

# Icicle Creek Reach Assessment

## Appendix C | Restoration Strategy

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# 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 and Appendix B: Reach-based Ecosystem Indicators), as the technical basis for identifying and prioritizing restoration actions. This framework of developing a restoration strategy provides a direct linkage between the technical analyses, identified limiting factors, and the actions that are moved forward towards implementation. The restoration objectives (targets) are used to guide the development of appropriate restoration action types for the assessment area. The Reach-Scale Restoration Strategies (Section 1.4) present summarized and compiled information in table format for the reaches. Conceptual maps and descriptions of the project opportunities are presented in Section 1.4.1. Project ranking in Section 3, lays out the targets, benefits, and costs scoring involved in prioritizing project opportunities for the restoration strategies.

## 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 Assessment 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 for the 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 in an effort to return the system close to its naturally functioning state. This is often not achievable, or advisable, due to existing changes to the underlying processes or to process impairments that are unlikely to change, such as a significant piece of infrastructure. 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 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 where it is currently lacking or that will not be created on its own in a reasonable timeframe given existing impairment. The 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 Icicle Creek assessment area, large sections of the floodplain vegetation were logged in the past and the forests are still recovering. Near some private property, campgrounds, and infrastructure, riparian vegetation has been cleared or impacted for homes/buildings, agricultural purposes, roads and trails, or crossings. Restoration actions are focused on restoring native riparian vegetation communities to reestablish natural stream stability, 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 Icicle Creek assessment area lack geomorphic and habitat complexity as a result of historical logging, floodplain grading, channel manipulations, 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” 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. For example, log placement may be recommended in a field-identified existing pool to provide salmonid hiding cover. In contrast, several thousand feet of the channel may be identified as appropriate for large wood loading. 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 functions, from helping to

restore reach-scale geomorphic processes (e.g., apex jams to create multi-thread channel conditions) to simply adding structural cover and other habitat complexity features (e.g., adding large wood to an existing pool).

*Examples:*

- ▶ 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 identified 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 mainstem-connected side channel or off-channel habitat via excavation.
- ▶ Enhance conditions in new or created off-channel habitat.

### **4. Floodplain and Channel Migration Zone (CMZ) 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 processes. Floodplain connectivity projects are identified in areas where there is the potential to increase the quantity or frequency of floodplain inundation, most notably 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. CMZ reconnection projects include projects that restore the natural lateral adjustment process to a channel. Floodplain and CMZ reconnection strategies include a broad range of potential project types, including floodplain grading to create hydraulic connectivity, inset floodplains, or wetlands; as well as removal of constructed levees or armoring to reengage existing floodplain surfaces (or oxbows) and

to restore channel migration processes. 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 the bed 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 for channels, riparian zones, and floodplains. These are only identified where it complements restoration actions or where there is believed to be specific future risk of impairment. Most of the assessment area upstream of RM 6.6 is within the Okanogan-Wenatchee National Forest, with intermittent clusters of private parcels along the river corridor. Many of the private parcels have vacation homes and most of them are located on the hillslopes above the river, and not within the floodplain. Working with landowners to perform riparian revegetation would have benefits in some areas. Downstream of RM 6.6 is mostly privately owned, with the exception of the Leavenworth National Fish Hatchery in Reach 3. There is also a large parcel owned by the Icicle Irrigation District near the Snow Creek confluence (and Icicle-Peshastin Canal diversion area). The lower two reaches (RM 0-3) are dominated by private lands and this is where most of the conservation opportunities are located. Conservation measures in these areas would help to prevent additional development, including parcels without homes yet, and would also help facilitate restoration actions with willing and interested landowners. Because these parcels are on the floodplain and/or within the historical 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 apply to many of these parcels and, in theory, provide some level of conservation protection already.

This assessment does not 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 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 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 REACH-SCALE RESTORATION STRATEGIES**

Restoration strategies for each reach are provided below. The reach-scale restoration strategies identify existing ecologic/geomorphic conditions, project objectives and recovery potential, a list of potential projects, and recommended restoration action types. The ecological function (Low, Moderate, or High) of each reach 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 Reach Assessment Report and Habitat Assessment Appendix A). 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. The recovery potential rating considers known limitations to recovery that are unlikely to be eliminated with or without implementation of this restoration strategy, such as the presence of transportation and residential infrastructure.

1.4.1 Reaches 1 – 2 Restoration Strategy

<b>Overall ecological function</b>	<b>Low</b> <i>Rating is based on the Reach Assessment evaluations of habitat, geomorphology, hydrology, hydraulics, and vegetation. Six of 11 REI metrics in Reach 1 and eight of 11 REI metrics in Reach 2 are at risk or unacceptable. Significant impairment of channel and riparian function due to riparian vegetation clearing, lost or reduced habitat complexity, lack of large wood in the channel, and limited off-channel habitat.</i>
<b>Trajectory if no action taken</b>	<b>Decline</b> <i>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. Predominately private landownership may increase potential for ecological decline trajectory without intervention.</i>
<b>Recovery potential</b>	<b>Moderate</b> <i>Projects address lack of large in-channel structure but have limited impact on recovery of root causes due to effects of reach-wide incision related to floodplain and CMZ lateral constrictions that are assumed to remain.</i>
<b>Restoration objectives</b>	<b>Target conditions in Table 1</b> <i>Bring existing conditions to target conditions (multiple habitat and geomorphic attributes), where possible, for the metrics identified in Table 1 below. To the extent possible at this stage of planning, the targets are presented as measurable quantities.</i>
<b>Action Types</b>	<b>Riparian Restoration</b> <b>Enhance Channel Complexity</b> <b>Side and Off-Channel Habitat Creation or Enhancement</b> <b>Floodplain and CMZ Connectivity</b> <b>Conservation</b> <i>Actions include enhancement/improvement of channel complexity via large wood placements. Where possible given existing infrastructure, modification of anthropogenic features, such as bank riprap, would improve channel condition and floodplain connectivity. Excavation of side channel or oxbow/alcove inlets would increase available, accessible off-channel habitat areas in a relatively high fish-use portion of Icicle Creek. Revegetation within the riparian zone of cleared areas would improve long-term riparian conditions.</i>
<b>Project Areas &amp; Prioritization</b>	<b>Eiszapfen Bach</b> <b>Hatchery</b> <i>The potential to improve the quantity and quality of available habitat in Reaches 1 and 2 is moderate, and primarily includes large wood addition, targeted side channel inlet excavation, and replacement of bank armoring with more naturalized bank protection features that include large wood structures. Existing private land uses and infrastructure limit recovery potential in Reaches 1 and 2, though acquisition and protection of parcels as they become available would improve potential outcomes. Riparian restoration where banks have been cleared can support long-term recovery of large wood processes. If needed, the projects could be phased or divided into multiple smaller projects.</i>

**Table 1. Reaches 1 – 2 Restoration Objectives, Action Types, and Projects.**

Attribute	Existing Condition (from assessment)	Target Condition [REI – Adequate Rating]	Action Type	Project
Habitat Quality	Gravels present and the presence of fine sediments is moderate in both reaches. 39 and 34 pieces of medium or large LW per mile for Reach 1 and Reach 2, respectively. Pool habitat is extensive, and pools are deep but have limited cover/complexity. Only 2 side channels (qualified according to Level 2 protocols) are present.	Gravels or small cobbles make up >50% of the bed materials in spawning areas and ≤12% fines/sand (<6 mm) in spawning gravel. At least 67.45 pieces/mile of large wood and sources for LW recruitment. Due to backwater effect from Wenatchee River, pool frequency is not considered in Target Conditions. Pools should be deep and have good fish cover and cool water. Contains side or off-channel refugia.	Side and Off-Channel Habitat Creation or Enhancement  Enhance Channel Complexity  Floodplain and CMZ Connectivity	Eiszapfen Bach Hatchery
Riparian Condition	Riparian areas in Reaches 1 and 2 are highly disturbed and modified, with riparian clearing, infrastructure or other human land uses present within the riparian zone resulting in 57% Large Tree cover in Reach 1 and 73% Large Tree in Reach 2. Reach 2 has more riparian disturbance (20.5%) and road density (8.1 mi/mi <sup>2</sup> ). Both reaches have low thermal shading of the channel.	At least a 200-ft riparian buffer with: > 80% large trees, or consistent with potential native community < 20% riparian disturbance (human); high proportion of daylight hours with thermal shading over channel; and <2 mile/miles <sup>2</sup> road density.	Riparian Restoration  Floodplain and CMZ Connectivity  Conservation	Eiszapfen Bach Hatchery
Channel Dynamics	Floodplain disconnection is widespread, with reduced rates of lateral migration due to bank armoring. Some incision and confinement in Reach 2 due to road crossing and anthropogenic development.	Floodplain areas are hydrologically linked to main channel within the context of the local process domain. Channel is migrating at or near natural rates within the geomorphic construct of the reach. No measurable trend of aggradation or incision beyond the natural geomorphic processes of the reach.	Floodplain and CMZ Connectivity  Enhance Channel Complexity  Conservation	Eiszapfen Bach Hatchery

1.4.2 Reach 3 Restoration Strategy

<b>Overall ecological function</b>	<b>Low</b> <i>Rating is based on the Reach Assessment evaluations of habitat, geomorphology, hydrology, hydraulics, and vegetation. 9 of 11 REI metrics are at risk or unacceptable. Impairment of channel and riparian function due to the LNFH and associated infrastructure, including dams, roads, diversions, canals, levees, and riparian vegetation clearing have resulted in fish passage issues, minimal habitat complexity, a lack of large wood in the channel, and limited natural geomorphic processes.</i>
<b>Trajectory if no action taken</b>	<b>Decline</b> <i>Continued degradation due to persistent anthropogenic impacts to floodplain and channel, riparian zone, and large wood processes are assumed if no action is taken, primarily due to the presence of the LNFH and related infrastructure and water delivery systems.</i>
<b>Recovery potential</b>	<b>Moderate - High</b> <i>The hatchery project has some of the greatest uplift potential of any project in the assessment area due to the level of impairment and the magnitude of enhancement that could be achieved with comprehensive restoration treatments. Projects address simplification of aquatic habitats by removing or modifying infrastructure. Project addresses the lack of large in-channel structure, side-channel/off-channel habitat, floodplain connectivity, riparian conditions, and fish passage issues. Recovery potential decreases if the LNFH canal infrastructure remains in place.</i>
<b>Restoration objectives</b>	<b>Target conditions in Table 2</b> <i>Bring existing conditions to target conditions (multiple habitat and geomorphic attributes), where possible, for the metrics identified in Table 1 below. To the extent possible at this stage of planning, the targets are presented as measurable quantities.</i>
<b>Action Types</b>	<b>Riparian Restoration</b> <b>Enhance Channel Complexity</b> <b>Side and Off-Channel Habitat Creation or Enhancement</b> <b>Floodplain and CMZ Connectivity</b> <b>Conservation</b> <i>Actions include Removal and/or modification of LNFH canal and related features, such as graded surfaces, riprap, and flow diversions to reestablish the historical channel, floodplain connectivity, and channel dynamics for notably uplifted aquatic habitat in a potentially high spawning zone. Habitat enhancements include increased channel complexity via large wood placements and improved fish passage via roughened channel features. Regrade to functional floodplain. Establish side channels and revegetate area to improve long-term riparian conditions.</i>
<b>Project Areas &amp; Prioritization</b>	<b>Hatchery</b> <i>The potential to improve the quantity and quality of available habitat in Reach 3 is moderate – high. Treatment alternatives are varied and range from installation of large wood in the existing historical channel to removal of existing flow diversion canal and its associated in-channel structures. The most uplift potential exists when the treatments are combined. Potential restoration work downstream of Structure #5 could occur relatively independent of what occurs upstream. Riparian revegetation throughout would improve long-term riparian and large wood processes. If the existing infrastructure cannot be removed or modified, it will limit recovery potential in Reach 3.</i>

**Table 2. Reach 3 Restoration Objectives, Action Types, and Projects.**

Attribute	Existing Condition (from assessment)	Target Condition [REI – Adequate Rating]	Action Type	Project
Habitat Quality	Gravels present with relatively limited amounts of fines. Only 10 pieces of medium or large LW per mile. Pool habitat is extensive, and pools are deep but have limited cover/complexity. Limited side channel habitats are available.	Gravels or small cobbles make up >50% of the bed materials in spawning areas and ≤12% fines/sand (<6 mm) in spawning gravel. At least 67.45 pieces/mile of large wood and sources for LW recruitment. Meets the pool frequency criteria for bankfull width of 18 pools/mile, and pools should be deep and have good fish cover and cool water. Contains side or off-channel refugia.	Enhance Channel Complexity  Side and Off-Channel Habitat Creation or Enhancement  Floodplain and CMZ Connectivity	Hatchery
Riparian Condition	Where riparian trees are present, they are 86% large trees; 21.1% of the riparian zone is disturbed; 3.7 hours of shade during summer solstice (moderate thermal shading); and 10.6 mile/miles <sup>2</sup> road density within 200-ft riparian buffer.	At least a 200-ft riparian buffer with: > 80% large trees, or consistent with potential native community < 20% riparian disturbance (human); high proportion of daylight hours with thermal shading over channel; and <2 mile/miles <sup>2</sup> road density	Riparian Restoration  Floodplain and CMZ Connectivity	Hatchery
Channel Dynamics	Constructed levees, canal, terraces, and flow control structures currently limit connectivity to floodplain and impair habitat conditions. Anthropogenic influences have notably decreased lateral processes, and altered hydrology reduces flow hydraulics and channel dynamics.	Floodplain areas are hydrologically linked to main channel within the context of the local process domain. Channel is migrating at or near natural rates within the geomorphic construct of the reach. No measurable trend of aggradation or incision beyond the natural geomorphic processes of the reach	Floodplain and CMZ Connectivity  Enhance Channel Complexity  Side and Off-Channel Habitat Creation or Enhancement	Hatchery

