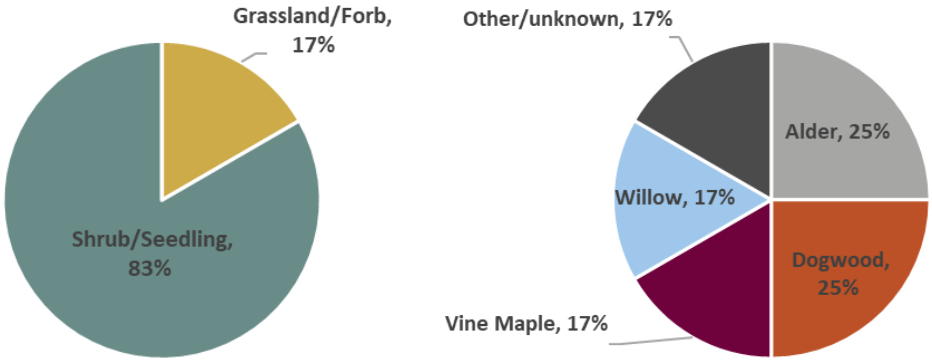


Figure 44. Dominant understory riparian vegetation class and species, based on 12 surveyed units, within 100 feet of Nason Creek by ocular estimate.

5.7 REACH 7

Location: River mile 6.3 – 7.4
Total length: 1.1 miles
Survey Date: September 15th, 2024

Figure 45. Representative photo of Reach 7. Habitat units were dominated by riffle.

5.7.1 Habitat Unit Composition

Reach 7 was 67% riffle habitat, 20% pool habitat and 12% side channel habitat (Figure 47). The reach was 1.1 miles long and the channel gradient was 0.96%, the steepest of any reach. Between RM 6.5 and 7.1, portions of the channel ran through the transmission line right-of way, and the riparian corridor had been cleared as a result. There was evidence of restoration work, particularly in the form of engineered log jams, throughout this reach. This reach was partially confined by Highway 2 along the river right side, and stretches of the reach had rip rap armoring the banks.

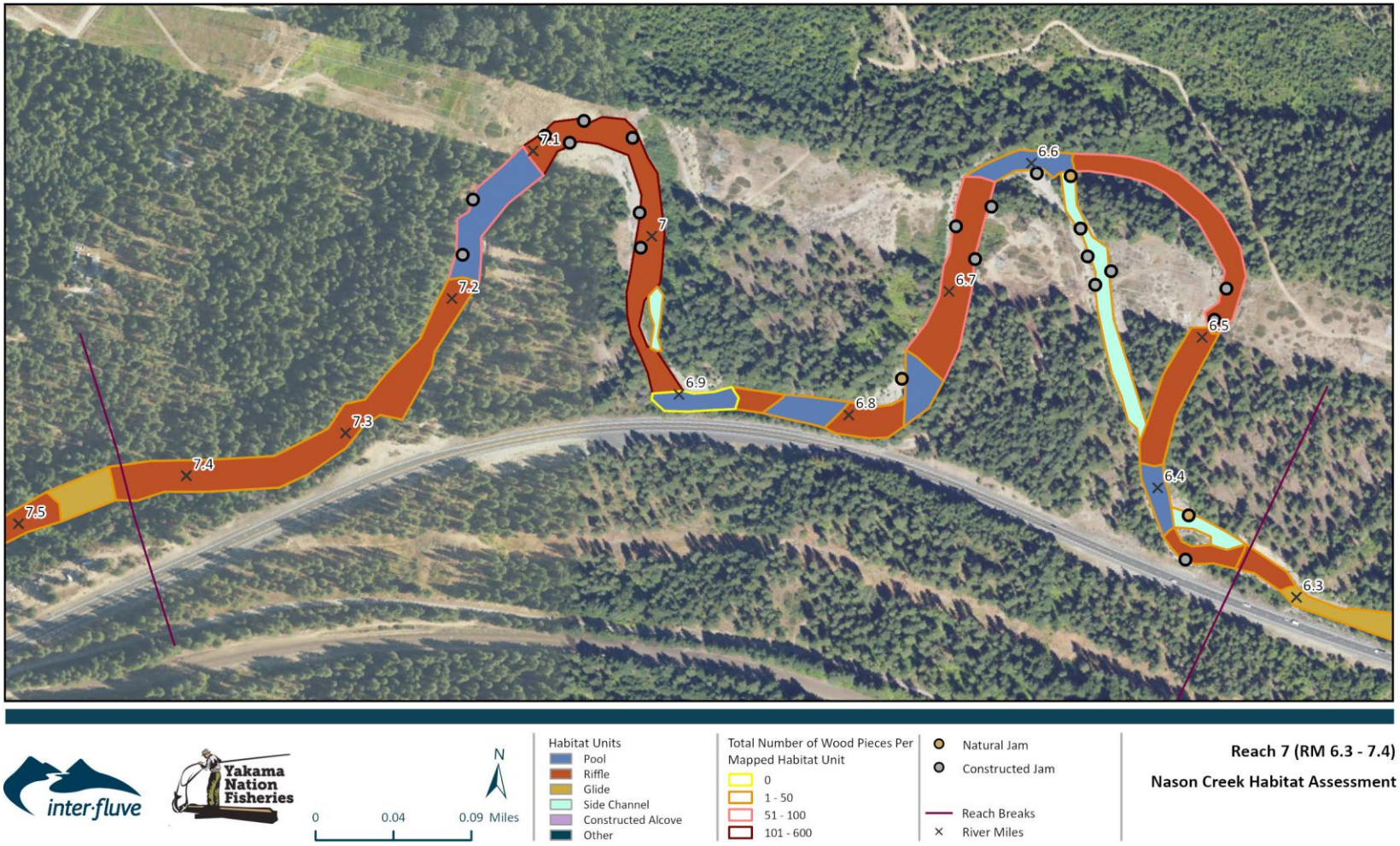


Figure 46. Map of the habitat unit composition and LWM in Reach 7 of Nason Creek. LWM count includes pieces in jams.

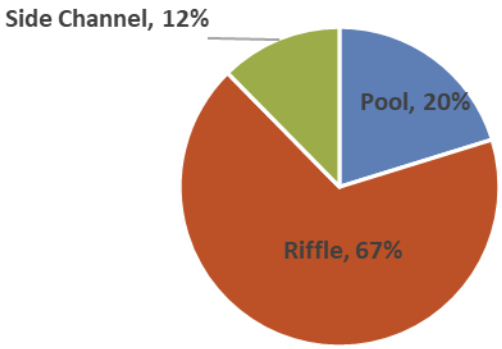


Figure 47. Stream habitat unit area composition of Reach 7.

5.7.2 Pools

There were six pools total in Reach 7. Mean pool spacing for this reach was five pools per mile, compared to the assessment area average of nine pools per mile. The average residual depth was 2.4 feet deep, with a residual depth range of 1.2-3.7 feet, and 17% of the pools had a residual depth greater than or equal to 3 feet deep. The assessment area average residual depth was 3.3 feet deep.

5.7.3 Side Channel Habitat

Reach 7 had three side channels, all were recorded as primarily fast water (e.g., riffle & glide habitat) and the total combined length was 1,232 feet. There were 14 individual pieces of LWM recorded. Five jams were observed in the three side channels, with a total of 122 pieces of LWM. See Table 14 below.

Table 14. Summary of the side channel habitat observed in Reach 7.

Location	Length (ft)	Dominant unit type	Wood count	Jam Count	Wood Count in Jams
Side 15	215	Side Fast	5	1	7
Side 16	837	Side Fast	7	4	115
Side 17	180	Side Fast	2	0	0
Total	*1,232*		*14*	*5*	*122*

5.7.4 Large Woody Material

A total of 652 pieces, equating to 593 pieces per mile, were found in Reach 7. This count includes both individually-recorded pieces of LWM as well as pieces observed in jams. Of the total pieces per mile, 244 pieces per mile were M+L (combined). There were 22 jams (20 jams per mile) in Reach 7 that contained 90% (n=585) of the wood (Table 15).

Table 15. Large woody material quantities in Reach 7.

	Small (6 in x 20 ft)	Medium (12 in x 35 ft)	Large (20 in x 35 ft)	Total
Number of pieces	40	16	11	67
Number of pieces per mile	36	25		61
Number of pieces per mile (including pieces in jams)	349	244		593
Number of jams	22			
Number of jams per mile	20			
Estimated Wood Count in Jams	585			

5.7.5 Riparian Corridor

Ten ocular vegetation surveys were performed in Reach 7. The overstory was primarily Ponderosa pine, grand fir, and Douglas fir in the large tree (21.0 - 31.9-inch dbh) size class. Ponderosa pines in the small tree size class (9.0-20.9-inch dbh) were also observed. The transmission line right-of-way that affected the riparian in Reach 6, also affected the riparian in Reach 7, resulting in units with no vegetation in the overstory between RM 6.5-6.7 and near RM 7 (Figure 49). The understory consisted of dogwood, alder, and cottonwood, in the shrub/seedling (1.0 - 4.9-inch) size class, except below the transmission lines. In these areas, an unknown species of grass made up the understory (Figure 49).

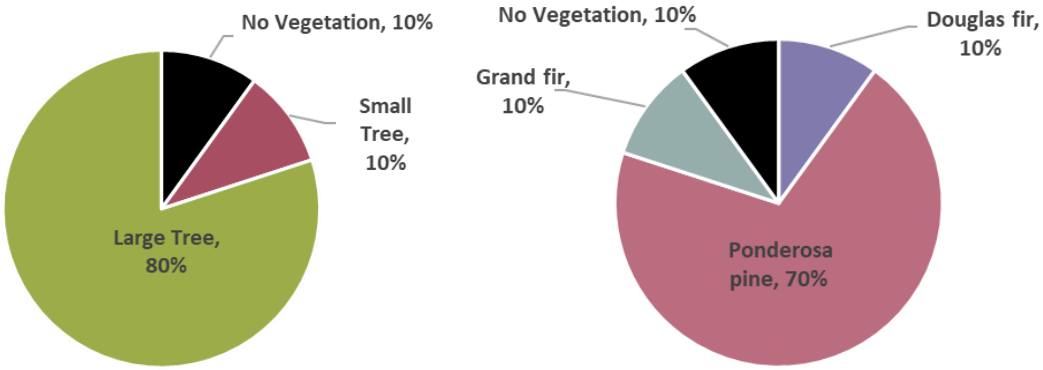


Figure 48. Dominant overstory riparian vegetation class and species, based on 10 surveyed units, within 100 feet of Nason Creek by ocular estimate.

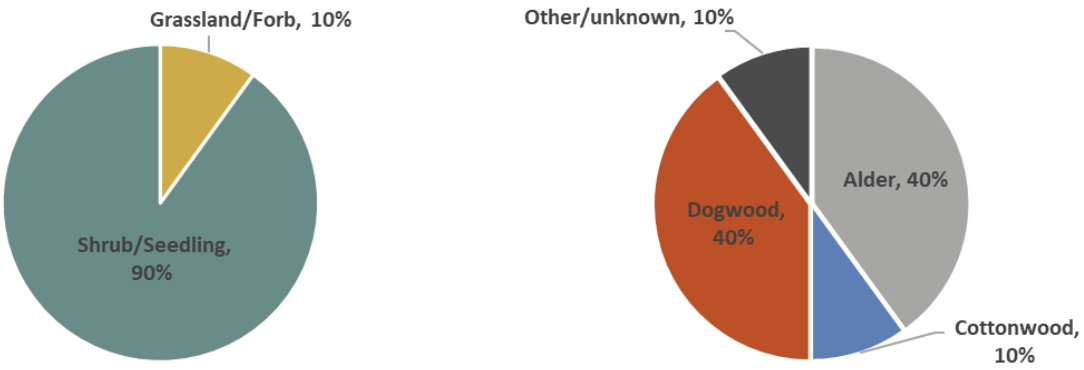


Figure 49. Dominant understory riparian vegetation class and species, based on 10 surveyed units, within 100 feet of Nason Creek by ocular estimate.

5.8 REACH 8

Location: River mile 7.4-8.6
Total length: 1.2 miles
Survey Date: September 15th, 2024

Figure 50. Representative photo of Reach 8. Habitat units were dominated by pools.

5.8.1 Habitat Unit Composition

Reach 8 was comprised of 57% pool habitat, 36% riffle habitat, 4% side channel, and 3% glide habitat (Figure 52). The reach was 1.2 miles long and had a gradient of 0.34%. There were some residential properties alongside the channel throughout most of the reach, as well as a bridge crossing near RM 7.9.

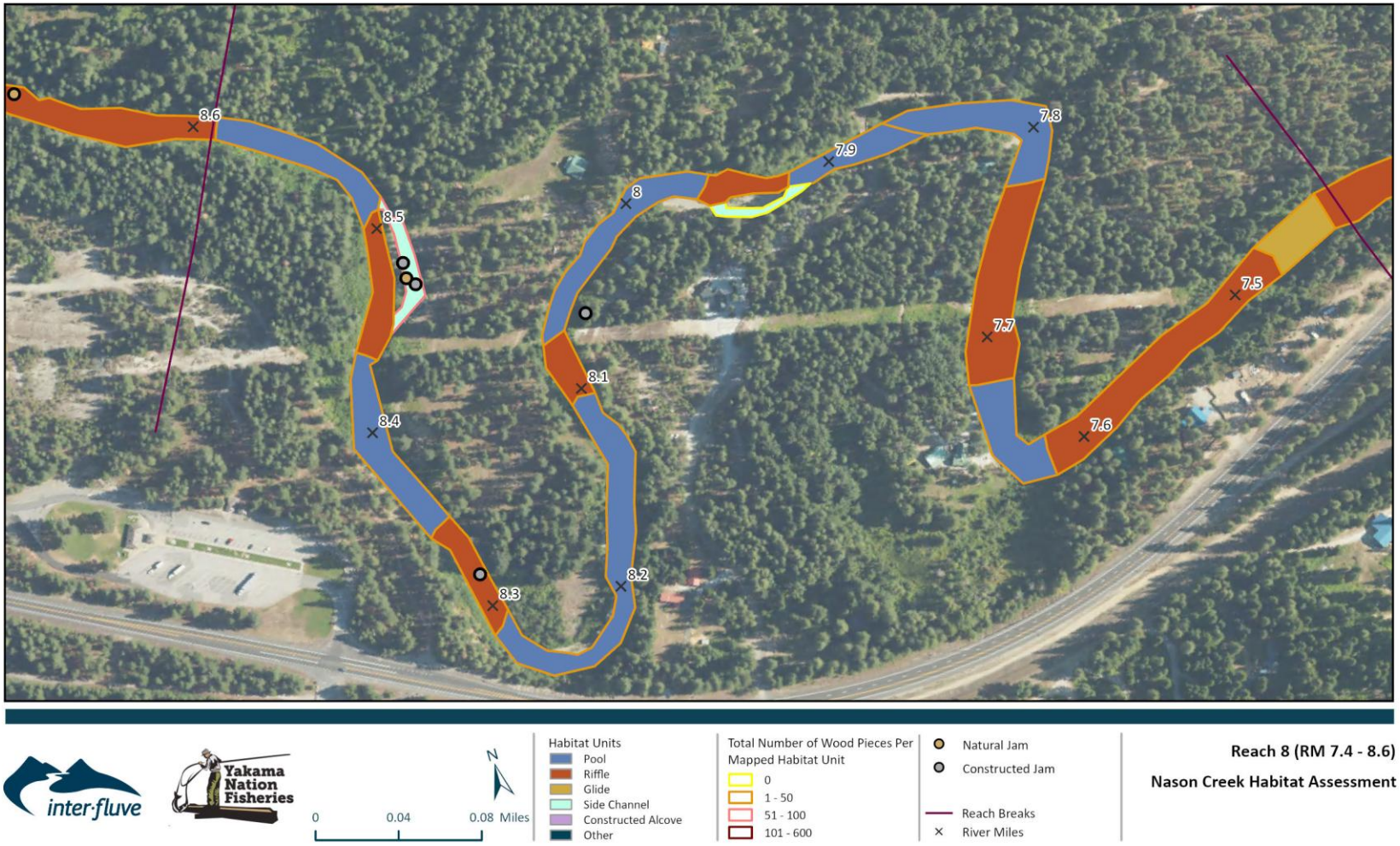


Figure 51. Map of the habitat unit composition and LWM in Reach 8 of Nason Creek. LWM count includes pieces in jams.

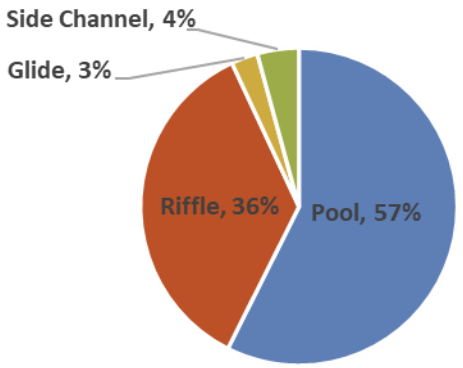


Figure 52. Stream habitat unit area composition of Reach 8.

5.8.2 Pools

Reach 8 had seven pools total, or six pools per mile. The assessment area average pool spacing was nine pools per mile. Most of the pools (86%) had a residual depth greater than or equal to 3 feet deep. The residual depths ranged from 2.3-4.2 feet with an average of 3.6 feet, compared to the assessment area average of 3.3 feet.

5.8.3 Side Channel Habitat

Two side channels, one predominantly fast water and one predominantly slow water, were observed in Reach 8. The total length of the two was 586 feet long. One individual piece of LWM was observed. Side 19 was constructed, with three bank buried jams along the river left side that contained a total of 91 pieces of LWM (Table 16).

Table 16. Summary of the side channel habitat observed in Reach 8.

Location	Length (ft)	Dominant unit type	Wood count	Jam Count	Wood Count in Jams
Side 18	238	Side Fast	0	0	0
Side 19	348	Side Slow	1	3	91
Total	*586*		*1*	*3*	*91*

5.8.4 Large Woody Material

Reach 8 had 162 total pieces of LWM. This total includes individual pieces and pieces observed in jams. LWM averaged to 135 pieces per mile, with 73 of those pieces per mile size M+L (combined). Five jams, four jams per mile, were observed in Reach 8, containing 76% (n=123) of the LWM (Table 17).

Table 17. Large woody material quantities in Reach 8.

	Small (6 in x 20 ft)	Medium (12 in x 35 ft)	Large (20 in x 35 ft)	Total
Number of pieces	29	4	6	39
Number of pieces per mile	24	8		33
Number of pieces per mile (including pieces in jams)	63	73		135
Number of jams	5			
Number of jams per mile	4			
Estimated Wood Count in Jams	123			

5.8.5 Riparian Corridor

Eight units had vegetation surveys in Reach 8. The overstory was primarily ponderosa pine, followed by grand fir and Douglas fir in the large tree (21 - 31.9-inch dbh) size class (Figure 53). The understory consisted of dogwood and alder in the shrub/seedling (1.0 - 4.9-inch dbh) size class. Between RM 7.9 and RM 8.0 there were multiple units where yards with ornamental species and landscaping (marked as "other" during the survey) made up the understory. Figure 54 shows the understory size and species composition.

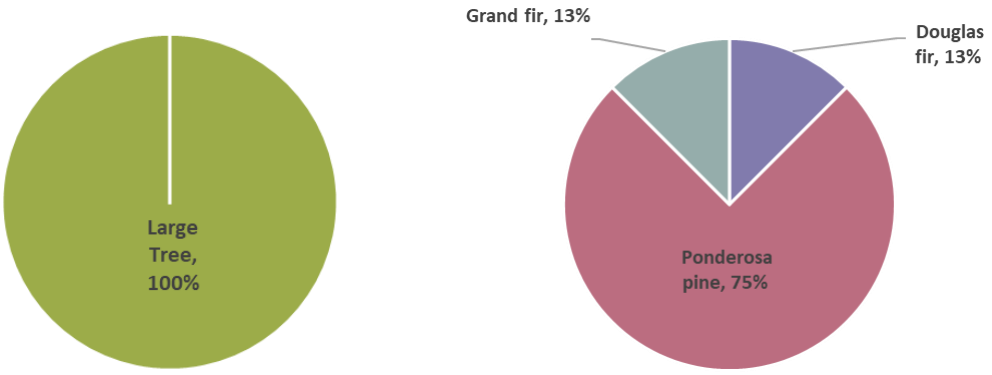


Figure 53. Dominant overstory riparian vegetation class and species, based on eight surveyed units, within 100 feet of Nason Creek by ocular estimate.

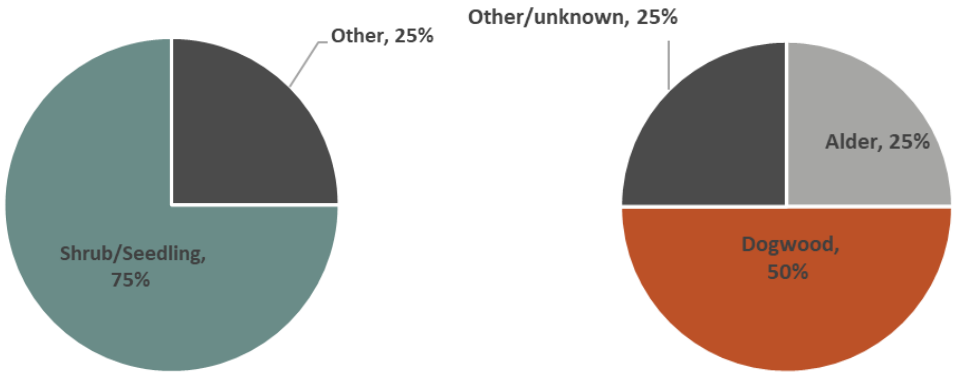


Figure 54. Dominant understory riparian vegetation class and species, based on eight surveyed units, within 100 feet of Nason Creek by ocular estimate.

5.9 REACH 9

Location: River mile 8.6-9.2
Total length: 0.6 miles
Survey Date: September 23rd, 2024

Figure 55. Representative photo of Reach 9. Habitat units were dominated by pools.

5.9.1 Habitat Unit Composition

Reach 9 was 0.6 miles long. The channel gradient was 0.37%. The dominant habitat type was pool, making up 50% of the total area. Riffle was the second most common habitat type (27%) in the reach, followed by glide (14%) and side channel (5%). See Figure 57 below.

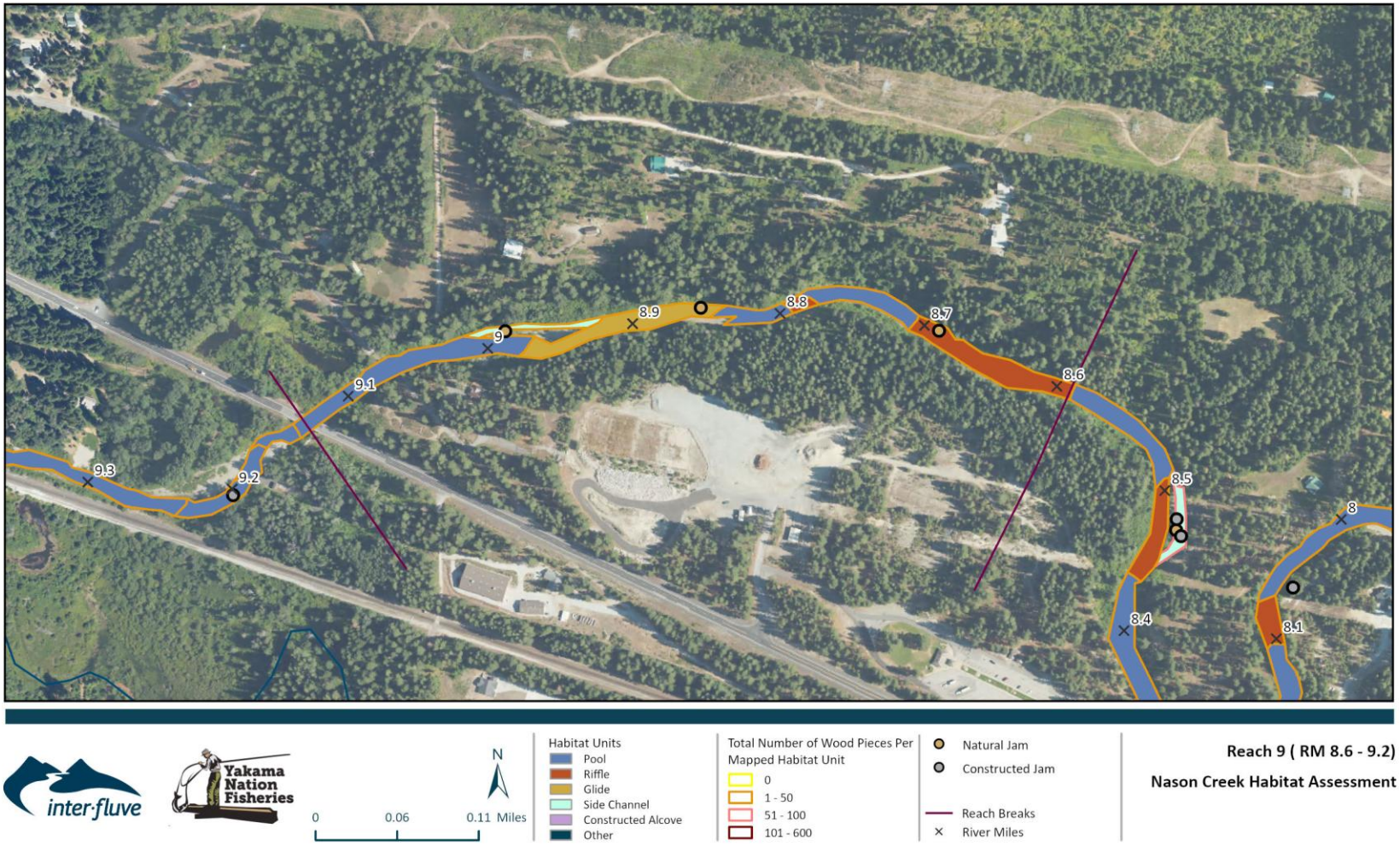


Figure 56. Map of the habitat unit composition and LWM in Reach 9 of Nason Creek. LWM count includes pieces in jams.

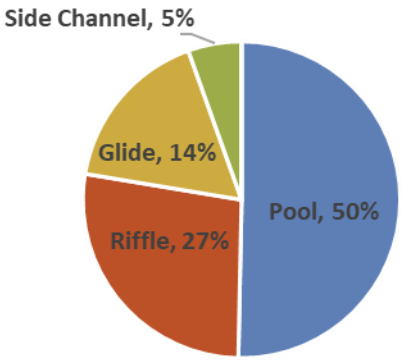


Figure 57. Stream habitat unit area composition of Reach 9.

5.9.2 Pools

Reach 9 had three pools total, or five pools per mile. The assessment area average pool spacing was nine pools per mile. Only one out of the three pools (33%) had a residual depth greater than or equal to 3 feet deep. The residual depths ranged from 2-3.1 feet with an average of 2.6 feet, compared to the assessment area average of 3.3 feet.

5.9.3 Side Channel Habitat

Reach 9 only had one side channel. It was primarily slow water and 454 feet long. There was one individual piece of LWM found in it and one jam with seven pieces of LWM (Table 18). Butcher Creek enters the river left side of Nason Creek at the upstream end of the reach, and extensive beaver activity was observed, including a large beaver pond and associated off-channel habitats. However, since the beaver pond was part of the tributary and not the mainstem of Nason Creek, it was not included in habitat area composition metrics for this assessment (Figure 58).

Table 18. Summary of the side channel habitat observed in Reach 9.

Location	Length (ft)	Dominant unit type	Wood count	Jam Count	Wood Count in Jams
Side 20	454	Side Slow	1	1	7
Total	*454*		*1*	*1*	*7*

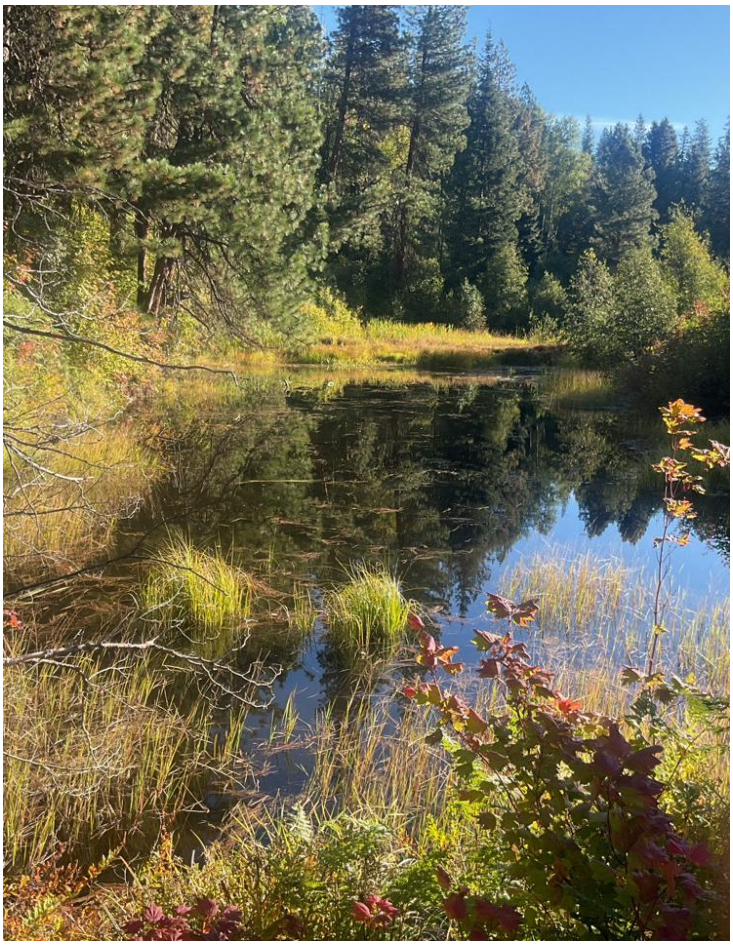


Figure 58. Large beaver pond from the Butcher Creek tributary in Reach 9.

5.9.4 Large Woody Material

A total of 61 pieces of LWM pieces were recorded in Reach 9. This equates to 102 LWM pieces per mile, of which, 48 pieces per mile are size M+L (combined). There were three jams in this reach, five jams per mile, which contained an estimated 15 pieces or 25% of the total pieces (Table 19).

Table 19. Large woody material quantities in Reach 9.

	Small (6 in x 20 ft)	Medium (12 in x 35 ft)	Large (20 in x 35 ft)	Total
Number of pieces	24	13	9	46
Number of pieces per mile	40	37		77
Number of pieces per mile (including pieces in jams)	53	48		102
Number of jams	3			
Number of jams per mile	5			
Estimated Wood Count in Jams	15			

5.9.5 Riparian Corridor

Three units in Reach 9 included ocular estimates of vegetation. In all the units surveyed ponderosa pine, in the large tree (21.0 - 31.9-inch dbh) size class, made up the overstory (Figure 59). The understory was made up of dogwood or vine maple in the shrub/seedling (1.0 - 4.9-inch dbh) size class (Figure 60).

Figure 59. Dominant overstory riparian vegetation class and species, based on three surveyed units, within 100 feet of Nason Creek by ocular estimate.

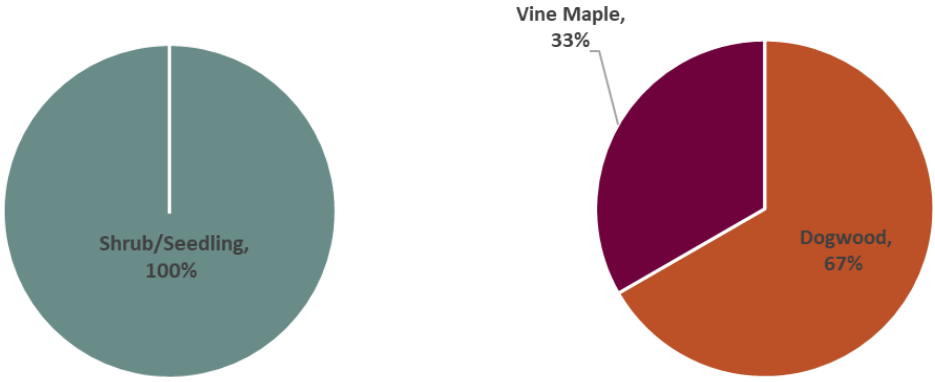


Figure 60. Dominant overstory riparian vegetation class and species, based on three surveyed units, within 100 feet of Nason Creek by ocular estimate.

5.10 REACH 10

Location: River mile 9.2-10.25
Total length: 1.05 miles
Survey Date: September 24th, 2024

Figure 61. Representative photo of Reach 10. Habitat units were dominated by pools.

5.10.1 Habitat Unit Composition

Reach 10 was 69% pool habitat, 18% glide habitat, 10% riffle habitat, and 3% side channel habitat (Figure 63). The reach was 1.05 miles long and the channel gradient 0.13%, the lowest gradient of any reach. The downstream end of Reach 10 flows under Highway 2, and the remainder of the reach is constricted between Highway 2 on river left and the railroad on river right. The reach is relatively straight and a small portion of the upstream section runs under a transmission right-of-way clearing.

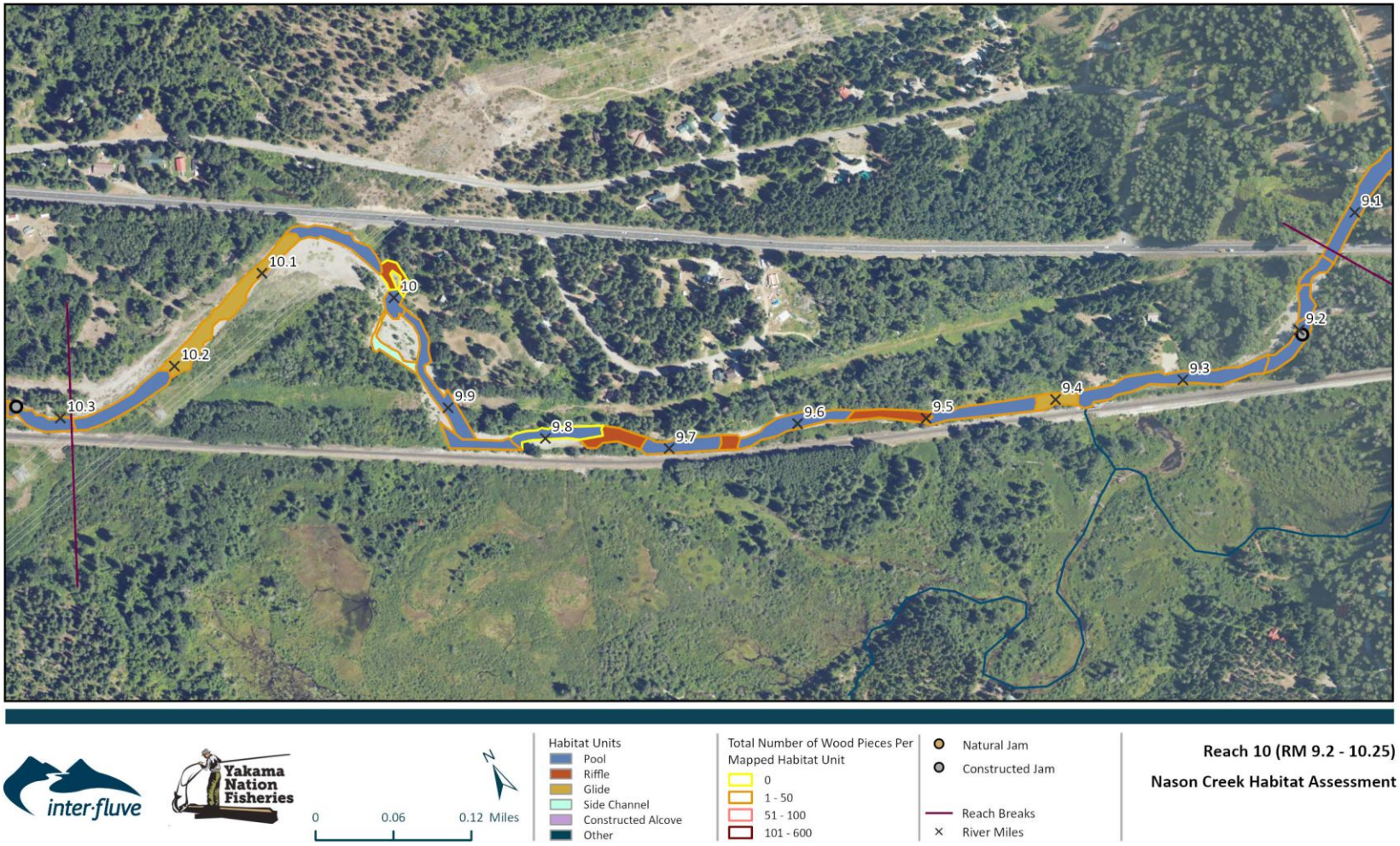


Figure 62. Map of the habitat unit composition and LWM in Reach 10 of Nason Creek. LWM count includes pieces in jams.

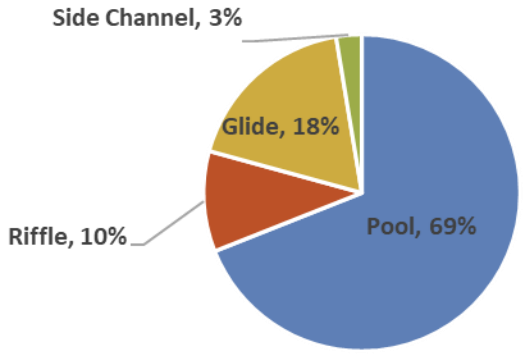


Figure 63. Stream habitat unit area composition of Reach 10.

5.10.2 Pools

There were 13 pools total in Reach 10. Mean pool spacing for this reach was 12 pools per mile, higher than the assessment area average of nine pools per mile. The average residual depth was 3.9 feet deep, with a residual depth range of 1.6-9.5 feet, and 54% of the pools had a residual depth greater than or equal to 3 feet deep. The assessment area average residual depth was 3.3 feet deep.

5.10.3 Side Channel Habitat

One side channel was observed in Reach 10, with a length of 226 feet. The side channel was predominantly slow water at the time of the survey. A total of nine individual pieces of LWM were observed in the side channel. There were no jams found in the side channel (Table 20). There is a large marsh area near RM 9.3, likely fed by two tributaries, that flows under a bridge in the railroad and provides off-channel habitat. However, the marsh was not connected to the mainstem at the time of the survey, so it was not included as a habitat survey unit. There was water from the mainstem backing up under the railroad bridge forming a small alcove, but the remainder of the marsh was disconnected. Beaver activity was present in the marsh area. See photo (Figure 64).

Table 20. Summary of the side channel habitat observed in Reach 10.

Location	Length (ft)	Dominant unit type	Wood count	Jam Count	Wood Count in Jams
Side 21	226	Side Slow	9	0	0
Total	*226*		*9*	*0*	*0*

Figure 64. Photo of the marsh area near RM 9.3. There was backwatering from the mainstem, but the area was not actively flowing or completely connected at the surface at the time of survey.

5.10.4 Large Woody Material

Reach 10 had a total of 131 pieces of LWM. This includes individual pieces of LWM and pieces observed in jams. LWM averages to 125 LWM pieces per mile, and of that, there were 91 M+L pieces combined per mile. Only one jam was counted in this reach (one jam per mile), containing roughly one-third (34%) of all recorded pieces of LWM in the reach (Table 21).

Table 21. Large woody material quantities in Reach 10.

	Small (6 in x 20 ft)	Medium (12 in x 35 ft)	Large (20 in x 35 ft)	Total
Number of pieces	32	27	27	86
Number of pieces per mile	30	51		82
Number of pieces per mile (including pieces in jams)	33	91		125
Number of jams	1			
Number of jams per mile	1			
Estimated Wood Count in Jams	45			

5.10.5 Riparian Corridor

Eight of the channel units in Reach 10 included ocular assessments of riparian vegetation. The overstory was split between cottonwood in the large tree (21.0 - 31.9-inch dbh) size class and no vegetation. The BNSF railroad ran adjacent to the river for most of the reach, causing the lack of vegetation in the overstory (Figure 65). The understory was primarily dogwood or willow in the shrub/seedling (1.0 - 4.9-

inch dbh) size class, except in units where the BNSF railroad also affected the understory. In those units the understory was either an unknown species of grass or no vegetation (Figure 66).

