RECLAMATION

Managing Water in the West

Lower White Pine Reach Assessment

Nason Creek

Chelan County, Washington

U.S. Department of the Interior

Bureau of Reclamation
Pacific Northwest Region
Boise, Idaho

February 2009

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

The assessment teams overarching hypothesis on ecosystem processes are:

The proposed potential habitat actions presented in this reach assessment will provide a cumulative benefit that will improve ecosystem resilience at the reach scale; and the processes that naturally create and sustain habitat upon which the species of concern will be maintained or improved resulting in a net increase in abundance, productivity, spatial diversity and structure of the populations.

Cover Photograph – A riffle in the straightened section of the active channel with the railroad grade acting as the right bank; view looking downstream to the east.
Lower White Pine Reach; Subreach LWP IZ-5, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

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Pacific Northwest Regional Office

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The Bureau of Reclamation (Reclamation) was fortunate to have the support and cooperation of multiple United States (U.S.) Forest Service staff who participated in the effort to produce the Lower White Pine Reach Assessment, Nason Creek, Chelan County, Washington. In particular, Reclamation acknowledges the collaborative efforts and contributions of U.S. Forest Service employees Dave Hopkins, Cindy Raekes, and Cameron Thomas with the integration of the Reach-based Ecosystem Indicators (REI) that is the overarching strength of this reach assessment.

The following Reclamation employees are acknowledged for their peer review of this report: Regional Geologist Richard A. Link, Geology, Exploration & Instrumentation Group, Pacific Northwest Regional Office; Wenatchee Habitat subcommittee.

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EXECUTIVE SUMMARY

Nason Creek is a tributary to the Wenatchee River which flows into the Columbia River in Chelan County, Washington (Figure 1). As part of the Columbia River Basin, Nason Creek contains salmon and steelhead habitat of the Columbia River fish species. The species of concern found in Nason Creek include Upper Columbia River spring Chinook salmon (*Oncorhynchus tshawysha*), Upper Columbia River steelhead (*Oncorhynchus mykiss*), and Columbia River bull trout (*Salvelinus confluentus*) which are included in the Threatened and Endangered list under the Endangered Species Act (UCSRB 2007).

The Lower White Pine reach is located between river miles (RM) 9.45 and 11.55 on Nason Creek, a 6th field Hydrologic Unit Code (HUC) watershed (Figure 1). In its natural state, Nason Creek maintained dynamic equilibrium by actively migrating laterally across its floodplain within the Lower White Pine reach. Typically, unconfined geomorphic reaches have flatter slopes and a complex network of channels that result in a high degree of interaction between the active channel and the floodplain. This lateral channel migration helps the stream maintain a flatter channel profile as sediment is stored on the floodplain before being eroded and transported downstream. The natural ecosystem processes create a healthy stream characterized by a dynamic cycle of conversion from stream to floodplain and vice versa, producing a constant renewal of fish habitat.

Ecosystem processes in the Lower White Pine reach are in a degraded state as a result of human-constructed constraints. Due to the impacts by human activities, the historic floodplain of Nason Creek has been substantially reduced. These conditions have altered or prevented the dissipation of stream energy, the recruitment and retention of large woody debris that forms cover for fish, and the natural production of fish spawning and rearing areas. In the case of this reach, sediment and wood are flushed through the Lower White Pine reach more frequently, resulting in diminished pool quantity and quality. These impacts have combined to reduce the total area of fish habitat in Nason Creek.

The Bureau of Reclamation produced this report to assist in meeting tributary habitat commitments contained in the 2008 Federal Columbia River Power System Biological Opinion (NMFS 2008). This report provides scientific information to Tribal, State, and local partners for identifying, prioritizing, and implementing sustainable field projects that improve survival and lead to the recovery of salmon and steelhead listed under the Endangered Species Act (NMFS 2008).

Field surveys and evaluations were conducted in the Lower White Pine reach to determine the condition of the riparian, hydrologic, and geomorphic regimes. The dynamic interactions of these regimes can produce sustainable fish habitat; however, if the interaction between these regimes has been altered, it impacts the availability of fish habitat and threatens the continuation of the species within the basin. This reach assessment evaluates condition of the reach, the impacts from human activities, and the sustainability of fish habitat within the reach.

Three reach assessments on Lower Nason Creek are being completed based on summer and fall of 2008 field surveys and evaluations. The three reaches were delineated at the valley segment scale from the refinement of data from the tributary assessment in which two reaches were identified (Reclamation 2008). The three reaches were characterized into two general geomorphic reach types, confined and unconfined, based on natural channel constraints. The confined and unconfined reaches were ranked based on their coarse-scale geomorphic potential. The Lower White Pine reach had the highest geomorphic potential for restoration to natural conditions, but the largest impact from human-constructed features within the low surface (i.e., more departed from a natural condition). Consequently, this particular reach was the primary focus of the first of three reach assessments on Nason Creek.

Purpose of the assessment: Refine understanding of geomorphic potential within the Lower White Pine reach and establish environmental baseline conditions to assist in the local selection, implementation, and monitoring of potential habitat actions.

Goal of the assessment: Provide sound integrative river science that will assist the local watershed action group in the development of an implementation strategy and aid in project selection. The reach assessment had these objectives:

1) Determine the functional arrangement of physical and biological components of the reach.
2) Establish an understanding of the predominant physical processes.
3) Interpret and document the problems.
4) Propose potential solutions.
5) Develop a recommended prioritization of the subreaches to be utilized by local watershed action groups when developing an implementation strategy and the selection of projects.

This reach assessment establishes environmental baseline conditions in Lower White Pine reach by examining fluvial geomorphic forms and processes (i.e., those landforms and processes that are related to the movement of flowing water) and assessing their influences on forming and maintaining fish habitat. A reach is comprised of smaller scale components that include the active main channel, the floodplain, and off-channel areas which are called subreaches. Subreaches are delineated by lateral and vertical controls with respect to the presence or absence of inner or outer zones (Figure 2). An inner zone (IZ) is an area where ground-disturbing flows take place, such as the active main channel or related side channels (USFS 2008). An outer zone (OZ) is an area that may become inundated at higher flows, but does not experience a ground-disturbing flow. The OZ, also known as the floodprone width, is typically a terrace that is generally coincidental with the historic channel migration zone except where the channel has been modified or incised, cutting the creek off from the historic floodplain.

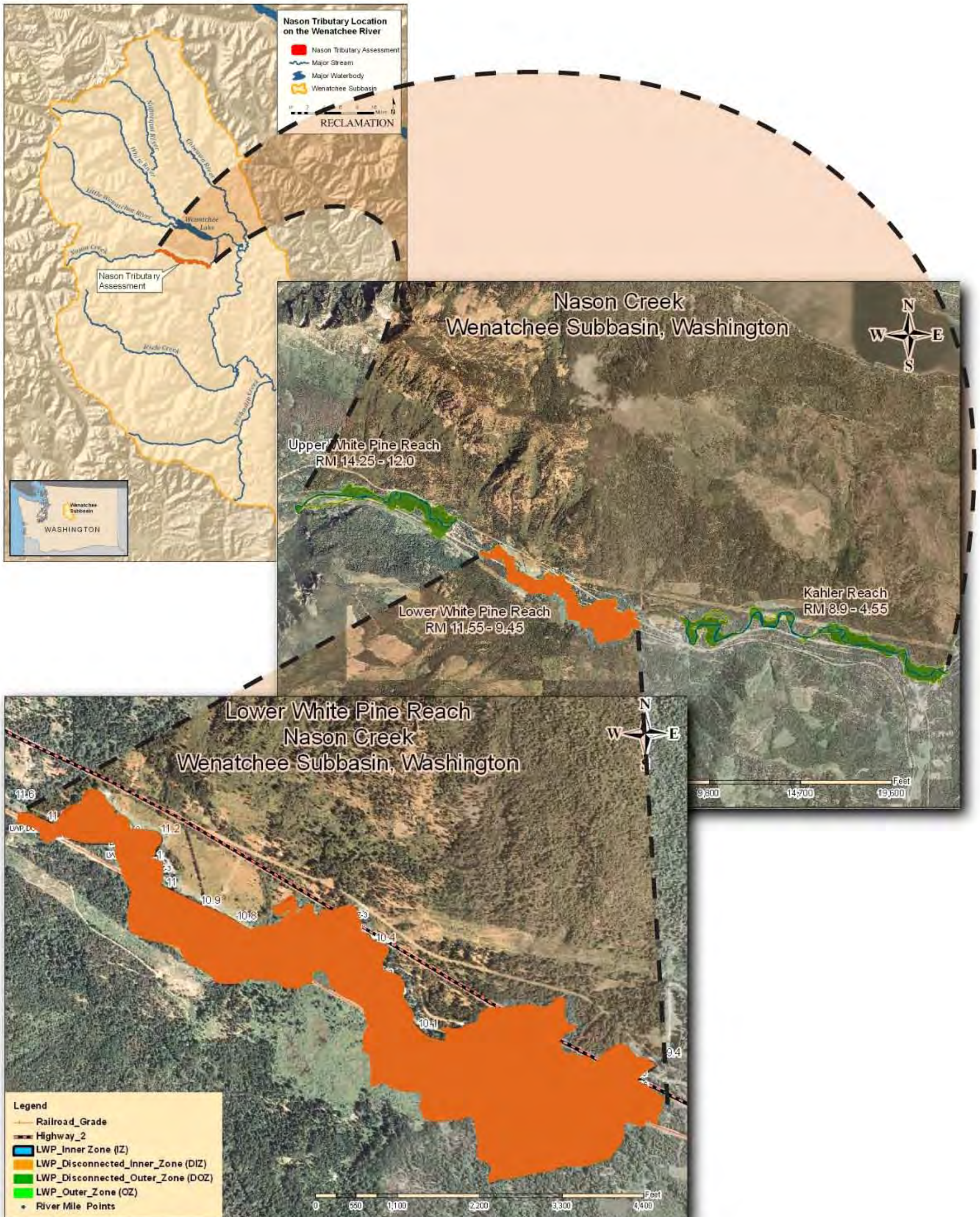

Figure 1 – Lower White Pine Reach. Assessments are spatially nested to address the spatial and temporal scales of an ecosystem. Location map for the Lower White Pine reach assessment demonstrating the nested geographic relationship of the Wenatchee watershed, Nason Creek tributary assessment area at the valley-segment scale and the Lower White Pine reach assessment study area.

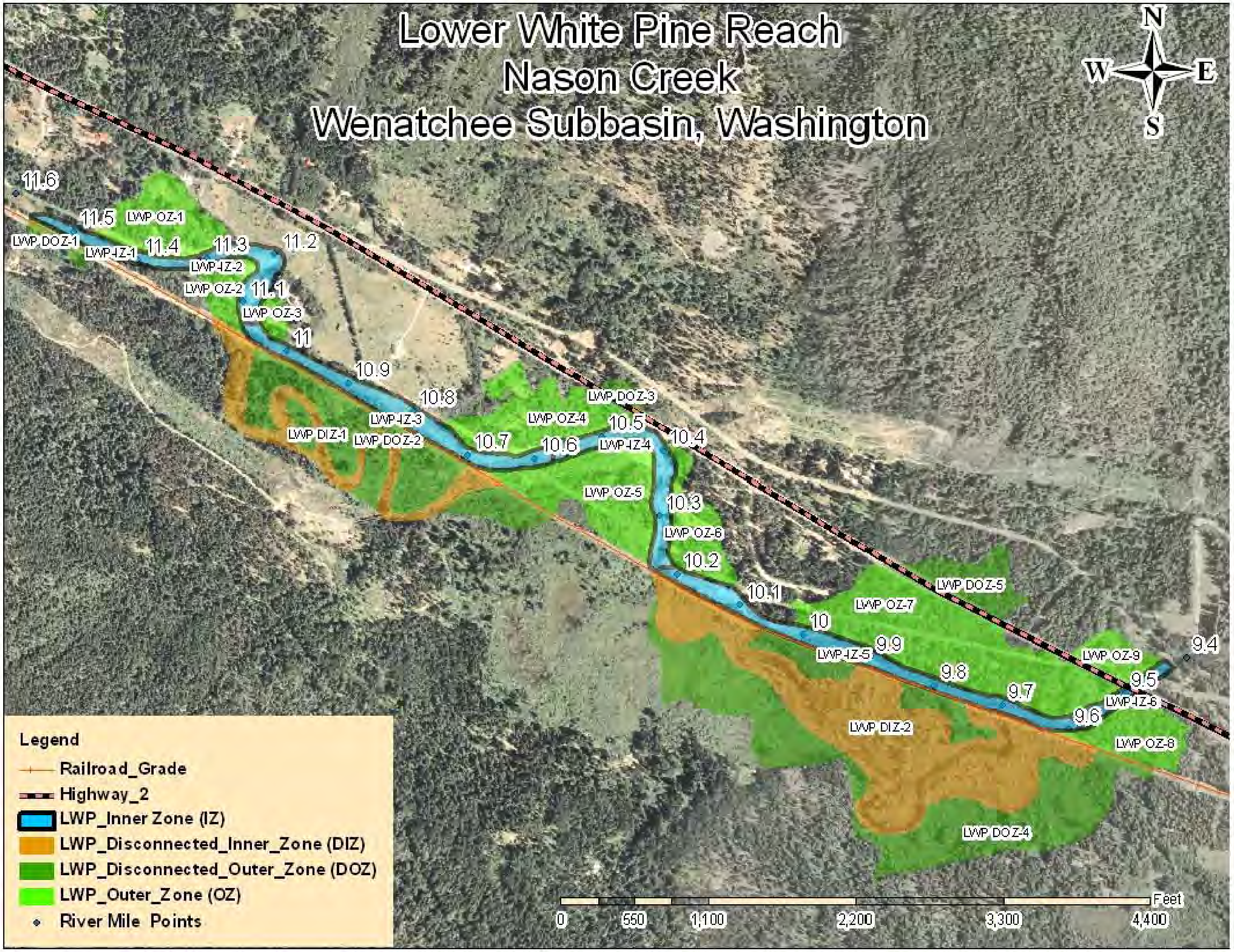

Figure 2 - Inner and Outer Zones of the Lower White Pine Reach, Nason Creek, Wenatchee Subbasin, Washington.

Table 1 - Reach-based ecosystem indicators (REI) for the Lower White Pine reach. Each indicator was interpreted to be in one of three conditions: adequate, at risk, or unacceptable risk.*

Pathway	Indicator	Condition
Water Quality	Temperature	Unacceptable Risk
	Turbidity	At Risk
	Chemical Contaminants/Nutrients	At Risk
Habitat Access	Physical Barriers	Adequate
Habitat Quality	Substrate	Adequate
	LWD	Unacceptable Risk
	Pool Frequency and Quality	At Risk
	Connectivity w/ Main Channel	Unacceptable Risk
Channel Condition and Dynamics	Floodplain connectivity	Unacceptable Risk
	Bank Stability/Channel Migration	Unacceptable Risk
	Vertical Channel Stability	At Risk
Riparian Vegetation	Structure	Unacceptable Risk
	Disturbance	At Risk
	Canopy Cover	Unacceptable Risk

*Existing conditions are defined based on criteria defined in the REI (appendix A)

The river condition describes the current state of fluvial processes and their relationship to habitat-forming processes. Human features can be analyzed to establish their impacts to the current river condition. Subsequently, the river condition provides a baseline for comparisons in future references. In the instance of the Lower White Pine reach, the habitat-forming processes have been unfavorably impacted, with over 85 percent of the river condition indicators in a degraded condition (i.e., over half of the indicators are at unacceptable risk and another third at risk, as shown in Table 1). With the exception of habitat access, all other habitat-forming processes have at least one river condition indicator with observed degraded conditions. Three indicators in particular, large woody debris, pool quality, and floodplain connectivity, are symptomatic of the larger issue of lost geomorphic potential.

The multiple functions associated with all three regimes have been impacted through the dissection of the floodplain by the railroad and Highway 2 and the hardening of the banks with riprap. These features have reduced the overall width of the available floodplain and length of the stream channel. The result is a diminished capacity to dissipate stream energy, a reduced ability to migrate in subreaches DIZ-1, DOZ-2, DIZ-2 and DOZ-4, and very little off-channel habitat for fish rearing (Figure 2). At low flow, only about 1 percent of the habitat area consists of side channels and off-channel habitat. An increase in stream power promotes incision of the channel bed; reduces heterogeneity of channel units; decreases large woody debris recruitment and retention; decreases deposition of spawning gravel; and reduces nutrient supply and storage in the connected inner zones. Impaired channel migration and the disconnection of the floodplain reduce the ability of the stream to rejuvenate ecosystem functions, such as riparian vegetation and substrate throughout the current main channel of the reach.

Geomorphic potential is the combined influence of water, sediment, and large woody debris in forming, connecting, and sustaining fish habitat. Over half of the Lower White Pine reach has been disconnected from the active channel and does not contribute to habitat-forming processes. Figure 3 shows a prioritized implementation approach by subreach unit for the Lower White Pine reach. A dual-track rehabilitation approach that would address both long-term and short-term goals with respect to time to implement is necessary to reestablish geomorphic potential and with it healthy stream conditions (Table 2). The long-term track of this approach would involve addressing the disconnected subreaches by a cooperative effort with the two large landowners, the Burlington Northern Railroad and the State of Washington Department of Transportation. The goal of the long-term track is to reconnect disconnected or "relict" subreaches that are currently disconnected by the highway or railroad grade. Subreaches of particular interest include DIZ-1 and DIZ-2, along with adjacent historic outer zone areas of DOZ-2 and DOZ-4, respectively. This cooperative effort can be executed in conjunction with the short-term track that focuses on the rehabilitation of connected subreaches in a series of potential habitat actions that will complement reconnection of the disconnected subreaches. Potential rehabilitation actions necessary in the short term include riparian plantings and noxious weed eradication; unimproved road relocations or removals; and instream large woody debris structures. Subreaches that are candidates for the short-term track of this approach include OZ-1, OZ-2, OZ-3, OZ-4, OZ-5, OZ-6, OZ-7 and OZ-8, all of which already offer form and connectivity, albeit in a diminished condition.

Restoration strategies identified by the Upper Columbia Salmon Recovery Board (UCSRB), consisting of both potential protection and rehabilitation actions, are recommended to prevent further degradation of the stream ecosystem (UCSRB 2007). While restoration may be the ultimate aim in many instances, a more measured approach is sometimes necessary due to multiple human constraints, which in this case are the Burlington Northern Railroad and Washington State Highway 2. Key rehabilitation strategies include a combination of floodplain reconnection and riparian improvement that promote a return of natural ecosystem processes.

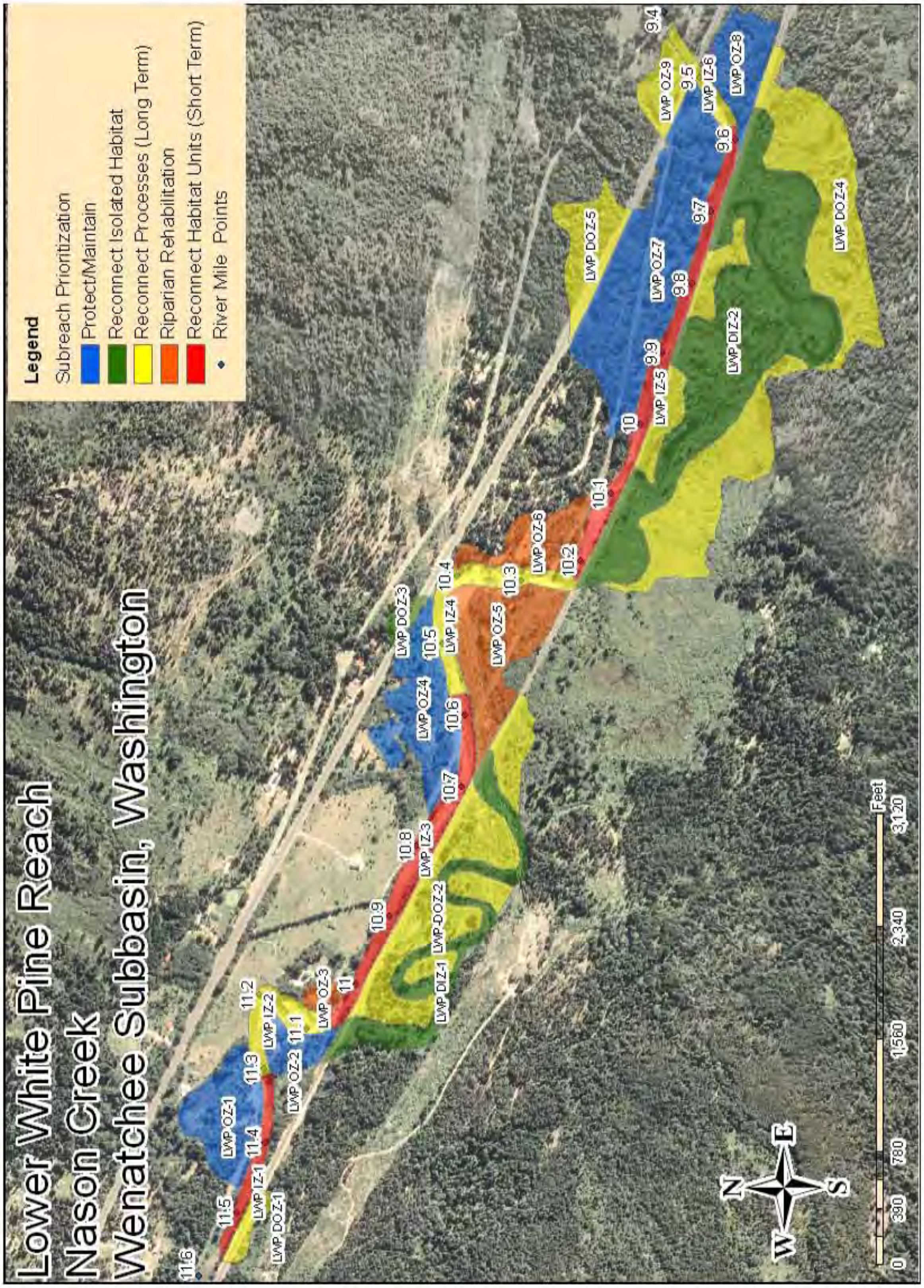

Figure 3 - Subreaches prioritized using the strategy from Roni, 2006.

OVERVIEW

Assessments are hierarchically nested to address the spatial and temporal scales of an ecosystem (Figure 4). Assessments telescope from a coarse scale (i.e., largest scale called a basin) to a finer scale (i.e., a smaller scale called a reach) from which habitat actions are implemented. This is called a top-down approach,. After implementation of a habitat action, monitoring of the physical and biological variables telescope from a finer scale (reach) to a coarser scale (basin), called a bottom-up approach, from which intervention analysis (i.e., monitoring) of the status assessments can be conducted to determine the overall trajectory of the species of concern. This nesting approach enables development an overall understanding of the ecosystem's current and historic conditions and how stream processes have been affected (i.e., creation and maintenance of aquatic habitat).

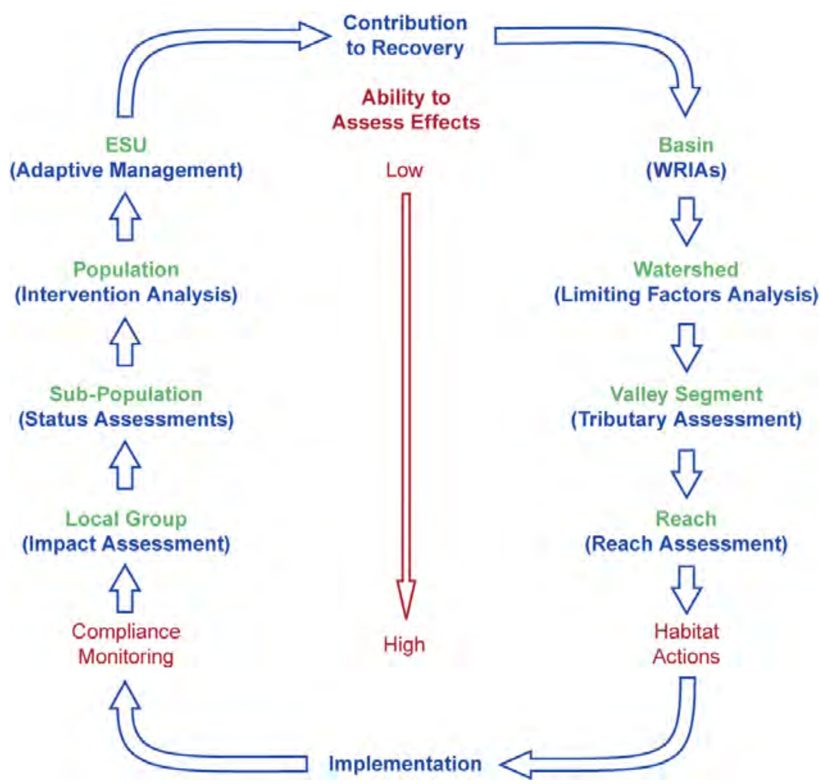

Figure 4. Hierarchy of reach assessments. Idealized model showing how assessments and monitoring are hierarchically nested and related. Clockwise from the top, Compiled from Hillman (2006), UCSRP (2007) and Stewart-Oaten and Bence (2001).

Tributary assessments can be conducted to further analyze impaired stream processes and their effects, and to provide a prioritized list of geomorphic reaches based on floodplain or valley confinement (i.e., confined, moderately confined, and unconfined). Not all reaches require a reach assessment. For example, naturally confined reaches that are not severely degraded and pose little risk to property and infrastructure may not need a reach assessment. Reach assessments are generally recommended for moderately to unconfined geomorphic reaches where complex processes have been degraded and where the implementation of habitat actions may pose risks to property and infrastructure. Even in instances where a reach assessment is not conducted, some baseline data should be collected prior to implementing any habitat action so that the action can be monitored for effectiveness.

The purpose of a reach assessment is to refine understanding of the geomorphic potential within a response reach and establish environmental baseline conditions at the reach-scale to assist in the local selection, implementation, and monitoring of potential habitat actions. The reach assessment evaluates the current condition of a group of indicators. The physical variables organized within the reach-based ecosystem indicator matrix (REI) are quantifiable and have geospatial reference. Incorporating quantifiable biological variables into the REI are currently being explored by Reclamation. The variables measured in the REI record the baseline environmental conditions and are hierarchical in nature in that they are used as information about the condition of higher-level indicators (i.e., pathways). The REI identifies deficiencies in the vegetation, geomorphic, and hydrologic regimes upon which habitat actions can be implemented using a cost effectiveness approach.

Following implementation of a habitat action or series of actions, the action is documented and includes what was done, where it was done, and why it was done (i.e., compliance monitoring). After several habitat actions have been implemented in a reach, an impact assessment can be completed using a subset of the physical variables from the REI based on the overall intent of the actions (i.e., reconnect isolated habitats).

Status assessments that document changes to physical and biological variables can be used to evaluate how the ecosystem and the species of concern are responding. This is known as an intervention analysis (i.e., before-and-after controlled impact analysis) to determine if the overall response is positive. If the response is positive, then the actions were effective and there is no need for adjustments. However, if the response is flat or negative, then the habitat actions may need to be adjusted within an adaptive management framework. These checks and balances are intended to improve the habitat upon which the species of concern depend and ultimately contribute to their recovery.

PURPOSE AND LOCATION

The Bureau of Reclamation (Reclamation) produced this report to help meet tributary habitat commitments contained in the 2008 Federal Columbia River Power System Biological Opinion (NMFS 2008). This report provides scientific information to help identify, prioritize, and implement sustainable field projects, in collaboration with Tribal, State, and local partners, that improve survival and lead to the recovery of salmon and steelhead listed under the Endangered Species Act (NMFS 2008).

The goal of a reach assessment is to set up local stakeholder processes for project selection based on sound integrative river science, through the objectives.

- *Determining the functional arrangement of physical and biological components of the response reach.* The first objective is to establish geomorphic potential of the river reach through a spatial framework and relevant scaling relationships for the assessment area. A local geomorphic regime has inherent constraints and capabilities for forming, connecting, and sustaining aquatic river habitat. This is done through scaling down the response reach to individual subreach and channel/geomorphic units, which are smaller scale structural components of the reach. Subreach units are comprised of the active main channel, floodplain, and off-channel areas.

- *Establishing an understanding of the predominant physical processes.* Identify linkages between physical processes and anthropogenic impacts based on understanding the key physical processes operating in the reach or within and among the context of subreach units; and identify how these processes have been impacted by past and present human activities.

- *Interpreting and documenting the problems.* Diagnose river conditions at the reach scale based on integrating physical, biological, and habitat information into a matrix of REI. The REI is a diagnostic tool for measuring baseline environmental baseline conditions and identifying deficiencies in three regimes: geomorphic, vegetation, and hydrologic.

- *Proposing potential solutions.* Identify and prioritize potential habitat actions at the subreach scale that support the greatest cumulative biological benefit based on a refined understanding of the geomorphic potential and environmental baseline conditions.

- *Prioritize the subreaches.* Develop a recommended prioritization of the subreaches based on refined understanding of geomorphic potential and ecosystem conditions that will in turn be utilized as a platform to develop an overall implementation strategy with local partners and stake holders.

- *Presenting the results to the local group for project selection.* Use the proposed implementation strategy along with other local factors provided by local stakeholders and partners to discuss a synthesis of all available information and ultimately, an implementation time line.

Nason Creek is a tributary to the Wenatchee River, Chelan County, Washington (Figure 5). A total of three reach assessments on Lower Nason Creek are being completed sequentially based on summer and fall of 2008 field surveys and evaluations. All three reach assessments collectively will provide a foundation for a holistic, comprehensive strategy for rehabilitation and protection at the scale of the valley segment (Figure 6).

The Lower White Pine Reach is located between river mile (RM) 9.45 and 11.55 on Nason Creek, a 6th field Hydrologic Unit Code (HUC 170100100104) watershed within the Eastern Cascade Section of the Cascade Province (Hillman 2006). The species of concern found in Nason Creek include Upper Columbia River (UCR) spring Chinook salmon (Oncorhynchus tshawysha), UCR steelhead (Oncorhynchus mykiss), and Columbia River bull trout (Salvelinus confluentus) (UCSRB 2007).

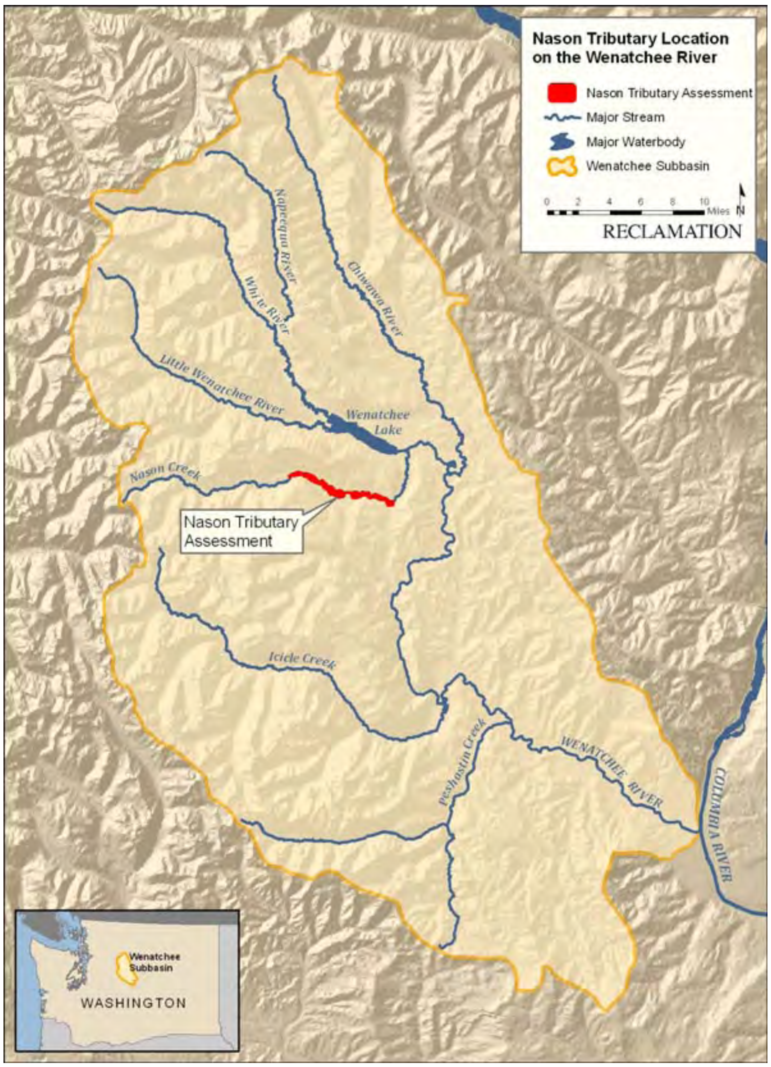

Figure 5 - Location map of Nason Creek within the Wenatchee subbasin. The section in red notes the valley segment that the tributary assessment was conducted on.

Limiting factors at the watershed scale that are the result of various anthropogenic impacts include riparian condition, streambank condition, channel function, floodplain connectivity, water quality, habitat diversity, and large wood (Andonaegui 2001; UCSRB 2007; RTT 2007).

The Upper Columbia Spring Chinook Salmon, Steelhead, and Bull Trout Recovery Plan identified potential restoration strategies based on a combination of available data, aquatic ecosystem modeling, and professional judgment of a panel of scientists (UCSRB 2007). Further technical evaluation was recommended to refine the level of detail needed to implement projects and determine if the recommendations are sustainable and compatible with the geomorphic conditions of the river. Regarding physical processes, the Upper Columbia Salmon Recovery Board (UCSRB) recommends conducting additional research to identify priority locations for protection and rehabilitation and examining fluvial geomorphic processes to assess how these processes affect habitat creation and maintenance. This reach assessment is intended to address those recommendations.

Figure 6 - Three response reaches identified by river miles in the Nason Creek Tributary Assessment, Chelan County, WA.

TRIBUTARY ASSESSMENT

Previously identified watershed-scale limiting factors are typically the result of various anthropogenic impacts and include riparian condition, streambank condition, channel function, floodplain connectivity, water quality, habitat diversity, and large woody debris (Andonaegui 2001; UCSRB 2007; RTT 2007). The Upper Columbia Spring Chinook Salmon, Steelhead, and Bull Trout Recovery Plan has identified potential restoration strategies based on a combination of available data, aquatic ecosystem modeling, and professional judgment of a panel of scientists and recommend refinement of existing data and/or the collection data at the appropriate scale that will allow habitat actions to be implemented (UCSRB 2007).

The Nason Creek Tributary Assessment, Chelan County, Washington (Tributary Assessment) was completed by a multidisciplinary team of hydraulic engineers, geologists, hydrologists, biologists, and botanists (Reclamation 2008). The focus of the Tributary Assessment was to complete a comprehensive geomorphic analysis of the fluvial system along about 10 miles of Nason Creek located in the Wenatchee subbasin in Chelan County, Washington (Figure 5).

The objectives of the Tributary Assessment were to (1) delineate and characterize channel reaches on the basis of their geomorphic characteristics and biological opportunities and develop potential rehabilitation strategies organized on a reach-based approach; (2) provide technical ranking of the geomorphic reaches that can be used to prioritize the potential habitat protection and improvement areas within the assessment area based on linkage to primary limiting factors for salmon recovery; (3) identify the recurrence intervals of natural and human-induced disturbances and how they affect channel processes within the assessment area; and (4) evaluate the habitat-forming physical processes and disturbance regimes working at the subbasin and reach scales from both historical and contemporary context (Reclamation 2008).

At the tributary scale, initially three reaches were delineated and characterized into two general geomorphic reach types based on natural channel constraints. These reach types are referred to as confined and unconfined geomorphic reaches (a third geomorphic reach type, moderately confined, was not encountered; Table 2). The confined reach (identified as Reach 2 in the Tributary Assessment) was not assessed. The unconfined and confined reaches were ranked based on their geomorphic potential. The White Pine reach had the higher geomorphic potential and the largest impact from anthropogenic features within the low surface (i.e., more departed from a natural condition).

At the reach assessment scale, the reach initially identified as geomorphic reach 3 (White Pine reach) in the Tributary Assessment was further delineated into two response reaches, the Upper and Lower White Pine, that are separated by a confined reach located at river miles 11.55 to 12.0 (reach 4) (Table 2).

Table 2 - Geomorphic reach and response reach location by river mile, reach type, and floodplain area for Lower Nason Creek between RM 4.5 and RM 14.3 (Reclamation, 2008a).

Geomorphic Reach Designation (Reclamation, 2008)	Reach Assessment Name	River Miles	Reach Type	Total Floodplain Area (approximate Acres)
Reach 1	Kahler	4.5-8.9	Unconfined	335
Reach 2	Reach 2	8.9-9.42	Confined	14
Reach 3	Lower White Pine	9.42-11.55	Unconfined	229
	Reach 4	11.55-12.0	Confined	
	Upper White Pine	12.0-14.25	Unconfined	135

Within the Lower White Pine reach, there has been no large-scale change to the balance between incoming water and sediment loads that would indicate a potential for incision or aggradation (Reclamation 2008); however, several sections of the river within the reach have been artificially straightened and confined by bank hardening. The Burlington Northern railroad grade and Highway 2 disconnect Nason Creek from its tributaries. The absence of sediment that would have been provided indicates a potential for increased sediment transport capacity and, thus, possible incision.

The largest impact to physical processes and habitat is from the construction of the railroad grade in the 1890s and the Highway 2 realignment and widening in the 1960s. The impacts of these features include channel straightening and relocation, reduced channel migration, reduced floodplain connectivity, altered sediment and large woody debris delivery and retention, and disconnecting tributaries and groundwater sources from the main channel. Bridges, small levees, and the powerline corridor also impact physical processes, but to a more localized degree.

The Lower White Pine reach assessment provides the recommended technical evaluation to refine the level of detail necessary for selecting and implementing potential habitat actions. The reach assessment establishes environmental baseline conditions tied into a geospatial reference. This is done through an in-field evaluation of fluvial geomorphic form and processes. In turn, this reach-based baseline can be used to assess the influence and feedback on habitat formation and maintenance over time.

REACH CHARACTERIZATION

The Lower White Pine reach encompasses about 229 acres of floodplain and active channel of Nason Creek within an alluvial valley from RM 9.45 to 11.55. The current channel and active floodplain are located between Highway 2 to the north and the railroad grade to the south (Figure 7). These two features disconnect sections of multiple inner and outer zones from the active channel and floodplain that total about 55 percent of the total reach area. Table 3 summarizes the acreages of the inner and outer zones.

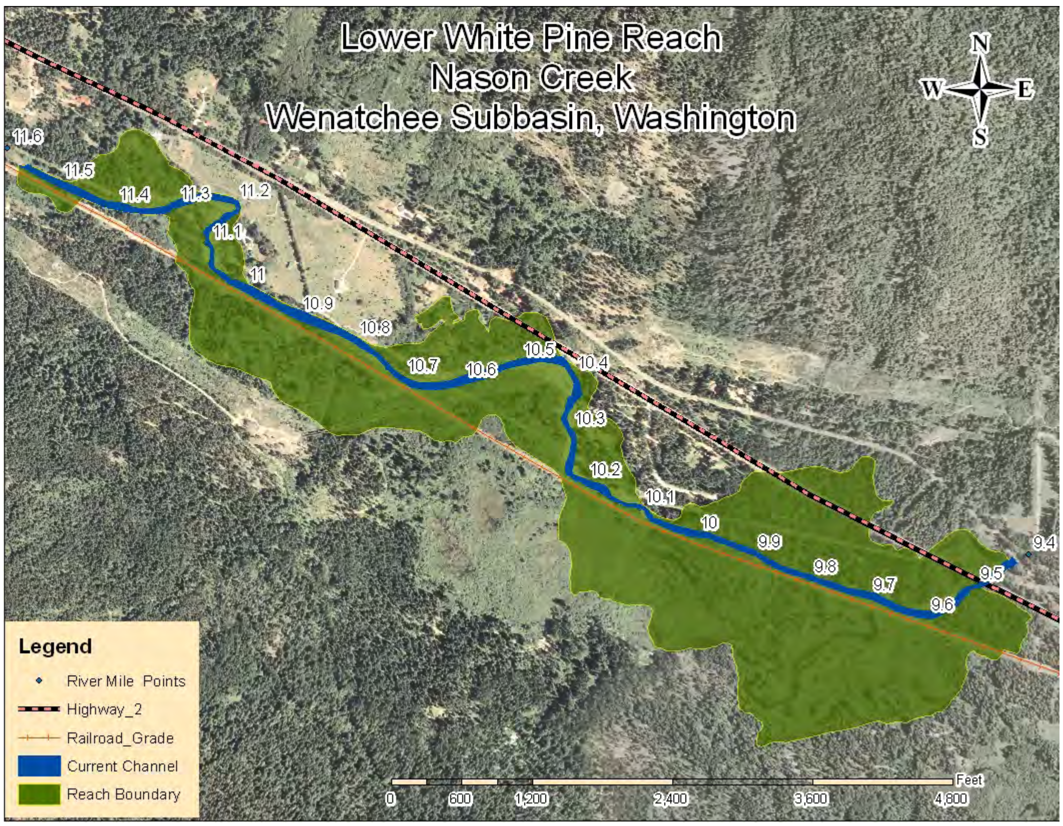

Figure 7 - Refined reach delineation and boundary conditions of the Lower White Pine Reach.

Table 3 - Acres by zone type on the Lower White Pine Reach, Nason Creek, Wenatchee Subbasin, Washington.

Inner Zone	Connected Outer Zone	Disconnected Outer Zone	Disconnected Inner Zone
28 Acres	75 Acres	72 acres	52 Acres

The valley bottom is classified as a U-shaped trough (U-1) with a valley bottom gradient less than 3 percent and an unconstrained, moderately sinuous channel (Naiman et al. 1992). The stream type is B to C type (Rosgen 1996), showing evidence of slight to moderate incision with predominantly riffle and run bedform (Montgomery and Buffington 1993) and gravel as the dominant substrate. Landforms typically include alluvial and glacial deposits comprising terraces and alluvial fans (Hillman 2006). Alluvial fan deposits provide lateral and vertical channel controls.

The reach is comprised of the active main channel, floodplain, and off-channel areas. The reach was further broken down into two types of morphologically distinct areas or subreach unit types to denote greater local control and variability. Called inner and outer zones, these subreach unit types essentially represent areas of existing and potential habitat formation and maintenance within the response reach. Subreaches are delineated by lateral and vertical controls based on the presence or absence of inner or outer zones processes (Figure 9). An inner zone (IZ) is characterized by the presence of primary and secondary side channels, a repetitious sequence of channel units, and relatively uniform physical attributes indicative of localized transport, transition, and deposition. An inner zone is generally associated with ground-disturbing flows with sufficient frequency that mature conifers are rare and a distinct hardwood zone is identifiable (USFS 2008). In the instance of the active main channel, it was further subdivided into six inner zones based on the mapping of channel units (Figure 9 and Figure 10).

In contrast, an outer zone (OZ), also known as the floodprone width, is typically a terrace tread and generally coincidental with the historic channel migration zone unless the channel has been modified or incised leading to the abandonment of the floodplain. This zone includes overflow channels, wetlands, and other off-channel habitat and is usually predominated by riparian vegetation and hillslope processes. An outer zone is further distinguished from an inner zone by the presence of flood deposits, a change in vegetation, and bounding geologic landforms (e.g., older terrace, bedrock or valley wall, alluvial fan, colluvium, or glacial deposits).

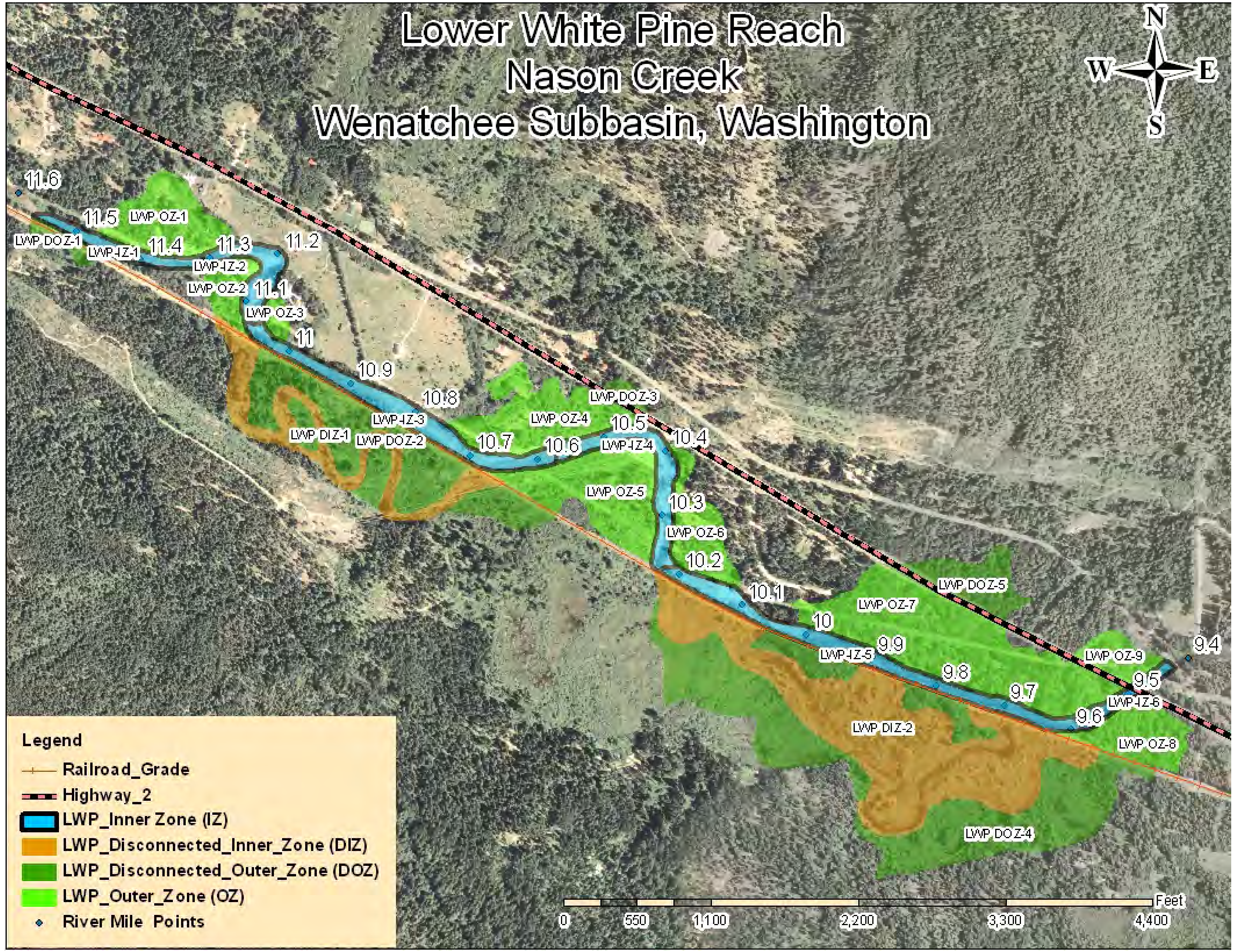

Figure 8 - Inner and Outer Zones of the Lower White Pine Reach, Nason Creek, Wenatchee Subbasin, Washington.