**1.4.3 Reaches 4 – 9 Restoration Strategy**

<b>Overall ecological function</b>	<b>Moderate</b> <i>Rating is based on the Reach Assessment evaluations of habitat, geomorphology, hydrology, hydraulics, and vegetation. Though Reach 4 is one of the most impacted reaches with 9 of 11 REI metrics at risk or unacceptable, Reaches 7 – 9 are less impacted due to the naturally confined channel conditions, all with 4 of 11 REI metrics at risk or unacceptable. Reach 5 has 6 of 11 and Reach 6 has 5 of 11 REI metrics at risk or unacceptable, indicating moderate impairment to ecological function. Some disturbance to riparian vegetation and loss of habitat complexity with very limited off-channel habitat in these naturally confined reaches.</i>
<b>Trajectory if no action taken</b>	<b>Maintain</b> <i>Effects of historical and ongoing degradation will remain due to anthropogenic impacts that have resulted in primarily altered riparian and large wood processes. Possible long-term natural recovery of riparian condition due to mix of private and federally-owned land, though high recreational use in these reaches may limit that recovery.</i>
<b>Recovery potential</b>	<b>Low-Moderate</b> <i>Projects address lack of large in-channel structure but have limited impact on recovery of root causes due to naturally confined channel condition in a majority of Reaches 4 – 9. Campgrounds and roads/bridges are assumed to remain.</i>
<b>Restoration objectives</b>	<b>Target conditions in Table 3</b> <i>Bring existing conditions to target conditions (multiple habitat and geomorphic attributes), where possible, for the metrics identified in Table 3 below. To the extent possible at this stage of planning, the targets are presented as measurable quantities.</i>
<b>Action Types</b>	<b>Riparian Restoration</b> <b>Enhance Channel Complexity</b> <b>Floodplain and CMZ Connectivity</b> <b>Side and Off-Channel Habitat Creation or Enhancement</b> <i>Actions include enhancement/improvement of channel complexity via large wood placements. The most promising places for wood treatments are in Reach 4 and the lower portion of Reach 5, the upper portion of Reach 7, and Reaches 8 and 9, where channel confinement is reduced. Activation of side channel features where floodplains exist would increase available, accessible refugia habitat for fish migrating or rearing in these reaches. No project opportunities are proposed in Reach 6. Revegetation and fuels management on the banks and hillslopes could improve long-term riparian and large wood recruitment processes in these reaches.</i>
<b>Project Areas &amp; Prioritization</b>	<b>Tunnel</b> <b>Trident</b> <b>Eightmile</b> <i>The potential to improve the quantity and quality of available habitat in Reaches 4 – 9 is limited due to the geomorphic site conditions.. Treatments are primarily focused on large wood additions and some riparian restoration. A few opportunities exist for side channel activation where low floodplain surfaces are present. All three project areas are complimentary to each other and together would provide the greatest potential for uplift in Reaches 4 – 9 but would also provide habitat and function benefits if completed independently.</i>

**Table 3. Reaches 4 – 9 Restoration Objectives, Action Types, and Projects.**

Attribute	Existing Condition (from assessment)	Target Condition [REI – Adequate Rating]	Action Type	Project
Habitat Quality	Substrate dominated by boulders/cobbles but gravels present with low fines in all reaches except Reach 9, which had only 21% gravels. Pieces of medium or large LW per mile exceeded the threshold in all reaches except Reach 6. However, the LW provides low to marginal influence on geomorphic processes. Pools/mile did not meet pool frequency criteria in any of the reaches, though that is a function of the relatively steep boulder step-pool channel type that is not being adequately included in the USFS survey protocols. Pool shade/cover was low to moderate. Side channels are present in all reaches except Reach 6.	Gravels or small cobbles make up >50% of the bed materials in spawning areas and ≤12%fines/sand (<6 mm) in spawning gravel. At least 67.45 pieces/mile of large wood; adequate sources for LW recruitment; and wood is providing geomorphic function. Pool frequency of 18 pools/mile for Reaches 4, 5, 6, and 9 and pool frequency of 15 pools/mile for Reaches 7 and 8. ≥50% of pools ≥1m (3ft) deep and good fish cover and cool water. Contains side or off-channel refugia.	Enhance Channel Complexity  Floodplain and CMZ Connectivity  Side and Off-Channel Habitat Creation or Enhancement	Tunnel Trident Eightmile
Riparian Condition	Riparian overstory consists of 100% large trees in Reaches 4, 5, 8 and 9, but does not meet criteria in Reaches 6 and 7. Nevertheless, past logging has reduced the size and availability of effective large wood for all reaches. Riparian zone disturbance is high and does not meet Adequate rating criteria in all reaches, and low-moderate thermal shading is available (shading increases in Reaches 8 and 9).	At least a 200-ft riparian buffer with: > 80% large trees, or consistent with potential native community < 20% riparian disturbance (human); high proportion of daylight hours with thermal shading over channel; and <2 mile/miles <sup>2</sup> road density.	Riparian Restoration	Tunnel Trident Eightmile
Channel Dynamics	Most of these reaches are naturally confined. Channel dynamics are impaired in Reach 7, where a riprap spur blocks connectivity to a side-channel and low floodplain area. There are also instances of fill in side-channel inlets in reaches 8 and 9. Where valley width allows, narrow functional floodplains and islands exist, and connectivity is generally maintained.	Floodplain areas are hydrologically linked to main channel within the context of the local process domain. Channel is migrating at or near natural rates within the geomorphic construct of the reach. No measurable trend of aggradation or incision beyond the natural geomorphic processes of the reach.	Floodplain and CMZ Connectivity  Enhance Channel Complexity  Side and Off-Channel Habitat Creation or Enhancement	Trident Eightmile

1.4.4 Reach 10 Restoration Strategy

<b>Overall ecological function</b>	<b>Low-Moderate</b> <i>Rating is based on the Reach Assessment evaluations of habitat, geomorphology, hydrology, hydraulics, and vegetation. Three of 11 REI metrics are at risk or unacceptable. Some impairment of channel and floodplain function due to channel modification and floodplain disconnection and riparian vegetation clearing, resulting in reduced habitat complexity and loss of large wood in the channel.</i>
<b>Trajectory if no action taken</b>	<b>Maintain</b> <i>Continued impairment due to persistent anthropogenic impacts to floodplain/channel migration zone, riparian conditions, and large wood processes. Possible long-term recovery of riparian conditions due to federal land ownership, though high-use recreational activities within the reach may limit that recovery.</i>
<b>Recovery potential</b>	<b>Moderate-High</b> <i>Moderate-High potential for recovery, assuming Bridge Creek Campground and associated infrastructure remain on the landscape. Levee removal and off-channel work on river-right near RM 10.7 has good potential to create high quality habitat. The reach has potential to provide improved and important migratory refugia and rearing habitat between the more confined and higher gradient reaches upstream and downstream of it.</i>
<b>Restoration objectives</b>	<b>Target conditions in Table 4</b> <i>Bring existing conditions to target conditions (multiple habitat and geomorphic attributes), where possible, for the metrics identified in Table 4 below. To the extent possible at this stage of planning, the targets are presented as measurable quantities.</i>
<b>Action Types</b>	<b>Riparian Restoration Enhance Channel Complexity Side and Off-Channel Habitat Creation or Enhancement Floodplain and CMZ Connectivity</b> <i>Actions include enhancement/improvement of channel complexity via large wood placements. Removal of levee and fill (associated with decommissioned campground) on river-right may increase floodplain and off-channel refugia potential. Reconnection and maintenance of side channels to increase availability and diversity of aquatic habitat. Revegetation of open bank areas would improve long-term riparian conditions.</i>
<b>Project Areas &amp; Prioritization</b>	<b>Bridge Creek</b> <i>The potential to improve the quantity and quality of available habitat in Reach 10 is moderate-high. If all channel and floodplain treatment actions are implemented jointly, notable improvements are possible. However, existing campground and bridge infrastructure limit recovery potential in Reach 10.</i>

**Table 4. Reach 10 Restoration Objectives, Action Types, and Projects.**

<b>Attribute</b>	<b>Existing Condition (from assessment)</b>	<b>Target Condition [REI – Adequate Rating]</b>	<b>Action Type</b>	<b>Project</b>
Habitat Quality	Substrate is primarily boulder-dominated, with some gravels present (39% and 17% in the two pebble counts) and little fines. 108 pieces of medium or large LW per mile. However, the LW provides low to marginal influence on geomorphic processes in the confined sections. Only 3 pools per mile with 67% pools > 1m (3ft) and moderate to high pool shade/cover. Three side channels present.	Gravels or small cobbles make up >50% of the bed materials in spawning areas and ≤12% fines/sand (<6 mm) in spawning gravel. At least 67.45 pieces/mile of large wood and sources for LW recruitment. Pool frequency of 18/mile with ≥50% of pools ≥1m (3ft) deep and good fish cover and cool water. Contains side or off-channel refugia.	Enhance Channel Complexity  Side and Off-Channel Habitat Creation or Enhancement  Floodplain and CMZ Connectivity	Bridge Creek
Riparian Condition	Riparian overstory consists of 62% large trees; 7.3% of the riparian zone is disturbed; 5.8 hours of shade during summer solstice (moderate thermal shading); and 13.8 mile/miles <sup>2</sup> road density within 200-ft riparian buffer. Past logging and modern clearing for recreation has reduced the size and availability of effective large wood contributions. The campground significantly affects riparian conditions in the lower portion of the reach.	At least a 200-ft riparian buffer with: > 80% large trees, or consistent with potential native community < 20% riparian disturbance (human); high proportion of daylight hours with thermal shading over channel; and <2 mile/miles <sup>2</sup> road density	Riparian Restoration	Bridge Creek
Channel Dynamics	Channel is naturally partially confined, with two sections, one at the upstream end and one at the downstream end, that provide available floodplain and channel complexity. The downstream unconfined section does seem to be impaired and limited by a river-right levee near RM 10.7.	Floodplain areas are hydrologically linked to main channel within the context of the local process domain. Channel is migrating at or near natural rates within the geomorphic construct of the reach. No measurable trend of aggradation or incision beyond the natural geomorphic processes of the reach	Floodplain and CMZ Connectivity  Enhance Channel Complexity  Side and Off-Channel Habitat Creation or Enhancement	Bridge Creek

1.4.5 Reaches 11 – 14 Restoration Strategy

<b>Overall ecological function</b>	<b>Moderate</b> <i>Rating is based on the Reach Assessment evaluations of habitat, geomorphology, hydrology, hydraulics, and vegetation. Five of 11 REI metrics are at risk or unacceptable in all Reaches 11 – 14. Some impairment of channel habitat and function due to roads and campgrounds, bank armoring, and riparian vegetation clearing has reduced habitat complexity.</i>
<b>Trajectory if no action taken</b>	<b>Maintain</b> <i>The combined reaches are mostly moderately steep and confined with boulder riffles and step-pool sections. Some degradation due to persistent anthropogenic impacts from roads and recreational uses is likely, but some long-term recovery of riparian conditions is possible due to federal landownership.</i>
<b>Recovery potential</b>	<b>Low - Moderate</b> <i>Large wood addition would increase habitat complexity but not necessarily address the reduced short-term large wood supply. Assuming the road remains in place, the potential for recovery of riparian processes and channel margin complexity is limited.</i>
<b>Restoration objectives</b>	<b>Target conditions in Table 5</b> <i>Bring existing conditions to target conditions (multiple habitat and geomorphic attributes), where possible, for the metrics identified in Table 5 below. To the extent possible at this stage of planning, the targets are presented as measurable quantities.</i>
<b>Action Types</b>	<b>Riparian Restoration Enhance Channel Complexity</b> <i>Actions primarily include enhancement/improvement of channel complexity via large wood placements. Targeted revegetation may improve localized long-term riparian conditions.</i>
<b>Project Areas &amp; Prioritization</b>	<b>Johnny Victoria</b> <i>The potential to improve the quantity and quality of available habitat in Reaches 11-14 is low-moderate due to the relatively steep and confined nature of the channel.</i>

**Table 5. Reaches 11 – 14 Restoration Objectives, Action Types, and Projects.**

Attribute	Existing Condition (from assessment)	Target Condition [REI – Adequate Rating]	Action Type	Project
Habitat Quality	All reaches meet Adequate ratings for substrate, because reaches are naturally boulder-cobble dominant and do not geomorphically support spawning areas. Small pockets of gravels and few fines are present in the reaches. Only Reach 14 meets the large wood criteria for pieces of medium and large LW per mile, all other reaches were rated as Unacceptable. The LW that is present usually provides low to marginal influence on geomorphic processes. Most reaches did not meet the pool frequency criteria, however, natural conditions (steep slope and bedrock confinement) limit formation of pools that met survey criteria. Pool cover was generally low overall. Side channels were relatively limited.	Gravels or small cobbles make up >50% of the bed materials in spawning areas and ≤12% fines/sand (<6 mm) in spawning gravel. At least 67.45 pieces/mile of large wood and sources for LW recruitment. Pool frequency of 18/mile with ≥50% of pools ≥1m (3ft) deep and good fish cover and cool water. Contains side or off-channel refugia.	Enhance Channel Complexity	Johnny Victoria
Riparian Condition	Riparian overstory consists of primarily large trees but not all reaches met the Adequate criteria. Past logging and roads have reduced the size and availability of effective large wood contributions. Up to 8% of the riparian zone was disturbed (Reach 13). Moderate channel shading is available in these reaches, and between 9.5 – 13.2 mile/miles <sup>2</sup> road density within 200-ft riparian buffer. The proximity of the roadway affects riparian conditions in numerous locations.	At least a 200-ft riparian buffer with: > 80% large trees, or consistent with potential native community < 20% riparian disturbance (human); high proportion of daylight hours with thermal shading over channel; and <2 mile/miles <sup>2</sup> road density	Riparian Restoration	Johnny Victoria
Channel Dynamics	Where valley width allows, narrow functional floodplains and islands exist, and connectivity is maintained. Channel is laterally migrating at natural or near natural rates (mostly naturally confined) and no measurable trend in incision or aggradation (beyond natural geomorphic processes) was observed.	Floodplain areas are hydrologically linked to main channel within the context of the local process domain. Channel is migrating at or near natural rates within the geomorphic construct of the reach. No measurable trend of aggradation or incision beyond the natural geomorphic processes of the reach	Enhance Channel Complexity	Johnny Victoria