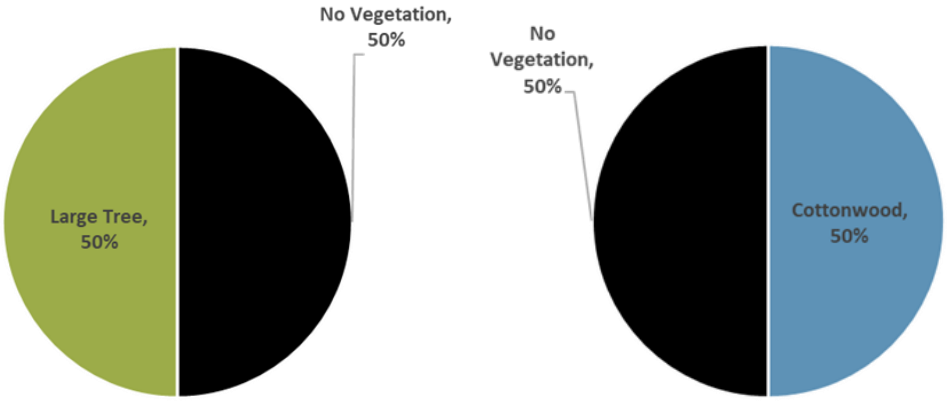


Figure 65. Dominant overstory riparian vegetation class and species, based on eight surveyed units, within 100 feet of Nason Creek by ocular estimate.

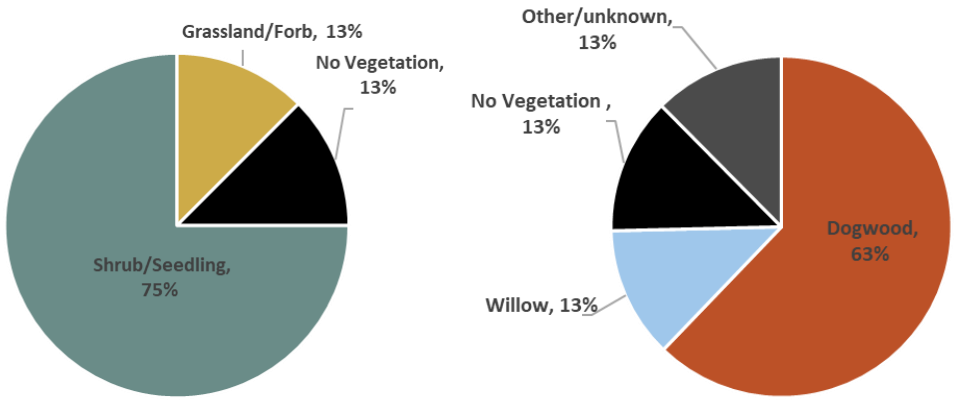


Figure 66. Dominant understory riparian vegetation class and species, based on three surveyed units, within 100 feet of Nason Creek by ocular estimate.

5.11 REACH 11

Location: River mile 10.25-11.25
Total length: 1.0 miles
Survey Date: September 25th, 2024

Figure 67. Representative photo of Reach 11. Habitat units were dominated by pools.

5.11.1 Habitat Unit Composition

Reach 11 had the second highest amount of pool habitat of any reach, with 77% of the total reach area being pool habitat. Riffle (15%) and side channel (8%) habitat made up the remaining habitat units. See Figure 69 below. Like Reach 10, Reach 11 was confined by Highway 2 on river left and the railroad on river right, and was relatively straight. Beaver activity was observed near RM 10.8, including a partial dam across the mainstem. See photo Figure 70 below. The reach was 1.0 miles long and the stream gradient was 0.20%.

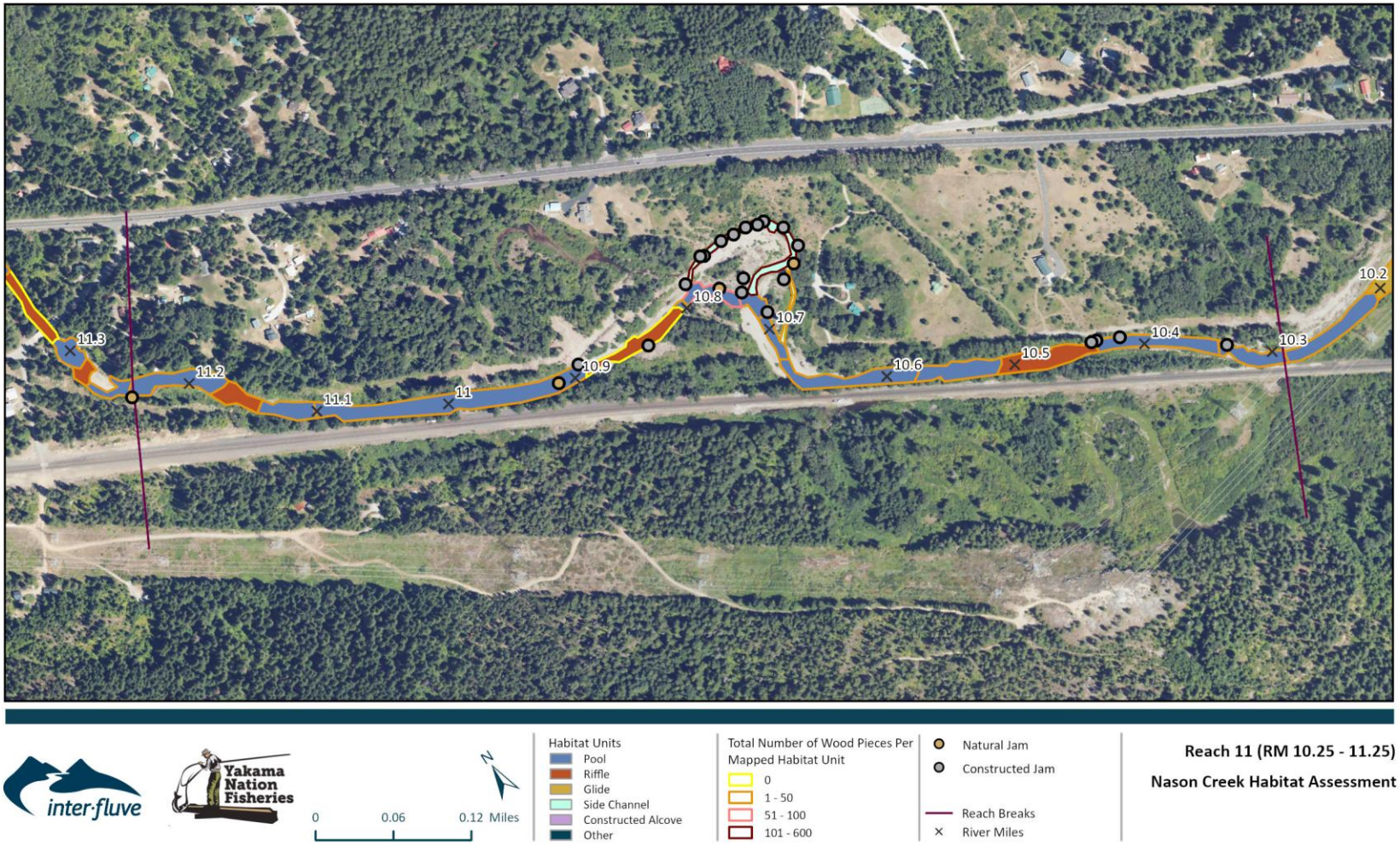


Figure 68. Map of the habitat unit composition and LWM in Reach 11 of Nason Creek. LWM count includes pieces in jams.

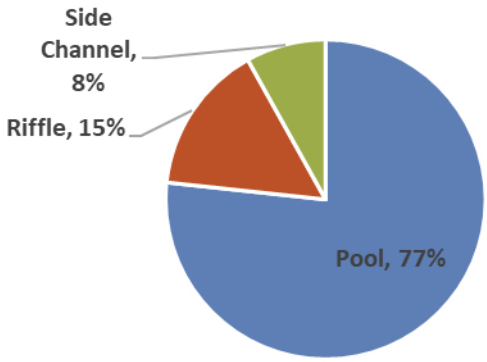


Figure 69. Stream habitat unit area composition of Reach 11.

Figure 70. Partial beaver dam across the mainstem of Nason Creek.

5.11.2 Pools

A total of 11 pools were observed in the 1.0-mile-long reach. There was an average of nine pools per mile for the entire assessment area. The average residual depth was 3.5 feet deep, ranging from 1.6-6.3 feet deep. The average residual depth across all reaches was 3.3 feet. Just over half (55%) of the pools had a residual depth greater than or equal to 3 feet.

5.11.3 Side Channel Habitat

Two side channels were observed in Reach 11, with a total combined length of 1,195 feet. Both side channels were predominantly slow water at the time of the survey, and both were constructed. A total of 17 individual pieces of LWM and 13 jams with an estimated 134 pieces of LWM were observed in the two side channels (Table 22).

Table 22. Summary of the side channel habitat observed in Reach 11.

Location	Length (ft)	Dominant unit type	Wood count	Jam Count	Wood Count in Jams
Side 22	323	Side Slow	5	1	41
Side 23	872	Side Slow	12	12	93
Total	*1,195*		*17*	*13*	*134*

5.11.4 Large Woody Material

Reach 11 had 381 total pieces of LWM, including individual pieces and pieces observed in jams. Since the reach was one mile long there were also 381 pieces per mile, of which, 239 (63%) pieces per mile were size M+L (combined). Twenty-three jams were counted, containing 84% (n = 319) of the total number of LWM pieces observed in the reach (Table 23).

Table 23. Large woody material quantities in Reach 11.

	Small (6 in x 20 ft)	Medium (12 in x 35 ft)	Large (20 in x 35 ft)	Total
Number of pieces	37	12	13	62
Number of pieces per mile	37	25		62
Number of pieces per mile (including pieces in jams)	142	239		381
Number of jams	23			
Number of jams per mile	23			
Estimated Wood Count in Jams	319			

5.11.5 Riparian Corridor

Six units in Reach 11 included ocular estimates of vegetation. The overstory was primarily cottonwood or grand fir in the large tree (21.0 - 31.9-inch dbh) size class. Cottonwood in the small tree (9.0-20.9-inch dbh) size class were also observed. See Figure 71 below. The understory consisted of dogwood, as well as alder and willow, in the shrub/seedling (1.0 - 4.9-inch dbh) size class (Figure 72).

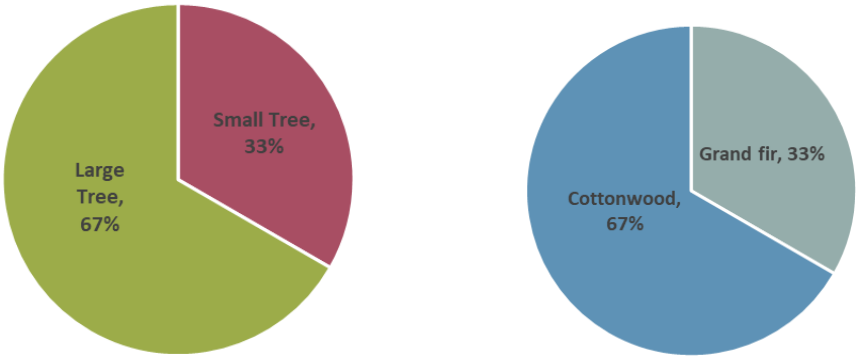


Figure 71. Dominant overstory riparian vegetation class and species, based on six surveyed units, within 100 feet of Nason Creek by ocular estimate.

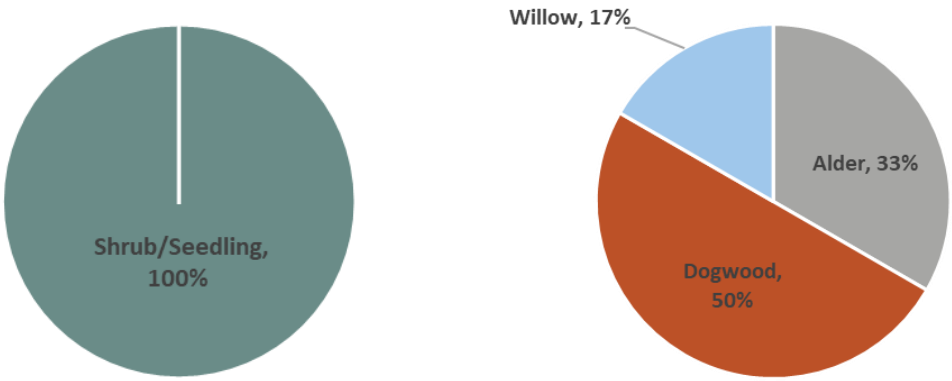


Figure 72. Dominant understory riparian vegetation class and species, based on six surveyed units, within 100 feet of Nason Creek by ocular estimate.

5.12 REACH 12

Location: River mile 11.25-12.6
Total length: 1.35 miles
Survey Date: September 26th, 2024

Figure 73. Representative photo of Reach 12. Habitat units were dominated by pools.

5.12.1 Habitat Unit Composition

Reach 12 was 1.35 miles long and 75% pool habitat. Riffle made up 14%, followed by "other" (a constructed alcove) at 8% and side channel made up 1% (Figure 75). The constructed alcove was found near RM 12.1 on river right. The alcove was an estimated 1,000 feet long and filled with wood. There was backwater from the main channel throughout the unit, with an estimated depth of 1.5 feet deep and wetted width of 15 feet (Figure 76). Wood was placed throughout the alcove, contributing to Reach 12 having the highest number of LWM pieces per mile. Reach 12 is still constrained by Highway 2 and the railroad, however, it is more sinuous than Reach 10 and Reach 11. Channel gradient in this reach was 0.32%.

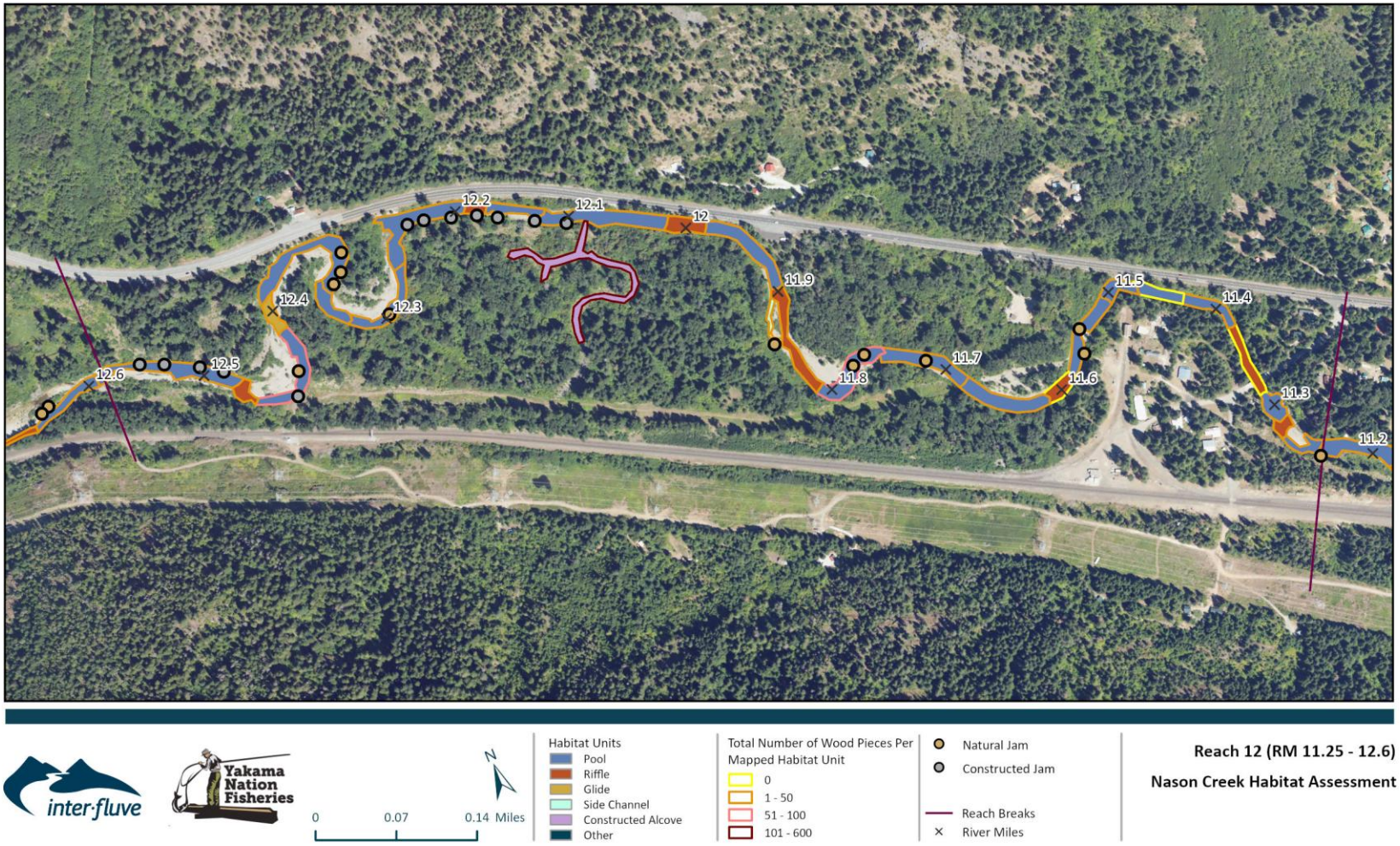


Figure 74. Map of the habitat unit composition and LWM in Reach 12 of Nason Creek. LWM count includes pieces in jams.

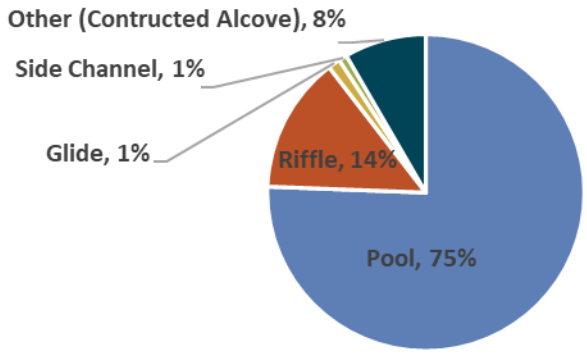


Figure 75. Stream habitat unit area composition of Reach 12.

Figure 76. Photo of the constructed alcove, loaded with wood, in Reach 12 near RM 12.1.

5.12.2 Pools

Reach 12 had 18 pools total, or 13 pools per mile. The assessment area average pool spacing was nine pools per mile. Most of the pools (72%) had a residual depth greater than or equal to 3 feet deep. The residual depths ranged from 1.6-5.6 feet with an average of 3.6 feet, compared to the assessment area average of 3.3 feet.

5.12.3 Side Channel Habitat

One side channel was recorded in Reach 12, it was predominantly slow water and totaled 233 feet in length. There were four pieces of LWM and one jam with four pieces of LWM observed. See Table 24 below. At the upstream end of the reach, an unnamed tributary enters the mainstem on river left. The tributary had substantial beaver activity, creating a large marsh and off-channel habitat. However, since this was part of the tributary it was excluded from the habitat unit composition.

Table 24. Summary of the side channel habitat observed in Reach 12.

Location	Length (ft)	Dominant unit type	Wood count	Jam Count	Wood Count in Jams
Side 24	233	Side Slow	4	1	4
Total	233		4	1	4

Figure 77. Photo overlooks the large beaver marsh fed from an unnamed tributary at the upstream end of Reach 12.

5.12.4 Large Woody Material

Reach 12 had the most LWM of any reach at 950 total pieces of LWM or 704 pieces per mile. That count includes individual LWM pieces and pieces observed in jams. Of the total wood count, 588 (84%) of those pieces were in the M+L class. Most of the wood (63%) was placed in the constructed alcove mentioned above (5.12.1). There were 24 jams observed in this reach, or 18 jams per mile, containing 236 pieces (25%) of LWM. See Table 25 below.

Table 25. Large woody material quantities in Reach 12.

	Small (6 in x 20 ft)	Medium (12 in x 35 ft)	Large (20 in x 35 ft)	Total
Number of pieces	65	326	323	714
Number of pieces per mile	48	481		529
Number of pieces per mile (including pieces in jams)	116	588		704
Number of jams	24			
Number of jams per mile	18			
Estimated Wood Count in Jams	236			

5.12.5 Riparian Corridor

Seven units in Reach 12 included ocular estimates of riparian vegetation. Cottonwood, grand fir, and Douglas fir in the large (21.0 - 31.9-inch dbh) and small tree (9.0-20.9-inch dbh) size classes made up the overstory. Vine maple, dogwood, and alder in the shrub/seedling (1.0 - 4.9-inch dbh) size class made up the understory. See Figure 78 and Figure 79 below.

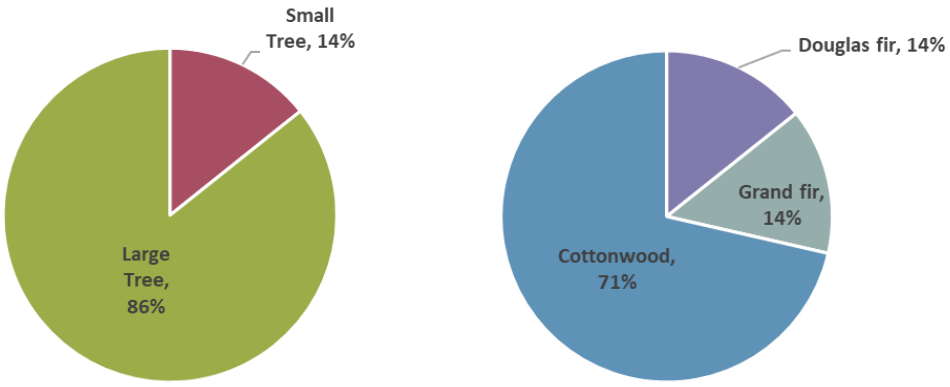


Figure 78. Dominant overstory riparian vegetation class and species, based on seven surveyed units, within 100 feet of Nason Creek by ocular estimate.

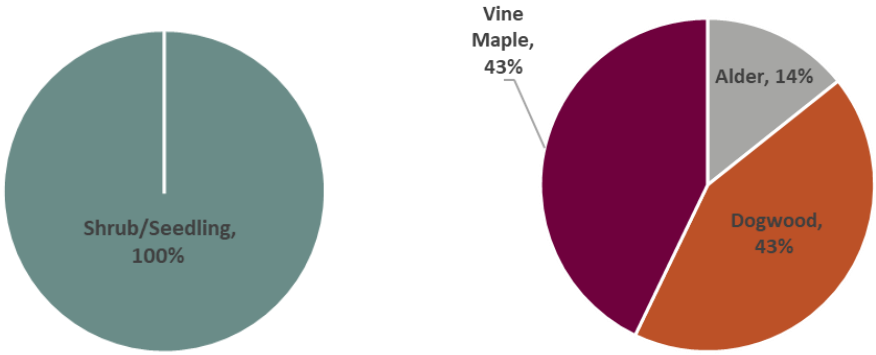


Figure 79. Dominant understory riparian vegetation class and species, based on seven surveyed units, within 100 feet of Nason Creek by ocular estimate.

5.13 REACH 13

Location: River mile 12.6-13.55
Total length: 0.95 miles
Survey Date: September 27th, 2024

Figure 80. Representative photo of Reach 13. Habitat units were split between pool and riffles.

5.13.1 Habitat Unit Composition

Reach 13 was 0.95 miles long and had a channel gradient of 0.33%. Forty-six percent (46%) of the reach was pool habitat, followed by riffle (43%), side channel (5%), glide (3%), and "other" (constructed alcove) with 2% (Figure 82). This reach had the highest percentage of anthropogenic bank instability, with 17% of the total bank length being unstable. The reach ran between the railroad on river right and a clear-cut area and a transmission right-of-way on river left, from RM 12.9-13.3 with riprap armoring both sides. There were two constructed alcoves as part of a restoration project to relocate the river away from the railroad between RM 12.7-12.9. The downstream constructed alcove had flow coming in from a culvert, but it was unclear if the source a tributary or subsurface flow. Although Reach 13 ran alongside the railroad for some of the reach, it was less confined than the previous two reaches.

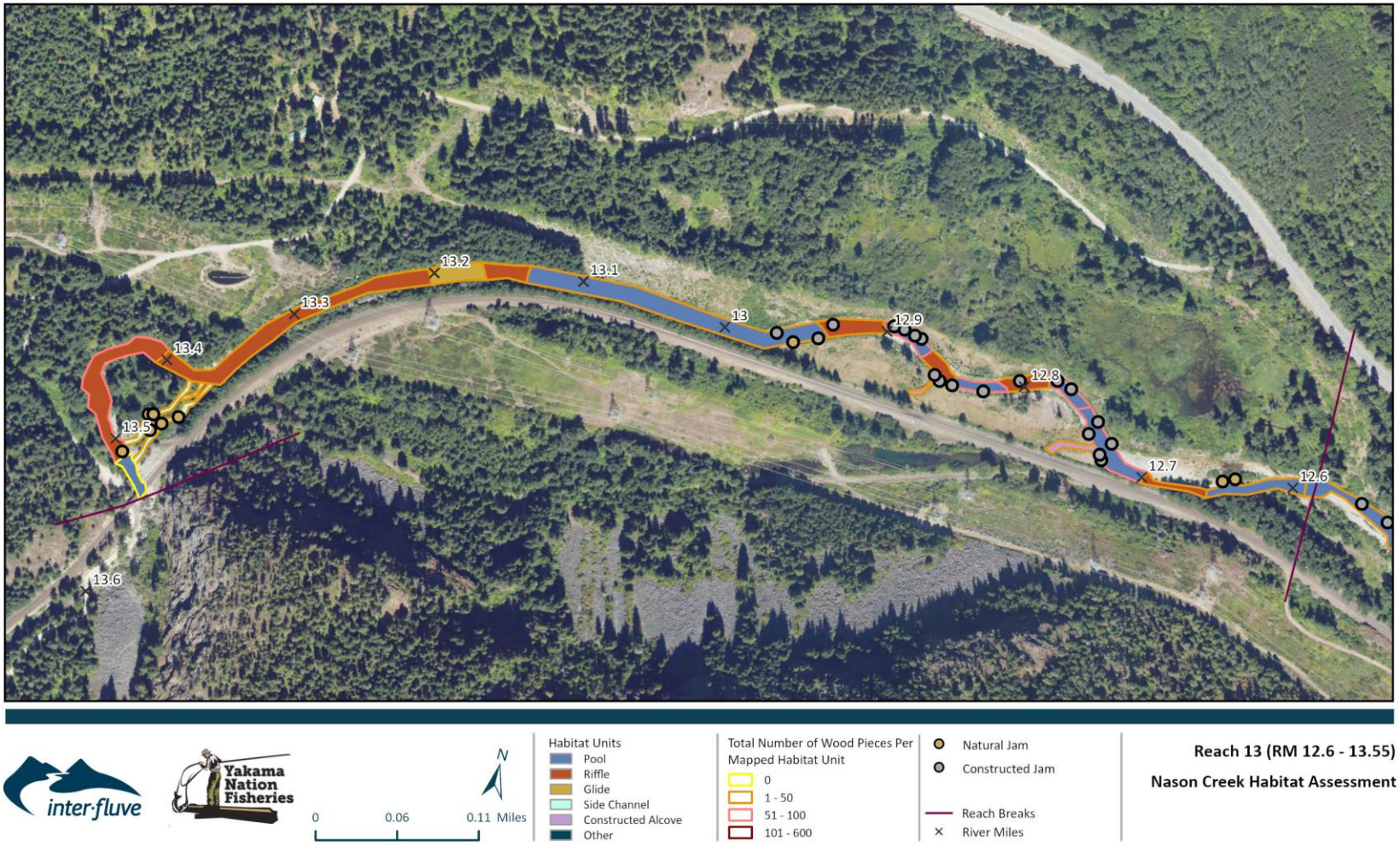


Figure 81. Map of the habitat unit composition and LWM in Reach 13 of Nason Creek. LWM count includes pieces in jams.

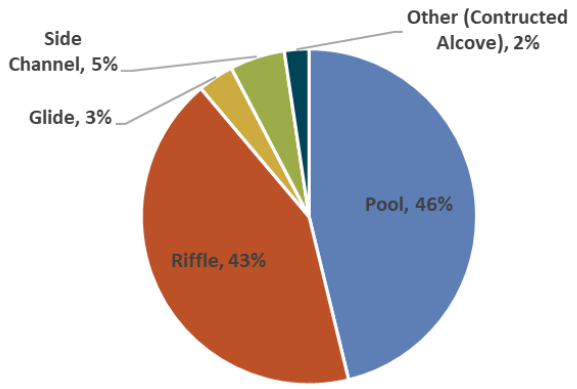


Figure 82. Stream habitat unit area composition of Reach 13.

5.13.2 Pools

There were seven pools total in Reach 13, which equates to seven pools per mile in the 0.95-mile-long reach. The assessment area average was nine pools per mile. The average residual depth was 3.0 feet deep, with a residual depth range of 1.8-5.1 feet, and 57% of the pools had a residual depth greater than or equal to 3 feet deep. The assessment area average residual depth was 3.3 feet deep.

5.13.3 Side Channel Habitat

Three side channels were observed in Reach 13, with an total combined length of 942 feet. One side channel was predominantly fast water, while the other two were predominantly slow water at the time of the survey. A total of nine individual pieces of LWM and five jams with an estimated 46 pieces of LWM were observed in the three side channels (Table 26).

Table 26. Summary of the side channel habitat observed in Reach 13.

Location	Length (ft)	Dominant unit type	Wood count	Jam Count	Wood Count in Jams
Side 25	403	Side Fast	2	3	28
Side 26	440	Side Slow	0	0	0
Side 27	99	Side Slow	7	2	18
Total	942		9	5	46

5.13.4 Large Woody Material

A total of 448 pieces of LWM pieces were recorded in Reach 13. This equates to 472 LWM pieces per mile, and roughly 264 M+L pieces per mile. These wood counts include individual pieces and pieces observed in jams. There were 28 jams in this reach (29 jams per mile), the most jams of any reach, which contained an estimated 372 pieces or 83% of the total pieces (Table 27).

Table 27. Large woody material quantities in Reach 13.

	Small (6 in x 20 ft)	Medium (12 in x 35 ft)	Large (20 in x 35 ft)	Total
Number of pieces	54	14	8	76
Number of pieces per mile	57	23		80
Number of pieces per mile (including pieces in jams)	207	264		472
Number of jams	28			
Number of jams per mile	29			
Estimated Wood Count in Jams	372			

5.13.5 Riparian Corridor

Ten units in Reach 13 included ocular estimates of vegetation. In most of the units, cottonwood, grand fir, or aspen in the large (21.0 - 31.9-inch dbh) or small tree (9.0-20.9-inch dbh) size class made up the overstory. There was a stretch of Reach 13, between RM 12.7 and RM 13.0, with recent restoration work, where there was no overstory (Figure 83). The understory was dominated by vegetation in the shrub/seedling size class, with species including willow, alder, and cottonwood. In one unit, near RM 13.5, a cleared gravel lot adjacent to the channel resulted in no understory (Figure 84).

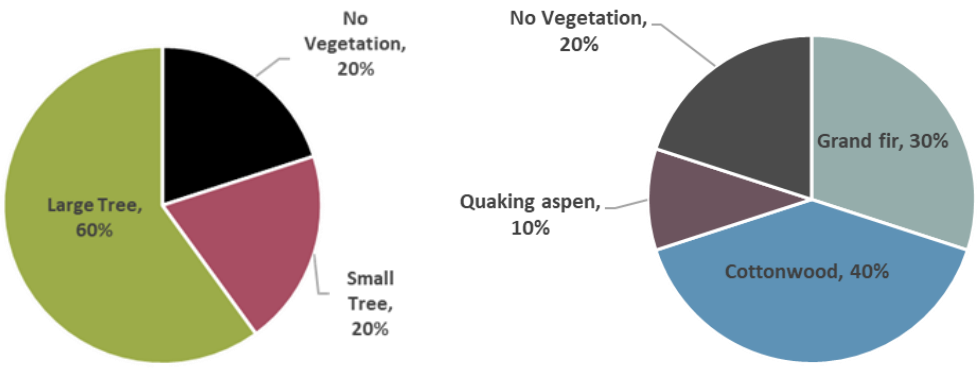


Figure 83. Dominant overstory riparian vegetation class and species, based on 10 surveyed units, within 100 feet of Nason Creek by ocular estimate.

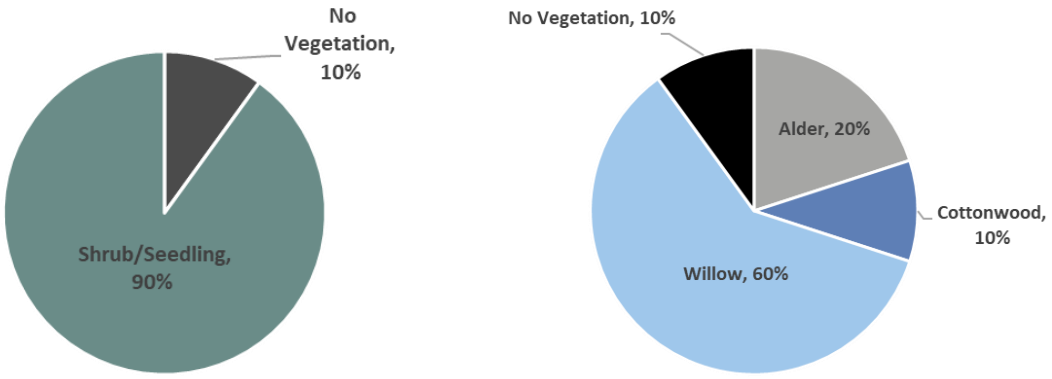


Figure 84. Dominant understory riparian vegetation class and species, based on 10 surveyed units, within 100 feet of Nason Creek by ocular estimate.

5.14 SUMMARY DATA

Table 28. Summary of all the data collected for the 2024 Habitat Assessment on Nason Creek.

	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	All Reaches
River Miles Surveyed	1.1	0.4	1	2.05	0.3	1.5	1.1	1.2	0.6	1.05	1	1.35	0.95	13.55
Stream Gradient	0.51%	0.22%	0.20%	0.35%	0.69%	0.92%	0.96%	0.34%	0.37%	0.13%	0.20%	0.32%	0.33%	0.43%
Average Wetted Width (ft)														
Pool														
Mean	51	55	50	44	45	47	55	63	47	45	53	51	44	49
Median	50	60	55	40	45	45	55	60	45	45	50	50	45	45
St. Dev.	13	19	12	9	14	8	9	10	13	7	11	14	6	12
Riffle														
Mean	55	n=0	30	40	60	52	58	57	55	41	43	44	43	49
Median	60	n=0	30	40	60	45	63	60	55	45	40	40	45	45
St. Dev.	20	n=0	n=1	17	21	11	10	8	14	11	15	13	8	14
Glide														
Mean	60	72	55	41	50	50	n=0	60	40	53	n=0	35	45	52
Median	60	70	55	43	50	50	n=0	60	40	53	n=0	35	45	48
St. Dev.	21	3	n=1	9	n=1	n=1	n=0	n=1	n=1	11	n=0	n=1	n=1	14
Side Channel														
Mean	n=0	n=0	17	19	n=0	6	21	25	20	20	9	15	14	17
Median	n=0	n=0	17	20	n=0	6	25	25	20	20	9	15	12	15
St. Dev.	n=0	n=0	2	10	n=0	1	8	7	n=1	n=1	2	n=1	4	8
Water Depth (ft)														
Pool Maximum Depth														
Mean	4.3	3.8	5.1	3.4	3.1	3.7	3.6	4.5	3.7	4.5	4.2	4.4	4.0	4.1
Median	4.3	3.2	4.5	3.1	3.1	4.0	3.4	5.0	3.5	3.7	4.0	4.5	4.0	4.0
St. Dev.	1.1	1.5	2.7	1.0	0.1	1.1	1.1	0.8	0.3	2.1	1.4	1.0	1.1	1.5
Pool Residual Depth														
Mean	3.3	2.7	4.4	2.6	1.9	2.7	2.4	3.6	2.6	3.9	3.5	3.6	3.0	3.3

	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	All Reaches
Median	2.9	2.2	3.8	2.2	1.9	3.1	2.5	3.8	2.6	3.2	3.4	3.6	3.1	3.1
St. Dev.	1.2	1.3	2.7	1.0	0.6	1.1	0.9	0.7	0.6	2.1	1.3	1.2	1.1	1.6
Riffle/Glide Average Depth														
Mean	1.2	1.3	0.9	1.0	1.4	1.0	1.0	0.9	1.4	0.8	0.8	1.1	1.1	1.1
Median	1.2	1.3	1.0	1.0	1.4	1.0	1.0	0.9	1.5	0.8	1.0	1.3	1.0	1.0
St. Dev.	0.3	0.4	0.2	0.3	0.3	0.2	0.1	0.3	0.2	0.1	0.3	0.4	0.4	0.3
Bankfull Characteristics														
Width (ft)														
Mean	75	94	75	81	82	78	79	74	85	67	68	87	73	77
Median	76	95	70	83	75	75	80	74	93	63	65	93	63	75
St. Dev.	8	8	14	21	16	6	4	8	11	13	10	20	24	16
Depth (ft)														
Maximum Depth (ft)	3.5	4.8	3.4	4.7	4.4	4.1	4.3	4.0	4.6	4.4	4.5	5.6	4.5	5.6
Minimum Depth (ft)	0.7	2.0	1.1	0.9	0.8	0.8	1.0	1.2	1.0	1.2	0.8	1.0	1.1	0.7
Mean Depth (ft)	2.7	3.7	3.0	3.2	3.1	2.7	2.8	2.8	3.0	3.0	3.3	3.2	3.1	3.0
Median	3.0	3.7	2.7	3.3	3.4	2.8	2.8	2.9	3.1	3.0	3.4	3.1	3.2	3.0
St. Dev.	0.7	0.7	0.5	0.7	1.0	0.8	0.7	0.5	1.0	0.8	0.9	1.2	0.8	0.8
Width:Depth Ratio														
Mean	28.47	25.56	28.85	25.74	26.20	28.38	28.42	26.24	35.51	22.37	21.00	26.97	23.62	26.05
Floodprone Width														
Mean	130	157	1014	768	671	361	195	101	127	1372	545	137	409	458
Median	119	102	1306	763	520	363	126	98	96	1508	731	119	470	346
St. Dev.	33	100	562	172	291	214	165	8	58	471	379	51	188	434
Habitat Area (%)														
Pool	55%	47%	79%	27%	22%	18%	20%	57%	50%	69%	77%	75%	46%	47%
Riffle	23%	0%	1%	8%	67%	68%	67%	36%	27%	10%	15%	14%	43%	26%
Glide	22%	53%	4%	9%	10%	5%	0%	3%	17%	18%	0%	1%	3%	8%
Side Channel	0%	0%	16%	56%	0%	2%	12%	4%	5%	3%	8%	1%	5%	17%
“Other” (Marsh)	0%	0%	0%	0%	0%	7%	0%	0%	0%	0%	0%	0%	0%	1%

	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	All Reaches
"Other" (Constructed Alcove)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	8%	2%	1%
Pools														
Pools per Mile	9	10	15	11	7	5	5	6	5	12	11	13	7	9
% of pools D<3 ft	50%	75%	13%	77%	100%	43%	83%	14%	67%	46%	45%	28%	43%	47%
% of pools D≥3ft	50%	25%	87%	23%	0%	57%	17%	86%	33%	54%	55%	72%	57%	53%
Riffle: Pool Ratio	0.50	0.00	0.07	0.45	1.00	1.57	1.33	0.86	0.67	0.31	0.27	0.39	1.00	0.53
Mean Pool Spacing (bankfull channel widths per pool)	7	6	5	6	10	15	12	12	11	6	7	5	10	7
Wood														
Total Number of Pieces (not including pieces in jams)														
Small	46	19	78	138	6	48	40	29	24	32	37	65	54	616
Medium	35	10	44	72	2	16	16	4	13	27	12	326	14	591
Large	27	11	26	63	3	16	11	6	9	27	13	323	8	543
Medium and Large (M+L)	62	21	70	135	5	32	27	10	22	54	25	649	22	1134
Total	108	40	148	273	11	80	67	39	46	86	62	714	76	1750
Number of Pieces/Mile (not including pieces in jams)														
Small	42	48	78	67	20	32	36	24	40	30	37	48	57	45
Medium	32	25	44	35	7	11	15	3	22	26	12	241	15	44
Large	25	28	26	31	10	11	10	5	15	26	13	239	8	40
Medium and Large (M+L)	56	53	70	66	17	21	25	8	37	51	25	481	23	84
Total	98	100	148	133	37	53	61	33	77	82	62	529	80	129
Jams														
Total Jams	8	2	18	17	0	10	22	5	3	1	23	24	28	161
Jams Per Mile	7	5	18	8	0	7	20	4	5	1	23	18	29	12
BF Small in Jams	24	8	154	123	0	31	344	46	8	3	105	91	143	1080
BF Medium in Jams	10	5	105	88	0	19	147	50	3	42	121	77	134	801
BF Large in Jams	10	6	82	58	0	12	94	27	4	0	93	68	95	549
Total BF Wood in Jams	44	19	341	269	0	62	585	123	15	45	319	236	372	2430

	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	All Reaches
Unstable Banks														
Percent Reach Length (both banks)	12%	1%	1%	1%	3%	2%	2%	6%	3%	12%	5%	7%	17%	4%
Vegetation - Percent of System														
Dominant Overstory Size Class														
Large Tree	75%	100%	60%	83%	100%	58%	80%	100%	100%	50%	67%	86%	60%	75%
Small Tree	25%	0%	20%	17%	0%	25%	10%	0%	0%	0%	33%	14%	20%	15%
Shrub/Seedling	0%	0%	20%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%
No Vegetation	0%	0%	0%	0%	0%	17%	10%	0%	0%	50%	0%	0%	20%	9%
Dominant Overstory Species Composition														
Douglas Fir	0%	0%	0%	0%	0%	0%	10%	13%	0%	0%	0%	14%	0%	3%
Ponderosa	25%	0%	20%	8%	0%	33%	70%	75%	100%	0%	0%	0%	0%	25%
Grand Fir	63%	100%	40%	42%	67%	17%	10%	13%	0%	0%	33%	14%	30%	28%
Cottonwood	13%	0%	40%	42%	33%	25%	0%	0%	0%	50%	67%	71%	40%	31%
Quaking Aspen	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	10%	1%
Alder	0%	0%	0%	8%	0%	8%	0%	0%	0%	0%	0%	0%	0%	2%
No Vegetation	0%	0%	0%	0%	0%	17%	10%	0%	0%	50%	0%	0%	20%	9%
Dominant Understory Size Class														
Sapling/Pole	13%	33%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	2%
Shrub/Seedling	88%	67%	80%	100%	100%	83%	90%	75%	100%	75%	100%	100%	90%	88%
Grassland/Forb	0%	0%	20%	0%	0%	17%	10%	0%	0%	13%	0%	0%	0%	5%
“Other”	0%	0%	0%	0%	0%	0%	0%	25%	0%	0%	0%	0%	0%	2%
No Vegetation	0%	0%	0%	0%	0%	0%	0%	0%	0%	13%	0%	0%	10%	2%
Dominant Understory Species Composition														
Alder	50%	67%	0%	33%	67%	25%	40%	25%	0%	0%	33%	14%	20%	27%
Cottonwood	13%	0%	0%	8%	0%	0%	10%	0%	0%	0%	0%	0%	10%	4%
Dogwood	25%	33%	40%	50%	33%	25%	40%	50%	67%	63%	50%	43%	0%	38%
Vine maple	0%	0%	0%	0%	0%	17%	0%	0%	33%	0%	0%	43%	0%	6%
Willow	13%	0%	40%	8%	0%	17%	0%	0%	0%	13%	17%	0%	60%	15%

	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	All Reaches
No Vegetation	0%	0%	0%	0%	0%	0%	0%	0%	0%	13%	0%	0%	10%	2%
“Other”/Unknown	0%	0%	20%	0%	0%	17%	10%	25%	0%	13%	0%	0%	0%	7%

6 References

Fox, M. and Bolton, S. 2007. A Regional and Geomorphic Reference for Quantities and Volumes of Instream Wood in Unmanaged Forested Basins of Washington State. North American Journal of Fisheries Management, 27(1), 342–359.