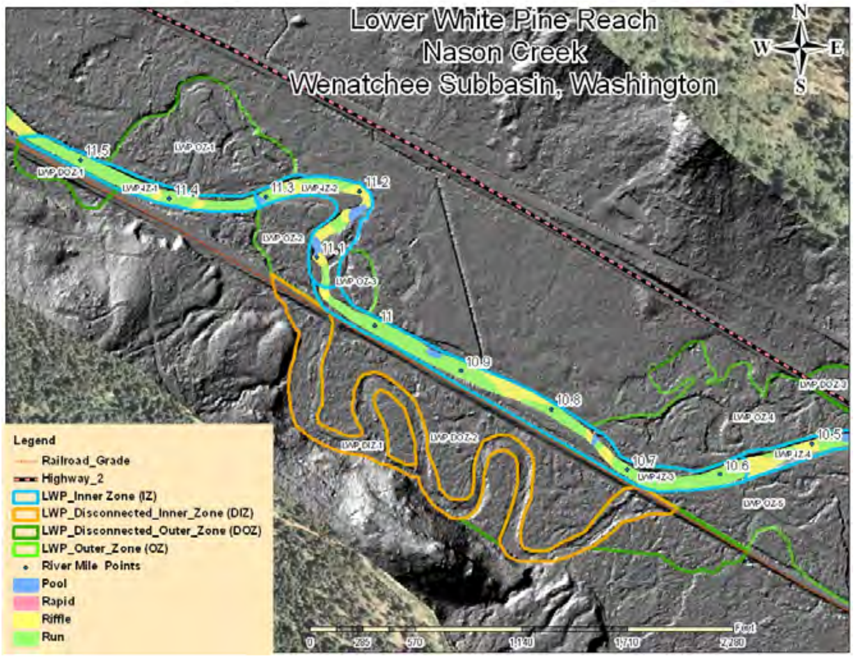

Figure 9 - Channel unit mapping of the upper portion of the Lower White Pine Reach including subreach unit boundary conditions.

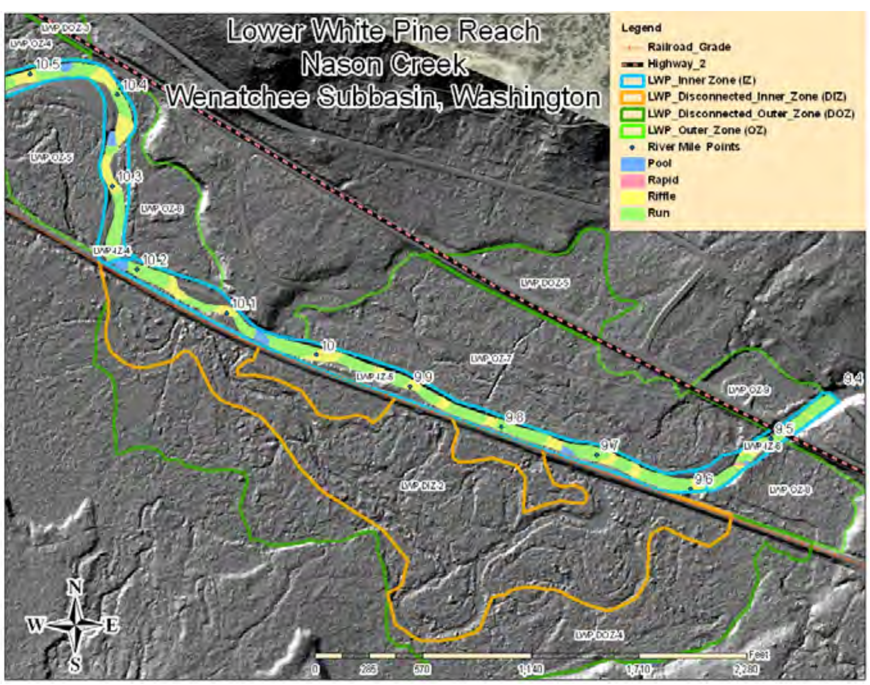

Figure 10 - Channel unit mapping of the lower portion of the Lower White Pine Reach including subreach unit boundary conditions.

RIVER REACH CONDITION

River reach condition is a synthesis of all available information at the time of the investigation. The REI matrix is a compilation of the information and data collection from multi-disciplinary analyses that were conducted prior to or during this investigation (Appendix A). Specific data collected and documented within separate disciplinary analyses are the Initial Site Evaluations (Appendix B), Level 2 Habitat Assessment (Appendix C), and 2-Dimensional Hydraulics and Sediment Analysis (Reclamation 2008, Appendix H). The biological ranking of the subreaches was performed by the Upper Columbia Regional Technical Team (RTT) subcommittee (Appendix G).

River condition limiting factors are determined by measuring and synthesizing results from indicators within five pathways: water quality, habitat access, habitat quality, channel dynamics, and riparian vegetation. The indicators measured in the REI record baseline environmental conditions and are hierarchical in nature in that they are used to inform the implementers on the condition of higher-level indicators such as pathways. The synthesis of the collected information provides a “snapshot” understanding of the combined condition of the geomorphic, riparian vegetation, and hydrologic regimes. In turn, this information is used to develop an overall interpretation of reach-based river condition with respect to the primary limiting factors.

Based on the best available information and measurements from the field evaluation, each indicator was determined as functioning at one of three conditions: adequate, at risk, or unacceptable risk based on criteria contained in the REI. Table 4 shows the results of the REI.

Table 4 - Reach-based ecosystem indicators (REI) for the Lower White Pine reach. Each indicator was interpreted to be in one of three conditions: adequate, at risk, or unacceptable risk.

Pathway	Indicator	Condition
Water Quality	Temperature	Unacceptable Risk
	Turbidity	At Risk
	Chemical Contaminants/Nutrients	At Risk
Habitat Access	Physical Barriers	Adequate
Habitat Quality	Substrate	Adequate
	Large Woody Debris	Unacceptable Risk
	Pool Frequency and Quality	At Risk
	Connectivity w/ Main Channel	Unacceptable Risk
Channel Condition and Dynamics	Floodplain connectivity	Unacceptable Risk
	Bank Stability/Channel Migration	Unacceptable Risk
	Vertical Channel Stability	At Risk
Riparian Vegetation	Structure	Unacceptable Risk
	Disturbance	At Risk
	Canopy Cover	Unacceptable Risk

The following are summary results of reach-based conditions:

- 50 percent of the indicators are at *unacceptable risk*.
- 36 percent of the indicators are *at risk*.
- 14 percent of the indicators are *adequate*.

Limiting factor indicators should be monitored to gauge the response of the river to the implemented actions. The assessment team suggests that monitoring these indicators may provide pro-active opportunities to maintain or improve the overall ecosystem resiliency of the Lower White Pine response reach.

Following implementation of a habitat action or series of actions, compliance monitoring documents what action was done, where it was done, and why it was done. After several habitat actions have been implemented in a river reach, an impact assessment is completed using a subset of the physical variables from the REI based on the overall intent of the actions (i.e., reconnect isolated habitats).

At the reach scale, the ability to assess both the physical and biological effects of the actions is considered high (Hillman 2006). Improvements made to physical variables coupled with the biological variables (i.e., status and trend) can be used to evaluate the ecosystem's trajectory and whether the species or assemblage of concern are responding. If the trajectory is positive, then the actions were effective and there is no need for adjustment. However, if the trajectory is flat or negative, adaptive management may need to be used through implementation of additional habitat actions to achieve the desired effect. These checks and balances are intended to improve fish habitat upon which the species of concern depend and ultimately their recovery.

Water Quality

The condition of the water quality pathway throughout the reach is at risk based on indicators of temperature, turbidity, and chemical contaminants. Temperature is at an unacceptable risk, due to the replacement of bank vegetation with riprap and the impoundment of runoff water behind man-made structures (Thomas 2007). Turbidity issues stem from increased timber harvest roads, development (UCSRB 2007) and sensitivity of the system. (Thomas 2007). The indicator of chemical contaminants and nutrients is interpreted to be at risk due to current water use/withdrawals upstream and the volatility of the system.

Although the water quality pathway and the associated indicators are an issue at the watershed scale, impacts can be attributed to acute problems observed at the subreach scale within the Lower White Pine reach. For example, by drawing a 10-meter buffer zone along the banks of the channel, the condition of canopy cover for shading can be quantified by looking at the seral stage and percent disturbed or altered vegetation. Given the overall level of disturbance and young seral stage, all subreaches likely contribute to the unacceptable risk condition to some extent, but at varying degrees. Subreaches that impound runoff and groundwater behind the railroad grade or highway (DIZ-1, DOZ-2, DOZ-3, DIZ-2, and DOZ-4) contribute a greater impact to the condition by allowing the temperature of the water to increase before entering the main channel. Connected subreaches with existing wetlands or ponds (OZ-1, OZ-7, and OZ-9) may contribute to a lesser extent to the overall degraded water quality conditions if inadequate shading exists along the perimeter of the wetlands.

Habitat Access

The condition of the habitat access pathway is adequate given that there are no barriers on the mainstem.

Habitat Quality

The habitat quality pathway is at risk due to the following conditions: (1) lack of large woody debris in the channel; (2) pool frequency and quality; and (3) culverts placed through the highway and railroad embankments to drain runoff water and base flow. The areas in the latter indicator do not provide adequate fish passage to isolated pockets of habitat.

All subreaches contribute to an at risk condition for habitat quality through the indicator of large woody debris in the channel. The connected inner zones (IZ-1, IZ-2, IZ-3, IZ-4, IZ-5, and IZ-6) contribute through a low large woody debris count. The connected outer zone subreaches (OZ-1, OZ-2, OZ-3, OZ-4, OZ-5, OZ-6, OZ-7, OZ-8, and OZ-9) have a low percent of large diameter trees available for recruitment. Disconnected subreaches (DOZ-1, DIZ-1, DOZ-2, DOZ-3, DIZ-2, DOZ-4, and DOZ-5) by definition cannot contribute large woody debris to the system. Low in-channel wood counts and diminished availability of large wood available for recruitment from all subreaches contribute directly to an at risk pool frequency and quality condition within the inner zones. The indicator of connectivity with the main channel is impacted in those disconnected subreaches (DOZ-1, DIZ-1, DOZ-2, DOZ-3, DIZ-2, DOZ-4, and DOZ-5) where anthropogenic features including the highway and railroad disconnect existing habitat from the current channel and/or where culverts do not allow access to off-channel habitat at base flow.

Channel Dynamics

The channel condition and dynamics pathway are at an unacceptable risk. The impacts of anthropogenic features, including Highway 2 and the railroad, on floodplain connectivity have been well documented (Andonaegui 2001; UCSRB 2007; RTT 2007). Not only are bank stability and channel migration affected by the railroad grade and Highway 2, but they are also impacted by bank hardening (riprap) and clearing of riparian vegetation.

The current channel and floodplain are located between Highway 2 to the north and the railroad grade to the south. These two human features disconnect fluvial processes in multiple inner and outer zones of the active channel and floodplain that total over half of the reach. The disconnection of fluvial processes results in a reduction of lateral channel migration and floodplain connectivity. Subreaches that contribute to the degraded condition of the floodplain connectivity indicator are the disconnected subreaches (DOZ-1, DIZ-1, DOZ-2, DOZ-3, DIZ-2, DOZ-4, and DOZ-5). Subreach inner zones (IZ-1, IZ-2, IZ-3, IZ-4, IZ-5, and IZ-6) contribute to a degraded condition for the bank stability and channel migration indicators. Where the banks of the inner zone are hardened with riprap, no lateral migration occurs. This increases the potential of vertical migration. Observations were made of accelerated channel migration at locations where riprap is not present and riparian vegetation is removed along banks.

Riparian Vegetation

The riparian vegetation pathway is at an unacceptable risk. The indicator of riparian structure is at unacceptable risk. Although the riparian composition at the floodplain width may have a high percentage of native species, the available large wood is only about 2 percent for the entire reach. The riparian disturbance indicator is at risk given that about 45 percent of floodplain vegetation has been disturbed by clearing and/or modification to some degree. The percentage of mature or late seral stage vegetation in the 30-meter buffer (USFS 2008) is low, thus large woody debris recruitment potential is low. The indicator of canopy cover is also at an unacceptable risk. Only 10 percent of the vegetation in the 10-meter buffer zone (Hillman 2006) is large diameter. All subreach indicators contribute to the observed conditions of the riparian vegetation pathway: structure, disturbance, and canopy cover. The common factor with all three indicators is a low percent of large diameter trees, with large diameter being defined as the mean diameter at breast height (DBH) of 12 inches or greater (USFS 2008). Additionally, some subreaches (OZ-3, OZ-5, and OZ-6) have disturbed vegetation that is greater than 20 percent of the total area of the subreach.

DISCUSSION

River condition describes the current condition of fluvial processes and their relationship to habitat-forming processes. Human features can be placed within a context for using current river condition to establish their impacts. Subsequently, river condition provides a baseline from which to compare for future references. In the instance of the Lower White Pine reach, the diagnosis is not favorable with over 85 percent of the indicators in either an at risk or unacceptable risk condition. With exception of habitat access, all other pathways possess at least one indicator with observed degraded condition (i.e., at risk or unacceptable risk). Three indicators in particular, large woody debris, pool quality, and floodplain connectivity, are symptomatic of a larger issue of lost geomorphic potential or the potential for geomorphic regime change. Geomorphic potential is essential in forming, connecting, and sustaining fish habitat because of the combined influence of hydrologic, riparian, and geomorphic regimes over time.

The multiple functions associated with all three regimes have been impacted through the dissection of the floodplain by the railroad and Highway 2 and hardening of the banks with riprap. These features have reduced the overall width of the available floodplain and length of the stream channel. The result is a diminished capacity to dissipate stream energy and a reduced ability to migrate in subreaches DIZ-1, DOZ-2, DIZ-2, and DOZ-4. The outcome is that very little off-channel habitat exists for rearing fish. At low flow, only about 1 percent of the habitat area consists of side channels and off-channel habitat. An increase in stream power promotes incision, reduces heterogeneity of channel units, decreases large woody debris recruitment, decreases spawning gravel and large woody debris retention, and reduces nutrient supply and storage in the connected inner zones. Impaired channel migration and the disconnection of the floodplain reduce the ability of the stream to rejuvenate ecosystem functions, such as riparian vegetation and substrate, throughout the current main channel of the reach.

Typically, unconfined geomorphic river reaches have flatter slopes and a complex network of channels and large woody debris that result in a high degree of interaction between the active channel and the floodplain. In a properly functioning system, the average channel bed elevations within the reach do not change over time so that there is no net change in the total volume of sediment stored in the reach beyond a natural range of fluctuation (Reclamation 2008). Lateral channel migration and floodplain connectivity are especially critical in the Lower White Pine reach to maintain the following at optimal levels that will create, maintain and rejuvenate habitat:

- Riparian structure and composition
- Groundwater recharge
- Water temperature
- Stream power,
- Large woody debris recruitment and retention
- Spawning gravel recruitment and retention
- Nutrient supply and storage

On Lower Nason Creek, impacts to the overall hydrologic regime have resulted in an increase in stream power that gives rise to transport as the dominant process, over-all homogeneity of channel units, and lack of channel complexity at the reach scale. At the subreach scale, small subreaches where transition-to-deposition is the dominant process alternate between longer subreaches of transportation. Within the transport subreaches, bed load is hypothesized to become mobile when flows are increasing and deposited when flows are decreasing with the ultimate result being plain-bed features. Conversely, it is hypothesized that the mobilized bed load from the transport reaches deposits in the smaller subreaches where transition-to-deposition is the dominant process during the increasing flows. As the runoff hydrograph descends, the newly deposited bed material is then incised with the ending result of tall bars and only moderate change on form.

The loss of riparian function within all subreaches at the floodplain width and within the 30-meter and 10-meter buffer zones has both direct and indirect impacts to multiple pathways. At the floodplain width, an overall young seral stage indicates an overall risk to ecosystem health. At the 30-meter buffer zone, high percentages of disturbed or removed vegetation and limited existing large diameter trees create a decreased large woody debris recruitment potential, thus a lack of large woody debris in the system. The same conditions within the 10-meter buffer zone reduce shading potential, which ultimately promote elevated water temperatures. Another contributing factor to an increase in water temperature in the main channel is due to the impounding of surface water behind the railroad grade and highway in the subreaches DIZ-1, DOZ-2, DOZ-3, DIZ-2 and DOZ-4.

Overall, ecosystem processes in the Lower White Pine reach are in a degraded state as a result of human impacts. Rehabilitation activities, consisting of both potential protection and rehabilitation actions, are recommended to prevent further degradation of the river ecosystem. Where restoration is the ultimate aim in many instances, a more measured approach is sometimes necessary due to multiple natural and human-made constraints (Figure 11). Rehabilitation provides an approach that is consistent with restoration objectives (UCSRB 2007) to return critical river ecosystem function to a pristine condition. In addition, rehabilitation is incremental and iterative in nature to accommodate the notion that complete restoration may not be possible due to structural limitations and disturbance regimes. Potential protection and rehabilitation actions specific to this river reach should be prioritized with the following objectives based on Table 5.9 in the Upper Columbia Spring Chinook Salmon, Steelhead, and Bull Trout Recovery Plan (UCSRB 2007).

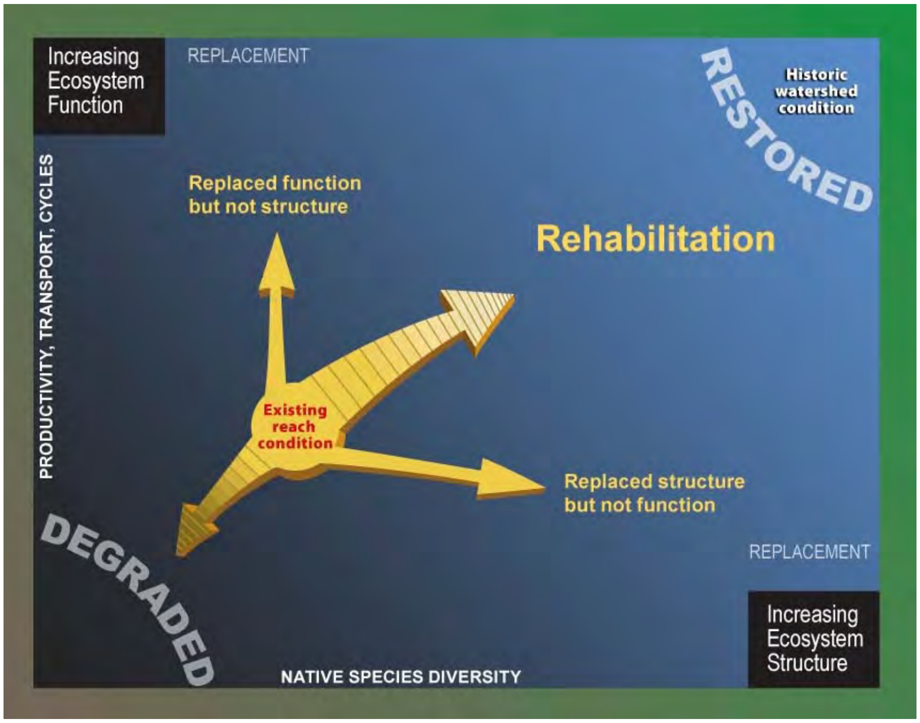

Figure 11 – Ecosystem processes and rehabilitation activities. Through time, land development and management activities lead to altering natural flows that sustain balance and ultimately, the trajectory of an ecosystem. Healthy aquatic stream ecosystems by nature are resilient and able to cope with impacts through feedback and adjustment. Rehabilitation offers the opportunity to resurrect balance and redirect stream aquatic habitat on a resilient trajectory once again.

High Priority/Long-term

1. Protection – protection of existing riparian habitat, channel migration processes, and floodplain function are listed as a Tier 1 habitat action in the Biological Strategy (UCRRT 2007). Protection should, when possible, be combined with an active rehabilitation effort, to maximize the gain of the action.

2. Floodplain Rehabilitation – a limiting factor that addresses four Viable Salmonid Population (VSP) parameters: productivity, abundance, diversity, and structure. This habitat action is listed as a Tier 1 habitat action in the Biological Strategy (UCRRT 2007). Multiple habitat actions can be used to accomplish this goal.
    a. The construction of Highway 2 and the railroad have reduced the overall acreage of available floodplain by acting as levees both along the main channel and in the floodplain.
    b. The culverts within the reach were observed to be functioning as run-off drains for the floodplain area presently disconnected by the railroad and highway. Some were observed to be undersized for fish passage, and others are elevated as to not provide access at base flow.
    c. Sections of artificially constrained channel within this reach promote the overall process of incision and transport.

3. Water quality – a limiting factor that addresses four VSP parameters: productivity, abundance, structure, and diversity.
    a. Nason Creek is on the 303(d) list for water temperature. Water temperature in streams tends to increase in the downstream direction and during the 2003 temperature survey, an increase from 15.3^{o}C to 19.1^{o}C occurred between RM 10.6 and 3.5 (Watershed Sciences 2003). Higher temperatures are noted, in part to be a result of the replacement of shading vegetation along the streambank with riprap along the railroad grade in the upper reach and along the highway in both reach (Thomas 2007). In addition, the clearing of riparian vegetation on the streambank and within the floodplain has reduced stream shading and large wood recruitment potential.

4. Riparian Rehabilitation – a limiting factor that addresses two VSP parameters, productivity and abundance, and addresses casual factors such as loss of bank stability, increased sediment input, elevated temperatures, depressed invertebrate production, and loss of natural large woody debris recruitment. This habitat action is listed as a Tier 2 action in the Biological Strategy (UCRRT 2007).
    a. Riparian condition for structure, disturbance, and canopy cover are interpreted to be at risk in this reach due to the percent of acres disturbed. The clearing of vegetation for the construction of Highway 2 and 207, the powerline right-of-way, and floodplain development have reduced overall riparian condition.

Lower Priority/Short-term

1. Large Woody Debris Rehabilitation – a limiting factor that address two VSP parameters, productivity and abundance, and causal factors such as loss of natural stream channel complexity, refugia and hiding cover, loss of floodplain connectivity, loss of pool-riffle formation, and spawning gravel and natural large woody debris recruitment, to name a few. Although this habitat action is listed as a Tier 1 action in the Biological Strategy, this habitat action should be implemented in conjunction with riparian rehabilitation to achieve a long term holistic approach.
    a. In the Lower White Pine reach, the number of pools is at an adequate level; however, overall the pools are functioning at an at-risk condition due to poor pool quality and lack of cover. As transport is the dominant process, large woody debris is not recruited or retained in the channel. Lack of complexity with plain-bed channel bottom is the result.

2. Use multiple habitat actions to address the specific indicators of Bank Stability/Channel Migration and Vertical Channel Stability. Each of the habitat action classes addresses two VSP parameters, productivity and abundance. Collectively the three have a long list of causal factors addressed. However, some common causal factors are channel complexity, refugia and hiding cover, and loss of natural large woody debris recruitment potential.

Many authors have documented strategies that emphasize restoring processes that form, connect, and sustain habitats (Beechie et al. 1996; Kauffman et al. 1997; Beechie and Bolton 1999; Montgomery and Bolton 2003; RTT 2007). Habitat actions of this nature often occur at the site or reach scale. Roni et al. (2002) introduced a hierarchical strategy that places site-specific actions within a watershed context. The Reclamation reach assessment and previous objectives purposely feed into this strategy by further telescoping options through several additional filters or layers of consideration at the reach scale. This so-called stratified strategy can be used to prioritize potential habitat actions within a geomorphic reach context based on the *Upper Columbia Spring Chinook Salmon, Steelhead, and Bull Trout Recovery Plan* objectives and reach assessment results by beginning with protection and transitioning through several forms of active rehabilitation (UCSRB 2007).

The hierarchical implementation strategy, which is illustrated in Figure 12, is tied to a corresponding gradational color scheme (Table 5) and used throughout the Subreach Unit Profile section to assist with correspondences throughout the project selection process. A subreach unit is recommended for protection actions where visual field evidence shows that 80 percent or more of the indicators are functioning adequately. A subreach unit is recommended for rehabilitation, where visual field evidence shows that less than 80 percent of the indicators are functioning adequately (i.e., the indicators are either at risk or are at unacceptable risk).

Table 5 - Definitions for river reach condition, which are tied into the hierarchical implementation strategy in Figure 12. The stratified strategy is used to filter results of the reach assessment to illustrate the differential responses expected for potential habitat protection and rehabilitation actions. Note corresponding gradational color scheme.

Protect/Maintain Processes: off-channel and riparian areas such as wetland, channel network, side channel, and riparian buffers possessing “adequate” ecological conditions and a present high or a potential high biological benefit.
Protect/Reconnect Isolated Habitats: off-channel and riparian areas possessing “adequate” ecological condition, but are fragmented by anthropogenic disturbances.
Reconnect Processes (Long-term): through regaining of channel dynamics and riparian interactions for areas possessing “adequate” or “at risk” ecological conditions that have a present high or potential high biological benefit.
Reconnect Processes and Habitats: through the regaining of channel dynamics and riparian interactions for areas possessing “at risk” ecological conditions that have a moderate to low present or high potential biological benefit.
Reconnect Habitat Units (Short Term): through in-channel replacement of wood and rock habitat features or structures.

However, the stratified strategy does not consider landowner willingness, construction feasibility, costs, and other local considerations. There are alternative methods that can be used to sequence project selection (i.e., degree of departure, landowner willingness, and construction costs) that can be factored in along with the results of reach assessment.

The potential for geomorphic regime change, or geomorphic potential, is essential for habitat-forming processes. Geomorphic potential is the combined influence of water, sediment, and large woody debris in forming, connecting, and sustaining fish habitat. Where over half of the Lower White Pine reach does not contribute to habitat-forming processes, a dual-track rehabilitation approach is necessary to reestablish geomorphic potential and with it healthy river conditions (Table 6). Figure 13 offers a spatial representation of subreaches in the Lower White Pine reach that are prioritized based on Roni (2005). The first track should focus on reconnecting the disconnected “relict” subreaches DIZ-1 and DIZ-2, along with adjacent historic outer zone areas of DOZ-2 and DOZ-4. Concurrently, the second track should focus on protecting and rehabilitating connected subreaches OZ-1, OZ-2, OZ-3, OZ-4, OZ-5, OZ-6, OZ-7, and OZ-8 that already offer form and connectivity, albeit in a diminished condition.

A dual-track rehabilitation approach is expected to run in parallel with a measured difference in timing for implementation. The track covering the disconnected subreaches is a long-term enterprise requiring engagement and full cooperation of two large landowners, the Burlington Northern Railroad and the State of Washington Department of Transportation. The latter track of rehabilitating connected subreaches is a series of potential short-term habitat actions that will both complement and set up the reconnection of the disconnected subreaches. Potential rehabilitation actions necessary in the short term include plantings and noxious weed eradication; road relocations or removals; small bridge placements; and culvert removals, modifications, or replacements.

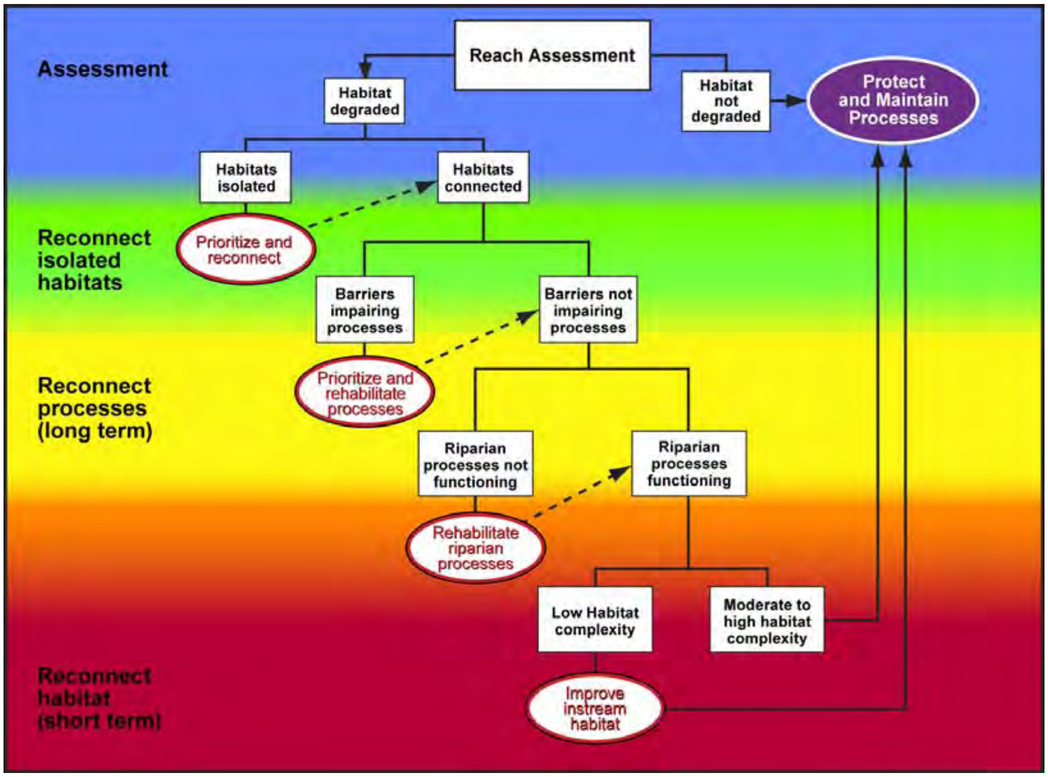

Figure 12 - Hierarchical implementation strategy for prioritizing potential habitat actions from protection-to-rehabilitation at the reach scale. Individual ovals indicate decisions and their interconnectivity correspond to stratified interrelationships (adapted from Roni et al. 2005).

Table 6 - Summary of subreaches prioritized by habitat actions. The time frame column represents both time to implement and time to see benefit. LT (Long Term) can be greater than 20 years; ST (short term) can be less than 1 year or up to 5 years.

Subreach	Acres	Habitat Action Type	Time Frame: Implementation	Time Frame: Effect time	Justification
LWP OZ-7	25	Protect/Maintain Processes	ST	ST	Less than 20% Riparian disturbance, no disconnection, contains wetlands.
LWP OZ-8	13	Protect/Maintain Processes	ST	ST	Less than 20% Riparian disturbance, no disconnection.
LWP OZ-4	11	Protect/Maintain Processes	ST	ST	Less than 20% Riparian disturbance, no disconnection.
LWP OZ-2	3	Protect/Maintain Processes	ST	ST	Less than 20% Riparian disturbance, no disconnection, contains wetlands.
LWP OZ-1	9	Protect/Maintain Processes	ST	ST	Less than 20% Riparian disturbance, no disconnection.
LWP DIZ-2	40	Reconnect Isolated off-channel and riparian areas fragmented by anthropogenic disturbances.	LT	ST	If reconnected, also reconnects Roaring and Coulter Creek subwatersheds.
LWP-DIZ-1	11	Reconnect Isolated off-channel and riparian areas fragmented by anthropogenic disturbances.	LT	ST	Reconnect section of historic channel.
LWP DOZ-3	1	Reconnect Isolated off-channel and riparian areas fragmented by anthropogenic disturbances.	LT	ST	Reconnect existing wetland habitat to adjacent floodplain.
LWP DOZ-4	38	Reconnect Processes (Long-term) through the regaining of channel dynamics and riparian interactions	LT	LT	Should be combined with riparian rehabilitation if DIZ-11 is reconnected at the upstream end.
LWP DOZ-2	18	Reconnect Processes (Long-term) through the regaining of channel dynamics and riparian interactions	LT	LT	Should be combined with riparian rehabilitation if DIZ-6 is reconnected at the upstream end.
LWP OZ-9	4	Reconnect Processes (Long-term) through the regaining of channel dynamics and riparian interactions	LT	ST	Reconnect subreach (and wetlands) to adjacent floodplain processes, combine with riparian rehabilitation.
LWP DOZ-5	7	Reconnect Processes (Long-term) through the regaining of channel dynamics and riparian interactions	LT	LT	Reconnect subreach to adjacent floodplain processes.
LWP DOZ-1	2	Reconnect Processes (Long-term) through the regaining of channel dynamics and riparian interactions	LT	LT	Reconnect floodplain to current channel to re-initiate floodplain processes.
LWP IZ-2	3	Reconnect Processes (Long-term) through the regaining of channel dynamics and riparian interactions	ST	ST	Increase current bed elevations to improve fluvial/riparian interactions, combine with riparian rehabilitation with adjacent outer zone.
LWP IZ-4	5	Reconnect Processes (Long-term) through the regaining of channel dynamics and riparian interactions	ST	ST	Increase current bed elevations to improve fluvial/riparian interactions, combine with riparian rehabilitation on bank.
LWP IZ-6	2	Reconnect Processes (Long-term) through the regaining of channel dynamics and riparian interactions	ST	ST	Increase current bed elevations to improve fluvial/riparian interactions, combine with riparian rehabilitation on bank.
LWP OZ-5	13	Reconnect Processes through the regaining of riparian interactions	ST	LT	Greater than 20% Riparian disturbance, no disconnecting features.
LWP OZ-6	6	Reconnect Processes through the regaining of riparian interactions	ST	LT	Greater than 20% Riparian disturbance, no disconnecting features.
LWP OZ-3	1	Reconnect Processes through the regaining of riparian interactions	ST	LT	Greater than 20% Riparian disturbance, no disconnecting features.
LWP IZ-1	3	Reconnect Habitats (Short Term): through in-channel placement of wood and rock habitat features or structures.	ST	ST	Place large wood as key members that will promote the retention of additional wood and spawning gravels to improve in-stream complexity.
LWP IZ-3	8	Reconnect Habitats (Short Term): through in-channel placement of wood and rock habitat features or structures.	ST	ST	Place large wood as key members that will promote the retention of additional wood and spawning gravels to improve in-stream complexity.
LWP IZ-5	9	Reconnect Habitats (Short Term): through in-channel placement of wood and rock habitat features or structures.	ST	ST	Place large wood as key members that will promote the retention of additional wood and spawning gravels to improve in-stream complexity.

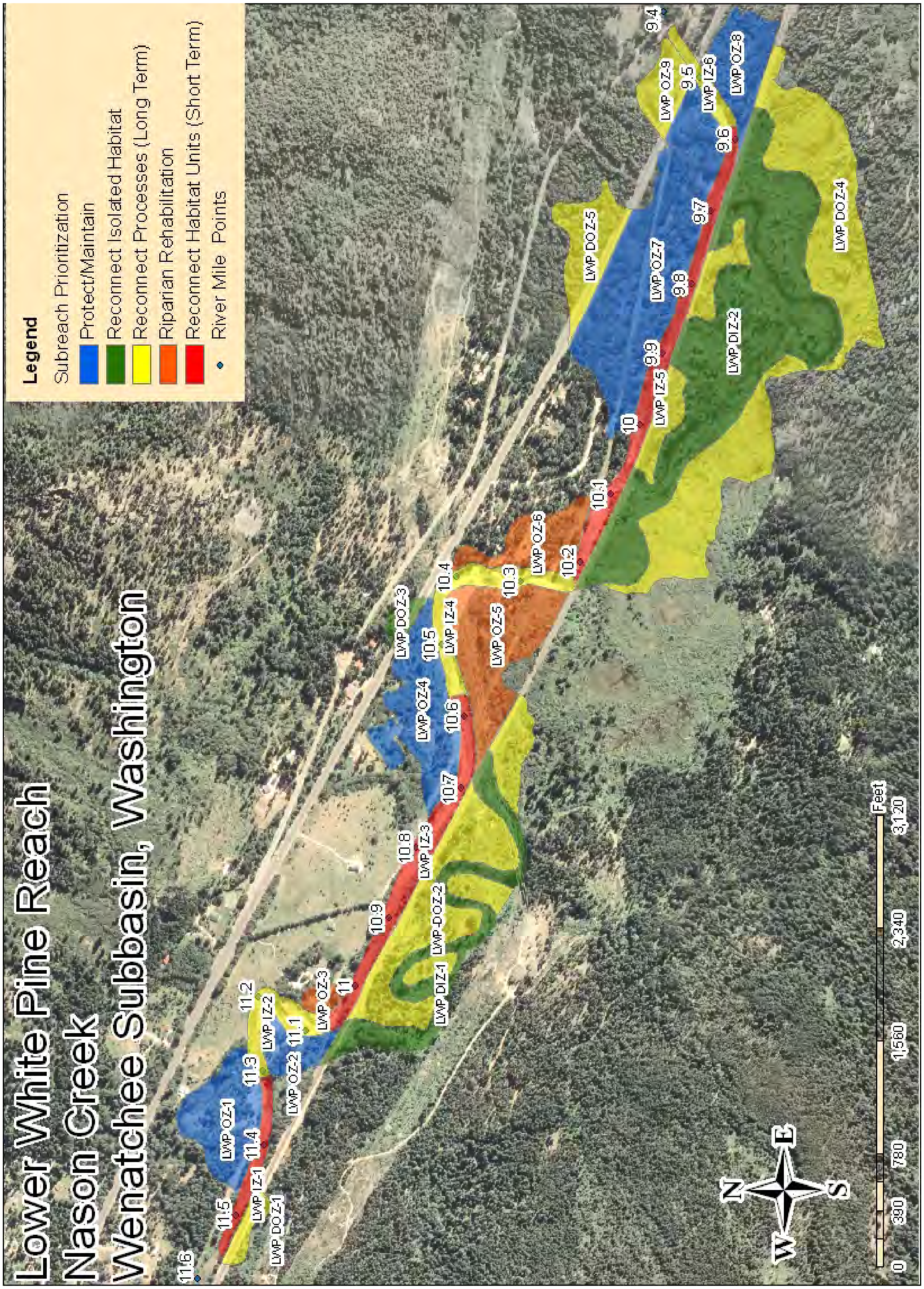

Figure 13 - Subreaches prioritized using the strategy from Roni, 2006

SUBREACH UNIT PROFILE

Within this section, the anthropogenic features and resulting existing conditions of each subreach are discussed. The subreaches are in a prioritized order based on potential habitat actions and are listed in the order presented in Table 6; however, the prioritization does not consider landowner willingness, construction feasibility, costs, and other local considerations. All of those factors, along with the utilization of the prioritization of the subreaches, will need to be taken into account when developing an overall implementation strategy.

LWP OZ-7

LWP OZ-7 is located in the downstream end of the Lower White Pine reach in the left floodplain along RM 10.0 to 9.5 (Figure 14).

The subreach is about 25 acres in size and contains about 0.2 acres of wetland areas. Natural lateral controls for the subreach are alluvial fan structures. Lengths of anthropogenic features in this subreach include about 2,104 feet of transmission line, 461 feet of undeveloped road, and 102 feet of road embankment (Figure 15). The acres of disturbed vegetation associated with the anthropogenic features listed above plus some clearing for development is 0.5 acre or about 2 percent of the total subreach. The inundation potential is low and when comparing 5,000 cubic feet per second (cfs) (approximate 20-year recurrence interval) stream flow for existing conditions versus potential conditions (i.e., with anthropogenic features removed), the two dimensional-hydraulic model (2D-hydraulic model) results show little change in the area of inundation. Most of the subreach is inundated at both modeled flows.

There are no anthropogenic features that disconnect the subreach from the active channel. The subreach is considered to be functioning at greater than 80 percent; therefore, the subreach is protection-oriented. However, riparian rehabilitation actions can be implemented in tandem with protection strategies to address the low percent of disturbed vegetation. Rehabilitation options are listed in Table 7 and are prioritized to maximize the geomorphic potential of the subreach. Rehabilitation actions in this subreach should be considered collectively with rehabilitation actions recommended in adjacent subreaches to achieve a holistic reconnection and reestablishment of processes at the reach scale.

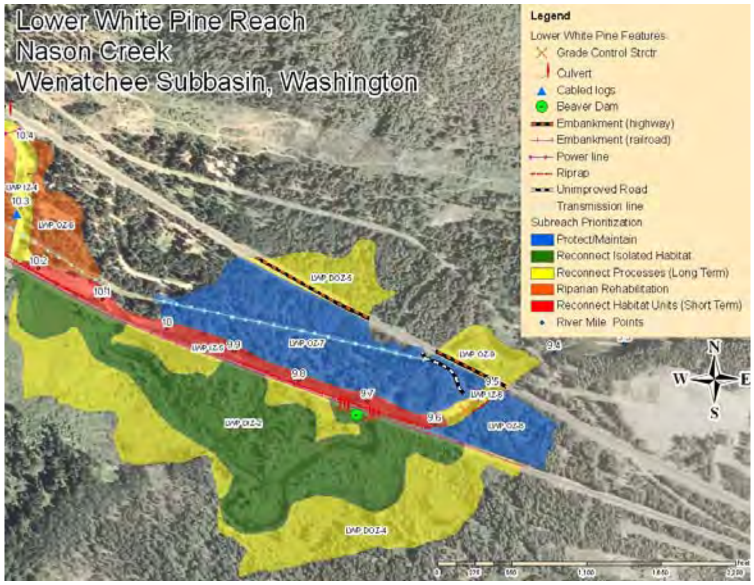

Figure 14 - A plan view showing the location of LWP OZ-7 in the downstream end of the Lower White Pine reach with, location of anthropogenic features, and the proximity of adjacent subreaches with the corresponding rehabilitation strategies.

Figure 15 - Embankment on the left bank of the stream that cuts off a wetland area on the south side of the road in Subreach OZ-12, view to the northwest. Lower White Pine Reach, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by R. McAffee, May 3, 2007.

Table 7 - Options for LWP OZ-7

Option	Habitat Action	Prioritized Habitat Actions	VSP Parameters Addressed	Geomorphic Potential
1	Rehabilitation + Protection	Protect and maintain current levels of rehabilitated geomorphic, hydrologic, and riparian function. Riparian Rehabilitation: Replant sections of riparian vegetation at 10-meter, 30-meter, and floodplain width to address the area impacted by the transmission and power lines (about 0.5 acres) and to improve canopy cover, large woody debris recruitment potential, and riparian composition within the floodplain. Address noxious weeds through planting and education/prevention programs.	4; Productivity, Abundance, Diversity and Structure	High
2	Rehabilitation	Riparian Rehabilitation: Replant sections of riparian vegetation at 10-meter, 30-meter, and floodplain widths to address the area impacted by the transmission and power lines (about 0.5 acres) and to improve canopy cover, large woody debris recruitment potential, and riparian composition within the floodplain. Address noxious weeds through planting and education/prevention programs.	2; Productivity and Abundance	Low

LWP OZ-8

LWP OZ-8 is located in the downstream end of the Lower White Pine reach in the right floodplain along RM 9.6 to 9.5 (Figure 16).

Although no anthropogenic features exist on the interior of the subreach, it is bound on the north side by Highway 2, by the railroad grade on the south side, and a small section of riprap along the right bank. All bounding anthropogenic features are addressed in other subreach descriptions. The inundation potential is low. When comparing approximate 20-year recurrence interval stream flow for existing conditions versus potential conditions (i.e., with anthropogenic features removed), the 2D-hydraulic model results show little change in area of inundation. Most of the subreach is inundated at both modeled flows. Rehabilitation options are listed in Table 8 and are prioritized to protect and maintain the geomorphic potential of the subreach.

The subreach is considered to be functioning at greater than 80 percent; therefore, the subreach is protection-oriented. Rehabilitation options are listed in Table 8 and are prioritized to protect and maintain the geomorphic potential of the subreach. Rehabilitation actions in this subreach should be considered collectively with rehabilitation actions recommended in other adjacent subreaches to achieve a holistic reconnection and reestablishment of processes at the reach scale.

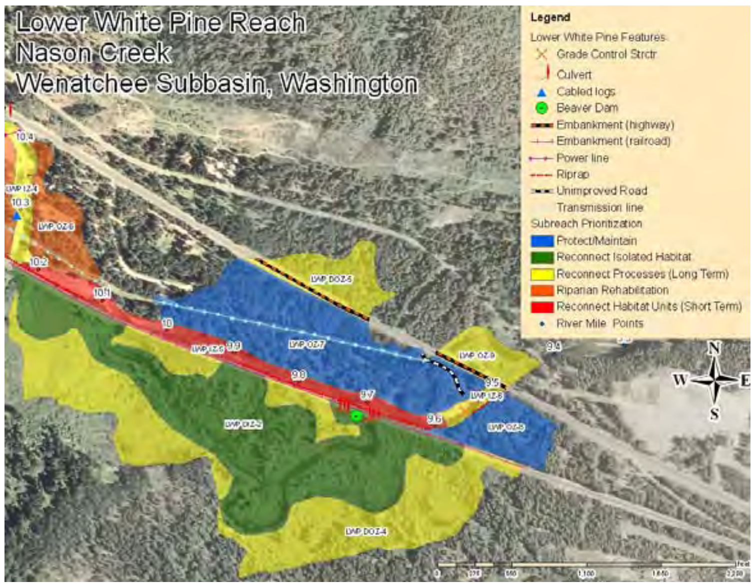

Figure 16 - A plan view showing the location of LWP OZ-8 in the downstream end of the Lower White Pine reach, location of anthropogenic features, and the proximity of adjacent subreaches with the corresponding rehabilitation strategies.