1.4.6 Reaches 15 – 20 Restoration Strategy

<b>Overall ecological function</b>	<b>Low</b> <i>Rating is based on the Reach Assessment evaluations of habitat, geomorphology, hydrology, hydraulics, and vegetation. Reach 17 and Reach 15 are more impacted reaches, with 9 out of 11 and 8 out of 11 REI metrics at risk or unacceptable, respectively. Reaches 14 and 18 had 5 out of 11 REI metrics at risk or unacceptable, and Reaches 16, 19, and 20 each had 7 of 11 REI metrics at risk or unacceptable. Impairment of channel habitat complexity, limited off-channel habitat, and disturbance to riparian vegetation are the primary impairments.</i>
<b>Trajectory if no action taken</b>	<b>Maintain or Improve</b> <i>Effects of degradation due to anthropogenic impacts to floodplain, channel migration and incision, riparian, and large wood processes continue, but recovery over the long term may be possible due to a more responsive channel type in these reaches compared to downstream. Possible long-term recovery of riparian condition, especially in the upper reaches.</i>
<b>Recovery potential</b>	<b>Moderate - High</b> <i>Significant available opportunities for improving aquatic habitat conditions via large wood addition and off-channel habitat reconnection. Projects address the lack of large in-channel structure and the processes that create and maintain it over the long-term.</i>
<b>Restoration objectives</b>	<b>Target conditions in Table 6</b> <i>Bring existing conditions to target conditions (multiple habitat and geomorphic attributes), where possible, for the metrics identified in Table 6 below. To the extent possible at this stage of planning, the targets are presented as measurable quantities.</i>
<b>Action Types</b>	<b>Riparian Restoration Enhance Channel Complexity Side and Off-Channel Habitat Creation or Enhancement Floodplain and CMZ Connectivity</b> <i>Actions include enhancement/improvement of channel complexity via large wood placements. Includes removal or modification of defunct anthropogenic features (i.e. old road fill and armoring in Reach 15) to improve floodplain connectivity. Excavation of side channels would increase available, accessible off-channel habitat or floodplain wetland areas. Revegetation of open areas and fuels reduction treatments in Reaches 17, 18 and 19 would support improved long-term riparian conditions. Upstream of the wilderness boundary in Reach 20 would require hand-felling or other non-machine constructed wood loading actions.</i>
<b>Project Areas &amp; Prioritization</b>	<b>Ida Doctor Jack Boggy Black Pine</b> <i>The potential to improve the quantity and quality of available habitat in Reaches 15 – 20 is moderate-high. If all channel and floodplain treatment actions are implemented, substantial improvements are possible. All Reach 15 – 20 project areas are complimentary to each other but would still provide habitat and function benefits if completed independently.</i>

**Table 6. Reaches 15 – 20 Restoration Objectives, Action Types, and Projects.**

Attribute	Existing Condition (from assessment)	Target Condition [REI – Adequate Rating]	Action Type	Project
Habitat Quality	Most reaches do not meet Adequate rating for substrate, though there are some gravels present in the reaches and low fines. Reach 18 is the only reach that did not meet the large wood criteria for pieces of medium and large LW per mile. However, Reach 18 is primarily bedrock confined and was also the only reach to meet the pools/mi criteria. Pool depths were highly variable across the reaches. Pool cover was moderate overall. Side channels were relatively limited, though present where the channel was less confined.	Gravels or small cobbles make up >50% of the bed materials in spawning areas and ≤12% fines/sand (<6 mm) in spawning gravel. At least 67.45 pieces/mile of large wood and sources for LW recruitment. Pool frequency of 15/mile (Reach 15) or 18/mile (Reaches 16 – 20) with ≥50% of pools ≥1m (3ft) deep and good fish cover and cool water. Contains side or off-channel refugia.	Enhance Channel Complexity  Side and Off-Channel Habitat Creation or Enhancement  Floodplain and CMZ Connectivity	Ida Doctor Jack Boggy Black Pine
Riparian Condition	Riparian overstory consists of primarily large trees, with between 2.5-7.2% of the riparian zone disturbed in Reaches 15 – 19. Little evidence of riparian disturbance is present in Reach 20. Less channel shading is available in these reaches compared to the more confined downstream reaches, and between 0 – 12.6 mile/miles <sup>2</sup> road density within 200-ft riparian buffer (Reach 20 = 0 mi/mi <sup>2</sup> , Reach 16 = 12.6 mi/mi <sup>2</sup> ). Most riparian impacts are relatively minor and are related to campgrounds and recreational areas.	At least a 200-ft riparian buffer with: > 80% large trees, or consistent with potential native community < 20% riparian disturbance (human); high proportion of daylight hours with thermal shading over channel; and <2 mile/miles <sup>2</sup> road density	Riparian Restoration  Floodplain and CMZ Connectivity	Ida Doctor Jack Boggy Black Pine
Channel Dynamics	There are currently active channel dynamics occurring in Reach 15 due to the Doctor Creek slide. Connected floodplains and off-channel habitats occur where channels are naturally unconfined. There are a few anthropogenic features that affect channel processes.	Floodplain areas are hydrologically linked to main channel within the context of the local process domain. Channel is migrating at or near natural rates within the geomorphic construct of the reach. No measurable trend of aggradation or incision beyond the natural geomorphic processes of the reach	Floodplain and CMZ Connectivity  Enhance Channel Complexity  Side and Off-Channel Habitat Creation or Enhancement	Ida Doctor Jack Boggy Black Pine

## 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 3.2).

### 2.2 PROJECT OPPORTUNITIES OVERVIEW

A total of 11 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.

A summary of the prioritization results is included in Table 7. The projects in the table are ranked by the Benefit-to-Cost score. The highest ranked projects are spread throughout the Icicle Creek Reach Assessment area. The Bridge Creek Project is located in a relatively unconfined reach bordered by mostly confined reaches up- and downstream. As such, it has the potential to provide important migratory and rearing refuge in an otherwise very high energy section of the assessment area. The Doctor and Ida projects also provide good opportunities for habitat uplift upstream of an extended confined section. The Hatchery Project in Reach 3 has tremendous habitat and geomorphic function uplift potential; however, costs could be relatively high and feasibility is more challenging so it does not rank as well from a benefit-to-cost perspective. These ranking results should be considered draft results and open to adjustment by technical teams and potential project sponsors depending on evolving circumstances and collaboration opportunities. In particular, the emphasis on total benefit versus cost-benefit may depend on funding levels or other considerations.

**Table 7. Summary results of project prioritization. The full matrix is presented in Section 3.1.**

Tiers	Project Name	Reach	Downstream RM	Upstream RM	Total Length (mi)	Total Benefit Score	Cost Score	Benefit-to-Cost Score	Feasibility Designation
<b>Tier 1</b>	Bridge Creek	10	10.30	11.40	1.10	6.5	2	3.3	High
	Doctor	15,16	15.80	17.20	1.40	6.5	2	3.3	High
	Hatchery	2,3	2.70	4.40	1.70	11	3.5	3.1	Moderate
	Eightmile	8,9	8.60	9.90	1.30	5.5	2	2.8	Moderate-High
	Ida	15	14.80	15.80	1.00	5.5	2	2.8	High
<b>Tier 2</b>	Tunnel	4,5	4.40	5.40	1.00	4.5	2	2.3	Moderate
	Trident	7	7.55	8.30	0.75	4.5	2	2.3	Moderate-High
	Jack	17,18	17.60	19.20	1.60	4.5	2	2.3	High
	Eiszapfen Bach	1,2	0.00	2.70	2.70	6.5	3	2.2	Low-Moderate
<b>Tier 3</b>	Boggy Black Pine	19,20	19.20	22.00	2.80	4	3	1.3	Moderate-High
	Johnny Victoria	12,13,14	12.20	14.70	2.50	3	3	1.0	Moderate-High