NMFS (National Marine Fisheries Service). 1996. Making Endangered Species Act Determinations of Effect for Individual or Grouped Actions at the Watershed Scale. NMFS - Environmental and Technical Services Division Habitat Conservation Branch.

UCSRB (Upper Columbia Salmon Recovery Board). 2024. Upper Columbia Spatial Framework. Accessed 2024. https://ucsrb.maps.arcgis.com/apps/webappviewer/index.html?id=af7b5caa1d4241eb99895883970cf393

USBR (US Bureau of Reclamation). 2009. Kahler Reach Assessment.

USBR (US Bureau of Reclamation). 2011. Lower Nason, Assessment of Geomorphic and Ecologic Indicators, Nason Creek, Wenatchee Subbasin.

USFS (US Forest Service). 2020. Stream Inventory Handbook: Level I and Level II. Version 2.20. Pacific Northwest Region. United States Department of Agriculture, United States Forest Service.

Appendix B | Reach-Based Ecosystem Indicators (REI)

NASON CREEK REACH ASSESSMENT UPDATE (RM 0 – 13.55)

January 2026

Contents

1 Introduction 1
1.1 Background 1
1.2 Summary of Results 1
1.3 Comparison to Previous REI Analyses 3
2 Metrics & Indicators 7
2.1 Watershed-Scale Metrics 7
2.2 Reach-Scale Metrics 8
3 REI Ratings 11
3.1 Watershed-Scale Ratings 11
3.2 Reach-Scale Ratings 13
4 References & Sources 24

1 Introduction

1.1 BACKGROUND

The Reach-based Ecosystem Indicators (REI) provide a consistent means of evaluating biological and physical conditions of a watershed in relation to regional standards and known habitat requirements for aquatic biota. These indicators, along with other scientific evaluations, describe the current quality of stream biophysical conditions and can help inform restoration targets and actions. The REI indicators used in this assessment are adaptations from previous efforts including the NMFS matrix of pathways and indicators (NMFS, 1996) and the USFWS (1998).

The REI evaluation for Nason Creek was conducted using field data, observations, previous studies, and available data for the study area. In particular, the rankings were developed based on: 1) quantitative inventory information from the Habitat Assessment performed as part of the Reach Assessment using USFS (2020) protocols, 2) assessment of geomorphic patterns and processes and how they have deviated, if at all, from historical conditions, and 3) analysis of existing watershed assessments and data (e.g., available ArcGIS layers and shapefiles). Functional ratings include Adequate, At Risk, or Unacceptable. The REI analysis helps to summarize habitat impairments and to distill the impairments down to a consistent value that can be compared among reaches.

1.2 SUMMARY OF RESULTS

At the watershed scale, 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 was the most impaired across all indicators.

Table 1. Summary ratings for Nason Creek reach assessment study area. 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 would be rated Unacceptable.

1.3 COMPARISON TO PREVIOUS REI ANALYSES

Four reach assessments with corresponding REIs have been conducted previously in the Nason assessment area (RM 0-13.55), including:

- 2011 Lower Nason Reach Assessment (USBR, 2011), RM 0 - 4.4
- Kahler Reach Assessment (USBR, 2009a), RM 4.4 – 8.6
- Lower White Pine Reach Assessment (USBR, 2009b),RM 9.15 – 11.25, and
- Upper White Pine Reach Assessment (USBR, 2009c)RM 11.5 – 13.55

Past REIs included ratings for watershed-scale metrics and reach-scale metrics; however, only reach-scale metrics are included in this comparison. Watershed-scale metrics were not comparable, as previous assessments used different classifications of watershed size and ratings criteria. Furthermore, ratings at the watershed scale are not predicted to have changed significantly within the timeframe since previous assessments. Reach-scale metrics contained comparable data, although in some cases, metric rating criteria differed among the assessments and may contribute to the variation in ratings between previous assessments and this current assessment. To the extent possible, the comparisons described below acknowledge where key differences in rating criteria occurred. The ratings that are compared include those related to instream aquatic habitat quality, riparian vegetation conditions, and physical channel dynamics of Nason Creek. Additional metrics were included in previous assessment REIs (i.e. water quality ratings at the reach scale) but only the metrics with similar or equal ratings performed in this assessment were included.

At the reach-scale, habitat access metrics have generally remained in an Adequate condition over time. Substrate ratings were either the same (Table 3) or worse (Table 2 and Table 4-Table 5) in the current assessment compared to prior assessments. This is mainly related to relatively high presence of fines/sand observed in the recent assessments for some reaches, which could indicate a worsening trend in bed material composition and spawning site quality. The current assessment rated LWM frequency lower in the downstream reaches (Table 2-Table 3) and higher in the upstream reaches (Table 4-Table 5). The lower current ratings are likely due to the use of a higher threshold number for LWM frequency (68 pieces/mi rather than 20 pcs/mi), which has been used for reach assessments over the last 15+ years based on the Fox and Bolton (2007) data. The higher numbers in the upper reaches can be attributed, in large part, to restoration work. Current pool frequency and off-channel habitat ratings were ranked lower in the downstream reaches (Table 2-Table 3) and remained the same in the upstream reaches (Table 4-Table 5). Part of the difference in pool ratings can be attributed to more stringent pool frequency thresholds for the current REI. The changes in off-channel habitat, however, appear to be more related to interpretation differences of the current and historical condition of off-channel habitat connectivity and availability in lower Nason Creek. Riparian vegetation ratings are generally comparable except for in lower Nason, where current ratings are lower for Disturbance and Canopy Cover. Differences in the Disturbance rating appear to be due to differences in interpretation and differences in the Canopy Cover rating are assumed to be due to the use of different methods (i.e. use of the ShadeMap tool in the current assessment compared to a buffer composition analysis in the prior assessment). The Channel Dynamics scoring varied between assessments. In lower Nason, ratings are generally comparable, except for Vertical Channel Stability, which was rated low in the current assessment due to incision related to channel cut-

offs, straightening, confinement, and armoring. Although these impacts were acknowledged in the prior assessment, conditions were still rated as Adequate "…based on overbank flows during spring high-flow events and floodplain area regularly accessed…" (USBR 2011). For the Kahler, LWP, and UWP segments, the current assessment rated Channel Dynamics either the same or, in most cases, lower than the prior assessments. This can be largely attributed to interpretation differences of the reach-scale effects of human manipulations to these areas. For the current assessment, we generally interpreted the human infrastructure modifications to have a strong influence in providing significant impairment to channel dynamics in these reaches. This includes the numerous channel and floodplain cut-offs, relocations, straightening, and bank armoring associated with Highway 2, the BNSF railroad, and residential uses, plus various other areas of levees and floodplain fill.

A summary of the past assessment ratings at the reach scale is shown in Table 2 through Table 5 below. Details on the methods used to determine REI ratings can be found in the past assessments listed above.

Table 2. REI ratings from the 2011 Lower Nason Reach Assessment (RM 0-4.4). The Lower Nason Reach area is equivalent to Reach 1- nearly all of Reach 4.

2011 Lower Nason Reach Scale Ratings (RM 0-4.4)				2024 Nason Reach Assessment Equivalent Reach Scale Ratings					
Pathway	**Specific Indicator**	**Rating**		**Pathway**	**Specific Indicator**	**Reach 1**	**Reach 2**	**Reach 3**	**Reach 4**
Habitat Access	Physical Barriers	Adequate		Habitat Access	Physical Barriers	At Risk	Adequate	Adequate	Adequate
Habitat Quality	Substrate	Adequate		Habitat Quality	Substrate	Unacceptable	At Risk	At Risk	At Risk
	LWM (frequency)	Adequate			LWM (frequency)	At Risk	At Risk	At Risk	At Risk
	Pools (frequency and quality)	Adequate	vs.		Pools (frequency and quality)	Unacceptable	Unacceptable	At Risk	At Risk
	Off-Channel Habitat	Adequate			Off-Channel Habitat	Unacceptable	Unacceptable	At Risk	At Risk
Riparian Vegetation	Structure	At Risk		Riparian Vegetation	Structure	At Risk	At Risk	At Risk	At Risk
	Disturbance	Adequate			Disturbance (Human)	Unacceptable	Unacceptable	Adequate	At Risk
	Canopy Cover	Adequate			Canopy Cover	At Risk	Adequate	At Risk	At Risk
Channel Dynamics	Floodplain Connectivity	At Risk		Channel Dynamics	Floodplain Connectivity	Unacceptable	At Risk	At Risk	Unacceptable
	Bank Stability and Channel Migration	At Risk			Bank Stability/ Channel Migration	Unacceptable	At Risk	At Risk	Unacceptable
	Vertical Channel Stability	Adequate			Vertical Channel Stability	At Risk	At Risk	Adequate	Unacceptable

Table 3. REI ratings from the 2009 Kahler Reach Assessment (RM 4.4-8.6). The Kahler Reach area is equivalent to Reach 5- Reach 8.

2009 Kahler Reach Assessment (RM 4.4-8.6)				2024 Nason Reach Assessment Equivalent Reach Scale Ratings					
Pathway	**Specific Indicator**	**Rating**		**Pathway**	**Specific Indicator**	**Reach 5**	**Reach 6**	**Reach 7**	**Reach 8**
Habitat Access	Physical Barriers	Adequate		Habitat Access	Physical Barriers	Adequate	Adequate	Adequate	Adequate
Habitat Quality	Substrate	At Risk		Habitat Quality	Substrate	At Risk	At Risk	At Risk	Adequate
	LWM	At Risk			LWM (frequency)	Unacceptable	Unacceptable	At Risk	At Risk
	Pools (frequency and quality)	At Risk	vs.		Pools (frequency and quality)	Unacceptable	Unacceptable	Unacceptable	Unacceptable
	Connectivity with the Main Channel	At Risk			Off-Channel Habitat	Unacceptable	At Risk	At Risk	At Risk
Riparian Vegetation	Structure	At Risk		Riparian Vegetation	Structure	At Risk	Unacceptable	At Risk	At Risk
	Disturbance	At Risk			Disturbance (Human)	At Risk	At Risk	Unacceptable	At Risk
	Canopy Cover	At Risk			Canopy Cover	At Risk	At Risk	At Risk	Adequate
Channel Dynamics	Floodplain Connectivity	At Risk		Channel Dynamics	Floodplain Connectivity	Unacceptable	Unacceptable	Unacceptable	Unacceptable
	Bank Stability and Channel Migration	At Risk			Bank Stability/ Channel Migration	Unacceptable	Unacceptable	Unacceptable	Unacceptable
	Vertical Channel Stability	At Risk			Vertical Channel Stability	Unacceptable	Unacceptable	Unacceptable	At Risk

Table 4. REI ratings from the 2009 Lower White Pine Reach Assessment (RM 9.15-11.25). The Lower White Pine Reach area is equivalent to Reach 10- Reach 11.

2009 Lower White Pine Reach Assessment (RM 9.15-11.25)				2024 Nason Reach Assessment Equivalent Reach Scale Ratings			
Pathway	**Specific Indicator**	**Rating**		**Pathway**	**Specific Indicator**	**Reach 10**	**Reach 11**
Habitat Access	Physical Barriers	Adequate		Habitat Access	Physical Barriers	At Risk	Adequate
Habitat Quality	Substrate	Adequate		Habitat Quality	Substrate	Unacceptable	Unacceptable
	LWM	Unacceptable			LWM (frequency)	At Risk	At Risk
	Pools (frequency and quality)	At Risk			Pools (frequency and quality)	At Risk	At Risk
	Connectivity with the Main Channel	Unacceptable	vs.		Off-Channel Habitat	Unacceptable	Unacceptable
Riparian Vegetation	Structure	Unacceptable		Riparian Vegetation	Structure	Unacceptable	Unacceptable
	Disturbance	At Risk			Disturbance (Human)	At Risk	Unacceptable
	Canopy Cover	Unacceptable			Canopy Cover	Unacceptable	Unacceptable
Channel Dynamics	Floodplain Connectivity	Unacceptable		Channel Dynamics	Floodplain Connectivity	Unacceptable	Unacceptable
	Bank Stability and Channel Migration	Unacceptable			Bank Stability/ Channel Migration	Unacceptable	Unacceptable
	Vertical Channel Stability	At Risk			Vertical Channel Stability	Unacceptable	Unacceptable

Table 5. REI ratings from the 2009 Upper White Pine Reach Assessment (RM 11.5-13.55). The Upper White Pine Reach area is equivalent to most of Reach 12-Reach 13.

2009 Upper White Pine Reach Assessment (RM 11.5-13.55)				2024 Nason Reach Assessment Equivalent Reach Scale Ratings			
Pathway	**Specific Indicator**	**Rating**		**Pathway**	**Specific Indicator**	**Reach 12**	**Reach 13**
Habitat Access	Physical Barriers	Adequate		Habitat Access	Physical Barriers	Adequate	Adequate
Habitat Quality	Substrate	At Risk		Habitat Quality	Substrate	Unacceptable	Unacceptable
	LWM	Unacceptable			LWM (frequency)	At Risk	At Risk
	Pools (frequency and quality)	At Risk			Pools (frequency and quality)	At Risk	At Risk
	Connectivity with the Main Channel	At Risk	vs.		Off-Channel Habitat	At Risk	At Risk
Riparian Vegetation	Structure	At Risk		Riparian Vegetation	Structure	At Risk	Unacceptable
	Disturbance	Unacceptable			Disturbance (Human)	At Risk	Unacceptable
	Canopy Cover	Unacceptable			Canopy Cover	At Risk	At Risk
Channel Dynamics	Floodplain Connectivity	At Risk		Channel Dynamics	Floodplain Connectivity	Unacceptable	Unacceptable
	Bank Stability / Channel Migration	At Risk			Bank Stability/ Channel Migration	Unacceptable	Unacceptable
	Vertical Channel Stability	At Risk			Vertical Channel Stability	Unacceptable	Unacceptable

2 Metrics & Indicators

2.1 WATERSHED-SCALE METRICS

Pathway	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Watershed Scale					
Watershed Condition	Drainage Network and Hydrologically Impaired Surfaces	Increase in Drainage Network/ Hydrologically Impaired Surfaces	Zero or minimal increases in the drainage network that is correlated with human caused disturbances. Hydrologically impaired surfaces in watershed total < 8%. Road density <1 mile/miles^2.	Low to moderate increase in the drainage network correlated with human caused disturbances. Hydrologically impaired surfaces in watershed total between 8 and 14.9%. Road density 1-2.4 miles/miles^2.	Substantial increase in the drainage network correlated with human caused disturbances. Hydrologically impaired surfaces in watershed total > 15%. Road density >2.4 miles/miles^2.
	Disturbance Regime	Natural/Human Caused	Environmental disturbance is short-lived; predictable hydrograph, high-quality habitat and watershed complexity providing refuge and rearing space for all life stages or multiple life-history forms. Natural processes are stable.	Localized events of hillslope contributions, avulsion, lateral migrations, minor bed incision, or wildfires. Resiliency of habitat to recover from environmental disturbances is moderate.	Frequent flood or drought producing highly variable and unpredictable flows, hillslope contributions, avulsion, lateral migrations, minor to major bed incision (head cuts), or wildfires throughout a majority of the watershed. The channel is simplified, providing little hydraulic complexity in the form of pools or side channels. Natural processes are unstable.
Flow/Hydrology	Streamflow	Alterations to Peak/Base Flows	Magnitude, timing, duration, and frequency of peak flows within a watershed are not altered relative to natural conditions of an undisturbed watershed of similar size, geology, and geography.	Some evidence of altered magnitude, timing, duration and/or frequency of peak flows relative to natural conditions of an undisturbed watershed of similar size, geology, and geography.	Pronounced changes in magnitude, timing, duration and/or frequency of peak flows relative to natural conditions of an undisturbed watershed of similar size, geology, and geography.
Water Quality	Temperature	7-day average maximum temperatures	**Bull Trout:** incubation 2 - 5°C rearing 4 - 12°C spawning 4 - 9°C **Other salmonids:** spawning <13°C rearing <15°C holding & migration <15°C Lamprey: rearing 10 – 18 °C, migration <18°C And, temperatures do not exceed 15°C in areas used by adults during migration (no thermal barriers)	**Bull Trout:** incubation <2 or 6°C rearing <4 or 13 - 15°C spawning <4 or 10°C **Other salmonids:** spawning 14-15.5°C rearing <14 – 17.5°C holding & migration <14 – 17.5°C Lamprey: rearing 18 – 22°C, migration 18 – 22°C And, temperatures in areas used by adults during migration sometimes exceed 15°C	**Bull Trout:** incubation <1 or >6°C rearing >15°C spawning <4 or >10°C **Other salmonids:** spawning >15.5°C rearing >17.5°C holding & migration >17.5°C Lamprey: rearing >22°C, migration >22°C And, temperatures in areas used by adults during migration regularly exceed 15°C (thermal barriers present)

2.2 REACH-SCALE METRICS

Pathway	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Reach Scale					
Habitat Access	Physical Barriers	Main Channel Barriers	No man-made barriers present in the mainstem that limit upstream or downstream migration at any flow.	Man-made barriers are present in the mainstem that have the potential to prevent or inhibit upstream or downstream migration at a subset of flows.	Man-made barriers present in the mainstem that prevent upstream or downstream migration at multiple or all flows.
Habitat Quality	Substrate	Dominant Substrate/Fine Sediment	Gravels (2.1-64mm) or small cobbles (64.1-256 mm) make up >50% of the bed materials where natural channel form and stream power support development of spawning areas, with ≤12% of substrates <5.6 mm in spawning gravel.	Gravels (2.1-64mm) or small cobbles (64.1-256 mm) make up 30-50% of the bed materials where natural channel form and stream power support the development of spawning areas, with 12-20% of substrates <5.6 mm in spawning gravel.	Gravels (2.1-64mm) or small cobbles (64.1-256 mm) make up <30% of the bed materials where natural channel form and stream power support the development of spawning areas, with >20% of substrates <5.6 mm in spawning gravel.
	LWM	Pieces per Mile at Bankfull	Based on Fox and Bolton (2007) metrics for Eastern Washington, at least 67.45 pieces/mile of “Medium” and “Large” size large woody material (LWM) are present in the reach, based on USFS (2020) size classifications. USFS Stream Inventory protocol (2020) large woody material criteria, under the Eastside Forests criteria: Medium = diameter > 12 in, length > 35 ft Large = diameter > 20 in, length > 35 ft In addition to a minimum of 67.45 pieces of medium or large wood/mile, an adequate rating also indicates the LWM are well-distributed throughout the reach and there are sources of woody debris available for both long- and short-term recruitment within the reach.	Current levels are able to maintain the minimum requirements for an "adequate" rating, but potential sources for long-term woody debris recruitment, as determined by the Riparian Structure reach metrics, are lacking in order to maintain these current levels or wood is not well-distributed throughout the reach.	Current levels are not meeting the minimum requirements for an “adequate” rating, and potential source of woody debris for short- and/or long-term recruitment are lacking or wood is not well-distributed throughout the reach.

<table>
<tr><th>Pathway</th><th>General Indicators</th><th>Specific Indicators</th><th>Adequate Condition</th><th>At Risk Condition</th><th>Unacceptable Risk Condition</th></tr>
<tr><td rowspan="5"></td><td>Pools</td><td>Pool Frequency and Quality; presence of large pools.</td><td>Pool frequency: Number of pools/mile for a given bankfull width (BFW) equal or exceed NMFS (1996) criteria (below). For channels with bankfull >100 ft, minimum number of pools/mile were extrapolated based on relationship between BFW and pools/mile in NMFS (1996) criteria.
Bankfull width:
<table><tr><td>25-50</td><td>26</td><td>pools/mile</td></tr><tr><td>51-75</td><td>23</td><td>pools/mile</td></tr><tr><td>76-100</td><td>18</td><td>pools/mile</td></tr><tr><td>101-130</td><td>15</td><td>pools/mile</td></tr></table>In addition, at least 50% of the total pools must be large pools with >1 m (3 ft) of residual depth and good fish cover.</td><td>Pool frequency meets or almost meets the values for the "adequate" rating, but pools have inadequate cover and/or there has been a moderate reduction of pool volume by fine sediment. Reaches have between 20-50% large pools present with good fish cover.</td><td>Pool frequency does not meet the pools/mile metric given in the “adequate” rating. Reaches have <20% large pools (>1 m deep). Pools also have inadequate cover and/or there has been a major reduction of pool volume by fine sediment.</td></tr>
<tr><td>Off-Channel Habitat and Refugia</td><td>Connectivity with Main Channel</td><td>Reach has side channels and/or groundwater fed tributaries. Aquatic refugia such as backwaters, alcoves, large boulder eddies exist within the reach. Well-vegetated floodplains with healthy riparian community are inundated on a 1-2-year recurrence frequency. No man-made barriers that prevent access to off-channel areas.</td><td>Reach provides some aquatic off-channel and refugia features but access varies or is at risk of disconnection due to human impacts or man-made barriers. Floodplains along the off-channel habitat are well-vegetated with inundation recurrence of 2-5-years.</td><td>Reach provides no or only minimal off-channel refugia. Floodplains are disconnected and riparian vegetation has been altered.</td></tr>
<tr><td rowspan="3">Riparian Vegetation</td><td rowspan="3">Condition</td><td>Structure</td><td>>80% large trees (>21” DBH; USFS, 2020) in the riparian zone (defined as a 100ft buffer along each bank) based on habitat assessment data. No visual evidence of human impact on vegetation (e.g., logging or residential/agricultural clearing) in the floodplain.</td><td>50-80% large trees (>21” DBH; USFS, 2020) in the riparian zone (defined as a 100ft buffer along each bank) based on habitat assessment data. Some visual evidence of human impact on vegetation (e.g., logging or residential/agricultural clearing) in the floodplain.</td><td><50% large trees (>21” DBH; USFS, 2020) in the riparian zone (defined as a 100ft buffer along each bank) based on habitat assessment data. Extensive visual evidence of human impact on vegetation (e.g., logging or residential/agricultural clearing) in the floodplain.</td></tr>
<tr><td>Disturbance (Human)</td><td><20% disturbance (e.g., agriculture and grazing, residential, roads, etc.) and <2 mile/miles^2 road density in the 200-foot channel buffer.</td><td>20-50% disturbance (e.g., agriculture and grazing, residential, roads, etc.) and 2-3 miles/miles^2 road density in the 200-foot channel buffer zone.</td><td>>50% disturbance (e.g., agriculture and grazing, residential, roads, etc.) and >3 miles/miles^2 road density in the in the 200-foot channel buffer zone.</td></tr>
<tr><td>Canopy Cover</td><td>Canopy cover provides high level of channel shading, based on the number of shaded daylight hours on the summer solstice (using publicly-available mapping dataset Shademap: https://shademap.app/). In addition, a high proportion of large trees (height > 100 feet) are present within 100-feet of the channel bank.</td><td>Canopy cover provides moderate level of channel shading, based on the number of shaded daylight hours on the summer solstice. In addition, a moderate proportion of large trees (height > 100 feet) are present within 100-feet of the channel bank.</td><td>Canopy cover provides low level of channel shading, based on the number of shaded daylight hours on the summer solstice. In addition, a small proportion of large trees (height > 100 feet) are present within 100-feet of the channel bank.</td></tr>
</table>

Pathway	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Channel	Dynamics	Floodplain Connectivity	Floodplain areas are hydrologically linked to main channel within the context of the local process domain; overbank flows occur and maintain wetland functions, and riparian vegetation. Naturally confined channels are considered adequate.	Reduced linkage of wetland, floodplains and riparian areas to main channel; overbank flows are reduced relative to historic frequency, as evidenced by moderate degradation of wetland function and riparian vegetation/succession.	Severe reduction in hydrologic connectivity between off-channel, floodplain, and riparian areas relative to historical connectivity; riparian vegetation/succession is altered significantly.
		Bank Stability/Channel Migration	Channel is migrating at or near natural rates within the geomorphic construct of the reach.	Channel migration is occurring at a faster or slower rate relative to natural rates, but significant change in channel width or planform is not detectable; large woody debris is still being recruited.	Little or no channel migration is occurring because of human actions preventing reworking of the floodplain and large woody debris recruitment; or channel migration is occurring at an accelerated rate such that channel width has at least doubled, possibly resulting in a channel planform change, and sediment supply has noticeably increased from bank erosion.
		Vertical Channel Stability	No measurable trend of aggradation or incision beyond the natural geomorphic processes of the reach.	Measurable trend of aggradation or incision that has the potential to, but has not yet caused, disconnection of the floodplain or a visible change in channel planform (e.g. single thread to braided.)	Enough incision or human infrastructure has occurred that the floodplain and off-channel habitat areas have been disconnected from the main channel; or enough aggradation has occurred to create a visible change in channel planform (e.g. single thread to braided.)

3 REI Ratings

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

3.1 WATERSHED-SCALE RATINGS

General Characteristics	General Indicators	Specific Indicators	Rating	Discussion
Watershed Scale				
Watershed Condition	Drainage Network and Hydrologically Impaired Surfaces	Increase in Drainage Network/ Hydrologically Impaired Surfaces	At Risk	Hydrologically impaired surfaces (roads, parking lots, and buildings) in the watershed were calculated using the 2024 National Land Cover Database (USGS, 2024). The raster dataset is broken into three categories: developed, roads, and non-developed. The percentage of developed and roads raster cells were compared to the cell count for the entire watershed, which was delineated using the Washington State Department of Ecology HUC-10 Watershed Boundary Dataset (WDOE, 2016). The percentage of hydrologically impaired surfaces for the entire contributing watershed was 3.0%. Road density was calculated using a Washington Department of Natural Resources state roads GIS dataset (WADNR GIS Open Data, 2025) and a Washington State Department of Transportation GIS railroad data set (*WSDOT, 2025*). The total length of roads and railroads in the Nason Creek watershed was calculated and compared to the total watershed area, resulting in a road density of 2.7 miles of road per square mile of watershed. The Nason Creek watershed as a whole is relatively undeveloped, with the most developed areas located along the valley bottom in the floodplain or directly adjacent to Nason Creek along the lower 12 miles. In addition, most of the roads are concentrated in the lower portion of the watershed, which serves to somewhat limit the impacts to watershed-scale hydrologic and sediment delivery processes. Several significant roads are located within the watershed, including Highway 2 and State Route 207. Given the low percentage of hydraulically impaired surfaces but relatively high level of road density, this indicator receives an At Risk rating.
	Disturbance Regime	Natural/Human Caused	Unacceptable	This disturbance history rating for the Nason Creek watershed reflects a history of logging, road and railroad development, residential development, and agriculture. Historical and continued legacy impacts to the watershed and the natural disturbance cycles have resulted from these human-caused disturbances. Logging along Nason Creek began in the early 1900s, and was especially prevalent in the lower 14 miles of Nason Creek between the 1960s and 1990s, resulting in increased erosion and reduced riparian vegetation (Andonaegui, 2001; U.S. Bureau of Reclamation, 2008). Rail lines, frequently associated with logging operations, included the widespread use of fire to clear vegetation for railroad development alongside Nason Creek (Bountry et al., 2008). The resulting railroad levees and bridges have limited Nason Creek channel complexity and sinuosity, altered LWM regimes and geomorphic processes, and reduced high-quality riparian vegetation along Nason Creek. Road development, especially Highway 2 and State Route 207, has similarly disconnected Nason Creek from the surrounding floodplain, further simplifying channel morphology, limiting LWM inputs, and altering riparian conditions. The disconnection of Nason Creek from the surrounding floodplains from road and railroad networks has the most severe impacts on habitat conditions in Nason Creek, as the lack of LWM or geomorphic drivers has led to a reduction of pool habitat and increased temperature by cutting off cold-water inputs (Andonaegui, 2001; U.S. Bureau of Reclamation, 2008). Given the severe impacts from road and railroad development along Nason Creek, and the reduction of riparian conditions from logging, this indicator receives an Unacceptable rating.
Flow/Hydrology	Streamflow	Alterations to Peak/Base Flows	At Risk	The hydrology of the Nason Creek watershed is driven by snowmelt and precipitation. Peak flows occur in the spring from snowmelt runoff, with a secondary peak in the late fall from precipitation (either snow or rain). Streamflow data from WDOE gage (gage #45J070) near RM 0.2 (Cedar Brae Rd bridge) for the period of record, 2002-2023, were analyzed to help determine this rating. The daily mean, 5% exceedance, and 95% exceedance were determined for each decade. Over the past two decades, peak discharges from the daily mean have generally occurred earlier in the year and peak discharges from the 5% exceedances have decreased in magnitude over time. Available streamflow data is limited, given the short period of record and that peak flows from the gage are impacted from backwatering of Lake Wenatchee. However, there is a discernable trend in the available streamflow data and trends align with the predicted reduction of snowpack across the Pacific Northwest from climate change (Mote & Salathé, 2010). Given these changes, this indicator receives an At-Risk rating.

General Characteristics	General Indicators	Specific Indicators	Rating	Discussion
Watershed Scale				
Water Quality	Temperature	7-day mean daily maximum temperatures	Unacceptable	Water temperature data from the WDOE gage (Gage #45J070) for the period of record 2002-2024 were evaluated for the 7-day mean daily maximum (7-DADMax) water temperature. Over the course of the 22-year period, the 7-DADMax exceeded 15°C every year, frequently between the months of July, August and September. Water temperatures over 15 °C most regularly occurred in August. The duration of water temperatures over 15 °C typically lasted for a month or longer. For these reasons, this indicator receives an Unacceptable rating.

3.2 REACH-SCALE RATINGS

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
			There were no anthropogenic barriers in the main channel. There were multiple man-made rock dams near Nason Creek campground that have the potential to impede fish passage at lower flows or if they were to become channel spanning.	There were no anthropogenic barriers in the main channel.	There were no anthropogenic barriers in the main channel.	There were no anthropogenic barriers in the main channel.	There were no anthropogenic barriers in the main channel.	There were no anthropogenic barriers in the main channel.	There were no anthropogenic barriers in the main channel.	There were no anthropogenic barriers in the main channel.	There were no anthropogenic barriers in the main channel.	There were no anthropogenic barriers in the main channel. There was a channel spanning rock weir and intake structure in the main channel near RM 9.25. The rock weir has the potential to impede fish passage at lower flows and the maintenance associated with the intake structure may also impede fish passage.	There were no anthropogenic barriers in the main channel.	There were no anthropogenic barriers in the main channel.	There were no anthropogenic barriers in the main channel.

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 Quality	Substrate	Dominant Substrate/ Fine Sediment	Unacceptable Based on ocular estimates during the geomorphic survey, the substrate consisted of equal amounts of boulders, cobbles, gravels, and sand. There was 12-20% interspersion of fines within spawning gravels, based on ocular estimates. Rated Unacceptable due to a lack of structure (to reduce energy and capture gravels) limiting the amount of spawning gravel deposits. Additionally, riprap impacts bed substrate conditions in this reach.	At Risk Based on ocular estimates during the geomorphic survey, the substrate was dominated by boulders, followed by gravels and cobbles. There was between 12-20% interspersion of fines within spawning gravels, based on ocular estimates.	At Risk Based on ocular estimates during the geomorphic survey, the substrate was dominated by gravels, followed by cobbles and sand. There was between 12-20% interspersion of fines within spawning gravels, based on ocular estimates.	At Risk Based on ocular estimates during the geomorphic survey, the substrate was dominated by gravels and cobbles. There was between 12-20% interspersion of fines within spawning gravels, based on ocular estimates. Riprap and a lack of structure (to reduce energy and capture gravels) impacts bed substrate in this reach.	At Risk Based on ocular estimates during the geomorphic survey, the substrate was dominated by large cobbles and small boulders. There was <12% interspersion of fines within spawning gravels, based on ocular estimates. Rated At Risk due to a lack of structure limiting the amount of spawning gravel deposits.	At Risk Based on ocular estimates during the geomorphic survey, the substrate was dominated by cobbles, followed by boulders and then gravels. There was <12% interspersion of fines within spawning gravels, based on ocular estimates. Rated At Risk due to a lack of structure limiting the amount of spawning gravel deposits.	At Risk Based on ocular estimates during the geomorphic survey, the substrate was dominated by small boulders, followed by cobbles and then gravels. There was <12% interspersion of fines within spawning gravels, based on ocular estimates. Rated At Risk due to a lack of structure and rip rap limiting the amount of spawning gravel deposits. Additionally, riprap impacts bed substrate conditions in this reach.	Adequate Based on ocular estimates during the geomorphic survey, the substrate was dominated by gravels and cobbles, followed by boulders. There was <12% interspersion of fines within spawning gravels, based on ocular estimates. Riprap impacts bed substrate conditions in this reach.	At Risk Based on ocular estimates during the geomorphic survey, the substrate was dominated by gravels, followed by cobbles and boulders. There was 12-20% interspersion of fines within spawning gravels, based on ocular estimates.	Unacceptable Based on ocular estimates during the geomorphic survey, the substrate was dominated by gravels, followed by boulders from high amounts of riprap. There was >20% interspersion of fines within spawning gravels, based on ocular estimates.	Unacceptable Based on ocular estimates during the geomorphic survey, the substrate was dominated by gravels, followed by cobbles. There was between 12-20% interspersion of fines within spawning gravels, based on ocular estimates. Rated Unacceptable due to severe impact on bed substrate conditions (composition, scour, recruitment potential) due to channel re-location and confinement along railroad.	Unacceptable Based on ocular estimates during the geomorphic survey, the substrate was dominated by gravels, followed by cobbles. Failed riprap was observed in the channel. There was between 12-20% interspersion of fines within spawning gravels, based on ocular estimates. Rated Unacceptable due to severe impact on bed substrate conditions (composition, scour, recruitment potential) due to channel straightening and confinement along highway.	Unacceptable Based on ocular estimates during the geomorphic survey, the substrate was dominated by cobbles, with gravels dominant at the downstream end and boulders dominant at the upstream end. There was between 12-20% interspersion of fines within spawning gravels, based on ocular estimates. Rated Unacceptable due to severe impact on bed substrate conditions (composition, scour, recruitment potential) due to channel re-location and confinement along railroad.

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 Quality	LWM	Pieces per Mile at Bankfull	At Risk M+L pieces/mi = 75 Percent in Jams = 29% Meets the minimum criteria of 67.45 pieces of M+L wood per mile. Less than 50% of the wood is within jams, and most of the jams are natural. The potential sources for short and long-term woody debris recruitment are limited, as determined by riparian condition ratings.	At Risk M+L pieces/mi = 80 Percent in Jams = 32% Meets the minimum criteria of 67.45 pieces of M+L wood per mile. Less than 50% of the wood is within jams, and all the jams are natural. The potential sources for short and long-term woody debris recruitment are limited, as determined by riparian condition ratings.	At Risk M+L pieces/mi = 257 Percent in Jams = 70% Meets the minimum criteria of 67.45 pieces of M+L wood per mile. Most (>50%) of the wood is within jams and most of those jams are natural. The potential sources for short and long-term woody debris recruitment are limited, as determined by riparian condition ratings.	At Risk M+L pieces/mi = 137 Percent in Jams = 50% Meets the minimum criteria of 67.45 pieces of M+L wood per mile. Half of the wood is within jams, all of which are natural. The potential sources for short and long-term woody debris recruitment are limited, as determined by riparian condition ratings.	Unacceptable M+L pieces/mi = 17 Percent in Jams = 0% (no jams observed) Does not meet the minimum criteria of 67.45 pieces of M+L wood per mile. There were no jams observed in the reach. The potential sources for short and long-term woody debris recruitment are limited, as determined by riparian condition ratings.	Unacceptable M+L pieces/mi = 42 Percent in Jams = 44% Does not meet the minimum criteria of 67.45 pieces of M+L wood per mile. Less than 50% of the wood is within jams, all of which are natural. The potential sources for short and long-term woody debris recruitment are limited, as determined by riparian condition ratings.	At Risk* M+L pieces/mi = 244 Percent in Jams = 90% Meets the minimum criteria of 67.45 pieces of M+L wood per mile. Most (>50%) of the wood is within jams and most of those jams are constructed. Without constructed jams there would be 36 M+L pieces per mile (an Unacceptable condition). The potential sources for short and long-term woody debris recruitment are limited, as determined by riparian condition ratings, and as restoration projects age the LWM conditions could degrade.	At Risk* M+L pieces/mi = 73 Percent in Jams = 76% Meets the minimum criteria of 67.45 pieces of M+L wood per mile. Most (>50%) of the wood is within jams and most of those jams are constructed. Without constructed jams there would be 10 M+L pieces per mile (an Unacceptable condition). The potential sources for short and long-term woody debris recruitment are limited, as determined by riparian condition ratings, and as restoration projects age the LWM conditions could degrade.	Unacceptable M+L pieces/mi = 48 Percent in Jams = 25% Does not meet the minimum criteria of 67.45 pieces of M+L wood per mile. Less than 50% of the wood is within jams, all of which are natural. The potential sources for short and long-term woody debris recruitment are limited, as determined by riparian condition ratings, and as restoration projects age the LWM conditions could degrade.	At Risk M+L pieces/mi = 91 Percent in Jams = 34% Meets the minimum criteria of 67.45 pieces of M+L wood per mile. Only one constructed jam was observed in the reach. The potential sources for short and long-term woody debris recruitment are limited, as determined by riparian condition ratings.	At Risk* M+L pieces/mi = 239 Percent in Jams = 84% Meets the minimum criteria of 67.45 pieces of M+L wood per mile. Most (>50%) of the wood is within jams and most of those jams are constructed. Without constructed jams there would be 29 M+L pieces per mile (an Unacceptable condition). The potential sources for short and long-term woody debris recruitment are limited, as determined by riparian condition ratings, and as restoration projects age the LWM conditions could degrade.	At Risk M+L pieces/mi = 588 Percent in Jams = 25% Meets the minimum criteria of 67.45 pieces of M+L wood per mile. Less than 50% of the wood is within jams, half of which were constructed. Most of the wood (63%) in Reach 12 was in a constructed alcove. Without restoration efforts there would be 83 M+L pieces/mile in Reach 12 (an Adequate condition). The potential sources for short and long-term woody debris recruitment are limited, as determined by riparian condition ratings, and as restoration projects age the LWM conditions could degrade.	At Risk* M+L pieces/mi = 264 Percent in Jams = 83% Meets the minimum criteria of 67.45 pieces of M+L wood per mile. Most (>50%) of the wood is within jams and most of those jams are constructed. Without constructed jams there would be 65 M+L pieces per mile (an Unacceptable condition). The potential sources for short and long-term woody debris recruitment are limited, as determined by riparian condition ratings, and as restoration projects age the LWM conditions could degrade.