Table 8 - Options for LWP OZ-8.

Option	Habitat Action	Prioritized Habitat Actions	VSP Parameters Addressed	Geomorphic Potential
1	Protection	Protect and maintain current levels of hydrologic, riparian, and geomorphic function.	4; Productivity, Abundance, Diversity, and Structure	Maintain

LWP OZ-4

LWP OZ-4 is located in the mid-section of the Lower White Pine reach in the left floodplain along RM 10.75 to 10.45 (Figure 17).

The subreach is about 11 acres in size. Natural lateral controls for the subreach are alluvial fan structures and higher terraces. Lengths of anthropogenic features are limited to about 502 feet of electrical transmission line running through the subreach. The area of vegetation disturbance from the anthropogenic impacts in this subreach totals just less than 3 acres with 0.62 acres from the transmission line and an additional 2 acres that are cleared for development. The percent of the subreach vegetation that is disturbed is 27 percent. The inundation potential is low. When comparing 5,000 cfs (approximate 20-year recurrence interval) stream flow for existing conditions versus potential conditions (i.e., with anthropogenic features removed), the 2D-hydraulic model results show little change in area of inundation. Most of the subreach is inundated at both modeled flows.

There are no anthropogenic features that disconnect the subreach from the active channel. The subreach is considered to be functioning at greater than 80 percent so the subreach is protection-oriented. However, riparian rehabilitation actions can be implemented in tandem with protection strategies to address the low percent of disturbed vegetation. Rehabilitation options are listed in Table 9 and are prioritized to maximize the geomorphic potential of the subreach through the reconnection and reestablishment of both long-term and short-term processes at the subreach scale. Rehabilitation actions in this subreach should be considered collectively with rehabilitation actions recommended in other adjacent subreaches to achieve a holistic reconnection and reestablishment of processes at the reach scale.

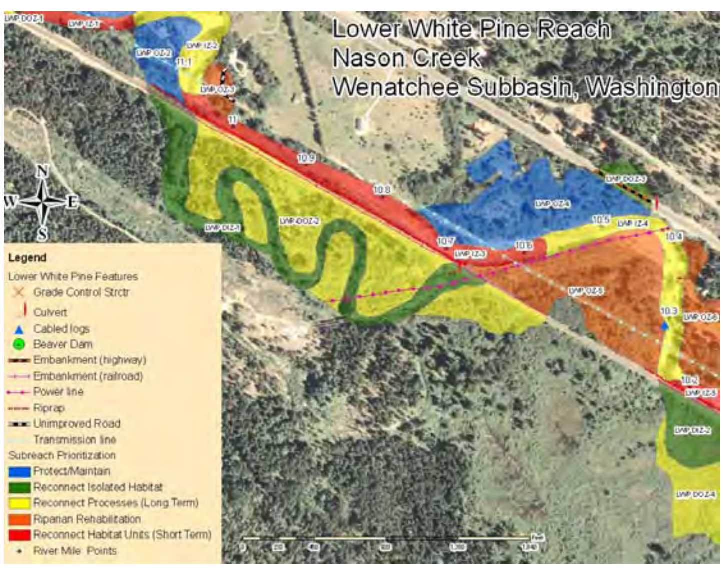

Figure 17 - A plan view showing the location of LWP OZ-4 in the mid-section of the Lower White Pine reach, location of anthropogenic features, and the proximity of adjacent subreaches with the corresponding rehabilitation strategies.

Table 9 - Options for LWP OZ-4

Option	Habitat Action	Prioritized Habitat Actions	VSP Parameters Addressed	Geomorphic Potential
1	Protection + Rehabilitation	Protect and maintain current levels of hydrologic, riparian, and geomorphic function. Riparian Rehabilitation: Replant sections of riparian vegetation at 10-meter, 30-meter, and floodplain widths to address the area impacted by the transmission line (about 3 acres) and to improve canopy cover, large woody debris recruitment potential, and riparian composition within the floodplain. Address noxious weeds through planting and education/prevention programs.	4; Productivity, Abundance, Diversity, and Structure	High
2	Rehabilitation	Riparian Rehabilitation: Replant sections of riparian vegetation at 10-meter, 30-meter, and floodplain widths to address the area impacted by the transmission line (about 3 acres) and to improve canopy cover, large woody debris recruitment potential, and riparian composition within the floodplain. Address noxious weeds through planting and education/prevention programs.	2; Productivity and Abundance	Low

LWP OZ-2

LWP OZ-2 is located in the upstream end of the Lower White Pine reach in the right floodplain along RM 13.3 to 11.05 (Figure 18).

The subreach is about 3 acres in size. Natural lateral controls for the subreach are alluvial fan structures and higher terraces. Anthropogenic features include 313 feet of powerline and 220 feet of riprap along the railroad grade. The effects of the anthropogenic features are 0.4 acres of disturbed vegetation or about 13 percent of the total subreach area. The riprap protects the railroad grade and should be addressed when looking at the rehabilitation potential of subreach LWP DIZ-1. The inundation potential is low. When comparing 5,000 cfs (approximate 20-year recurrence interval) stream flow for existing conditions versus potential conditions (i.e., with anthropogenic features removed), the 2D-hydraulic model results show little change in area of inundation. Most of the subreach is inundated at both modeled flows.

There are no anthropogenic features that disconnect the subreach from the active channel. The subreach is considered to be functioning at greater than 80 percent so the subreach is protection-oriented. However, riparian rehabilitation actions can be implemented in tandem with protection strategies to address the low percent of disturbed vegetation. Rehabilitation options are listed in Table 10 and are prioritized to maximize the geomorphic potential of the subreach through the reconnection of both long-term and short- term processes. Rehabilitation actions in this subreach should be considered along with the collective rehabilitation actions recommended in other adjacent subreaches to achieve a holistic rehabilitation at the reach scale.

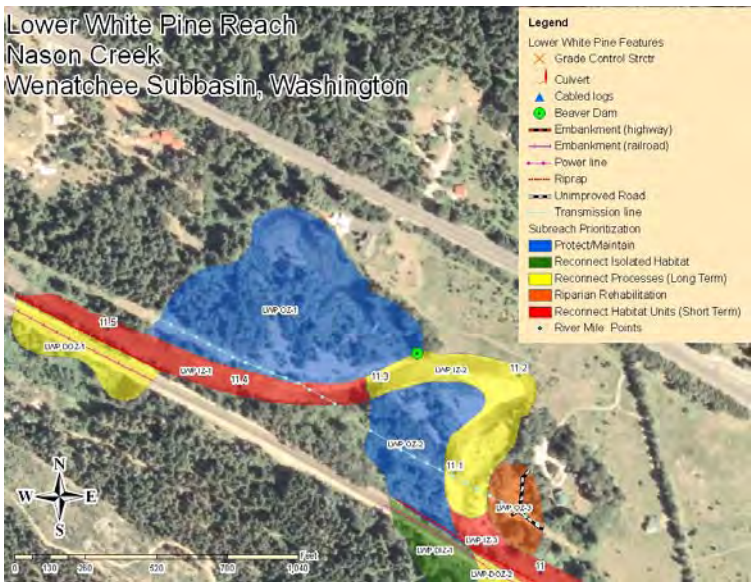

Figure 18 - A plan view showing the location of LWP OZ-2 in the upstream end of the Lower White Pine reach, location of anthropogenic features, and the proximity of adjacent subreaches with the corresponding rehabilitation strategies.

Table 10 - Options for LWP OZ-2.

Option	Habitat Action	Prioritized Habitat Actions	VSP Parameters Addressed	Geomorphic Potential
1	Protection + Rehabilitation	Protect and maintain current levels of geomorphic and hydrologic function. Combine with Riparian Rehabilitation: Replant sections of riparian vegetation at 10-meter, 30-meter, and floodplain widths to address the area impacted by the powerline (about 0.4 acres) and to improve canopy cover, large woody debris recruitment potential, and riparian composition within the floodplain. Address noxious weeds through planting and education/prevention.	4; Productivity, Abundance, Diversity, and Structure	High
2	Rehabilitation	3) Riparian Rehabilitation: Replant sections of riparian vegetation at 10-meter, 30-meter, and floodplain widths to address the area impacted by the powerline (about 0.4 acres) and to improve canopy cover, large woody debris recruitment potential, and riparian composition within the floodplain. Address noxious weeds through planting and education/prevention programs.	2; Productivity and Abundance	Low

LWP OZ-1

LWP OZ-1 is located in the upstream end of the Lower White Pine reach in the left floodplain along RM 11.48 to 11.27 (Figure 19).

The subreach is about 9 acres in size and contains just over 2 acres of wetlands. The vegetation in this subreach, which has been altered or disturbed in association with 556 feet of powerline, is 0.56 acres or about 6 percent of the total area of the subreach. Natural lateral controls for the subreach are alluvial fan structures and higher terraces. There are no anthropogenic features that disconnect the subreach from the active channel. The inundation potential is low. When comparing 5,000 cfs (approximate 20-year recurrence interval) stream flow for existing conditions versus potential conditions (i.e., with anthropogenic features removed), the 2D-hydraulic model results show little change in area of inundation. Most of the subreach is inundated at both modeled flows.

There are no anthropogenic features that disconnect the subreach from the active channel. The subreach is considered to be functioning at greater than 80 percent so the subreach is protection-oriented. However, riparian rehabilitation actions can be implemented in tandem with protection strategies to address the low percent of disturbed vegetation. Rehabilitation options are listed in Table 11 and are prioritized to maximize the geomorphic potential of the subreach through the reconnection and reestablishment of both long-term and short-term processes at the subreach scale. Rehabilitation actions in this subreach should be considered collectively with rehabilitation actions recommended in other adjacent subreaches to achieve a holistic reconnection and reestablishment of processes at the reach scale.

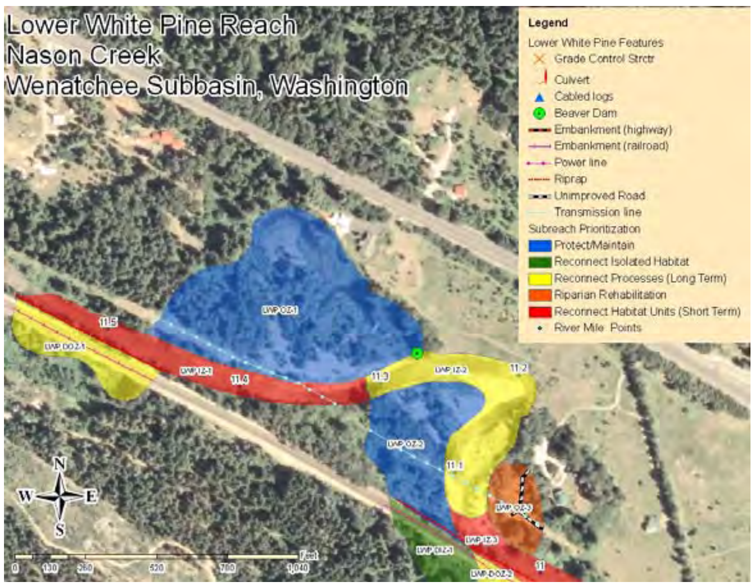

Figure 19 - A plan view showing the location of LWP OZ-1 in the upstream end of the Lower White Pine reach, location of anthropogenic features, and the proximity of adjacent subreaches with the corresponding rehabilitation strategies.

Table 11 - Options for LWP OZ-1.

Option	Habitat Action	Prioritized Habitat Actions	VSP Parameters Addressed	Geomorphic Potential
1	Protection + Rehabilitation	Protect existing wetlands (2 acres) and maintain current levels of geomorphic and hydrologic function. Combined with Riparian Rehabilitation: Replant sections of riparian vegetation at 10-meter, 30-meter, and floodplain widths to address the area impacted by the powerline (about 0.6 acres) and to improve canopy cover, large woody debris recruitment potential, and riparian composition within the floodplain. Address noxious weeds through planting and education/prevention programs.	4; Productivity, Abundance, Diversity, and Structure	High
2	Rehabilitation	3) Riparian Rehabilitation: Replant sections of riparian vegetation at 10 meter, 30 meter and floodplain widths to address the area impacted by the powerline (about 0.6 acres) and to improve canopy cover, large woody debris recruitment potential and riparian composition within the floodplain. Address noxious weeds through planting and education/prevention programs.	2; Productivity and Abundance	Low

LWP DIZ-2

LWP DIZ-2 is located in the downstream end of the Lower White Pine reach. The subreach is the historic active channel located to the south side of the Burlington Northern railroad grade near RM 10.2 to 9.6 (Figure 20).

The subreach is about 40 acres in size and represented 5,494 linear feet of historic channel path prior to the construction of the railroad. Natural lateral controls for the subreach are alluvial fan structures. About 36 acres of wetland areas are contained within the subreach (Figure 21 and Figure 22). Anthropogenic features include about 2,333 feet of railroad grade that disconnect the subreach from the current channel at the upstream (RM 10.2), middle (RM 9.9), and downstream ends (RM 9.7). Artificial lateral control from the railroad grade has disconnected this subreach from the active channel at the upstream and downstream ends. At the downstream end of the subreach, there are two sets of triple culverts; however, fish access to existing habitat behind the railroad grade is thought to be limited through these culverts due to water velocities (Andonaegui 2001). Disturbed area of vegetation associated with the railroad grade is about 2 acres or 5 percent of the subreach. The inundation potential of this subreach is 37 acres or 36 percent of the inundation potential for the entire Lower White Pine reach.

The result of anthropogenic features include the loss of habitat, impoundment of runoff and groundwater, and a change in the vegetation composition from mixed hardwood to small brush vegetation. The lack of canopy cover along the perimeter of the artificial wetland allows the water to warm before entering the main channel. The narrowing of the active floodplain decreases the system's ability to accommodate floodwaters and rejuvenate off-channel habitat. Habitat is not generated in this area at higher flows. The railroad grade acts as a levee, so any water that does inundate the subreach does not have sufficient energy to create habitat features. The impacts of anthropogenic features make this subreach rehabilitation-oriented. Rehabilitation options are listed in Table 12 and are prioritized to maximize the geomorphic potential of the subreach through the reconnection and re-establishment of both long-term and short-term processes at the subreach scale. Rehabilitation actions in this subreach should be considered collectively with rehabilitation actions recommended in other adjacent subreaches to achieve a holistic reconnection and reestablishment of processes at the reach scale. It should be noted that if this subreach unit is reconnected to the channel, an additional 7 square miles of the Roaring Creek subwatershed and 5 square miles of the Coulter Creek subwatershed would be connected as well.

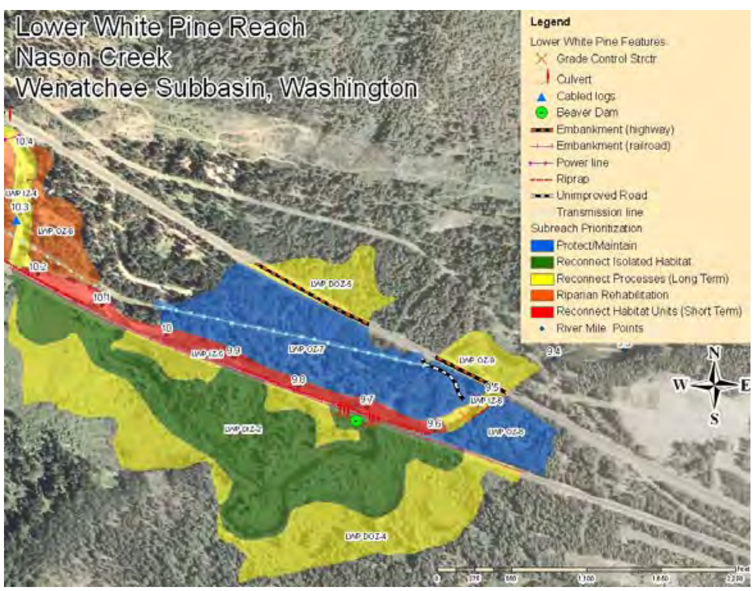

Figure 20 - A plan view showing the location of LWP DIZ-2 in the mid-section of the Lower White Pine reach, location of anthropogenic features, and the proximity of adjacent subreaches with the corresponding rehabilitation strategies.

Figure 21 - A 4-foot tall beaver dam in the wetlands on the south side of the railroad grade, view to the south. Lower White Pine Reach; Subreach DIZ-2, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by R. McAffee, May 5, 2007.

Figure 22 – A larger beaver dam in a wetland complex located on the south side of the railroad grade, view to the southeast. Lower White Pine Reach; Subreach DIZ-2, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by R. McAffee, May 4, 2007.

Table 12 - Options for LWP DIZ-2

Option	Habitat Action	Prioritized Habitat Actions	VSP Parameters Addressed	Geomorphic Potential
1	Rehabilitation + Protection	Reconnect Isolated Habitat: Remove or modify railroad grade with bridges where appropriate to reconnect subwatersheds and floodplain and reinitiate habitat-forming processes. Combine with riparian rehabilitation at 10-meter, 30-meter, and floodplain widths to provide adequate composition, canopy cover, and large woody debris recruitment potential within the rehabilitated floodplain. Protect and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	High
2	Rehabilitation + Protection	Reconnect Processes: Remove or modify railroad grade with culverts where appropriate, or improve existing culverts to reconnect floodplain and provide access to off-channel habitat. Combine with riparian rehabilitation at 10-meter, 30-meter, and floodplain widths to provide adequate composition, canopy cover, and large woody debris recruitment potential within the rehabilitated floodplain. Protect and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	High
3	Rehabilitation + Protection	Reconnect Isolated Habitat: Remove or modify railroad grade with bridges where appropriate to reconnect subwatersheds and floodplain and reinitiate habitat-forming processes. Protect and maintain resulting levels of rehabilitated geomorphic, hydrologic function, and maintain current level of riparian function.	4; Productivity, Abundance, Diversity, and Structure	Medium

Option	Habitat Action	Prioritized Habitat Actions	VSP Parameters Addressed	Geomorphic Potential
4	Rehabilitation + Protection	Reconnect Processes: Modify railroad grade with culverts where appropriate, or improve existing culverts to reconnect floodplain and provide access to off-channel habitat. Protect and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	Medium
5	Rehabilitation + Protection	Riparian Rehabilitation: Restore sections of riparian vegetation impacted by the railroad grade (about 2 acres) by planting trees and shrubs to increase large woody debris recruitment potential within the current floodplain and reduce the amount of altered vegetation. Address noxious weeds through planting and education/prevention programs. Protect and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	Medium
6	Rehabilitation	Reconnect Isolated Habitat: Remove or modify railroad grade with bridges where appropriate to reconnect subwatersheds and floodplain and reinitiate habitat-forming processes. Riparian Rehabilitation: Restore sections of riparian vegetation impacted by the railroad grade (about 2 acres) by planting trees and shrubs to increase large woody debris recruitment potential within the current floodplain and reduce the amount of altered vegetation. Address noxious weeds through planting and education/prevention programs.	2; Productivity and Abundance	Medium
7	Rehabilitation	Reconnect Processes: Modify railroad grade with culverts where appropriate, or improve existing culverts to reconnect floodplain and provide access to off-channel habitat. Riparian Rehabilitation: Restore sections of riparian vegetation impacted by the railroad grade (about 2 acres) by planting trees and shrubs to increase large woody debris recruitment potential within the current floodplain and	2; Productivity and Abundance	Medium

Option	Habitat Action	Prioritized Habitat Actions	VSP Parameters Addressed	Geomorphic Potential
		reduce the amount of altered vegetation. Address noxious weeds through planting and education/prevention programs.		
8	Rehabilitation	Reconnect Isolated Habitat: Remove or modify railroad grade with bridges where appropriate to reconnect subwatersheds and floodplain and reinitiate habitat-forming processes	4; Productivity, Abundance, Diversity, and Structure	Low
9	Rehabilitation	Reconnect Processes: Remove or modify railroad grade with culverts where appropriate, or improve existing culverts to reconnect floodplain and provide access to off-channel habitat.	2; Productivity and Abundance	Low
10	Rehabilitation	Riparian Rehabilitation: Restore sections of riparian vegetation impacted by the railroad grade (about 2 acres) by planting trees and shrubs to increase large woody debris recruitment potential within the current floodplain and reduce the amount of altered vegetation. Address noxious weeds through planting and education/prevention programs.	2; Productivity and Abundance	Low
11	Protection	Protect existing wetlands and maintain current levels of hydrologic, riparian, and geomorphic function.	4; Productivity, Abundance, Diversity, and Structure	Maintain

LWP DIZ-1

LWP DIZ-2 is located in the mid-section of the Lower White Pine reach. The subreach is the historic active channel located to the south side of the Burlington Northern railroad grade near RM 11.05 to 10.65 (Figure 23).

The subreach is about 11 acres in size and represented about 4,755 linear feet of historic channel path prior to the construction of the railroad. About 5 acres of wetland area is contained within the subreach (Figure 24). Natural lateral controls for the subreach are bedrock and alluvial fan structures. Anthropogenic features include about 597 feet of railroad grade and about 492 feet of transmission line that crosses the subreach at two locations. Artificial lateral control from the railroad grade has disconnected this subreach from the active channel at the upstream and downstream ends. There is a culvert at the downstream end (Figure 25); however, fish access to existing habitat behind the railroad grade is thought to be limited to the observance of the elevation of the culvert on the active channel side at base flow (Figure 52 in the LWP IZ-3 profile). The inundation potential of this subreach is 9 acres or 9 percent of the inundation potential for the entire Lower White Pine reach. Vegetation disturbed by anthropogenic features totals about 3 acres which is about 28 percent of the total subreach area.

The impacts of anthropogenic features make this subreach rehabilitation-oriented. The result is loss of habitat through the disconnection of the floodplain from the active channel at the upstream (RM 11.05) and downstream ends (RM 10.67), impoundment of runoff and groundwater, and a change in the vegetation composition from mixed hardwood to small brush vegetation. The lack of canopy cover along the perimeter of the artificial wetland allows the water to warm before entering the main channel. The narrowing of the active floodplain decreases the system's ability to accommodate floodwaters and rejuvenate off-channel habitat. Habitat is not generated in this area at higher flows. The railroad grade acts as a levee, so any water that does inundate the subreach does not have sufficient energy to create habitat features. Rehabilitation options are listed in Table 13 and are prioritized to maximize the geomorphic potential of the subreach through the reconnection and reestablishment of both long-term and short-term processes at the subreach scale. Rehabilitation actions in this subreach should be considered collectively with rehabilitation actions recommended in other adjacent subreaches to achieve a holistic reconnection and reestablishment of processes at the reach scale.

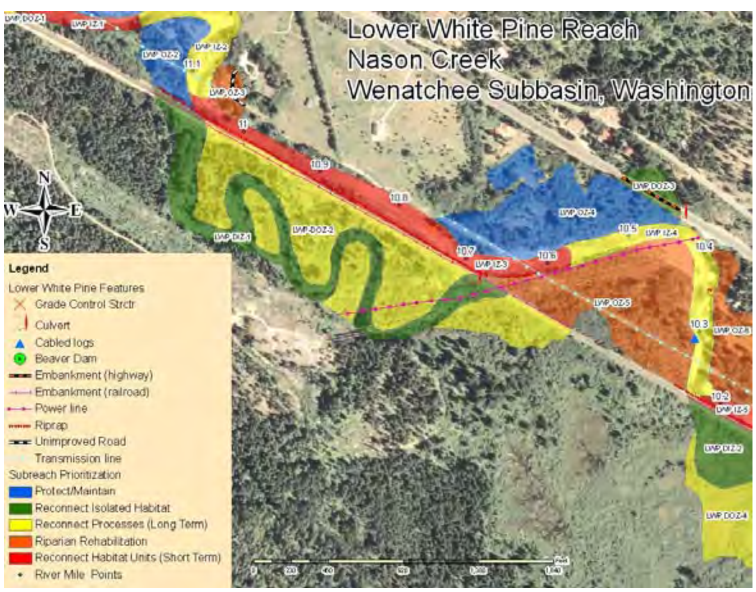

Figure 23 - A plan view showing the location of LWP DIZ-1 in the downstream end of the Lower White Pine reach, location of anthropogenic features, and the proximity of adjacent subreaches with the corresponding rehabilitation strategies.

Figure 24 - Wetlands within the historic main channel that is currently disconnected by the railroad grade, view to the south. Lower White Pine Reach; Subreach DIZ-1, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by R. McAffee, September 9, 2008.

Figure 25 - Culvert that drains the wetlands on the south side of the railroad grade at the downstream end of the subreach, view to the southeast. Lower White Pine Reach; Subreach DIZ-1, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by R. McAffee, May 5, 2007.

Table 13 - Options for LWP DIZ-1.

Option	Habitat Action	Prioritized Habitat Actions	VSP Parameters Addressed	Geomorphic Potential
1	Rehabilitation + Protection	Reconnect Isolated Habitat: Remove or modify railroad grade with bridges where appropriate to reconnect floodplain and reinitiate habitat-forming processes. Combine with riparian rehabilitation at 10-meter, 30-meter, and floodplain widths to provide adequate composition, canopy cover, and large woody debris recruitment potential within the rehabilitated floodplain. Protect and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	High
2	Rehabilitation + Protection	Reconnect Processes: Remove or modify railroad grade with culverts where appropriate, or improve existing culverts to reconnect floodplain and provide access to off-channel habitat. Combine with riparian rehabilitation at 10-meter, 30-meter, and floodplain widths to provide adequate composition, canopy cover, and large woody debris recruitment potential within the rehabilitated floodplain. Protect and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	2; Productivity and Abundance	High
3	Rehabilitation + Protection	Riparian Rehabilitation: Restore sections of riparian vegetation impacted by the railroad grade and transmission line (about 3 acres) by planting trees and shrubs to increase large woody debris recruitment potential within the current floodplain and reduce the amount of altered vegetation. Address noxious weeds through planting and education/prevention programs. Protect and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	2; Productivity and Abundance	Medium

Option	Habitat Action	Prioritized Habitat Actions	VSP Parameters Addressed	Geomorphic Potential
4	Rehabilitation	Reconnect Isolated Habitat: Remove or modify railroad grade with bridges where appropriate to reconnect floodplain and reinitiate habitat-forming processes. Combine with riparian rehabilitation at 10-meter, 30-meter, and floodplain widths to provide adequate composition, canopy cover, and large woody debris recruitment potential within the rehabilitated floodplain.	4; Productivity, Abundance, Diversity, and Structure	Medium
5	Rehabilitation	Reconnect Processes: Remove or modify railroad grade with culverts where appropriate, or improve existing culverts to reconnect floodplain and provide access to off-channel habitat. Combine with riparian rehabilitation at 10-meter, 30-meter, and floodplain widths to provide adequate composition, canopy cover, and large woody debris recruitment potential within the rehabilitated floodplain.	2; Productivity, Abundance	Medium
6	Rehabilitation	Reconnect Isolated Habitat: Remove or modify railroad grade with bridges where appropriate to reconnect floodplain and reinitiate habitat-forming processes.	4; Productivity, Abundance, Diversity, and Structure	Low
7	Rehabilitation	Reconnect Processes: Remove or modify railroad grade with culverts where appropriate, or improve existing culverts to reconnect floodplain and provide access to off-channel habitat.	2; Productivity and Abundance	Low
8	Rehabilitation	Riparian Rehabilitation: Restore sections of riparian vegetation impacted by the railroad grade and transmission line (about 3 acres) by planting trees and shrubs to increase large woody debris recruitment potential within the current floodplain and reduce the amount of altered vegetation. Address noxious weeds through planting and education/prevention programs.	2; Productivity and Abundance	Low
9	Protection	Protect existing wetlands (5 acres) and maintain current levels of hydrologic, riparian, and geomorphic function.	4; Productivity, Abundance, Diversity, and Structure	Maintain

LWP DOZ-3

LWP DOZ-3 is located in the mid-section of the Lower White Pine reach in the left floodplain near RM 10.45 (Figure 26).

The subreach is about 1.4 acres in size and is disconnected from subreach OZ-4 by about 411 feet of highway embankment. Natural lateral controls for the subreach are alluvial fan structures and higher terraces. Currently about 1 acre of wetland area exists within the subreach (Figure 27). There is one culvert at the downstream end of the disconnected floodplain (Figure 28); however, it may not provide fish access at base flow. The area of disturbed vegetation from the highway embankment in this subreach is 0.6 acres or 43 percent of the subreach. The inundation potential is 1 acre or about 1 percent of the inundation potential for the entire Lower White Pine reach.

This subreach is rehabilitation-oriented due artificial lateral control in the form of the highway. Rehabilitation options are listed in Table 14 and are prioritized to maximize the geomorphic potential of the subreach through the reconnection and reestablishment of both long-term and short-term processes at the subreach scale. Rehabilitation actions in this subreach should be considered collectively with rehabilitation actions recommended in other adjacent subreaches to achieve a holistic reconnection and reestablishment of processes at the reach scale.

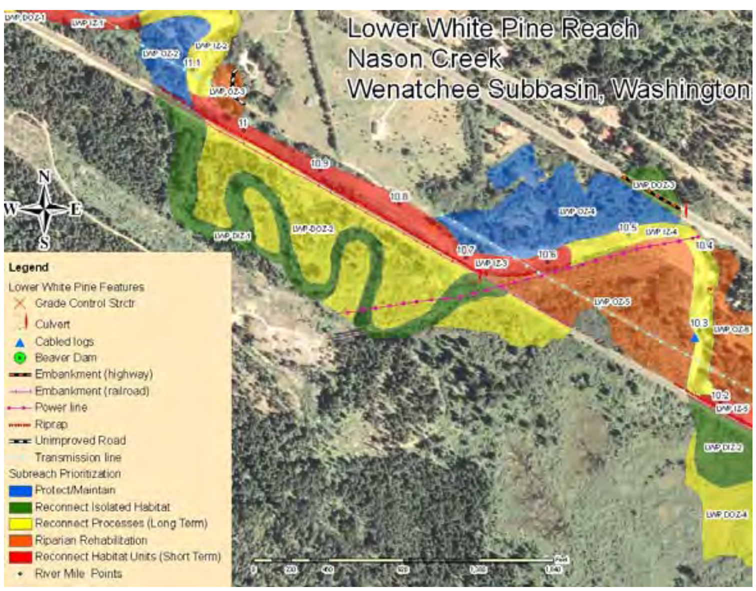

Figure 26 - A plan view showing the location of LWP DOZ-3 in the downstream end of the Lower White Pine reach, location of anthropogenic features, and the proximity of adjacent subreaches with the corresponding rehabilitation strategies.

Figure 27 - Bottom of the wetlands on the north side of the road, view to the northwest. Lower White Pine Reach; Subreach DOZ-3, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by R. McAffee, May 3, 2007.

Figure 28 - Culvert that drains the wetlands on the north side of Highway 2. Lower White Pine Reach; Subreach DOZ-3, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by R. McAffee, May 3, 2007.

Table 14 - Options for LWP DOZ-3.

Option	Habitat Action	Prioritized Habitat Actions	VSP Parameters Addressed	Geomorphic Potential
1	Rehabilitation + Protection	Reconnect Isolated Habitat: Remove or modify Highway 2 with bridges where appropriate to reconnect floodplain and reinitiate habitat-forming processes. Combine with riparian rehabilitation at 10-meter, 30-meter, and floodplain widths to provide adequate composition, canopy cover, and large woody debris recruitment potential within the rehabilitated floodplain. Protect existing wetlands and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	High
2	Rehabilitation + Protection	Reconnect Processes: Modify Highway 2 with culverts where appropriate to reconnect existing wetland area to riverine system. Combine with riparian rehabilitation of sections of riparian vegetation at 10-meter, 30-meter, and floodplain widths to address the area impacted by the highway (about 0.6 acres) and to improve canopy cover, large woody debris recruitment potential, and riparian composition within the floodplain. Address noxious weeds through planting and education/prevention programs. Protect existing wetlands and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	High
3	Rehabilitation + Protection	Reconnect Isolated Habitat: Remove or modify Highway 2 with bridges where appropriate to reconnect floodplain and reinitiate habitat-forming processes. Protect existing wetlands and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	Medium

Option	Habitat Action	Prioritized Habitat Actions	VSP Parameters Addressed	Geomorphic Potential
4	Rehabilitation + Protection	Riparian rehabilitation Replant sections of riparian vegetation at 10-meter, 30-meter, and floodplain widths to address the area impacted by the transmission line (about 0.6 acres) and to improve canopy cover, large woody debris recruitment potential, and riparian composition within the floodplain. Address noxious weeds through planting and education/prevention programs. Protect existing wetlands and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	Medium
5	Rehabilitation	Reconnect Isolated Habitat: Remove or modify Highway 2 with bridges where appropriate to reconnect floodplain and reinitiate habitat-forming processes. Riparian Rehabilitation: Replant sections of riparian vegetation at 10-meter, 30-meter, and floodplain widths to address the area impacted by the transmission line (about 0.6 acres) and to improve canopy cover, large woody debris recruitment potential, and riparian composition within the floodplain. Address noxious weeds through planting and education/prevention programs.	2; Productivity and Abundance	Medium
6	Rehabilitation	Reconnect Processes: Modify Highway 2 with culverts where appropriate to reconnect existing wetland area to riverine system. Combine with riparian rehabilitation of sections of riparian vegetation at 10-meter, 30-meter, and floodplain widths to address the area impacted by the highway (about 0.6 acres) and to improve canopy cover, large woody debris recruitment potential, and riparian composition within the floodplain. Address noxious weeds through planting and education/prevention programs.	2; Productivity and Abundance	Medium

Option	Habitat Action	Prioritized Habitat Actions	VSP Parameters Addressed	Geomorphic Potential
7	Rehabilitation	Reconnect Isolated Habitat: Remove or modify Highway 2 with bridges where appropriate to reconnect floodplain and reinitiate habitat-forming processes.	2; Productivity and Abundance	Low
8	Rehabilitation	Reconnect Processes: Modify Highway 2 with culverts where appropriate to reconnect existing wetland area to riverine system	2; Productivity and Abundance	Low
9	Rehabilitation	Riparian Rehabilitation: Replant sections of riparian vegetation at 10-meter, 30-meter, and floodplain widths to address the area impacted by the transmission line (about 0.6 acres) and to improve canopy cover, large woody debris recruitment potential, and riparian composition within the floodplain. Address noxious weeds through planting and education/prevention programs.	2; Productivity and Abundance	Low
10	Protection	Protect existing wetlands (1 acre) and maintain current levels of hydrologic, riparian, and geomorphic function.	4; Productivity, Abundance, Diversity, and Structure	Maintain

LWP DOZ-4

LWP OZ-4 is located in the downstream end of the Lower White Pine reach. The subreach is the corresponding floodplain area associated with DIZ-2. Both subreaches are located to the south side of the Burlington Northern railroad grade near RM 10.2 to 9.6 (Figure 29).

The subreach is about 38 acres in size and represents the historic outer zone or floodplain of the active channel that existed prior to the construction of the railroad. About 22 acres of wetlands exist within the subreach. Natural historic lateral controls within the subreach are alluvial fan structures and higher terraces.

The area is disconnected from the active channel by about 1,710 feet of railroad grade. The area of disturbed vegetation associated with the railroad grade is 1.3 acres or 3 percent of the subreach. The inundation potential of this subreach is 34 acres or 34 percent of the inundation potential for the entire Lower White Pine reach.

The impacts of anthropogenic features make this subreach rehabilitation-oriented. Impacts from anthropogenic features and activities include the clearing of vegetation during early development of the valley and artificial lateral control from the railroad grade that disconnects this subreach from the historic and active channel. The result is loss of floodplain processes and a change in riparian vegetation composition from mixed hardwood to small brush vegetation. The lack of canopy cover within the historic 10-meter buffer zone allows the impounded runoff and groundwater to warm before entering the main channel. The narrowing and disconnection of the active floodplain decreases the system's ability to accommodate floodwaters, rejuvenate off-channel habitat, and provide high-flow refugia. Habitat is not generated in this area at higher flows. The railroad grade acts as a levee, so any water that does inundate the subreach does not have sufficient energy to create habitat features. Rehabilitation options are listed in Table 15 and are prioritized to maximize the geomorphic potential of the subreach through the reconnection and re-establishment of both long-term and short-term processes at the subreach scale. Rehabilitation actions in this subreach should be considered collectively with rehabilitation actions recommended in other adjacent subreaches to achieve a holistic reconnection and reestablishment of processes at the reach scale.

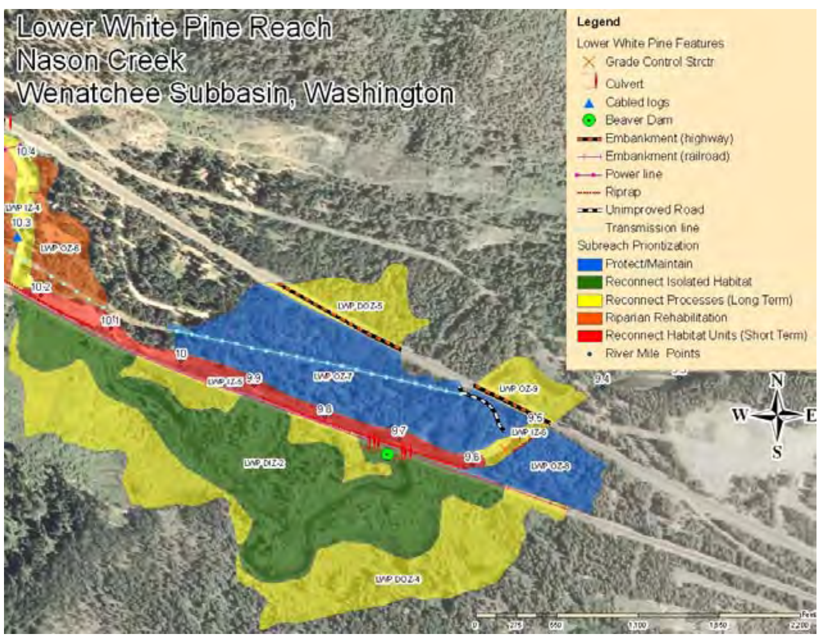

Figure 29 - A plan view showing the location of LWP DOZ-4 in the downstream end of the Lower White Pine reach, location of anthropogenic features, and the proximity of adjacent subreaches with the corresponding rehabilitation strategies.

Table 15 - Options for LWP DOZ-4.

Option	Habitat Action	Prioritized Habitat Actions	VSP Parameters Addressed	Geomorphic Potential
1	Rehabilitation + Protection	Riparian Rehabilitation: Restore sections of riparian vegetation impacted by the railroad grade and power line (about 1 acre) by planting trees and shrubs at 10-meter, 30-meter, and floodplain widths. This will also provide adequate composition, canopy cover, and large woody debris recruitment potential within the rehabilitated floodplain. Address noxious weeds through planting and education/prevention programs. Protect and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	High
2	Rehabilitation	Riparian Rehabilitation: Restore sections of riparian vegetation impacted by the railroad grade and power line (about 1 acre) by planting trees and shrubs at 10-meter, 30-meter, and floodplain widths. This will also provide adequate composition, canopy cover, and large woody debris recruitment potential within the rehabilitated floodplain. Address noxious weeds through planting and education/prevention programs.	2; Productivity and Abundance	Low
3	Protection	Protect existing wetlands (22 Acres) and maintain current levels of hydrologic, riparian, and geomorphic function.	4; Productivity, Abundance, Diversity, and Structure	Maintain

LWP DPZ-2

LWP DOZ-2 is located in the mid-section of the Lower White Pine reach. The subreach is the corresponding floodplain to LWP DIZ-1. The subreach is located to the south side of the Burlington Northern railroad grade near RM 11.05 to 10.65 (Figure 30).

The subreach is about 18 acres in size and represents the historic outer zone or floodplain of the active channel that existed prior to the construction of the railroad. Natural historic lateral controls within the subreach are higher terraces. About 7 acres of wetlands are contained within the subreach. Anthropogenic features are concentrated along the northeast edge of the subreach where there is about 1,897 feet of railroad grade that runs parallel to the current channel. This section of railroad grade disconnects the subreach from the active channel. There is also about 296 feet of powerline running through the southeast corner of the subreach. The percentage of the area with disturbed vegetation is about 27 percent. The inundation potential of this subreach is 5.5 acres or 5 percent of the inundation potential for the entire Lower White Pine reach.

The impacts of anthropogenic features make this subreach rehabilitation-oriented. The vegetation was likely cleared during early development of the valley and artificial lateral control from the railroad grade has disconnected this subreach from the active channel. The result is loss of floodplain processes and the change in riparian vegetation composition from mixed hardwood to small brush vegetation. The lack of canopy cover within the historic 10-meter buffer zone allows the impounded runoff and groundwater to warm before entering the main channel. The narrowing and disconnection of the active floodplain decrease the system’s ability to accommodate floodwaters, rejuvenate off-channel habitat, and provide high-flow refugia. Habitat is not generated in this area at higher flows. The railroad grade acts as a levee, so any water that does inundate the subreach does not have sufficient energy to create habitat features. Rehabilitation options are listed in Table 16 and are prioritized to maximize the geomorphic potential of the subreach through the reconnection and re-establishment of both long-term and short-term processes at the subreach scale. Rehabilitation actions in this subreach should be considered collectively with rehabilitation actions recommended in other adjacent subreaches to achieve a holistic reconnection and re-establishment of processes at the reach scale.

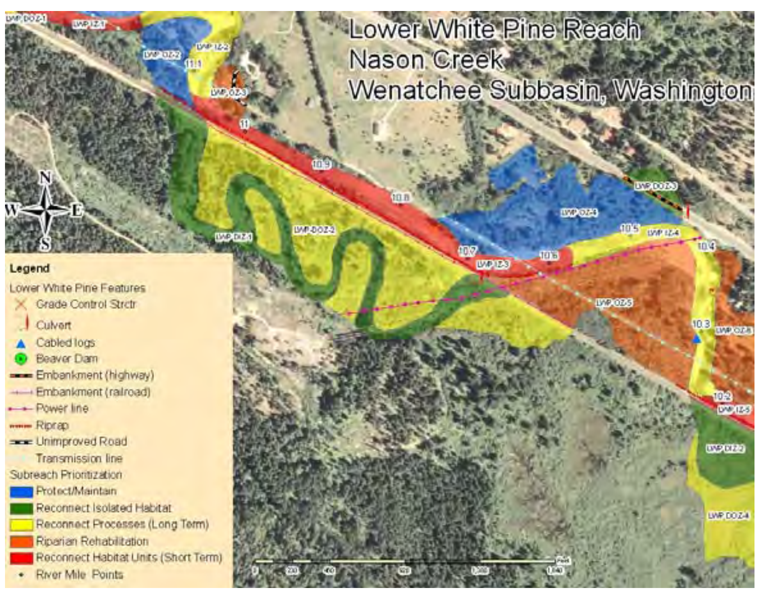

Figure 30 - A plan view showing the location of LWP DOZ-2 in the downstream end of the Lower White Pine reach with, location of anthropogenic features, and the proximity of adjacent subreaches with the corresponding rehabilitation strategies.

Table 16 - Options for LWP DOZ-2.

Option	Habitat Action	Prioritized Habitat Actions	VSP Parameters Addressed	Geomorphic Potential
1	Rehabilitation + Protection	Riparian Rehabilitation: Restore sections of riparian vegetation impacted by the railroad grade and power line (about 5 acres) by planting trees and shrubs at 10-meter, 30-meter, and floodplain widths. This will also provide adequate composition, canopy cover, and large woody debris recruitment potential within the rehabilitated floodplain. Address noxious weeds through planting and education/prevention programs. Protect existing wetlands (7 acres) and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	High
2	Rehabilitation	Riparian Rehabilitation: Restore sections of riparian vegetation impacted by the railroad grade and power line (about 5 acres) by planting trees and shrubs at 10-meter, 30-meter, and floodplain widths. This will also provide adequate composition, canopy cover, and large woody debris recruitment potential within the rehabilitated floodplain. Address noxious weeds through planting and education/prevention programs.	2; Productivity and Abundance	Low
3	Protection	Protect existing wetlands (7 acres) and maintain current levels of hydrologic, riparian and geomorphic function.	4; Productivity, Abundance, Diversity, and Structure	Maintain

LWP OZ-9

LWP OZ-9 is located in the downstream section of the Lower White Pine reach in the left floodplain along RM 9.5 to 9.43 (Figure 31).

The subreach is about 4 acres in size. The subreach contains about 1 acre of wetland area (Figure 32). Natural lateral controls are alluvial fans structures on the north side. The subreach is disconnected from subreach LWP OZ-7 by 493 feet of highway embankment. There is an additional 173 feet of road embankment in the subreach. The percent of disturbed vegetation in the subreach is 25 percent. The inundation potential is about 1 acre or about 1 percent of the inundation potential for the entire Lower White Pine reach and is essentially the area of the foot-print of Highway 2.

The subreach is rehabilitation-oriented due to the fact that it is disconnected from subreach LWP OZ-7 by 493 feet of highway embankment. Rehabilitation options are listed in Table 17 and are prioritized to maximize the geomorphic potential of the subreach through the reconnection and re-establishment of both long-term and short-term processes at the subreach scale. Rehabilitation actions in this subreach should be considered collectively with rehabilitation actions recommended in other adjacent subreaches to achieve a holistic reconnection and reestablishment of processes at the reach scale.

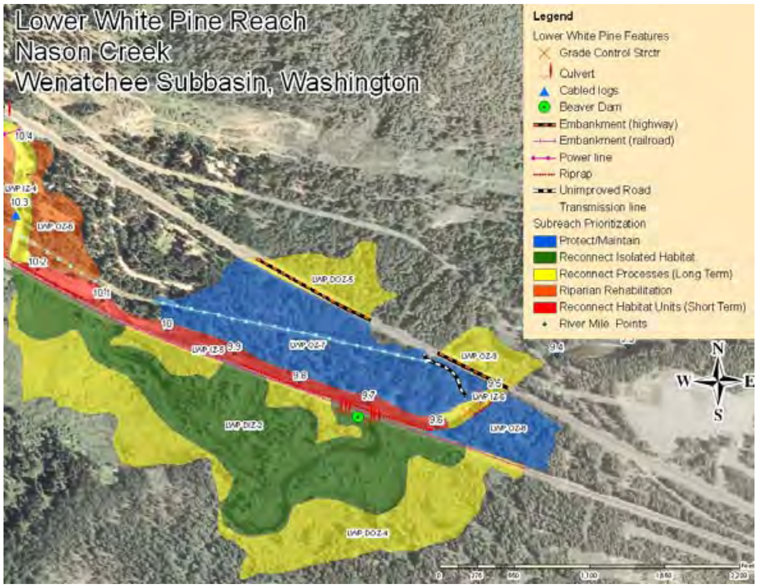

Figure 31 - A plan view showing the location of LWP OZ-9 in the downstream end of the Lower White Pine reach, location of anthropogenic features, and the proximity of adjacent subreaches with the corresponding rehabilitation strategies.