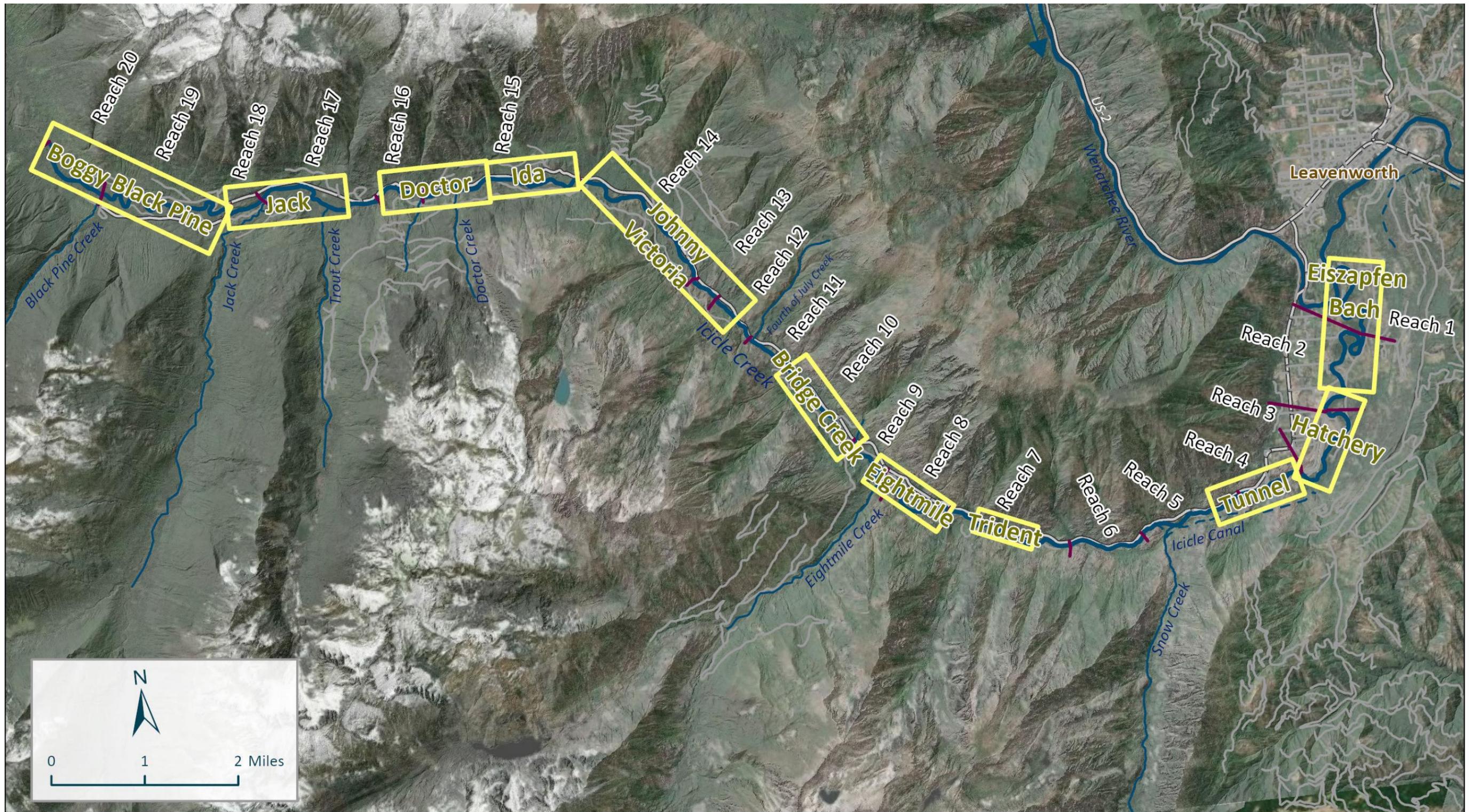


Figure 1. Overview map of project area locations and names

**2.3 PROJECT DESCRIPTIONS**

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

Reach	River Miles	Project Name	Project Description
1-2	0 – 2.7	<i>Eiszapfen Bach</i>	<p>This project area has a lot of habitat uplift potential, including to the channel, riparian zone, and floodplain. Existing conditions are affected by impacts associated with residential and agricultural uses as well as historical impacts. The many private parcels and adjacent infrastructure (e.g. roads and houses) do pose challenges to restoration work. There is abundant bank armoring, development, floodplain manipulations, and riparian clearing. This is also a popular recreational area for river users with access points within the project area.</p> <p>There are many areas of cleared riparian and floodplain vegetation, much of it associated with rural residential development. Riparian replanting areas are identified on the project map for areas with cleared riparian vegetation within approximately 200 feet of the channel and where not bisected by development or roads. It is acknowledged that many of these areas are private lawns where revegetation may be unlikely. Some small bank revegetation projects are underway or planned that do overlap with, and thus support, this restoration prescription. The objective would be to work with willing landowners to replant / reestablish riparian vegetation where possible, especially in areas that would provide shade and potential future wood recruitment to the channel. There are some larger cleared areas that could benefit greatly from revegetation efforts, such as the river-right bank from RM 0.8 – 1.0 where there is no substantial development. Riparian revegetation is especially important given the active meander scrolling in this area (somewhat mitigated by existing bank treatments).</p> <p>There are numerous places where bank armoring protects houses or other structures. Property acquisitions would be a consideration and would allow removal of armoring, but widespread property acquisitions and removal of structures are believed to be impractical and overly costly in these reaches. In lieu of acquisitions, in some of the locations with armoring, where hydraulics allow, the hard armoring (mostly riprap) could be removed and replaced with bank-buried large wood structures that would enhance margin complexity, cover, and pool scour but would still provide bank some degree of protection. In other locations some (e.g. toe protection) or all of the existing riprap could remain but could be augmented with large wood to improve habitat conditions. Near RM 0.9 along the channel are rock spurs and failed large boulder riprap in the channel that could be removed. A set of large wood structures have been placed along the bank near RM 1 for bank protection but these could be augmented with additional complexity wood. The downstream portion of the bank is untreated; jams could be placed here to moderate erosion, combined with riparian revegetation. Numerous pools, glides, and alcoves throughout the project area would benefit from wood placements for habitat cover and complexity.</p> <p>At RM 1.3/1.7 a partial neck cutoff occurred in 1972 and action was taken to repair the cutoff and restore the previous alignment using hard armoring. This site is nevertheless still potentially at risk of a cutoff during a large flood. There is riprap armoring along the left-bank on the upstream side and a headcut scour hole on the downstream side. Although there would be some loss in sinuosity, a cutoff here may not significantly impair habitat and may create split-flow conditions for a while and eventually transition to an abandoned oxbow connected to the channel as off-channel habitat. This area is low gradient, and so significant upstream channel adjustment may not be a risk; however, this should be further evaluated prior to performing restoration work. The riprap armoring along the upstream side could be removed and replaced with channel-margin cover wood. The avulsion path should be revegetated and treated with large wood for floodplain roughness to mimic a forested condition. Large wood could be added to the headcut scour pool to provide habitat cover and also some degree of erosion resistance. These treatments would remove the hard armoring but provide some replacement of erosion resistance and bank strength to allow the channel evolution to occur at a more natural pace.</p> <p>There are a few places where the connectivity of existing floodplain swales could be increased or where new side-channels or off-channel features (e.g. alcoves or floodplain wetlands) could be created to both add complexity and reduce flow hydraulics along the outside of meander bends during flood events. Potential locations are located on the insides of large meander bends between RMs 0.5 and 2.0. Further analysis is required to understand excavation requirements and the potential for mainstem log jams to help activate these areas.</p> <p><b>Conservation:</b> Although this project area is one of the most developed within the assessment area, there are still large undeveloped parcels or portions of parcels that could potentially be further developed. Because of the high fish use (migration and rearing) and restoration potential of these reaches, any undeveloped parcels within riparian zones or floodplains in this area should be viewed as high priority for protection. The large forested inside meander bends from 0.5 to 2.0 are relatively well-functioning and warrant protection of existing conditions at the least. The large cleared inside meander bend/floodplain on river-right between RM 0.3 and 1.0 has been heavily impacted but would benefit from protections that would prevent new development and would allow for vegetative and habitat restoration actions.</p>

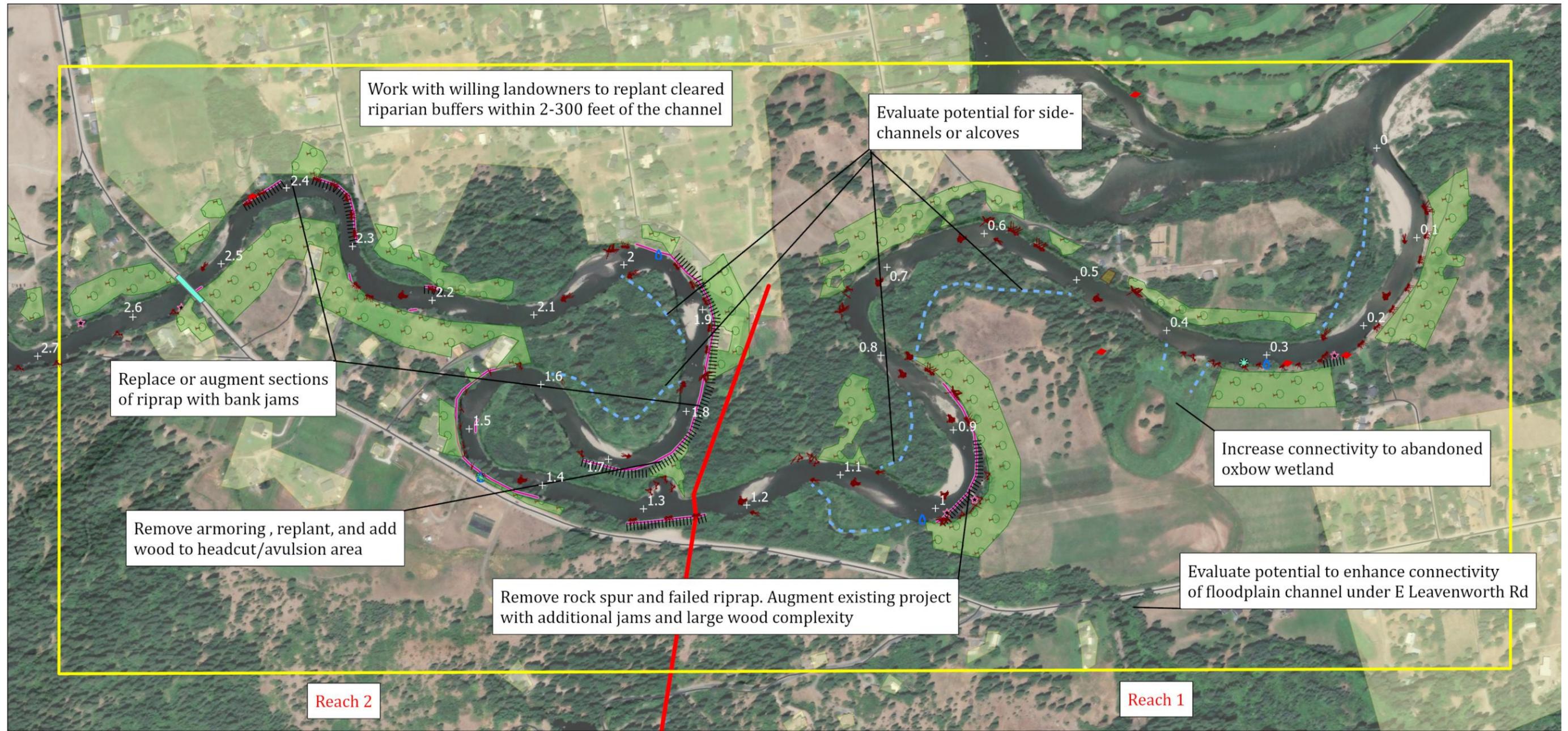
Reach	River Miles	Project Name	Project Description
3	2.7 – 4.3	Hatchery	<p>The hatchery project has some of the greatest uplift potential of any project in the assessment area for the channel, riparian zone, and floodplain reconnection. Some of the actions described and mapped in this strategy may require potential changes to the fish collection system and an alternate location/means for flow monitoring through the site. It is acknowledged that modifications to these systems would require close coordination with the hatchery and other various parties, and would require significant planning, design, and construction costs to make sure multiple objectives are achieved. A range of different restoration options are described below.</p> <p>The most comprehensive alternative at this site with the most ecologic and geomorphic uplift includes removing the hatchery diversion canal, the downstream canal spillway, and both dam structures #2 and #5 as well as the remnant pieces of structures #3 and #4. The dam Structure #2 location would be converted to a flow monitoring station. The fish trapping function at dam Structure #5 would be replaced at an appropriate location, ideally with a seasonally operated structure that allows for the free movement of fish and bed sediments throughout most of the year. In the currently leveed and graded area between the left (west) side of the existing canal and the natural channel, anthropogenic fill and features would be removed and grading performed to recreate a connected floodplain with diverse topography able to support a variety of ecologically beneficial conditions such as riparian zone, potentially wetlands, and floodplains of varied inundation frequencies. New side-channel(s) through the re-created floodplain would provide quality off-channel habitat and floodplain/groundwater recharge, including design to support groundwater recharge of the existing wells used by the hatchery. An alcove that extends deep pool habitat at the downstream end of the project could also provide additional quality off-channel habitat refuge and rearing. A constructed riffle at the upstream end of the project area may be required to maintain channel grade for side channel activation. The addition of large wood in the mainstem channel and newly created side channel(s) would add cover and complexity. The long-term sustainability of this scenario would, like all projects, require further evaluation, modeling, and analysis. The area would be revegetated with native vegetation communities. This is the alternative that is portrayed in the project map later in this section. This alternative has feasibility challenges and associated high costs due to the infrastructure modifications and grading that would be required. There are also challenges associated with fulfilling multiple goals and objectives at this site, including water management.</p> <p>Other alternatives include:</p> <p>moderate uplift = keeping the canal but removing one or both mainstem dams (Structures #2 and #5) and replacing #2 with a roughened channel and #5 with another fish collection system if needed, or</p> <p>minimal uplift = keeping the canal and the dams and only adding large wood structures to the existing natural channel. This action has the most feasibility of the alternatives.</p> <p>Potential restoration work downstream of Structure #5 could occur relatively independent of what occurs upstream. There are currently rock spurs with a few pieces of large wood, providing minimal ecological benefit along the river-left bank downstream of the spillway (canal return). These spurs could be replaced or enhanced with habitat- enhancing large wood jams, improving margin complexity and cover habitat. Riparian areas could be planted with more robust native vegetation. A small island complex on river-right just downstream of Structure #5 could be enhanced with apex jams and complexity wood to help maintain and increase split flows, scour pools, and trap and sort gravels and sediments. The size and depth of the large pool at the spillway would need to be maintained as this is an important and productive tribal fishing area. Fishing access in general in this vicinity would need to be maintained.</p> <p><b>Conservation:</b> Most of this project area is National Fish Hatchery land except for a couple of parcels that may be necessary to perform restoration actions, depending on the scale of the restoration. The primary parcel that would allow for the larger site restoration effort that may be beneficial to acquire is the private parcel at the upstream end between the canal and the natural channel. The other parcel is on the right-bank at the downstream end. In lieu of acquisition, cooperation from these landowners may be necessary to accomplish certain restoration actions.</p>
4-5	4.4 – 5.4	Tunnel	<p>Between RM 4.4 – 4.7 the channel geomorphology provides opportunity to enhance habitat with the addition of large wood at island apexes and within existing side channels. The private property on both sides of the channel will require access permissions. An established RV park and the related armored bank limit action that would notably alter inundation patterns here. However, riparian restoration along the front of the RV park, as well as other cleared areas would benefit long-term function. Upstream of RM 4.7, the channel is relatively steep, boulder-dominated, and confined by hillslopes and extended sections of riprap armoring along a pipeline. There are numerous pools with large boulders where large wood could be braced or wedged between boulders to provide habitat cover and complexity. However, wood would create only minor geomorphic response and should be considered relatively temporary. Wood could also be braced against standing riparian trees in some locations or extended into pools from high banks. Access would be challenging due to steep banks down from roadway or lack of access on opposite (south) bank.</p>

Reach	River Miles	Project Name	Project Description
7	7.6 – 8.3	<i>Trident</i>	<p>From RM 7.6 - 7.8 the channel is lower gradient and there is potential for large wood placements and retention for cover and complexity, as well as for geomorphic functions including gravel capture and pool scour. Placement of large wood is an option in specific locations where flow hydraulics and existing boulder or bank ballasting provide structural support.</p> <p>The large pools on river-left from RM 7.9 to 8.1 would benefit from the addition of large wood as cover and complexity. However, access and conflict with recreation (swimming) could be challenging.</p> <p>On river-right near RM 7.95 is a private roadway that is armored along the channel and also a riprap spur that blocks the entrance to a short side-channel (~300 ft long). This spur could be removed to re-activate the side channel for high-flow refuge and added quality habitat. There may be some residential structure conflicts, but these may be temporary seasonal structures.</p>
8-9	8.65 – 9.9	<i>Eightmile</i>	<p>There is a channel scar depression river-right set within the downstream portion of the terrace upstream of the Rat Creek Moraine near RM 8.7-8.8. There may be the potential to connect this as a side-channel or as a groundwater-fed channel. Survey and analysis is required to understand the amount of excavation that would be required.</p> <p>There is a floodplain on river right near RM 9.8 developing on the remnants of landslide debris contributions. Enhancement of the existing high-flow side channel with an inlet jam (RM 9.86) could promote additional floodplain connectivity and development. Access could be challenging.</p> <p>There is a side-channel through the campground that starts on river-left near RM 9.1 that has been disconnected at the inlet except for very high flows. Connectivity could be enhanced via inlet excavation. There is a lot of campground-related recreational use in this area that would make this challenging.</p> <p>There are several areas noted in the map where placed large wood could provide cover and complexity to existing pools. There are other areas, such as in the split-flow section RM 9.1-9.3 and downstream that are low gradient planebed sections that are dominated by small boulders and cobbles. Wood structures that extend from the banks and sit tight to the channel could be effective at trapping and sorting sediments including spawning gravels. In many areas, banks are low and structures may be able to be ballasted by stacking wood above high flow levels. Boulder ballast may also be necessary to anchor wood placements. The split-flow sections around the island provide a good opportunity for wood placements given the lower energy than the single-thread sections.</p>
10	10.4 – 11.3	<i>Bridge Creek</i>	<p>In the river-right floodplain from ~RM 10.7-10.8 there is a levee, fill, cleared areas, a concrete pad, and other features that suggest the decommissioning of a campground or other prior use of this area. Groundwater monitoring stations (PVC standpipes) were observed in this area, suggesting that investigations regarding the restoration potential of this area are underway. There are channel scar depressions in this floodplain, and potential for connected side-channels or groundwater-fed channels in this area, pending further investigation. Preliminary modeling suggests this surface gets wetted at the 25-year event and likely more frequently.</p> <p>There are numerous low gradient planebed sections that are dominated by small boulders and cobbles. Wood structures that extend from the banks and sit tight to the channel could be effective at trapping and sorting sediments including spawning gravels. In many areas, banks are low and structures may be able to be ballasted by stacking wood above high flow levels, including mid-channel apex-type structures meant to split flows. Boulder ballast may also be necessary to anchor wood placements.</p> <p>Large wood structures could be placed downstream of the Eightmile Bridge, similar to upstream of the bridge. However, this area runs along campsites at Bridge Creek Campground and there is heavy recreational use. Structures were therefore not depicted on the map for this section.</p>
12-14	12.2 – 14.7	<i>Johnny Victoria</i>	<p>This is a long project area, extending 3.4 miles from RM 11.4 to 14.8 and comprising all of reaches 11-14. These are moderate-to-high gradient (1.5-4%) channels and mostly confined. The channels are dominated by small boulders and cobbles, much of it planebed, with a few step-pool sections. The reaches are lacking in large wood but the high energy makes it challenging for wood restoration. There are two primary types of potential wood installations that were identified:</p> <p>There are numerous low gradient planebed sections that are dominated by small boulders and cobbles. Wood structures that extend from the banks and sit tight to the channel could be effective at trapping and sorting sediments including spawning gravels. In many areas, banks are low and structures may be able to be ballasted by stacking wood above high flow levels, including mid-channel apex-type structures meant to split flows. Boulder ballast may also be necessary to anchor wood placements.</p> <p>Cover and complexity wood in pools, including in some of the larger step-pools and especially in a few longer pools that lack complexity, such as near RM 12.9. There may be numerous other potential sites for cover and complexity treatments that could take advantage of easier access and willing landowners. Not all of the potential sites were identified for wood treatment in the project map.</p>