* Without restoration efforts, this reach would be in Unacceptable condition of LWM.

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 Quality	Pools	Pool Frequency and Quality; Presence of large pools.	Unacceptable Total Pools = 10 Pools/mi = 9 Pools ≥ 3 ft = 5 (50%) Avg residual pool depth: 3.3 ft Cover: low Does not meet the pool frequency criteria for bankfull width (average BFW = 78, requires 18 pools/mile). Half of the pools are large but cover, from LWM and riparian vegetation, is lacking.	Unacceptable Total Pools = 4 Pools/mi = 10 Pools ≥ 3 ft = 1 (25%) Avg residual pool depth: 2.7 ft Cover: low Does not meet the pool frequency criteria for bankfull width (average BFW = 94, requires 18 pools/mile). Only a quarter of the pools are large, and cover, from LWM and riparian vegetation, is lacking.	At Risk Total Pools = 15 Pools/mi = 15 Pools ≥ 3 ft = 13 (87%) Avg residual pool depth: 4.4 ft Cover: moderate Almost meets the pool frequency criteria for bankfull width (average BFW = 75, requires 23 pools/mile), however, this reach is not lacking in pool habitat (79% by area), but rather in the heterogeneity of habitat units. Most of the pools are large and cover, from LWM and riparian vegetation is relatively available.	At-Risk Total Pools = 22 Pools/mi = 11 Pools ≥ 3 ft = 5 (23%) Avg residual pool depth: 2.6 ft Cover: moderate Does not meet the pool frequency criteria for bankfull width (average BFW = 81, requires 18 pools/mile). Less than half of the pools are large, but with LWM and cover relatively available.	Unacceptable Total Pools = 2 Pools/mi = 7 Pools ≥ 3 ft = 0 (0%) Avg residual pool depth: 1.9 ft Cover: low Does not meet the pool frequency criteria for bankfull width (average BFW = 82, requires 18 pools/mile). None of the pools are large and cover, from LWM and riparian vegetation, is lacking.	Unacceptable Total Pools = 7 Pools/mi = 5 Pools ≥ 3 ft = 4 (50%) Avg residual pool depth: 2.7 ft Cover: low Does not meet the pool frequency criteria for bankfull width (average BFW = 78, requires 18 pools/mile). Half of the pools are large, but cover, from LWM and riparian vegetation, is lacking.	Unacceptable Total Pools = 6 Pools/mi = 5 Pools ≥ 3 ft = 1 (17%) Avg residual pool depth: 2.4 ft Cover: moderate Does not meet the pool frequency criteria for bankfull width (average BFW = 79, requires 18 pools/mile). Less than half of the pools are large, but with LWM and cover relatively available.	Unacceptable Total Pools = 7 Pools/mi = 6 Pools ≥ 3 ft = 6 (86%) Avg residual pool depth: 3.6 ft Cover: low Does not meet the pool frequency criteria for bankfull width (average BFW = 74, requires 23 pools/mile). Most of the pools are large, but cover, from LWM and riparian vegetation, is lacking.	Unacceptable Total Pools = 3 Pools/mi = 5 Pools ≥ 3 ft = 1 (33%) Avg residual pool depth: 2.6 ft Cover: low Does not meet the pool frequency criteria for bankfull width (average BFW = 85, requires 18 pools/mile). Less than half of the pools are large and cover, from LWM and riparian vegetation, is lacking.	At Risk Total Pools = 13 Pools/mi = 12 Pools ≥ 3 ft = 7 (54%) Avg residual pool depth: 3.9 ft Cover: low Does not meet the pool frequency criteria for bankfull width (average BFW = 67, requires 23 pools/mile), however, this reach is not lacking in pool habitat (69% by area), but rather in the heterogeneity of habitat units. Most of the pools are large, but cover, from LWM and riparian vegetation, is lacking.	At Risk Total Pools = 11 Pools/mi = 11 Pools ≥ 3 ft = 6 (55%) Avg residual pool depth: 3.5 ft Cover: moderate Does not meet the pool frequency criteria for bankfull width (average BFW = 68, requires 23 pools/mile), however, this reach is not lacking in pool habitat (79% by area), but rather in the heterogeneity of habitat units. Most of the pools are large and cover, from LWM and riparian vegetation is relatively available.	At Risk Total Pools = 18 Pools/mi = 13 Pools ≥ 3 ft = 13 (72%) Avg residual pool depth: 3.6 ft Cover: high Almost meets the pool frequency criteria for bankfull width (average BFW = 87, requires 18 pools/mile), however, this reach is not lacking in pool habitat (69% by area), but rather in the heterogeneity of habitat units. Most of the pools are large, and cover is relatively high with LWM and riparian vegetation offer high quality pool availability.	At Risk Total Pools = 7 Pools/mi = 7 Pools ≥ 3 ft = 4 (57%) Avg residual pool depth: 3.0 ft Cover: moderate Does not meet the pool frequency criteria for bankfull width (average BFW = 73, requires 23 pools/mile). Most of the pools are large, and cover from LWM and riparian vegetation is relatively available.

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 Quality	Off-Channel Habitat and Refugia	Connect-ivity with Main Channel	Unacceptable Total SC = 0 Fast water = 0 Slow water = 0 Constructed off-channel features: 0 No perennial off-channel habitat exists. Floodplains are not regularly inundated, and infrastructure from State Route 207, the Cedar Brae road bridge, and Nason Creek campground limits the amount of off channel habitat available, as determined by field observations, aerial imagery, and hydraulic modeling.	Unacceptable Total SC = 0 Fast water = 0 Slow water = 0 Constructed off-channel features: 0 No perennial off-channel habitat exists. Floodplains are not regularly inundated. This reach is naturally geo-morphically confined, but infrastructure from State Route 207 and Kahler Glen golf course limits the amount of off-channel habitat available, as determined by field observations, aerial imagery, and hydraulic modeling.	At Risk Total SC = 2 Fast water = 0 Slow water = 2 Constructed off-channel features: 1 Connected off-channel habitat is present, but infrequent. Floodplains are well connected at the 2-5 year flood events, and improved slightly by constructed restoration projects, but remain constricted by State Route 207 and Kahler Glen golf course, as determined by field observations, aerial imagery, and hydraulic modeling.	At Risk Total SC = 10 Fast water = 0 Slow water = 10 Constructed off-channel features: 0 Off-channel habitat that is connected at a variety of flows exists within the reach. Floodplains are well connected at the 2-5 year flood events, but off-channel habitat is limited by State Route 207 and residential development, as determined by field observations, aerial imagery, and hydraulic modeling.	Unacceptable Total SC = 0 Fast water = 0 Slow water = 0 Constructed off-channel features: 0 No perennial off-channel habitat exists within the reach. However, a large side channel flows from Reach 6 to Reach 4 along the river left side of Reach 5. Floodplains are well connected at the 2-5 year flood events, but off-channel habitat is limited by State Route 207 and HWY 2, as determined by field observations, aerial imagery, and hydraulic modeling.	At Risk Total SC = 2 Fast water = 0 Slow water = 2 Constructed off-channel features: 0 Connected off-channel habitat is present, but infrequent. Floodplains are inundated at the 2–5-year flood events, but off-channel habitat is limited by HWY 2, as determined by field observations, aerial imagery, and hydraulic modeling.	At Risk Total SC = 3 Fast water = 3 Slow water = 0 Constructed off-channel features: 1 Connected off-channel habitat is present, but infrequent. Floodplains are not regularly inundated, however, conditions are improved slightly by constructed restoration projects, but infrastructure from HWY has limited the amount of off-channel habitat, as determined by field observations, aerial imagery, and hydraulic modeling.	At Risk Total SC = 2 Fast water = 1 Slow water = 1 Constructed off-channel features: 1 Connected off-channel habitat is present, but infrequent. Floodplains are inundated at the 2–5-year flood events, and improved slightly by constructed restoration projects, but off-channel habitat is limited by residential development and road infrastructure throughout the reach, as determined by field observations, aerial imagery, and hydraulic modeling.	At Risk Total SC = 1 Fast water = 0 Slow water = 1 Constructed off-channel features: 0 Connected off-channel habitat is present, but infrequent. Floodplains are not regularly inundated. This reach is naturally geo-morphically confined, but infrastructure from roads and bridges, has limited the amount of off-channel habitat available, as determined by field observations, aerial imagery, and hydraulic modeling.	Unacceptable Total SC = 1 Fast water = 0 Slow water = 1 Constructed off-channel features: 0 Connected off-channel habitat is present, but infrequent. Floodplains are inundated at the 2–5-year flood events, but off-channel habitat is limited by the BNSF railroad, HWY 2, and residential development, as determined by field observations, aerial imagery, and hydraulic modeling.	Unacceptable Total SC = 2 Fast water = 0 Slow water = 2 Constructed off-channel features: 2 Connected off-channel habitat is present, but infrequent. Floodplains are inundated at the 2–5-year flood events, but off-channel habitat is limited by the BNSF railroad and residential development, as determined by field observations, aerial imagery, and hydraulic modeling.	At Risk Total SC = 1 Fast water = 0 Slow water = 1 Constructed off-channel features: 1 Connected off-channel habitat is present, but infrequent. Floodplains are inundated at the 2–5-year flood events and improved slightly by constructed restoration projects but remain constricted by the BNSF railroad, HWY 2, and residential development, as determined by field observations, aerial imagery, and hydraulic modeling.	At Risk Total SC = 3 Fast water = 1 Slow water = 2 Constructed off-channel features: 2 Connected off-channel habitat is present, but infrequent. Floodplains are inundated at the 2–5-year flood events (especially at the downstream end of the reach) and improved slightly by constructed restoration projects. However, off-channel habitat is limited by the BNSF railroad, as determined by field observations, aerial imagery, and hydraulic modeling.

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
Riparian Vegetation	Condition	Structure	At Risk The riparian canopy overstory composition within the 100-foot riparian buffer was recorded as 75% large trees and 25% small trees. Reach has extensive visual evidence of human disturbance that has reduced the width of the riparian buffer and impacted stand age and structural complexity in many areas of this reach as determined by field estimates, tree height data, and aerial photographs.	At Risk The riparian canopy overstory composition within the 100-foot riparian buffer was recorded as 100% large trees. Reach has extensive visual evidence of human disturbance that has reduced the width of the riparian buffer and impacted stand age and structural complexity in many areas of this reach as determined by field estimates, tree height data, or aerial photographs. Though percentage of large trees is in Adequate condition, the high level of disturbance in this reach puts the riparian structure in an At-Risk condition.	At Risk The riparian canopy overstory composition within the 100-foot riparian buffer was recorded as 60% large trees, 20% small trees, and 20% shrub/ seedling. Reach has minimal visual evidence of human disturbance that has reduced the width of the riparian buffer and impacted stand age and structural complexity in many areas of this reach as determined by field estimates, tree height data, or aerial photographs.	At Risk The riparian canopy overstory composition within the 100-foot riparian buffer was recorded as 83% large trees and 17% small trees. Reach has visual evidence of human disturbance that has reduced the width of the riparian buffer and impacted stand age and structural complexity in many areas of this reach, as determined by field estimates, tree height data, or aerial photographs. Though percentage of large trees is in Adequate condition, the high level of disturbance in this reach puts the riparian structure in an At-Risk condition.	At Risk The riparian canopy overstory composition within the 100-foot riparian buffer was recorded as 100% large trees. Reach has visual evidence of human disturbance that has reduced the width of the riparian buffer and impacted stand age and structural complexity in many areas of this reach, as determined by field estimates, tree height data, or aerial photographs. Though percentage of large trees is in Adequate condition, the high level of disturbance in this reach puts the riparian structure in an At-Risk condition.	Unacceptable The riparian canopy overstory composition within the 100-foot riparian buffer was recorded as 58% large trees, 25% small trees, and 17% grassland/forb. Reach has visual evidence of human disturbance that has reduced the width of the riparian buffer and impacted stand age and structural complexity in many areas of this reach, as determined by field estimates, tree height data, or aerial photographs. Though percentage of large trees is in At-Risk condition, the high level of disturbance in this reach puts the riparian structure in an Unacceptable condition.	At Risk The riparian canopy overstory composition within the 100-foot riparian buffer was recorded as 80% large trees, 10% small trees, and 10% grassland/forb. Reach has extensive visual evidence of human disturbance that has reduced the width of the riparian buffer and impacted stand age and structural complexity in many areas of this reach as determined by field estimates, tree height data, or aerial photographs.	At Risk The riparian canopy overstory composition within the 100-foot riparian buffer was recorded as 100% large trees. Reach has visual evidence of human disturbance that has reduced the width of the riparian buffer and impacted stand age and structural complexity in many areas of this reach, as determined by field estimates, tree height data, or aerial photographs. Though percentage of large trees is in Adequate condition, the high level of disturbance in this reach puts the riparian structure in an At-Risk condition.	At Risk The riparian canopy overstory composition within the 100-foot riparian buffer was recorded as 100% large trees. Reach has visual evidence of human disturbance that has reduced the width of the riparian buffer and impacted stand age and structural complexity in many areas of this reach, as determined by field estimates, tree height data, or aerial photographs. Though percentage of large trees is in Adequate condition, the high level of disturbance in this reach puts the riparian structure in an At-Risk condition.	Unacceptable The riparian canopy overstory composition within the 100-foot riparian buffer was recorded as 50% large tree, 25% grassland/forb, and 25% no vegetation. Reach has visual evidence of human disturbance that has reduced the width of the riparian buffer and impacted stand age and structural complexity in many areas of this reach, as determined by field estimates, tree height data, or aerial photographs. Though percentage of large trees is in At-Risk condition, the high level of disturbance in this reach puts the riparian structure in an Unacceptable condition.	Unacceptable The riparian canopy overstory composition within the 100-foot riparian buffer was recorded as 67% large trees and 33% small trees. Reach has extensive visual evidence of human disturbance that has reduced the width of the riparian buffer and impacted stand age and structural complexity in many areas of this reach, as determined by field estimates, tree height data, or aerial photographs. Though percentage of large trees is in At-Risk condition, the high level of disturbance in this reach puts the riparian structure in an Unacceptable condition.	At Risk The riparian canopy overstory composition within the 100-foot riparian buffer was recorded as 86% large trees and 14% small trees. Reach has visual evidence of human disturbance that has reduced the width of the riparian buffer and impacted stand age and structural complexity in many areas of this reach, as determined by field estimates, tree height data, or aerial photographs. Though percentage of large trees is in Adequate condition, the high level of disturbance in this reach puts the riparian structure in an At-Risk condition.	Unacceptable The riparian canopy overstory composition within the 100-foot riparian buffer was recorded as 60% large tree, 20% small tree, and 20% no vegetation. Reach has extensive visual evidence of human disturbance that has reduced the width of the riparian buffer and impacted stand age and structural complexity in many areas of this reach, as determined by field estimates, tree height data, or aerial photographs. Though percentage of large trees is in At-Risk condition, the high level of disturbance in this reach puts the riparian structure in an 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
Riparian Vegetation	Condition	Dist-urbance (Human)	Unacceptable	Unacceptable	Adequate	At Risk	At Risk	At Risk	Unacceptable	At Risk	At Risk	At Risk	Unacceptable	At Risk	Unacceptable
			22% disturbance in the 200-foot buffer zone and 15.1 miles/miles^2 road density in the 200-foot riparian buffer zone.	46% disturbance in the 200-foot buffer zone and 15.4 miles/miles^2 road density in the 200-foot riparian buffer zone.	4% disturbance in the 200-foot buffer zone and 0.0 miles/miles^2 road density in the 200-foot riparian buffer zone.	10% disturbance in the 200-foot buffer zone and 4.4 miles/miles^2 road density in the 200-foot riparian buffer zone.	7% disturbance in the 200-foot buffer zone and 4.6 miles/miles^2 road density in the 200-foot riparian buffer zone.	19% disturbance in the 200-foot buffer zone and 8.2 miles/miles^2 road density in the 200-foot riparian buffer zone.	24% disturbance in the 200-foot buffer zone and 8.7 miles/miles^2 road density in the 200-foot riparian buffer zone.	18% disturbance in the 200-foot buffer zone and 9.3 miles/miles^2 road density in the 200-foot riparian buffer zone.	7% disturbance in the 200-foot buffer zone and 8.0 miles/miles^2 road density in the 200-foot riparian buffer zone.	35% disturbance in the 200-foot buffer zone and 2.0 miles/miles^2 road density in the 200-foot riparian buffer zone.	29% disturbance in the 200-foot buffer zone and 5.7 miles/miles^2 road density in the 200-foot riparian buffer zone.	18% disturbance in the 200-foot buffer zone and 7.9 miles/miles^2 road density in the 200-foot riparian buffer zone.	32% disturbance in the 200-foot buffer zone and 5.3 miles/miles^2 road density in the 200-foot riparian buffer zone.

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
Riparian Vegetation	Condition	Canopy Cover	At Risk	Adequate	At Risk	At Risk	At Risk	At Risk	At Risk	Adequate	At Risk	Unacceptable	Unacceptable	At Risk	At Risk
			Reach average of 6.8 hours shaded during daylight hours on the summer solstice, determined from the weighted average of raster data from the shademap tool for each reach. A moderate number of tall trees are present within the riparian buffer.	Reach average of 8.9 hours shaded during daylight hours on the summer solstice, determined from the weighted average of raster data from the shademap tool for each reach. Tall trees are widely present within the riparian buffer. Though this reach meets the criteria for Adequate conditions for canopy cover, the riparian conditions in this reach are far from natural conditions due to the high level of disturbance in the riparian from the Kahler Glen golf course on river left and State Route 207 on river right.	Reach average of 6.6 hours shaded during daylight hours on the summer solstice, determined from the weighted average of raster data from the shademap tool for each reach. A moderate number of tall trees are present within the riparian buffer.	Reach average of 9.1 hours shaded during daylight hours on the summer solstice, determined from the weighted average of raster data from the shademap tool for each reach. A moderate number of tall trees are present within the riparian buffer. Though the reach receives ample amounts of shade, the lack of tall trees within 100-feet of the channel puts this reach in an At-Risk condition.	Reach average of 7.9 hours shaded during daylight hours on the summer solstice, determined from the weighted average of raster data from the shademap tool for each reach. Tall trees are widely present within the riparian buffer. Though tall trees are widely present within the 100-foot riparian buffer, the lack of shade the reach receives puts this reach in an At-Risk condition.	Reach average of 7.0 hours shaded during daylight hours on the summer solstice, determined from the weighted average of raster data from the shademap tool for each reach. Few tall trees are present within the riparian buffer.	Reach average of 7.9 hours shaded during daylight hours on the summer solstice, determined from the weighted average of raster data from the shademap tool for each reach. A moderate number of tall trees are present within the riparian buffer.	Reach average of 9.0 hours shaded during daylight hours on the summer solstice, determined from the weighted average of raster data from the shademap tool for each reach. Tall trees are widely present within the riparian buffer.	Reach average of 6.6 hours shaded during daylight hours on the summer solstice, determined from the weighted average of raster data from the shademap tool for each reach. Tall trees are widely present within the riparian buffer. Though tall trees are widely present within the 100-foot riparian buffer, the lack of shade the reach receives puts this reach in an At-Risk condition.	Reach average of 5.0 hours shaded during daylight hours on the summer solstice, determined from the weighted average of raster data from the shademap tool for each reach. Few tall trees are present within the riparian buffer.	Reach average of 6.4 hours shaded during daylight hours on the summer solstice, determined from the weighted average of raster data from the shademap tool for each reach. Few tall trees are present within the riparian buffer.	Reach average of 8.6 hours shaded during daylight hours on the summer solstice, determined from the weighted average of raster data from the shademap tool for each reach. A moderate number of tall trees are present within the riparian buffer.	Reach average of 10.2 hours shaded during daylight hours on the summer solstice, determined from the weighted average of raster data from the shademap tool for each reach. Few tall trees are present within the riparian buffer. Though the reach receives ample amounts of shade, the lack of tall trees within 100-feet of the channel puts this reach in an At-Risk 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
			Unacceptable	At Risk	At Risk	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	At Risk	Unacceptable	Unacceptable	Unacceptable	Unacceptable
Channel	Dynamics	Flood-plain Connec-tivity	Nearly the entire reach length has channel and floodplain areas that have been cut off due to State Route 207 or are otherwise impacted by the Cedar Brae Road bridge and fill or by the Nason Creek Campground fill. Floodplain wetlands, vegetation, and off-channel areas have been significantly impacted by the roadway encroachments, clearing from the campground, and other infrastructure in the confluence area.	State Route 207 cuts off about one-third of the historical channel alignment at the downstream end. The reach is otherwise naturally confined.	Reach 3 has mostly intact floodplain connections, with nearly full inundation of the valley occurring at the 100-year flood event. An At Risk rating is given due to riparian clearing, localized areas of fill, and residential uses within the floodplain that affect floodplain wetlands, vegetation, and off-channel availability and quality.	Significant portions of the main channel (~one-half the total channel length) and floodplain have been disconnected due to State Route 207. This fill and associated armoring have significantly reduced floodplain connections. Floodplain wetlands, vegetation, and off-channel areas have been significantly impacted by the highway encroachments, clearing from the powerline corridor, and some residential developments.	Significant portions of the main channel (~one-third the total channel length) and floodplain have been disconnected due to the highway and development/fill around Coles Corner. This has significantly reduced floodplain connections and has contributed to incision. Floodplain wetlands, vegetation, and off-channel areas have been significantly impacted by the highway encroachments and Coles Corner area land uses.	Significant portions of the main channel (~one-quarter the total channel length) and floodplain have been disconnected due to the highway. This and associated armoring have significantly reduced floodplain connections and has contributed to incision. Floodplain wetlands, vegetation, and off-channel areas have been significantly impacted by the highway encroachments and clearing from the powerline corridor.	Significant portions of the main channel (~half the total channel length) and floodplain have been disconnected due to the highway. This and associated armoring have significantly reduced floodplain connections and has contributed to incision. Floodplain wetlands, vegetation, and off-channel areas have been significantly impacted by the highway encroachments and clearing from the powerline corridor.	The Butcher Creek Road bridge and associated approach fills confine the channel and impact floodplain connectivity. This constriction, along with some areas of bank armoring and fill for residential, has likely contributed to channel incision. The 100-year flood inundation is widespread but assumed less than historical. Floodplain wetlands, vegetation, and off-channel areas have been significantly impacted by development along the reach.	Reach 9 is mostly naturally confined between landslide and glacial terrace deposits. At the upstream end, there have been some constraints on floodplain connectivity due to the highway crossing and other fill in the area.	Nason Creek through Reach 10 was relocated to the northeast with the construction of the railroad in the late 1800s. Of the ~1.0 mile valley length, ~0.7 miles lies directly adjacent to the railroad, with a significant portion of the floodplain cut off from the channel. The channel is incised. Although the 100-year flood backwaters into the old channel alignment across the railroad as a result of past restoration actions, the natural processes of lateral connectivity are largely severed.	Nason Creek through Reach 11 was relocated to the northeast with the construction of the railroad in the late 1800s. Of the 0.9 mile valley length, 0.6 miles lies directly adjacent to the railroad. The channel is incised. The 100-year flood currently occupies only a portion (less than a third) of the valley bottom, whereas historically it would likely have completely, or nearly completely, inundated the valley bottom.	The channel is straightened and confined along the highway and likely at Merritt, which is assumed to be built at least partially on fill. This results in greater than 40% of the valley length with the channel confined along the highway. The channel is incised. The 100-year flood currently occupies only a portion (roughly half) of the valley bottom, whereas historically it would likely have completely inundated the valley bottom.	Approximately 3,500 feet of the mainstem channel was relocated associated with railroad re-alignment in the late 1950s/early 1960s, creating essentially a ditched channel and severing nearly all floodplain connections. Restoration completed in 2018 reconnected significant portions of the floodplain, but the reach is still highly incised and disconnected overall compared to historical conditions.

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
Channel	Dynamics	Bank Stability/ Channel Migration	Unacceptable	At Risk	At Risk	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	At Risk	Unacceptable	Unacceptable	Unacceptable	Unacceptable
			Nearly the entire reach length has channel and channel migration areas that have been cut off due to State Route 207 fill and associated armoring, the Cedar Brae Road bridge confinement, and by the Nason Creek Campground fill and armoring.	State Route 207 cuts off about one-third of the historical channel alignment at the downstream end. The reach is otherwise naturally confined.	Reach 3 has mostly intact channel migration rates, with some increase in rates in several areas due to cleared or young riparian conditions.	Significant portions of the main channel (~one-half the total channel length) and floodplain have been disconnected due to State Route 207. This fill and associated armoring have significantly reduced channel migration. Approximately 30% of the historical channel migration zone has been severed by the highway, with significant impacts to channel planform and adjustment processes.	Significant portions of the main channel (~one-third the total channel length) and floodplain have been disconnected due to the highway and development/fill around Coles Corner. This has significantly impacted channel migration rates and natural planform patterns and adjustments.	Significant portions of the main channel (~one-quarter the total channel length) and floodplain have been disconnected due to the highway. The associated fill and armoring have significantly reduced channel migration rates and riparian recruitment potential. Channel migration rates are either lower due to armoring or higher due to lack of mature vegetation (especially within powerline corridor) and higher stream energy due to reduced sinuosity.	Significant portions of the main channel (~half the total channel length) and floodplain have been disconnected due to the highway. This and associated armoring have significantly reduced channel migration potential. Channel migration rates are either lower due to armoring or higher due to lack of mature vegetation (especially within powerline corridor) and higher stream energy due to reduced sinuosity.	The Butcher Creek Road crossing, a section of riprap between RM 7.6 and 7.7, and floodplain fill associated with residential development have reduced channel migration rates. Channel migration access to the large interior floodplain area river-right RM 7.6 – 8 has largely been cut off due to the bridge, powerlines, fill, armoring, and residential development, with significant impacts to long-term channel planform adjustment processes and potential.	Reach 9 is mostly naturally confined between landslide and glacial terrace deposits. At the upstream end, there have been some constraints on channel migration due to the Highway 2 crossing and due to remaining bridge abutments from the now removed Nason Ridge Road crossing.	Nason Creek through Reach 10 was relocated to the northeast with the construction of the railroad in the late 1800s. Of the ~1.0 mile valley length, ~0.7 miles lies directly adjacent to the railroad and armored with riprap. Channel migration rates are either lower due to armoring or higher due to lack of mature vegetation (especially within powerline corridor) and higher stream energy due to reduced sinuosity.	Nason Creek through Reach 11 was relocated to the northeast with the construction of the railroad in the late 1800s. Of the 0.9 mile valley length, 0.6 miles lies directly adjacent to the railroad and is armored with riprap. Channel migration rates are either lower due to armoring or higher due to lack of mature vegetation and higher stream energy due to reduced sinuosity.	The channel is straightened and confined along the highway and likely at Merritt, which is assumed to be built at least partially on fill. This results in greater than 40% of the valley length with the channel confined along the highway. The channel is incised and armored along much of the reach. Channel migration rates are either lower due to armoring or higher due to lack of mature vegetation and higher stream energy due to reduced sinuosity.	Approximately 3,500 feet of the mainstem channel was relocated associated with railroad re-alignment in the late 1950s/early 1960s, creating essentially a ditched channel, with the majority of the bank length on both sides still armored with riprap despite past restoration efforts that have removed levees and riprap in a large portion of the reach.

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
Channel	Dynamics	Vertical Channel Stability	At Risk	At Risk	Adequate	Unacceptable	Unacceptable	Unacceptable	Unacceptable	At Risk	At Risk	Unacceptable	Unacceptable	Unacceptable	Unacceptable
			The entire reach has been heavily impacted by channel confinement features that would be expected to impact vertical stability, but lidar elevations of the disconnected channel segments across the highway suggest relatively little incision of the channel has occurred, potentially due to base level control from the Wenatchee River downstream.	State Route 207 cuts off about one-third of the historical channel alignment at the downstream end, contributing to incision. Elevations from lidar of the disconnected channel segment across the highway suggests 1-3 feet of incision may have occurred.	No measurable trend of human-caused aggradation or incision.	Significant portions of the main channel (~one-half the total channel length) and floodplain have been disconnected due to State Route 207. This fill and associated armoring have contributed to incision. Elevations from lidar of disconnected channel segments across highway suggest 1-3 feet of incision may have occurred.	Significant portions of the main channel (~one-third the total channel length) and floodplain have been disconnected due to the highway and development/ fill around Coles Corner. This has significantly reduced floodplain connections and has contributed to incision. Elevations from lidar of disconnected channel segments across highway suggest several feet of incision may have occurred.	Significant portions of the main channel (~one-quarter the total channel length) and floodplain have been disconnected due to the highway. This and associated armoring have significantly reduced floodplain connections and has contributed to incision. Elevations from lidar of disconnected channel segments across highway suggest several feet of incision may have occurred.	Significant portions of the main channel (~half the total channel length) and floodplain have been disconnected due to the highway. This and associated armoring have significantly reduced floodplain connections and has contributed to incision. Elevations from lidar of disconnected channel segments across highway suggest several feet of incision may have occurred.	The Butcher Creek Road crossing, a section of riprap between RM 7.6 and 7.7, and floodplain fill associated with residential development have contributed to incision, with associated floodplain and off-channel disconnections .	Reach 9 is mostly naturally confined between landslide and glacial terrace deposits. At the upstream end, artificial confinement has likely resulted in some base level lowering of the channel.	Nason Creek through Reach 10 was relocated to the northeast with the construction of the railroad in the late 1800s. Of the ~1.0 mile valley length, ~0.7 miles lies directly adjacent to the railroad. The channel is incised with associated floodplain and off-channel disconnections .	Nason Creek through Reach 11 was relocated to the northeast with the construction of the railroad in the late 1800s. Of the 0.9 mile valley length, 0.6 miles lies directly adjacent to the railroad. The channel is incised with associated floodplain and off-channel disconnections .	The channel is straightened and confined along the highway and likely at Merritt, which is assumed to be built at least partially on fill. This results in greater than 40% of the valley length with the channel confined along the highway. The channel is incised with associated floodplain and off-channel disconnections .	Approximately 3,500 feet of the mainstem channel was relocated associated with railroad re-alignment in the late 1950s/early 1960s, creating essentially a ditched and artificially incised channel.

4 References & Sources

Andonaegui, C. (2001). Salmon, Steelhead, and Bull Trout Habitat Limiting Factors for the Wenatchee Subbasin (Water Resource Inventory Area 45) and Portions of WRIA 40 within Chelan County (Squilchuck, Stemilt and Colockum drainages).

Fox, M. and Bolton, S. (2007). A Regional and Geomorphic Reference for Quantities and Volumes of Instream Wood in Unmanaged Forested Basins of Washington State. North American Journal of Fisheries Management, 27(1), 342–359.

Mote, P. W. and Salathé, E. P. (2010). Future climate in the Pacific Northwest. In D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor, & H. L. Miller (Eds.), Climatic Change: The physical science basis, Vol. 102, Issues 1–2, pp. 29–50). Cambridge University Press.

NMFS (National Marine Fisheries Service). 1996. Making Endangered Species Act Determinations of Effect for Individual or Grouped Actions at the Watershed Scale. NMFS - Environmental and Technical Services Division Habitat Conservation Branch.

USBR (US Bureau of Reclamation). (2008). Nason Creek Tributary Assessment. US Bureau of Reclamation, Technical Service Center, Denver, CO & PNW Regional Office, Boise, ID. Authors: J. Bountry, L. Piety, R. McAffee, E. Lyon, C. Raekes, D. Sutley, K. Willie, T. Maguire, D. Bennett, D. Sisneros, J. Boutwell, and D. Callahan.

USBR (US Bureau of Reclamation). (2009a). Kahler Reach Assessment.

USBR (US Bureau of Reclamation). (2009b). Lower White Pine Reach Assessment.

USBR (US Bureau of Reclamation). (2009c). Upper White Pine Reach Assessment.

USBR (US Bureau of Reclamation). (2011). Lower Nason, Assessment of Geomorphic and Ecologic Indicators, Nason Creek, Wenatchee Subbasin.

USFS (US Forest Service). (2020). Stream Inventory Handbook: Level I and Level II. Version 2.20. Pacific Northwest Region. United States Department of Agriculture, United States Forest Service.

USFWS (US Fish and Wildlife Service). (1998). Matrix of Physical/Environmental Pathways and Indicators for East-Side Streams.

USGS (US Geological Survey). (2024). Annual NLCD Collection 1 Science Products (ver. 1.1, June 2025). U.S. Geological Survey, 2025, 1–4.

WADNR GIS Open Data. (2025). WADNR Active Roads. https://data-wadnr.opendata.arcgis.com/datasets/bfdb0455c3b24aa6ae46c9502f814c25_5/explore?location=47.056789%2C-120.749700%2C7.81

WDOE (WA State Dept of Ecology). (2016, December 16). National Watershed Boundary Dataset (WBD): Hydrologic Unit Code 10-Digit Basins of Washington State | Washington State Geospatial Open Data Portal. https://geo.wa.gov/datasets/waecy::national-watershed-boundary-dataset-wbd-hydrologic-unit-code-10-digit-basins-of-washington-state/about

WSDOT (WA State Dept of Transportation). 2025. Shared/Rail (MapServer). (n.d.). Retrieved October 24, 2025, from https://data.wsdot.wa.gov/arcgis/rest/services/Shared/Rail/MapServer

DRAFT Appendix C| Restoration Strategy

NASON CREEK REACH ASSESSMENT UPDATE

January 2026

Table of Contents

1 Restoration Strategy 1

1.1 Introduction 1
1.2 Restoration Objectives 1
1.3 Action Types 1
1.4 Segment-Scale Restoration Strategies 4
1.4.1 Segment 1: Lower Lower Nason (Reaches 1 – 2) Restoration Strategy 6
1.4.2 Segment 2: Upper Lower Nason (Reaches 3 - 4) Restoration Strategy 7
1.4.3 Segment 3: Lower Kahler Segment (Reaches 5 – 6) Restoration Strategy 8
1.4.4 Segment 4: Upper Kahler Segment (Reaches 7 - 9) Restoration Strategy 9
1.4.5 Segment 5: Lower White Pine Segment (Reaches 10 - 11) Restoration Strategy 10
1.4.6 Segment 6: Upper White Pine Segment (Reaches 12 - 13) Restoration Strategy 11

2 Project Opportunities 12

2.1 Project Identification and Evaluation Approach 12
2.2 Project Opportunities Overview 12
2.3 Project Descriptions 15
2.4 Project Opportunity Reach Maps 20

3 Project Prioritization and Ranking 32

3.1 Prioritization Matrix (ranked by Total Benefit score) 32
3.2 Project Ranking Methods 34

1 Restoration Strategy

1.1 INTRODUCTION

The Restoration Strategy uses field surveys, inventories, and analyses performed in the reach assessment and accompanying appendices (Appendix A: Habitat Assessment, Appendix B: Reach-based Ecosystem Indicators, and Appendix D: Hydraulic Modeling), as the technical basis for identifying and prioritizing restoration actions. The framework for developing a restoration strategy provides a direct linkage between the technical analyses, identified limiting factors, and the actions that are moved forward towards implementation. Restoration objectives (targets) are used to guide the development of appropriate restoration action types for the assessment area. The Segment-Scale Restoration Strategies (Section 1.4) present the summarized and compiled information in table format for the six Nason segments. Conceptual maps and descriptions of the project opportunities are presented in Section 1.1.1. Project ranking is provided in Section **Error! Reference source not found.**, and lays out the targets, benefits, and costs scoring involved in prioritizing project opportunities for the restoration strategy.

1.2 RESTORATION OBJECTIVES

Restoration objectives were developed for multiple ecological attributes, including instream habitat, geomorphologic processes, and riparian function. These objectives are presented as restoration targets. They are made to be as quantifiable as possible at this stage of analysis. These target conditions are compared to existing conditions from the reach assessment. This highlights habitat deficiencies and the "gap" that needs to be filled to recover habitat.

Target conditions were developed using the Reach-Based Ecosystem Indicators (REI) targets (see Appendix B) as well as reference to site conditions and inference from local and regional studies. See the reach assessment main report and Appendix B for more information on the REI analysis.

1.3 ACTION TYPES

Recommended actions are categorized here into five action types. There are four restoration action types plus a conservation action. We use the term 'restoration' as a broad catch-all when we refer to actions; however, we acknowledge that many of the actions are not restoration in the true sense of the word and would be more appropriately labeled as "enhancement" or "creation." We consider true restoration actions to be those that address root causes of impairments that aim to return the system close to its naturally functioning state. This is often not achievable, or advisable, due to past changes to the underlying processes or to process impairments that are unlikely to change. An example of a true restoration project would be a project that fully removes a levee, returns the channel to its historical form, and replants the valley floor to restore natural floodplain inundation patterns. Enhancement measures are those that improve or rehabilitate habitat to the extent possible given existing impaired processes and anthropogenic constraints. Placement of large wood in an existing pool to provide cover is an example of habitat enhancement. Creation projects are those that create new habitat that is currently lacking or that will not be created on its own in a reasonable

timeframe given existing impairment. Excavation of a new side-channel where one did not exist already is an example of a creation project. Action types are often combined, and each project typically incorporates numerous action types. The five action types are described below.

1. Riparian Restoration

Riparian restoration projects are recommended in areas where native riparian vegetation communities have been impacted by historical or current anthropogenic activities such that riparian function and connection with the stream are compromised. In the Nason Creek assessment area, large sections of the floodplain vegetation were logged in the past and the forests are still recovering. Near some private property and infrastructure, riparian vegetation has been cleared (or impacted) for homes/buildings, agricultural purposes, utilities, roads and railroads, or crossings. Restoration actions are focused on restoring native riparian vegetation communities to reestablish natural stream stability (including supporting beaver), stream shading, nutrient exchange, ecologic diversity, long-term large wood recruitment, and wildfire resilience. Riparian restoration may also include the development or enhancement of wetlands or riparian function along off-channel features. Even though it is not always explicitly stated, riparian restoration is a recommended component of most restoration actions, particularly within the disturbance limits of the action.

Examples:

- Replanting a riparian buffer area with native vegetation.
- Controlling invasive species within the riparian zone.
- Placing willow or cottonwood baffles on bars to encourage vegetated island development.