Figure 32 - Top of wetlands in an oxbow on the north side of the road, view to the northeast. Lower White Pine Reach; Subreach OZ-9, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by R. McAffee, May 3, 2007.

Table 17 - Options for LWP OZ-9.

Option	Habitat Action	Prioritized Habitat Actions	VSP Parameters Addressed	Geomorphic Potential
1	Rehabilitation + Protection	Reconnect Isolated Habitat: Remove or modify Highway 2 with bridges where appropriate to reconnect wetlands to the adjacent floodplain and reinitiate habitat-forming processes. Combine with riparian rehabilitation at 10-meter, 30-meter, and floodplain widths to provide adequate composition, canopy cover, and large woody debris recruitment potential within the rehabilitated floodplain. Protect existing wetlands (1 acre) and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	High
2	Rehabilitation + Protection	Reconnect Processes: Modify Highway 2 with culverts where appropriate to reconnect wetlands to the adjacent floodplain. Remove, modify, or maintain the additional 173 feet of road embankment within the subreach. Combine with riparian rehabilitation of sections of riparian vegetation at 10-meter, 30-meter, and floodplain widths to address the area impacted by the highway (about 1 acre) and to improve canopy cover, large woody debris recruitment potential, and riparian composition within the floodplain. Address noxious weeds through planting and education/prevention programs. Protect existing wetlands (1 acre) and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	2; Productivity and Abundance	High

Option	Habitat Action	Prioritized Habitat Actions	VSP Parameters Addressed	Geomorphic Potential
3	Rehabilitation	Reconnect Isolated Habitat: Remove or modify Highway 2 with bridges where appropriate to reconnect wetlands to the adjacent floodplain and reinitiate habitat-forming processes. Combine with riparian rehabilitation at 10-meter, 30-meter, and floodplain widths to provide adequate composition, canopy cover, and large woody debris recruitment potential within the rehabilitated floodplain.	2; Productivity and Abundance	Medium
4	Rehabilitation	Reconnect Processes: Modify Highway 2 with culverts where appropriate to reconnect wetlands to the adjacent floodplain. Remove modify or maintain the additional 173 feet of road embankment within the subreach. Combine both road maintenance action with riparian rehabilitation of sections of riparian vegetation at 10-meter, 30-meter, and floodplain widths to address the area impacted by the highway (about 1 acre) and to improve canopy cover, large woody debris recruitment potential, and riparian composition within the floodplain. Address noxious weeds through planting and education/prevention programs.	2; Productivity and Abundance	Medium
5	Rehabilitation	Reconnect Isolated Habitat: Remove or modify Highway 2 with bridges where appropriate to reconnect wetlands to the adjacent floodplain and reinitiate habitat-forming processes.	2; Productivity and Abundance	Low
6	Rehabilitation	Reconnect Processes: Modify Highway 2 with culverts where appropriate to reconnect wetlands to the adjacent floodplain. Remove modify or maintain the additional 173 feet of road embankment within the subreach.	2; Productivity and Abundance	Low

Option	Habitat Action	Prioritized Habitat Actions	VSP Parameters Addressed	Geomorphic Potential
7	Rehabilitation	Riparian Rehabilitation: Replant sections of riparian vegetation at 10-meter, 30-meter, and floodplain widths to address the area impacted by the highway (about 1 acre) and to improve canopy cover, large woody debris recruitment potential, and riparian composition within the floodplain. Address noxious weeds through planting and education/prevention programs.	2; Productivity and Abundance	Low
8	Protection	Protect existing wetlands (1 acre) and maintain current levels of hydrologic, riparian, and geomorphic function.	4; Productivity, Abundance, Diversity, and Structure	Maintain

LWP DOZ-5

LWP DOZ-5 is located in the downstream section of the Lower White Pine reach. The subreach is the historic floodplain located to the north of Washington State Highway 2 (Figure 33).

The subreach is about 7 acres in size and is disconnected from the subreach LWP OZ-7 by 945 feet of highway embankment. Natural lateral controls for the subreach are alluvial fan structures and higher terraces. The area of disturbed vegetation associated with the highway embankment is 2 acres or 29 percent of the subreach area. The inundation potential is 6 acres or about 6 percent of the inundation potential for the entire Lower White Pine reach.

The impacts of anthropogenic features make this subreach rehabilitation-oriented. Rehabilitation options are listed in Table 18 and are prioritized to maximize the geomorphic potential of the subreach through the reconnection and re-establishment of both long-term and short-term processes at the subreach scale. Rehabilitation actions in this subreach should be considered collectively with rehabilitation actions recommended in other adjacent subreaches to achieve a holistic reconnection and reestablishment of processes at the reach scale.

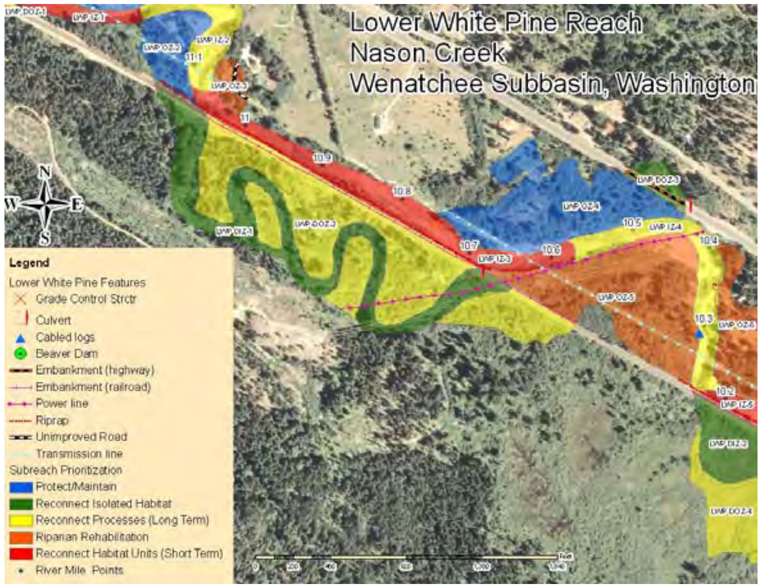

Figure 33 - A plan view showing the location of LWP DOZ-5 in the downstream end of the Lower White Pine reach, location of anthropogenic features, and the proximity of adjacent subreaches with the corresponding rehabilitation strategies.

Table 18 - Options for LWP DOZ-5.

Option	Habitat Action	Prioritized Habitat Actions	VSP Parameters Addressed	Geomorphic Potential
1	Rehabilitation + Protection	Reconnect Isolated Habitat: Remove or modify Highway 2 with bridges where appropriate to reconnect floodplain and reinitiate habitat-forming processes. Combine with riparian rehabilitation at 10-meter, 30-meter, and floodplain widths to provide adequate composition, canopy cover and large woody debris recruitment potential within the rehabilitated floodplain. Protect and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	High
2	Rehabilitation + Protection	Reconnect Processes: Modify Highway 2 with culverts where appropriate to reconnect existing wetland area to riverine system; Combine with riparian rehabilitation of sections of riparian vegetation at 10-meter, 30-meter, and floodplain widths to address the area impacted by the highway (about 2 acres) and to improve canopy cover, large woody debris recruitment potential, and riparian composition within the floodplain. Address noxious weeds through planting and education/prevention programs. Protect and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	High
3	Rehabilitation	Reconnect Isolated Habitat: Remove or modify Highway 2 with bridges where appropriate to reconnect floodplain and reinitiate habitat-forming processes. Combine with riparian rehabilitation of sections of riparian vegetation at 10-meter, 30-meter, and floodplain widths to address the area impacted by the highway (about 2 acres) and to improve canopy cover, large woody debris recruitment potential, and riparian composition within the floodplain. Address noxious weeds through planting and education/prevention programs.	4; Productivity, Abundance, Diversity, and Structure	Medium

Option	Habitat Action	Prioritized Habitat Actions	VSP Parameters Addressed	Geomorphic Potential
4	Rehabilitation	Reconnect Processes: Modify Highway 2 with culverts where appropriate to reconnect existing wetland area to riverine system. Combine with riparian rehabilitation of sections of riparian vegetation at 10-meter, 30-meter, and floodplain widths to address the area impacted by the highway (about 2 acres) and to improve canopy cover, large woody debris recruitment potential, and riparian composition within the floodplain. Address noxious weeds through planting and education/prevention programs.	2; Productivity and Abundance	Medium
5	Rehabilitation	Reconnect Isolated Habitat: Remove or modify Highway 2 with bridges where appropriate to reconnect floodplain and reinitiate habitat-forming processes.	2; Productivity and Abundance	Low
6	Rehabilitation	Reconnect Processes: Modify Highway 2 with culverts where appropriate to reconnect existing wetland area to riverine system.	2; Productivity, and Abundance	Low
7	Rehabilitation	Riparian Rehabilitation: Replant sections of riparian vegetation at 10-meter, 30-meter, and floodplain widths to address the area impacted by the transmission line (about 2 acres) and to improve canopy cover, large woody debris recruitment potential, and riparian composition within the floodplain. Address noxious weeds through planting and education/prevention programs.	2; Productivity and Abundance	Low
8	Protection	Protect and maintain current levels of hydrologic, riparian, and geomorphic function (1 acre).	4; Productivity, Abundance, Diversity, and Structure	Maintain

LWP DOZ-1

LWP DOZ-1 is located in the upstream section of the Lower White Pine reach in the right floodplain along RM 11.55 to 11.45 (Figure 34) on the south side of the Burlington Northern railroad grade.

The subreach, about 2 acres in size, is completely disconnected from the active channel by 572 feet of railroad grade. The railroad grade footprint disturbs about 0.9 acres of vegetation or about 25 percent of the subreach.

Natural lateral control for the subreach is an alluvial fan; however, artificial lateral control from the railroad grade has disconnected this subreach from the active channel the entire length of the subreach. The inundation potential is 2 acres, which accounts for 2 percent of the inundation potential for the entire reach.

The impacts of anthropogenic features make this subreach rehabilitation-oriented. The results of impacts from anthropogenic features include the loss of habitat and a diminished riparian vegetation composition. The narrowing of the active floodplain decreases storage capacity and floodwater accommodation. This is vital for rejuvenating off-channel habitat. Habitat is not generated in this area at higher flows. For example, the railroad grade acts as a levee, so any water that does inundate the subreach does not have sufficient energy to create habitat features. Rehabilitation options are listed in Table 19; they are prioritized to maximize geomorphic potential of the subreach through the reconnection and reestablishment of both long-term and short-term processes at the subreach scale. Rehabilitation actions in this subreach should be considered collectively with rehabilitation actions recommended in other adjacent subreaches to achieve a holistic reconnection and reestablishment of processes at the reach scale.

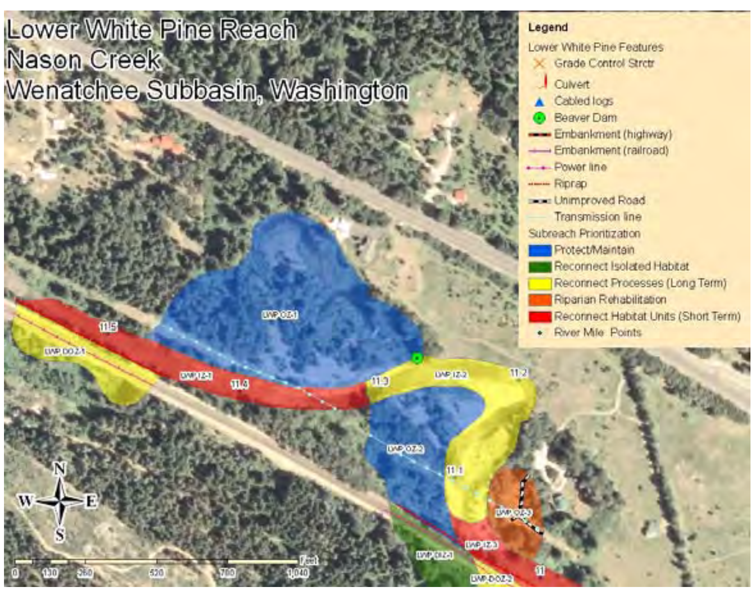

Figure 34 - A plan view showing the location of LWP DOZ-1 in the downstream end of the Lower White Pine reach with, location of anthropogenic features, and the proximity of adjacent subreaches with the corresponding rehabilitation strategies.

Table 19 - Options for LWP DOZ-1.

Option	Habitat Action	Prioritized Habitat Actions	VSP Parameters Addressed	Geomorphic Potential
1	Rehabilitation + Protection	Reconnect Processes: Remove or modify railroad grade with culverts where appropriate to reconnect floodplain. Combine with riparian rehabilitation at 10-meter, 30-meter, and floodplain widths to provide adequate composition, canopy cover, and large woody debris recruitment potential within the rehabilitated floodplain. Protect and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	High
2	Rehabilitation + Protection	Reconnect Processes: Remove or modify railroad grade with culverts where appropriate to reconnect floodplain. Protect and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	Medium
3	Rehabilitation + Protection	Riparian Rehabilitation: Replant sections of riparian vegetation impacted by the railroad grade (about 1 acre) by planting trees and shrubs to increase large woody debris recruitment potential within the current floodplain and reduce the amount of altered vegetation. Address noxious weeds through planting and education/prevention programs. Protect and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	Medium
4	Rehabilitation	Riparian Rehabilitation: Replant sections of riparian vegetation impacted by the railroad grade (about 1 acre) by planting trees and shrubs to increase large woody debris recruitment potential within the current floodplain and reduce the amount of altered vegetation. Address noxious weeds through planting and education/prevention programs.	2; Productivity and Abundance	Low
5	Protection	Protect and maintain current levels of hydrologic, riparian, and geomorphic function.	4; Productivity, Abundance, Diversity, and Structure	Maintain

LWP IZ-2

LWP IZ-2 comprises a section of the current active channel and bars from RM 11.31 to 11.07 in the Lower White Pine reach (Figure 35).

The subreach area is about 3 acres. This subreach contains greater heterogeneity of channel units than adjacent inner zone subreaches with 13 percent pools, 30 percent riffles, and 57 percent runs. There are no in-stream structures within this subreach and anthropogenic features are limited to a transmission line crossing in the downstream end. Natural lateral control for the subreach is an alluvial fan. In this subreach, the channel has limited ability to migrate and it was observed to do so at an accelerated rate as a result of impacts to the riparian vegetation (Figure 36 and Figure 37). Large woody debris is concentrated in complexes at a few locations (Figure 38).

The overall lack of large woody debris prevents the creation of complexity at higher flows. It is hypothesized that material is deposited when flows are increasing and eroded when flows are decreasing. The result is incised gravel bars with little change in overall form. The impacts of anthropogenic features in the form of slight to moderate incision and the proximity of protection-oriented subreaches make this subreach rehabilitation-oriented. Rehabilitation options are listed in Table 20. With the effort to reconnect processes, various habitat actions from multiple habitat action classes may be implemented. For example, the habitat actions of reconnecting wetlands and creating diverse channel patterns are listed under the habitat action class floodplain rehabilitation. The habitat action of slowing of water velocities is listed under the habitat action class of in-stream structures. The habitat action of adding large woody debris and engineered log jams is listed under the action class of large woody debris restoration (UCSRB 2007). Floodplain rehabilitation addresses all four VSP parameters while large woody debris replacement and in-stream structures address two. The number of VSP parameters addressed in respect to reconnecting processes will depend on the action that is implemented. Options are prioritized to maximize geomorphic potential of the subreach through the reconnection and reestablishment of both long-term and short-term processes at the subreach scale. Rehabilitation actions in this subreach should be considered collectively with rehabilitation actions recommended in other adjacent subreaches to achieve a holistic reconnection and reestablishment of processes at the reach scale.

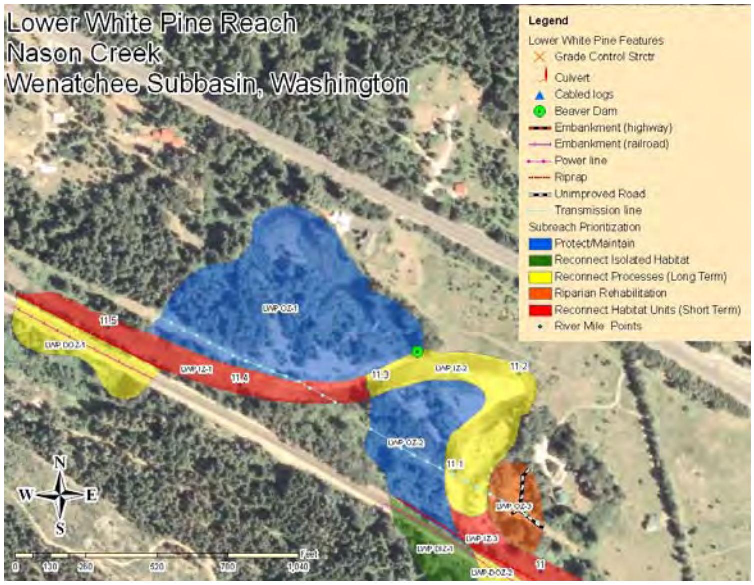

Figure 35 - A plan view showing the location of LWP IZ-2 in the downstream end of the Lower White Pine reach, location of anthropogenic features, and the proximity of adjacent subreaches with the corresponding rehabilitation strategies.

Figure 36 - Accelerated erosion along the cleared left bank, view is to the east looking downstream. Lower White Pine Reach; Subreach IZ-2, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Figure 37 - Stratified material in the left bank at a bank profile site, view is to the north. Lower White Pine Reach; Subreach IZ-2, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Figure 38 - Large woody debris complexes and pool channel units, view is to the south looking downstream. Lower White Pine Reach; Subreach IZ-2, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Table 20 - Options for LWP IZ-2.

Option	Habitat Action	Prioritized Habitat Actions	VSP Parameters Addressed	Geomorphic Potential
1	Rehabilitation + Protection	Reconnect Processes through the use of various habitat actions from multiple habitat action classes including in-stream structures, floodplain rehabilitation and large woody debris rehabilitation that will result in an increase in the current bed elevation. This will in turn allow fluvial processes to work within adjacent outer zones more frequently. Combine with Riparian rehabilitation: Apply efforts for a long-term approach that will result in increased large woody debris recruitment potential, increased sinuosity, sorting and retention of spawning gravels, increased number of complex pools, and water quality. Protect and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	High
2	Rehabilitation + Protection	Reconnect Processes through the use of various habitat actions from multiple habitat action classes including in-stream structures, floodplain rehabilitation and large woody debris replacement that will result in an increase in the current bed elevation. Combine with Riparian rehabilitation: Apply efforts for a long-term approach that will result in increased large woody debris recruitment potential, increased sinuosity, sorting and retention of spawning gravels, increased number of complex pools, and water quality.	4; Productivity, Abundance, Diversity, and Structure	Medium
3	Rehabilitation + Protection	Reconnect Processes through the use of various habitat actions from multiple habitat action classes including in-stream structures, floodplain rehabilitation and large woody debris replacement that will result in an increase in the current bed elevation. Protect and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	Medium

Option	Habitat Action	Prioritized Habitat Actions	VSP Parameters Addressed	Geomorphic Potential
4	Rehabilitation + Protection	Riparian rehabilitation: Apply efforts for a long-term approach that will result in increased large woody debris recruitment potential, increased sinuosity, sorting and retention of spawning gravels, increased number of complex pools, and water quality. Protect and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	Medium
5	Rehabilitation	Reconnect Processes through the use of various habitat actions from multiple habitat action classes including in-stream structures, floodplain rehabilitation and large woody debris replacement that will result in an increase in the current bed elevation.	Ranges from 2 up to 4 depending on action and action class	Low
6	Rehabilitation	Riparian rehabilitation: Apply efforts for a long-term approach that will result in increased large woody debris recruitment potential, increased sinuosity, sorting and retention of spawning gravels, increased number of complex pools, and water quality.	2; Productivity, and Abundance	Low
7	Protection	Protect and maintain current levels of geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	Maintain

LWP IZ-4

LWP IZ-4 comprises a section of the current active channel and bars from RM 10.57-10.21 in the Lower White Pine reach (Figure 39).

The subreach area is about 5 acres in size and contains only a slightly greater level of heterogeneity than adjacent inner zone subreaches with 5 percent pools, 29 percent riffles and 66 percent runs. Natural lateral control for the subreach is an alluvial fan. In-stream structures mapped include a riprap/ecology block structure at RM 10.35 (Figure 40) and a cabled log at RM10.29. Additional anthropogenic features include transmission crossings at the top and bottom of the subreach and a powerline crossing in the midsection. About 70 feet of riprap associated with the railroad grade is located along the right bank at the downstream end of the subreach along the right bank (Figure 41). Large woody debris was observed at a few locations.

Existing conditions in this subreach include an accelerated rate of migration as a result of impacts to the riparian vegetation. The overall lack of large woody debris prevents the creation of complexity at higher flows. It is hypothesized that material is deposited when flows are increasing and eroded when flows are decreasing. The result is incised gravel bars with little change in overall form. Slight to moderate incision and the proximity of protection-oriented outer zones make this subreach rehabilitation-oriented. Rehabilitation options are listed in Table 21. With the effort to reconnect processes, various habitat actions from multiple habitat action classes may be implemented. For example, the habitat actions of reconnecting wetlands and creating diverse channel patterns are listed under the habitat action class floodplain rehabilitation. The habitat action of slowing of water velocities is listed under the habitat action class of in-stream structures. The habitat action of adding large woody debris and engineered log jams is listed under the action class of large woody debris replacement. Floodplain rehabilitation addresses all four viable salmonid populations (VSP) parameters while large woody debris replacement and in-stream structures address two. The number of VSP parameters addressed in respect to reconnecting processes will depend on the action that is implemented. Options are prioritized to maximize geomorphic potential of the subreach through the reconnection and reestablishment of both long-term and short-term processes at the subreach scale. Rehabilitation actions in this subreach should be considered collectively with rehabilitation actions recommended in other adjacent subreaches to achieve a holistic reconnection and reestablishment of processes at the reach scale.

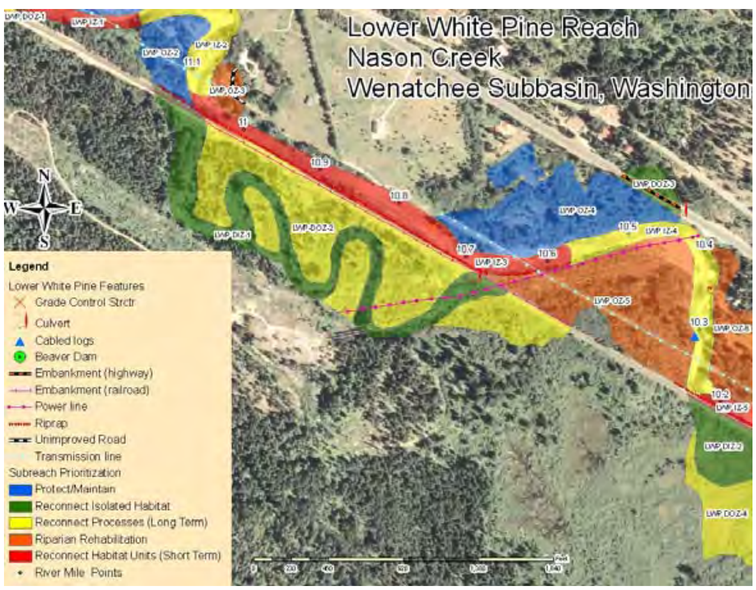

Figure 39 - A plan view showing the location of LWP IZ-4 in the downstream end of the Lower White Pine reach, location of anthropogenic features, and the proximity of adjacent subreaches with the corresponding rehabilitation strategies.

Figure 40 - In-channel structure comprised of concrete ecology blocks, miscellaneous concrete slabs and riprap, view to the south. Lower White Pine Reach; Subreach LWP IZ-4, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Figure 41 - Channel unit transition from riffle to run and riprap along the right bank, view is to the southeast looking downstream. Lower White Pine Reach; Subreach LWP IZ-4, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Table 21 - Options for LWP IZ-4.

Option	Habitat Action	Prioritized Habitat Actions	VSP Parameters Addressed	Geomorphic Potential
1	Rehabilitation + Protection	Reconnect Processes through the use of various habitat actions from multiple habitat action classes including in-stream structures, floodplain rehabilitation and large woody debris replacement that will result in an increase in the current bed elevation. This will in turn allow fluvial processes to work within adjacent outer zones more frequently. Combine with Riparian rehabilitation: Apply efforts for a long-term approach that will result in increased large woody debris recruitment potential, increased sinuosity, sorting and retention of spawning gravels, increased number of complex pools, and water quality. Protect and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	High
2	Rehabilitation + Protection	Reconnect Processes through the use of various habitat actions from multiple habitat action classes including in-stream structures, floodplain rehabilitation and large woody debris replacement that will result in an increase in the current bed elevation. This will in turn allow fluvial processes to work within adjacent outer zones more frequently. Protect and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	Medium
3	Rehabilitation + Protection	Riparian rehabilitation: Implement efforts for a long-term approach that results in increased large woody debris recruitment potential, increased sinuosity, sorting and retention of spawning gravels, increased number of complex pools, and water quality. Protect and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	Medium

Option	Habitat Action	Prioritized Habitat Actions	VSP Parameters Addressed	Geomorphic Potential
4	Rehabilitation	Reconnect Processes through the use of various habitat actions from multiple habitat action classes including in-stream structures, floodplain rehabilitation and large woody debris replacement that will result in an increase in the current bed elevation. This will in turn allow fluvial processes to work within adjacent outer zones more frequently	Ranges from 2 up to 4 depending on action and action class	Low
5	Rehabilitation	Riparian rehabilitation: Apply efforts for a long-term approach that results in increased large woody debris recruitment potential, increased sinuosity, sorting and retention of spawning gravels, increased number of complex pools, and water quality. Existing In-stream structures should be evaluated and potentially modified to improve the functionality of refugia and hiding cover, sorting and retention of spawning gravel, and large woody debris retention. This is listed as a Tier 1 habitat action in the Biological Strategy (RTT 2007).	2; Productivity, and Abundance	Low
6	Protection	Protect and maintain current levels of geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	Maintain

LWP IZ-6

LWP-6 comprises a section of the current active channel and bars from RM 9.59 to 9.45 in the Lower White Pine reach (Figure 42).

The subreach area is about 2 acres in size. This subreach contains 1 percent rapids, 5 percent pools, 14 percent riffle, and 79 percent runs, only a slightly greater level of heterogeneity than adjacent inner zone subreaches. In-stream structures within this subreach include V-weir that acts as grade control structure at RM 9.56 (Figure 43). Additional anthropogenic features include about 255 feet of riprap along the right bank and two sets of bridge abutments (Figure 44).

Natural lateral control for the subreach is an alluvial fan; however, artificial lateral control from the bridge abutments imposes some influence on the active channel. Large woody debris is low and the lack of large woody debris prevents the creation of complexity at higher flows.

It is hypothesized that material is eroded when flows are increasing and deposited when flows are decreasing. The result is a plane bed with no real change in form. Impacts of anthropogenic features in the form of slight to moderate incision make this subreach rehabilitation-oriented. Rehabilitation options are listed in Table 22. With the effort to reconnect processes, various habitat actions from multiple habitat action classes may be implemented. For example, the habitat actions of reconnecting wetlands and creating diverse channel patterns are listed under the habitat action class floodplain rehabilitation. The habitat action of slowing water velocities is listed under the habitat action class of in-stream structures. The habitat action of adding large woody debris and engineered log jams is listed under the action class of large woody debris replacement. Floodplain rehabilitation addresses all four VSP parameters while large woody debris replacement and in-stream structures address two. The number of VSP parameters addressed in respect to reconnecting processes will depend on the action that is implemented. Options are prioritized to maximize geomorphic potential of the subreach through the reconnection and reestablishment of both long-term and short-term processes at the subreach scale. Rehabilitation actions in this subreach should be considered collectively with rehabilitation actions recommended in other adjacent subreaches to achieve a holistic reconnection and reestablishment of processes at the reach scale.

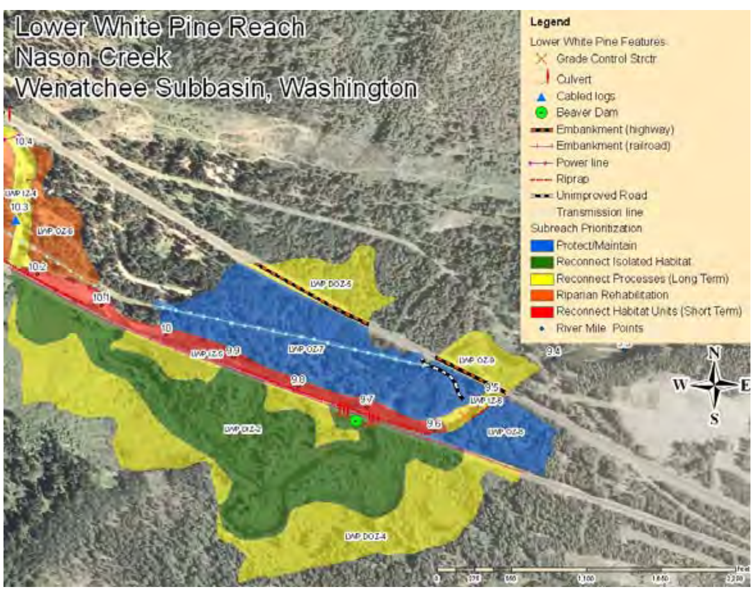

Figure 42 - A plan view showing the location of LWP IZ-6 in the downstream end of the Lower White Pine reach, location of anthropogenic features, and the proximity of adjacent subreaches with the corresponding rehabilitation strategies.

Figure 43 - In-channel rock weir, view is to the east. Lower White Pine Reach; Subreach LWP IZ-6, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Figure 44 - Run and pool channel units, brush-vegetated banks and bridge abutments, view is to the northeast looking downstream. Lower White Pine Reach; Subreach LWP IZ-6, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Table 22 - Options for LWP IZ-6.

Option	Habitat Action	Prioritized Habitat Actions	VSP Parameters Addressed	Geomorphic Potential
1	Rehabilitation + Protection	Reconnect Processes through the use of various habitat actions from multiple habitat action classes including in-stream structures, floodplain rehabilitation and large woody debris replacement that will result in an increase in the current bed elevation. This will in turn allow fluvial processes to work within adjacent outer zones more frequently. Combine with Riparian rehabilitation: Apply efforts for a long-term approach that will result in increased large woody debris recruitment potential, increased sinuosity, sorting and retention of spawning gravels, increased number of complex pools, and water quality. Protect and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	High
2	Rehabilitation + Protection	Reconnect Processes through the use of various habitat actions from multiple habitat action classes including in-stream structures, floodplain rehabilitation and large woody debris replacement that will result in an increase in the current bed elevation. This will in turn allow fluvial processes to work within adjacent outer zones more frequently. Protect and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	High
3	Rehabilitation + Protection	Riparian rehabilitation: Implement efforts for a long-term approach that results in increased large woody debris recruitment potential, increased sinuosity, sorting and retention of spawning gravels, increased number of complex pools, and water quality. Protect and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	Medium

Option	Habitat Action	Prioritized Habitat Actions	VSP Parameters Addressed	Geomorphic Potential
4	Rehabilitation	Reconnect Processes through the use of various habitat actions from multiple habitat action classes including in-stream structures, floodplain rehabilitation and large woody debris replacement that will result in an increase in the current bed elevation. This will in turn allow fluvial processes to work within adjacent outer zones more frequently	Ranges from 2 up to 4 depending on action and action class	Low
5	Rehabilitation	Riparian rehabilitation: Apply efforts for a long-term approach that results in increased large woody debris recruitment potential, increased sinuosity, sorting and retention of spawning gravels, increased number of complex pools, and water quality. Existing In-stream structures should be evaluated and potentially modified to improve the functionality of refugia and hiding cover, sorting and retention of spawning gravel, and large woody debris retention. This is listed as a Tier 1 habitat action in the Biological Strategy (RTT 2007).	2; Productivity, and Abundance	Low
6	Protection	Protect and maintain current levels of geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	Maintain

LWP OZ-5

LWP OZ-5 is located in the mid-section of the Lower White Pine reach in the right floodplain along RM 10.65 to 10.25 (Figure 45).

The subreach is about 13 acres in size. Natural lateral controls for the subreach are alluvial fan structures and higher terraces. There are no anthropogenic features that disconnect the subreach from the active channel. Lengths of anthropogenic features in this subreach are about 1,060 feet of transmission line and 1,138 feet of powerline. The area of disturbed vegetation associated with the powerline and transmission lines in the subreach is 4 acres or 39 percent of the subreach. The inundation potential is 1 acre and is due to the removal of anthropogenic features in other subreaches.

The percent of disturbed vegetation from the powerline and transmission lines make this subreach rehabilitation-oriented. Rehabilitation options are listed in Table 23 and are prioritized to maximize the geomorphic potential of the subreach through the reconnection and reestablishment of both long-term and short-term processes at the subreach scale. Rehabilitation actions in this subreach should be considered collectively with rehabilitation actions recommended in other adjacent subreaches to achieve a holistic reconnection and re-establishment of processes at the reach scale.

Figure 45 - A plan view showing the location of LWP OZ-5 in the downstream end of the Lower White Pine reach, location of anthropogenic features, and the proximity of adjacent subreaches with the corresponding rehabilitation strategies.

Table 23 - Options for LWP OZ-5.

Option	Habitat Action	Prioritized Habitat Actions	VSP Parameters Addressed	Geomorphic Potential
1	Protection + Rehabilitation	Riparian Rehabilitation: Replant sections of riparian vegetation at 10-meter, 30-meter, and floodplain widths to address the area impacted by the transmission and power lines (about 4 acres) and to improve canopy cover, large woody debris recruitment potential, and riparian composition within the floodplain. Address noxious weeds through planting and education/prevention programs. Protect and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	High
2	Rehabilitation	Riparian Rehabilitation: Replant sections of riparian vegetation at 10-meter, 30-meter, and floodplain widths to address the area impacted by the transmission and power lines (about 4 acres) and to improve canopy cover, large woody debris recruitment potential, and riparian composition within the floodplain. Address noxious weeds through planting and education/prevention programs.	2; Productivity and Abundance	Low
3	Protection	Protect and maintain current levels of hydrologic, riparian, and geomorphic function.	4; Productivity, Abundance, Diversity, and Structure	Maintain

LWP OZ-6

LWP OZ-6 is located in the downstream section of the Lower White Pine reach in the left floodplain along RM 10.4 to 4.11 (Figure 46).

The subreach is about 6 acres in size. Natural lateral control for the subreach is a higher terrace. There are no anthropogenic features that disconnect the subreach from the active channel. Lengths of anthropogenic features in this subreach are about 590 feet of transmission line and 65 feet of powerline. The acres of disturbed vegetation associated with the transmission and powerline are 0.7 and 0.1 acres, respectively. There is an additional 1 acre of cleared vegetation associated with development. The percent of disturbed vegetation for the subreach is 30 percent. The inundation potential is low; the 2D-hydraulic model results show little change in area of inundation when comparing (approximate 20-year recurrence interval) stream flow for existing conditions versus potential condition (i.e., with anthropogenic features removed).

The percent of disturbed vegetation from the powerline and transmission lines make this subreach rehabilitation-oriented. Rehabilitation options are listed in Table 24 and are prioritized to maximize the geomorphic potential of the subreach through the reconnection and reestablishment of both long-term and short-term processes at the subreach scale. Rehabilitation actions in this subreach should be considered collectively with rehabilitation actions recommended in other adjacent subreaches to achieve a holistic reconnection and reestablishment of processes at the reach scale.

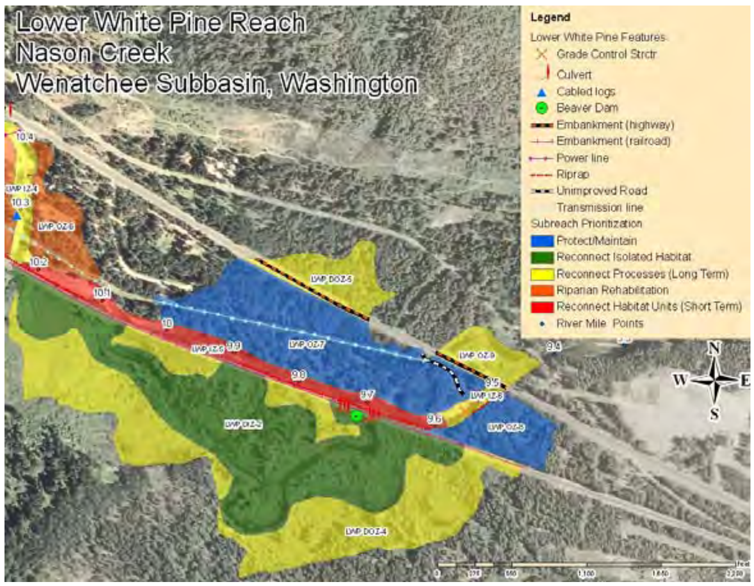

Figure 46 - A plan view showing the location of LWP OZ-6 in the downstream end of the Lower White Pine reach, location of anthropogenic features, and the proximity of adjacent subreaches with the corresponding rehabilitation strategies.

Table 24 - Options for LWP OZ-6.

Option	Habitat Action	Prioritized Habitat Actions	VSP Parameters Addressed	Geomorphic Potential
1	Protection + Rehabilitation	Riparian Rehabilitation: Replant sections of riparian vegetation at 10-meter, 30-meter, and floodplain widths to address the area impacted by the transmission and power lines (about 2 acres) and to improve canopy cover, large woody debris recruitment potential, and riparian composition within the floodplain. Address noxious weeds through planting and education/prevention programs. Protect and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	High
2	Rehabilitation	Riparian Rehabilitation: Replant sections of riparian vegetation at 10-meter, 30-meter, and floodplain widths to address the area impacted by the transmission and power lines (about 2 acres) and to improve canopy cover, large woody debris recruitment potential, and riparian composition within the floodplain. Address noxious weeds through planting and education/prevention programs.	2; Productivity and Abundance	Low
3	Protection	Protect and maintain current levels of hydrologic, riparian, and geomorphic function.	4; Productivity, Abundance, Diversity, and Structure	Maintain

LWP OZ-3

LWP OZ-3 is located in the upstream end of the mid-section of the Lower White Pine reach in the left floodplain from RM 11.1 to 11.0 (Figure 47).

The subreach is about 1 acre in size. There are no anthropogenic features that disconnect the subreach from the active channel. Anthropogenic features include about 307 feet of unimproved road and 239 feet of transmission line. The effects of the road and transmission line include increased fine sediment input and 0.36 acres of disturbed vegetation or 36 percent of the total subreach acreage. The inundation potential is low; the 2D-hydraulic model results show little change in area of inundation when comparing 5,000 cfs (approximate 20-year recurrence interval) stream flow for existing conditions versus potential condition (i.e., with anthropogenic features removed).

The existence of unimproved roads and percent of disturbed vegetation make this subreach rehabilitation-oriented. Rehabilitation options are listed in Table 25 and are prioritized to maximize the geomorphic potential of the subreach through the reconnection and reestablishment of both long-term and short-term processes at the subreach scale. Rehabilitation actions in this subreach should be considered collectively with rehabilitation actions recommended in other adjacent subreaches to achieve a holistic reconnection and reestablishment of processes at the reach scale.

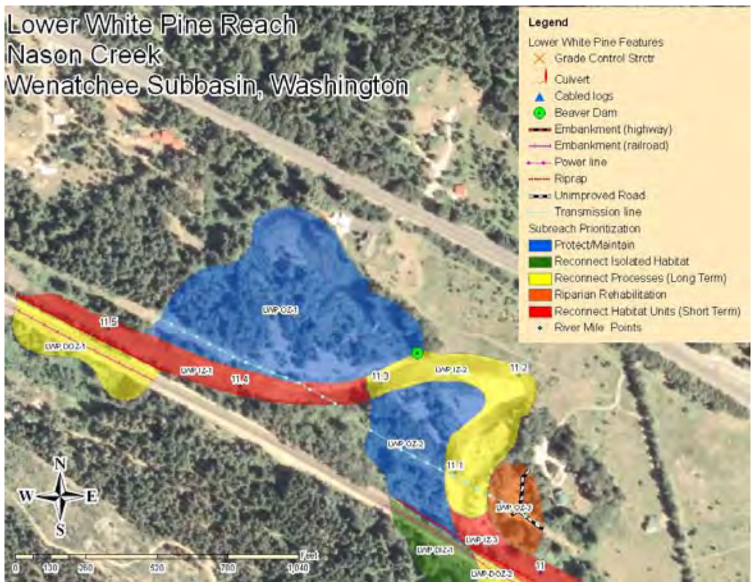

Figure 47 - A plan view showing the location of LWP OZ-3 in the downstream end of the Lower White Pine reach, location of anthropogenic features, and the proximity of adjacent subreaches with the corresponding rehabilitation strategies.

Table 25 – Options for LWP OZ-3.

Option	Habitat Action	Prioritized Habitat Actions	VSP Parameters Addressed	Geomorphic Potential
1	Protection + Rehabilitation	Reconnect Processes: Remove, relocate, or modify sections of unimproved roads within the floodplain to decrease amount of fine sediment input to the system. Combine with riparian rehabilitation of sections of riparian vegetation at 10-meter, 30-meter, and floodplain widths to address the area impacted by the transmission line (about 0.4 acres) and to improve canopy cover, large woody debris recruitment potential, and riparian composition within the floodplain. Address noxious weeds through planting and education/prevention programs. Protect and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	High
2	Protection + Rehabilitation	Reconnect Processes: Remove, relocate, or modify sections of unimproved roads within the floodplain to decrease amount of fine sediment input to the system. Protect and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	Medium
3	Protection + Rehabilitation	Riparian Rehabilitation: Replant sections of riparian vegetation at 10-meter, 30-meter, and floodplain widths to address the area impacted by the transmission line (about 0.4 acres) and to improve canopy cover, large woody debris recruitment potential, and riparian composition within the floodplain. Address noxious weeds through planting and education/prevention programs. Protect and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	Medium

Option	Habitat Action	Prioritized Habitat Actions	VSP Parameters Addressed	Geomorphic Potential
4	Rehabilitation	Reconnect Processes: Remove, relocate, or modify sections of unimproved roads within the floodplain to decrease amount of fine sediment input to the system. Combine with riparian rehabilitation of sections of riparian vegetation at 10-meter, 30-meter, and floodplain widths to address the area impacted by the transmission line (about 0.4 acres) and to improve canopy cover, large woody debris recruitment potential, and riparian composition within the floodplain. Address noxious weeds through planting and education/prevention programs.	2; Productivity, and Abundance	Medium
5	Rehabilitation	Reconnect Processes: Remove, relocate, or modify sections of unimproved roads within the floodplain to decrease amount of fine sediment input to the system.	2; Productivity and Abundance	Low
6	Rehabilitation	Riparian rehabilitation: Replant sections of riparian vegetation at 10-meter, 30-meter, and floodplain widths to address the area impacted by the transmission line (about 0.4 acres) and to improve canopy cover, large woody debris recruitment potential, and riparian composition within the floodplain. Address noxious weeds through planting and education/prevention programs.	2; Productivity and Abundance	Low
7	Protection	Protect and maintain current levels of geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	Maintain

LWP IZ-1

LWP IZ-1 comprises a section of the current active channel and bars from RM 11.55 to 11.31 (Figure 48).

The subreach area is about 3 acres in size and contains much less heterogeneity of channel units than adjacent inner zone subreaches with 10 percent riffles and 90 percent runs. The largest anthropogenic impact comes from riprap. The 550 linear feet of riprap in this subreach protects the railroad grade (Figure 49). Other impacts include a transmission line crossing at the downstream end of the reach. Natural lateral control for the subreach is an alluvial fan; however, artificial lateral control from the railroad grade imposes greater influence due to the close proximity to the channel. Where the channel was observed to run against riprap, the noted consequences are reduced lateral migration, increased stream power, and thus vertical migration, homogeneity of channel units, and decreased in-stream habitat complexity. Large woody debris is low and pieces that do exist are concentrated in complexes at a few locations. The lack of large woody debris prevents the creation of complexity at higher flows. It is hypothesized that material is eroded when flows are increasing and deposited when flows are decreasing. The result is a plane bed with no real change in form.

Due to the straightened nature and simplification of the system, this subreach is rehabilitation-oriented. Rehabilitation options are listed in Table 26. Options are prioritized to maximize geomorphic potential of the subreach through the reconnection and reestablishment of both long-term and short-term processes at the subreach scale. Rehabilitation actions in this subreach should be considered collectively with rehabilitation actions recommended in other adjacent subreaches to achieve a holistic reconnection and reestablishment of processes at the reach scale.

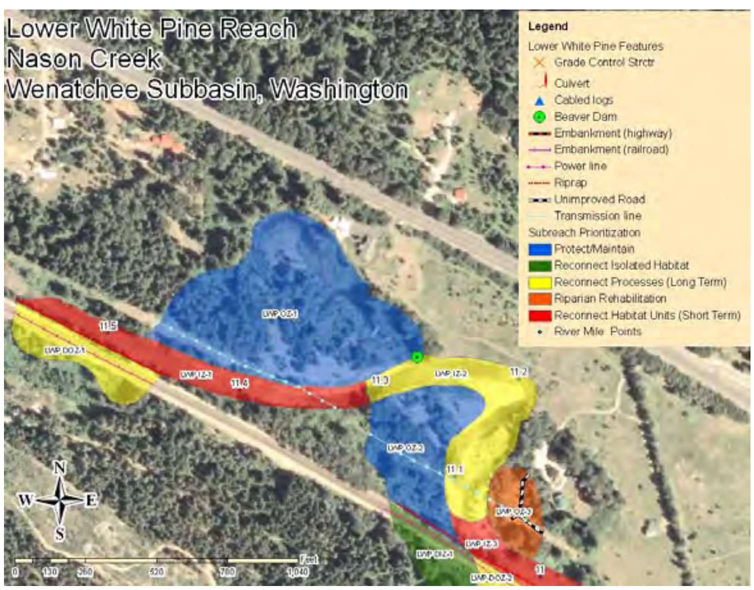

Figure 48 - A plan view showing the location of LWP IZ-1 in the downstream end of the Lower White Pine reach, location of anthropogenic features, and the proximity of adjacent subreaches with the corresponding rehabilitation strategies.