Reach	River Miles	Project Name	Project Description
15	14.85 – 15.8	<i>Ida</i>	<p>This is a low gradient section with restoration opportunities associated with campground infrastructure, side-channel connectivity, and large wood additions to encourage geomorphic processes and habitat complexity. At the upstream portion of the project area, the road has been relocated far up the river-left hillslope, opening up restoration opportunities.</p> <p>At the upstream end on river-left is the former road alignment with at least one area with remnant armoring that could be removed, plus opportunities to enhance vegetation conditions on the former roadbed.</p> <p>At Ida Creek Campground on river-left, there is riprap and a berm/fill that could be removed to enhance connectivity of the downstream floodplain.</p> <p>In the downstream portion, from RM 14.85 to 15.2, there may be opportunities to enhance or create side-channel and backbar channels on both sides of the river using log jams to divert water and select excavation in the floodplain.</p> <p>Bar apex and bank jams throughout most of the project area could be used to create split-flow conditions, encourage sediment/gravel deposition, direct flow into banks to recruit trees, and sustain existing or create new mid-channel islands. Other wood placements can be used to enhance cover and complexity in existing pools and glides.</p>
15-16	15.85 – 17.2	<i>Doctor</i>	<p>Similar to downstream (Ida Project), this is a low gradient section with significant restoration opportunities, including removing human fill and features and working with existing dynamic processes to enhance complexity and habitat. The road has been relocated far up the river-left hillslope, opening up restoration opportunities. A groundwater-level observation tube was observed on site during the field survey, indicating that evaluation for potential restoration efforts are underway.</p> <p>At the upstream end of the abandoned road alignment, there is old fill associated with the road and other activities in the floodplain. This fill could be removed and a new side-channel alignment may be possible in an old meander scar in the left-bank floodplain (RM 16.3-16.5), pending further analysis of required excavation quantities.</p> <p>There is impaired riparian vegetation throughout this floodplain related to the old road and dispersed recreational uses. Replanting would help to restore the forested riparian and floodplain vegetation community.</p> <p>At the Doctor Creek slide area (~RM 16.1-16.4), there are still active dynamics occurring since the 2008 slide that washed out the road, changed the channel path, and activated new side channels. Wood additions could be used to work with these dynamics, including apex and bank jams downstream of the slide location to capture wood that originated from the slide and jams to better activate existing side-channels that are only wetted during higher flows.</p> <p>Bar apex and bank jams throughout most of the project area could be used to create split-flow conditions, encourage sediment/gravel deposition, direct flow into banks to recruit trees, and sustain existing or create new mid-channel islands. Other wood placements can be used to enhance cover and complexity in existing pools and glides.</p>
17-18	17.7 – 19.1	<i>Jack</i>	<p>The upstream portion (RM 18.8 to 19.2) is a confined bedrock canyon. There is little work to be done in the channel through this section but there has been past clearing of riparian trees on the river-right bank through here where revegetation work would benefit long-term shade and wood recruitment.</p> <p>Downstream of the canyon to RM 18.2 is a moderate gradient planebed section that is dominated by small boulders and cobbles. Wood structures that extend from the banks and sit tight to the channel could be effective at trapping and sorting sediments including spawning gravels. In many areas, banks are low and structures may be able to be ballasted by stacking wood above high flow levels, including occasional mid-channel apex-type structures meant to split flows. Boulder ballast may also be necessary to anchor wood placements.</p> <p>Downstream of RM 18.2 is lower gradient with more pool-riffle morphology with higher complexity including active channel splitting around a large forested island complex. There are numerous existing large wood jams. Additional large wood could be used to build off of these existing processes, including bar apex jams to create split-flow conditions, encourage sediment/gravel deposition, direct flow into banks to recruit trees, and sustain existing or create new mid-channel islands. Other wood placements can be used to enhance cover and complexity in existing pools and glides.</p>

Reach	River Miles	Project Name	Project Description
<b>19-20</b>	19.2 – 22	<i>Boggy Black Pine</i>	<p>This project area is a low gradient (&lt;0.5%) pool-riffle channel with relatively abundant existing large wood, log jams, and complex habitats supported by active lateral channel dynamics. However, much of the wood is smaller than needed to act as key pieces and is relatively mobile. Adding log jams throughout the project area would help trap and retain large wood moving through the system and would build off of existing conditions to even further improve habitat and channel complexity. Constructed log jams throughout most of the project area could be used to create/maintain split-flow conditions, direct flow into side-channels, and encourage gravel deposition. There are some older tree stands, including some pockets of old growth, where jams could direct flow into banks to recruit trees. Other wood placements can be used to enhance cover and complexity in existing pools and glides.</p> <p>There is an area of potential fill on river-right near RM 19.35, where an old road/trail accesses the river. According to the hydraulic model, this fill obstructs the continuity of floodplain flow on this surface. This needs further investigation to understand the origin of the material, but if it is fill, then its removal would help to reconnect this surface.</p> <p>Construction access is challenging throughout the reach, especially upstream of the end of the roads (located on both sides but set back from channel) near RM 21.3. Upstream of RM 21.6 is within the Alpine Lakes Wilderness, which significantly limits access options. The treatment types vary depending on these access constraints. The work located in the wilderness may need to include felling of riparian trees with hand tools, or helicopter wood loading, if allowed. Downstream of the wilderness boundary, occasional access routes are possible from the roads on either side of the channel, but there would be impacts to riparian and floodplain vegetation. Helicopter placements and felling of streamside trees may also be a viable option.</p> <p>At the downstream end river-right there is a dispersed camping area where there has been past clearing of riparian trees; revegetation work would benefit long-term shade and wood recruitment.</p>

## **2.4 PROJECT MAPS**



Icicle Creek Reach Assessment

*Project Opportunities*

**Eiszapfen Bach**



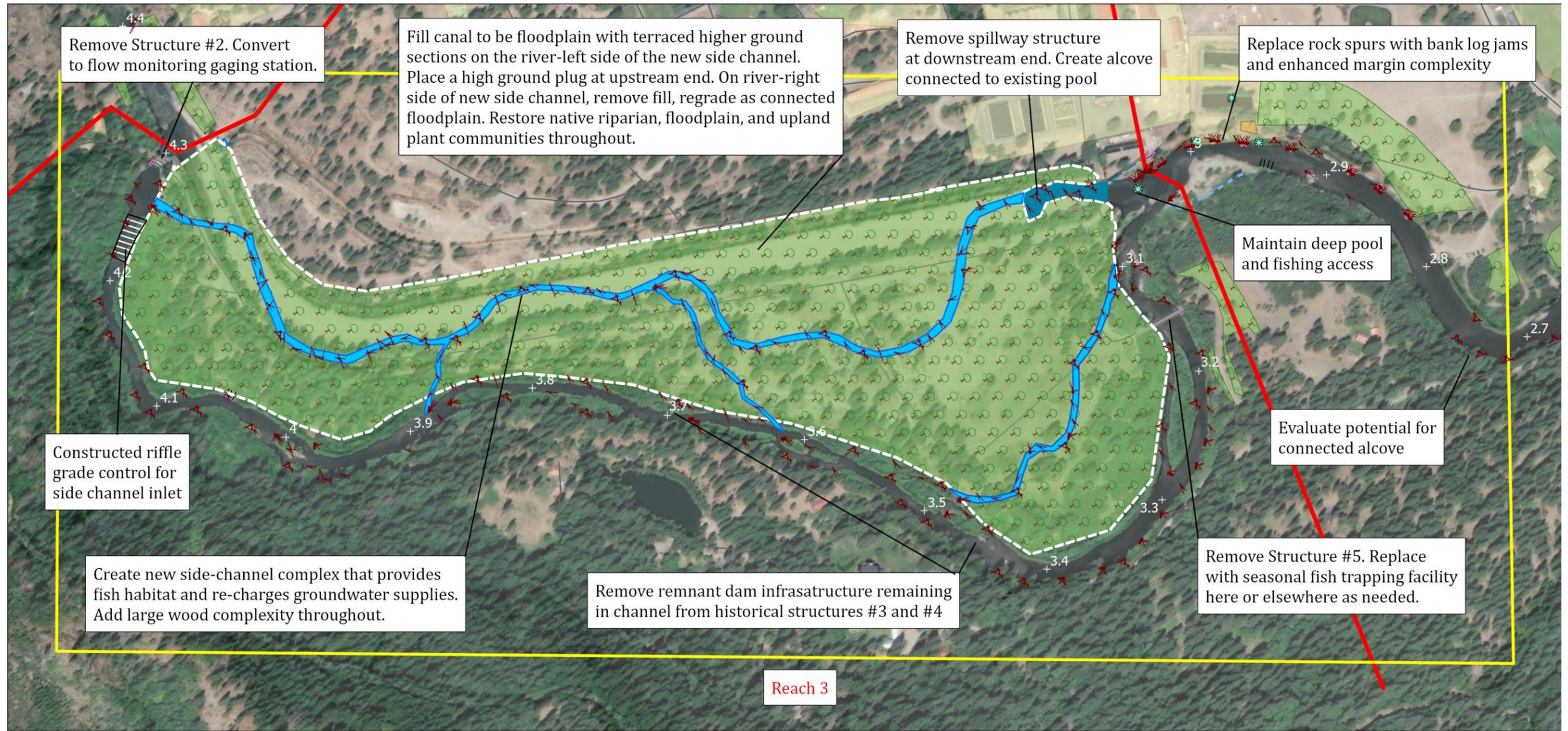
**Project Elements**

- - - - 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**

- ⬇ Water Withdrawals
- ★ Spur Dikes
- + Municipal Water Outtake Structure
- ⊗ Discharge Outfalls
- Culverts
- ◆ Previous Restoration Effort
- Roads
- Cement Wall
- Levee
- Bank Armoring
- Road Debris Boulders
- Canals
- Recreational Areas
- Structures
- Bridges
- Dams



Icicle Creek Reach Assessment

*Project Opportunities*

**Hatchery**



**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**

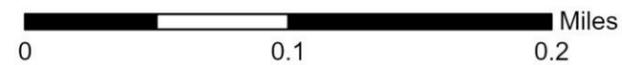
- ⬇ Water Withdrawals
- ★ Spur Dikes
- + Municipal Water Outtake Structure
- Discharge Outfalls
- Culverts
- ◆ Previous Restoration Effort
- Roads
- Cement Wall
- Levee
- Bank Armoring
- Road Debris Boulders
- Canals
- Recreational Areas
- Structures
- Bridges
- Dams



Icicle Creek Reach Assessment

*Project Opportunities*

**Tunnel**



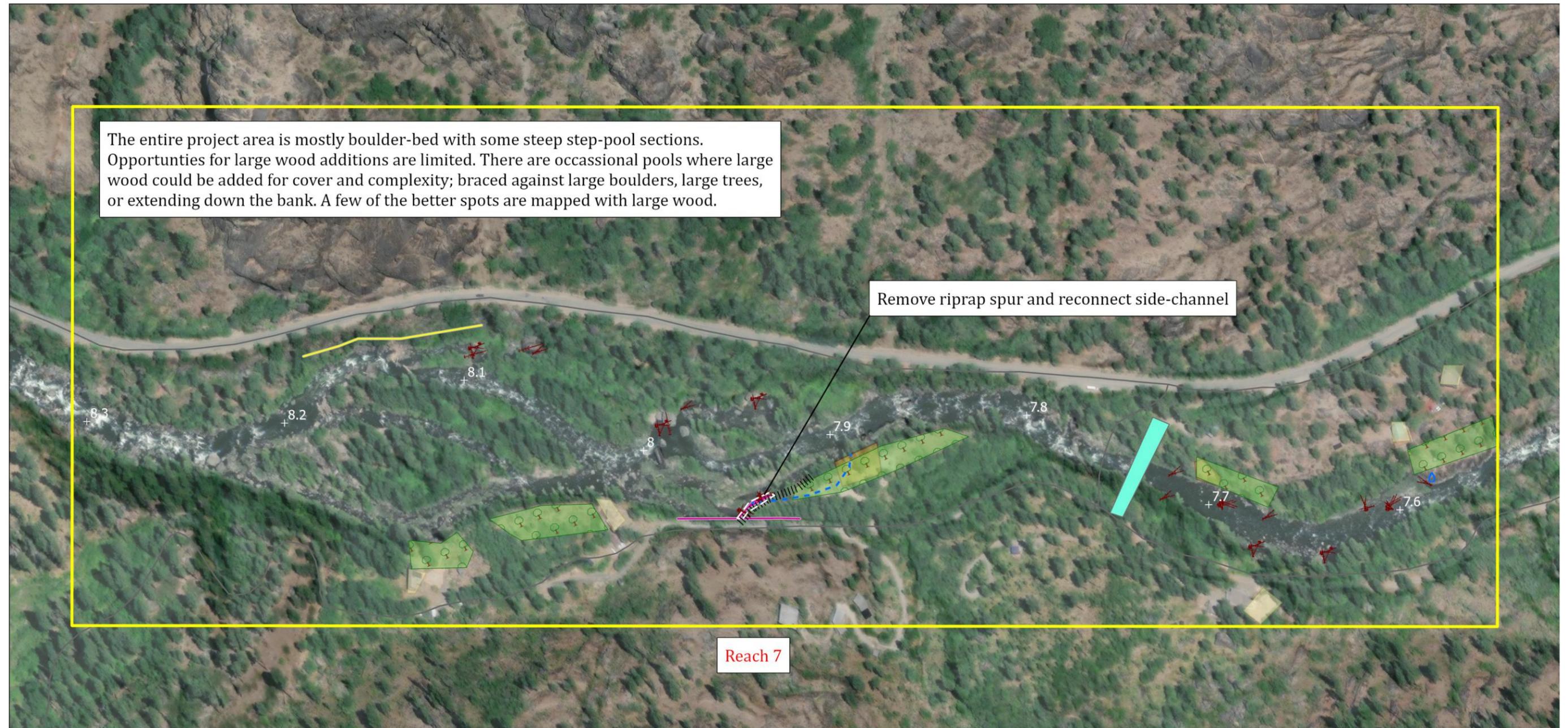
**Project Elements**

- - - - Side Channel Activation
- ||||| Remove or Modify Armoring
- - - - Fill Removal
- Riparian Restoration
- Individual logs
- Complexity jams
- Whole trees
- Apex jams
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**Built Features**

- ⬇ Water Withdrawals
- ★ Spur Dikes
- + Municipal Water Outtake Structure
- Discharge Outfalls
- Culverts
- ◆ Previous Restoration Effort
- Roads
- Cement Wall
- Levee
- Bank Armoring
- Road Debris Boulders
- Canals
- Recreational Areas
- Structures
- Bridges
- Dams



The entire project area is mostly boulder-bed with some steep step-pool sections. Opportunities for large wood additions are limited. There are occasional pools where large wood could be added for cover and complexity; braced against large boulders, large trees, or extending down the bank. A few of the better spots are mapped with large wood.