2. Enhance Channel Complexity

Channel complexity enhancement actions are aimed at increasing quantity or improving the quality of existing channel habitat and geomorphology. This type of action is designed to improve the geomorphic complexity of the system, which in turn supports instream aquatic habitat conditions and builds system resiliency. Sections of the Nason Creek assessment area lack geomorphic and habitat complexity as a result of historical logging, floodplain grading, channel manipulations/relocations, transportation corridors, utility corridors, and channel clearing practices. Due to the removal of old-growth trees, many of the riparian and floodplain forests lack sufficiently-sized trees to act as "key logs" that are capable of influencing and maintaining channel complexity. Where sufficient large wood jams do occur, geomorphic complexity and habitat function are notably increased. The Enhance Channel Complexity strategy includes a broad range of large wood installation types of varied sizes and purposes. Enhance Channel Complexity is recommended in the mainstem channel, side channels, and off-channel habitat. The recommendations include broad treatment types as well as site-specific actions. The structural elements (e.g., large wood) included in these actions are placed in areas where they would naturally accumulate and be maintained by stream hydrology and geomorphology. These actions can exhibit a wide range of intended function, from helping to restore reach-scale geomorphic processes (e.g., apex jams to create multi-thread

channel conditions) to simply adding structural cover and complexity habitat (e.g., adding large wood to an existing pool).

Examples:

- Log jams to replace removed bank armor to enhance margin complexity and provide interim stability until streambank and riparian revegetation can mature and provide long-term stability.
- Installation of individual large wood pieces or jams for cover, pool scour, sediment sorting, and hydraulic complexity (e.g., high flow refuge for rearing juvenile fish).
- Installation of apex jam to promote scour, sediment retention, and split-flow conditions to support mid-channel bar/island development or side-channel initiation.

3. Side and Off-Channel Habitat Creation or Enhancement

Off-channel habitat creation or enhancement projects are located in areas where there is the potential to increase the quantity, quality, or connectivity of off-channel habitat (i.e. alcoves, side channels, floodplain wetlands). Off-channel habitat features provide important rearing and refugia areas for juvenile salmonids, including high flow refugia, temperature refugia, and highly productive feeding areas. These projects may include the activation of existing habitat areas that have been disconnected via channel incision or floodplain alterations. In other cases, off-channel areas can be created via excavation and construction of features such as side channels or alcoves. Off-Channel Habitat Creation or Enhancement is often paired with Enhance Channel Complexity actions.

Examples:

- Increase the degree of connectivity (i.e., for surface flow and fish passage) of an existing off-channel area such as a floodplain oxbow wetland for juvenile feeding, flood refuge, or thermal refuge.
- Create new connected side-channel or off-channel habitat via excavation.
- Enhance conditions in new or created off-channel habitat.

4. Floodplain and Channel Migration Zone Reconnection

Floodplain and CMZ connectivity actions are those that increase the frequency, duration, or extent of hydrologic connection between the mainstem channel and the floodplain or that re-establish natural channel migration functions. Floodplain and CMZ connectivity projects are located in areas where there is the potential to increase the quantity or quality of floodplain habitats and are typically located in areas where floodplains have been disconnected via channel incision/straightening, channel bypass or diversions, anthropogenic confinement such as undersized bridges or levees, or floodplain modifications that inhibit connectivity such as road prisms or hardened banks. This strategy includes a broad range of potential project types, including floodplain grading to create valley-wide hydraulic connectivity, inset floodplains, or wetlands, as well as removal of constructed levees that in turn reengage existing floodplain surfaces or oxbows. It may

also require grading to reactivate or reconnect abandoned channel sections or flow routes, especially those resulting from anthropogenic manipulations.

Examples:

- Remove or modify levees, bank armor, roads, or bridges to reestablish natural floodplain inundation and channel migration processes.
- Raise or promote aggradation of an incised channel.
- Create multi-threaded channel corridor with valley-wide hydraulic connectivity.

6. Conservation

Conservation actions include such things as land acquisitions, easements, or other measures that provide enduring protection to channels, riparian zones, and floodplains. They are only identified where they would complement and/or increase restoration action potential, or where there is believed to be specific future risk of impairment. Some of the Nason Creek assessment area is already protected by federal lands, including much of the surrounding hillslopes. However, a substantial portion of the valley bottom and existing floodplain within the assessment area is privately-owned. Working with landowners to develop conservation easements within the riparian zones on their parcels, or to conduct riparian revegetation, would also have benefits in many areas. In many areas, the private parcels are relatively small with narrow river-frontage; in these cases, strategic and opportunistic acquisition of several neighboring parcels may be necessary prior to restoration implementation. Conservation measures in these areas would help to prevent development of currently undeveloped parcels and would also help facilitate restoration actions. Because these parcels lie within the floodplain and/or channel migration zone of the river, portions of nearly all of these private lands could be considered targets for conservation. However, existing county-level shorelines, critical areas, and floodplain regulations would apply to many of these parcels and in theory would provide important protections. This assessment does not, however, include any type of land-use analysis such as looking at zoning patterns or the adequacy of local regulations. Due to these uncertainties, conservation actions are not identified broadly for the private lands. Instead, this assessment identifies conservation actions in the following situations: 1) private lands with high restoration value, where long-term protection of the land would complement or increase the opportunity for restoration actions, and 2) where site or other observations indicate there are impending encroachments or development potential, such as land clearing, road building, land subdivision, or undeveloped properties advertised for sale.

1.4 SEGMENT-SCALE RESTORATION STRATEGIES

Restoration strategies for each segment of the assessment area are provided below. The segment-scale restoration strategies identify existing ecologic/geomorphic conditions, project objectives and recovery potential, a list of projects, and recommended restoration action types. The ecological function (Low, Moderate, or High) of each segment is characterized by the ratings that resulted from

the REI (see Appendix B). The trajectory (decline, same, improve) is determined by evaluation of the modern geomorphic trends, related existing habitat conditions, and continued limitations such as infrastructure and land-use (see the main reach assessment report and Appendix A-Habitat Assessment). The recovery potential (Low, Moderate, and High) is based on the potential for the site to recover functioning habitat and processes with implementation of restoration actions. To do so, the potential for the REI indicator ratings to improve via restoration actions is considered. The recovery potential rating considers known limitations to recovery that are unlikely to be eliminated as part of implementation of this restoration strategy, such as the presence of transportation and residential infrastructure that is unlikely to change.

1.4.1 Segment 1: Lower Lower Nason (Reaches 1 – 2) Restoration Strategy

Overall ecological function	**Low**
	Segment 1 (Reaches 1-2) received low-moderate ratings in the REI in terms of habitat access and condition. There were no complete fish passage barriers, however, a lack of in-channel structure has reduced prevalence of spawning gravels. The amount of large woody material (LWM) meets criteria for an adequate ranking, but pool habitat and off-channel habitat are severely lacking throughout the segment. The riparian conditions in Segment 1 ranked low-moderate in the REI. Large trees exist within the 100-foot buffer, however, high levels of disturbance reduce the condition and function of the riparian vegetation. Channel dynamics in Segment 1 ranked low in the REI. Large amounts of floodplain and CMZ have been cut off by State Route 207, bank armoring at the Nason Creek Campground, and other infrastructure, limiting lateral migration and increasing incision. Some natural confinement occurs in the upper portion of this segment.
Trajectory if no action taken	**Maintain-Decline**
	Continued degradation due to persistent anthropogenic impacts on floodplain surfaces and large wood processes, including the effects of channel incision, bank armoring, riparian vegetation clearing, and anthropogenic development. There is private landownership adjacent to the channel and in the floodplain that may increase potential for ecological decline trajectory without intervention.
Recovery potential	**Low**
	Projects address lack of large in-channel structure but have limited impact on recovery of root causes due to large-scale floodplain and CMZ lateral constrictions that are assumed to remain.
Restoration objectives	**Target conditions from REI**
	Target "Adequate" functional rating criteria as described in the Reach-based Ecosystem Indicators (REI), provided in Appendix B.
Action Types	**Riparian Restoration** **Enhance Channel Complexity** **Floodplain and CMZ Connectivity** **Side and Off-Channel Habitat Creation or Enhancement**
	Actions include enhancement of channel complexity via LWM placements, side and off-channel habitat creation or enhancement of existing side channel features, and riparian restoration. Modification of anthropogenic features, such as bank riprap, should be considered wherever possible to improve channel condition, but may be limited due to proximity of the highway and other infrastructure adjacent to the channel. LW placement could also encourage more frequent connectivity of existing natural or constructed side channels to increase accessible off-channel habitat areas in a relatively high fish use corridor. Existing private land uses and infrastructure may limit overall recovery potential, however. Riparian restoration where banks have been cleared can support long-term recovery of LW processes. If needed, projects could be phased or divided into multiple smaller projects.
Project Areas & Prioritization	**Confluence** **Campground**

1.4.2 Segment 2: Upper Lower Nason (Reaches 3 - 4) Restoration Strategy

Overall ecological function	**Low-Moderate**
	Segment 2 (Reach 3-4) had moderate functional ratings in the REI for habitat access and quality. There are no passage barriers but channel segments have been cut off by State Route 207. LWM meets criteria and off-channel habitat is present, although infrastructure limits the amount and connectivity of off-channel areas. Pool habitat is generally lacking, especially in the upstream portion of the segment. Though large trees exist within the 100-foot riparian buffer, high levels of disturbance adjacent to the channel have reduced the condition and function of the riparian vegetation. Channel dynamics in Segment 2 ranked low in the REI. Large amounts of floodplain have been cut off by State Route 207 at the upstream end of the segment (in Reach 4) and residential uses in the segment impact floodplain connectivity. There is localized fill from infrastructure that further impacts floodplain connectivity in this segment. Lateral migration is limited and incision has occurred near State Route 207 at the upstream end (Reach 4). The BPA powerline crossing creates a persistent impact on riparian and floodplain vegetation.
Trajectory if no action taken	**Maintain-Decline**
	Previous restoration has improved habitat and ecological function and planned restoration will provide additional benefits. However, there remain infrastructure constraints, especially in Reach 4, that will continue to have impacts. Continued maturity of riparian and floodplain forests will improve conditions over time. However, there are still many undeveloped areas within private lands that could potentially be developed, which would further impact conditions and limit future potential restoration.
Recovery potential	**Moderate**
	Segment 2 has moderate potential for uplift given past and planned projects and landownership. Currently proposed projects focus on adding large wood in targeted locations where it is absent , encouraging increased connectivity of floodplains and side-channel/off-channel habitat, and partially addressing the floodplain disconnection resulting from Highway 207. 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.
Restoration objectives	**Target conditions from REI**
	Target "Adequate" functional rating criteria as described in the Reach-based Ecosystem Indicators (REI), provided in Appendix B.
Action Types	**Riparian Restoration** **Enhance Channel Complexity** **Floodplain and CMZ Connectivity** **Side and Off-Channel Habitat Creation or Enhancement** **Conservation**
	Actions include enhancement/improvement of channel complexity via large wood placements, the creation or enhancement of side channel habitats, floodplain and CMZ reconnections via road relocation, and riparian revegetation. Revegetation of select open areas in the riparian corridor areas is proposed to continue to improve long-term riparian conditions. The proximity of Highway 207 to the channel in this segment limits uplift potential, unless significant action to remove the highway from the floodplain surface is implemented and full CMZ connectivity is restored. Private lands within the floodplain and riparian zone, most notably midway through the segment in the river-right floodplain, should be considered for conservation measures.
Project Areas & Prioritization	**Miracle Mile** **Nason Ridge**

1.4.3 Segment 3: Lower Kahler Segment (Reaches 5 – 6) Restoration Strategy

Overall ecological function	**Low**
	Segment 3 (Reach 5-6) had generally low ecological function. There are no fish passage barriers in the segment. LWM is lacking in both number of M+L per mile and in geomorphic function. This lack of in-channel structure has reduced the amount of spawning gravels, but where spawning gravels did exist there was a low level of embeddedness of fines observed. The frequency of pool habitat is limited, and the amount of off-channel habitat has been reduced as a result of human infrastructure. The riparian conditions in Segment 3 ranked low-moderate in the REI. There are areas with large trees, however, a large amount of disturbance and riparian clearing (from roads and utility transmission lines) has reduced the riparian condition and function. Channel dynamics are in poor condition and ranked the lowest of any other indicator in this segment. Floodplain connectivity and lateral migration have both been reduced significantly by Highway 2 and other infrastructure/development in the segment. Incision occurs throughout the segment.
Trajectory if no action taken	**Maintain-Decline**
	Though restoration projects for this segment are in planning stages and may improve the habitat conditions and ecological function, continued long-term degradation due to persistent anthropogenic impacts to floodplain and channel, riparian zone, and large wood processes are assumed if no action is taken. There are still undeveloped areas within private lands that could potentially be developed, which would further impact conditions and limit future potential restoration.
Recovery potential	**Moderate**
	Project actions address lack of large in-channel structure and loss of off-channel/floodplain habitat where it would be present but have limited impact on recovery of root causes of riparian condition and the large wood cycle due to persistent anthropogenic impacts in the CMZ. More significant recovery potential is possible if large-scale actions to modify infrastructure are undertaken. 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.
Restoration objectives	**Target conditions from REI**
	Target "Adequate" functional rating criteria as described in the Reach-based Ecosystem Indicators (REI), provided in Appendix B.
Action Types	**Riparian Restoration** **Enhance Channel Complexity** **Floodplain and CMZ Connectivity** **Side and Off-Channel Habitat Creation or Enhancement** **Conservation**
	The potential to improve the quantity and quality of available habitat in Segment 3 is moderate where the channel is not immediately adjacent to Highway 2. Opportunities for side channel enhancement from large wood placement in the main channel occur where low floodplain surfaces are present, including potential for a highly complex network of off-channel areas in the upstream portion of Reach 6. There are conservation priorities in Reach 6.
Project Areas & Prioritization	**Coles** **Kahler**

1.4.4 Segment 4: Upper Kahler Segment (Reaches 7 - 9) Restoration Strategy

Overall ecological function	**Low**
	Ecological function in Segment 4 (Reach 7-9) is overall low. Although there are no fish passage barriers, riprap and a lack of in-channel structure has reduced the amount of spawning gravels available in the segment. LWM quantities are generally lacking, but restoration efforts have improved conditions. Where LWM was observed, it was often concentrated in constructed jams or had little influence on channel dynamics. Off-channel habitat exists but is limited by infrastructure throughout the segment. Riparian conditions in Segment 4 ranked low-moderate in the REI. There are areas with large trees, however, large amounts of disturbance and riparian clearing (from roads and transmission lines) has reduced the riparian condition and function. Channel dynamics in Segment 5 ranked low in the REI. Large amounts of floodplain have been cut off by Highway 2 and other infrastructure in the segment. Although some natural confinement is present in Reach 9, infrastructure in the segment has generally limited lateral migration and increased incision.
Trajectory if no action taken	**Maintain-Decline**
	Although previous restoration efforts have improved habitat conditions and ecological function in the segment, continued long-term degradation due to persistent anthropogenic impacts to floodplain, channel, riparian zone, and large wood processes are assumed if no action is taken. 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.
Recovery potential	**Moderate**
	Project actions address lack of large in-channel structure and loss of off-channel/floodplain habitat where it would be present but have limited impact on recovery of root causes of riparian condition and the large wood cycle due to persistent anthropogenic impacts in the CMZ.
Restoration objectives	**Target conditions from REI**
	Target "Adequate" functional rating criteria as described in the Reach-based Ecosystem Indicators (REI), provided in Appendix B.
Action Types	**Riparian Restoration** **Enhance Channel Complexity** **Floodplain and CMZ Connectivity** **Side and Off-Channel Habitat Creation or Enhancement**
	Although portions of this segment are naturally confined and have limited opportunities, there are several locations where restoration of habitat complexity and quality is possible, particularly in the lower portion of the segment. Specific project actions include enhancement/improvement of channel complexity via large wood placements and creation or enhancement of side channel habitats. Both the Kahler and Rest Stop project areas include potential mainstem realignment opportunities to move the channel away from the highway. Revegetation in some areas would support continued improvement of long-term riparian conditions.
Project Areas & Prioritization	**Kahler** **Rest Stop**

1.4.5 Segment 5: Lower White Pine Segment (Reaches 10 - 11) Restoration Strategy

Overall ecological function	**Low**
	Ecological function in Segment 5 (Reach 10-11) is low. There are no complete fish passage barriers, but a rock weir in Reach 10 has the potential to impede fish passage at lower flows. There are also large portions of former channel where fish access has been cut off or severely limited. Substrate conditions are severely impacted from the railroad in terms of bed composition, scour, and recruitment potential. LWM is lacking, but restoration efforts have improved conditions in some areas. Where LWM was observed, it was mostly concentrated in constructed jams or had little influence on channel dynamics. Off-channel habitat is limited, largely due to the adjacent BNSF railroad. Riparian conditions ranked low in the REI. There are few large trees and high levels of disturbance and clearing. Channel dynamics are poor and ranked the lowest of any other indicator in this segment. Floodplain connectivity and lateral migration have both been reduced significantly by the BNSF railroad and other infrastructure / development in the segment. The entire channel was relocated to the northeast during the construction of the railroad.
Trajectory if no action taken	**Decline**
	Although previous restoration efforts have improved habitat and ecological function, continued long-term degradation is assumed due to persistent impacts to floodplain, channel, riparian zone, and LW processes. There remain undeveloped areas in private lands that could be developed, further impacting conditions and limiting future restoration.
Recovery potential	**Moderate**
	Moderate potential for recovery assuming some, but not all infrastructure changes are made. Assumes utility setback options and localized main channel realignments occur, but that railroad and Highway 2 remain. Conservation of critical existing high-quality floodplain and off-channel areas is an important piece of Segment 5's recovery potential. Landownership is currently 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.
Restoration objectives	**Target conditions from REI**
	Target "Adequate" functional rating criteria as described in the Reach-based Ecosystem Indicators (REI), provided in Appendix B.
Action Types	**Riparian Restoration** **Enhance Channel Complexity** **Side and Off-Channel Habitat Creation or Enhancement** **Floodplain and CMZ Connectivity** **Conservation**
	Actions include enhancement/improvement of channel complexity via large wood placements and creation or enhancement of side channel habitats. Channel reconnections and/or infrastructure modifications associated with the BNSF railroad, Highway 2, and transmission corridors would help to address root causes of impairment and allow greater uplift. Revegetation would support continued improvement of long-term riparian conditions. If needed, projects could be phased or divided into multiple smaller projects. There are multiple land conservation opportunities to prevent further impacts and allow restoration.
Project Areas & Prioritization	**LWP Sunland** **LWP Second Bend** **LWP First Bend**

1.4.6 Segment 6: Upper White Pine Segment (Reaches 12 - 13) Restoration Strategy

Overall ecological function	**Low**
	Ecological function in Segment 6 (Reach 12-13) is overall low. There are no fish passage barriers in the segment. Substrate conditions in the segment are severely impacted from Highway 2 and the railroad in terms of bed composition, scour, and recruitment potential. LWM met the M+L per mile criteria, in part from restoration actions, but was often concentrated in constructed jams, alcoves, or had little influence on channel dynamics. Off-channel habitat is limited or disconnected. The riparian conditions in Segment 6 ranked low in the REI. Large trees exist in the riparian zone, but not at levels they would have historically. This is due to high levels of disturbance and vegetation clearing. Channel dynamics are in poor condition and ranked the lowest of any other indicator in this segment. Floodplain connectivity and lateral migration have both been reduced significantly by the BNSF railroad, Highway 2 and other infrastructure/development in the segment. The channel is incised throughout the segment. Restoration efforts have improved conditions, but channel dynamics are still severely impacted.
Trajectory if no action taken	**Maintain-Decline**
	Although previous restoration efforts have improved habitat conditions and ecological function in the segment, continued long-term degradation due to persistent anthropogenic impacts to floodplain, channel, riparian zone, and large wood processes are assumed if no action is taken. Continued growth of riparian and floodplain vegetation, on lands that are mostly protected from development, will help to reduce further degradation.
Recovery potential	**Moderate-High**
	Moderate-High potential for recovery, assuming large-scale utility setback options and main channel realignment occurs in Reach 12 to remove the channel from the highway, which is limiting lateral processes and floodplain connectivity. Most of the segment lies within the Wenatchee National Forest with a few private parcels at the upstream and downstream ends and some county-owned and CDLT conservation lands at the downstream end.
Restoration objectives	**Target conditions from REI**
	Target "Adequate" functional rating criteria as described in the Reach-based Ecosystem Indicators (REI), provided in Appendix B.
Action Types	**Riparian Restoration** **Enhance Channel Complexity** **Side and Off-Channel Habitat Creation or Enhancement** **Floodplain and CMZ Connectivity**
	Actions include enhancement/improvement of channel complexity via large wood placements and creation or enhancement of side channel habitats. Removal of bank armor and channel re-alignments are proposed to address floodplain and CMZ connectivity. Previous restoration projects in this segment can be revisited to continue to improve habitat availability and complexity. Revegetation in some areas would support continued improvement of long-term riparian conditions. If needed, projects could be phased or divided into multiple smaller projects.
Project Areas & Prioritization	**Lower UWP** **Upper UWP**

2 Project Opportunities

2.1 PROJECT IDENTIFICATION AND EVALUATION APPROACH

Projects were identified through field surveys and analysis performed in the reach assessment. A map of the project areas is provided in Figure 1. Project elements were identified that are believed to best achieve target conditions and address fish habitat limiting factors. The projects represent an initial first step; it is expected that projects will be modified once project-specific surveys, analysis, and stakeholder coordination are performed. Project descriptions and maps are provided below. Project prioritization was performed to rank the projects into three priority tiers. Prioritization occurred by subjecting the projects to a set of scoring criteria. These criteria are based on several factors, including how well projects address the "gap" between existing and target conditions, species use/potential use of the area, and whether or not projects address root causes of impairments. Projects are also given a relative cost score estimate and feasibility designation in order to provide a relative cost perspective in project selection and planning. A description of the scoring methods and guidance is provided at the end of this document (Section **Error! Reference source not found.**).

2.2 PROJECT OPPORTUNITIES OVERVIEW

A total of 12 project areas were identified. An effort was made to identify project boundaries that group similar actions or that address similar reach-scale conditions; however, in many cases the selection of boundaries was qualitative, but a necessary means to divide up the study area into distinct projects that can be evaluated and ranked. Actual project extents for projects that are brought forward for implementation are likely to change depending on factors such as funding, landowner cooperation, schedule, phasing, etc. Areas where there are believed to be very few restoration opportunities are not included in the project maps. In some cases, project opportunities proposed here include revisiting or additional treatments to previous restoration project areas. Project opportunities are intended to complement and/or extend the lifespan or trajectory of the previous project actions. The appetite for stakeholders and landowners to revisit previously enhanced areas for additional project treatments may vary and influence the ultimate direction of project opportunities proposed.

A summary of the prioritization results is included in Table 1. The projects in the table are ranked by the Total Benefit score. The highest ranked projects are spread throughout the Nason Creek reach assessment area. The highest ranked "Miracle Mile" project is in an area that is relatively well-functioning but would nevertheless be expected to have high habitat uplift potential and high feasibility. The other Tier 1 projects also rank high primarily because of the uplift potential, and also because it is possible to address more of the root causes of degradation. The Tier 2 and 3 projects have either a lower uplift potential because of significant infrastructure constraints that are not expected to change, are in areas with less fish use, or the feasible actions do not address root causes of degradation. Notes are included in the ranking table explaining the rationale for the rankings. A feasibility designation and notes are also included. These ranking results should

be considered draft results and open to adjustment by technical teams and potential project sponsors depending on various circumstances and interpretations. In particular, the emphasis on total benefit versus cost-benefit may depend on funding levels or other considerations.

Table 1. Summary results of project prioritization. Ranked by Total Benefit Score. The full matrix is presented in Section** Error! Reference source not found.**.

Tiers	Project Name	Reach	Down-stream RM	Up-stream RM	Total Length (mi)	Total Benefit Score	Cost Score (1-4)	Benefit-to-Cost Score	Feasibility Designation
1	Miracle Mile	3, 4	1.50	3.00	1.50	7.5	1	7.5	High
	Lower UWP	12	11.50	12.60	1.10	6.5	3	2.2	Moderate - High
	Nason Ridge	4	3.00	4.50	1.50	6	3	2.0	Moderate
	LWP Second Bend	10, 11	9.90	10.60	0.70	5.5	3	1.8	Low - Moderate
	Upper UWP	13	12.60	13.40	0.80	5.5	2	2.8	Moderate - High
2	Confluence	1	0.00	0.60	0.60	5	2.5	2.0	Moderate
	Kahler	6, 7	5.40	7.50	2.10	5	3	1.7	Moderate
	LWP First Bend	11	10.60	11.30	0.70	4.5	1.5	3.0	Moderate - High
3	Campground	1, 2	0.60	1.50	0.90	4	2	2.0	Low - Moderate
	Coles	5, 6	4.50	5.40	0.90	4	1.5	2.7	Moderate - High
	LWP Sunland	10	9.10	9.90	0.80	4	2.5	1.6	Low
	Rest Stop	8, 9	7.50	9.10	1.60	3.5	3	1.2	Low - Moderate

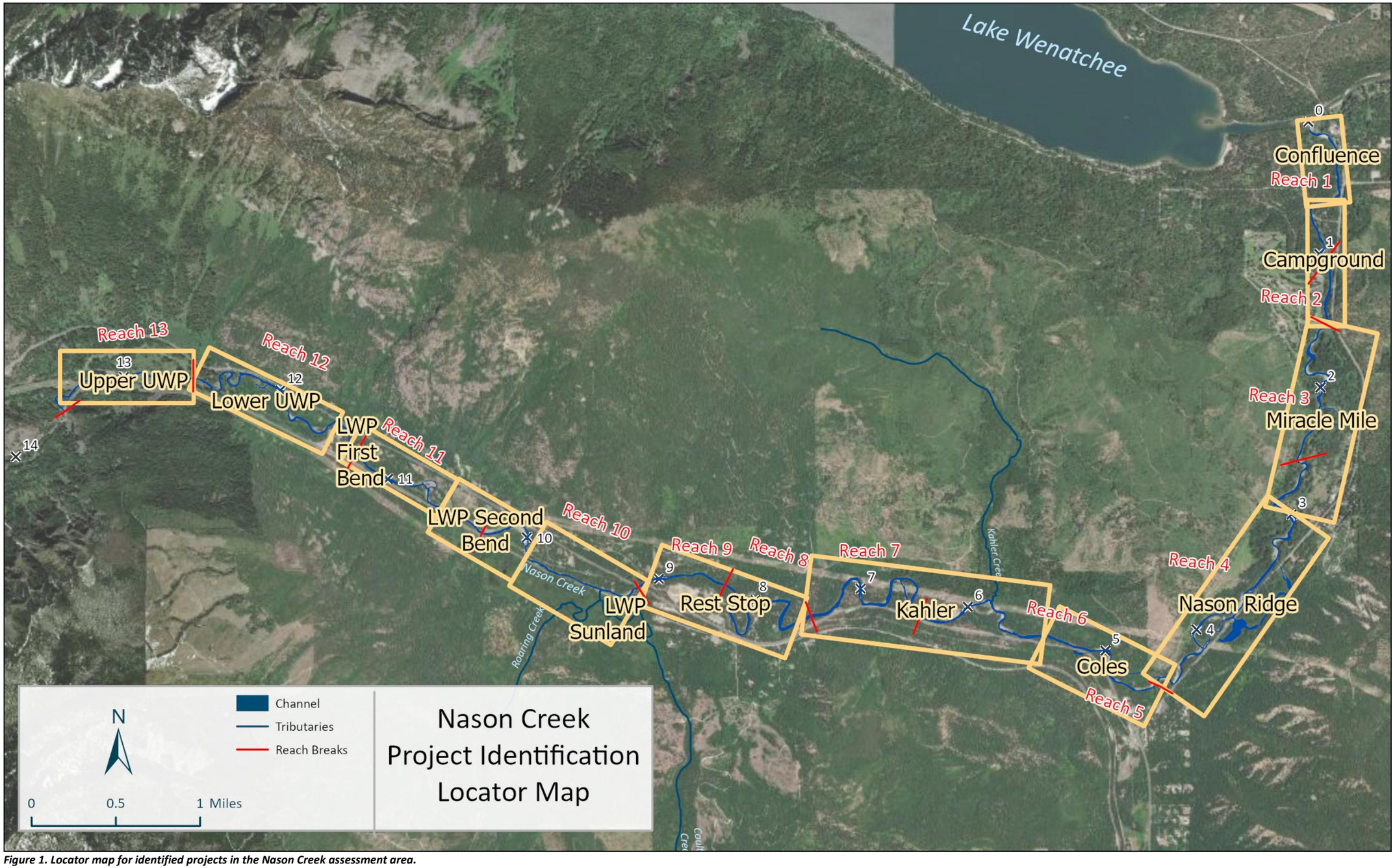


Figure 1. Locator map for identified projects in the Nason Creek assessment area.

2.3 PROJECT DESCRIPTIONS

This table describes project opportunities by project area within the Nason Creek assessment area. Concept maps of the project opportunities are included below the table.

Reach	River Miles	Project Area Name	Project Description
1	0 – 0.6	Confluence	The Confluence project is located within an unconfined portion of Nason Creek but is artificially confined by anthropogenic land uses and features. 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. River process and habitat conditions are highly degraded in this segment. Prior restoration efforts included creation/enhancement of a side-channel at the confluence and large wood placements throughout the project area. There remain significant opportunities for restoration, some of which may require infrastructure modifications to realize meaningful improvements. Potential actions include the following: • Large wood loading throughout the project area to enhance channel complexity, pool scour, gravel capture, and cover. The proximity of the road and residential/commercial development on river-right near the confluence may limit large wood loading potential if additional flow conveyance features such as side channels are not created. • Side-channel connections in the river-left floodplain to increase flow at existing high flow swales with inlets near RM 0.6, 0.55, 0.43, and 0.31. Large wood structures placed at the entrances and in the mainstem to help force flow into side-channels. Side-channel activation will likely require excavation, at least at the upper end of swales. Public landownership of the majority of the river-left floodplain may increase feasibility of side-channel reconnection actions. • Side-channel activation at the downstream river-left floodplain could include channels that connect directly to the Wenatchee River, potentially increasing fish use. • Feasibility of rerouting the mainstem Nason Creek channel away from Highway 207 and through the low floodplain surfaces on river-left downstream of RM 0.6 could be evaluated. This could improve riparian conditions and lateral channel adjustment potential. • If channel is not rerouted, opportunities to remove or replace riprap with bioengineered bank treatment should be evaluated. • There could be State Route 207 re-route options for opening up more of the floodplain and off-channel habitats around the confluence, including shifting the road east or potentially west up on the glacial terrace through the state park. This could reconnect significant portions of floodplain to inundation and lateral channel adjustment potential. These have considerable expense and feasibility challenges, including the need for continued access to private properties, impacts to public recreation lands, and potentially the need for a new crossing at the Wenatchee River. For these reasons, potential road relocation scenarios are not included on the map or in the project scoring evaluation.
1 – 2	0.6 – 1.5	Campground	The Campground project is located within a confined reach of Nason Creek. It is naturally confined at the upstream end and artificially confined elsewhere. River process and habitat conditions are highly degraded in this project area. There are limited opportunities for restoration due to the confinement and the high amount of recreational use. Potential actions include the following: • Large wood loading in existing pools at RM 1.27, 1.17, 1.04, and 0.55 to increase cover and refugia habitat for aquatic species. Feasibility would need to be evaluated due to the proximity of the campground. • Large wood loading in the left-bank alcove/side-channel complex near RM 1.1, but there is already some decent complexity and large wood here and access may be challenging. • Construction of a bar apex log jam where the channel is over-widened near RM 0.63 to encourage split flows and island development. Feasibility would need to be evaluated due to the presence of the campground on both sides of the river.
3 – 4	1.5 – 3.0	Miracle Mile	Landownership is mostly Chelan County on the west side with a combination of ownership to the east including private, CDLT conservation lands, and National Forest. Past restoration work includes a side-channel project, 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, has become channel-spanning, and is having a strong influence on geomorphic processes and is creating complex habitat conditions. There remain significant opportunities for restoration, particularly mainstem large wood complexity and activation of side-channels and floodplain areas. • Large wood placements could occur throughout a majority of the Miracle Mile project area to enhance channel complexity, flow-splits, pool scour, gravel capture, and cover. There are also opportunities to use jams to force erosion of banks for recruitment of large trees. A few locations have constructed jams or natural wood complexity and are lower priority work areas, including between RM 2.04 – 2.12, RM 2.2 – 2.25, and near 2.52. A substantial amount of wood loading could occur in this section of Nason Creek. Compared to other reaches, it is relatively unimpacted by human land uses/infrastructure, and wood loading would not only be highly feasible, but would contribute significant habitat uplift. • There are numerous opportunities to create or enhance connectivity and complexity of side-channels, most of which occur in the river-right floodplain. In the upstream portion of the project area, off-channel enhancement actions on both sides of the channel are available, including activation of a side channel inlet off an existing side channel near RM 3.03 that extends for several hundred feet through the river-right floodplain surface; this runs through private lands and much of it is cleared. It is not currently identified for revegetation but if side-channel activation were to occur here, it should be revegetated. Water is barely flowing through the existing side channel at RM 3.03 – 2.88. Large wood loading at the inlet of the existing side channel would direct additional flow into that feature. On river-left, a side channel could be created from RM 2.75 - 2.5. Downstream, side-channel activation could occur with inlets near RM 1.73 and 1.88 (which could outlet at the large pool at RM 1.5). • Between RM 2.15 - 2.25 there is a previously constructed side channel on river-right, flowing into a small back-bar side channel. Both off-channel features could use additional wood loading to increase cover and complexity. Additional LW loading in the large RM 2.15 – 2.25 side-channel should take into consideration effects of increasing roughness on sedimentation, especially given the greater sinuosity and lower energy compared to the mainstem. • Revegetation could occur in numerous locations. Floodplain clearing has occurred on river-right near RM 2.97 and RM 2.4. Revegetating these areas would improve long-term riparian functions (shade, LW recruitment, natural erosion resistance, hydraulic roughness). • Conservation priorities include private lands in the river-right floodplain to prevent future degradation and allow more opportunities for restoration. Conservation of these existing low, relatively complex floodplains are a critical action to maintain geomorphic and ecosystem function within the lower Nason Creek assessment area.

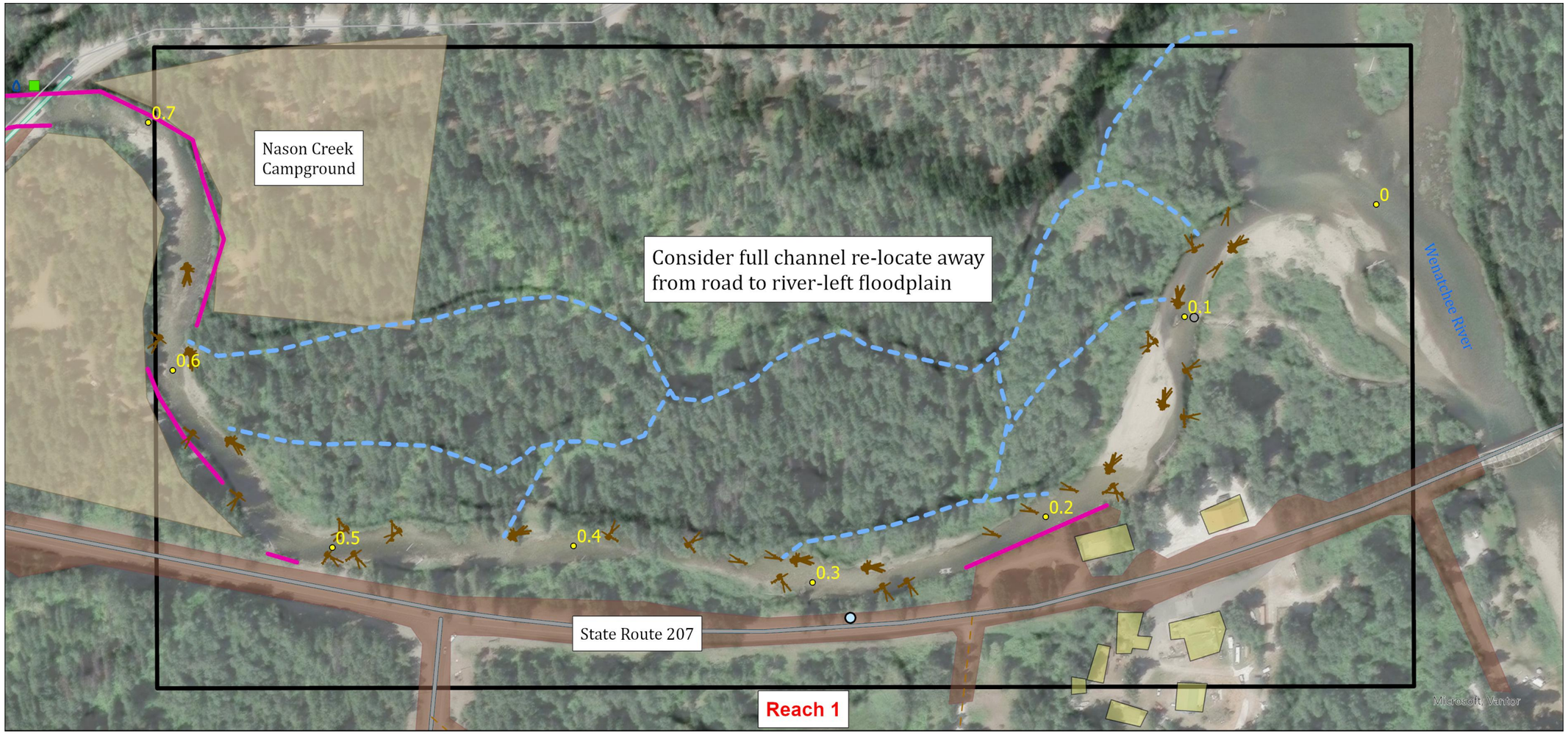
Reach	River Miles	Project Area Name	Project Description
4	**3.0 – 4.5**	**Nason Ridge**	Landownership is mostly Chelan County on the west side with private and National Forest on the east. River process and habitat conditions are degraded in this segment due to past and ongoing anthropogenic impacts including channel cut-offs, straightening, bank armoring, the transmission line corridor, and clearing and development in the floodplain. Past restoration work includes the "oxbow" reconnection project across State Route 207, which has improved the quantity of accessible off-channel habitat. Not much work has been done in the mainstem but projects are planned, including as part of the Nason Creek RM 3.4 – 4.6 Floodplain Enhancement Project (Yakama Nation). This includes partial relocation of State Route 207, mainstem large wood jams, side-channel habitat enhancement, and riparian and floodplain revegetation. However, there remain significant opportunities for restoration, including additional potential highway set-backs and similar mainstem and side-channel actions expanding into other areas. • State Route 207 cuts off portions of former main channel and floodplain in this segment. Re-routing the highway to the east, to avoid the floodplain/CMZ, would reconnect these areas and allow for restoration that would have many benefits to short- and long-term instream, off-channel, riparian, and floodplain processes (e.g., lateral adjustment potential). The Nason Creek RM 3.4 – 4.6 Floodplain Enhancement Project, currently in design, includes a portion of State Route 207 re-alignment. Future longer re-alignments may also be possible, and should continue to be considered. • Large wood placements could occur throughout a majority of the project area to enhance channel complexity, flow-splits, pool scour, gravel capture, and cover. There are also opportunities to use jams to force erosion of banks for recruitment of large trees. In a few locations, there is bedrock, which is especially prevalent around RM 4 where the channel abuts the Chumstick Formation. This will provide challenges for ballasting wood structures in these locations. • Large wood jams could be placed along armored sections of channel along the highway, potentially building out from the armoring to create a buffer, and increasing channel margin complexity with wood jams. • There are numerous opportunities to create or enhance connectivity and complexity of side-channels, most of which occur in the river-left floodplain. These take advantage of existing high-flow swales or old channel scars and will need additional investigation to identify feasibility and to determine if and how much excavation may be required. All of these would be loaded with large wood complexity and would include log jams at the inlet and typically in the mainstem opposite the inlet to encourage flow into the side-channel. There is one particularly long side-channel opportunity in the river-left floodplain from RM 3.6 to 3.2. Enhancement of this side-channel via excavation and large wood placements is included in the planned Nason Creek RM 3.4 – 4.6 Floodplain Enhancement Project. • The existing side-channel on river-right from RM 4.15 to 3.8 has good wood complexity at the upstream end but would benefit from large wood placements at least through the downstream half to enhance pool scour, cover, and hydraulic complexity. • Revegetation could occur in a few locations, including one expansive bar on river-left from RM 3.6 to 3.8 that is not recolonizing and could benefit from willow and cottonwood plantings. The vegetation under the BPA powerline corridor is heavily impaired and regularly maintained but there was shrub vegetation observed here during the early July 2025 survey. The vegetation maintenance strategy is unknown to the authors, but the lines are high and there could be an opportunity to work with BPA to increase the allowable height of vegetation in the corridor. • Conservation priorities include private lands at the downstream end, especially the parcel(s) to the west of State Route 207. Conserving these lands would help to prevent future degradation and may increase opportunities for restoration.
5 – 6	**4.5 – 5.4**	**Coles**	Landownership is primarily National Forest, with a few private parcels around Coles Corner. The Coles project area has been impacted by road fill associated with construction of Highway 2, which has disconnected portions of the channel and floodplain. Bank armoring is present at several locations where the channel and highway prism interact. There has not been any significant past restoration work in this project area, but there are several opportunities for restoration. In the upstream portion of the Coles project area, the Nason Creek channel flows adjacent to Highway 2 on river-right. This, combined with a steep channel through this area, limits enhancement options. • Large wood placements could occur in a few locations; however, opportunities are somewhat limited by steep channel conditions through the upstream half of the project area. There are opportunities to enhance mainstem complexity and alcove cover at the outside of the bend at RM 5.0 (though bedrock through here could provide anchoring challenges) and then opportunities for large wood complexity downstream of RM 4.7 to enhance channel complexity, flow-splits, pool scour, gravel capture, and cover. There are a few locations to use jams to force erosion of banks for recruitment of large trees • There are a few opportunities to create or enhance connectivity and complexity of side- and off-channel habitats. Water is currently flowing out of a channel at the downstream end of the river-left floodplain at RM 5.0, potentially capturing groundwater seepage from the valley toe. A side channel could be excavated through this river-left surface extending up to RM 5.4, though excavations may need to be fairly deep in some portions. Alternatively, a backwater alcove could be expanded and enhanced on river-left at the outlet near RM 5.0. Between RM 4.88 – 5.05 is a low floodplain surface on the inside of a meander bend. Side channel excavation and large wood loading through here could create complex off-channel habitat. A side-channel could be created in a river-right floodplain channel scar from RM 4.7 to 4.8, while still keeping it off the highway. Downstream on river-right near RM 4.55 there may be opportunities for activating floodplain and historical channel scars present on the floodplain. • In the river-left floodplain near RM 4.75, there is floodplain fill that could be removed, ideally in combination with side-channel creation. There is also fill in the river-left floodplain that could be removed, but impacts to vegetation via access is likely not worth it. Removing the fill would restore more natural floodplain inundation patterns and extents. • 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, restoring riparian conditions, floodplain inundation extents, and lateral adjustment processes.