Figure 49 - Channel unit transition from riffle to run and the hardened right bank, view is to the southeast looking downstream. Lower White Pine Reach; Subreach LWP IZ-1, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Table 26 - Options for LWP IZ-1.

Option	Habitat Action	Prioritized Habitat Actions	VSP Parameters Addressed	Geomorphic Potential
1	Rehabilitation + Protection	Riparian rehabilitation: Apply efforts for a long-term approach that will result in increased large woody debris recruitment potential, increased sinuosity, sorting and retention of spawning gravels, increased number of complex pools, and water quality. This habitat action should be implemented in conjunction with Reconnect Habitat (short term): Modify riprap with and/or construct large woody debris complexes to increase retention of incorporated large woody debris, improve channel complexity, and provide cover and biomass. Existing In-stream structures should be evaluated and potentially modified to improve the functionality of refugia and hiding cover, sorting and retention of spawning gravel, and large woody debris retention. This is listed as a Tier 1 habitat action in the Biological Strategy (RTT 2007). Protect and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	High
2	Rehabilitation + Protection	Riparian rehabilitation: Implement efforts for a long-term approach that results in increased large woody debris recruitment potential, increased sinuosity, sorting and retention of spawning gravels, increased number of complex pools, and water quality. Protect and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	Medium

Option	Habitat Action	Prioritized Habitat Actions	VSP Parameters Addressed	Geomorphic Potential
3	Rehabilitation + Protection	Reconnect Habitat (short term): Modify riprap with and/or construct large woody debris complexes to increase retention of incorporated large woody debris, improve channel complexity, and provide cover and biomass. Existing in-stream structures should be evaluated and potentially modified to improve the functionality of refugia and hiding cover, sorting and retention of spawning gravel, and large woody debris retention. This is listed as a Tier 1 habitat action in the Biological Strategy (RTT 2007). Protect and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	Medium
4	Rehabilitation	Reconnect Habitat (short term): Modify riprap with and/or construct large woody debris complexes to increase retention of incorporated large woody debris, improve channel complexity, and provide cover and biomass.	2; Productivity, and Abundance	Low
5	Rehabilitation	Riparian rehabilitation: Apply efforts for a long-term approach that results in increased large woody debris recruitment potential, increased sinuosity, sorting and retention of spawning gravels, increased number of complex pools, and water quality. Existing in-stream structures should be evaluated and potentially modified to improve the functionality of refugia and hiding cover, sorting and retention of spawning gravel, and large woody debris retention. This is listed as a Tier 1 habitat action in the Biological Strategy (RTT 2007).	2; Productivity, and Abundance	Low
6	Protection	Protect and maintain current levels of geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	Maintain

LWP IZ-3

LWP IZ-3 comprises a section of the current active channel and bars from RM 11.05 to 10.57 in the mid-section of the Lower White Pine reach (Figure 50).

The subreach area is about 8 acres in size and contains 2 percent pools, 16 percent riffles and 82 percent runs, less heterogeneity of channel units than adjacent inner zone subreaches. The greatest impact of anthropogenic features is two sections of riprap along the right bank that are associated with the railroad grade (Figure 51). The total length of the riprap is 2,295 feet. A culvert runs through the railroad grade at the downstream end of the subreach; however, it does not allow passage at base flow (Figure 52). Additional human features include a log that acts as grade control structure at RM 10.75 and a transmission line crossing in the downstream end. Natural lateral controls for the subreach are an alluvial fan and bedrock. However, artificial lateral control from the railroad grade imposes greater influence due to the close proximity to the channel. Where the channel was observed to run against riprap, the noted consequences are reduced lateral migration, increased stream power, and thus the potential for an increase in vertical migration, homogeneity of channel units, and decreased in-stream habitat complexity. Large woody debris is very low, which prevents the creation of complexity at higher flows. It is hypothesized that material is eroded when flows are increasing and deposited when flows are decreasing. The result is a plane bed with no real change in form.

Due to the straightened nature and simplification of the system, this subreach is rehabilitation-oriented. Rehabilitation options are listed in Table 27. Options are prioritized to maximize geomorphic potential of the subreach through the reconnection and reestablishment of both long-term and short-term processes at the subreach scale. Rehabilitation actions in this subreach should be considered collectively with rehabilitation actions recommended in other adjacent subreaches to achieve a holistic reconnection and reestablishment of processes at the reach scale.

Figure 50 - A plan view showing the location of LWP IZ-3 in the downstream end of the Lower White Pine reach, location of anthropogenic features, and the proximity of adjacent subreaches with the corresponding rehabilitation strategies.

Figure 51 - Transition from rifle to run and the railroad grade acting as the right bank, view is to the southeast looking downstream. The railroad grade disconnects LWP DIZ-1 and LWP DOZ-2 from the active channel. Lower White Pine Reach; Subreach LWP IZ-3, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Figure 52 - Elevated culvert through the railroad grade that drains run off water from the area of LWP DIZ-1 and LWP DOZ-2, view is to the south. Lower White Pine Reach; Subreach IZ-3, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Table 27 - Options for LWP IZ-3.

Option	Habitat Action	Prioritized Habitat Actions	VSP Parameters Addressed	Geomorphic Potential
1	Rehabilitation + Protection	Reconnect Habitat (Short Term): Modify riprap with and/or construct large woody debris complexes to increase retention of incorporated large woody debris, improve channel complexity, and provide cover and biomass. Existing in-stream structures should be evaluated and potentially modified to improve the functionality of refugia and hiding cover, sorting and retention of spawning gravel, and large woody debris retention. This is listed as a Tier 1 habitat action in the Biological Strategy (RTT 2007). This habitat action should be implemented in conjunction with Riparian rehabilitation: Apply efforts for a long-term approach that will result in increased large woody debris recruitment potential, increased sinuosity, sorting and retention of spawning gravels, increased number of complex pools, and water quality. Protect and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	High
2	Rehabilitation + Protection	Riparian rehabilitation: Implement efforts for a long-term approach that results in increased large woody debris recruitment potential, increased sinuosity, sorting and retention of spawning gravels, increased number of complex pools, and water quality. Protect and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	Medium

Option	Habitat Action	Prioritized Habitat Actions	VSP Parameters Addressed	Geomorphic Potential
3	Rehabilitation + Protection	Reconnect Habitat (Short Term): Modify riprap with and/or construct large woody debris complexes to increase retention of incorporated large woody debris, improve channel complexity, and provide cover and biomass. Existing in-stream structures should be evaluated and potentially modified to improve the functionality of refugia and hiding cover, sorting and retention of spawning gravel, and large woody debris retention. This is listed as a Tier 1 habitat action in the Biological Strategy (RTT 2007). Protect and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	Medium
4	Rehabilitation	Reconnect Habitat (Short Term): Modify riprap with and/or construct large woody debris complexes to increase retention of incorporated large woody debris, improve channel complexity, and provide cover and biomass. Existing in-stream structures should be evaluated and potentially modified to improve the functionality of refugia and hiding cover, sorting and retention of spawning gravel, and large woody debris retention. This is listed as a Tier 1 habitat action in the Biological Strategy (RTT 2007). This habitat action should be implemented in conjunction with Riparian rehabilitation: Apply efforts for a long-term approach that will result in increased large woody debris recruitment potential, increased sinuosity, sorting and retention of spawning gravels, increased number of complex pools, and water quality.	2; Productivity, and Abundance	Medium
5	Rehabilitation	Reconnect Habitat (Short Term): Modify riprap with and/or construct large woody debris complexes to increase retention of incorporated large woody debris, improve channel complexity, and provide cover and biomass.	2; Productivity, and Abundance	Low

Option	Habitat Action	Prioritized Habitat Actions	VSP Parameters Addressed	Geomorphic Potential
6	Rehabilitation	Riparian rehabilitation: Apply efforts for a long-term approach that results in increased large woody debris recruitment potential, increased sinuosity, sorting and retention of spawning gravels, increased number of complex pools, and water quality. Existing in-stream structures should be evaluated and potentially modified to improve the functionality of refugia and hiding cover, sorting and retention of spawning gravel, and large woody debris retention. This is listed as a Tier 1 habitat action in the Biological Strategy (RTT 2007).	2; Productivity, and Abundance	Low
7	Protection	Protect and maintain current levels of geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	Maintain

LWP IZ-5

LWP IZ-59 comprises a section of the current active channel and bars from RM 10.21 to 9.59 in the Lower White Pine reach (Figure 53).

The subreach area is about 9 acres in size and contains 5 percent pools, 26 percent riffles and 69 percent runs, similar heterogeneity of adjacent inner zone subreaches. The straightened nature and simplification of the system promote a dominant process of transport. The largest anthropogenic impact comes from riprap. The majority of the riprap in this subreach protects the railroad grade and is located in two separate sections that total about 2,082 feet (Figure 54 and Figure 55). Two sets of triple culverts are located at the downstream end of the subreach, but may not allow passage at base flow (Figure 56 and Figure 57). Additional anthropogenic features include a small rock spur associated with a log boat ramp near RM 9.67 (Figure 58). Natural lateral control for the subreach is an alluvial fan; however, artificial lateral control from the railroad grade imposes greater influence due to the close proximity to the channel. Where the channel was observed to run against riprap, the noted consequences are reduced lateral migration, increased stream power, and thus vertical migration, homogeneity of channel units, and decreased in-stream habitat complexity. Large woody debris is low and the lack of large woody debris prevents the creation of complexity at higher flows. It is hypothesized that material is eroded when flows are increasing and deposited when flows are decreasing. The result is a plane bed with no real change in form.

Due to the straightened nature and simplification of the system, this subreach is rehabilitation-oriented. Rehabilitation options are listed in Table 28. Options are prioritized to maximize geomorphic potential of the subreach through the reconnection and reestablishment of both long-term and short-term processes at the subreach scale. Rehabilitation actions in this subreach should be considered collectively with rehabilitation actions recommended in other adjacent subreaches to achieve a holistic reconnection and reestablishment of processes at the reach scale.

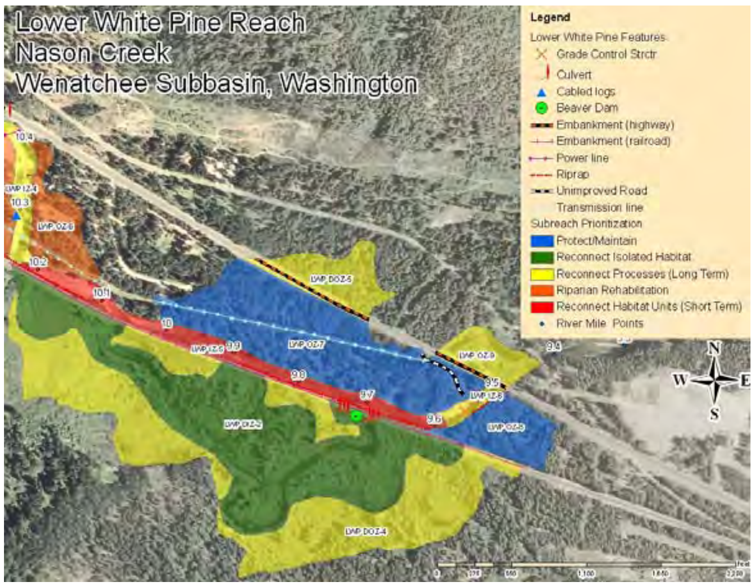

Figure 53 - A plan view showing the location of LWP IZ-5 in the downstream end of the Lower White Pine reach, location of anthropogenic features, and the proximity of adjacent subreaches with the corresponding rehabilitation strategies.

Figure 54 - Channel unit transition from riffle to run; the railroad grade that acts as the right bank and a high left bank, view is to the southeast looking downstream. Lower White Pine Reach; Subreach LWP IZ-5, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Figure 55 - Riffle in the straightened section of the active channel with the railroad grade acting as the right bank, view looking downstream to the east. Lower White Pine Reach; Subreach LWP IZ-5, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Figure 56 - Three elevated metal culverts that run through the railroad grade and drain the area of LWP DIZ-2 and LWP DOZ-4, view to the northwest. Lower White Pine Reach; Subreach LWP IZ-5, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by R. McAffee; May 4, 2007.

Figure 57 - Three concrete culverts that run through the railroad grade on the right bank, view is to the south. The culverts drain the area of LWP DIZ-2 and LWP DOZ-4. Lower White Pine Reach; Subreach LWP IZ-5, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Figure 58 - Small riprap and a constructed boat launch on left bank, view is to the north. Lower White Pine Reach; Subreach LWP IZ-5, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Table 28 - Options for LWP IZ-5.

Option	Habitat Action	Prioritized Habitat Actions	VSP Parameters Addressed	Geomorphic Potential
1	Rehabilitation + Protection	Reconnect Habitat (Short Term): Modify riprap with and/or construct large woody debris complexes to increase retention of incorporated large woody debris, improve channel complexity, and provide cover and biomass. Existing in-stream structures should be evaluated and potentially modified to improve the functionality of refugia and hiding cover, sorting and retention of spawning gravel, and large woody debris retention. This is listed as a Tier 1 habitat action in the Biological Strategy (RTT 2007). This habitat action should be implemented in conjunction with Riparian rehabilitation: Apply efforts for a long-term approach that will result in increased large woody debris recruitment potential, increased sinuosity, sorting and retention of spawning gravels, increased number of complex pools, and water quality. Protect and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	High
2	Rehabilitation + Protection	Riparian rehabilitation: Implement efforts for a long-term approach that results in increased large woody debris recruitment potential, increased sinuosity, sorting and retention of spawning gravels, increased number of complex pools, and water quality. Protect and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	Medium

Option	Habitat Action	Prioritized Habitat Actions	VSP Parameters Addressed	Geomorphic Potential
3	Rehabilitation + Protection	Reconnect Habitat (Short Term): Modify riprap with and/or construct large woody debris complexes to increase retention of incorporated large woody debris, improve channel complexity, and provide cover and biomass. Existing in-stream structures should be evaluated and potentially modified to improve the functionality of refugia and hiding cover, sorting and retention of spawning gravel, and large woody debris retention. This is listed as a Tier 1 habitat action in the Biological Strategy (RTT 2007). Protect and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	Medium
4	Rehabilitation	Reconnect Habitat (Short Term): Modify riprap with and/or construct large woody debris complexes to increase retention of incorporated large woody debris, improve channel complexity, and provide cover and biomass. Existing in-stream structures should be evaluated and potentially modified to improve the functionality of refugia and hiding cover, sorting and retention of spawning gravel, and large woody debris retention. This is listed as a Tier 1 habitat action in the Biological Strategy (RTT 2007). This habitat action should be implemented in conjunction with Riparian rehabilitation: Apply efforts for a long-term approach that will result in increased large woody debris recruitment potential, increased sinuosity, sorting and retention of spawning gravels, increased number of complex pools, and water quality.	2; Productivity, and Abundance	Low
5	Rehabilitation	Reconnect Habitat (Short Term): Modify riprap with and/or construct large woody debris complexes to increase retention of incorporated large woody debris, improve channel complexity, and provide cover and biomass.	2; Productivity, and Abundance	Low

Option	Habitat Action	Prioritized Habitat Actions	VSP Parameters Addressed	Geomorphic Potential
6	Rehabilitation	Riparian rehabilitation: Apply efforts for a long-term approach that results in increased large woody debris recruitment potential, increased sinuosity, sorting and retention of spawning gravels, increased number of complex pools, and water quality. Existing in-stream structures should be evaluated and potentially modified to improve the functionality of refugia and hiding cover, sorting and retention of spawning gravel, and large woody debris retention. This is listed as a Tier 1 habitat action in the Biological Strategy (RTT 2007).	2; Productivity, and Abundance	Low
7	Protection	Protect and maintain resulting levels of rehabilitated geomorphic, hydrologic, and riparian function.	4; Productivity, Abundance, Diversity, and Structure	Maintain

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GLOSSARY

Some terms in this glossary appear in this *Tributary Assessment.*

	DEFINITION
2D-hydraulic analysis	Information derived from a two-dimensional computer model that calculates the water surface profiles and features or processes (i.e., sediment, water velocity) that may affect stream flows.
adaptive management	A management process that applies the concept of experimentation to design and implementation of natural resource plans and policies.
alluvial fan	A low, outspread, relatively flat to gently sloping mass of loose rock material, shaped like an open fan or a segment of a cone, deposited by a stream at the place where it issues from a narrow mountain valley upon a plain or broad valley, or where a tributary stream is near or at its junction with the main stream, or wherever a constriction in a valley abruptly ceases or the gradient of the stream suddenly decreases; it is steepest near the mouth of the valley where its apex points upstream, and it slopes gently and convexly outward with a gradually decreasing gradient (Neuendorf et al. 2005).
alluvium	A general term for clay, silt, sand, gravel, or similar unconsolidated detrital material, deposited during comparatively recent geologic time by a stream, as a sorted or semi-sorted sediment on the river bed and floodplain (Neuendorf et al. 2005).
anadromous (fish)	A fish, such as the Pacific salmon, that spawns and spends its early life in freshwater but moves into the ocean where it attains sexual maturity and spends most of its life span (Owen & Chiras 1995).
anthropogenic	Caused by human activities.
bedload	The sediment that is transported intermittently along the bed of the river channel by creeping, rolling, sliding, or bouncing along the bed. Typically includes sizes of sediment ranging between coarse sand to boulders (the larger or heavier sediment).
bed-material	Sediment that is preserved along the channel bottom and in adjacent bars; it may originally have been material in the suspended load or in the bed load.
bedrock	A general term for the rock, usually solid, that underlies soil or other unconsolidated, superficial material (Neuendorf et al. 2005). The bedrock is generally resistant to fluvial erosion over a span of several decades, but may erode over longer time periods.

	DEFINITION
canopy cover (of a stream)	Vegetation projecting over a stream, including crown cover (generally more than 1 meter (3.3 feet) above the water surface) and overhang cover (less than 1 meter (3.3 feet) above the water).
cfs	Cubic feet per second; measure of water flows
channel morphology	The physical dimension, shape, form, pattern, profile, and structure of a stream channel.
channel planform	Characteristics of the river channel that determine its two-dimensional pattern as viewed on the ground surface, aerial photograph, or map.
channel sinuosity	The ratio of length of the channel or thalweg to down-valley distance. Channel with a sinuosity value of 1.5 or more are typically referenced as meandering channels (Neuendorf et al. 2005).
channel stability	The ability of a stream, over time and under the present climatic conditions, to transport the sediment and flows produced by its watershed in such a manner that the stream maintains its dimension, pattern, and profile without either aggrading or degrading.
channelization	The straightening and deepening of a stream channel to permit the water to move faster, to reduce flooding, or to drain wetlands.
constructed features	Human-made features that are constructed in the river and/or floodplain areas (e.g., levees, bridges, riprap). These features are referred to as human features in the *Map Atlas*.
controls	A feature that is highly resistant to erosion by flowing water and limits the ability of a river or stream to migrate across a valley in either the lateral (horizontal) or vertical direction or both. Geologica controls are naturally occuring features such as bedrock outcrops, landslides, or alluvial fans that erode slowly over long periods of time. Human-constructed features such as shighways, railroads, bridge abutments, or riprap may also act as controls and limit the ability of a river to migrate.
degradation	Wearing down of the land surface through the processes of erosion and/or weathering
depositional areas (stream)	Local zones within a stream where the energy of flowing water is reduced and sediment settles out, accumulating on the streambed.
diversity	All the genetic and phenotypic (life history traits, behavior, and morphology) variation within a population.
ecosystem	A unit in ecology consisting of the environment with its living elements, plus the non-living factors, that exist in and affect it (Neuendorf et al. 2005).

	DEFINITION
floodplain	The surface or strip of relatively smooth land adjacent to a river channel constructed by the present river in its existing regimen and covered with water when the river overflows its banks. It is built on alluvium, carried by the river during floods and deposited in the sluggish water beyond the influence of the swiftest current. A river has one floodplain and may have one or more terraces representing abandoned floodplains (Neuendorf et al. 2005).
flow regime	The quantity, frequency, and seasonal nature of water flow.
Fluvial process	Those processes related to the movement of flowing water that shape the surface of the earth through the erosion, transport, and deposition of sediment, soil particles, and organic debris.
geomorphic potential	The potential for geomorphic adjustment or change due to the combined influence of water, sediment, and large wood. The form of geomorphic adjustment within a geomorphic reach that most influences the configuration of a river should generally be considered at three scales minimum; for example, bed or substrate organization, channel geometry, and the channel-floodplain relationship.
geomorphic province	A large area comprised of similar land forms that exhibit comparable hydrologic, erosional, and tectonic processes (Montgomery and Bolton 2003); any large area or region considered as a whole, all parts of which are characterized by similar features or by a history differing significantly from that of adjacent areas (Neuendorf et al 2005); also referred to as a basin.
geomorphic reach	A geomorphic reach, represents an area containing the active channel and its floodplain bounded by vertical and/or lateral geologic controls, such as alluvial fans or bedrock outcrops, and frequently separated from other reaches by abrupt changes in channel slope and valley confinement. Within a geomorphic reach, similar fluvial processes govern channel planform and geometry through driving variables of flow and sediment. A geomorphic reach is comprised of a relatively consistent floodplain type and degree of valley confinement. Geomorphic reaches may vary in length from 100 meters in small, headwater streams to several miles in larger systems (Frissell et al. 1986).
geomorphology	The study of the classification, description, nature, origin, and development of present landforms and their relationships to underlying structures, and of the history of geologic changes caused by the actions of flowing water.
GIS	Geographical information system. An organized collection of computer hardware, software, and geographic data designed to capture, store, update, manipulate, analyze, and display all forms of geographically referenced information.

habitat action	Proposed restoration or protection strategy to improve the potential for sustainable habitat upon which endangered species act (ESA) listed salmonids depend on. Examples of habitat actions include the removal or alteration of project features to restore floodplain connectivity to the channel, reconnection of historic side channels, placement of large woody debris, reforestation of the low surface, or implementation of management techniques.
habitat connectivity (stream)	Suitable stream conditions that allow fish and other aquatic organisms to access habitat areas needed to fulfill all life stages.
habitat unit	A morphologically distinct area within a geomorphic reach comprised of floodplain and channel areas; typically less than several channel widths in length (Montgomery and Bolton 2003). They generally correspond to different habitat types for aquatic species. Basic channel units may include pools, riffles, bars, steps, cascades, rapids, floodplain features, and transitional zones characterized by relatively homogeneous substrate, water depth, and cross-sectional averaged velocities. *Also known as channel or geomorphic units*.
indicator	A variable used to forecast the value or change in the value of another variable; for example, using temperature, turbidity, and chemical contaminents or nutrients to measure water quality.
inner zone (IZ)	Area where ground-disturbing flows take place; characterized by the presence of primary (perennial) and secondary (ephemeral) side channels, a repetitious sequence of channel units, and relatively uniform physical attributes indicative of localized transport, transition, and deposition.
intevention analysis	Consists of computer models and methods based on samples collected at an impact site before and after an intervention, such as a habitat action, so that effects of the intervention may be determined.
large woody debris (LWD)	Large downed trees that are transported by the river during high flows and are often deposited on gravel bars or at the heads of side channels as flow velocity decreases. The trees can be downed through river erosion, wind, fire, or human-induced activities. Generally refers to the woody material in the river channel and floodplain whose smallest diameter is at least 12 inches and has a length greater than 35 feet in eastern Cascade streams.
limiting factor	Any factor in the environment that limits a population from achieving complete viability with respect to any Viable Salmonid Population (VSP) parameter.
low-flow channel	A channel that carries streamflow during base flow conditions.
mass wasting	General term for the dislodgement and downslope transport of soil and rock under the influence of gravitational stress (mass movement). Often referred to as shallow-rapid landslide, deep-seated failure, or debris flow.

	DEFINITION
overflow channel	A channel that is expressed by no or little vegetation through a vegetated area. There is no evidence for water at low stream discharges. The channel appears to have carried water recently during a flood event. The upstream and/or downstream ends of the overflow channel usually connect to the main channel.
outer zone (OZ)	Area that may become inundated at higher flows but does not experience a ground-disturbing flow; generally coincidental with the historic channel migration zone unless the channel has been modified or incised leading to the abandonment of the floodplain. (also knows as the floodprone zone)
pathways	Interpretation of one or more indicators (i.e., water quality) that is used to define or refine potential environmental deficiencies caused by natural or anthropogenic impacts that negatively affect a life stage(s) of the species of concern (i.e., limiting factor). Pathways are typically analyzed at the reach, valley segment, watershed, and basin scales.
peak flow	Greatest stream discharge recorded over a specified period of time, usually a year, but often a season.
planform	The shape of a feature, such as a channel alignment, as seen in two dimensions, horizontally, as on an aerial photograph or map.
reach-based ecosystem indicators (REI)	Measure of physical variables that are quantifiable and have geospatial reference.
Reclamation	U.S. Department of Interior, Bureau of Reclamation
response reach	A reach that is more responsive to change and often characterized by unconfined and moderately confined alluvial plains/channels that lack geologic controls which often define confined channels. A response reach can be further broken down to individual subreach units that comprise finer morphologically distinct areas providing geomorphic control and transitional habitat and biological potential.
riparian area	An area with distinctive soils and vegetation community/composition adjacent to a stream, wetland, or other body of water.
riprap	Large angular rocks that are placed along a river bank to prevent or slow erosion.
river mile (RM)	Miles from the mouth of a river or for upstream tributaries; miles from the point where the tributary joins the main river.
side channel	A channel that is not part of the main channel, but appears to have water during low-flow conditions and has evidence for recent higher flow (e.g., may include unvegetated areas (bars) adjacent to the channel). At least the upstream end of the channel connects to, or nearly connects to, the main channel. The downstream end may connect to the main channel or to an overflow channel. Can also be referred to as a secondary channel.

	Definition
spawning and rearing habitat	Stream reaches and the associated watershed areas that provide all habitat components necessary for adult spawning and juvenile rearing for a local salmonid population. Spawning and rearing habitat generally supports multiple year classes of juveniles of resident and migratory fish, and may also support subadults and adults from local populations.
subbasin	A subbasin represents the drainage area upslope of any point along a channel network (Montgomery & Bolton 2003). Downstream boundaries of subbasins are typically defined in this assessment at the location of a confluence between a tributary and mainstem channel. An example would be the Twisp River Subbasin.
subreach units	Distinct areas are comprised of the floodplain and off-channel and active-channel areas. They are delineated by lateral and vertical controls with respect to position and elevation based on the presence/absence of inner or outer riparian zones. An inner zone is generally associated with ground-disturbing flows with sufficient frequency that mature conifers are rare and a distinct hardwood zone is identifiable (USFS 2008). An outer zone, also known as the floodprone width, includes overflow channels, wetlands, and other off-channel habitat and is usually predominated by riparian vegetation and hillslope processes.
terrace	A relatively stable, planar surface formed when the river abandons the floodplain that it had previously deposited. It often parallels the river channel, but is high enough above the channel that it rarely, if ever, is covered by water and sediment. The deposits underlying the terrace surface are alluvial, either channel or overbank deposits, or both. Because a terrace represents a former floodplain, it can be used to interpret the history of the river.
tributary	A stream feeding, joining, or flowing into a larger stream or lake (Neuendorf et al. 2005).
UCSRB	Upper Columbia Salmon Recovery Board
UCRTT	Upper Columbia Regional Technical Team
valley segment	An area of river within a watershed sometimes referred to as a subwatershed that is comprised of smaller geomorphic reaches. Within a valley segment, multiple floodplain types exist and may range between wide, highly complex floodplains with frequently accessed side channels to narrow and minimally complex floodplains with no side channels. Typical scales of a valley segment are on the order of a few to tens of miles in longitudinal length.
vertical migration	Movement of a stream channel across a floodplain; movement of a topographic feature from one place in a plain to another.

	DEFINITION
viable salmonid population	An independent population of Pacific salmon or steelhead trout that has a negligible risk of extinction over a 100-year time frame. Viability at the independent population scale is evaluated based on the parameters of abundance, productivity, spatial structure, and diversity.
watershed	The area of land from which rainfall (and/or snow melt) drains into a stream or other water body. Watersheds are also sometimes referred to as drainage basins. Ridges of higher ground form the boundaries between watersheds. At these boundaries, rain falling on one side flows toward the low point of one watershed, while rain falling on the other side of the boundary flows toward the low point of a different watershed.

LOWER WHITE PINE REACH ASSESSMENT, NASON CREEK (RM 9.46-11.6), WASHINGTON
Reach-based Ecosystem Indicators (REI) Version 1.1

The Lower White Pine reach assessment team was comprised of Edward W. Lyon, Jr., L.G. (Reclamation geologist), Rob McAffee (Reclamation geologist), Jennifer Bountry, P.E. (Reclamation hydraulic engineer), Lucy Piety, (Reclamation Geomorphologist), Todd Maguire (Reclamation Activity Coordinator), Cindy Raekes (U.S. Forest Service Fisheries Technician) and Dave Hopkins, (U.S. Forest Service Fisheries Biologist Technician). Rating of each indicator was done as an iterative process by integrating new data collected for this reach assessment, data contained in the *Tributary Assessment* (Reclamation, 2008), and literature review. The ranges of criteria presented here are not absolute and should be adjusted to each unique subbasin as data becomes available.

PATHWAY: WATERSHED CONDITION

INDICATOR: WATERSHED ROAD DENSITY AND EFFECTIVE DRAINAGE NETWORK (ROAD DENSITY)

Criteria: The following criteria were developed by USFWS (1998).

Pathway	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Watershed Condition	Effective Drainage Network and Watershed Road Density	Increase in Drainage Network/ Road Density	Zero or minimum increases in active channel length correlated with human caused disturbance. And Road density <1 miles/miles^2.	Low to moderate increase in active channel length correlated with human caused disturbances. And Road density 1-2.4 miles/miles^2.	Greater than moderate increase in active channel length correlated with human caused disturbances. And Road density >2.4 miles/miles^2.

Data: Data was obtained through unpublished USFS graphical information system (GIS) data (USFS, 2008b).

Road Density:	**River Miles Effected**	**Density**
Lower Nason Creek	RM 0-12.2	3.88 mi/mi^2
Upper Nason Creek	RM 12.2-headwaters	1.1 mi/mi^2

Interpretation:

Watershed Condition:	**Condition**
Road Density Indicator	Unacceptable Risk Condition
Location	Unacceptable Risk Condition
Effective Drainage network	Unacceptable Risk Condition

Narrative:

Nason Creek watershed is a 5^{th} field hydrologic unit code (HUC 5) and Lower Nason is a 6^{th} HUC (USGS HUC code 170200110602) watershed. Road Densities in Lower Nason Creek are 3.88 mi/mi^2 (RM 0-12.2) and 1.1 mi/mi^2 for the Upper Nason Creek (RM 12.2-headwaters) (USFS, 2008). Road mapping in a geographical information system (GIS) by Forest Service include hillslope and valley bottom roads; however, the data represents a minimum value since it does not include all logging roads, powerline roads, private roads and railroad grades. Road densities have increased, mostly between 1975 and 1985, as a result of increased logging/access roads and an increase in private and public roads that reflect the increase in development (USFS, 1996). Some road related impacts include restriction and constriction of the floodplain, decrease in infiltration rates, and increase in surface runoff and erosion (USFS, 1996).

USFS Watershed Analysis Report (USFS, 1996) indicates areas with high road density can alter drainage networks and increase fine sediment delivered to the river. Given the geologic material that includes glacial outwash and alluvial fan material that parallel the streams and the proximity of roads to streams, sediment delivery from non-paved roads can be high. However, in RM 0 to RM 14 many of the drainages are presently disconnected by the railroad grade or highway embankment. Increase in road density and location of roads, especially in valley bottom locations in the Lower Nason have adversely affected the effective drainage network, which is noted to be at an 'Unacceptable Risk Condition' (Thomas, 2007). Based on USFS data the specific indicator of road density would be at 'Unacceptable Risk Condition' downstream of RM 12.2 and 'At Risk Condition' for upstream of RM 12.2.

INDICATOR: DISTURBANCE REGIME (NATURAL/HUMAN CAUSED)

Criteria: The following criteria were modified from USFWS (1998).

Pathway	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Watershed Condition	Disturbance Regime	Natural/ Human Caused	Environmental disturbance is short lived; predictable hydrograph, high quality habitat and watershed complexity providing refuge and rearing space for all life stages or multiple life-history forms. Natural processes are stable.	Scour events, debris torrents, or catastrophic fires are localized events that occur in several minor parts of the watershed. Resiliency of habitat to recover from environmental disturbances is moderate.	Frequent flood or drought producing highly variable and unpredictable flows, scour events, debris torrents, or high probability of catastrophic fire exists throughout a major part of the watershed. The channel is simplified, providing little hydraulic complexity in the form of pools or side channels. Natural processes are unstable.

Interpretation:

Disturbance Regime:	**Condition**
Lower Nason Creek	At Risk Condition

Narrative:
At the 5th HUC (Watershed) scale disturbance history in the Lower Nason is noted to be functioning at an 'At Risk Condition' due to multiple clearcuts and logging roads that have been constructed over at least the last 50 years (Thomas, 2007). Between 1985 and 1992, as timber harvest activity increased, mass erosion became more evident (Andonaegui, 2001; USFS 1996; Golder and Associates 2003). Fifty-four site damage reports associated with debris flows from the 1990 flood were recorded in the Nason Creek watershed (USFS 1996). However, many of the earlier concentrated disturbances are in an early successional recovery stage.

PATHWAY: FLOW/HYDROLOGY

INDICATOR: STREAMFLOW (CHANGE IN PEAK/BASE FLOW)

Criteria: The following criteria were developed by USFWS (1998).

Pathway	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Flow/ Hydrology	Streamflow	Change in Peak/Base Flows	Magnitude, timing, duration and frequency of peak flows within a watershed are not altered relative to natural conditions of an undisturbed watershed of similar size, geology and geography.	Some evidence of altered magnitude, timing duration and/or frequency of peak flows relative to natural conditions of an undisturbed watershed of similar size, geology and geography.	Pronounced changes in magnitude, timing, duration and/or frequency of peak flows relative to natural conditions of an undisturbed watershed of similar size, geology and geography.

Interpretation:

Streamflow:	Condition
Nason Creek Watershed	At Risk Condition

Narrative:
Discharges were calculated at each RM 1 through 14 for a 2, 5, 10, 25, 50 and 100 year recurrence interval (Reclamation 2007). There are no dams within the Nason Creek drainage basin that alter the magnitude, timing, duration and frequency of flows. However, several tributaries are disconnected from the mainstem because of the railroad grade or highway embankment resulting in an impact to the timing of run-off flows. Based on noted large clearcut areas on hillslopes and reduced connectivity of mainstem with tributary drainages due to railroad and highway embankments, and channelization of the mainstem Nason Creek, the hydrology is assumed to be altered and considered ‘At Risk Condition’ at the 5th HUC scale (Thomas, 2007).

PATHWAY: WATER QUALITY

INDICATOR: TEMPERATURE (MWMT/MDMT/7-DADMax)

Criteria: The following criteria were developed by Hillman and Giorgi (2002), USFWS (1998), and WDOE (2008).

Pathway	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Water Quality	Temp.	MWMT/ MDMT/ 7-DADMax	Bull Trout: Incubation: 2-5°C Rearing: 4-10°C Spawning: 1-9°C Salmon and Steelhead: Spawning: June-Sept 15°C Sept-May 12°C Rearing: 15°C Migration: 15°C Adult holding: 15°C Or 7-DADMax performance standards: Salmon spawning 13°C Core summer salmonid habitat 16°C Salmonid spawning, rearing and migration 17.5°C Salmonid rearing and migration only 17.5°C	MWMT in reach during the following life history stages: Incubation: <2°C or 6°C Rearing: <4°C or 13-15°C Spawning: <4°C or 10°C Temperatures in areas used by adults during the local spawning migration sometimes exceed 15°C. Or 7-DADMax performance standards exceeded by ≤15%	MWMT in reach during the following life history stages: Incubation: <1°C or >6°C Rearing: >15°C Spawning: <4°C or >10°C Temperatures in areas used by adults during the local spawning migration regularly exceed 15°C. Or 7-DADMax performance standards exceeded by >15%

Date: The following information was obtained through a literature review of USFS unpublished data (USFS, 2008b) and Wenatchee River Temperature Total Maximum Daily Load Study (WDOE, 2005) WDOE website data: http://www.ecy.wa.gov/ecyhome.html

Temperature Parameter	**Location**	**Agency**	**Year**	**7-day mean of max. daily temp.**	**Maximum daily temperature**
	Above Whitepine	WDOE	2003	17.9°C	18.4°C
	Bern Facility	WDOE	2003	18.4°C	18.9°C
	Above Mahar	WDOE	2003	18.0°C	18.8°C
	Coles Corner	WDOE	2003	21.4°C	22.0°C
	Above Gill Creek	WDOE	2003	18.4°C	19.0°C
	Cedar Brae	WDOE	2003	18.9°C	19.7°C
	Above Kahler	WDOE	2003	22.0°C	22.8°C
	Nason RM 0.8	WDOE	2002	18.9°C	19.7°C
	Nason RM 3.8	USFS	2002	18.9°C	19.6°C
	Nason RM 0.4	USFS	2002	19.4°C	20.0°C
	Nason near mouth	USFS	2001	No data	22.3°C
	Nason near mouth	USFS	2000	20.6°C	21.4°C
	Nason near mouth	USFS	1999	17.5°C	18.2°C
	Near Coles Corner	USFS	2001	19.1°C	19.7°C
	Near Coles Corner	USFS	2000	19.3°C	20.8°C
	Near Coles Corner	USFS	1999	17.1°C	17.6°C

Interpretation: Washington Department of Ecology water quality indicators were used to determine the water temperature condition for the reach assessment.

Temperature:	**Condition**
Salmon spawning	Unacceptable Risk Condition
Core summer salmonid habitat	Unacceptable Risk Condition
Salmonid spawning, rearing and migration	Unacceptable Risk Condition
Salmonid rearing and migration only	Unacceptable Risk Condition

Narrative:
The Wenatchee River from the Wenatchee National Forest boundary (RM 27.1) to its headwaters is considered Class AA (extraordinary). Because Nason Creek discharges to the AA portion of the Wenatchee River, it is considered Class AA as well. Nason Creek is a Category 5 stream meaning that Washington Department of Ecology (WDOE) has data showing that the water quality standards have been violated for one or more pollutants and there is no TMDL or pollution control plan in place (http://www.ecy.wa.gov/ecyhome.html).

Although high water temperatures noted in 2001 can be attributed in great part to low-flow conditions, a maximum water temperature of 70.7^{o} F was recorded in 1995 (Thomas, 2007). At the 5th HUC scale, the reach with the most sustained longitudinal heating occurred between RM 10.6 and 3.5 (Watershed Sciences, 2003). Given that recorded temperatures in the tributaries were below the temperature measured in Nason Creek, the temperature problem is related to Nason Creek where stream shading has been reduced by the clearing of vegetation and riprapping of banks along the highway. Temperature above RM 12 is functioning at an 'At Risk Condition' due to anthropogenic impacts including wastewater return, surface diversions/withdraws, regulatory guidelines, and because any slight temperature increase in this valley segment could have serious consequences downstream (Thomas, 2007). Lower Nason (RM 0.0 to 12.0) is functioning at an 'Unacceptable Risk Condition' based on temperature measurements at Coles Corner and the mouth where temperature is approaching 20.6° C (DOE website, http://www.ecy.wa.gov/ecyhome.html).

INDICATOR: TURBIDITY

Criteria: The performance standard for this indicator is from Hillman and Giorgi (2002).

Pathway	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Water Quality	Turbidity	Turbidity	Performance Standard: Acute <70 NTU Chronic <50 NTU For streams that naturally exceed these standards: Turbidity should not exceed natural baseline levels at the 95% CL. <15% exceedance Or Turbidity shall not exceed: 5 NTU over background when the background is 50 NTU or less; or a 10 percent increase in turbidity when the background turbidity is more than 50 NTU (WDOE – 173-201A-200).	15-50% exceedance.	>50% exceedance.

Data: Between 10/6/91 to 9/28/93, twenty turbidity measurements were taken at 'station 19' near Nason Creek Campground (CCCD, 1993).

Turbidity:	**NTU**
Maximum observed	3.5
Minimum observed	0.1

Interpretation:

Turbidity:	**Condition**
Nason Creek	At Risk Condition

Narrative:
Turbidity and sediment are noted to be functioning at an 'At Risk Condition' at the 5th HUC scale based on the volatility of the system which translates into an altered sediment budget and the rivers ability to sort and route suspended load material (Thomas, 2007). Turbidity at the 6th HUC scale is interpreted to be functioning at an 'At Risk Condition'. Future monitoring maybe needed as tributaries and hillslopes are reconnected through project implementation.

INDICATOR: CHEMICAL CONTAMINATION/NUTRIENTS (METALS/POLLUTANTS, pH, DO, NITROGEN, PHOSPHOROUS)

Criteria: The following criteria were developed by USFWS (1998) and Washington State Department of Ecology.

Pathway	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Condition
Water Quality	Chemical Contamination/ Nutrients	Metals/ Pollutants, pH, DO, Nitrogen, Phosphorous	Low levels of chemical contamination from landuse sources, no excessive nutrients, no CWA 303d designated reaches Or Washington State Department of Ecology standards – 173-201A-200.	Moderate levels of chemical contamination from landuse sources, some excess nutrients, one CWA 303d designated reach.	High levels of chemical contamination from landuse sources, high levels of excess nutrients, more than one CWA 303d designated reach.

Data:

Between 10/6/19 to 9/28/93, twenty measurements were taken at 'station 19' located near Nason Creek Campground (CCCD, 1993).

Indicators:	Maximum Observed	Minimum Observed
Dissolved Oxygen	15.7 mg/L	8.1 mg/L
pH	7.13	6.37
Conductivity	48.0 uSiemens	19.1 uSiemens
Total Dissolved Solids	24.0 mg/L	9.6 mg/L
NO3/No2-N	0.19 mg/L	0.01 mg/L
Suspended Solids	44 mg/L	2 mg/L
Phosphorus	44 mg/L	3 mg/L
Fecal Caliform	24 (#/100)	1 (#/100)

Interpretation:

Chemical Contamination/Nutrients:	Condition
Nason Creek	At Risk Condition

Narrative:

Chemical contaminants and nutrients at the 5th HUC scale are functioning at an 'At Risk Condition' (Thomas, 2007). In the upper sections of the watershed there are factors such as wastewater return from a small Class IV Advanced Wastewater Treatment Plant (tertiary treatment with alum addition) that services the ski resort area and discharges to Nason Creek (WDOE, 2006), and compounded by surface diversions/withdraws. Given that these practices can have an affect on the downstream section of the watershed, the chemical contaminants and nutrients were interpreted to be functioning at an 'At Risk Condition' at the 6th HUC scale.

PATHWAY: HABITAT ACCESS

INDICATOR: PHYSICAL BARRIERS (MAIN CHANNEL BARRIERS)

Criteria: The following criteria have been modified from USFWS (1998).

Pathway	**General Indicators**	**Specific Indicators**	**Adequate Condition**	**At Risk Condition**	**Unacceptable Risk Condition**
Habitat Access	Physical Barriers	Main Channel Barriers	No man-made barriers present in the mainstem that limit upstream or downstream migration at any flow.	Man-made barriers present in the mainstem that prevent upstream or downstream migration at some flows that are biologically significant.	Man-made barriers present in the mainstem that prevent upstream or downstream migration at multiple or all flows.

Interpretation:

Physical Barriers:	**Condition**
Nason Creek	Adequate Condition

Narrative:
There are no manmade barriers on Nason Creek between RM 0 and RM 16.8. At RM 16.8 there is a falls that is a natural barrier. On the mainstem Wenatchee River, Dryden Dam is a non-channel spanning structure and does not present passage issues. However, Tumwater Dam has fish passage capability (LFA), but could be a partial barrier. Physical barriers at both 5th and 6th HUC scales are interpreted to be functioning at an ‘Adequate Condition’ (Thomas 2007).

PATHWAY: HABITAT QUALITY

INDICATOR: SUBSTRATE (DOMINANT SUBSTRATE)

Criteria: Performance standards for these criteria are from Hillman and Giorgi (2002).

Pathway	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Habitat Quality	Substrate	Dominant Substrate/ Fine Sediment	Gravels or small cobbles make-up >50% of the bed materials in spawning areas. Reach embeddedness in rearing areas <20%. <12% fines (<0.85mm) in spawning gravel or ≤12% surface fines of ≤6mm.	Gravels or small cobbles make-up 30-50% of the bed materials in spawning areas. Reach embeddedness in rearing areas 20-30% 12-17% fines (<0.85mm) in spawning gravel or 12-20% surface fines of ≤6mm.	Gravels or small cobbles make-up <30% of the bed materials in spawning areas. Reach embeddedness in rearing areas >30% >17% fines (<0.85mm) in spawning gravel or >20% surface fines of ≤6mm.

Data: The following information was collected by the Methow Valley Ranger District (Appendix C).

Substrate: Pebble Count Data.	**RM 9.42-11.75**
# of Pebble counts in Reach	1
Surface fines (<6mm)	11%
D35	32 mm
D50	47 mm
D84	84 mm

Data: The following information was collected by the Methow Valley Ranger District for this reach assessment (Appendix C).

Substrate: Ocular estimate %	**RM 9.42-11.75**
% Sand	10%
% Gravel	57%
% Cobble	30%
% Boulder	3% (riprap)

Data: McNeil core samples were collected by USFS at riffles sites downstream of Coles Corner in 1993 and 2007 and upstream of Coles Corner in 2005 and 2006; however, the 2007 data was not available (USFS, 2008b).