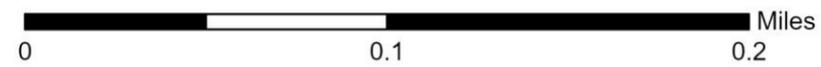
Remove riprap spur and reconnect side-channel

Reach 7

Icicle Creek Reach Assessment

Project Opportunities

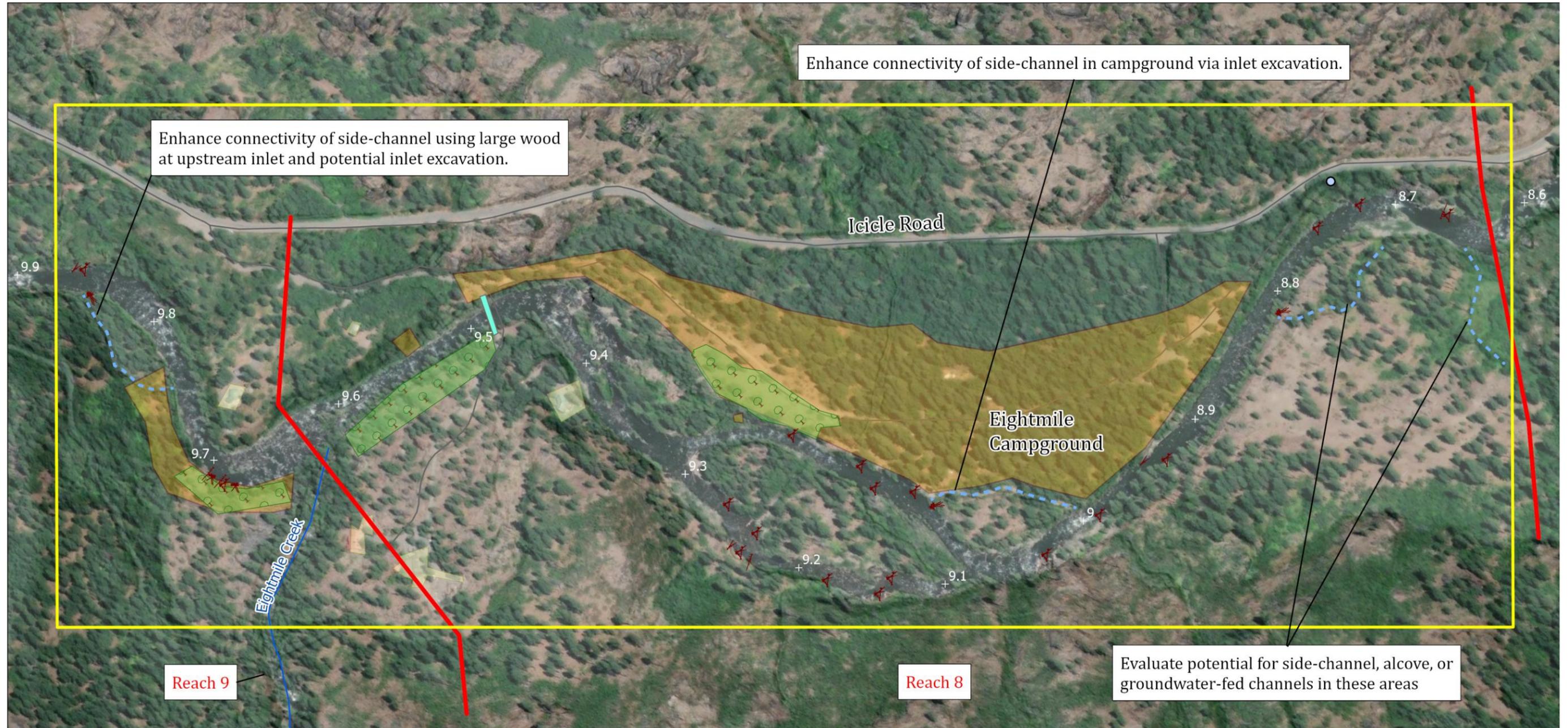
Trident



- 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.

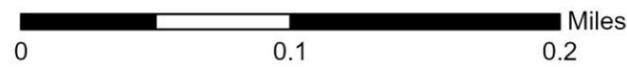
- Built Features**
- ⦿ Water Withdrawals
  - ★ Spur Dikes
  - ⊕ Municipal Water Outtake Structure
  - ⊗ Discharge Outfalls
  - Culverts
  - ◆ Previous Restoration Effort
  - Roads
  - Cement Wall
  - Levee
  - Bank Armoring
  - Road Debris Boulders
  - Canals
  - Recreational Areas
  - Structures
  - Bridges
  - Dams



Icicle Creek Reach Assessment

Project Opportunities

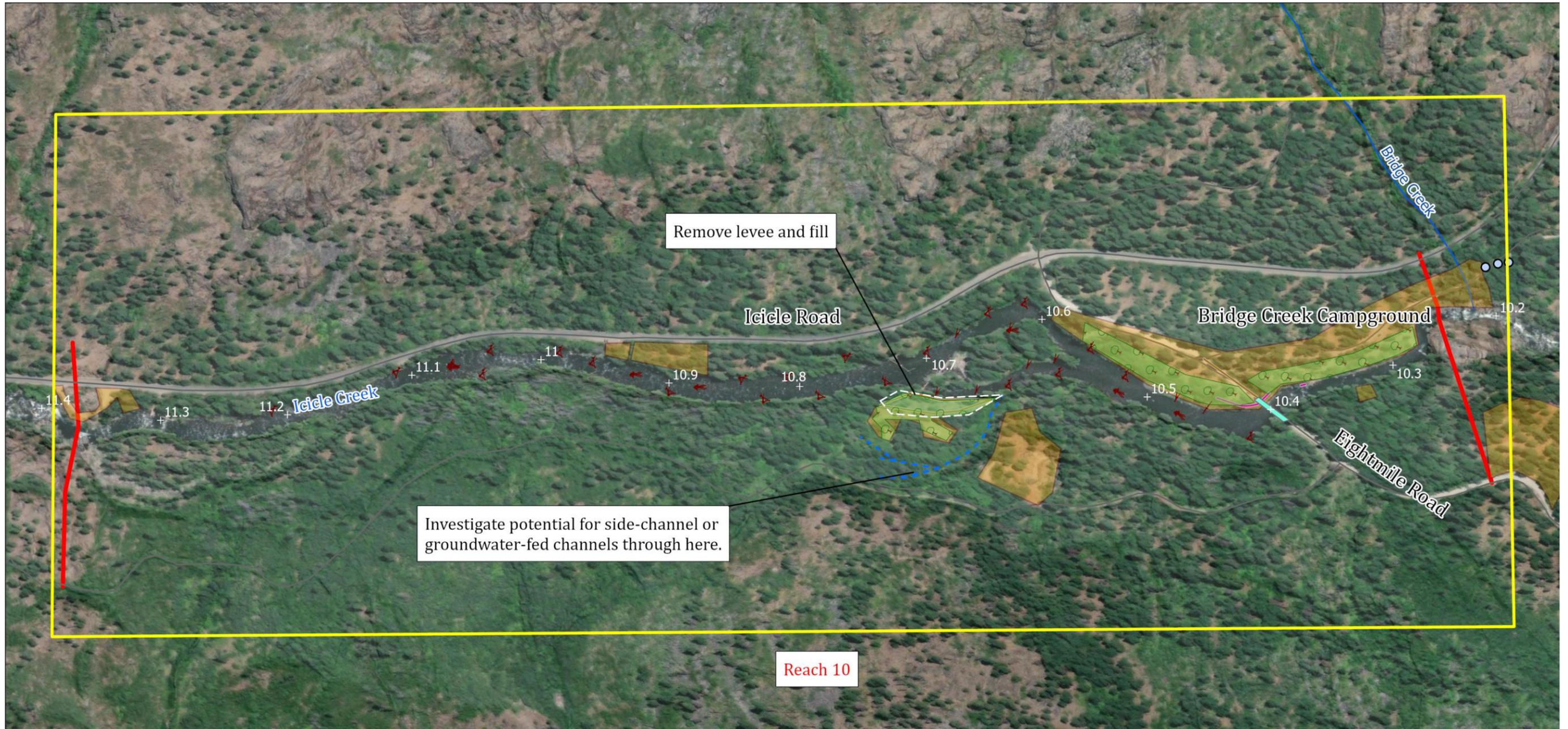
**Eightmile**



- 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**
- ⦿ Water Withdrawals
  - ★ Spur Dikes
  - ⊕ Municipal Water Outtake Structure
  - ⊗ Discharge Outfalls
  - Culverts
  - ◆ Previous Restoration Effort
  - Roads
  - Cement Wall
  - Levee
  - Bank Armoring
  - Road Debris Boulders
  - Canals
  - Recreational Areas
  - Structures
  - Bridges
  - Dams

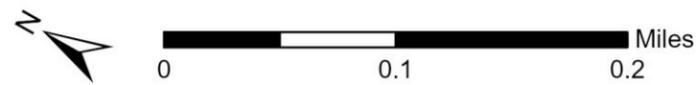


Reach 10

Icicle Creek Reach Assessment

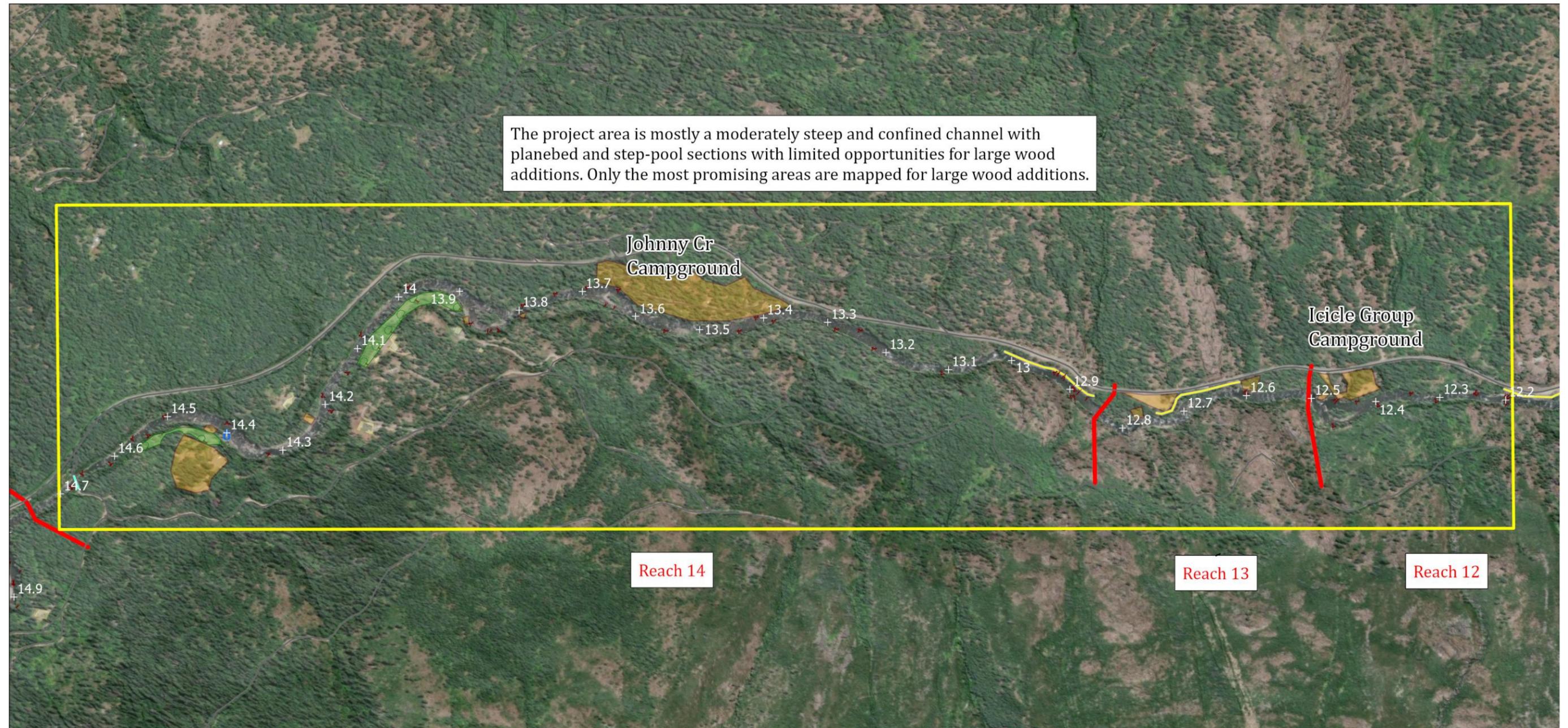
Project Opportunities

Bridge Creek



Project Elements		Built Features	
Side Channel Activation	Individual logs	Water Withdrawals	Cement Wall
Remove or Modify Armoring	Complexity jams	Spur Dikes	Levee
Fill Removal	Whole trees	Municipal Water Outtake Structure	Bank Armoring
Riparian Restoration	Apex jams	Discharge Outfalls	Road Debris Boulders
	Bank jams	Culverts	Canals
		Previous Restoration Effort	Recreational Areas
		Roads	Structures
			Bridges
			Dams

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.