Reach	River Miles	Project Area Name	Project Description
6 – 7	5.4 – 7.5	Kahler	The Kahler 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 and side-channel reconnection work is identified. The proximity of the highway and some residences may provide challenges to work in some areas. • Large wood placements could occur in several locations to enhance channel complexity, flow-splits, pool scour, gravel capture, and cover. Most of the remaining opportunities for large wood placements are in the downstream end of the project area from RM 5.5 to 6.3. Jams through here could also serve to aggrade the main channel and reduce past incision to help reconnect floodplains, and thereby complement the side-channel actions described below. There are also opportunities to use jams to force erosion of banks for recruitment of large trees. In the upstream portion of the project area, there are a few places for wood placements, but significant portions of this segment have already been treated and much of the remaining portion is steep and not well-suited to wood placements. • There are opportunities to create or enhance connectivity and complexity of side-channels, most of which occur in the downstream portion of the project area in the same location as the wood complexity opportunities and very much associated with those. Wood placements in this zone can work in concert with side-channel excavations to help to create a multi-thread channel network. However, denuded vegetation conditions maintained under the powerlines will limit the overall uplift potential of work in this area. • There may be a couple of opportunities to shift the river away from the highway where the channel directly abuts the highway embankment with hard armoring (RM 6.8-6.9 and RM 6.2-6.4). 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. • 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, restoring riparian conditions, floodplain inundation extents, and lateral adjustment processes. • Revegetation could occur in a few locations, in particular along the river-right bank near RM 6.1. The vegetation under the BPA powerline corridor is kept low. The vegetation maintenance strategy is unknown to the authors, but the lines are relatively high and there could be an opportunity to work with BPA to increase the allowable height of vegetation in the corridor. • Conservation priorities include private lands in the river-right floodplain near RM 5.8. Conserving these lands would help to prevent future degradation and may increase opportunities for restoration.
8 – 9	7.5 – 9.1	Rest Stop	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. The downstream portion, some of which is artificially confined by the Gill Creek Road fill, bridge, and floodplain fill, has greater opportunity for mainstem log structures. However, adjacent residential uses, the highway, and the Gill Creek Road crossing will limit the potential intensity of the approach. • Large wood placements could occur through much of the channel to enhance channel complexity, flow-splits, pool scour, gravel capture, and cover. There are also opportunities in a few locations to use jams to force erosion of banks for recruitment of large trees. There are opportunities at the upstream portion of the project area from RM 8.8 to 9.1, but this is naturally confined so it would mainly be complexity and cover work, and some potentially challenging access. RM 8.3 to 8.6 is another area to increase complexity and later dynamics, building off of past restoration work. The CPUD powerline crossing will need to be considered here. From RM 8.2 to 7.9 the channel could benefit from complexity and forcing of lateral recruitment of gravels and large trees, but private lands and nearby residences present challenges. Near the bend at RM 7.8 has good opportunities for complexity work. There may be opportunities also at the bend from RM 7.6-7.7 but there is a nearby residence. • There are limited side-channel or floodplain reconnection opportunities due to confinement and adjacent residential uses. There may be an opportunity for side-channels in the river-left floodplain near the Gill Creek Road bridge, but these would require excavation and a culvert or bridge under the road to the north to make the connection. • Revegetation is needed in numerous locations, mostly the inside of the bend RM 8-8.5. • 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. • Several of the private lands in this project area could be considered for conservation, but only limited benefits would be gained in the absence of addressing some of the larger infrastructure-based limitations like the confinement from the Gill Creek Road crossing.

Reach	River Miles	Project Area Name	Project Description
10	9.1 – 9.9	LWP Sunland	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. To realize meaningful improvements to habitat and ecological processes in this area would require significant infrastructure modifications. 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. • There are opportunities for placing large wood jams in the straight confined segment to enhance cover and complexity, but jams that would initiate strong lateral processes or increase floodplain inundation may be challenging given adjacent land uses. • There are limited off-channel habitat enhancement opportunities. There may be some, albeit limited, opportunity for engagement of the river-left floodplain. This could potentially include excavation of a side-channel linking together a few channel scars, but excavation depths are likely to be large. It may be possible to bump the river away from the railroad in a couple of shallow meanders, providing at least a larger buffer between the channel and railroad in a few locations and improving channel margin habitat. Private property and residencies present challenges. • Vegetation conditions are highly impaired by the railroad, powerlines, and residential uses. Revegetation could occur in numerous locations on the river-left bank where impacted by residential uses. Larger infrastructure modifications would be required for revegetation efforts in other areas. Revegetating these areas would improve long-term riparian functions (shade, LW recruitment, natural erosion resistance, hydraulic roughness). • 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. Moving the lines would improve habitat conditions, provide space for natural lateral channel adjustments, provide greater restoration potential, and would reduce flood and erosion risk to the lines. It is understood that some consideration has been given to this in the past, and there are logistical challenges and expense. • 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. A reconnection scenario here could enhance the extent of floodplain inundation (closer to historical), lateral channel migration potential, and length of available habitat. • Conservation priorities include private lands in the river-left floodplain if there are willing landowners. Conserving these lands would help to prevent future degradation and may increase opportunities for restoration.
10, 11	9.9 – 10.6	LWP Second Bend	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 and side-channel work. However, infrastructure modifications or major channel re-routes may be necessary to realize meaningful improvements. • Large wood placements could occur throughout the project area to enhance channel complexity, flow-splits, pool scour, gravel capture, and cover. In the upstream straightened section along the railroad, jams that initiate lateral processes will be challenged by the adjacent railroad and private residential parcels. However, at the second bend area, despite the powerlines above and a tower in the floodplain, there is more opportunity to initiate lateral dynamics and promote side-channel and floodplain connectivity. Jams to push the channel off of the highway embankment at RM 10.05 could create a narrow buffer and increase channel margin habitat. • There is an opportunity to create an additional flow-through side channel(s) in the vicinity of the former LWP Groups 2&3 Project. This could entail a side-channel that begins near RM 10.35 and enters into the previously created backwater alcove complex. At the least, the existing connection point to the constructed backwater alcove should be cleared out and measures taken to keep the entrance open. It was disconnected from the river at the time of the late June 2025 field survey. • Vegetation conditions are highly impaired by the railroad, powerlines, and residential uses. However, larger infrastructure modifications will be required for any significant revegetation improvements. Revegetating these areas would improve long-term riparian functions (shade, LW recruitment, natural erosion resistance, hydraulic roughness). • 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 and allow for renewed lateral channel adjustment potential. • 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. Moving the lines would improve habitat conditions, provide space for natural lateral channel adjustments, provide greater restoration potential, and would reduce flood and erosion risk to the lines. It is understood that some consideration has been given to this in the past, and there are logistical challenges and expense. • 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. • Conservation priorities include private lands in the north floodplain at the upstream end and in the south floodplain in the interior of the 'Second Bend'. Conserving these lands would help to prevent future degradation and may increase opportunities for restoration.

Reach	River Miles	Project Area Name	Project Description
11	**10.6 – 11.3**	**LWP First Bend**	The LWP First Bend project includes main channel complexity work and potentially larger infrastructure improvements. Wood additions and off-channel enhancement opportunities include work within previous work areas that would complement the past projects. • Large wood placements could occur throughout a majority of the project area to enhance channel complexity, flow-splits, pool scour, gravel capture, and cover. This includes some work within previous project areas. Work along the straightened and confined upstream stretch along the railroad could have challenges due to the railroad on one side and private residential parcels on the other. • There is one primary side-channel opportunity. 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. • Revegetation could occur in numerous locations mostly in and around the prior 'LWP First Bend' Project. Field observations during the late June 2025 survey indicated that much of the planted riparian forest is thriving; however, the gravel bar between the old and new channels has not recolonized with vegetation and could benefit from targeted planting of willow and cottonwood cuttings deep enough to access enough groundwater for growth. Floodplain roughness large wood could help protect plantings. Planting work could also occur at a few areas at the top of bank that either have not recovered adequately or may be maintained cleared by 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. Moving the lines would improve habitat conditions, provide space for natural lateral channel adjustments, provide greater restoration potential, and would reduce flood and erosion risk to the lines. It is understood that some consideration has been given to this in the past, and there are logistical challenges and expense. • Conservation priorities include the private lands around the First Bend, where conservation could help to prevent future degradation and may increase opportunities for restoration.
12	**11.5 – 12.6**	***UWP-Lower Revisit***	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 and potential floodplain and side-channel reconnection work throughout the project area. However, infrastructure modifications or major channel re-routes may be necessary to realize meaningful improvements. • Large wood placements could occur throughout the project area to enhance channel complexity, flow-splits, pool scour, gravel capture, and cover. At areas where the channel abuts the highway, large jams could be used to push the river away from the bank armoring, creating expanded vegetated buffers and improving channel margin and pool habitat. For the long stretch along the highway, shorter meanders could be used to the same effect; however, a larger full or partial channel re-route away from the highway should be considered as described below. • There are numerous opportunities to create or enhance connectivity and complexity of side-channels, 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, thereby increasing fish access and long-term sustainability of the channel (i.e., via sediment flushing). 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. • Revegetation could occur in numerous locations. Revegetating these areas would improve long-term riparian functions (shade, LW recruitment, natural erosion resistance, hydraulic roughness). • 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. These actions would increase sinuosity and pool-riffle habitat development, would increase lateral adjustment potential, and would improve riparian conditions. • 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. Moving the lines would improve habitat conditions, provide space for natural lateral channel adjustments, provide greater restoration potential, and would reduce flood and erosion risk to the lines. It is understood that some consideration has been given to this in the past, and there are logistical challenges and expense. • At the downstream end, a more local relocation (assuming full relocation does not occur) of the CPUD powerlines could allow for more active engagement of the river-right floodplain between RM 11.6 and 11.8+. This would include the relocation of 2-3 existing powerpoles to tie back into the existing line at Merritt.
13	**12.6 – 13.4**	**UWP-Upper Revisit**	The UWP Upper project area has opportunities that would build off and complement past work. Proposed actions include bank armor removal, mainstem large wood complexity, revegetation, and potential side-channel creation. 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. • Given robust riparian and floodplain vegetation growth since the previous project (completed in 2018), it is now reasonable to remove additional riprap along the river-left bank upstream of the prior channel re-meanders (upstream from RM 13). This could potentially extend 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. A section of failing riprap armoring could also be removed at the downstream end river-right RM 12.65 down to ~12.6, and replaced with large wood structures. This previously was protecting a CPUD powerline tower that was removed as part of the prior project. • Log jams and cover wood could be placed throughout the main channel in the project area, including within the previously re-meandered section. The jams could extend further out into the channel than the existing jams, and would be designed to create flow-splits, encourage lateral process, capture and sort bed material, and provide complex cover. Activation of one or more side-channels, such as described below, may be required to offset conveyance impacts due to the jams, given the proximity and elevation of the railroad. • Creation of a side-channel could be considered in the river-left floodplain with an inlet somewhere between RM 13 and 13.1. The channel would connect into existing tributary-fed wetlands. This would potentially require a deep dig and will need further investigation. • 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. Floodplain roughness large wood would also help with revegetation and erosion protection of this surface.

2.4 PROJECT OPPORTUNITY REACH MAPS



Nason Creek Reach Assessment Update

Project Opportunities

Confluence

N

0 0.1 Miles

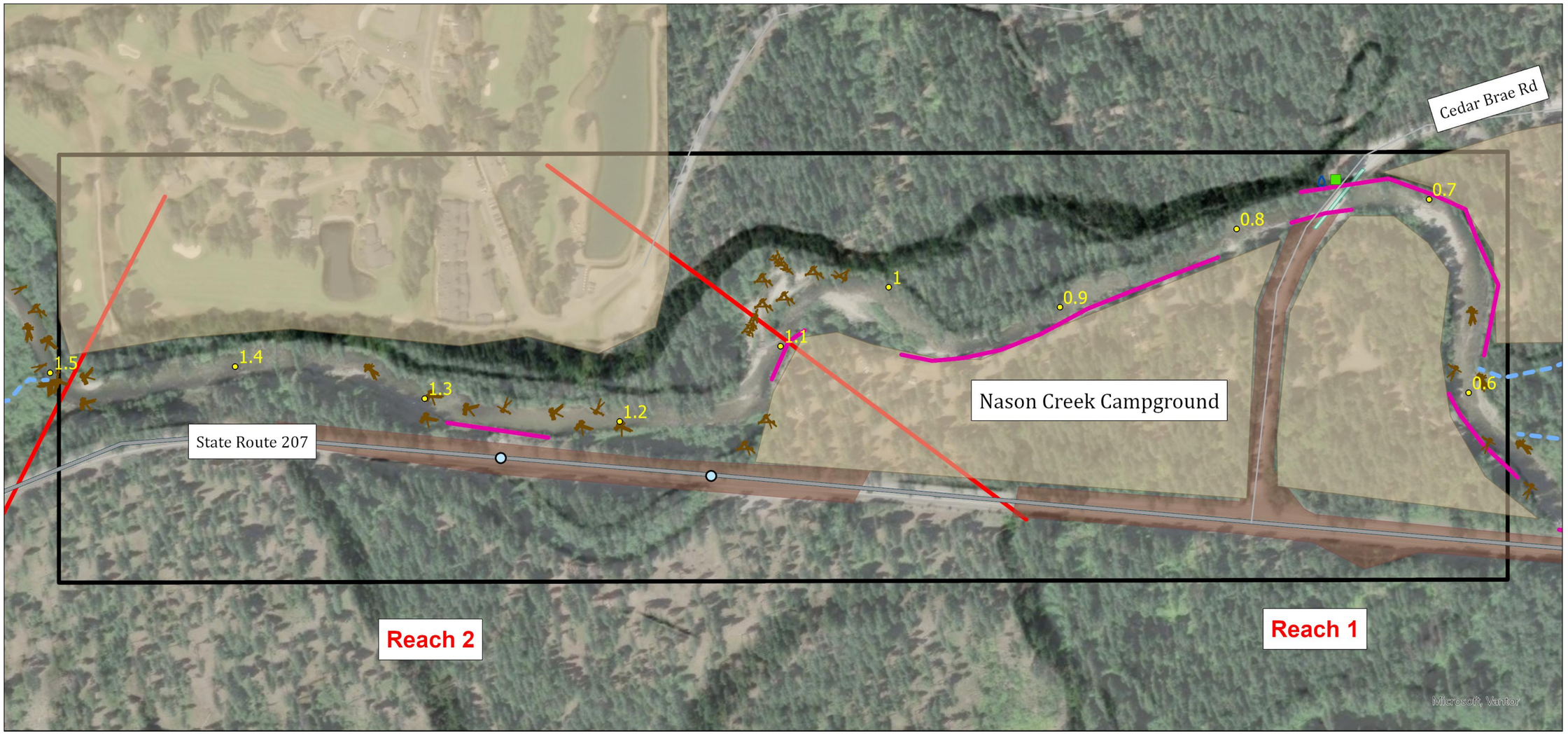
Project Elements

- Side Channel Activation
- Remove or Modify Armoring
- Fill Removal
- Riparian Restoration
- Individual logs
- Complexity jams
- Whole trees
- Apex jams
- Bank jams

These are preliminary concepts intended to describe the type of potential restoration work that could be performed. Additional site investigations and analysis will be necessary to determine specific treatment types and locations.

Built Features

- Constructed Jam
- Culvert
- Gaging Station
- PIT Tag Array
- Water Withdrawal
- Bank Armoring
- Powerline
- Primary Road
- Secondary Road
- Gravel Road
- Railroad
- Utility Corridor
- Levee/Fill
- Bridge
- Mining
- Recreation
- Structure



Nason Creek Reach Assessment Update

Project Opportunities

Campground

N

0 0.1 0.2 Miles

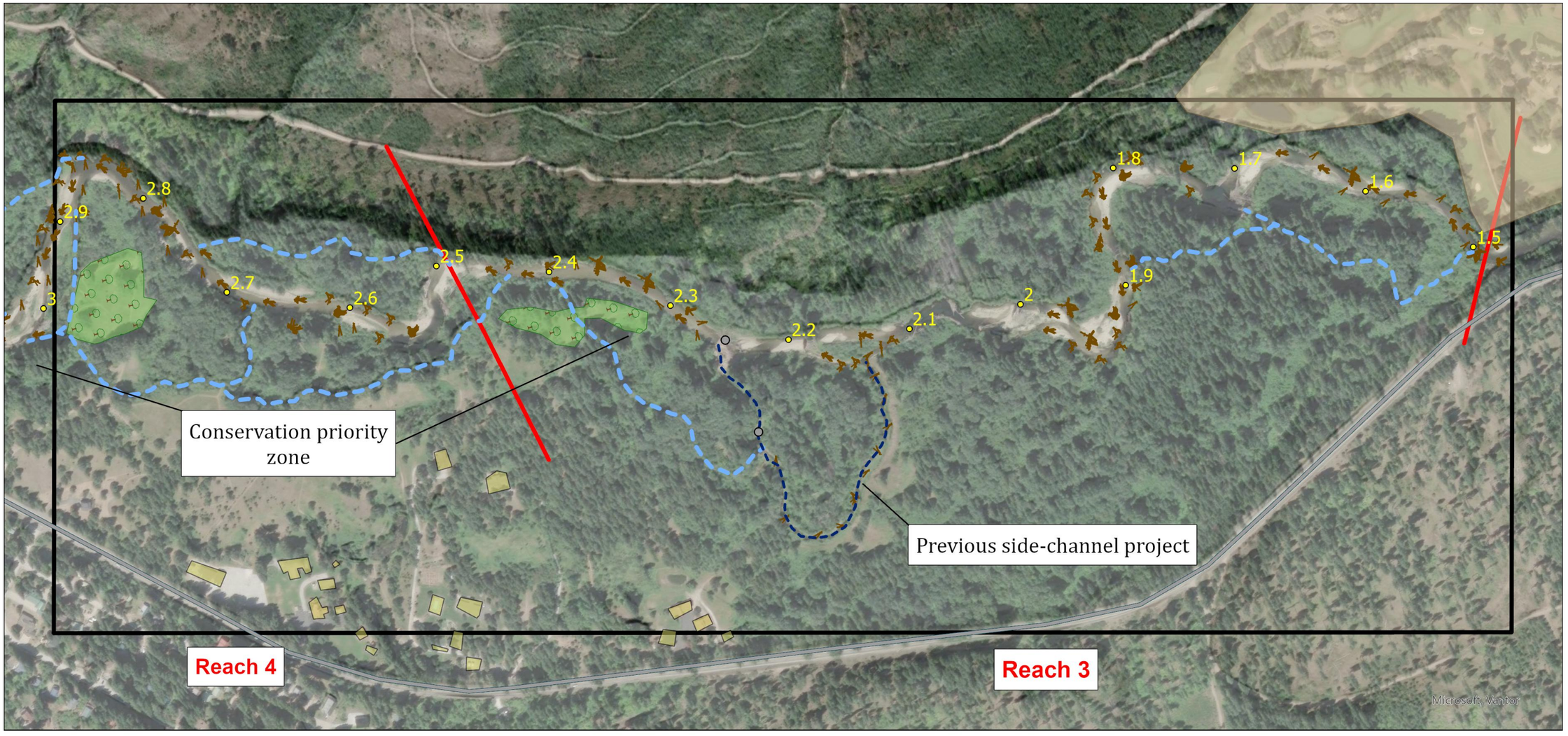
Project Elements

- Side Channel Activation
- Remove or Modify Armoring
- Fill Removal
- Riparian Restoration
- Individual logs
- Complexity jams
- Whole trees
- Apex jams
- Bank jams

These are preliminary concepts intended to describe the type of potential restoration work that could be performed. Additional site investigations and analysis will be necessary to determine specific treatment types and locations.

Built Features

- Culvert
- Gaging Station
- PIT Tag Array
- Water Withdrawal
- Bank Armoring
- Powerline
- Primary Road
- Secondary Road
- Gravel Road
- Railroad
- Utility Corridor
- Levee/Fill
- Bridge
- Mining
- Recreation
- Structure



Nason Creek Reach Assessment Update

Project Opportunities

Miracle Mile

N

0 0.1 0.2 Miles

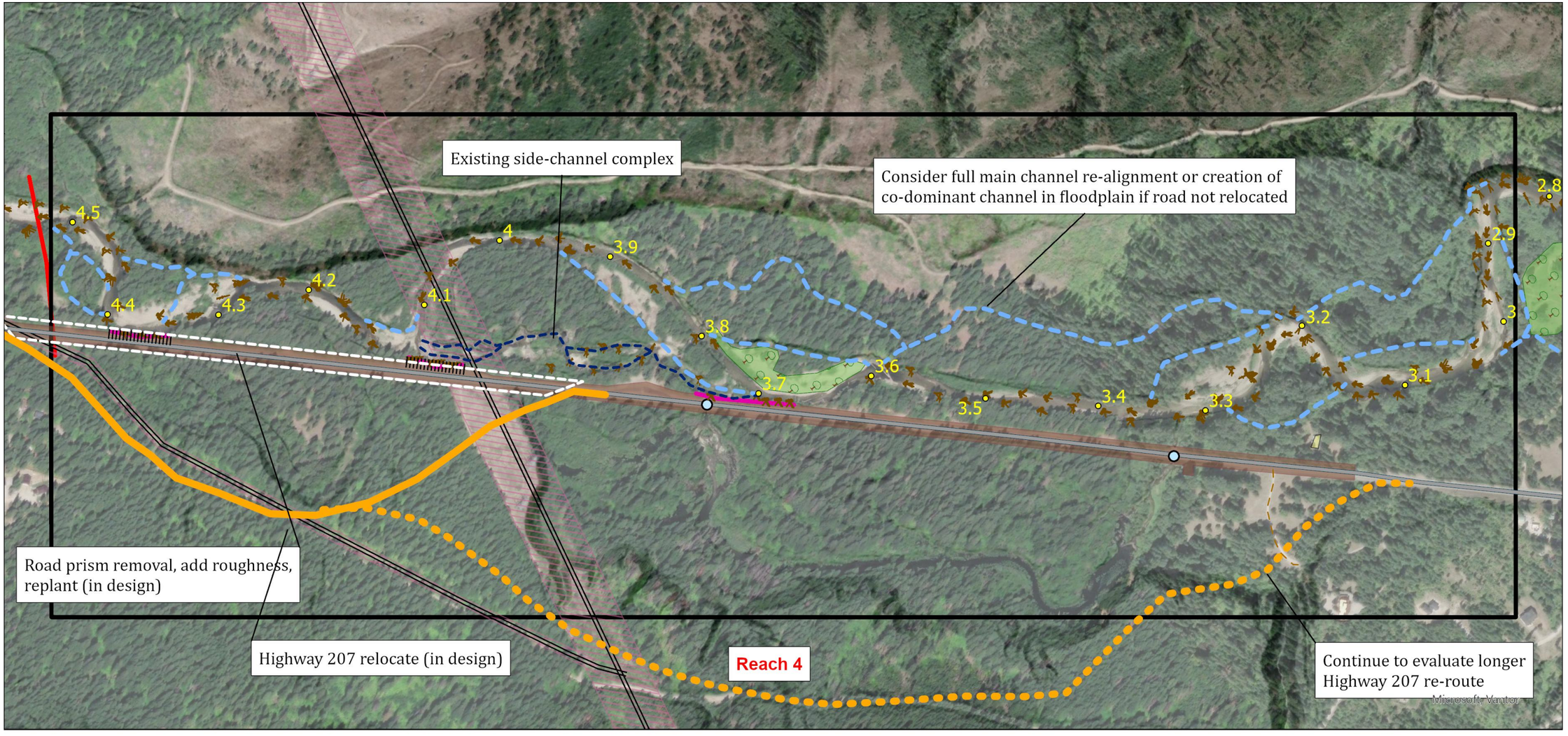
Project Elements

- Side Channel Activation
- Remove or Modify Armoring
- Fill Removal
- Riparian Restoration
- Individual logs
- Complexity jams
- Whole trees
- Apex jams
- Bank jams

These are preliminary concepts intended to describe the type of potential restoration work that could be performed. Additional site investigations and analysis will be necessary to determine specific treatment types and locations.

Built Features

- Constructed Jam
- Culvert
- Gaging Station
- PIT Tag Array
- Water Withdrawal
- Bank Armoring
- Powerline
- Primary Road
- Secondary Road
- Gravel Road
- Railroad
- Utility Corridor
- Levee/Fill
- Bridge
- Mining
- Recreation
- Structure



Nason Creek Reach Assessment Update

Project Opportunities

Nason Ridge

N

0 0.1 0.2 Miles

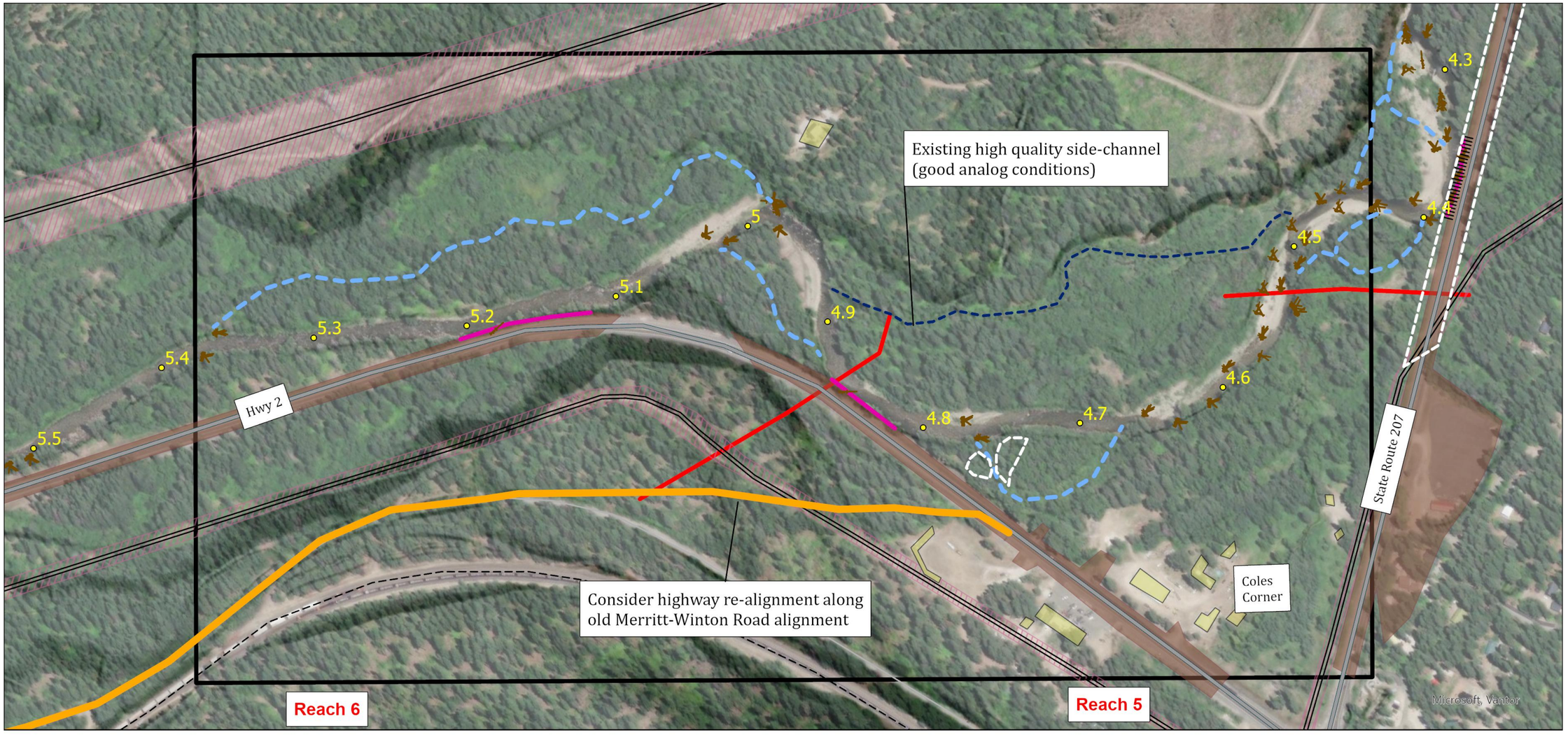
Project Elements

- Side Channel Activation
- Remove or Modify Armoring
- Fill Removal
- Riparian Restoration
- Individual logs
- Complexity jams
- Whole trees
- Apex jams
- Bank jams

These are preliminary concepts intended to describe the type of potential restoration work that could be performed. Additional site investigations and analysis will be necessary to determine specific treatment types and locations.

Built Features

- Culvert
- Gaging Station
- PIT Tag Array
- Water Withdrawal
- Bank Armoring
- Powerline
- Primary Road
- Secondary Road
- Gravel Road
- Railroad
- Utility Corridor
- Levee/Fill
- Bridge
- Mining
- Recreation
- Structure



Nason Creek Reach Assessment Update

Project Opportunities

Coles

N

0 0.1 0.2 Miles

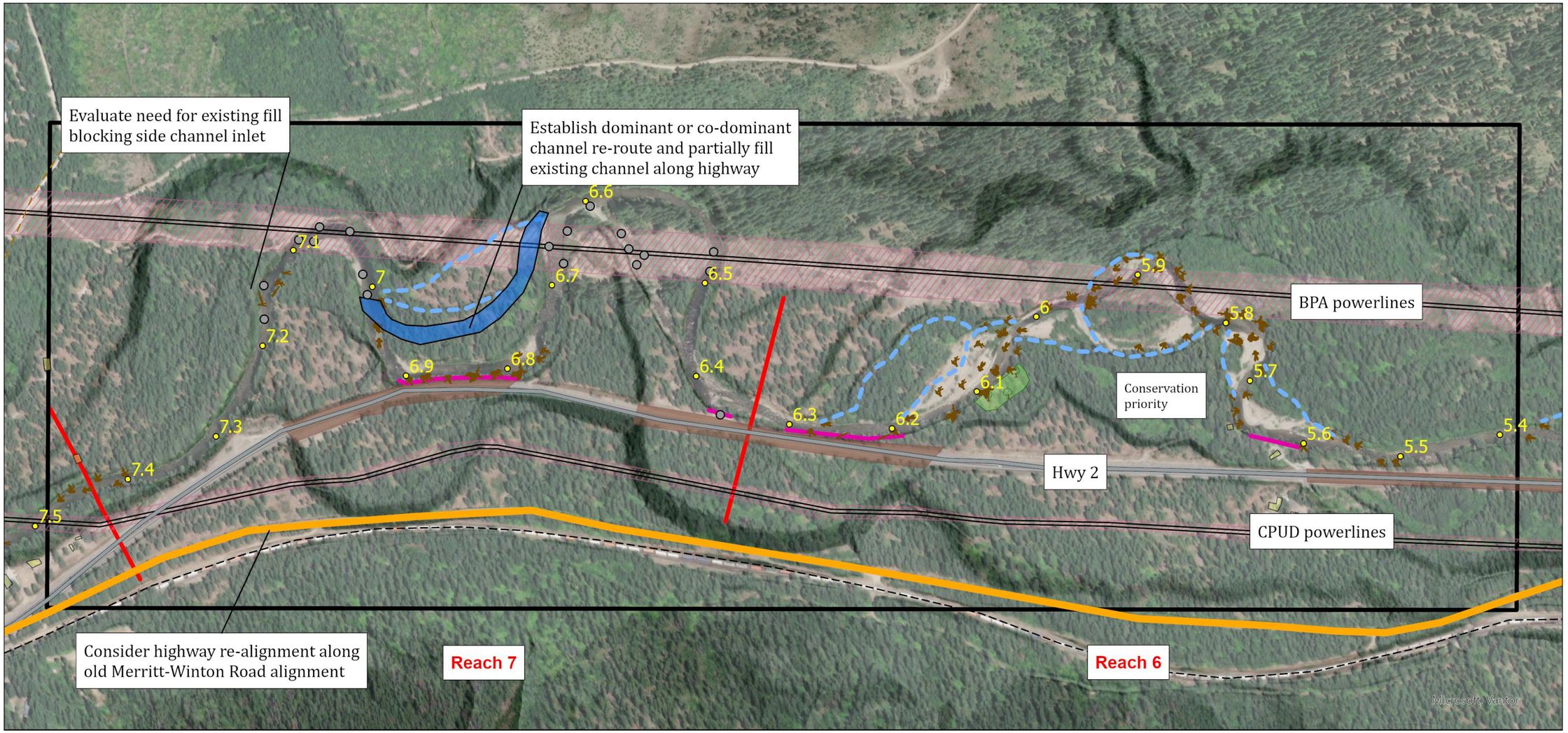
Project Elements

- Side Channel Activation
- Remove or Modify Armoring
- Fill Removal
- Riparian Restoration
- Individual logs
- Complexity jams
- Whole trees
- Apex jams
- Bank jams

These are preliminary concepts intended to describe the type of potential restoration work that could be performed. Additional site investigations and analysis will be necessary to determine specific treatment types and locations.

Built Features

- Culvert
- Gaging Station
- PIT Tag Array
- Water Withdrawal
- Bank Armoring
- Powerline
- Primary Road
- Secondary Road
- Gravel Road
- Railroad
- Utility Corridor
- Levee/Fill
- Bridge
- Mining
- Recreation
- Structure



Nason Creek Reach Assessment Update

Project Opportunities

Kahler

N

0 0.1 0.2 Miles

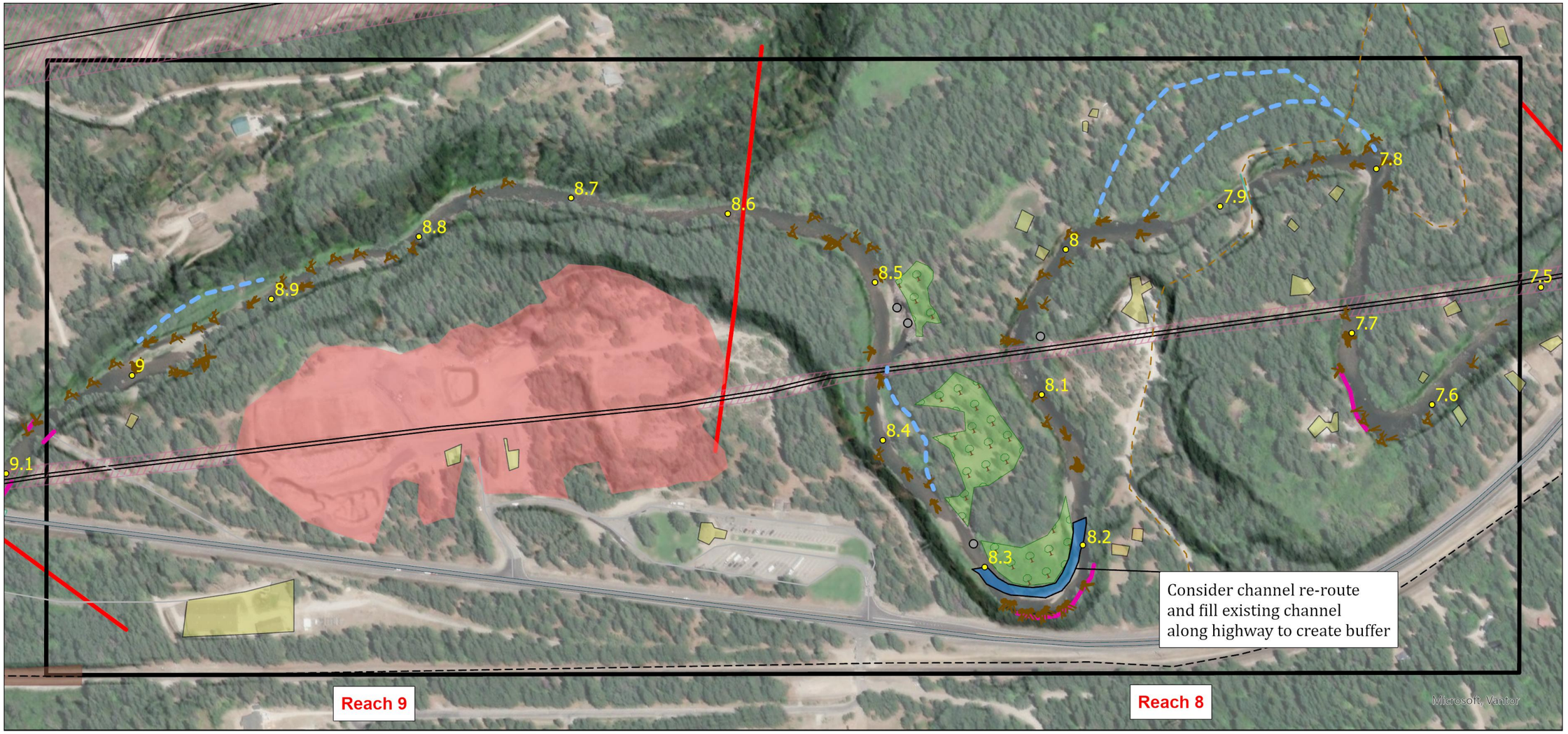
Project Elements

- Side Channel Activation
- Remove or Modify Armoring
- Fill Removal
- Riparian Restoration
- Individual logs
- Complexity jams
- Whole trees
- Apex jams
- Bank jams

These are preliminary concepts intended to describe the type of potential restoration work that could be performed. Additional site investigations and analysis will be necessary to determine specific treatment types and locations.