McNeil Core Samples Data:	**Average % fines <1mm**
1993	22.7%
2005	12.7%
2006	9.71%

Interpretation:

Substrate:	**Condition**
Dominant Substrate	Adequate Condition
Embeddedness	At Risk Condition
Fine Sediment	Adequate Condition

Narrative:
Pebble counts and ocular estimations conducted during the habitat assessment indicated that the dominant substrate is gravel from RM 9.42-13.37 and cobble from RM 13.37 to 14.3. Each channel segment also had an ocular estimation recorded for sand, gravel, cobble and boulder percentages. The data does not account for natural variability and the sample sites may not be representative of the entire reach. Time series McNeil core sample data taken at pool tail-out sites within lower Nason Creek also show a wide range of percent fines (<1mm). It is unknown how this data related to sediment sources such as landslides and debris flows, and especially those that are fire related. Based on the available data, Lower Nason Creek is functioning at an 'At Risk Condition' for embeddedness. Overall, substrate embeddedness for Nason Creek at the 5th HUC scale is noted to be functioning at an 'At Risk Condition' for juvenile rearing habitat due to the volatility of the system. However, embeddedness was noted not to be a problem based on visual observations during the habitat assessment at the 6th HUC scale. The interpretation for the indicator of dominant substrate and fine sediment is functioning at an 'Adequate Condition' (Thomas, 2007).

INDICATOR: LARGE WOODY DEBRIS (PIECES PER MILE AT BANKFULL)

Criteria: The following criteria were developed by USFWS (1998).

Pathway	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Habitat Quality	Large Woody Debris (LWD)	Pieces Per Mile at Bankfull	>20 pieces/mile >12" diameter >35 ft length; and adequate sources of woody debris available for both long- and short-term recruitment.	Currently levels are being maintained at minimum levels desired for "adequate", but potential sources for long-term woody debris recruitment is lacking to maintain these minimum values.	Current levels are not at those desired values for "adequate", and potential sources of woody debris for short- and/or long-term recruitment are lacking.

Data: The following information was collected by the Methow Valley Ranger District for this reach (Appendix C).

LWD	**RM 9.42-11.75**
Large wood per mile:	
Large (>35' long, >20" diameter)	5.4
Medium (>35' long, 12-20" diameter)	10.3
Total large and medium	15.7
Small (>20' long, >6" diameter)	21.9

Interpretation:

LWD	**RM 9.42-11.6**
Total large and medium	Unacceptable Risk Condition
LWD recruitment potential	Unacceptable Risk Condition

Narrative:
At the 5th HUC scale, LWD is noted to be functioning at an 'At Risk Condition' (Thomas, 2007). At the 6th HUC scale, Nason Creek is interpreted to be functioning at an 'At Risk Condition' due to current levels of medium and large wood being below 'Adequate Condition' (Thomas, 2007), but recruitment potential is at reasonable levels (above 50%). The Lower White Pine reach (RM 9.42 to 11.6) is functioning at 'Unacceptable Risk Condition' due to current levels of medium and large wood pieces being below the levels identified for an 'Adequate Condition' coupled with limited recruitment potential due to large sections of constrained channel lined with riprap or meandering sections migrating into surfaces that have been cleared of riparian vegetation.

INDICATOR: POOLS (POOL FREQUENCY AND QUALITY)

Criteria: The following criteria were developed by USFWS (1998).

Pathway	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Habitat Quality	Pools	Pool Frequency and Quality Large Pools (in adult holding, juvenile rearing, and over-wintering reaches where streams are >3 m in wetted width at base flow)	Pool frequency: Channel width No. pools/mile 0-5 ft 39 5-10 ft 60 10-15 ft 48 15-20 ft 39 20-30 ft 23 30-35 ft 18 35-40 ft 10 40-65 ft 9 65-100 ft 4 Pools have good cover and cool water and only minor reduction of pool volume by fine sediment. Each reach has many large pools >1 m deep with good fish cover.	Pool frequency is similar to values in "functioning adequately", but pools have inadequate cover/temperature, and/or there has been a moderate reduction of pool volume by fine sediment. Reaches have few large pools (>1 m) present with good fish cover.	Pool frequency is considerably lower than values for "functioning adequately", also cover/temperature is inadequate, and there has been a major reduction of pool volume by fine sediment. Reaches have no deep pools (>1 m) with good fish cover.

Data: The following information was collected by the Methow Valley Ranger District (Appendix C).

Pool Frequency and Quality:	**RM 9.42-11.75**
Average wetted channel width	55 ft
Average thalweg depth (riffles)	1.0 ft
Average thalweg depth (runs)	1.2 ft
Number of pools >1 meter deep/mile	21
Average pool maximum depth	4.2 ft
Riffle to pool ratio (main channel)	0.42 : 1
Percent runs (non-turbulent riffles)	7.4%
Percent side channels	1.2%

Data: The following information was collected by the Methow Valley Ranger District (Appendix C).

Pools:	**RM 9.42 to 10.2**	**RM 10.2 to 10.6**	**RM 10.6 to 11.0**	**RM 11.0 to 11.35**	**RM 11.35 to 11.7**
Pools per mile	11.5	20.0	10.0	20.0	14.2
Pools > 5' deep per mile	1.3	12.5	2.5	8.5	0
Residual depth	2.4 ft	4.3 ft	3.1 ft	3.5 ft	1.9 ft
LWD per mile (pools)[1]	12, 10, 0	20, 12, 5	18, 4, 0	68, 38, 28	5, 0, 5

[1]Small, medium, and large size class, respectively, in table. Calculation is large wood per mile of pool habitat.

Interpretation of pool quality by the Methow Valley Ranger District stream inventory surveyors (Appendix C).

RM 9.42 to 10.2	**RM 10.2 to 10.6**	**RM 10.6 to 11.0**	**RM 11.0 to 11.35**	**RM 11.35 to 11.7**
At 'Unacceptable Risk' due to lack of cover (lacks wood).	'Adequate' lots of deep pool habitat.	At 'Unacceptable Risk', lacks of wood.	'Adequate', lots of wood, deep pools.	'Unacceptable Risk'

Interpretation:

Pool Frequency and Quality:	**Condition**
Frequency	Adequate condition
Quality	At risk condition
Pool cover	Unacceptable Risk condition
Large pools (greater than 5')	At risk condition
Overall	At risk condition

Narrative:

On Nason Creek, pool frequency and pool quality at the 5th HUC scale are noted to be functioning at an 'At Risk Condition' (Thomas, 2007). At the 6th HUC scale, Nason Creek is functioning at an 'Adequate Condition' in terms of pool frequency based on the number of pools noted in the habitat survey (Appendix C), thalweg profile (Reclamation, 2008) and comparison to reference reaches on similar stream types (Woodsmith and Bookter, 2008). Complex pools formed by LWD or bedrock, typically deeper than 5 feet, have biological significance on Nason Creek. The number of 5 feet deep (or greater) pools was observed to be fewer than natural, and many of the pools were scour pools formed in artificially constrained channel sections and not at meander bends. The quality of the pools at the 6th HUC scale is noted to be functioning either at an 'Unacceptable Risk Condition' or 'At Risk Condition' due to lack of large wood associated with the pools. Two channel sections had pool quality that is functioning at an 'Adequate Condition' (RM 10.2-10.6 and RM 11.0-11.35), but overall Lower Nason Creek is functioning at an 'At Risk Condition'.

INDICATOR: OFF-CHANNEL HABITAT (CONNECTIVITY WITH MAIN CHANNEL)

Criteria: The following criteria have been modified from USFWS (1998).					
Pathway	**General Indicators**	**Specific Indicators**	**Adequate Condition**	**At Risk Condition**	**Unacceptable Risk Condition**
Habitat Quality	Off-channel Habitat	Connectivity with Main Channel	Reach has many ponds, oxbows, backwaters, and other off-channel areas with cover, and side channels are low energy areas. No manmade barriers present along the mainstem that prevent access to off-channel areas.	Reach has some ponds, oxbows, backwaters, and other off-channel areas with cover, and side channels are generally high energy areas. Manmade barriers present that prevent access to off-channel habitat at some flows that are biologically significant.	Reach has few or no ponds, oxbows, backwaters, and other off-channel areas. Manmade barriers present that prevent access to off-channel habitat at multiple or all flows.

Data: The following information was generated by Reclamation using a 2D hydraulic model at 5000 cfs, (Appendix D), LiDAR data and field observations during the initial and follow-up site assessment (Appendix B).

Total length of disconnected channel (feet)	8,655 ft
Total area of disconnected inner zone (acres)	52 acres

Data: The following information was collected by Reclamation for this reach (Appendix B).

Physical Barriers:	**RM 9.42-11.6**
Culverts	8
Levees/Berms/Embankments	7,629of railroad grade
Riprap	5,198 ft
Bridges	1
Floodplain development	Yes

Interpretation:

Connectivity With Main Channel:	**Condition**
Lower White Pine Reach	Unacceptable Risk Condition

Narrative:

Culverts were observed in both the railroad grade and the highway. However, fish passage through culverts has not been evaluated and many culverts appear to be undersized and elevated above the main channel. At the 5^{th} HUC scale off-channel habitat in the Lower Nason is noted to be functioning at an 'Unacceptable Risk Condition' due to the impact of the railroad and highway (Thomas, 2007). At the 6^{th} HUC scale connectivity with the main channel is functioning at an 'Unacceptable Risk Condition', with the exception being between RM 5.2 and 6.6 which is functioning at an 'At Risk Condition' (Thomas, 2007).

PATHWAY: CHANNEL

INDICATOR: CONDITION (AVERAGE BANKFULL WIDTH/MAXIMUM DEPTH RATIO)

Criteria: The following description of channel condition is intended to be informative as described in Hillman (2006).

Pathway	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Channel	Condition	Valley Segment & Channel Segment Characterization	Informative; no criteria presented.	Informative; no criteria presented.	Informative; no criteria presented.

Data: The following data was collected by Reclamation and the Methow Valley Ranger District stream survey crew.

Valley Segment:	**RM 9.42-11.75**
Valley bottom type	U1
Channel patterns	Mod. Sinuosity, no braids, few side channels
Valley type	Alluvial
Bed-form types	Pool-riffle
Predominant bed material	Gravel/Cobble
Typical confinement	Unconfined
Bankfull width/depth ratio	47.7
Channel types	C4, F4
Width/depth ratio value (+/- 2.0)	No data

INDICATOR: DYNAMICS (FLOODPLAIN CONNECTIVITY)

Criteria: The following criteria have been modified from USFWS (1998).

Pathway	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Channel	Dynamics	Floodplain Connectivity	Floodplain areas are frequently hydrologically linked to main channel; overbank flows occur and maintain wetland functions, riparian vegetation and succession.	Reduced linkage of wetland, floodplains and riparian areas to main channel; overbank flows are reduced relative to historic frequency, as evidenced by moderate degradation of wetland function, riparian vegetation/succession	Severe reduction in hydrologic connectivity between off-channel, wetland, floodplain and riparian areas; wetland extent drastically reduced and riparian vegetation/succession altered significantly.

Data: The following information was collected during the initial site assessment by Reclamation (Appendix B).

Floodplain Connectivity: Area of anthropogenic impact	**RM 9.42-11.6**
Engineered/altered channel	13 acres
Buildings (acres)	0.01 acres
Cleared Area (Includes buildings and roads)(acres)	2 acres
Embankment/highway (acres)	3 acres
Embankment/road (acres)	0.05 acres
Embankment/railroad (acres)	9 acres
Powerline right of way (acres)	14 acres
Transmission line (acres)	7 acres
Total (acres)	49 acres
Percent floodplain area occupied by anthropogenic features	21%

Data: The following information was collected during the initial site assessment by Reclamation (Appendix B).

Floodplain Connectivity: Length of anthropogenic impact	**RM 9.42-11.6**
Embankment/highway (feet)	1,952 ft
Embankment/railroad (feet)	7,629 ft
Embankment/road (feet)	275 ft
Total (feet)	8,956 ft

Data: The following information was collected during the follow-up site assessment by Reclamation (Appendix B).

Floodplain Connectivity: Area (in m^2) of Channel units at low flow	**RM 9.42-11.6**
Pool	2,424 m^2
Riffle	13,350 m^2
Run	36,921 m^2
Total (sq meters)	52,749 m^2

Data: The following information was collected during the follow-up site assessment by Reclamation (Appendix B).

Floodplain Connectivity: Area of Inner and Outer Zones at 5,000cfs.	**RM 9.42-11.6**
Inner Zone (Acres)	28 acres
Outer Zone (Acres)	75 acres
Disconnected Inner Zone (Acres)	51 Acres
Disconnected Outer Zone (Acres)	71 Acres
TOTAL (Reach)	225 acres

Data: The following information was generated by Reclamation using a 2D hydraulic model (Appendix D).

Floodplain Connectivity:	**RM 9.42-11.6**
Existing area of inundation (acres):	
2,500 cfs	58 acres
5,000 cfs	106 acres
10,000 cfs	204 acres
15,000 cfs	311 acres
Potential area of inundation (acres):	
2,500 cfs	102 acres
5,000 cfs	201 acres
10,000 cfs	298 acres
15,000 cfs	361acres
Percent of potential inundation achieved under current conditions:	
2,500 cfs	57%
5,000 cfs	53%
10,000 cfs	69%
15,000 cfs	86%

Interpretation:

Floodplain Connectivity	**Condition**
Lower White Pine Reach	Unacceptable Risk Condition

Narrative:
The valley segment encompasses the section of Lower Nason Creek at the 6th HUC scale where the floodplain is naturally very wide, and the numerous abandoned channels that are interpreted from the LiDAR hillshade and aerial photographs indicate that the historic channel migration zone was once a very dynamic, interconnected system. The floodplain connectivity is considered to be at an 'Unacceptable Risk Condition' because the river's connectivity with the floodplain has been decreased due to anthropogenic impacts that have disconnected about half of the floodplain. Additionally, in two areas the historical main channel has been replaced by a straightened, confined channel. In these areas the river is predominantly transport. Historic channels (interpreted from aerial photographs and LiDAR hillshade) in the disconnected historic channel migration zone now pond water from tributaries and snowmelt that are partially connected to the main channel with culverts.

INDICATOR: DYNAMICS (BANK STABILITY/CHANNEL MIGRATION)

Criteria: The criteria for bank stability/channel migration were agreed upon by the assessment team as a "relative" indication to the functionality of the specific indicator.

Pathway	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Channel	Dynamics	Bank Stability/ Channel Migration	Channel is migrating at or near natural rates.	Limited amount of channel migration is occurring at a faster/slower rate relative to natural rates, but significant change in channel width or planform is not detectable; large woody debris is still being recruited.	Little or no channel migration is occurring because of human actions preventing reworking of the floodplain and large woody debris recruitment; or channel migration is occurring at an accelerated rate such that channel width has a least doubled, possibly resulting in a channel planform change, and sediment supply has noticeably increased from bank erosion.

Data: The following information was collected by the Methow Valley Ranger District (Appendix C).

Bank Erosion:	**RM 9.42-11.75**
Total bank erosion (both Banks)	2,585 ft
Linear length per mile	1,068 ft
Percent eroding banks	10.1%
Channel Characteristics:	
Length	2.42 mi
Gradient	<0.5%
Sinuosity (present)	1.20

Data: The following information was collected during the initial site assessment by Reclamation (Appendix B).

Bank Stability/ Channel Migration:	**RM 9.42-11.6**
Riprap (linear feet)	5,713 ft
Percent channel length with riprap	52%
Bridge	1
Other	1 cabled log

Data: Parameters developed by Reclamation (Appendix D).

Bank Stability/ Channel Migration:	**RM 9.42-11.6**
Total area of inner zone (acres)	28 acres
Percent of floodplain that is disconnected or impacted (acres)	123 acres
Percent of 2006 bank length with human features that disconnect or impact HCMZ	62%

Interpretation:

Bank Stability/Channel Migration:	**Condition**
Lower Nason Creek	Unacceptable Risk Condition

Narrative:

Channel migration in this reach is considered to at an 'Unacceptable Risk Condition' due to marked decreases in the historic channel migration zone and channel length. Nearly 62 percent of the banks are bordered with anthropogenic features that do not allow lateral channel migration. As a result the channel has incised slightly and is now predominantly a transport reach, further hindering natural channel migration processes. In areas where bank hardening is not present, but the riparian vegetation has been altered channel migration occurs at an un-natural accelerated rate,

INDICATOR: DYNAMICS (VERTICAL CHANNEL DYNAMICS)

Criteria: The criteria for vertical channel stability were agreed upon by the assessment team as a "relative" indication to the functionality of the specific indicator.

Pathway	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Channel	Dynamics	Vertical Channel Stability	No measurable trend of aggradation or incision and no visible change in channel planform.	Measurable trend of aggradation or incision that has the potential to but not yet caused disconnection of the floodplain or a visible change in channel planform (e.g. single thread to braided).	Enough incision that the floodplain and off-channel habitat areas have been disconnected; or, enough aggradation that a visible change in channel planform has occurred (e.g. single thread to braided).

Data: The following information was collected by the Methow Valley Ranger District (Appendix C).

Bankfull data (main channel):	**RM 9.42-11.75**
Average bankfull width (feet)	99 ft
Average bankfull depth (feet) based on average of 7 measurements per bankfull width	2.1 ft
Average width/depth ratio	47.7
Entrenchment ratio	4.6

Data: The following information was collected by Reclamation (Appendix B).

Bank Protection and Channel Constrictions:	**RM 9.42-11.6**
Riprap (linear feet)	5,713 ft
Highway bridge	1
Other	1 cabled log

Data: Thalweg profile by Reclamation (Appendix D).

Channel slope	0.2%

Interpretation:

Vertical Channel Dynamics:	Condition
Lower White Pine Reach	At Risk

Narrative:

Vertical stability is interpreted to be in an 'At Risk Condition'. A sediment budget or numerical modeling to look at historical and potential future channel bed incision or aggradation was not done for this effort. There has been no large-scale change to the balance between incoming water and sediment loads (at the upstream end at RM 14.3) that would indicate a potential for incision or aggradation. However, several sections of the lower 14 miles of river have been artificially straightened and confined (reduced floodplain access) indicating there is a potential for increased sediment transport capacity and reduced sediment recruitment from bank erosion in meandering channel sections. The most extensive impact has been that two meandering sections have been disconnected and/or straightened by anthropogenic features. Channel bed elevation analyses from a 1980s FEMA analysis and 2006 LiDAR and 2007 thalweg profile show that in confined channel segments the present channel bed is 1 to 5 feet lower than the historic main channel. The channel was observed to be slightly incised with bank heights ranging from 1 to 3 meters. Riffles and runs were noted to be the dominant channel unit, with gravel being the dominant substrate. This observation indicates that the dominant process is transport, which lends itself to decreased vertical stability.

PATHWAY: RIPARIAN VEGETATION

INDICATOR: CONDITION (STRUCTURE)

Criteria: The criteria for riparian vegetation structure were agreed upon by the assessment team as a “relative” indication to the functionality of the specific indicator.

Pathway	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Riparian Vegetation	Condition	Structure	>80% species composition, seral stage, and structural complexity are consistent with potential native community.	50-80% species composition, seral stage, and structural complexity are consistent with potential native community.	<50% species composition, seral stage, and structural complexity are consistent with potential native community.

Data: The following riparian vegetation information was computed utilizing the geographic information system (GIS) vegetation mapping from the *Tributary Assessment* (Reclamation, 2008; APPENDIX I).

Riparian Vegetation Structure (Acres):	**RM 9.42-11.6**
Large Conifer forest (A)	3 acres
Small Conifer Forest (B)	6 acres
Small Mixed Forest (F)	34 acres
Large Hardwood Forest (G)	2 acres
Small Hardwood Forest (H)	44 acres
Valley Shrub Land (K)	128 acres
Gravel Bar (GR)	5 acres
Gravel Bar/Shrub (Gr-Sh)	1 acres
Herbaceous (Herb)	11acres
Percent disturbed	11%

Data: The following riparian vegetation information was computed utilizing the geographic information system (GIS) vegetation mapping from the *Tributary Assessment* (Reclamation, 2008; APPENDIX I).

Riparian Vegetation Structure (% of floodplain):	**RM 9.42-11.6**
Large Conifer forest (A)	1%
Small Conifer Forest (B)	3%
Small Mixed Forest (F)	16%
Large Hardwood Forest (G)	1%
Small Hardwood Forest (H)	20%
Valley Shrub Land (K)	40%
Gravel Bar/Shrub (Gr-Sh)	1%
Herbaceous (Herb)	5%
Percent disturbed	11%

Interpretation:

Riparian Vegetation Structure:	**Condition**
Lower White Pine Reach	Unacceptable Risk Condition

Narrative:
Riparian vegetation structure is interpreted to be in an 'Unacceptable Risk Condition'. Although the vegetation is interpreted to recovering back to the historic conditions, localized areas of the floodplain vegetation have been completely cleared due to construction of the highway railroad, power lines, and development. The result is a younger seral stage of the vegetation community that lacks the large and small coniferous and deciduous species.

INDICATOR: CONDITION (DISTURBANCE - HUMAN)

Criteria: The criteria for riparian vegetation disturbance were agreed upon by the assessment team as a "relative" indication to the functionality of the specific indicator.

Pathway	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Riparian Vegetation	Condition	Disturbance (Human)	>80% mature trees (medium-large) in the riparian buffer zone (defined as a 30 m belt along each bank) that are available for recruitment by the river via channel migration; <20% disturbance in the floodplain (e.g., agriculture, residential, roads, etc.); <2 mi/mi^2 road density in the floodplain.	50-80% mature trees (medium-large) in the riparian buffer zone (defined as a 30 m belt along each bank) that are available for recruitment by the river via channel migration; 20-50% disturbance in the floodplain (e.g., agriculture, residential, roads, etc.); 2-3 mi/mi^2 road density in the floodplain.	<50% mature trees (medium-large) in the riparian buffer zone (defined as a 30 m belt along each bank) that are available for recruitment by the river via channel migration; >50% disturbance in the floodplain (e.g., agriculture, residential, roads, etc.); >3 mi/mi^2 road density in the floodplain.

Data: The following riparian vegetation information was computed utilizing the geographic information system (GIS) vegetation mapping from the *Tributary Assessment* (Reclamation, 2008; APPENDIX I).

Riparian Vegetation Structure (Acres) in 30m Buffer:	**RM 9.42-11.6**
Large Conifer forest (A)	0.2 acres
Small Conifer Forest (B)	2 acres
Small Mixed Forest (F)	6 acres
Large Hardwood Forest (G)	0.3 acres
Small Hardwood Forest (H)	20 acres
Valley Shrub Land (K)	12 acres
Gravel Bar (GR)	5 acres
Gravel Bar/Shrub (Gr-Sh)	1acres
Herbaceous (Herb)	2 acres
Percent disturbed	25%

Data: The following riparian disturbance information was computed utilizing the geographic information system (GIS) vegetation mapping from the *Tributary Assessment* (Reclamation, 2008; APPENDIX I).

Disturbance - Floodplain:	**RM 9.42-11.6**
Cleared area (acres)	4 acres
Area of vegetation impacted by railroad (acres)	9acres
Area of vegetation impacted by residence	8 acres
Area of roads	4 acres
Percent disturbed	24%

Data: The following riparian disturbance information was computed utilizing the geographic information system (GIS) database from the *Tributary Assessment* (Reclamation, 2008; APPENDIX).

Disturbance - Floodplain:	**RM 9.42-11.6**
Cleared area (acres)	2 acres
Area of vegetation impacted by railroad, highway and roads (acres)	13 acres
Area of vegetation impacted by power lines	14 acres
Area of vegetation impacted by transmission lines	7 acres
Percent area of disturbed vegetation	21%
Road density in floodplain (mile/miles^2)	5 mi/mi^2

Interpretation:

Floodplain Disturbance:	**Condition**
Lower White Pine Reach	At Risk Condition

Narrative:

At the 6th HUC scale, riparian disturbance is interpreted to functioning at an 'At Risk Condition'. Anthropogenic impacts in the riparian area include: construction and maintenance for U.S. Highway 2, primitive or access roads, private homes, campgrounds, powerline construction and railroad activities. All of these factors as described in the Nason Creek Watershed Analysis (USFS, 1996) have changed the character of the riparian corridor and severely limited the lands ability to produce riparian tree vegetation (WDOE, 2003). The effects of the disturbances are wide ranging and can affect multiple ecosystem indicators. For example, oxbows and wetlands have been disconnected from the main channel of Nason Creek. The results include the loss of natural sources of large woody debris (LWD) (USFS, 1996 in WDOE, 2003) and an increase in the overall size of wetlands. The vegetation in the wetland areas are considered natural for the current condition (inundated); however, it is believed that prior to the railroad and highway embankments impounding the wetlands the vegetation would have been mixed riparian and upland vegetation.

INDICATOR: CONDITION (CANOPY COVER)

Criteria: The criteria for riparian vegetation canopy cover were agreed upon by the assessment team as a "relative" indication to the functionality of the specific indicator.

Pathway	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Riparian Vegetation	Condition	Canopy Cover	Trees and shrubs within one site potential tree height distance or 10 m buffer zone have >80% canopy cover that provides thermal shading to the river.	Trees and shrubs within one site potential tree height distance or 10 m buffer zone have 50-80% canopy cover that provides thermal shading to the river.	Trees and shrubs within one site potential tree height distance or 10 m buffer zone have <50% canopy cover that provides thermal shading to the river.

Data: The following riparian buffer zone (10 m) information was computed utilizing the geographic information system (GIS) vegetation mapping from the *Tributary Assessment* (Reclamation, 2008; Appendix I). The percent medium-large wood along the 10 meter riparian buffer is used as a surrogate to interpret the percent canopy cover by mature trees.

Canopy Cover within 10m Buffer:	**RM 9.42-11.6**
Percent large wood available in riparian buffer	10%

Interpretation:

Canopy Cover:	**Condition**
Lower White Pine Reach	Unacceptable Risk Condition

Narrative:

Canopy cover is interpreted to be at an "Unacceptable Risk Condition". Canopy cover provides shading to the stream and is a factor for LWD recruitment potential. In the lower White Pine reach, anthropogenic impacts in the form of the railroad and highway have replaced the natural vegetation in the 10 meter buffer zone and create artificially confined sections of channel. These confined section show limited bar development or floodplain surfaces for vegetation to establish. The removal of the vegetation and placement of riprap reduces bank shade potential (Thomas, 2007).

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Wenatchee Subbasin, Washington
Nason Creek Initial Site Assessment
LWP DIZ-1

Personnel: PNRO Geologist E. Lyon, R. McAffee

Purpose: Photo graphic documentation of baseline conditions and geologic mapping of anthropogenic features associated with floodplain connectivity. The location of the subreach is shown in figure 1.

Observations:

- 597 feet of railroad grade disrupts the historic main channel path. The current channel is now located on the north side of the railroad grade (Image 1, Photographs 1-4).
- 492 feet of transmission line that crosses the subreach at two locations.
- There is a culvert at the downstream end; however the culvert does not provide access from the current channel at base flow (Photograph 5).

Summary Table: Features used in the Reach-based Ecosystem Indicators (REI)

Pathway:	**Indicator:**	**Feature:**
Habitat Access	Physical Barriers (mainstem)	Railroad grade
Habitat elements	Wetlands	5 Acres
	Off-channel habitat	Historic main & overflow channels
	Refugia	Accessible at higher flows
Channel condition and floodplain dynamics	Floodplain connectivity	Disconnected
Watershed conditions	Road Density & Location (Floodplain	0.11 mi/0.02 mi^2
	Riparian corridor	Small diameter/young seral stage, 28% disturbed.
	Protection Area	0 Acres
	Total Area	11 Acres

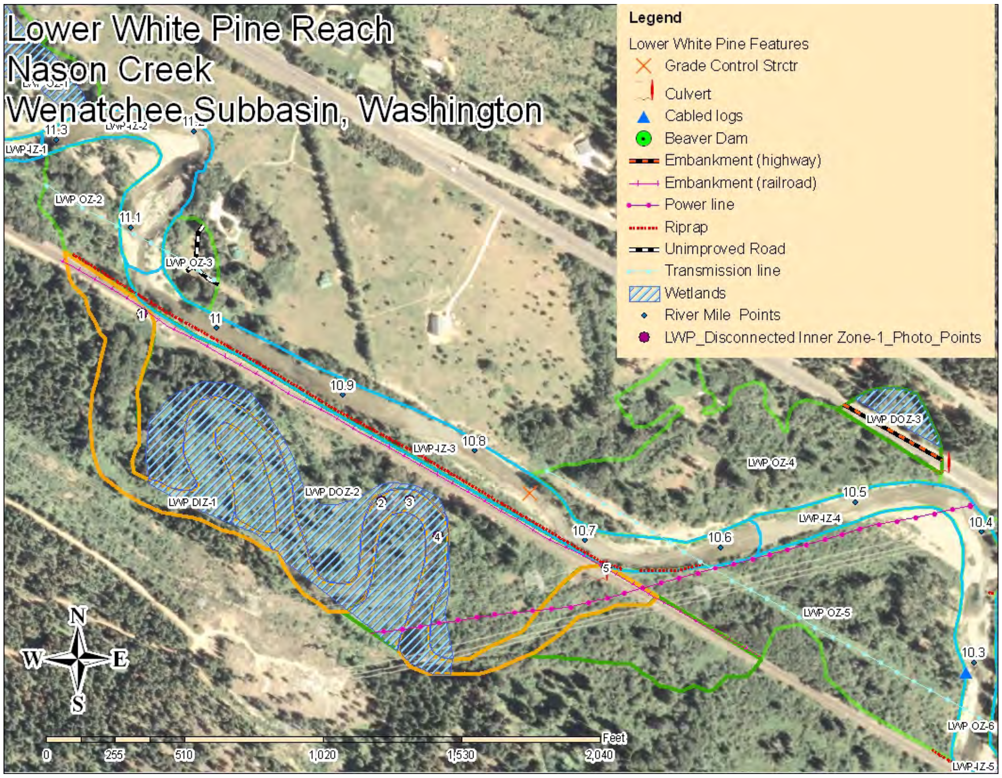

Figure 1. A plan view showing the mid-section of the Lower White Pine reach with the location of LWP IZ-1, photo points, location of anthropogenic features, and the proximity of adjacent subreaches.

Photograph No. 1. View to the southeast of a historic meander of the main channel cutoff by the railroad grade. Lower White Pine Reach; Subreach DIZ-6, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by R. McAffee, May 5, 2007.

Photograph No. 2. View to the southwest of the historic main channel that is currently disconnected by the railroad grade. Lower White Pine Reach; Subreach DIZ-6, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by R. McAffee, September 9, 2008.

Photograph No. 3. View to the southeast of the historic main channel that is currently disconnected by the railroad grade. Lower White Pine Reach; Subreach DIZ-6, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by R. McAffee, September 9, 2008.

Photograph No. 4. View to the south of wetlands within the historic main channel tha is currently disconnected by the railroad grade. Lower White Pine Reach; Subreach DIZ-6, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by R. McAffee, September 9, 2008.

Photograph No. 5. View to the southeast of the culvert that drains the wetlands on the south side of the railroad grade at the downstream of the subreach. Lower White Pine Reach; Subreach DIZ-6, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by R. McAffee, May 5, 2007.

Wenatchee Subbasin, Washington
Nason Creek Initial Site Assessment
LWP DIZ-2

Personnel: PNRO Geologist E. Lyon, R. McAffee

Purpose: Photo graphic documentation of baseline conditions and geologic mapping of anthropogenic features associated with floodplain connectivity. The location of the subreach is shown in figure 1.

Observations:

- 2,333 feet of railroad grade disconnect2 the subreach from the current channel at the upstream (RM 10.2), middle (RM 9.9) and downstream end (RM 9.7). In addition to the disconnection, the railroad grade acts as an embankment to impound water behind, and attract beaver (Image 1 and Photographs 1 and 3).
- Slightly disturbed vegetation due to 556 feet of transmission line and the railroad grade
- A culvert is located at the downstream end of the subreach, but the culvert does not provide passage at base flow. (Photograph 2).

Summary Table: Features used in the Reach-based Ecosystem Indicators (REI)

Pathway:	**Indicator:**	**Feature:**
Habitat Access	Physical Barriers (mainstem)	Railroad grade
Habitat elements	Wetlands	36 Acres
	Off-channel habitat	Historic main & overflow channels
	Refugia	Access at higher flows
Channel condition and floodplain dynamics	Floodplain connectivity	Disconnected
Watershed conditions	Road Density & Location (Floodplain	0 mi/mi^2
	Riparian corridor	Small diameter/ young seral stage, 5% disturbed
	Protection Area	0 Acres
	Total Area	40 Acres

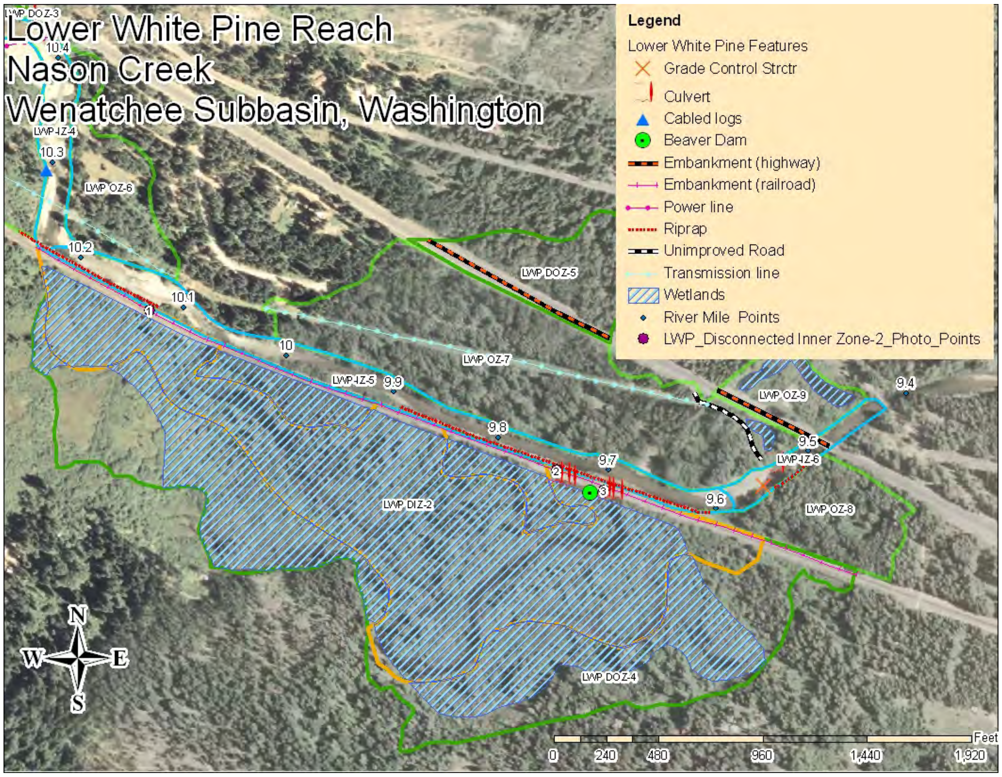

Figure 1. A plan view showing the downstream end of the Lower White Pine reach with the location of LWP DIZ-2, photo points within, location of anthropogenic features, and the proximity of adjacent subreaches.

Photograph No. 1. View to the south showing a 4-foot tall beaver dam in the wetlands on the south side of the railroad grade. Lower White Pine Reach; Subreach DIZ-11, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by R. McAffee, May 5, 2007.

Photograph No. 2. View to the south of three 36-inch concrete culverts that drain the wetland complex to the river. Lower White Pine Reach; Subreach DIZ-11, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by R. McAffee, May 4, 2007.

Photograph No. 3. View to the southeast of a larger beaver dam in a wetland complex located on the south side of the railroad grade. Lower White Pine Reach; Subreach DIZ-11, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by R. McAffee, May 4, 2007.

Wenatchee Subbasin, Washington
Nason Creek Initial Site Assessment
LWP DOZ-1

Personnel: PNRO Geologist E. Lyon, R. McAffee

Purpose: Photo graphic documentation of baseline conditions and geologic mapping of anthropogenic features associated with floodplain connectivity. Location of the subreach is shown in figure 1.

Observations:

- 572 feet of railroad embankment disconnects the area from the active channel.
- Moderately disturbed vegetation due to the footprint of the railroad grade.

Summary Table: Features used in the Reach-based Ecosystem Indicators (REI)

Pathway:	**Indicator:**	**Feature:**
Habitat Access	Physical Barriers (mainstem)	572 feet of railroad embankment
Habitat elements	Wetlands	None
	Off-channel habitat	Disconnected
	Refugia	Disconnected
Channel condition and floodplain dynamics	Floodplain connectivity	572 feet of railroad embankment
Watershed conditions	Road Density & Location (Floodplain	0.11 mi/0.003mi^2
	Riparian corridor	Varying seral stage, 25% disturbed
	Protection Area	0 Acres
	Total Area	2 Acres

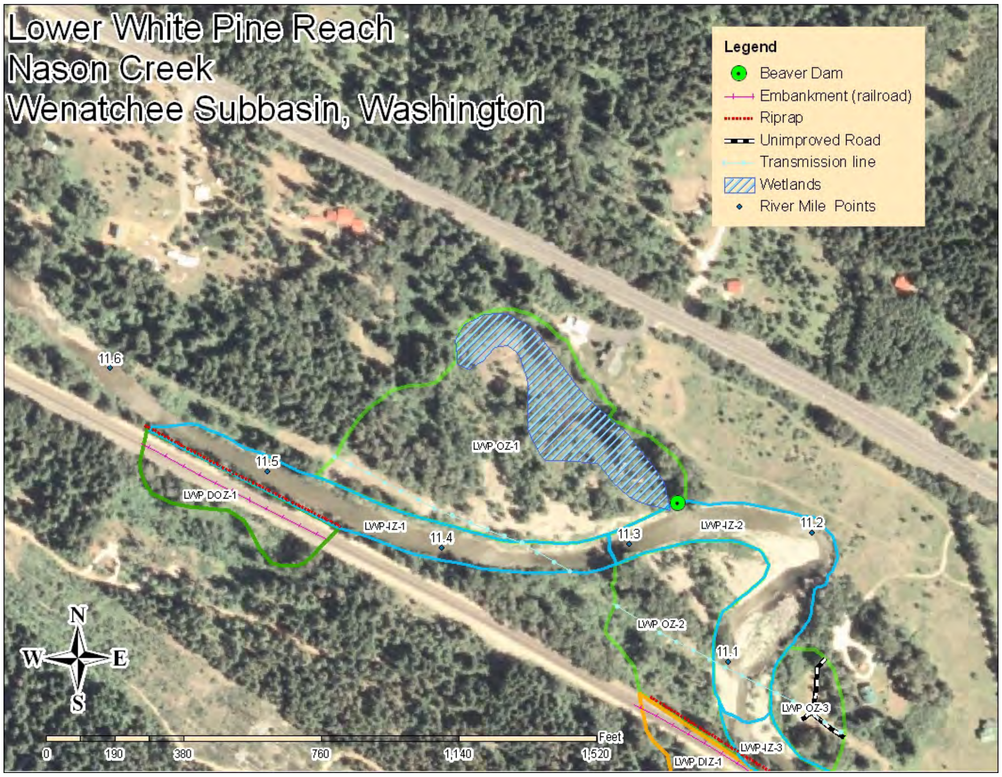

Figure 1. A plan view showing the upstream end of the Lower White Pine reach with the location of LWP DOZ-1, location of anthropogenic features, and the proximity of adjacent subreaches.

Wenatchee Subbasin, Washington
Nason Creek Initial Site Assessment
DOZ-2

Personnel: PNRO Geologist E. Lyon, R. McAffee

Purpose: Photo graphic documentation of baseline conditions and geologic mapping of anthropogenic features associated with floodplain connectivity. The location of the subreach is shown in figure 1

Observations:

- 2,343 feet of railroad grade runs parallel to the current channel.
- 296 feet of powerline crosses the southeast corner.
- Vegetation is about 27% disturbed from impacts from the railroad grade and powerline.

Summary Table: Features used in the Reach-based Ecosystem Indicators (REI)

Pathway:	**Indicator:**	**Feature:**
Habitat Access	Physical Barriers (mainstem)	Railroad grade
Habitat elements	Wetlands	7 Acres
	Off-channel habitat	Historic overflow channels
	Refugia	Inundated at higher flows
Channel condition and floodplain dynamics	Floodplain connectivity	Disconnected
Watershed conditions	Road Density & Location (Floodplain	0 mi/mi^2
	Riparian corridor	Mostly small diameter/young seral stage, 27% disturbed
	Protection Area	0 Acres
	Total Area	18 Acres

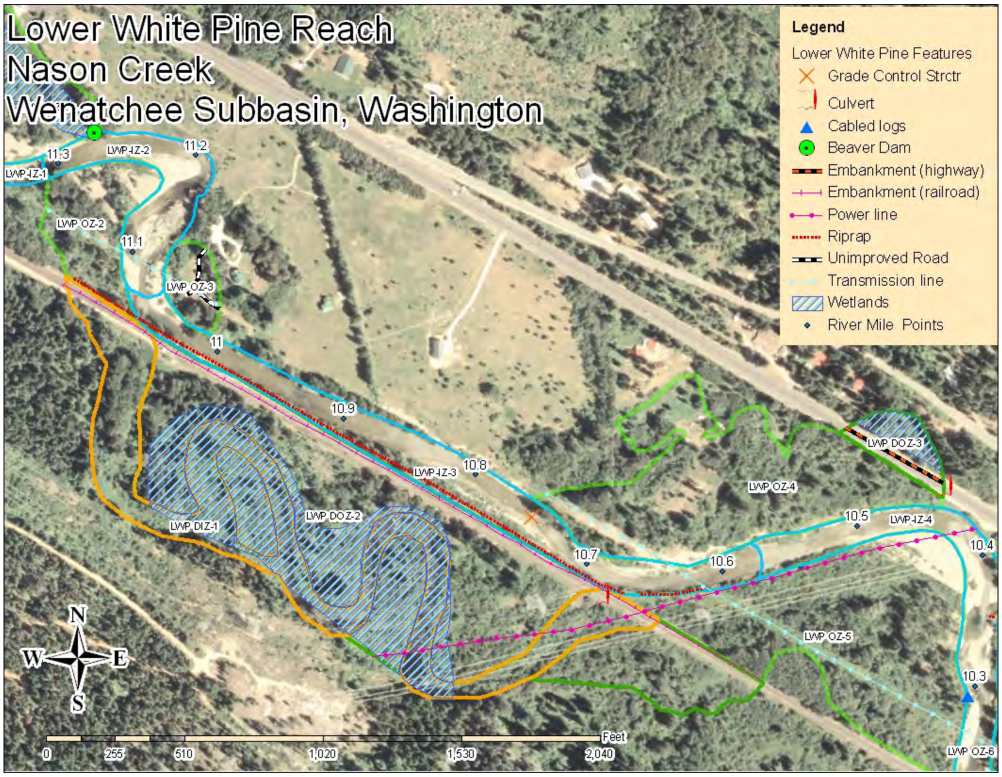

Figure 1. A plan view showing the mid-section of the Lower White Pine reach with the location of LWP DOZ-2, location of anthropogenic features, and the proximity of adjacent subreaches.

Wenatchee Subbasin, Washington
Nason Creek Initial Site Assessment
DOZ-3

Personnel: PNRO Geologist E. Lyon, R. McAffee

Purpose: Photo graphic documentation of baseline conditions and geologic mapping of anthropogenic features associated with floodplain connectivity. The location of the subreach is shown in figure 1.

Observations:

- 411 feet of Highway 2 disconnects this subreach from the adjacent floodplain.
- Just over a half of an acre of wetlands is located in the subreach (photographs 1-3).
- A culvert was noted in the downstream end of the subreach, but is believed to function as run off and ground water control, rather than fish passage (Photograph 4) .

Summary Table: Features used in the Reach-based Ecosystem Indicators (REI)

Pathway:	**Indicator:**	**Feature:**
Habitat Access	Physical Barriers (mainstem)	Highway 2
Habitat elements	Wetlands	0.6
	Off-channel habitat	Historic overflow channels
	Refugia	Inundated with ground and surface run off water
Channel condition and floodplain dynamics	Floodplain connectivity	Disconnected
Watershed conditions	Road Density & Location (Floodplain	0 mi/mi^2
	Riparian corridor	Mostly small diameter/young seral stage, 27% disturbed
	Protection Area	0 Acres
	Total Area	1 Acres

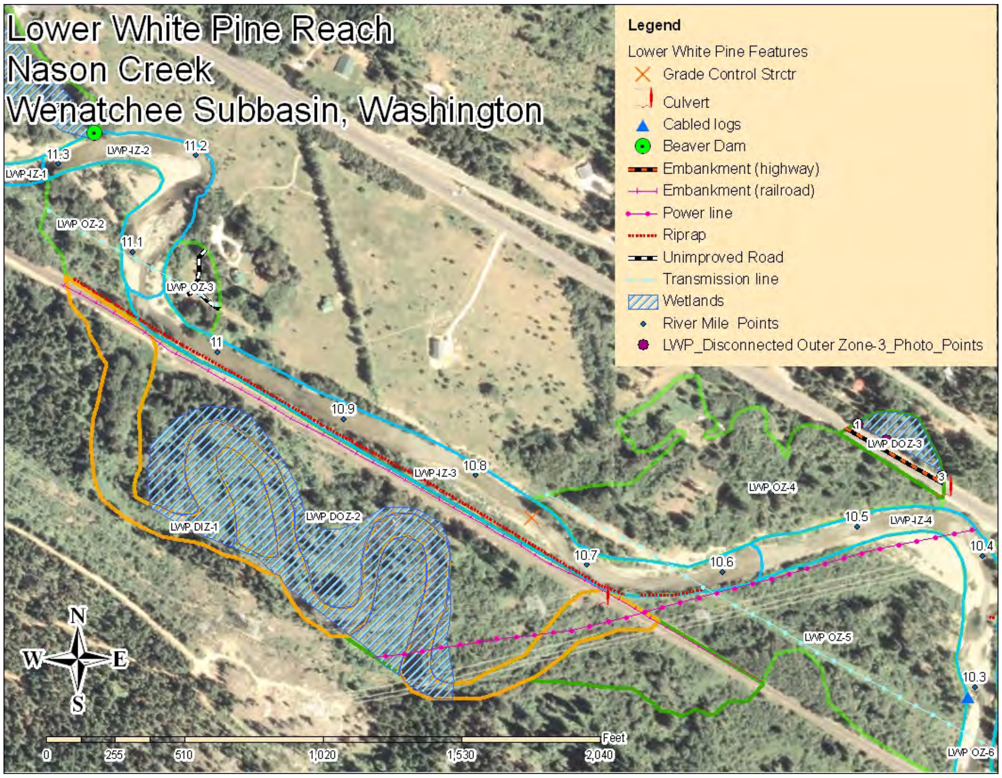

Figure 1. A plan view showing the mid-sectionof the Lower White Pine reach with the location of LWP DOZ-3, photo points, location of anthropogenic features, and the proximity of adjacent subreaches.