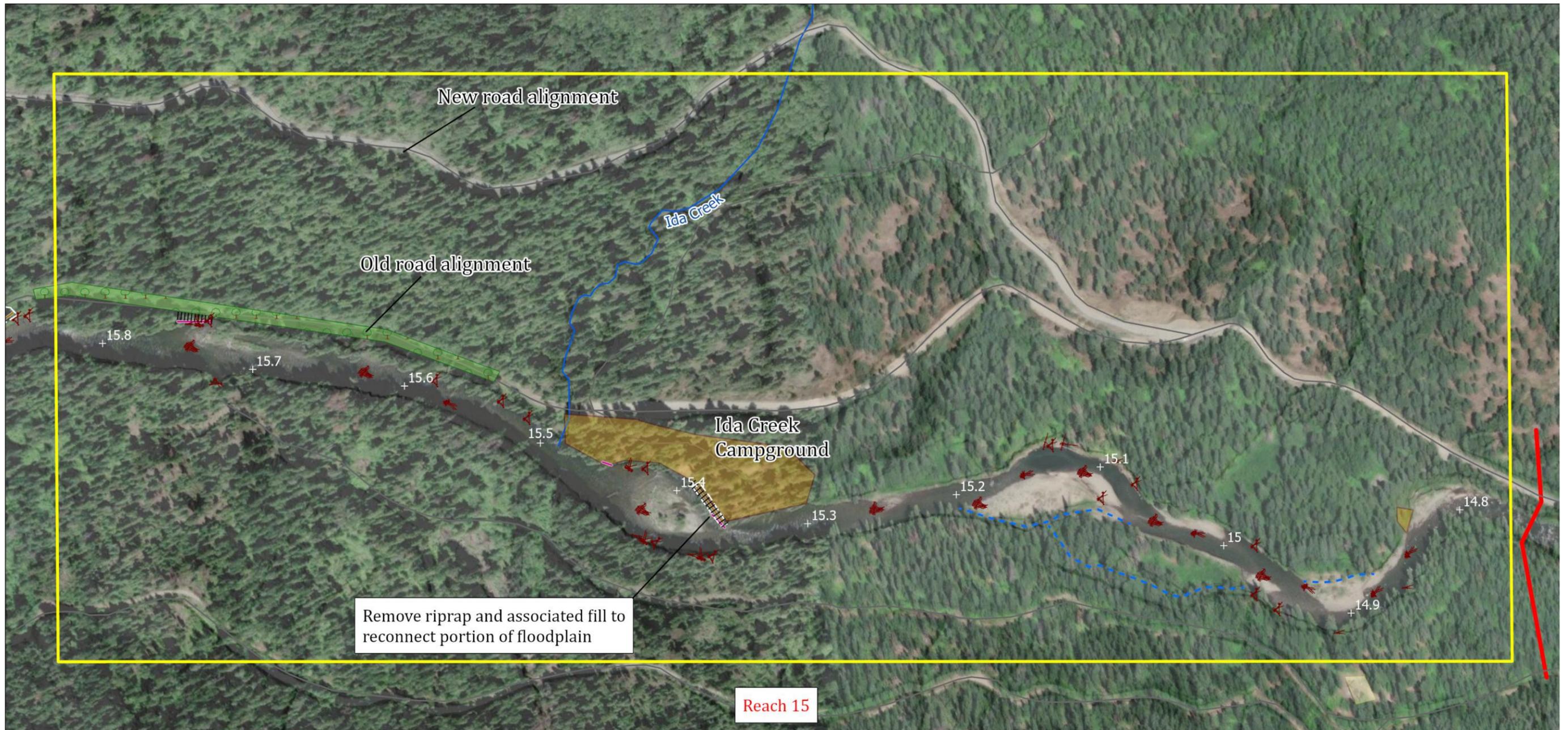
The project area is mostly a moderately steep and confined channel with planebed and step-pool sections with limited opportunities for large wood additions. Only the most promising areas are mapped for large wood additions.

Icicle Creek Reach Assessment  
 Project Opportunities  
**Johnny Victoria**



Project Elements		Built Features	
Side Channel Activation	Individual logs	Water Withdrawals	Cement Wall
Remove or Modify Armoring	Complexity jams	Spur Dikes	Levee
Fill Removal	Whole trees	Municipal Water Outtake Structure	Bank Armoring
Riparian Restoration	Apex jams	Discharge Outfalls	Road Debris Boulders
	Bank jams	Culverts	Canals
		Previous Restoration Effort	Recreational Areas
		Roads	Structures
			Bridges
			Dams

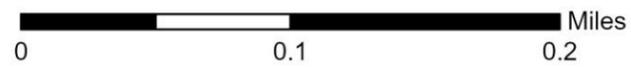
These are preliminary concepts intended to describe the type of potential restoration work that could be performed. Additional site investigations and analysis will be necessary to determine specific treatment types and locations.



Icicle Creek Reach Assessment

*Project Opportunities*

**Ida**



Reach 15

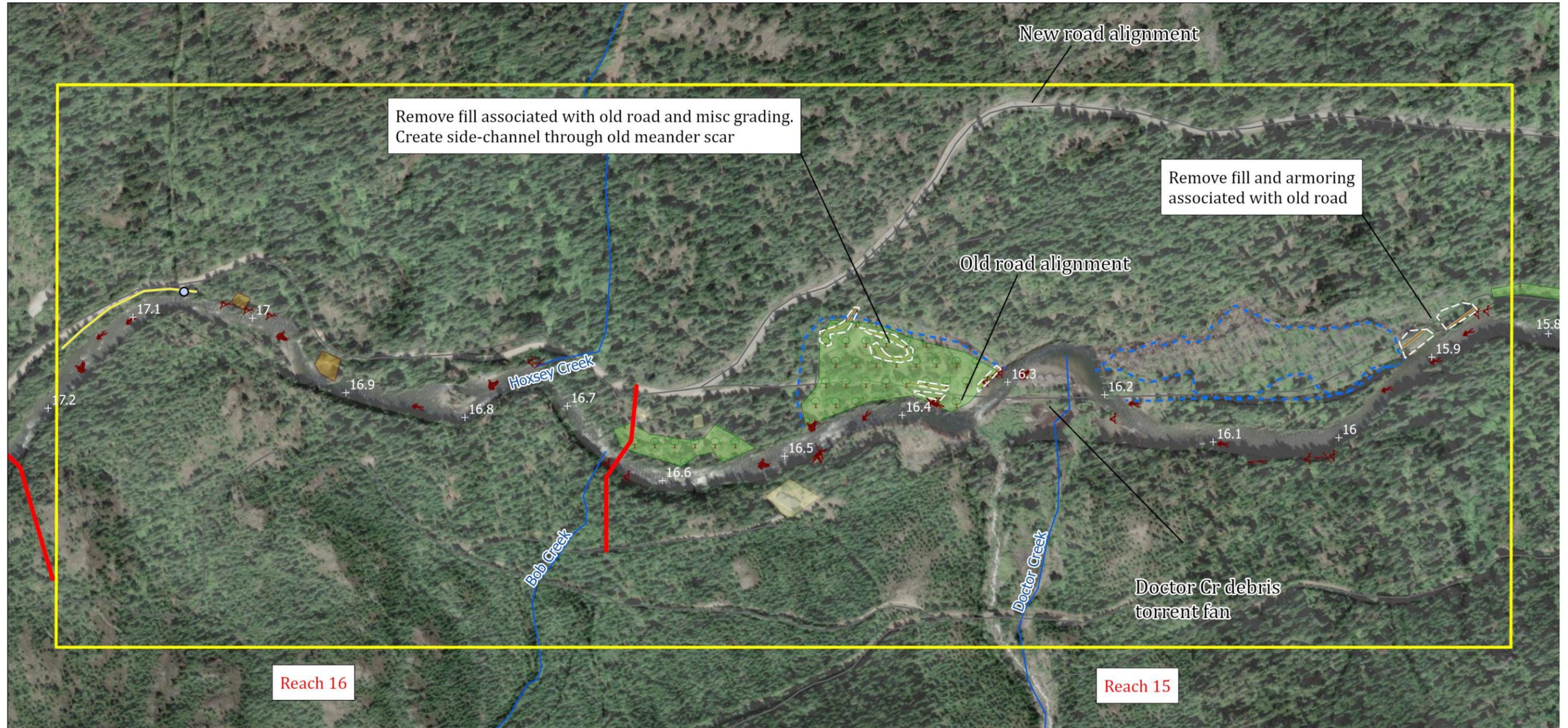
**Project Elements**

- 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**

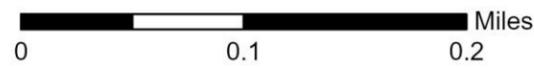
- Water Withdrawals
- Spur Dikes
- Municipal Water Outtake Structure
- Discharge Outfalls
- Culverts
- Previous Restoration Effort
- Roads
- Cement Wall
- Levee
- Bank Armoring
- Road Debris Boulders
- Canals
- Recreational Areas
- Structures
- Bridges
- Dams



Icicle Creek Reach Assessment

*Project Opportunities*

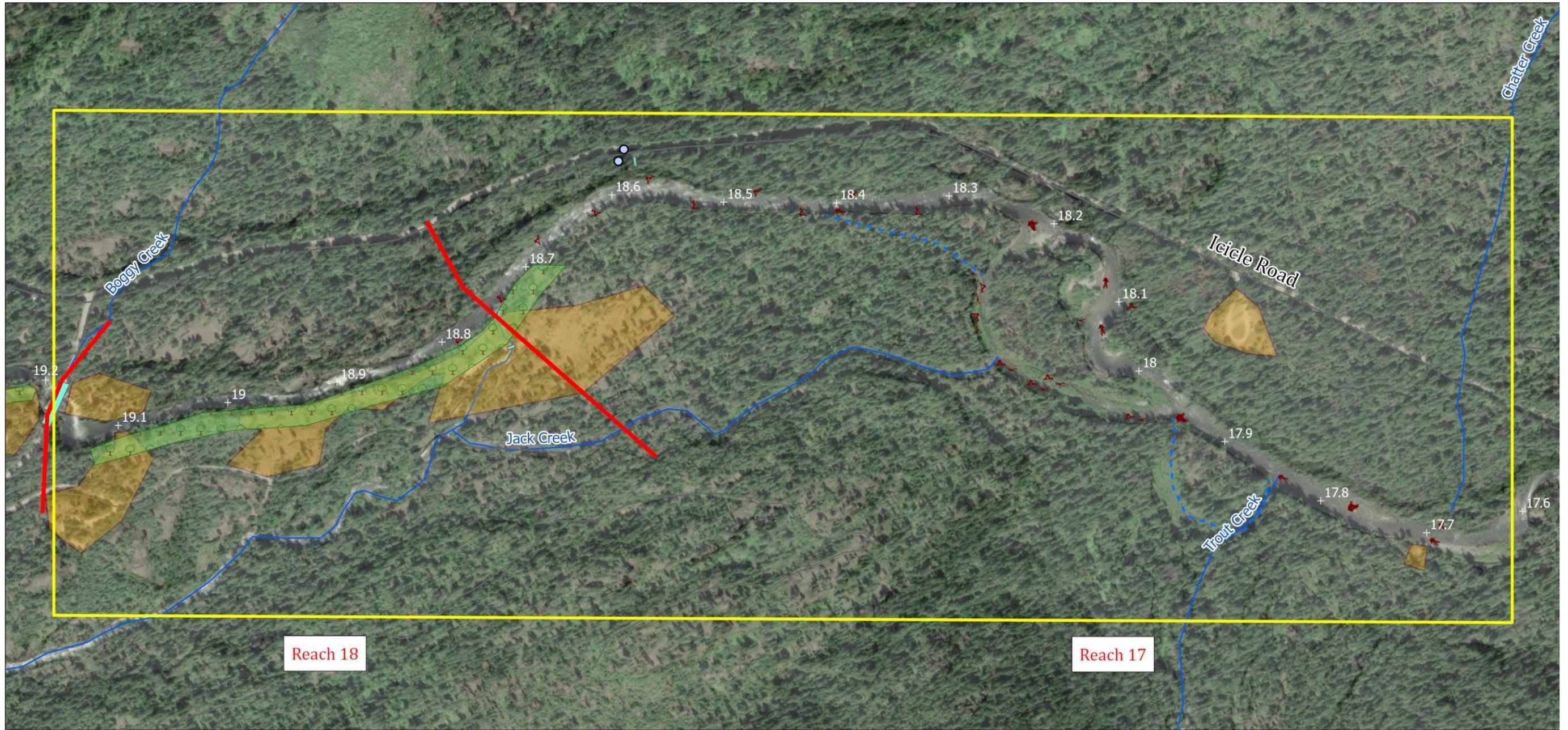
**Doctor**



- 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.