Built Features

- Constructed Jam
- Culvert
- Gaging Station
- PIT Tag Array
- Water Withdrawal
- Bank Armoring
- Powerline
- Primary Road
- Secondary Road
- Gravel Road
- Railroad
- Utility Corridor
- Levee/Fill
- Bridge
- Mining
- Recreation
- Structure



Nason Creek Reach Assessment Update

Project Opportunities

Rest Stop

N

0 0.1 0.2 Miles

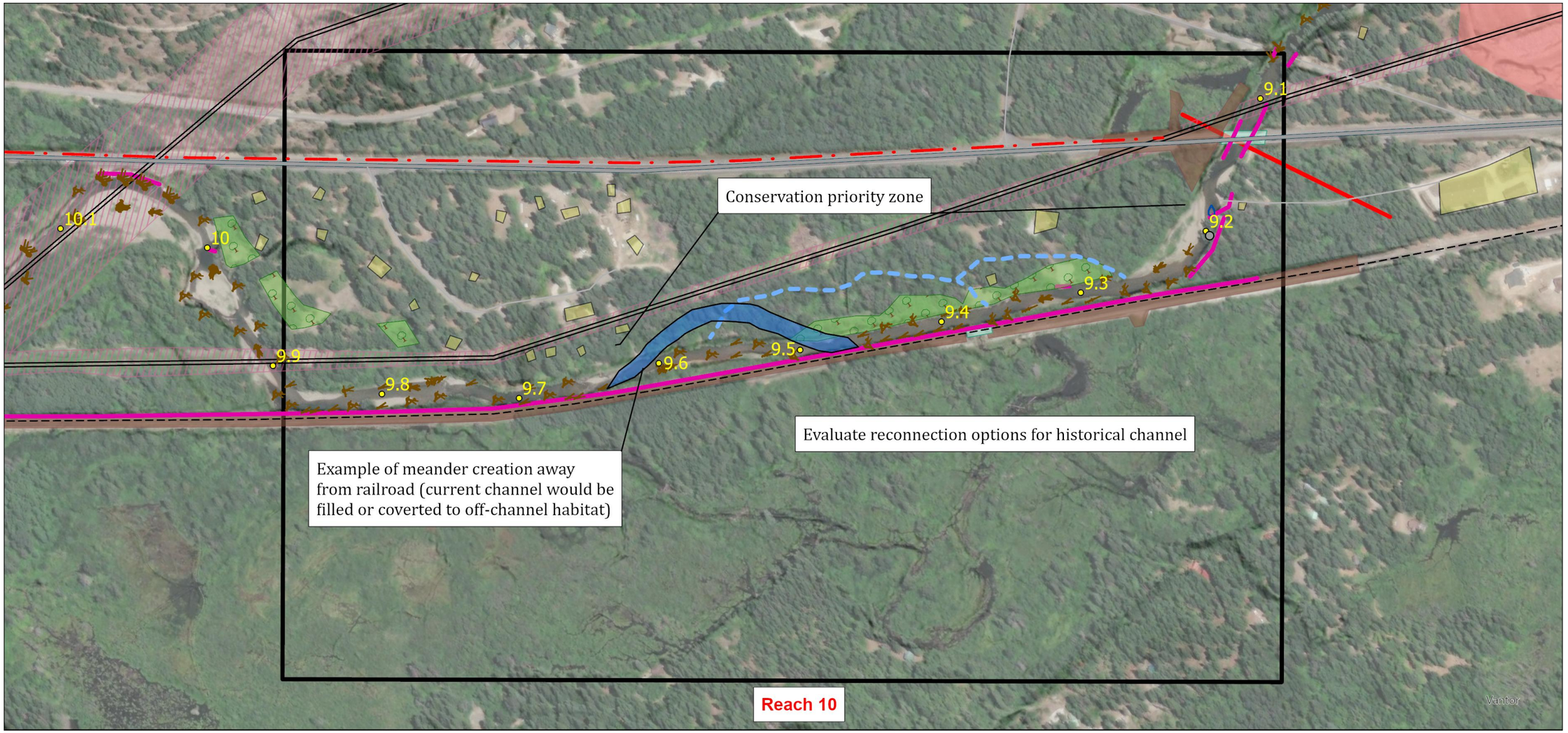
Project Elements

- Side Channel Activation
- Remove or Modify Armoring
- Fill Removal
- Riparian Restoration
- Individual logs
- Complexity jams
- Whole trees
- Apex jams
- Bank jams

These are preliminary concepts intended to describe the type of potential restoration work that could be performed. Additional site investigations and analysis will be necessary to determine specific treatment types and locations.

Built Features

- Constructed Jam
- Culvert
- Gaging Station
- PIT Tag Array
- Water Withdrawal
- Bank Armoring
- Powerline
- Primary Road
- Secondary Road
- Gravel Road
- Railroad
- Utility Corridor
- Levee/Fill
- Bridge
- Mining
- Recreation
- Structure



Nason Creek Reach Assessment Update

Project Opportunities

LWP Sunland

N

0 0.1 0.2 Miles

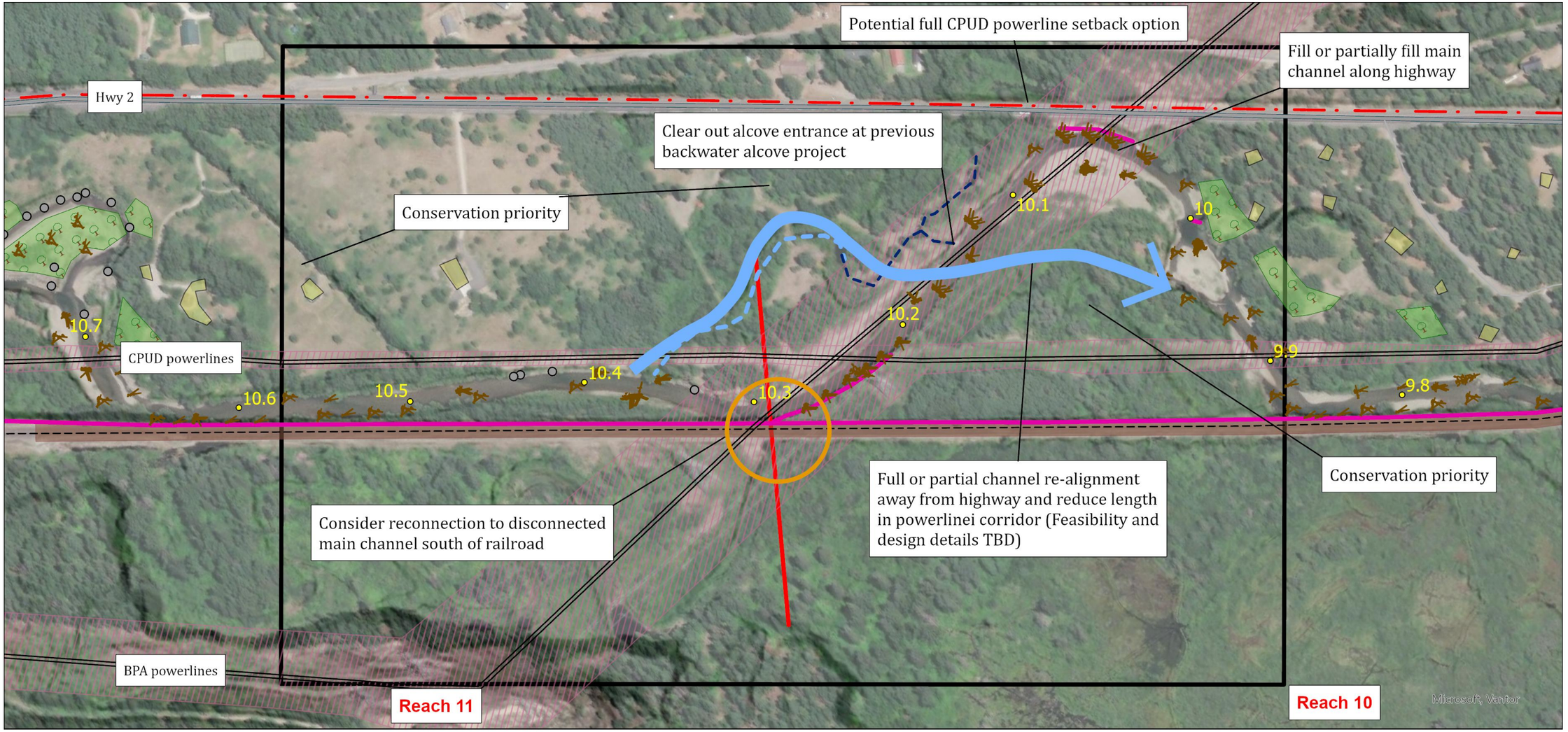
Project Elements

- Side Channel Activation
- Remove or Modify Armoring
- Fill Removal
- Riparian Restoration
- Individual logs
- Complexity jams
- Whole trees
- Apex jams
- Bank jams

These are preliminary concepts intended to describe the type of potential restoration work that could be performed. Additional site investigations and analysis will be necessary to determine specific treatment types and locations.

Built Features

- Constructed Jam
- Culvert
- Gaging Station
- PIT Tag Array
- Water Withdrawal
- Bank Armoring
- Powerline
- Primary Road
- Secondary Road
- Gravel Road
- Railroad
- Utility Corridor
- Levee/Fill
- Bridge
- Mining
- Recreation
- Structure



Nason Creek Reach Assessment Update

Project Opportunities

LWP Second Bend

N

0 0.1 0.2 Miles

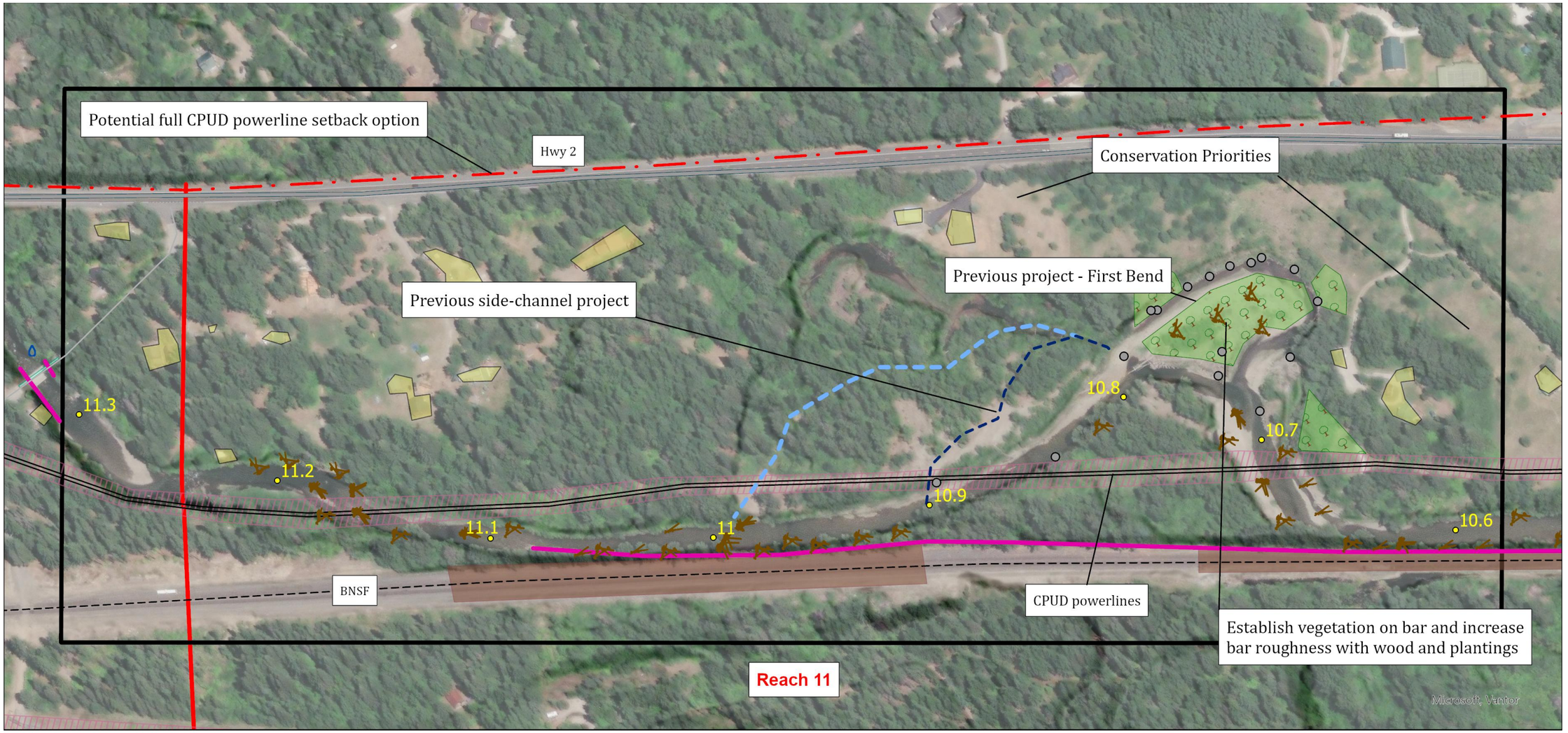
Project Elements

- Side Channel Activation
- Remove or Modify Armoring
- Fill Removal
- Riparian Restoration
- Individual logs
- Complexity jams
- Whole trees
- Apex jams
- Bank jams

These are preliminary concepts intended to describe the type of potential restoration work that could be performed. Additional site investigations and analysis will be necessary to determine specific treatment types and locations.

Built Features

- Constructed Jam
- Culvert
- Gaging Station
- PIT Tag Array
- Water Withdrawal
- Bank Armoring
- Powerline
- Primary Road
- Secondary Road
- Gravel Road
- Railroad
- Utility Corridor
- Levee/Fill
- Bridge
- Mining
- Recreation
- Structure



Nason Creek Reach Assessment Update

Project Opportunities

LWP First Bend

N

0 0.1 0.2 Miles

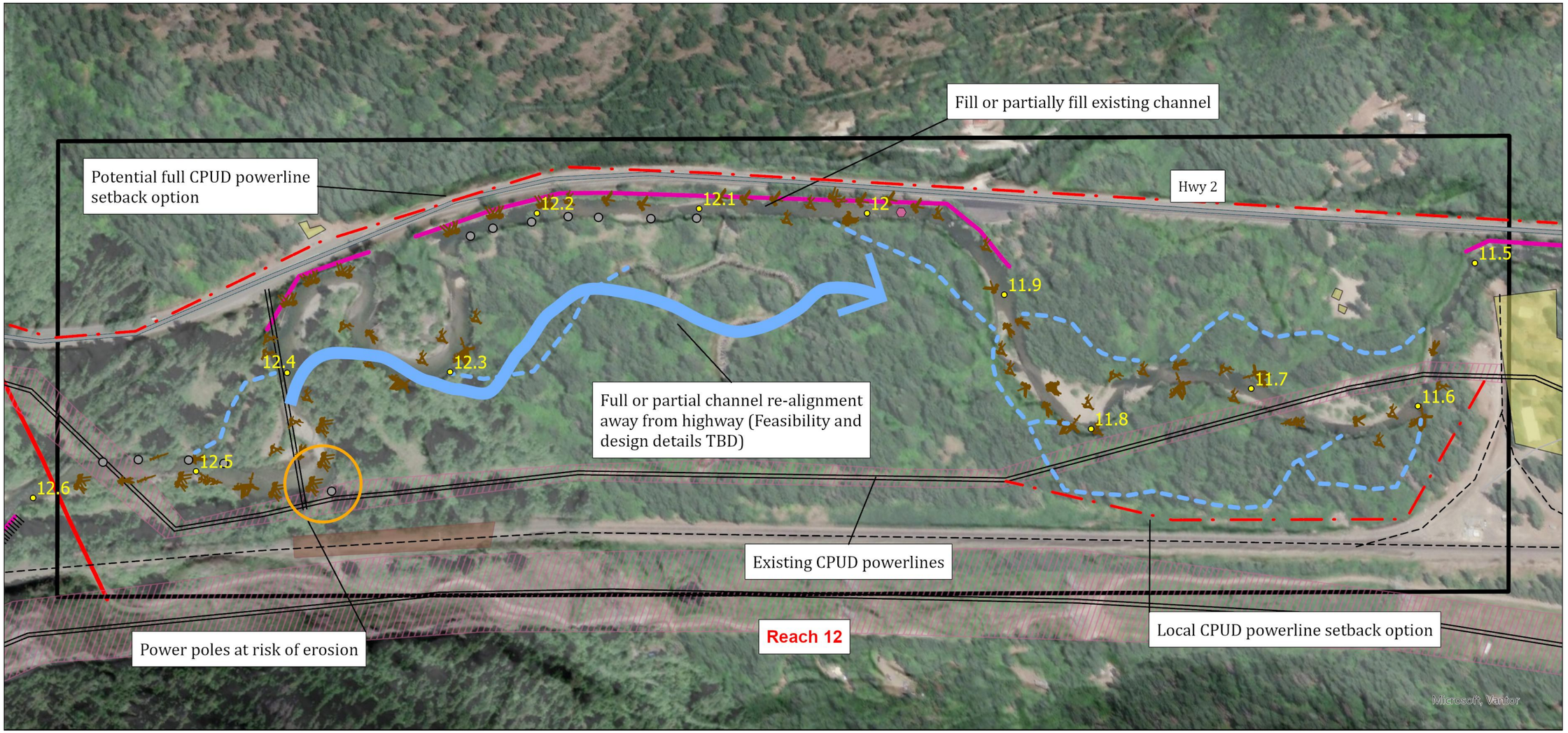
Project Elements

- Side Channel Activation
- Remove or Modify Armoring
- Fill Removal
- Riparian Restoration
- Individual logs
- Complexity jams
- Whole trees
- Apex jams
- Bank jams

These are preliminary concepts intended to describe the type of potential restoration work that could be performed. Additional site investigations and analysis will be necessary to determine specific treatment types and locations.

Built Features

- Constructed Jam
- Culvert
- Gaging Station
- PIT Tag Array
- Water Withdrawal
- Bank Armoring
- Powerline
- Primary Road
- Secondary Road
- Gravel Road
- Railroad
- Utility Corridor
- Levee/Fill
- Bridge
- Mining
- Recreation
- Structure



Nason Creek Reach Assessment Update

Project Opportunities

Lower UWP

N

0 0.1 0.2 Miles

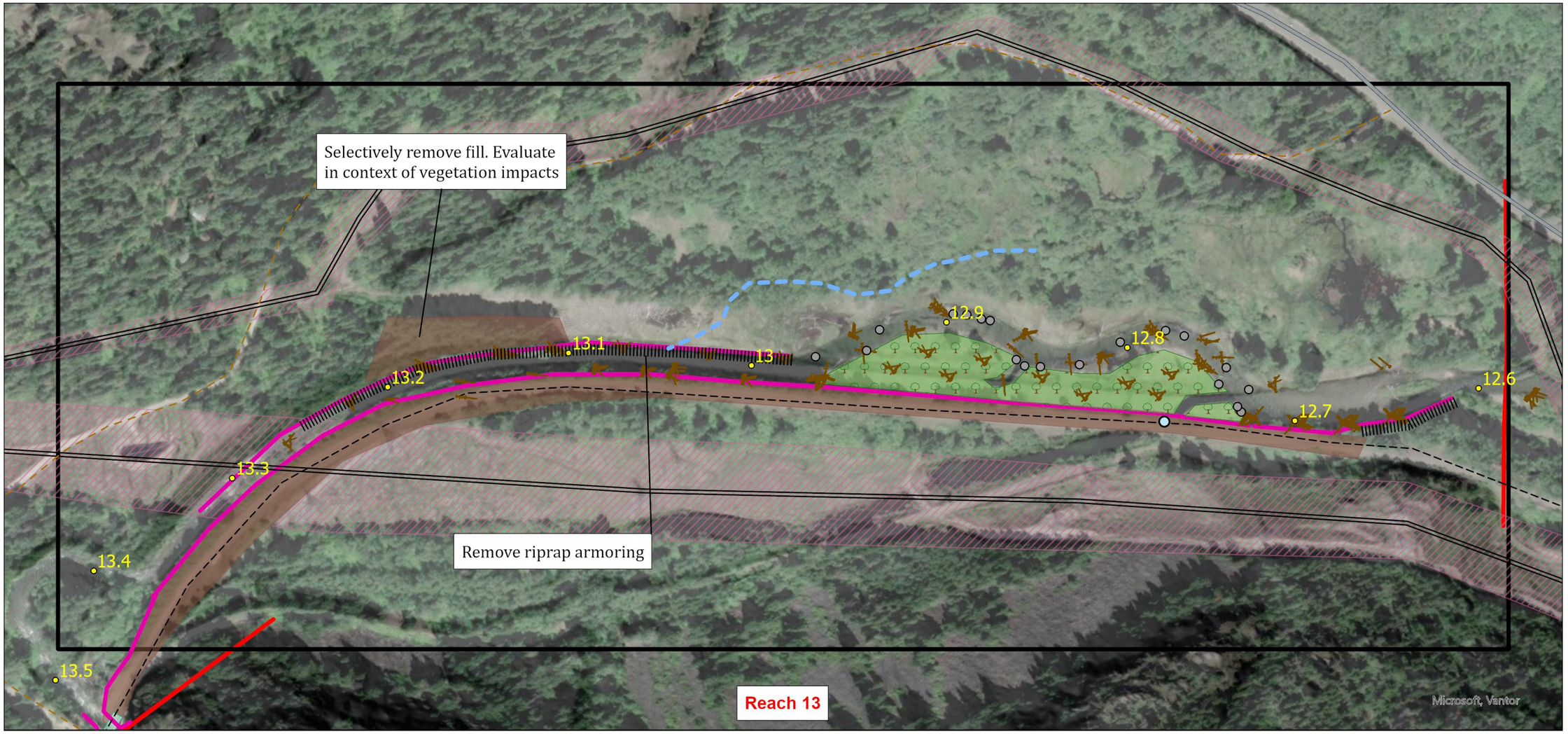
Project Elements

- Side Channel Activation
- Remove or Modify Armoring
- Fill Removal
- Riparian Restoration
- Individual logs
- Complexity jams
- Whole trees
- Apex jams
- Bank jams

These are preliminary concepts intended to describe the type of potential restoration work that could be performed. Additional site investigations and analysis will be necessary to determine specific treatment types and locations.

Built Features

- Constructed Jam
- Culvert
- Gaging Station
- PIT Tag Array
- Water Withdrawal
- Bank Armoring
- Powerline
- Primary Road
- Secondary Road
- Gravel Road
- Railroad
- Utility Corridor
- Levee/Fill
- Bridge
- Mining
- Recreation
- Structure



Nason Creek Reach Assessment Update

Project Opportunities

Upper UWP

N

0 0.1 0.2 Miles

Project Elements

- Side Channel Activation
- Remove or Modify Armoring
- Fill Removal
- Riparian Restoration
- Individual logs
- Complexity jams
- Whole trees
- Apex jams
- Bank jams

These are preliminary concepts intended to describe the type of potential restoration work that could be performed. Additional site investigations and analysis will be necessary to determine specific treatment types and locations.

Built Features

- Constructed Jam
- Culvert
- Gaging Station
- PIT Tag Array
- Water Withdrawal
- Bank Armoring
- Powerline
- Primary Road
- Secondary Road
- Gravel Road
- Railroad
- Utility Corridor
- Levee/Fill
- Bridge
- Mining
- Recreation
- Structure

3 Project Prioritization and Ranking

3.1 PRIORITIZATION MATRIX (RANKED BY TOTAL BENEFIT SCORE)

Project Area						Benefit Score									Cost Score		Cost Benefit	Feasibility Designation	
						Restoration Gap Analysis				Existing and Potential Fish Use		Root Causes							
Tiers	Project Name	Reach	Down-stream RM	Up-stream RM	Total Length (mi)	Existing Condition (1-7)	Achievable Target (1-7)	Final Gap Score (Target - Existing) (0-6)	Rationale/ assumption	Score (1-3)	Rationale/ assumption	Score (1-3)	Rationale/ assumption	Total Benefit Score	Cost Score (1-4)	Rationale/ assumption	Benefit-to-Cost Score	Feasibility Designation	Rationale/ assumption
1	Miracle Mile	3, 4	1.50	3.00	1.50	3.5	5.5	2	Mostly undeveloped. Past harvest and private lands main impacts. Good uplift potential.	3	Low gradient, good gravels, abundant potential spawning and rearing habitat types.	2.5	Root causes are lack of wood and young vegetation. Some temperature and watershed -scale impacts that originate upstream are not addressed.	7.5	1	Straightforward complexity and side-channel work. Lots of public or conservation lands. Good access.	7.5	High	Majority of public or conservation lands. Good access.
	Lower UWP	12	11.50	12.60	1.10	2.5	4	1.5	Assumes full or partial channel re-route away from highway.	2.5	Low gradient, good gravels, abundant potential spawning and rearing use, despite impacts.	2.5	Assumes full or partial channel re-route away from highway, which would remove a fundamental process barrier.	6.5	3	Channel re-route would be expensive. Mostly public or conservation lands.	2.2	Moderate - High	Public lands. Infrastructure changes present challenges.
	Nason Ridge	4	3.00	4.50	1.50	3	4	1	Does not assume full State Route 207 re-route, but does assume partial as part of existing project in design.	3	Low gradient, good gravels, abundant potential spawning and rearing habitat types.	2	Does not assume full State Route 207 re-route, but does assume partial as part of existing project in design.	6	3	Road relocate is expensive	2.0	Moderate	Public and private lands. Infrastructure changes present challenges.
	LWP Second Bend	10, 11	9.90	10.60	0.70	1.5	2.5	1	Assumes no reconnection across railroad but does assume channel re-route or partial re-route near powerline crossing.	2.5	Low gradient, good gravels, abundant potential spawning and rearing use, despite impacts.	2	Assumes no reconnection across railroad but does assume channel re-route or partial re-route near powerline crossing.	5.5	3	Channel re-route would be expensive. Private lands.	1.8	Low - Moderate	Private lands. Infrastructure changes present challenges.
	Upper UWP	13	12.60	13.40	0.80	2	3.5	1.5	Much of channel still in relocated ditch along railroad. Assumes removal of armoring and fill upstream river-left and removal of riprap section downstream river-right, and subsequent lateral movement left over time.	2	Combination of low gradient with high potential use habitats and steeper gradient with less spawning and rearing habitat types.	2	Removing upstream river-left riprap and fill, and section of downstream riprap will help to restore lateral processes.	5.5	2	Fairly straightforward armoring/fill removal and large wood work. Public lands. Some potential railroad coordination and limitations.	2.8	Moderate - High	Public lands plus potential railroad ROW coordination. Infrastructure changes present challenges.
2	Confluence	1	0.00	0.60	0.60	2	2.5	0.5	Does not include moving State Route 207. Does include major side-channel or codominant main channel in west floodplain.	3	Use by Nason plus Wenatchee River fish. Low gradient, good potential spawning and rearing habitat types.	1.5	Does not include moving State Route 207. Does include major side-channel or codominant main channel in west floodplain.	5	2.5	Significant side-channel / codominant channel work	2.0	Moderate	Public and private lands. Infrastructure changes present challenges.
	Kahler	6, 7	5.40	7.50	2.10	3.5	4.5	1	Does not include Highway 2 relocate but does assume bumping channel off highway sections. Assumes powerlines stay in place. These constraints limit ultimate potential. But work at RM 5.9 bend have high potential benefits.	2	Steeper channel. limited spawning habitat. Good rearing potential, especially for steelhead.	2	Does not include Highway 2 relocate. Assumes powerlines stay in place. But adding wood will address loss of wood especially at RM 5.9 bend.	5	3	Highway bump-outs are expensive and have challenges. Some private lands.	1.7	Moderate	Public and private lands. Infrastructure changes present challenges.
	LWP First Bend	11	10.60	11.30	0.70	2	2.5	0.5	Given slightly higher existing due to past restoration work. Assumes no reconnection across railroad. Additional work will only add incremental additional benefit.	2.5	Low gradient, good gravels, abundant potential spawning and rearing use, despite impacts.	1.5	Assumes no reconnection across railroad. Not a lot of fundamental processes can be addressed with hard constraints remaining.	4.5	1.5	Mainly straightforward wood and side-channel work with landowners that have already allowed work. Some challenges with railroad adjacent work that might be in ROW	3.0	Moderate - High	Public and private lands. Infrastructure changes present challenges.

Project Area						Benefit Score									Cost Score		Cost Benefit	Feasibility Designation	
						Restoration Gap Analysis				Existing and Potential Fish Use		Root Causes							
Tiers	Project Name	Reach	Down-stream RM	Up-stream RM	Total Length (mi)	Existing Condition (1-7)	Achievable Target (1-7)	Final Gap Score (Target - Existing) (0-6)	Rationale/ assumption	Score (1-3)	Rationale/ assumption	Score (1-3)	Rationale/ assumption	Total Benefit Score	Cost Score (1-4)	Rationale/ assumption	Benefit-to-Cost Score	Feasibility Designation	Rationale/ assumption
3	Campground	1, 2	0.60	1.50	0.90	1.5	2	0.5	Assumes campground and road crossing stay in place. Needle cannot be moved far with hard constraints.	2.5	Low-to-moderate gradient, good potential spawning and rearing habitat types.	1	Assumes campground and road crossing stay in place.	4	2	Mainly just wood placements, but challenging access and safety measures.	2.0	Low - Moderate	Public lands. Recreational use and access challenges.
	Coles	5, 6	4.50	5.40	0.90	3.5	4	0.5	Does not include Highway 2 relocate or changes to Coles Corner area development. Only limited opportunities here.	2	Steeper channel. limited spawning habitat. Good rearing potential, especially for steelhead.	1.5	Does not include Highway 2 relocate or changes to Coles Corner area development.	4	1.5	Some potential access challenges. But public lands.	2.7	Moderate - High	Public lands. Infrastructure changes present challenges.
	LWP Sunland	10	9.10	9.90	0.80	1.5	2	0.5	Assumes no reconnection across railroad. Assumes minor bumping of channel off of railroad in placed.	2.5	Low gradient, good gravels, abundant potential spawning and rearing use, despite impacts.	1	Assumes no reconnection across railroad. Not a lot of fundamental processes can be addressed with hard constraints remaining.	4	2.5	Mainly wood work. But some landowner and railroad ROW challenges.	1.6	Low	Private lands. Infrastructure changes present challenges.
	Rest Stop	8, 9	7.50	9.10	1.60	3	3.5	0.5	Does not include Highway 2 relocate but does assume bumping channel off highway sections. Assumes powerlines stay in place. These constraints limit ultimate potential.	2	Steeper channel. limited spawning habitat. Good rearing potential, especially for steelhead.	1	Does not include Highway 2 relocate. Assumes powerlines stay in place. Not a lot of fundamental processes can be addressed with these hard constraints remaining.	3.5	3	Highway bump-outs are expensive and have challenges. Some private lands.	1.2	Low - Moderate	Mostly private lands. Infrastructure changes present challenges.

3.2 PROJECT RANKING METHODS

Step 1: **Benefit Score**: Projects are scored according to 3 benefit categories, which include a "recovery gap" category and 2 additional categories. Scores for each category are summed to obtain the ***Benefit Score***.

Step 2: **Cost Score**: Projects are given a ***Cost Score***, which reflects the overall *relative cost* for the project based on techniques, access, and construction feasibility issues.

Step 3: **Benefit-to-Cost Score**: Total benefit score (sum of all 4 benefit scores) is divided by the cost score to obtain the ***Benefit-to-Cost Score***.

Step 4: **Feasibility Designation:** Projects are given a ***Feasibility Designation*** based on the overall likely feasibility of being able to implement the project within a 10-year timeframe.

Benefit Score

The Benefit Score includes the summation of scores from 3 categories. These include the Recovery Gap score (0-6 points), the Fish Use score (1-3 points), and the Root Causes score (1-3 points). The guidelines for scoring are provided below.

Recovery Gap

Existing Condition Rating (1-7)

1 – Very low ecosystem function and habitat quality. Highly altered systems.
2 – Low ecosystem function and habitat quality.
3 – Low-to-moderate ecosystem function and habitat quality.
4 – Moderate ecosystem function and habitat quality.
5 – Moderate-to-high ecosystem function and habitat quality.
6 – High ecosystem function and habitat quality.
7 – Very high level of natural ecosystem function and habitat quality. Pristine, unaltered systems.

Achievable Condition Rating (1-7)

These ratings use the same categories as above but reflect the future potential recovery trajectory. This is a rating of what can realistically be achieved given past and on-going impacts and constraints of land use, infrastructure, social acceptance, and ownership. Ratings should reflect an "optimistic potential scenario" in order to not discount large potential changes.

Final Gap Score (0-6)

This is simply the achievable condition rating minus the existing condition rating. This represents the gap that can be filled between existing and target conditions through restoration measures.

Fish Use

3 – High existing or potential productivity area for spawning or rearing for multiple species
2 – Moderate existing or potential productivity area for one or more species
1 – Low existing or potential productivity area for one or two species

Root Causes

3 – Restoration of root causes and key physical processes that create and maintain habitat over time
2 – Partial restoration of root causes
1 – Primarily a structurally-focused restoration strategy that doesn't significantly address underlying causes

Cost Score

The cost score reflects the relative cost for the project based on techniques, access, and feasibility issues. This is a relative cost, not an absolute cost, so the scale of the project is NOT factored into this score. The cost score ranges from 1 to 4, with 1 reflecting relatively lower cost projects. The following guidelines/examples can help to determine the cost score.

4 – High relative cost

- Requires high-cost techniques or materials (e.g., highly engineered log jams, extensive channel shaping, water crossings or bridges)
- Deep excavation or long-distance hauling of spoils
- Entails construction of additional new flood control or bank erosion features (e.g. set-back levees or buried rip-rap)
- Intensive de-watering requirements
- Limited, difficult, or remote access

2-3 – Moderate relative cost

- Uses moderate cost techniques (e.g. typical log jam structures)
- Moderate excavation and hauling distance of spoils
- Typical planting or invasive weed control
- Moderate access conditions
- Standard or no de-watering requirements

1 – Low relative cost

- Uses low cost techniques (e.g. non-ballasted log placements)
- Minimal excavation and hauling distance of spoils
- Little to no planting or weed control
- Easy access conditions
- No de-watering required
- Availability of free materials or volunteer labor

Benefit-to-Cost Score

The benefit-to-cost score is simply the benefit score divided by the cost score. This is a relative value used to compare project benefits.

Feasibility Designation

The feasibility designation is the overall likely feasibility of being able to implement the project within a 10-year timeframe. This is based on landownership, as well as economic, regulatory, political, social, permitting, or other considerations that are known to impact the feasibility of conducting projects within a reasonable timeframe. The feasibility designation is not used as part of the project scoring because feasibility issues may change over time and it is desirable to evaluate project benefits independent of feasibility. The designations include the following:

High feasibility

- No known feasibility issues.
- One or two landowners; or landowner(s) has already indicated willingness

Moderate feasibility

- There are potential feasibility constraints that could affect the likelihood of project implementation within a 10-year timeframe
- Three to five landowners; or there is reason to believe landowner(s) would grant permission

Unlikely feasibility

- There are known feasibility constraints that would be expected to limit the ability to implement the project within a 10-year timeframe
- More than five landowners: or there is reason to believe landowner(s) would not grant permission

Appendix D| Hydraulic Model

NASON CREEK REACH ASSESSMENT UPDATE

January 2026

Table of Contents

1 Introduction 2

2 Hydraulic Model Methodology 2

2.1 Model Setup 2

2.1.1 Model Terrain 2

2.1.2 Model Domain and Geometry 2

2.1.3 Bridges and Water Control Structures 4

2.2 Model Inputs 4

2.2.1 Model Roughness 4

2.2.2 Model Hydrology 6

2.2.3 Model Boundary Conditions 7

2.3 Model Calibration and Verification 8

3 Summary of Hydraulic Model Results 9

3.1 Modeled Velocity and Depth Results 9

3.2 Model Results Discussion 14

3.2.1 Model Results Overview 14

3.2.2 Model Results Considerations 14

4 References 16

1 Introduction

A hydraulic analysis of Nason Creek was conducted as part of the reach assessment. This analysis includes a preliminary-level 2-dimensional (2-D) hydraulic model of Reaches 1 to 13 of Nason Creek (RM 0 to 13.5). The model is used to understand general hydraulic characteristics of the river at a range of high flows, including stream energy (e.g. velocity), floodplain inundation patterns, and the effects of human and natural features on streamflow patterns. Model results were used to support the geomorphological interpretations that are included in the main document.

2 Hydraulic Model Methodology

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. Characteristics of Nason Creek, such as regions of high sinuosity, multiple regions of split flow, and a wide and complex floodplain, make it a good candidate for a 2-D model, as such features are difficult to accurately model using a 1-dimensional model. The model was developed for existing conditions to assess the current channel and floodplain dynamics, as well as to assess the impacts of a range of flows on the landscape. This model only accounts for surface water flows and does not include groundwater inputs. This document describes parameterization, assumptions, and set up of the hydraulic model. Results are depicted and discussed in Section 3.

2.1 MODEL SETUP

2.1.1 Model Terrain

A digital terrain model (DTM) was created using LiDAR data. The LiDAR includes 2022 topobathymetric data (NV5 Geospatial 2023), which captures below water terrain. This was mosaiced atop a topographic LiDAR dataset from 2020 (NV5 Geospatial 2022) that covered regions of the Nason Creek floodplain not included in the 2022 LiDAR. It should be noted that factors such as thick aquatic vegetation or algal growth, high turbidity, and pool depth can affect the accuracy of bathymetric LiDAR, so more detailed bathymetric surveys would likely be required to support project design work in specific locations.

2.1.2 Model Domain and Geometry

The model's domain extends from the Wenatchee River approximately a half-mile downstream of the State Route 207 bridge to just upstream of the Cascade Meadows Campground near RM 15.5 (Figure 1). The computational mesh consists of grid cells ranging from 15 to 50 feet, with the smallest grid cells used to provide higher resolution results along the channel and at features of interest (Figure 2). Channel cell sizes ranged from 15x15 to 20x20 ft, whereas much of the floodplain is made up of 50x50 ft cells. Larger cells on the floodplain can sometimes result in overestimation of inundation if cells span across high ground areas that would, in reality, be a flow barrier. Breaklines were added along topographic high points to align cell faces along high ground to improve the representation of the underlying terrain and to limit this "leaking" effect, but there can still be overestimation of floodplain inundation in some areas. Breaklines are also added along the channel to force cell alignment perpendicular to flow, improving efficiency and accuracy.

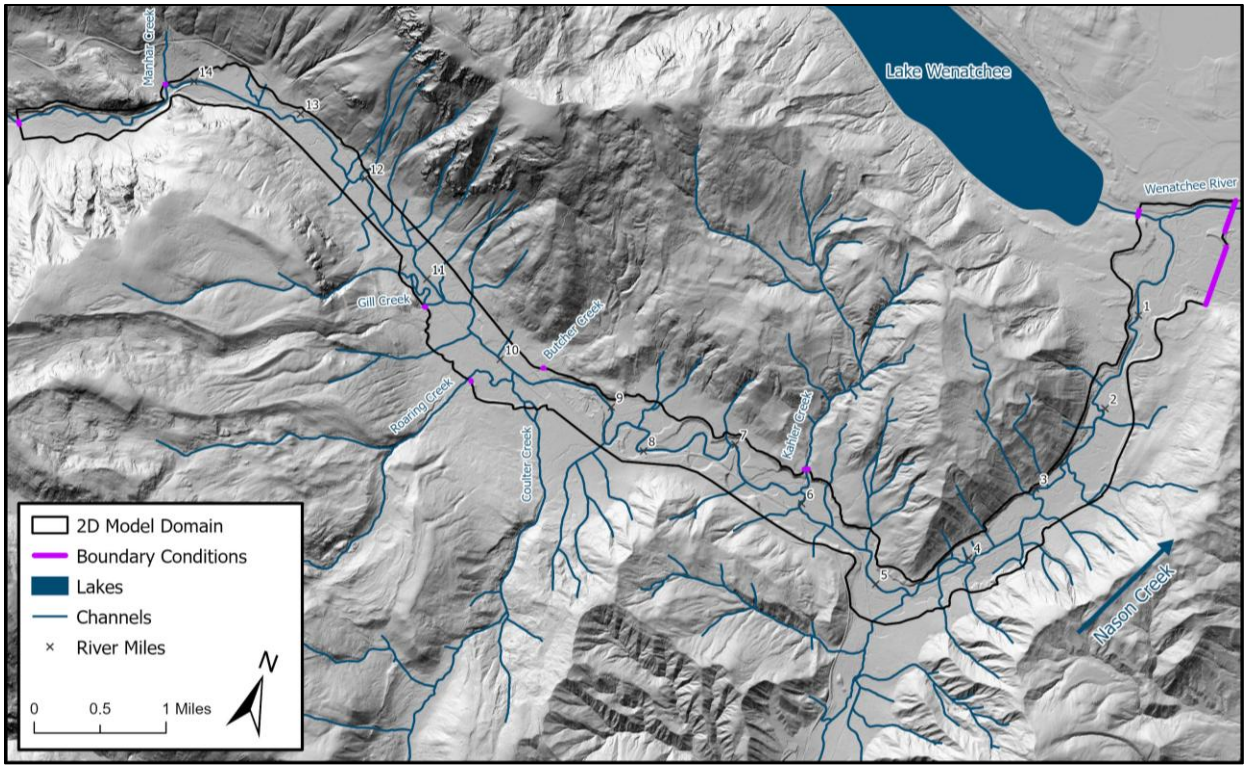


Figure 1. 2D model domain for Nason Creek showing tributaries included in the model, roads, and model external boundary locations.