Photograph No. 1. View to the Northwest of the top of an oxbow cut off by Highway 2. Lower White Pine Reach; Subreach DOZ-8a, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by R. McAffee, May 3, 2007.

Photograph No. 2. View to the northeast of the top of a wetlands area on the north side of Highway 2. Lower White Pine Reach; Subreach DOZ-8a, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by R. McAffee, May 3, 2007.

Photograph No. 3. View to the northwest of the bottom of the wetlands on the north side of the road. Lower White Pine Reach; Subreach DOZ-8a, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by R. McAffee, May 3, 2007.

Photograph No. 4. View of the culvert that drains the wetlands on the north side of Highway 2. Lower White Pine Reach; Subreach DOZ-8a, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by R. McAffee, May 3, 2007.

Wenatchee Subbasin, Washington
Nason Creek Initial Site Assessment
LWP DOZ-4

Personnel: PNRO Geologist E. Lyon, R. McAffee

Purpose: Photo graphic documentation of baseline conditions and geologic mapping of anthropogenic features associated with floodplain connectivity. The location of the subreach is shown in figure 1.

Observations:

- 1,710 feet of railroad grade disconnects the area from the active channel.
- Slightly disturbed vegetation due to the railroad grade
- 22 acres of wetland exist within the subreach

Summary Table: Features used in the Reach-based Ecosystem Indicators (REI)

Pathway:	**Indicator:**	**Feature:**
Habitat Access	Physical Barriers (mainstem)	Embankment
Habitat elements	Wetlands	22 Acres
	Off-channel habitat	Historic overflow channels
	Refugia	Inundated at higher flows
Channel condition and floodplain dynamics	Floodplain connectivity	Disconnected
Watershed conditions	Road Density & Location (Floodplain	0 mi/mi^2
	Riparian corridor	Small diameter/young seral stage, 3% disturbed
	Protection Area	0 Acres
	Total Area	38 Acres

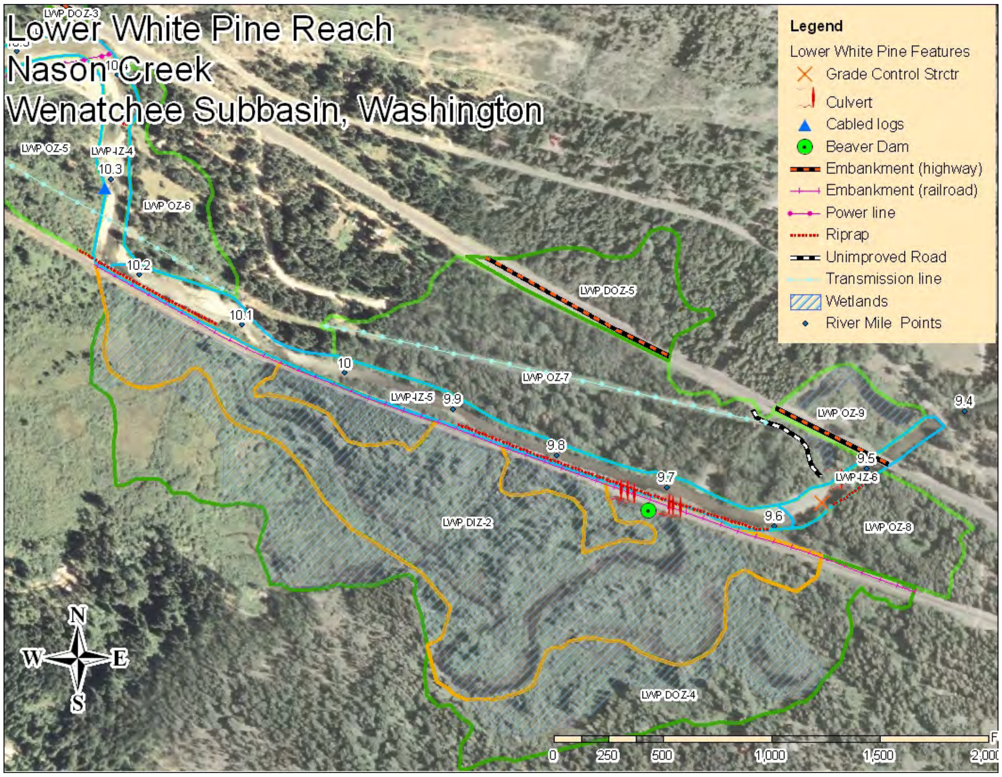

Figure 1. A plan view showing the downstream end of the Lower White Pine reach with the location of LWP DOZ-4, photo points, location of anthropogenic features, and the proximity of adjacent subreaches.

Wenatchee Subbasin, Washington
Nason Creek Initial Site Assessment
LWP DOZ-5

Personnel: PNRO Geologist E. Lyon, R. McAffee

Purpose: Photo graphic documentation of baseline conditions and geologic mapping of anthropogenic features associated with floodplain connectivity. The location of the subreach is shown in figure 1.

Observations:

- 945 feet of highway embankment disconnect the subreach from the adjacent subreach.
- Significantly disturbed vegetation due to the footprint of Highway 2.

Summary Table: Features used in the Reach-based Ecosystem Indicators (REI)

Pathway:	**Indicator:**	**Feature:**
Habitat Access	Physical Barriers (mainstem)	Highway Embankment
Habitat elements	Wetlands	None
	Off-channel habitat	Historic overflow channels
	Refugia	Disconnected
Channel condition and floodplain dynamics	Floodplain connectivity	Disconnected
Watershed conditions	Road Density & Location (Floodplain	0.18 mi/0.01 mi^2
	Riparian corridor	Varying seral stage, 29% disturbed
	Protection Area	0 Acres
	Total Area	7 Acres

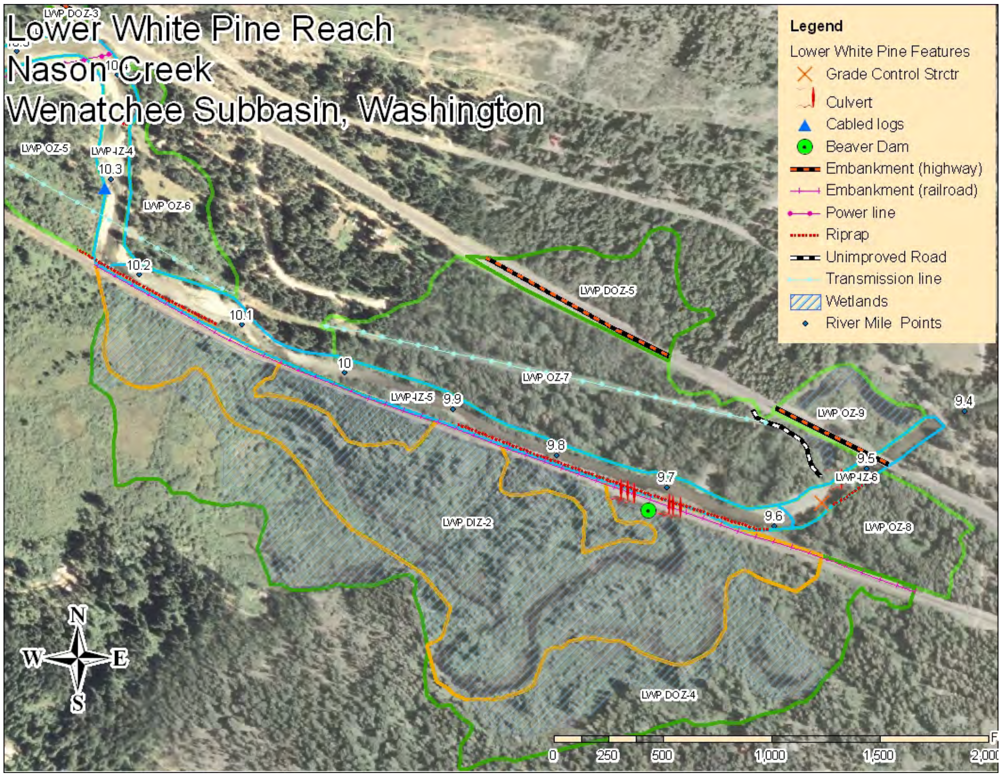

Figure 1. A plan view showing the downstream end of the Lower White Pine reach with the location of LWP DOZ-5, location of anthropogenic features, and the proximity of adjacent subreaches.

Wenatchee Subbasin, Washington
Nason Creek Initial Site Assessment
LWP IZ-1

Personnel: PNRO Geologist E. Lyon, R. McAffee and D. Bennett

Purpose: Photo graphic documentation of baseline conditions and geologic mapping of anthropogenic features associated with floodplain connectivity. The location of the subreach is shown in figure 1.

Observations:

- 550 feet of riprap protects the railroad grade along the right bank (Photograph 1). The current channel is now located on the north side of the railroad grade.
- Local erosion was noted at location along the left bank (Photograph 2).
- Channel units are run and riffle with a plane-bed form (Photographs 3-6).
- 170 feet of transmission line crosses the subreach at the downstream end.
- There are no culverts through the railroad grade.

Summary Table: Features used in the Reach-based Ecosystem Indicators (REI)

Pathway:	**Indicator:**	**Feature:**
Habitat Access	Physical Barriers (mainstem)	Railroad (Lateral)
Habitat elements	Substrate	Gravel & Cobble
	Large wood	Very low
	Channel units	Predominantly Run
Channel condition and floodplain dynamics	Bank Stability/Channel Migration	Local bank erosion, Limited migration
	Vertical Stability	Increased scour along riprap
Watershed conditions	Road Density & Location (Floodplain)	0.11 mi/0.02 mi^2
	Riparian corridor	Small diameter/young seral stage, 28% disturbed.
	Protection Area	0 Acres
	Total Area	3 Acres

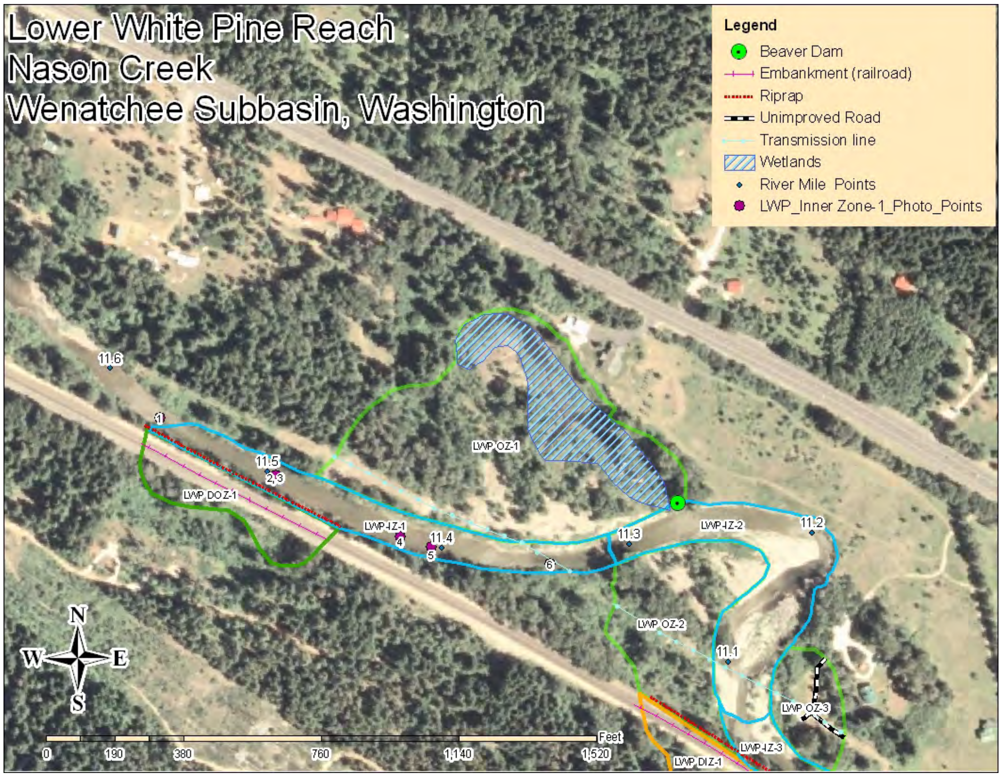

Figure 1. A plan view showing the upstream end of the Lower White Pine reach with the location of LWP IZ-1, photo points, location of anthropogenic features, and the proximity of adjacent subreaches.


Photograph No. 1. View is to the southeast looking downstream at a channel unit transition from riffle to run and the hardened right bank. Lower White Pine Reach; Subreach

IZ-1, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 2. View is to the north showing undercutting erosion and brush vegetation on left the bank. Lower White Pine Reach; Subreach IZ-1, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 3. View is to the south looking at the right bank where the railroad grade disconnects LWP DOZ-2 from the active channel. Lower White Pine Reach; Subreach IZ-1, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 4. View is to the southwest looking at the gravel-sized plain-bed and the right bank. Lower White Pine Reach; Subreach IZ-1, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 5. View is to the southeast looking downstream at a channel unit sequence of run-riffle-run and brush vegetation along both banks. Lower White Pine Reach; Subreach IZ-1, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 6. View is to the northeast looking downstream showing a run channel unit and the various seral stage of the vegetation along both banks. Lower White Pine Reach; Subreach IZ-1, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Wenatchee Subbasin, Washington
Nason Creek Initial Site Assessment
LWP IZ-2

Personnel: PNRO Geologist E. Lyon, R. McAffee and D. Bennett

Purpose: Photo graphic documentation of baseline conditions and geologic mapping of anthropogenic features associated with floodplain connectivity. Location of the subreach and the photo points are shown in figure 1.

Observations:

- Vegetation has been cleared from the left bank and the left bank is actively eroding (Photographs 1-3).
- Large wood is concentrated in 1 complex (Photographs 4 & 5).
- Substrate is gravel and cobble (Photograph 6).
- Tall gravel bars and brush vegetation observed along banks (Photograph 7 & 8).

Summary Table: Features used in the Reach-based Ecosystem Indicators (REI)

Pathway:	**Indicator:**	**Feature:**
Habitat Access	Physical Barriers (mainstem)	None
Habitat elements	Substrate	Gravel & Cobble
	Large wood	1 complex
	Channel units	Predominantly Run
Channel condition and floodplain dynamics	Bank Stability/Channel Migration	Extensive bank erosion, Limited migration
	Vertical Stability	Increased scour
Watershed conditions	Road Density & Location (Floodplain)	0.11 mi/0.02 mi^2
	Riparian corridor	Small diameter/young seral stage, 28% disturbed.
	Protection Area	0 Acres
	Total Area	3 Acres

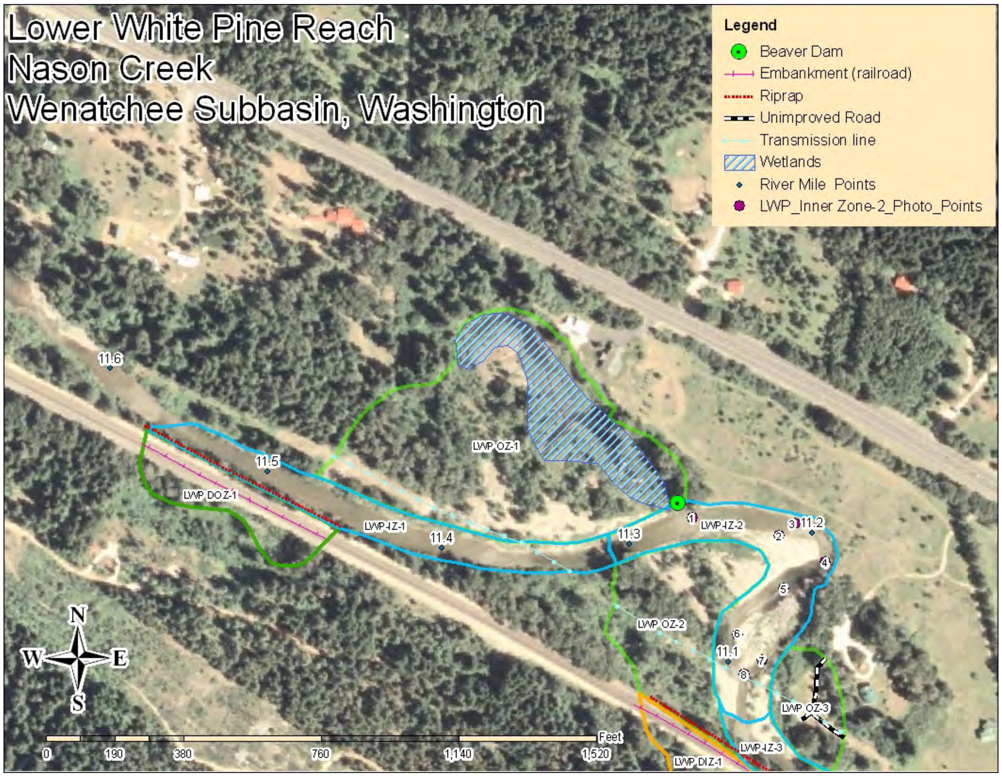

Figure 1. A plan view showing the upstream end of the Lower White Pine reach with the location of LWP IZ-2, photo points, location of anthropogenic features, and the proximity of adjacent subreaches with the corresponding restoration strategies.

Photograph No. 1. View is to the east looking downstream at the accelerated erosion along the cleared left bank. Lower White Pine Reach; Subreach IZ-2, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 2. View is to the north showing the stratified material in the left bank at a bank profile site. Lower White Pine Reach; Subreach IZ-2, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 3. View is to the west looking upstream, showing stratified material and accelerated erosion along the left bank. Lower White Pine Reach; Subreach IZ-2, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 4 View to the south looking downstream at a channel spanning large wood complex and pool channel unit. Lower White Pine Reach; Subreach IZ-2, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 5 View is to the south looking downstream at large wood complexes and pool channel units. Lower White Pine Reach; Subreach IZ-2, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 6. View is of material on gravel bar with gravelometer for scale. Lower White Pine Reach; Subreach IZ-2, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 7. View is to the north looking upstream of wood within the channel and a channel unit sequence of pool-run-riffle. Lower White Pine Reach; Subreach IZ-2, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 8. View is to the south looking downstream showing a channel unit transition from riffle to scour pool, and the railroad grade along the right bank where the channel bends to the left. Lower White Pine Reach; Subreach IZ-2, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Wenatchee Subbasin, Washington
Nason Creek Initial Site Assessment
LWP IZ-3

Personnel: PNRO Geologist E. Lyon, R. McAffee and D. Bennett

Purpose: Photo graphic documentation of baseline conditions and geologic mapping of anthropogenic features associated with floodplain connectivity. Location of the subreach is shown in figure 1.

Observations:

- 2057 feet of riprap protects the railroad grade along the right bank (Photographs 1 & 9). The railroad grade disrupts the historic main channel path. The current channel is now located on the north side of the railroad grade.
- Channel units are mostly riffle and run with a plane-bed form (Photographs 1, 4, 5, 8 & 11).
- Substrate is gravel with cobbles (photographs 2, 6 & 7)
- Erosion was noted along the left bank where vegetation has been altered or removed (Photographs 5 & 8)
- 192 feet of power line crosses the subreach at the downstream end (Photograph 9).
- There is a culvert through the railroad grade at the downstream end; however the culvert does not provide access from the current channel at base flow (Photograph 10).
- An additional 237 feet of riprap protects the powerline along the right bank at the downstream end of the subreach (Photograph 11).

Summary Table: Features used in the Reach-based Ecosystem Indicators (REI)

Pathway:	**Indicator:**	**Feature:**
Habitat Access	Physical Barriers (mainstem)	Railroad (Lateral)
Habitat elements	Substrate	Gravel & Cobble
	Large wood	Very low
	Channel units	Predominantly Run
Channel condition and floodplain dynamics	Bank Stability/Channel Migration	Local bank erosion, Limited migration
	Vertical Stability	Increased scour along riprap
Watershed conditions	Road Density & Location (Floodplain)	0.11 mi/0.02 mi^2
	Riparian corridor	Small diameter/young seral stage, 28% disturbed.
	Protection Area	0 Acres
	Total Area	8 Acres

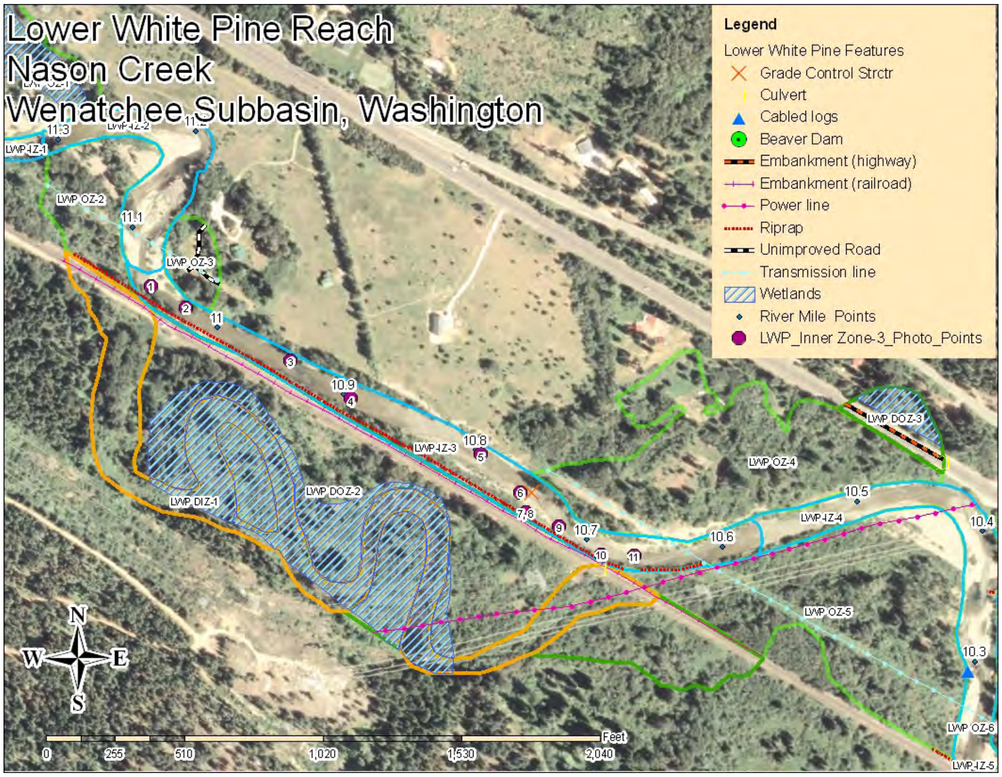

Figure 1. A plan view showing the mid-section of the Lower White Pine reach with the location of LWP IZ-3, photo points, location of anthropogenic features and adjacent subreaches.


Photograph No. 1. View is to the southeast looking downstream of a transition from rifle to run and the railroad grade acting as the right bank. The railroad grade

disconnects LWP DIZ-2 and LWP 4from the active channel. Lower White Pine Reach; Subreach IZ-3, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 2. View is of material on the gravel bar with gravelometer for scale. Lower White Pine Reach; Subreach IZ-3, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 3. View is to the north at bank profile site on the left bank. Lower White Pine Reach; Subreach IZ-3, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 4. View is to the southeast looking downstream at a channel unit transition from run to riffle. Lower White Pine Reach; Subreach IZ-3, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 5. View is to the southeast looking downstream at erosion along the left bank. Note the vegetation removal and a long run for the channel unit. Lower White Pine Reach; Subreach IZ-3, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 6. View is of material on the gravel bar with gravelometer for scale. Lower White Pine Reach; Subreach IZ-3, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 7. View of the material on the gravel bar with gravelometer for scale. Lower White Pine Reach; Subreach IZ-3, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by R. McAffee; May 5, 2007.

Photograph No. 8. View to the northwest of the eroding left bank with vegetation removed. Lower White Pine Reach; Subreach IZ-3, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by R. McAffee; May 5, 2007.

Photograph No. 9. View is to the southeast looking downstream showing a long run for the channel unit and the railroad grade on the right bank that disconnects LWP DIZ-2 and DOZ-4. Lower White Pine Reach; Subreach IZ-3, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 10. View is to the south looking at an elevated culvert through the railroad grade that drains run off water from the area of LWP DIZ-2 and LWP DOZ-4. Lower White Pine Reach; Subreach IZ-3, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 11. View is to the northeast looking downstream at a long run for the channel unit, and brush vegetation along both banks. Lower White Pine Reach; Subreach IZ-3, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Wenatchee Subbasin, Washington
Nason Creek Initial Site Assessment
LWP IZ-4

Personnel: PNRO Geologist E. Lyon, R. McAffee and D. Bennett

Purpose: Photo graphic documentation of baseline conditions and geologic mapping of anthropogenic features associated with floodplain connectivity. The location of the subreach is shown in figure 1.

Observations:

- Erosion was noted along left bank (Photographs 1-6).
- An instream structure is located at RM 10.35 (Photograph 7) and a cabled log at RM 10.29.
- Tall gravel bars with brush vegetation were noted (Photograph 8 & 9)
- Substrate is gravel and cobble (Photographs 10 & 12)
- Slightly more complexity exists in the downstream end of the subreach (Photograph 11).
- About 70 feet of riprap protects the railroad grade along the right bank at the downstream end of the subreach (Photograph 13).
- 122 feet of powerline crosses the subreach in the mid-section.
- 130 feet of transmission line that crosses the subreach at the downstream end.

Summary Table: Features used in the Reach-based Ecosystem Indicators (REI)

Pathway:	**Indicator:**	**Feature:**
Habitat Access	Physical Barriers (mainstem)	None
Habitat elements	Substrate	Gravel & Cobble
	Large wood	Very low
	Channel units	Predominantly Run
Channel condition and floodplain dynamics	Bank Stability/Channel Migration	Local bank erosion, Limited migration
	Vertical Stability	Increased scour along riprap
Watershed conditions	Road Density & Location (Floodplain)	0.11 mi/0.02 mi^2
	Riparian corridor	Small diameter/young seral stage, 28% disturbed.
	Protection Area	0 Acres
	Total Area	5 Acres

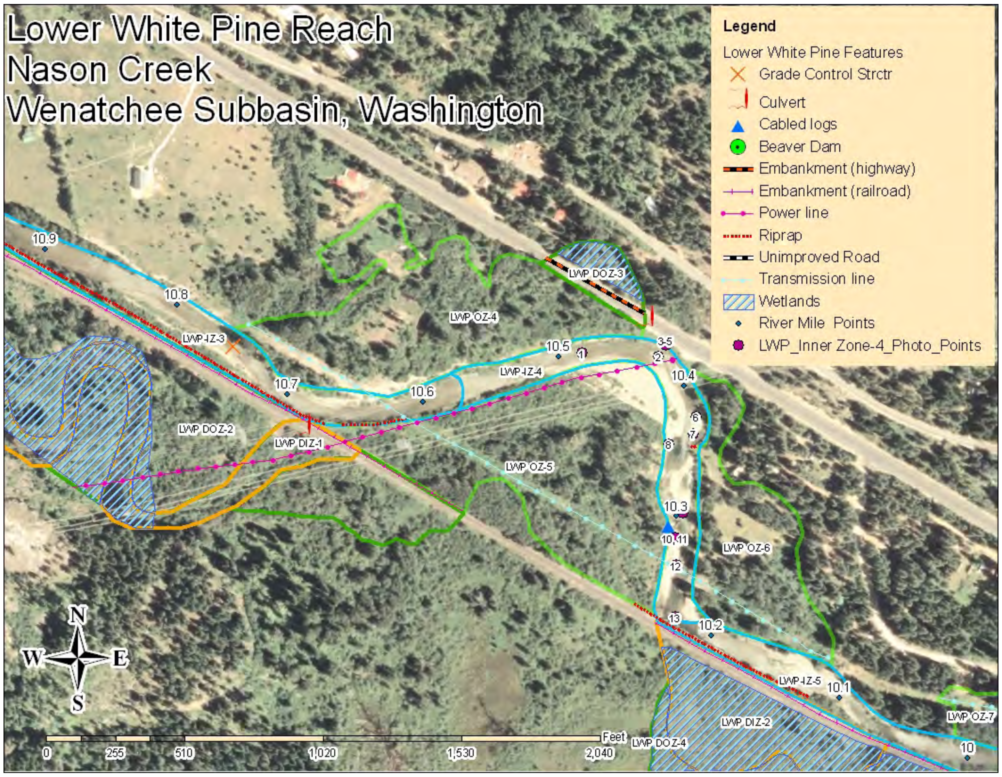

Figure 1. A plan view showing the mid-section of the Lower White Pine reach with the location of LWP IZ-4, photo points, location of anthropogenic features and the proximity of adjacent subreaches.

Photograph No. 1. View is to the northeast looking downstream at a channel unit sequence of run-riffle-pool and erosion along the left bank. Lower White Pine Reach;

Subreach IZ-4, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

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Photograph No. 2. View is to the east looking downstream at pool and glide channel units and erosion along the left bank. Lower White Pine Reach; Subreach IZ-4, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 3. View to the northwest looking upstream at brushy vegetation and the undercut/eroding along the left bank. Lower White Pine Reach; Subreach IZ-4, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by R. McAffee; May 3, 2007.

Photograph No. 4. View looking downstream to the southeast of grass and brush vegetation of, and undercut/eroding along the left bank. Lower White Pine Reach; Subreach IZ-4, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by R. McAffee; May 3, 2007.

Photograph No. 5. View to the southwest of a channel unit sequence of riffle-run-riffle and undercut/eroding along the left bank. Lower White Pine Reach; Subreach IZ-4, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by R. McAffee; May 3, 2007.

Photograph No. 6. View is to the south looking downstream at a split flow with a channel unit transition of run to riffle/rapid and erosion along the left bank. Lower White Pine Reach; Subreach IZ-4, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 7. View to the south looking at an in-channel structure comprised of concrete ecology blocks, miscellaneous concrete slabs and riprap. Lower White Pine Reach; Subreach IZ-4, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 8. View to the south looking downstream at a channel unit sequence of run-riffle pool, and a gravel point bar along the left bank. Lower White Pine Reach; Subreach IZ-4, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 9. View is to the south looking downstream of a channel unit transition from pool to run and a gravel point bar along the right bank. Lower White Pine Reach; Subreach IZ-4, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 10. View showing the material on the gravel bar with the gravelometer for scale. Lower White Pine Reach; Subreach IZ-4, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by R. McAffee; May 5, 2007.

Photograph No. 11. View looking upstream to the northwest showing meanders, gravel bars and large wood. Lower White Pine Reach; Subreach IZ-4, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by R. McAffee; May 5, 2007.

Photograph No. 12. View of the substrate in the channel with a gravelometer for scale. Lower White Pine Reach; Subreach IZ-4, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 13. View is to the southeast looking downstream of a channel unit transition from riffle to run and riprap along the right bank. Lower White Pine Reach; Subreach IZ-4, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Wenatchee Subbasin, Washington
Nason Creek Initial Site Assessment
LWP IZ-5

Personnel: PNRO Geologist E. Lyon, R. McAffee and D. Bennett

Purpose: Photo graphic documentation of baseline conditions and geologic mapping of anthropogenic features associated with floodplain connectivity. The location of the subreach is shown in figure 1.

Observations:

- Two sections of riprap totaling 2,082 feet protect the railroad grade along the right bank (Photographs 1, 2, 4, 9 and 10). The railroad grade disrupts the historic main channel path. The current channel is now located on the north side of the railroad grade.
- Point bars ranging from small to large are noted throughout the subreach (photographs 1, 2, 6, 9, 10, 16, 18 and 19).
- Dominant substrate is gravel and cobble (Photograph 3).
- Channel units are predominantly run and riffle (Photographs 4, 6, 9, 10, 16 and 18).
- Two sets of triple culverts are placed in the railroad grade at the downstream end (Photographs 12-15); however the culverts may not provide access from the current channel at base flow.
- The bank is modified with a small rock spur and log boat ramp near RM 9.67 (Photograph 17).

Summary Table: Features used in the Reach-based Ecosystem Indicators (REI)

Pathway:	**Indicator:**	**Feature:**
Habitat Access	Physical Barriers (mainstem)	Railroad (Lateral)
Habitat elements	Substrate	Gravel & Cobble
	Large wood	Very low
	Channel units	Predominantly Run
Channel condition and floodplain dynamics	Bank Stability/Channel Migration	Local bank erosion, Limited migration
	Vertical Stability	Increased scour along riprap
Watershed conditions	Road Density & Location (Floodplain)	0.11 mi/0.02 mi^2
	Riparian corridor	Small diameter/young seral stage, 28% disturbed.
	Protection Area	0 Acres
	Total Area	9 Acres

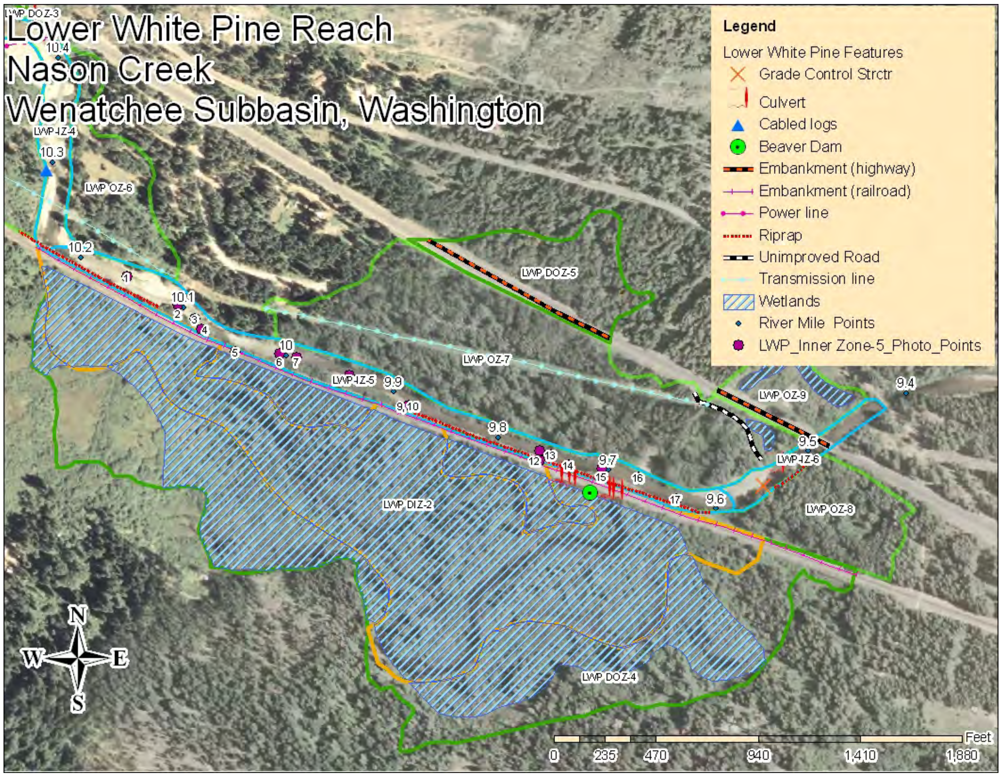

Figure 1. A plan view showing the downstream end of the Lower White Pine reach with the location of LWP IZ-5, photo points, location of anthropogenic features, and the proximity of adjacent subreaches.

Photograph No. 1. View is to the southeast looking downstream at a channel unit transition of riffle to run and the railroad grade acting as the right bank. The railroad grade disconnects LWP DIZ-2 and LWP DOZ-4 from the active channel. Lower White

Pine Reach; Subreach IZ-5, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 2. View is to the southeast looking downstream at a channel unit transition from riffle to run, the railroad grade that acts as the right bank and a high left bank. Lower White Pine Reach; Subreach IZ-5, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 3. View of material on gravel bar with gravelometer for scale. Lower White Pine Reach; Subreach IZ-5, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 4. View to the southeast looking downstream showing a long run, the high left bank and the railroad grade that acts as the right bank. Lower White Pine Reach; Subreach IZ-5, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 5. View to the northwest of the high surface that is the left bank. Lower White Pine Reach; Subreach IZ-5, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by R. McAffee; May 5, 2007.

Photograph No. 6. View is to the southeast looking downstream at a long riffle and brushy vegetation along both banks. Lower White Pine Reach; Subreach IZ-5, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 7. View is to the south looking at small woody and brush vegetation along the right bank at the base of the railroad grade. Lower White Pine Reach; Subreach IZ-5, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 8. View is to the north looking at a bank profile site on the left bank. Lower White Pine Reach; Subreach IZ-5, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 9. View looking downstream to the east at a riffle in the straightened section of the active channel with the railroad grade acting as the right bank. Lower White Pine Reach; Subreach IZ-5, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 10. View looking downstream to the east at a riffle in the straightened section of the active channel with the railroad grade acting as the right bank. Lower White Pine Reach; Subreach IZ-5, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by R. McAffee; May 4, 2007.

Photograph No. 11. View to the northeast showing the left bank. Lower White Pine Reach; Subreach IZ-5, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by R. McAffee; May 4, 2007.

Photograph No. 12. View is to the south of elevated corrugated through the railroad grade that acts as the right bank. The culverts drain the area of LWP DIZ-2 and LWP DOZ-4. Lower White Pine Reach; Subreach IZ-5, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 13. View to the northwest of three elevated metal culverts that run through the railroad grade and drain the area of LWP DIZ-2 and LWP DOZ-4. Lower White Pine Reach; Subreach IZ-5, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by R. McAffee; May 4, 2007.

Photograph No. 14. View is to the south looking at three concrete culverts that run through the railroad grade on the right bank. The culverts drain the area of LWP DIZ-2 and LWP DOZ-4. Lower White Pine Reach; Subreach IZ-5, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 15. View to the northwest of three concrete culverts that drain the area of LWP DIZ-2 and LWP DOZ-4. Lower White Pine Reach; Subreach IZ-5, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by R. McAffee; May 4, 2007.

Photograph No. 16. View is to the southeast looking downstream at a run with alternating gravel point bars. Lower White Pine Reach; Subreach IZ-5, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 17. View is to the north looking at small riprap and a constructed boat launch on left bank. Lower White Pine Reach; Subreach IZ-5, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 18. View is to the southeast looking downstream at a long run, a gravel point bar on the left bank and the railroad grade acting as the right bank at both banks. Lower White Pine Reach; Subreach IZ-5, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 19. View to the northeast of a channel unit sequence of pool-run-riffle and a gravel point bar on left bank. Two bridges are visible in the back ground. Lower White Pine Reach; Subreach IZ-5, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by R. McAffee; May 4, 2007.

Wenatchee Subbasin, Washington
Nason Creek Initial Site Assessment
LWP IZ-6

Personnel: PNRO Geologist E. Lyon, R. McAffee and D. Bennett

Purpose: Photo graphic documentation of baseline conditions and geologic mapping of anthropogenic features associated with floodplain connectivity. The location of the subreach is shown in figure 1.

Observations:

- Local bank erosion noted along right bank (Photograph 1).
- About 255 feet of riprap is located along the right bank that is associated with the Highway 2 Bridge crossing (Photographs 1 & 5).
- Dominant substrate is cobble and gravel (Photographs 2 & 4).
- A v-weir is located near RM 9.56 (Photograph 3).

Summary Table: Features used in the Reach-based Ecosystem Indicators (REI)

Pathway:	**Indicator:**	**Feature:**
Habitat Access	Physical Barriers (mainstem)	None
Habitat elements	Substrate	Cobble & Gravel
	Large wood	Very low
	Channel units	Predominantly Run
Channel condition and floodplain dynamics	Bank Stability/Channel Migration	Local bank erosion, Limited migration
	Vertical Stability	Increased scour along riprap
Watershed conditions	Road Density & Location (Floodplain)	0.11 mi/0.02 mi^2
	Riparian corridor	Small diameter/young seral stage, 28% disturbed.
	Protection Area	0 Acres
	Total Area	2 Acres

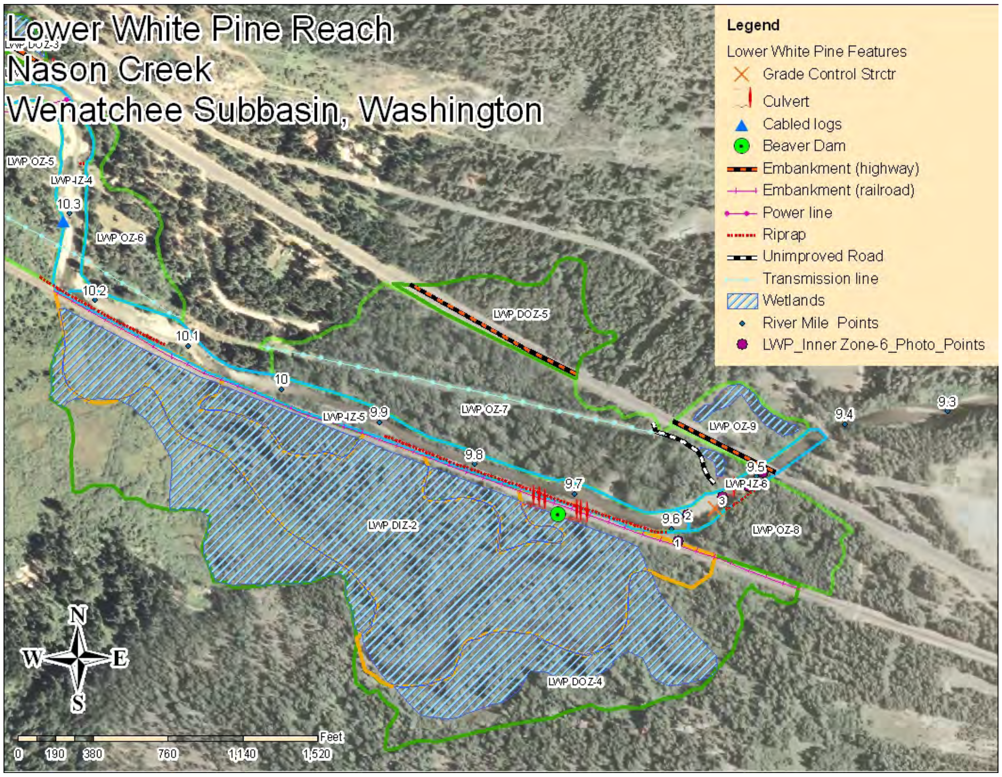

Figure 1. A plan view showing the downstream end of the Lower White Pine reach with the location of LWP IZ-6, photo points, location of anthropogenic features, and the proximity of adjacent subreaches.

Photograph No. 1. View is to the northeast looking downstream at a channel unit transition of riffle-pool-run and a gravel point bar on the left bank. Lower White Pine Reach;

Subreach IZ-6, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 2. View of material on the gravel bar with gravelometer for scale. Lower White Pine Reach; Subreach IZ-6, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by R. McAffee; May 6, 2007.

Photograph No. 3. View is to the east looking at an in-channel rock weir. Lower White Pine Reach; Subreach IZ-6, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 4. View of material on gravel bar with gravelometer for scale. Lower White Pine Reach; Subreach IZ-6, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Photograph No. 5. View is to the northeast looking downstream at run and pool channel units, brush-vegetated banks and bridge abutments. Lower White Pine Reach; Subreach IZ-6, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by D. Bennett; August 8, 2007.

Wenatchee Subbasin, Washington
Nason Creek Initial Site Assessment
LWP OZ-1

Personnel: PNRO Geologist E. Lyon, R. McAffee

Purpose: Photo graphic documentation of baseline conditions and geologic mapping of anthropogenic features associated with floodplain connectivity. The location of the subreach is shown in figure 1.

Observations:

- Slightly disturbed vegetation due to 556 feet of transmission line
- An embankment is located at the outlet of the wetland area.

Summary Table: Features used in the Reach-based Ecosystem Indicators (REI)

Pathway:	**Indicator:**	**Feature:**
Habitat Access	Physical Barriers (mainstem)	Embankment
Habitat elements	Wetlands	2 Acres
	Off-channel habitat	Historic overflow channels
	Refugia	Inundated at higher flows
Channel condition and floodplain dynamics	Floodplain connectivity	Connected
Watershed conditions	Road Density & Location (Floodplain	0 mi/mi^2
	Riparian corridor	Varying seral stage, 6% disturbed
	Protection Area	9 Acres
	Total Area	9 Acres

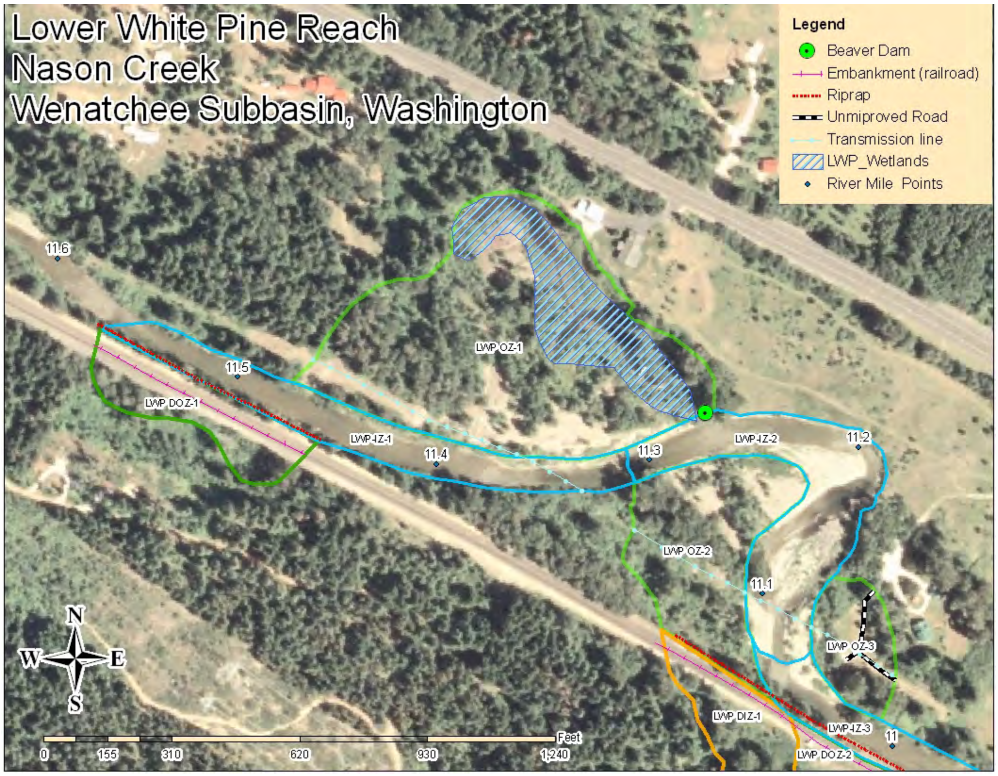

Figure 1. A plan view showing the upstream end of the Lower White Pine reach with the location of LWP OZ-1 location of anthropogenic features, and the proximity of adjacent subreaches.