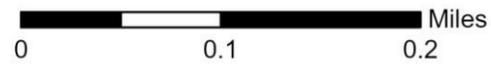
- Built Features**
- ⦿ Water Withdrawals
  - ★ Spur Dikes
  - ⊕ Municipal Water Outtake Structure
  - ⊗ Discharge Outfalls
  - Culverts
  - ◆ Previous Restoration Effort
  - Roads
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  - Canals
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Icicle Creek Reach Assessment

*Project Opportunities*

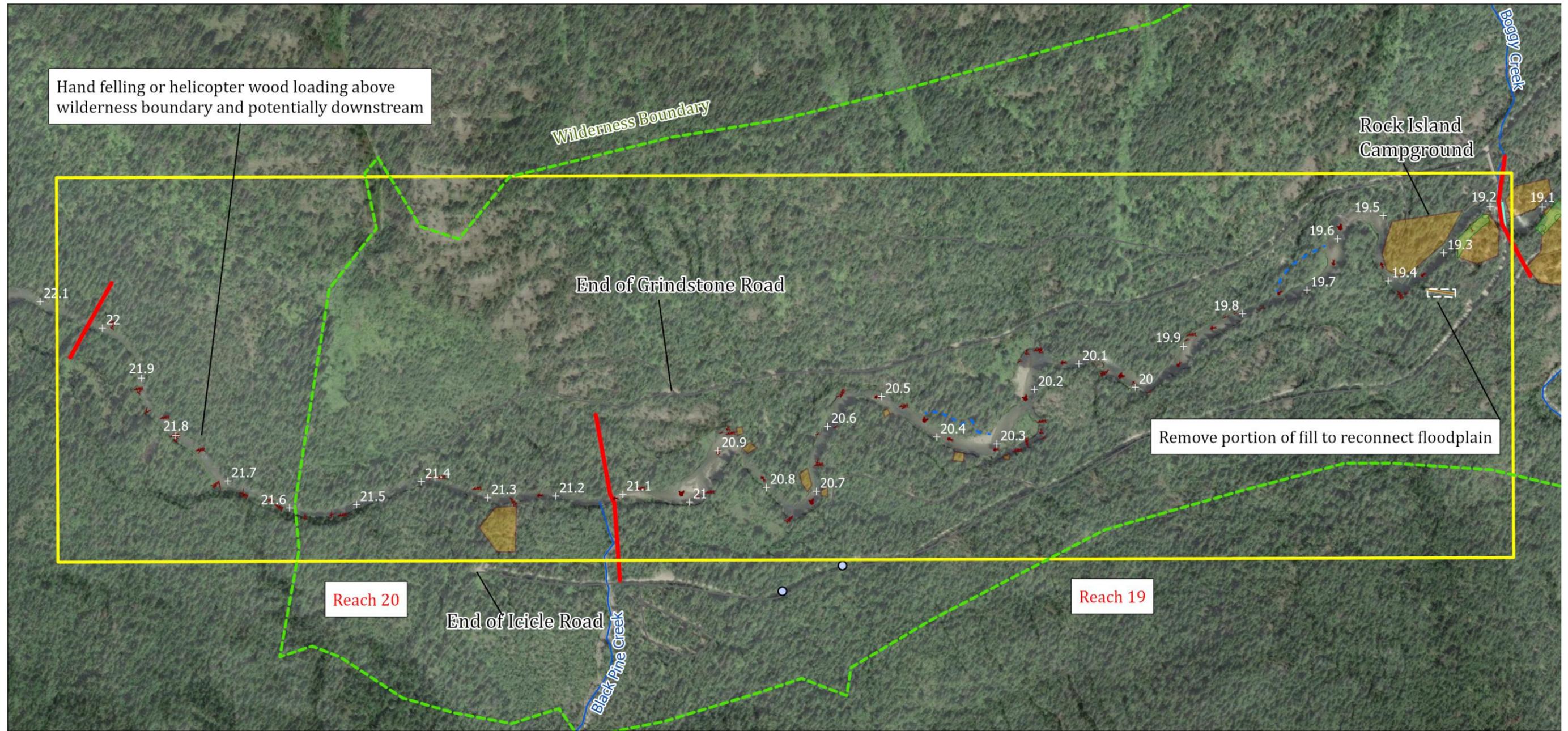
**Jack**



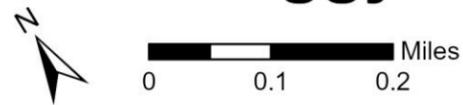
- Project Elements**
- Side Channel Activation
  - ||||| Remove or Modify Armoring
  - Fill Removal
  - █ Riparian Restoration
  - Individual logs
  - Complexity jams
  - Whole trees
  - Apex jams
  - Bank jams

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**
- ⦿ Water Withdrawals
  - ★ Spur Dikes
  - ⊕ Municipal Water Outtake Structure
  - ⊗ Discharge Outfalls
  - Culverts
  - ◆ Previous Restoration Effort
  - Roads
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  - Canals
  - Recreational Areas
  - Structures
  - Bridges
  - Dams



Icicle Creek Reach Assessment  
*Project Opportunities*  
**Boggy Black Pine**



Project Elements		Built Features	
Side Channel Activation	Individual logs	Water Withdrawals	Cement Wall
Remove or Modify Armoring	Complexity jams	Spur Dikes	Levee
Fill Removal	Whole trees	Municipal Water Outtake Structure	Bank Armoring
Riparian Restoration	Apex jams	Discharge Outfalls	Road Debris Boulders
	Bank jams	Culverts	Canals
		Previous Restoration Effort	Recreational Areas
		Roads	Structures
			Bridges
			Dams

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.

### 3 Project Prioritization and Ranking

#### 3.1 PRIORITIZATION MATRIX

Project Area						Benefit Score									Cost Score	Cost Benefit	Feasibility Designation	
Tiers	Project Name	Reach	Downstream RM	Upstream RM	Total Length (mi)	Restoration Gap Analysis				Existing and Potential Fish Use		Root Causes		Total Benefit Score	Cost Score	Benefit-to-Cost Score	Feasibility Designation	Rationale/ assumption
						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					
Tier 1	Bridge Creek	10	10.30	11.40	1.10	4.5	6	1.5	Some impairment of channel and floodplain function due to channel modification and floodplain disconnection and riparian vegetation clearing, resulting in reduced habitat complexity and loss of large wood in the channel. Recovery is relatively high especially river-right levee and off-channel potential; less so at Bridge Creek campground assuming bridge and campground remain.	2.5	Above boulder field (limits passage for some species). Less confined and lower gradient than up and downstream with some potential off-channel habitat. Could be important stepping-stone habitat within otherwise canyon section.	2.5	Removal of river-left levee, and riparian restoration, would address root causes. Large wood supplementation would not address the processes that create and maintain it over time. Side-channel creation in river-left floodplain would partially address root causes.	6.5	2	3.3	High	No major constraints. National Forest
	Doctor	15,16	15.80	17.20	1.40	4.5	6	1.5	Project area is impacted by fill/berms associated with prior uses, the old road bed and related impacts to riparian veg, some residential impacts, and lack of large wood in channel. Area has the potential for significant improvement given that much of the human infrastructure has been removed. Doctor Cr slide is creating healthy dynamism that can be built upon for high quality off-channel habitat and floodplain connections.	2.5	Above boulder field (limits passage for some species). Low gradient with floodplains, with some existing and abundant potential off-channel habitat.	2.5	Removal of fill and armoring and riparian work addresses root causes. Large wood work does not address the processes that create and maintain LW over the long-term.	6.5	2	3.3	High	Mostly public land. Road mostly far from channel so few impacts to existing infrastructure
	Hatchery	2,3	2.70	4.40	1.70	1	6	5	Impairment of channel and riparian function due to the LNFH and associated infrastructure, including dams, roads, diversions, canals, levees, and riparian vegetation clearing have resulted in fish passage issues, minimal habitat complexity, a lack of large wood in the channel, and limited natural geomorphic processes. However, the hatchery project has some of the greatest uplift potential of any project in the study area due to the level of impairment and the magnitude of enhancement that could be achieved with comprehensive restoration treatments.	3	Reach is highly used by multiple species in the downstream portion, but dams block passage upstream. Potential use is very high.	3	The primary root causes of impairments (canal,dams, fill) would be removed/addressed as part of the project, assuming the more aggressive is approach is taken.	11	3.5	3.1	Moderate	Would require significant commitment from LNFH and funders.
	Eightmile	8,9	8.60	9.90	1.30	4.5	6	1.5	The primary impacts are riparian and recreational disturbances, a couple of side-channel disconnections, and lack of large wood. Impacts are limited due to partial confinement and moderate gradient.	1.5	Above boulder field (limits passage for some species), partially confined and moderately steep, but some side-channel and potential off-channel habitat compared to upstream and downstream.	2.5	Removal of side-channel inlet fill, and riparian restoration, would address root causes. Large wood supplementation would not address the processes that create and maintain it over time.	5.5	2	2.8	Moderate-High	Mix of private and public lands.
	Ida	15	14.80	15.80	1.00	5	5.5	0.5	Project area is impacted by fill associated with the campground, the old road bed and related impacts to riparian veg, and lack of large wood in channel. Area has the potential for significant improvement given that much of the human infrastructure has been removed, though campground and road is expected to still remain at downstream end.	2.5	Above boulder field (limits passage for some species). Low gradient with floodplains, with some existing and potential off-channel habitat.	2.5	Removal of riprap spur (and fill) and riparian work addresses root causes. Large wood work does not address the processes that create and maintain LW over the long-term.	5.5	2	2.8	High	Mostly public land

Project Area						Benefit Score						Cost Score		Cost Benefit	Feasibility Designation				
Tiers	Project Name	Reach	Downstream RM	Upstream RM	Total Length (mi)	Restoration Gap Analysis				Existing and Potential Fish Use		Root Causes		Total Benefit Score	Cost Score (1-4)	Rationale/ assumption	Benefit-to-Cost Score	Feasibility Designation	Rationale/ assumption
						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						
Tier 2	Tunnel	4,5	4.40	5.40	1.00	5	6	1	The primary impacts are the diversion, riparian disturbance, and a lack of large wood, but the departure from historical conditions is lower due to the natural confinement and high gradient of the channel.	2.5	Current fish use is affected by the hatchery dams and diversions downstream, but potential fish use for multiple species is high since this is still below the boulder field, which limits the degree of passage for some species. However, the steep gradient and confinement limits fish use overall.	1	Addresses lack of large in-channel structure but does not address the processes that create and maintain it over the long-term. Riparian work addresses root causes.	4.5	2	Good access. No major constraints	2.3	Moderate	Access is challenging due to confinement (canyon) and some private lands.
	Trident	7	7.55	8.30	0.75	5	6	1	The primary impacts are riparian disturbance, a lack of large wood, and a riprap spur that is blocking a side channel inlet; but the departure from historical conditions is lower due to the natural confinement and high gradient of the channel.	1	Above boulder field (limits passage for some species) and mostly confined and steep, limiting fish use	2.5	Removal of riprap spur and riparian restoration would address root causes. Large wood supplementation would not address the processes that create and maintain it over time.	4.5	2	Generally good access, especially for riprap spur removal and riparian work.	2.3	Moderate-High	Mix of private and public lands.
	Jack	17,18	17.60	19.20	1.60	5	6	1	Project area has relatively few impacts. Primary impacts are from riparian clearing, recreational impacts on riparian areas, and loss of large wood. There is the potential for relatively high functioning conditions in project area.	2.5	Above boulder field (limits passage for some species). Low gradient with floodplains, with some existing and potential off-channel habitat.	1	Project is primarily addition of large wood. This work benefits instream habitat but does not address the processes that create and maintain LW over the long-term.	4.5	2	Good access. No major constraints	2.3	High	Mostly public land
	Eiszapfen Bach	1,2	0.00	2.70	2.70	2	4.5	2.5	Significant impairment of channel and riparian function due to riparian vegetation clearing, lost or reduced habitat complexity, lack of large wood in the channel, and limited off-channel habitat. Achievable target is moderate-to-high, decremented due to unlikelihood of widespread acquisitions that would be required for full recovery.	3	Reach is highly used for spawning and rearing for multiple species and the project would increase quality of in-channel aquatic habitat as well as expand quantity / access to off-channel habitat.	1	Addresses lack of large in-channel structure and lack of off-channel connections in some locations, but does not address the processes that create and maintain these over the long-term (wood recruitment, greater floodplain connectivity).	6.5	3	Large jams that restore habitat plus protect homes are expensive. Alternative of property acquisitions is very expensive.	2.2	Low-Moderate	Many private parcels and structures. High recreational use.
Tier 3	Boggy Black Pine	19,20	19.20	22.00	2.80	6	6.5	0.5	Project area has relatively few impacts. Primary impacts are from past logging and loss of instream large wood. There is the potential for relatively high functioning conditions in project area, especially given wilderness in upper portion.	2.5	Above boulder field (limits passage for some species). Low gradient with floodplains, with some existing and potential off-channel habitat.	1	Project is primarily addition of large wood. This work benefits instream habitat but does not address the processes that create and maintain LW over the long-term.	4	3	Some access challenges due to lack of roads and wilderness in upstream portion	1.3	Moderate-High	Public land but feasibility somewhat affected by wilderness.
	Johnny Victoria	12,13,14	12.20	14.70	2.50	5	6	1	The primary impacts are riparian disturbance, a lack of large wood, and riprap/road debris boulders along Icicle Road; but the departure from historical conditions is lower due to the natural confinement and high gradient of the channel.	1	Above boulder field (limits passage for some species) and mostly confined and steep, limiting fish use	1	Addresses lack of large in-channel structure but does not address the processes that create and maintain it over the long-term. Riparian work addresses root causes, but it's limited.	3	3	Challenging access in steep canyon.	1.0	Moderate-High	Mostly public land but disturbance to banks and riparian zones may not be worth impact.

### 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 3, 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