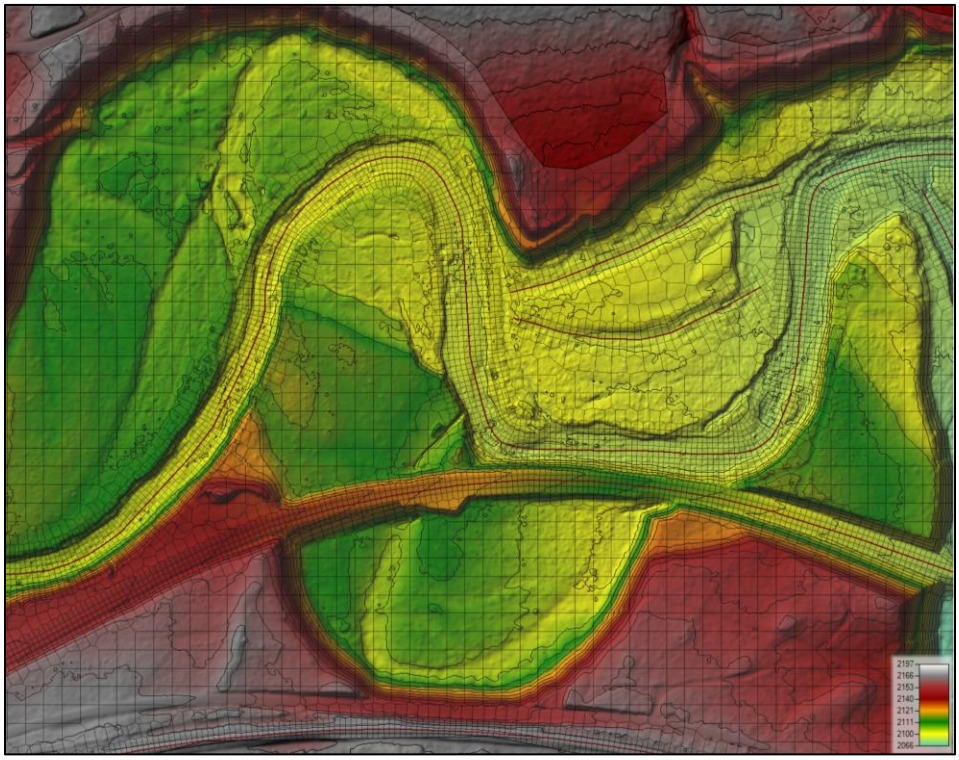


Figure 2. Representative computational mesh in the model domain (5 ft contours shown). Grid cells within the channel have a nominal size of 15-20 ft, while the outer floodplain cells are 50 ft. Breaklines (red) are enforced along channels and high ground features to align cell faces perpendicular to the prominent flow direction.

2.1.3 Bridges and Water Control Structures

Although there are several bridges that cross Nason Creek within the assessment area, bridge surveys were not performed and therefore no bridges were included in the model. Most of the bridges are high and likely have relatively minor or insignificant effects at the reach-scale at the flows used in the model. Nason Creek is confined by US Highway 2, State Route 207, and a BNSF railway embankment throughout much of the assessment area. Based on several sources of information, culverts were included in the model that allow flow connectivity through these features. Details of these culverts are listed in Table 1. Future design-level modeling will require survey of the specific locations and dimensions of bridges and water control structures.

Table 1. Culverts Included in the Nason Creek Preliminary Hydraulic model.

Name	Description	Location (RM)	Shape	Diameter (ft)	Material	Data Source
Culvert 1	Culvert beneath BSNF Railroad at Upper White Pine	13.5	RND	3	CMP*	1
Culvert 2	Culvert beneath BNSF Railroad for Gill Creek	10.8	RND	3	SST	2
Culvert 3	Upstream culvert of the Oxbow Reconnection Project	4	RND, Burried Bottom	12	CMP	3
Culvert 4	Downstream culvert of the Oxbow Reconnection Project	3.6	RND, Burried Bottom	12	CMP	3
Culvert 5	Upstream culvert beneath State Route 207 connecting wetland to Nason Creek	1.3	RND	12	CMP	2
Culvert 6	Downstream culvert beneath State Route 207 connecting wetland to Nason Creek	1.2	RND	12	CMP	2

1. United States Bureau of Reclamation (UWP Upper Project Design Plans)
2. Washington Department of Fish and Wildlife (WDFW 2021a, 2021b, 2021c)
3. Chelan County Natural Resources Department
*** Materials assumed based on nearby culvert descriptions and satellite imagery**

2.2 MODEL INPUTS

2.2.1 Model Roughness

A spatially varying Manning's n layer was developed using ArcGIS tools to represent hydraulic roughness throughout the model domain. The roughness layer was developed using a vegetation height layer created by subtracting the LiDAR bare ground layer (DTM) from the LiDAR first return layer (Digital Surface Model) and reclassifying these data to approximate vegetation communities by canopy height that would be represented by different Manning's n values. These data were supplemented with hand-digitized polygons representing more discrete features such as channels and roads. A table of

Manning's n coefficients and their associated classifications is provided in Table 2. Assumed channel roughness coefficients were 0.04 across most of the assessment area for both Nason Creek and the Wenatchee River. Floodplain roughness coefficients range from 0.03 to 0.08. Assumed roughness values were based upon previous project work in the region, professional judgement, and US Army Corps of Engineers guidance documents (USACE 2025a, 2025b).

Table 2. Roughness coefficients (Manning's n values) utilized in the preliminary existing conditions modeling.

Area Description	Roughness Coefficient (Manning's n Value)
Bare Earth and Grasses (<0.5ft)	0.03
Herbaceous Veg and Shrubs (0.5-2ft)	0.04
Shrubs (2-5ft)	0.055
Trees and Shrubs (5-10ft)	0.055
Forest (10-20ft)	0.055
Mature Forest (>20ft)	0.08
Road	0.025
Wenatchee River Channel	0.04
Main Nason Channel	0.04
Wood Loaded Side Channel	0.065
Side Channel	0.045
Corrugated Metal Pipe Culvert (CMP)	0.024
Steel Culvert (SST)	0.016
Gravel Buried Culvert Bottom	0.033

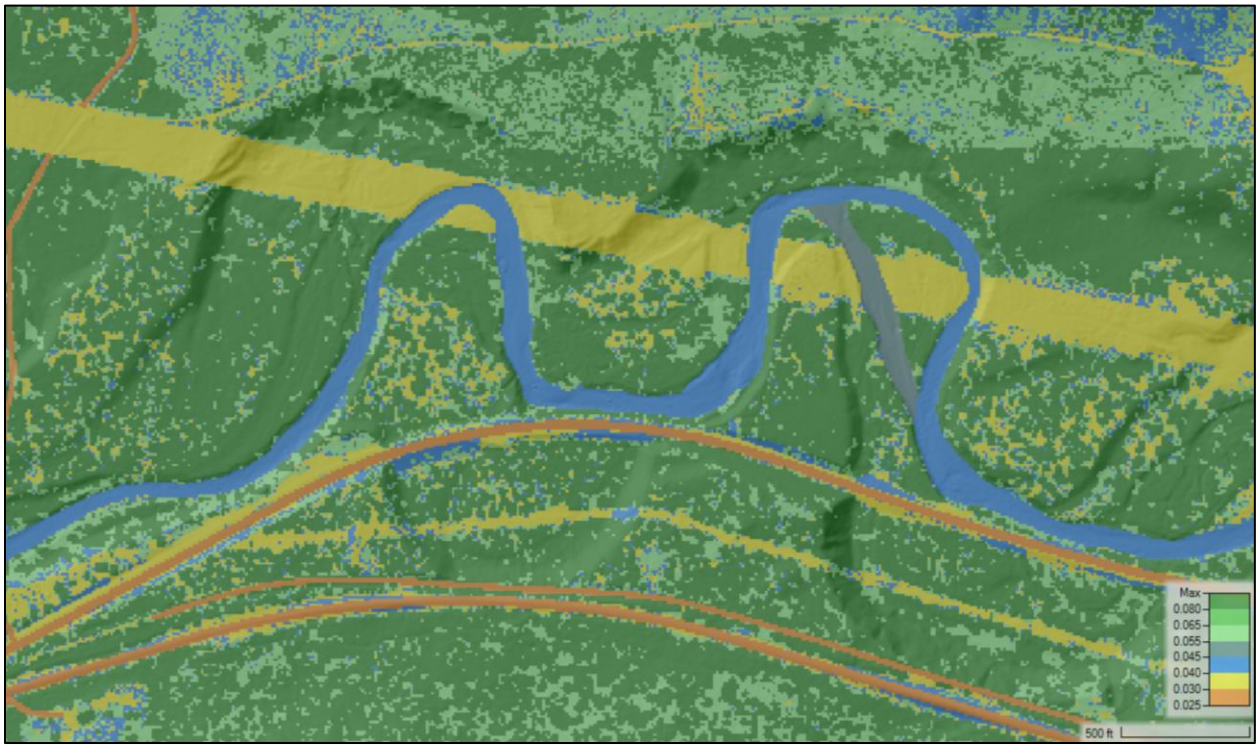


Figure 3. Representative depiction of roughness regions assigned to the existing conditions Nason Creek model.

2.2.2 Model Hydrology

The Washington Department of Ecology Nason Creek gage (Station 45J070) is affected by backwatering from the Wenatchee River at high flows (see Section 3.2.2 of the main report). Therefore, the hydrology for this model was estimated using similar methods as the Nason Creek Tributary Assessment (USBR 2008), which included taking the average of basin-area weighted peak flows for several nearby gages. 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), 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 for each gage using the Bulletin 17C flood frequency analysis methods using the HEC-SSP software (USACE 2023). A weighted skew was used, with a regional skew of -0.07 and a regional skew MSE of 0.18, following the guidelines in Mastin et al. (2017) (Table 1). The entire peak flow record for each gage was used to complete the analysis. The HEC-SSP results were then adjusted to the basin area of the assessment area using Equation 11 in Mastin et al. (2017) based on the drainage area of the gage and the drainage area of the top of the project area (RM 13.5) and the bottom of the project area (RM 0). These weighted peak flows for each gage were then averaged to estimate flows at the top and bottom of the project area. The difference between the estimated RM 13.5 and RM 0 estimates was apportioned to tributaries within the assessment area according to the methods described below.

Six tributaries to Nason Creek were identified as flow input locations within the assessment area: Mahar Creek, Gill Creek, Roaring Creek, Coulter Creek, Butcher Creek, and Kahler Creek. These inputs were represented as external tributary boundary conditions in the model. Roaring Creek and Coulter Creek were lumped into a single boundary condition due to their proximity. The difference in flows between the top and bottom of the project area were divided among the tributaries based on drainage area. The drainage area for each tributary was calculated as the difference between the drainage area of Nason Creek directly below the tributary confluence and the drainage area of the next upstream tributary included in the model. Drainage areas were calculated using StreamStats (USGS 2022).

An external boundary condition representing the Wenatchee River was included to simulate backwatering from the Wenatchee River at peak flow, assuming that peak flows in the two streams occur simultaneously. Peak flows for the Wenatchee River upstream of the confluence with Nason Creek were estimated using the "Ungaged Locations along the Wenatchee River Mainstem" regression equation developed in the Nason Creek Tributary Assessment (Eq.1) (U.S. Bureau of Reclamation 2008).

Table 3. Modeled flow events for Nason Creek and tributaries used in hydraulic modeling.

Flow Event	Nason (RM 13.5)	Mahar Creek	Gill Creek	Roaring and Coulter Creeks	Butcher Creek	Kahler Creek	Wenatchee River US of Confluence
2 - year	1,760	80	280	410	50	200	6,820
5 - year	2,410	110	370	550	60	270	9,080
10 - year	2,870	130	430	640	70	310	10,780
20 - year	3,470	150	510	760	90	370	13,180
50 - year	3,940	170	570	860	100	420	15,160
100 - year	4,430	190	630	950	110	460	17,300

The hydraulic model was used to evaluate existing conditions at flow events ranging from the 2-year to the 100-year event. A synthetic hydrograph containing inflows of interest was used as the model input hydrograph to simulate steady-state flow conditions for the peak flows, where the discharge of interest remains constant long enough to allow the model to reach a state of equilibrium (Figure 4). Allowing the model to reach a steady state during large flood events may overestimate flooding results, as floodplain storage areas throughout the model domain must reach capacity for the outflow of the model to reach steady-state conditions. In reality, this may not occur during short-duration events. However, it is a safe assumption for longer-duration events and is a more conservative (i.e., more likely to predict larger flooding extents) approach that was deemed appropriate for this preliminary-level model.

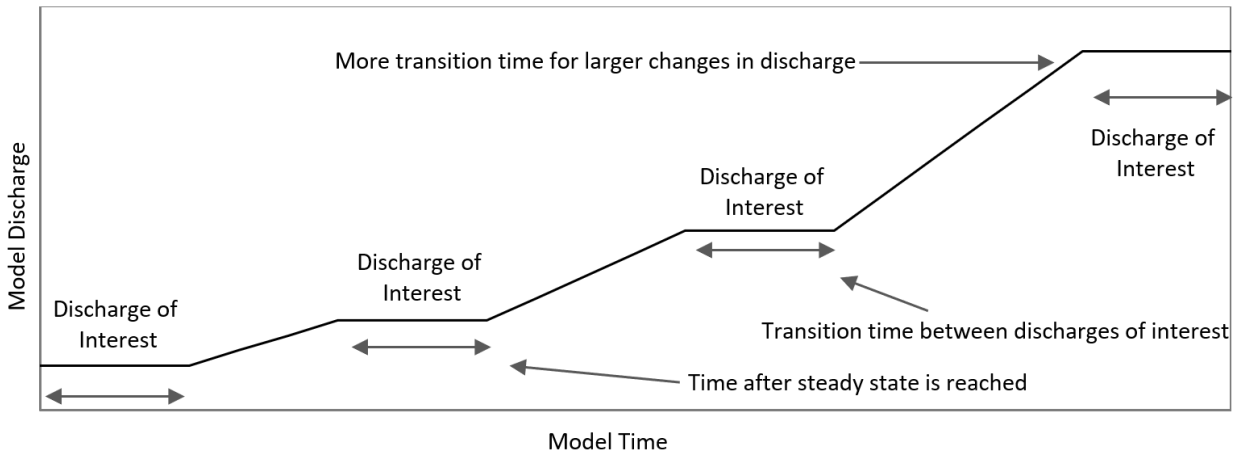


Figure 4. Demonstration of "stepped" flow input hydrograph.

2.2.3 Model Boundary Conditions

The upstream boundary condition was set to input the "Nason (RM 13.5)" flows at the top of the model as an external boundary condition, with an assumed energy grade line slope of 0.012 based on the terrain at the location of the upstream boundary, which estimates the energy loss across the boundary condition. Each of the tributaries, Mahar Creek, Gill Creek, Roaring/Coulter Creek, Butcher Creek, and Kahler Creek, were also added to the model as external boundary conditions with their own hydrograph and energy slopes estimated based on the channel bed slope from the LiDAR-based terrain, and with peak flow timings corresponding to the mainstem Nason Creek peak flows. The downstream boundary of the model is a normal depth downstream boundary condition approximately half a mile downstream of the

Nason Creek confluence with the Wenatchee River, with an assumed energy grade line slope of 0.002 based on the terrain at the location of the boundary.

2.3 MODEL CALIBRATION AND VERIFICATION

This model was not calibrated as discharge values from the nearby gage are backwatered by the Wenatchee River and the datum has not been published. The available bathymetric LiDAR was deemed to be a sufficient representation of the Nason Creek channel and floodplain for this analysis. Roughness values were informed by previous work done in the area that were calibrated based on previous field observations.

3 Summary of Hydraulic Model Results

The results of the Nason Creek model were used to assess existing condition channel hydraulics and floodplain dynamics. A wide range of flows were run in the model (2, 5, 10, 20, 50, and 100-year recurrence flood events). The 2-year and 100-year results are presented below. These flows were selected for inclusion because the 2-year flood represents a common high flow event and the 100-year represents an uncommon, very large flood and also has regulatory implications.

3.1 MODELED VELOCITY AND DEPTH RESULTS

Modeled velocity results for the 2-year and 100-year floods are included below in Figure 5 and 6. Modeled depth results for the 2-year and 100-year floods are shown in Figure 7 and 8.

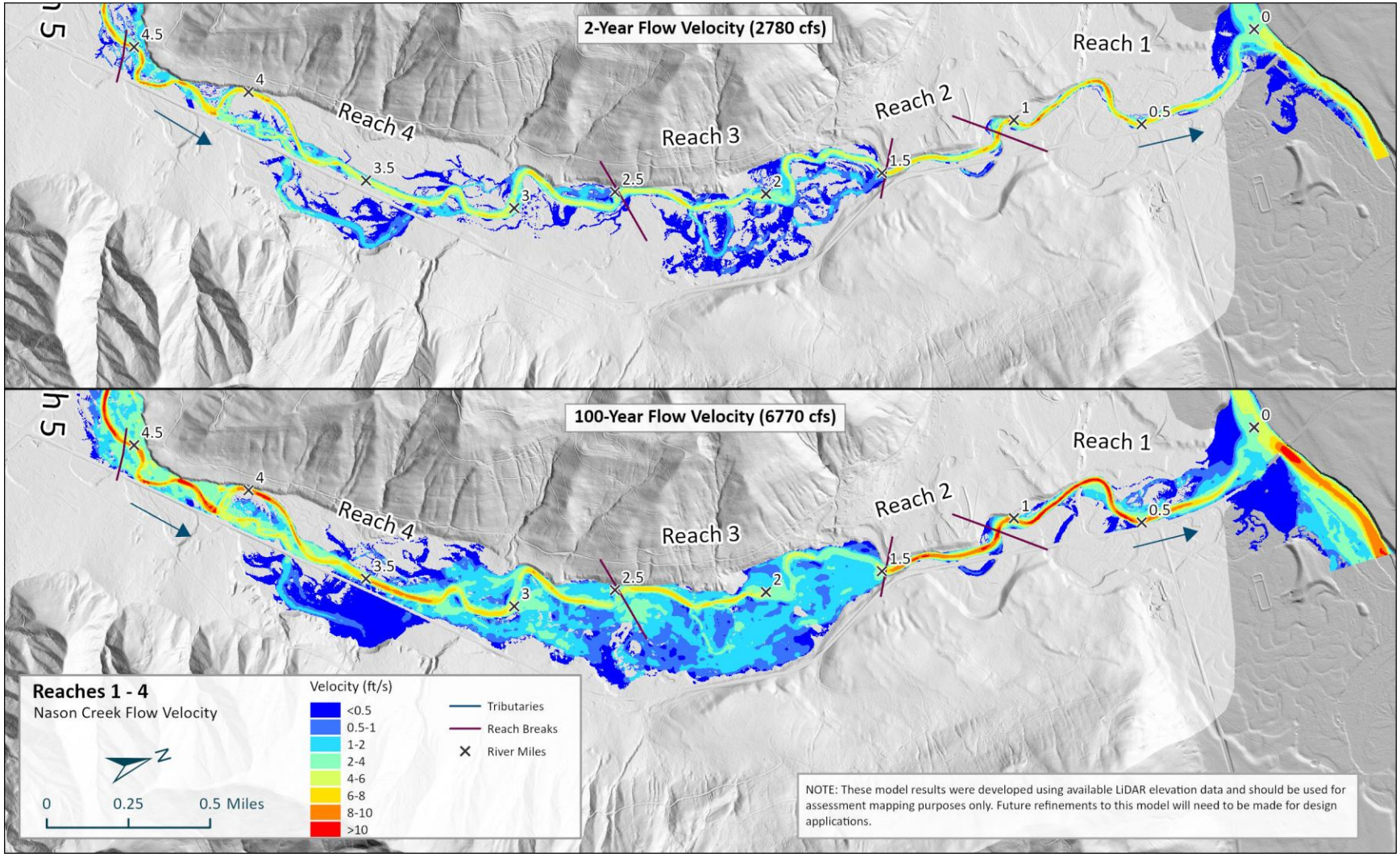


Figure 5. Modeled Nason Creek 2-year flood and 100-year flood velocities for reaches 1 to 4, labeled with the Nason Creek flowrate at the mouth.

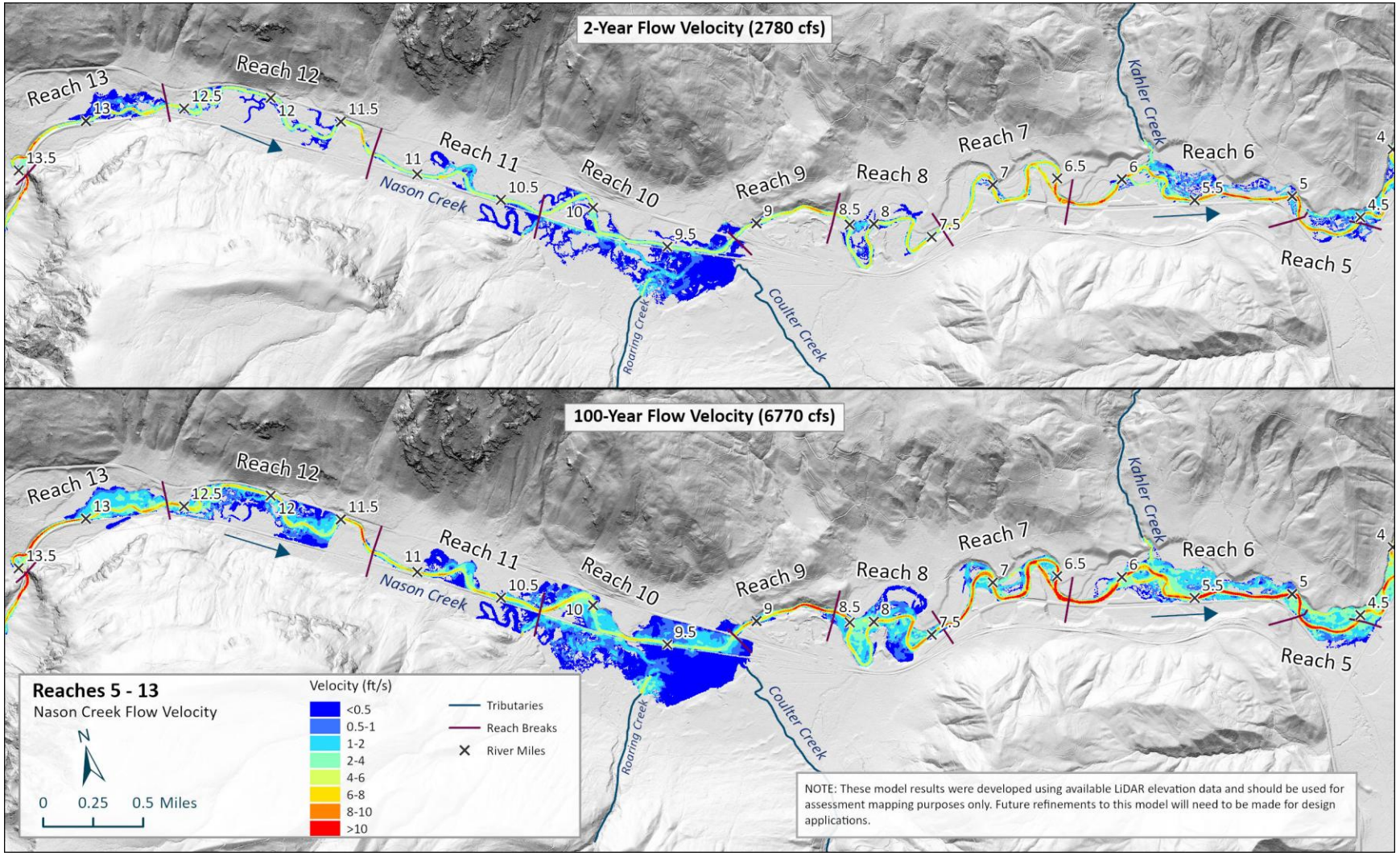


Figure 6. Modeled Nason Creek 2-year flood and 100-year flood velocities for reaches 5 to 13, labeled with the Nason Creek flowrate at the mouth.

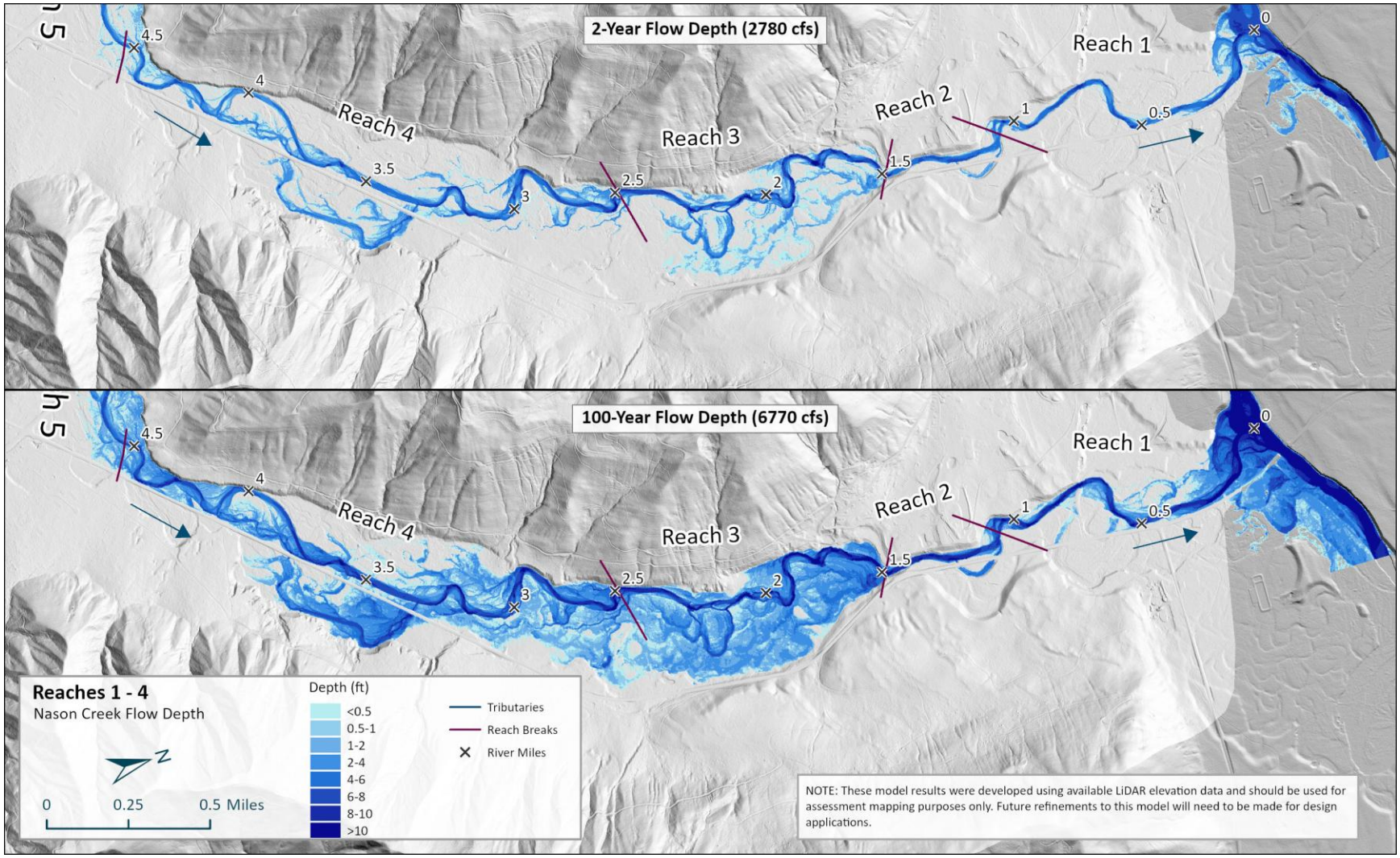


Figure 7. Modeled Nason Creek 2-year flood and 100-year flood depths for reaches 1 to 4, labeled with the Nason Creek flowrate at the mouth.

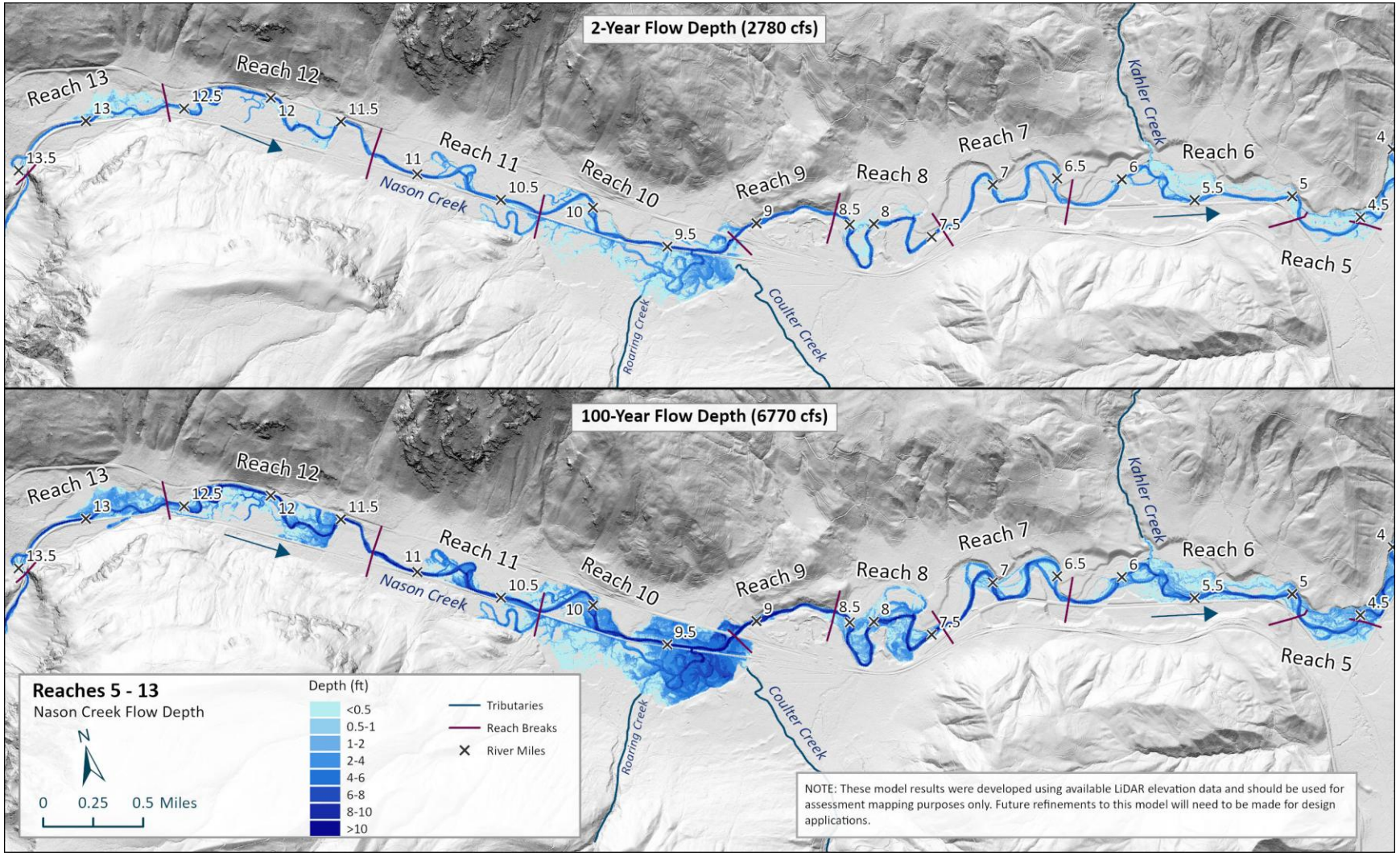


Figure 8. Modeled Nason Creek 2-year flood and 100-year flood depths for reaches 5 to 13, labeled with the Nason Creek flowrate at the mouth.

3.2 MODEL RESULTS DISCUSSION

3.2.1 Model Results Overview

Nason Creek is confined within the project area by natural hillslopes on river left through much of the study area, as well as by the BNSF railroad, State Route 207, and US Highway 2 on river right and left throughout the study area. Some hydraulic connection across these anthropogenic features is maintained through culverts and small bridges, some of which were included in the model (see Section 2.1.3). Culverts in reaches 2 and 4 allow side channels to flow beneath State Route 207 at all of the flows modeled in this analysis.

Because of the barriers, most of the flow at the 2-year event is confined to the main channel of Nason Creek throughout the assessment area. However, reaches 3 to 6 (and the downstream end of Reach 13) are an exception, with much of the floodplain inundated (<1 foot depth) and several side channels activated. In Reach 10, the large breach in the railroad facilitates greater connectivity to the historical channel alignment and wetland complex, where Coulter Creek and Roaring Creek flow into Nason Creek. During the 2-year flood, velocities in the main channel in reaches 5 to 7, and the upstream end of reach 13, exceed 10 feet per second (fps). At the 100-year flood, there is increased floodplain and side channel activation and increased velocities and depths across the assessment area, with main channel velocities exceeding 10 fps in reaches 1, 2, 4-9, and 13. Most floodplain velocities range from 1 to 4 fps and most floodplain depths range from 0.5 to 2 feet. As noted in Section 2.5.2 of the main report, terrace deposits possibly augmented with anthropogenic fill in Reach 12 push Nason Creek toward Highway 2 abruptly between RM 11.4 and 11.5, confining flow between the terrace and hillslope. Flow remains confined to the channel in this area, even during the 100-year flood event, with velocities downstream of the area exceeding 10 fps.

The model results indicate that high flows impact infrastructure within the assessment area. Model results indicate that at the 100-year flood, State Route 207 is inundated just upstream from the mouth (confluence area) with 0.5 to 2 feet of water. This is consistent with FEMA Zone A and Zone B boundaries designated in FIRM 5300150775B from 1989 for Chelan County. In addition, small private roads and structures are impacted by the 100-year flood event in numerous upstream reaches, including in reaches 4, 6, 8, 10, 11, and 12.

3.2.2 Model Results Considerations

This preliminary model was built using readily available data for the key terrain and hydrology inputs for the assessment area. Although these data are informative, they lack the detail to be used to design restoration projects. Future restoration projects will need to conduct additional surveys and other analyses to provide more accurate and precise data to support restoration design. Bathymetric surveys should be conducted to confirm that the available bathymetric LiDAR sufficiently represents the Nason Creek channel and major side-channels that contribute to conveyance. Topographic surveys should be conducted to assess infrastructure that may be affected by a given project. While this model included several large culverts connecting Nason Creek's side channels and tributaries, it is likely missing many others connecting Nason Creek with its floodplain. Upon review of model results with the reach assessment survey teams, it was noted that several culverts connecting Nason Creek and old meanders

cut off by the BNSF railroad in the floodplain are missing, in reaches 10 and 11 especially. In addition, the several bridge crossings within the study area that were not explicitly represented in these hydraulic models should be further investigated to assess how they impact surrounding flow and inundation.

As discussed in Section 3.2.1, reliable flow data for Nason Creek is limited and there are no gages monitoring inflows from tributaries in the project area. This results in uncertainty in the accuracy of the peak flows used in this model. In addition, this model includes only six tributaries to Nason Creek in the study area, while there are many smaller creeks that flow into Nason Creek throughout the study area as can be seen in Figure 1. Future design efforts should investigate indicators of high flow events in a given project area as well as what additional flow inputs may be relevant. In addition, this model does not include groundwater inflow into Nason Creek, nor the infiltration of surface water into soil on the floodplain. The interchange of flow between groundwater and surface water within future project areas may warrant investigation to inform restoration design. Based on feedback from the reach assessment survey teams, this lack of groundwater data appears to be underestimating inundation in several areas, especially in Reach 13's river-right floodplain, which is cut off from the main channel of Nason Creek by the railroad.

4 References

Mastin, M. C., C. P. Konrad, A. G. Veilleux, and A. E. Tecca. 2017. Magnitude, Frequency, and Trends of Floods at Gaged and Ungaged Sites in Washington, Based on Data through Water Year 2014 (ver 1.2). U.S. Geological Survey Scientific Investigations Report:2016–5118.

NV5 Geospatial. 2022. WA_EASTERNCASCADES_2019_B19 LIDAR Processing Report.

NV5 Geospatial. 2023. Methow and Wenatchee River Basins, Washington Topobathymetric Lidar Technical Data Report. Corvallis, OR.

USACE. 2023. Hydrologic Engineering Center Statistical Software Package (HEC-SSP 2.3). U.S. Army Corps of Engineers Hydrologic Engineering Center.

USACE. 2024. Hydrologic Engineering Center River Analysis System (HEC-RAS), HEC-RAS 6.6.

USACE. 2025a. HEC-RAS River Analysis System Manning's Roughness Coefficient.

USACE. 2025b. HEC-RAS River Analysis System Energy Loss Coefficients.

USBR (US Bureau of Reclamation). 2008. Nason Creek Tributary Assessment. US Bureau of Reclamation, Technical Service Center, Denver, CO & PNW Regional Office, Boise, ID. Authors: J. Bountry, L. Piety, R. McAffee, E. Lyon, C. Raekes, D. Sutley, K. Willie, T. Maguire, D. Bennett, D. Sisneros, J. Boutwell, and D. Callahan.

USGS. 1957. Railroad Creek at Lucerne, WA 12451500 - USGS Water Data for the Nation. https://waterdata.usgs.gov/monitoring-location/12451500/#dataTypeId=daily-00060-0&period=P1Y.

USGS. 2022. The StreamStats program. U.S. Geological Survey.

USGS. 2024a. USGS Surface-Water data for Washington. https://waterdata.usgs.gov/monitoring-location/12458000/#dataTypeId=continuous-00065-0&period=P7D&showMedian=false.

USGS. 2024b. USGS Surface-Water data for Washington. https://waterdata.usgs.gov/monitoring-location/12457000/#dataTypeId=continuous-00065-0&period=P7D&showMedian=false.

USGS. 2025a. Entiat River Near Ardenvoir, WA - USGS Water Data for the Nation. https://waterdata.usgs.gov/monitoring-location/12452800/#dataTypeId=continuous-00065-0&period=P7D.

USGS. 2025b. Stehekin River at Stehekin, WA 12451000 - USGS Water Data for the Nation. https://waterdata.usgs.gov/monitoring-location/12451000/#dataTypeId=continuous-00065-0&period=P7D.

USGS. 2025c. Chiwawa River Near Plain, WA 12456500 - USGS Water Data for the Nation. https://waterdata.usgs.gov/monitoring-location/12456500/#dataTypeId=continuous-00065-0&period=P7D.

WDFW. 2021a. Fish and Wildlife Fish Passage & Diversion Screening Inventory Database Report Cover Sheet, Unnamed Wetland, Site 961018.

WDFW. 2021b. Fish and Wildlife Fish Passage & Diversion Screening Inventory Database Report Cover Sheet, Gill Creek Culvert, Site 603012.

WDFW. 2021c. Fish and Wildlife Fish Passage & Diversion Screening Inventory Database Report Cover Sheet, Unnamed Wetland, Site 991635.

WDOE. 2024. Freshwater DataStream Station Information White R. nr Plain (45K090).