Wenatchee Subbasin, Washington
Nason Creek Initial Site Assessment
LWP OZ-2

Personnel: PNRO Geologist E. Lyon, R. McAffee

Purpose: Photo graphic documentation of baseline conditions and geologic mapping of anthropogenic features associated with floodplain connectivity. The location of the subreach is shown in figure 1.

Observations:

- Slightly disturbed vegetation due to 556 feet of transmission line.
- 220 feet of riprap along the railroad grade is addressed in another subreach.

Summary Table: Features used in the Reach-based Ecosystem Indicators (REI)

Pathway:	**Indicator:**	**Feature:**
Habitat Access	Physical Barriers (mainstem)	None
Habitat elements	Wetlands	None
	Off-channel habitat	Historic overflow channels
	Refugia	Inundated at higher flows
Channel condition and floodplain dynamics	Floodplain connectivity	Connected
Watershed conditions	Road Density & Location (Floodplain	0 mi/mi^2
	Riparian corridor	Varying seral stage, 13% disturbed
	Protection Area	3 Acres
	Total Area	3 Acres

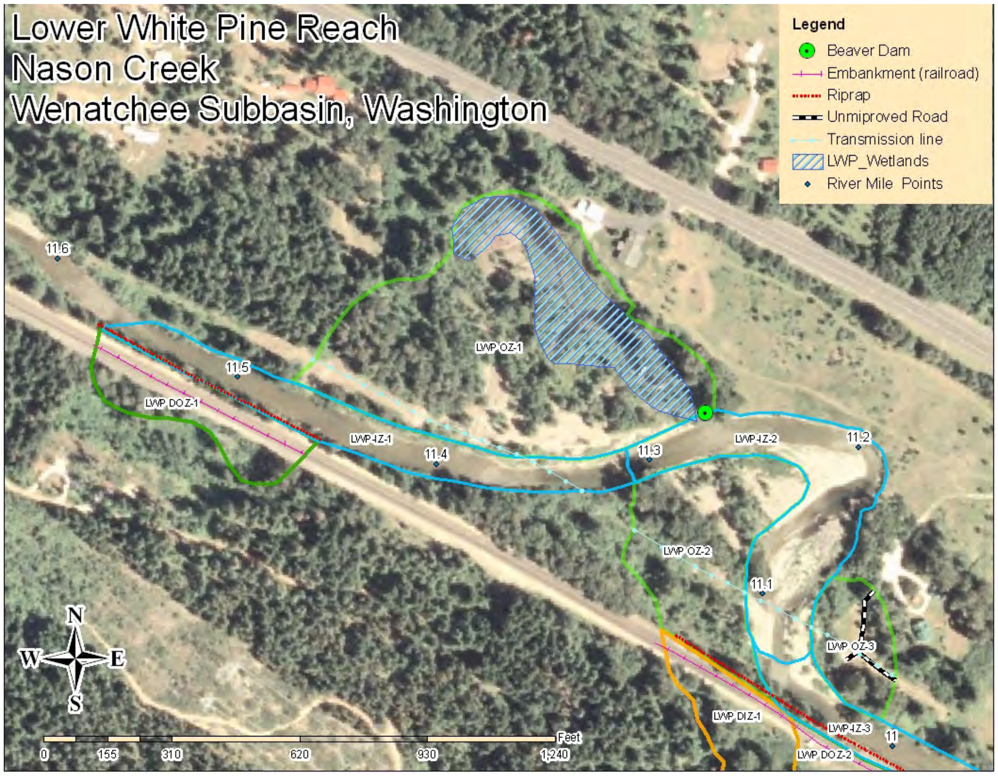

Figure 1. A plan view showing the upstream end of the Lower White Pine reach with the location of LWP OZ-2, location of anthropogenic features, and the proximity of adjacent subreaches.

Wenatchee Subbasin, Washington
Nason Creek Initial Site Assessment
LWP OZ-3

Personnel: PNRO Geologist E. Lyon, R. McAffee

Purpose: Photo graphic documentation of baseline conditions and geologic mapping of anthropogenic features associated with floodplain connectivity. The location of the subreach is shown in figure 1.

Observations:

- Moderately disturbed vegetation due to 239 feet of transmission line and 307 feet of unimproved road within the subreach.

Summary Table: Features used in the Reach-based Ecosystem Indicators (REI)

Pathway:	**Indicator:**	**Feature:**
Habitat Access	Physical Barriers (mainstem)	None
Habitat elements	Wetlands	None
	Off-channel habitat	Historic overflow channels
	Refugia	Inundated at higher flows
Channel condition and floodplain dynamics	Floodplain connectivity	Connected
Watershed conditions	Road Density & Location (Floodplain	0.06 mi/0.002mi^2
	Riparian corridor	Varying seral stage, 36% disturbed
	Protection Area	0 Acres
	Total Area	1 Acres

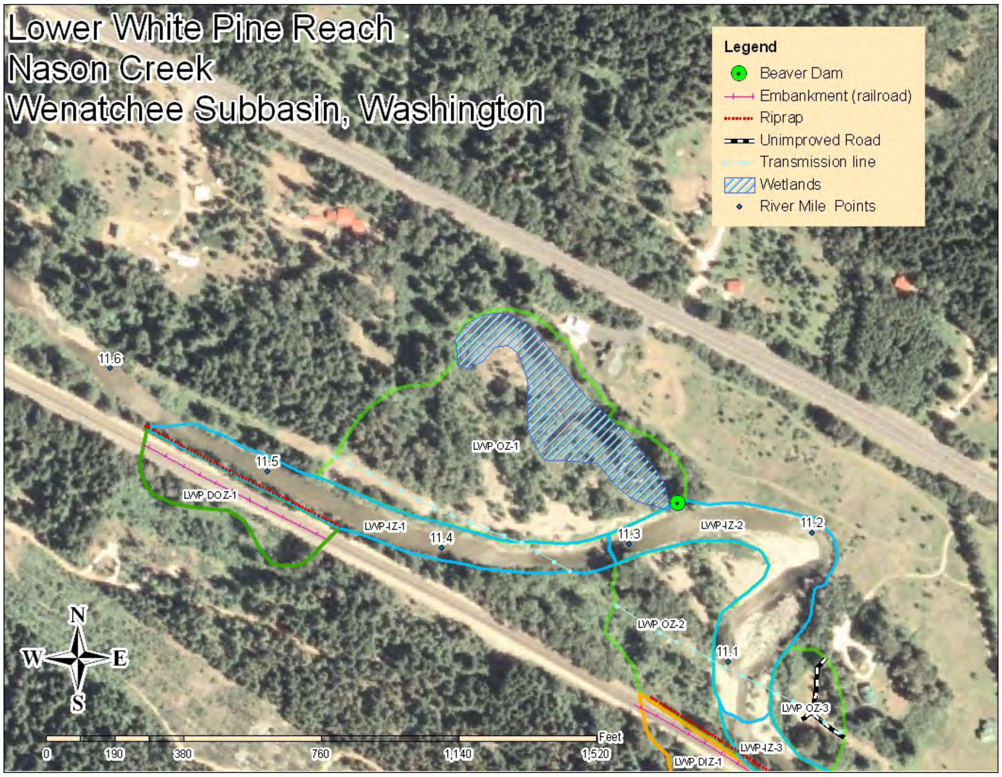

Figure 1. A plan view showing the upstream end of the Lower White Pine reach with the location of LWP OZ-3, location of anthropogenic features, and the proximity of adjacent subreaches.

Wenatchee Subbasin, Washington
Nason Creek Initial Site Assessment
LWP OZ-4

Personnel: PNRO Geologist E. Lyon, R. McAffee

Purpose: Photo graphic documentation of baseline conditions and geologic mapping of anthropogenic features associated with floodplain connectivity. The location of the subreach is shown in figure 1.

Observations:

- Slightly disturbed vegetation due to 502 feet of transmission line and additional clearing for development

Summary Table: Features used in the Reach-based Ecosystem Indicators (REI)

Pathway:	**Indicator:**	**Feature:**
Habitat Access	Physical Barriers (mainstem)	None
Habitat elements	Wetlands	None
	Off-channel habitat	Historic overflow channels
	Refugia	Inundated at higher flows
Channel condition and floodplain dynamics	Floodplain connectivity	Connected
Watershed conditions	Road Density & Location (Floodplain	0 mi/mi^2
	Riparian corridor	Varying seral stage, 27% disturbed
	Protection Area	11 Acres
	Total Area	11 Acres

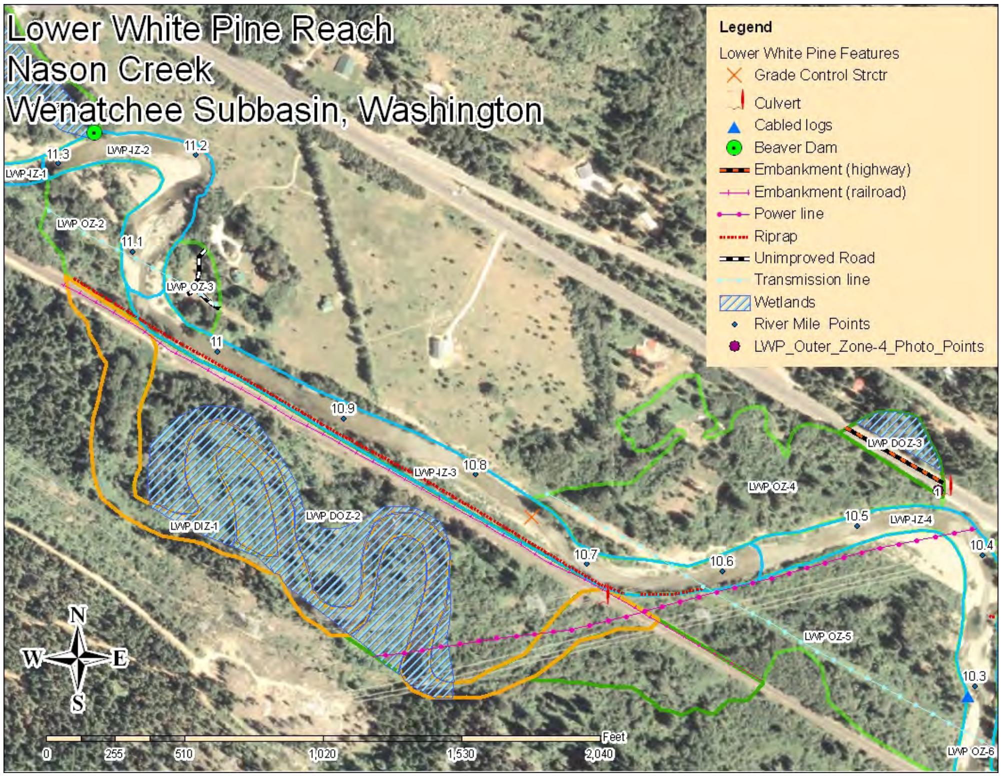

Figure 1. A plan view showing the mid-section of the Lower White Pine reach with the location of LWP OZ-4, photo points, location of anthropogenic features, and the proximity of adjacent subreaches.

Wenatchee Subbasin, Washington
Nason Creek Initial Site Assessment
LWP OZ-5

Personnel: PNRO Geologist E. Lyon, R. McAffee

Purpose: Photo graphic documentation of baseline conditions and geologic mapping of anthropogenic features associated with floodplain connectivity. The location of the subreach is shown in figure 1.

Observations:

- Significantly disturbed vegetation due to 1,060 feet of transmission line and 1,138 feet of powerline.

Summary Table: Features used in the Reach-based Ecosystem Indicators (REI)

Pathway:	**Indicator:**	**Feature:**
Habitat Access	Physical Barriers (mainstem)	None
Habitat elements	Wetlands	None
	Off-channel habitat	Historic overflow channels
	Refugia	Inundated at higher flows
Channel condition and floodplain dynamics	Floodplain connectivity	Connected
Watershed conditions	Road Density & Location (Floodplain	0 mi/mi^2
	Riparian corridor	Varying seral stage, 39% disturbed
	Protection Area	0 Acres
	Total Area	13 Acres

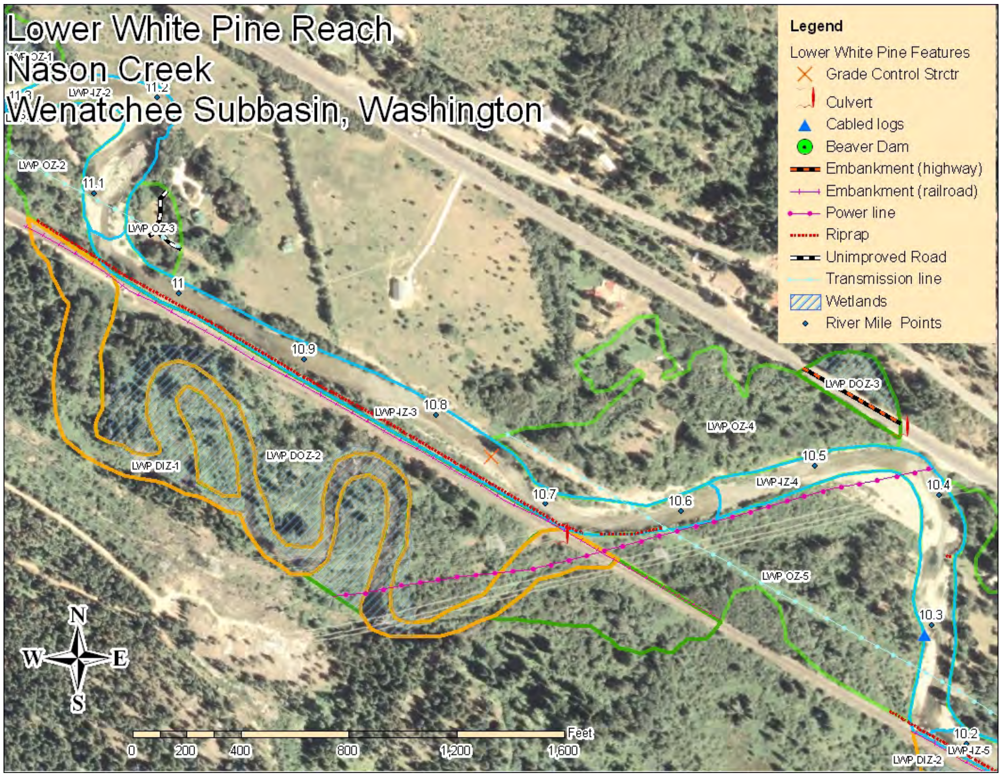

Figure 1. A plan view showing the upstream end of the Lower White Pine reach with the location of LWP OZ-5, location of anthropogenic features, and the proximity of adjacent subreaches.

Wenatchee Subbasin, Washington
Nason Creek Initial Site Assessment
LWP OZ-6

Personnel: PNRO Geologist E. Lyon, R. McAffee

Purpose: Photo graphic documentation of baseline conditions and geologic mapping of anthropogenic features associated with floodplain connectivity. The location of the subreach is shown in figure 1.

Observations:

- Significantly disturbed vegetation due to 590 feet of transmission line and 65 feet of powerline.
- There is and additional 1 acre of cleared vegetation associated with development.

Summary Table: Features used in the Reach-based Ecosystem Indicators (REI)

Pathway:	**Indicator:**	**Feature:**
Habitat Access	Physical Barriers (mainstem)	Embankment
Habitat elements	Wetlands	2 Acres
	Off-channel habitat	Historic overflow channels
	Refugia	Inundated at higher flows
Channel condition and floodplain dynamics	Floodplain connectivity	Connected
Watershed conditions	Road Density & Location (Floodplain	0 mi/mi^2
	Riparian corridor	Varying seral stage, 30% disturbed
	Protection Area	0 Acres
	Total Area	6 Acres

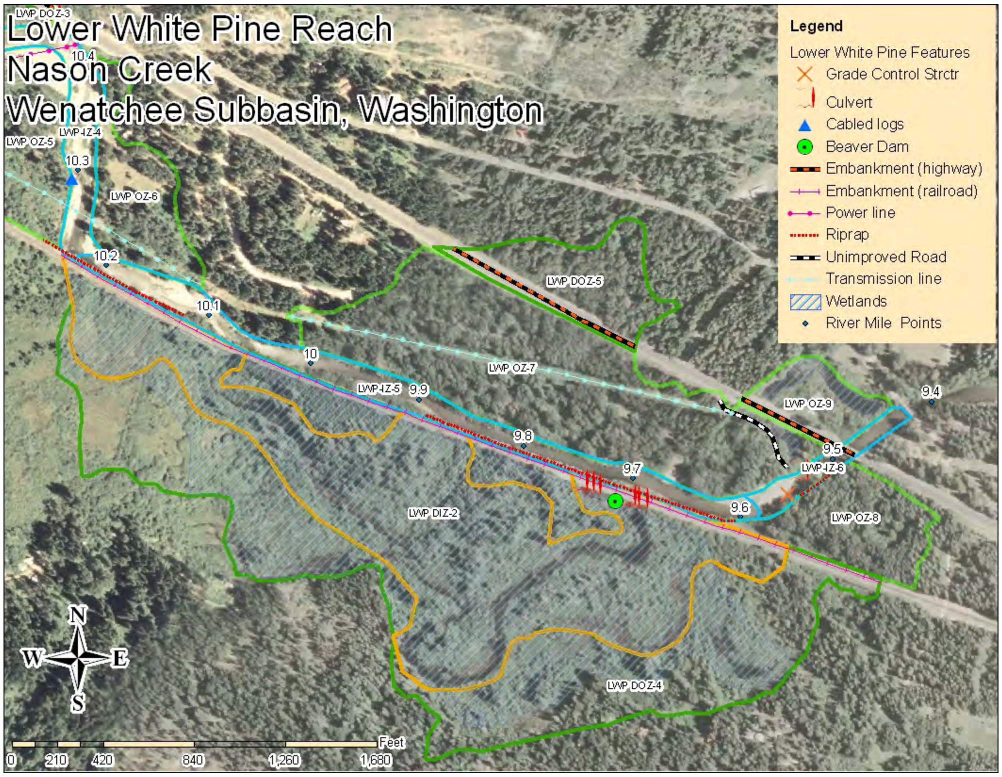

Figure 1. A plan view of the down stream end of the Lower White Pine reach with the location of LWP OZ-6, location of anthropogenic features, and the proximity of adjacent subreaches.

Wenatchee Subbasin, Washington
Nason Creek Initial Site Assessment
LWP OZ-7

Personnel: PNRO Geologist E. Lyon, R. McAffee

Purpose: Photo graphic documentation of baseline conditions and geologic mapping of anthropogenic features associated with floodplain connectivity. The location of the subreach is shown in figure 1.

Observations:

- 102 feet of road embankment and berms dissect the subreach (Photograph No. 1).
- 461 feet unimproved road is located within the subreach (Photograph No. 2 and 3).
- A culvert drains the wetland area to the main channel
- Slightly disturbed vegetation due to transmission line, undeveloped roads and road embankments.

Summary Table: Features used in the Reach-based Ecosystem Indicators (REI)

Pathway:	**Indicator:**	**Feature:**
Habitat Access	Physical Barriers (mainstem)	None
Habitat elements	Wetlands	0.2 Acres
	Off-channel habitat	Historic overflow channels
	Refugia	Inundated at higher flows
Channel condition and floodplain dynamics	Floodplain connectivity	2,104 feet of transmission line 461 feet undeveloped road 102 feet of road embankment 1 culvert
Watershed conditions	Road Density & Location (Floodplain	0.11 mi/0.04 mi^2
	Riparian corridor	Varying seral stage, 2% disturbed
	Protection Area	0 Acres
	Total Area	25 Acres

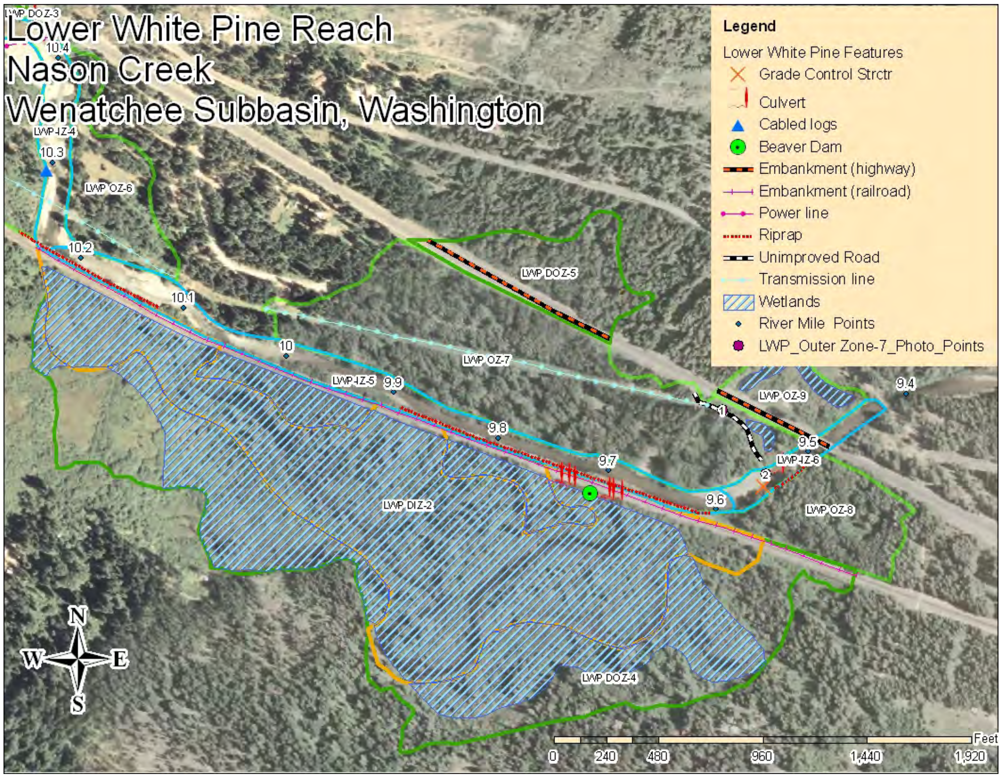

Figure 1. A plan view showing the downstream end of the Lower White Pine reach with the location of LWP OZ-7, photo points, location of anthropogenic features, and the proximity of adjacent subreaches.

Photograph No. 1. View to the northwest of an embankment on the left bank of the river that cuts off a wetland area on the south side of the road. Lower White Pine Reach; Subreach OZ-12, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by R. McAffee, May 3, 2007.

Photograph No. 2. View to the north east of a wetland cutoff by an access road embankment. Lower White Pine Reach; Subreach OZ-12, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by R. McAffee, May 3, 2007.

Photograph No. 3. View to the southwest of a wetland cut off by an access road. Lower White Pine Reach; Subreach OZ-12, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by R. McAffee, May 3, 2007.

Wenatchee Subbasin, Washington
Nason Creek Initial Site Assessment
LWP OZ-8

Personnel: PNRO Geologist E. Lyon, R. McAffee

Purpose: Photo graphic documentation of baseline conditions and geologic mapping of anthropogenic features associated with floodplain connectivity. The location of the subreach is shown in figure 1.

Observations:

- No anthropogenic features exist within the subreach, however it is bound on the north side by Highway 2, by the railroad grade on the south side and a small section of riprap along the bank. All bounding anthropogenic features are addressed in other subreaches.

Summary Table: Features used in the Reach-based Ecosystem Indicators (REI)

Pathway:	**Indicator:**	**Feature:**
Habitat Access	Physical Barriers (mainstem)	None
Habitat elements	Wetlands	0 Acres
	Off-channel habitat	No Side channels or overflow channels
	Refugia	Inundated at higher flows
Channel condition and floodplain dynamics	Floodplain connectivity	No human development/disturbance noted
Watershed conditions	Road Density & Location (Floodplain	0 mi/mi^2
	Riparian corridor	Mature seral stage
	Protection Area	6 Acres
	Total Area	6 Acres

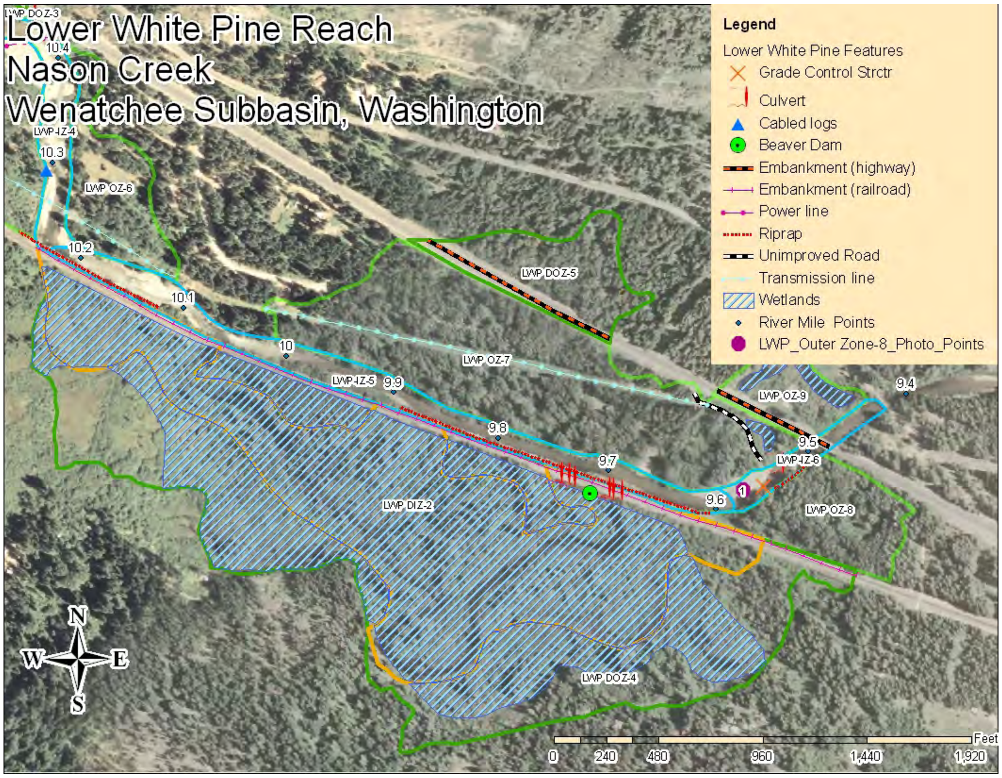

Figure 1. A plan view showing the downstream end of the Lower White Pine reach with the location of LWP OZ-8, photo points, location of anthropogenic features, and the proximity of adjacent subreaches.

Photograph No. 1. View to the southeast of the eroding right bank. Lower White Pine Reach; Subreach OZ-13, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by R. McAffee, May 3, 2007.

Wenatchee Subbasin, Washington
Nason Creek Initial Site Assessment
LWP OZ-9

Personnel: PNRO Geologist E. Lyon, R. McAffee

Purpose: Photo graphic documentation of baseline conditions and geologic mapping of anthropogenic features associated with floodplain connectivity. The location of the subreach is shown in figure 1.

Observations:

- ~500 feet of highway embankment disconnects the subreach from adjacent subreaches.
- An additional ~200 feet of road embankment exists in the subreach.
- Vegetation is moderately disturbed.

Summary Table: Features used in the Reach-based Ecosystem Indicators (REI)

Pathway:	**Indicator:**	**Feature:**
Habitat Access	Physical Barriers (mainstem)	None
Habitat elements	Wetlands	1 Acre
	Off-channel habitat	No Side channels or overflow channels
	Refugia	Inundated at higher flows
Channel condition and floodplain dynamics	Floodplain connectivity	~500 feet of highway embankment ~200 feet of road embankment
Watershed conditions	Road Density & Location (Floodplain	0 mi/mi^2
	Riparian corridor	Impacted
	Protection Area	1 Acres
	Total Area	4 Acres

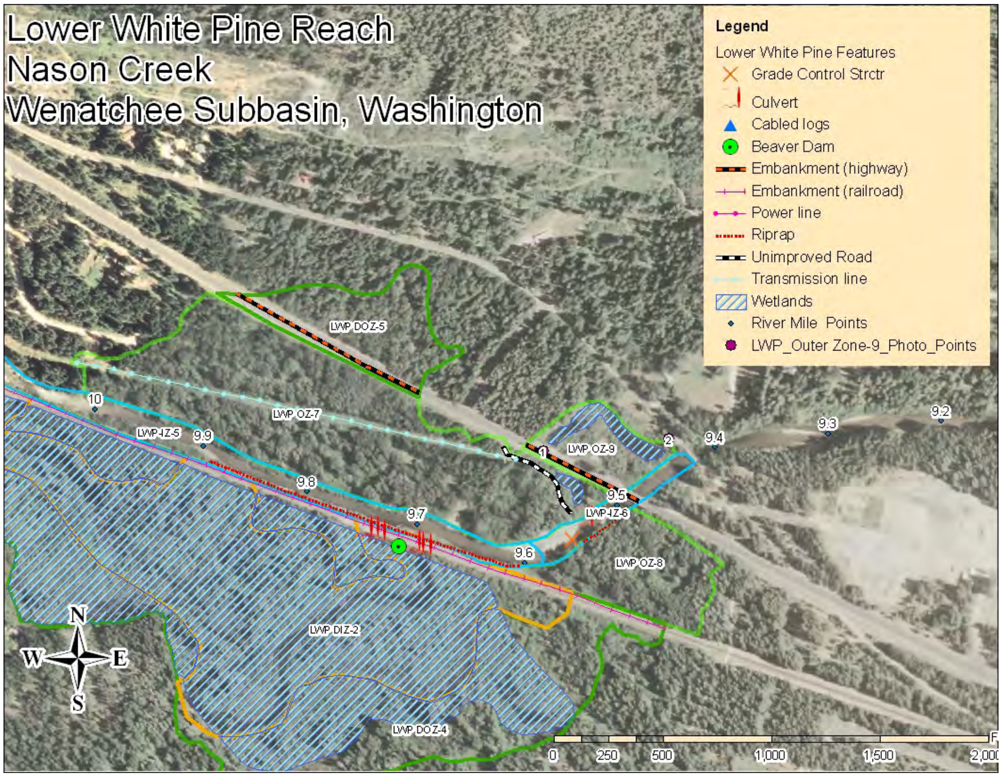

Figure 1. A plan view showing the downstream end of the Lower White Pine reach with the location of LWP OZ-9, photo points, location of anthropogenic features, and the proximity of adjacent subreaches.

Photograph No.1. View to the northeast of the top of wetlands in an oxbow on the north side of the road. Lower White Pine Reach; Subreach OZ-14, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by R. McAffee, May 3, 2007.

Photograph No. 2. View to the southwest of a wetlands area currently being utilized as an acclamation pond. Lower White Pine Reach; Subreach OZ-14, Nason Creek - Wenatchee Subbasin, Washington. Bureau of Reclamation Photograph by R. McAffee, May 3, 2007.

NASON CREEK HABITAT ASSESSMENT
From the Bend at RM 4.6 to the Railroad Bridge Crossing at RM 14.2

Survey Dates:
September 17 to 19, 2007 AND September 24 and 25, 2007

Prepared by Dave Hopkins and Cameron Thomas
Okanogan-Wenatchee National Forest
October 15, 2007

Reviewed and Finalized by Cindy Raekes
Okanogan-Wenatchee National Forest
May 28, 2008

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References: USFS 1998. White and Little Wenatchee Rivers Watershed Assessment. Wenatchee National Forest, Lake Wenatchee Ranger District.

NASON CREEK HABITAT SURVEY REPORT
RM 4.6 to RM 14.2
September 2007

Methodology and Objectives: A modified Hankin-Reeves Level II habitat survey (USDA Forest Service *Stream Inventory Handbook, 2006, Version 2.6*, Pacific Northwest Region) was conducted on a 9.6 mile segment of Nason Creek located between a major bend in the creek at RM 4.6 and the railroad bridge crossing at RM 14.2. The survey was conducted to help determine fish habitat quantity and quality in the surveyed area. The surveyed stream area was broken into five segments, two located above the bridge crossing at RM 9.4 and three located below the bridge (the bridge crossing is about 0.1 miles below the Highway 2 bridge crossing). Floodprone widths were measured at each bankfull width sampling site.

-Reach 1: A 4.3 mile segment of creek located from a major bend in the creek at RM 4.6 to where the channel becomes constricted at RM 8.9 (BOR Reach NC1).
-Reach 2: A 0.5 mile segment in a naturally constricted area of the creek located between RM 8.9 and a bridge crossing located 0.1 miles below the Highway 2 bridge crossing (BOR Reach NC2).
-Reach 3: A 2.3 mile segment of the creek located from the bridge crossing at RM 9.4 to where the creek is constricted at RM 11.8 (just below the town of Merritt).
-Reach 4: From RM 11.8 to where the creek has been channelilzed to protect the railroad (river right bank) and power lines (left bank) at RM 13.4.
-Reach 5: From RM 13.4 to the railroad bridge crossing at RM 14.2.
Reaches 3 to 5 comprise BOR Reach NC3.

Habitat data was collected and compared in the five surveyed stream segment areas.

Data Attributes: The following data attributes were collected during the habitat survey conducted from September 17 and September 19, and on September 26 and September 27.

●Stream Habitat Type: Habitat in the main channel and all the wetted side channels was broken into 4 main habitat unit types; riffles, pools, runs (glides), and side channels. The % habitat type was compared in the three surveyed stream segments. Run (glide) habitat measured in the survey is non-turbulent riffle habitat (very low gradient slower moving riffles with little surface turbulence). The long tail-outs in the glide pools in Nason Creek were included as pool habitat.

●Habitat Area: The length and wetted width of all habitat units were measured. The % area (square footage) of all 4 habitat unit types was calculated.

●Pools: Pools were counted and pools per mile were calculated. The average maximum depth and average residual depth (max depth minus pool crest) were calculated. Pool data was compared in the surveyed stream segments between reaches and to similar Okanogan Wenatchee National Forest data sets when available and appropriate.

●Riffles and Runs: Habitat dimensions, average thalweg depth, and maximum thalweg depth in riffles and runs were measured.

●Large woody debris: Pieces of large wood that intersected the bankfull channel width were counted in three size categories; small (> 20' long with a diameter of at least 6"), medium (> 35' long with a diameter between 12" and 20"), and large (> 35' long with a diameter greater than 20").

●Bank Erosion: The linear distance of eroding banks above the bankfull width was measured and compared by stream segment (bank erosion per mile, % eroding banks).

●Substrate: Wolman pebble counts were conducted in each reach. Substrate composition was visually estimated in every habitat unit in 5 size categories (sand, gravel, cobble, boulder, bedrock) based on size categories from Wolman pebble counts.

●Chinook salmon redds: The number of spring Chinook salmon redds in the channel were counted during the survey.

●Bankfull width/depth measurements were taken in each surveyed stream segment. A total of 17 bankfull width/depth measurements and floodprone width measurements were taken during the survey at about ½ mile intervals (approximate).   The floodprone area was defined based on survey protocol (floodprone area is the elevation calculated at two times the maximum bankfull depth in each bankfull channel cross-section). Floodprone width measurements are compared to the low surface elevations estimated by the BOR in the reach summary segment of this report.

Stream Flow: The Washington State Department of Ecology operates a stream flow monitoring station at the mouth of Nason Creek. Stream flow from the gage measured 37 to 38 cfs on September 26 and 27, during the time of the survey. Stream flow in the Wenatchee River at a site located between Lake Wenatchee and Nason Creek measured 166 to 183 cfs on the same dates (Washington State Department of Ecology gage station 45A240 data, from the State DOE website).

Fish Distribution: Fish distribution surveys were not conducted in the survey area.

NASON CREEK HABITAT ASSESSMENT OVERVIEW

Although some high quality fish habitat currently exists in the surveyed segment of Nason Creek (i.e. RM 9.2-9.3, RM 11.1-11.4, RM 12.8-13.3), past human activities appear to have greatly simplified the stream segment that we surveyed. The railroad bed, Highway 2 and the power line right of way have disconnected much of the stream from its floodplain. As a result, very little off-channel habitat exists for rearing fish. At low flow, only about 1% of the habitat area in the surveyed segment of Nason Creek consists of side channels and off-channel habitat. Nason Creek is not properly functioning for off-channel habitat under USFWS Matrix of Pathways and Indicators (MPI), which was developed as a guide to help action and regulatory agencies (USFS, BLM, USFWS, NMFS)to standardize habitat quality determinations (USFWS, 1998).

In addition to providing rearing habitat for juveniles and holding habitat for adult salmonids, large wood sorts sediment and creates spawning gravels, channel complexity and dissipates stream energy, The construction and maintenance of the railroad bed, highway and power lines has straightened the stream channel, reducing the sinuosity and total stream length (BOR, 2007). The resulting simplified and constrained channel appears to have reduced both the amount of large wood in the channel and the future recruitment potential for large wood from the riparian corridor. The lack of wood has reduced both the quality and quantity of salmonid habitat in the main channel. Juvenile fish were most typically observed in close proximity to the few log jams that currently exist in the surveyed segment of Nason Creek. Spring Chinook salmon redds were also typically in close proximity to large pieces of wood in the channel (see details in reach summaries found later in this report). Fifteen pieces of wood per mile greater than 35' long with a diameter of at least 12" were counted in the surveyed segment of Nason Creek. Much of the wood was found along the channel margins and on bars. The MPI standards for large wood calls for a minimum of 20 pieces per mile greater than 35' long with a diameter of at least 12" for properly functioning habitat, with adequate sources of woody debris recruitment in riparian areas. Nason Creek is not functioning properly for large wood. Relatively "unimpacted" stream segments that are comparable to Nason Creek have LWD amounts that range from 19 pieces per mile to 70 pieces per mile (Appendix A on page 22).

Although pool habitat is abundant as a percentage of total habitat area in much of the surveyed segment of Nason Creek, channel constriction and the lack of wood in the channel appears to have reduced pool quality. About 10.6 pools per mile were counted, which is below the pool frequency standard in the MPI, but within the low range (10-24.6 pools per mile, see Appendix A) of similar stream segments that are considered to be relatively healthy (not impacted by management activities). Although most pools counted as part of our data set in Nason Creek are greater than 1 meter deep, holding pools for migratory spring Chinook are typically at least five feet deep and associated with wood and or bedrock. Although we completed surveys after the Nason Creek spring Chinook spawned in 2007 and therefore did not see holding adult salmon, we did observe most Chinook redds at the tail-outs and in proximity to deeper pools (5' or >). About three pools per mile in Nason Creek were deeper than five feet, likely below historic levels found before European development began in the late 1800's. In addition to needed cover, the deep pools may provide thermal refuge to a stream that likely has elevated water temperatures due to a lack of shade. Nason Creek is functioning at risk for pool quality.

Cobble and gravel are the dominant substrate types we documented in the surveyed reach, which in proper relation to other habitat elements, provides preferred spawning substrate for anadromous fish. In the channeled segment of the creek between RM 13.4 and 14.1, substrate was > than the cobble size class. Substrate embeddedness did not appear to be excessive in our ocular estimates, as very little of the substrate was judged by surveyors to be embedded. Fine sediments appeared to be a problem only in a few areas in Nason Creek (see attached reach summaries for details). The MPI has a properly functioning standard for fine sediments in spawning gravel (<12% fines < 0.85 mm), which is measured by using McNeil Core sampling. Surface fine sediments were measured during the survey by conducting 6 Wolman pebble counts, spaced throughout the survey. The MPI standard for an appropriately functioning stream is < 12% surface fines < 6 mm. Surface fine sediments < 6 mm averaged about 12% in the six Wolman pebble counts, with a range of 7% to 19% surface fine sediments < 6 mm. Nason Creek appears to be properly functioning for substrate and fine sediments in most of the surveyed segment of the stream.

About 6.5% of the stream-banks are actively eroding, below the 10% threshold in The MPI (streams with > 90% stable banks are considered properly functioning in the Matrix). Although bank erosion is caused by constrictions in the channel from the highway and railroad bridge and by the removal of vegetation to maintain the power line right of way, the human caused erosion is offset by the large amount of rip-rap on the banks in areas where natural bank erosion would be occurring (in the outer bends of the creek).

No physical barriers to upstream or downstream fish migration were observed in the surveyed segment of Nason Creek.

The habitat attributes measured in the survey and briefly discussed in this overview are presented in greater detail in the reach summaries on the following 13 pages of the report. A statistical summary by reach is found on pages 19-20 of this report.

1. HABITAT ASSESSMENT: NASON CREK REACH 1 (BOR Reach NC1)
From a major bend at RM 4.6 to where the creek becomes constricted at RM 8.9

Summary of Habitat Data:

●**Reach Description:** This 4.3 mile reach is a somewhat sinuous, low gradient (1%) channel segment comprised mainly of riffles and runs. U.S. Highway 2 parallels the right bank of the creek throughout the entire reach. The road has cut off the creek from its floodplain in some segments of the reach. Some stream segments within the reach are unconfined (Rosgen C3 channel type). There are both naturally confined stream segments within the reach and areas that have been confined by the road and occasionally, the BPA power line (Rosgen F3 channel type, with a small segment of F4 low gradient contained channel type at the end of the reach).

●**Habitat Area:** The habitat area in the reach is about 159,000 square yards (36,400 square yards per mile), consisting of about 70% riffle and run habitat, 28.5% pool habitat, and 1.5% side channel habitat. (See page 19 for a summary of attributes by reach.).

●**Large Wood:** Large wood is very scarce in the 4.3 mile segment of stream, likely due in part to past wood removal, U.S. Highway 2 and the power line construction . Flows have likely accelerated in the reach due to the highway, which may increase the transport of wood. A total of 46 pieces of wood (10.5 pieces per mile) greater than 35' long with a diameter of at least 12" were counted in the reach. Most of the wood was found along the channel margins and on bars. Four log jams were observed in the reach. Log jams at RM 5.3 and RM 7.0 are creating deep pools (the pool at RM 7 is estimated to be about 9' deep). Two log jams at RM 6.2 are creating side channels, which are scarce in the reach. The future recruitment potential (several decades from now) for large wood is fair in this stream segment despite the highway, houses and power lines, as the riparian area is often well forested with second growth conifers and cottonwood trees.

●**Pool Habitat:** The number of pools per mile is low, with about eight pools per mile counted in the reach. Although some deep pool habitat exists in the reach, pools generally do not have cover and lack complexity. A total of nine pools greater than five feet deep were observed in the reach (two per mile). The number of five foot deep pools per mile is less than half of the deep pools observed above RM 9.4, due mainly to the lower amount of wood in the channel below RM 9.4.

●**Riffle Habitat:** About 70% of the total habitat area consisted of riffles and runs. Hiding cover for juveniles in the riffles was fair in the higher gradient riffles, with boulders and large cobble providing pocket pools and cover. Hiding cover was poor in the riffles that did not have large substrate as there was almost no large wood, the channel bottom was uniform and there was little overhead cover above the stream surface. The average thalweg depth in the riffles was slightly above 1.3 feet, providing good passage for fish migration.

●**Side Channel and Off-Channel Habitat:** Very little side channel and off-channel habitat exist in the reach. About 1.5% of the total habitat area at low flow consists of side channel habitat, which is very low for a (natural) C3 stream type. U.S. Highway 2 has cut off the creek from segments of its floodplain along the right side of the channel. Rip-rap to protect houses and the power line has also reduced the availability of the floodplain to the creek, although to a lesser degree than the highway. Some backwater pools were observed in the reach, usually at the tops of pools at bends in the creek.

●**Fish Spawning Habitat:** A total of 17 spring Chinook salmon redds were observed in the reach. Eight of the redds were found in the upper half mile of the reach, which is lower gradient and gravel dominated. No redds were observed in the lower mile of the reach, where substrate is generally too coarse for spawning. Five redds were observed between RM 7.4 and RM 7.7. Pockets of good spawning habitat exist within this area of the creek.

●**Juvenile Salmonid Rearing Habitat:** Fish rearing habitat is limited in the reach due to the lack of off-channel habitat, lack of side channels, and lack of fish hiding cover (lack of wood). Salmonid juveniles were observed in the two side channels at RM 6.2. Boulders in some areas of the reach and rip-rap that is protecting U.S. Highway 2 are providing some hiding cover for rearing fish.

●**Substrate and Fine Sediment:** Two pebble counts were conducted in the reach. About 13% of the substrate at the pebble counts sites consisted of fine sediments < 6 mm, which is considered functioning at risk in the USFWS Matrix of Pathways and Indicators (12% to 20% surface fine sediments < 6 mm is considered at risk; The MPI does not have a standard for surface fines). Substrate embeddedness did not appear to be a problem in the reach, as very little of the coarse gravel/small cobble substrate was judged to be embedded by surveyors. Fine sediment does not appear to be negatively affecting spawning habitat in this reach.

●**Bank Erosion:** About 7% of the banks are actively eroding in the reach. While about half of the erosion appears to be naturally occurring, the remaining erosion is caused by the removal of vegetation for the construction/maintenance of power line corridors, private property development (home construction, and from the constriction of the channel due to the road.

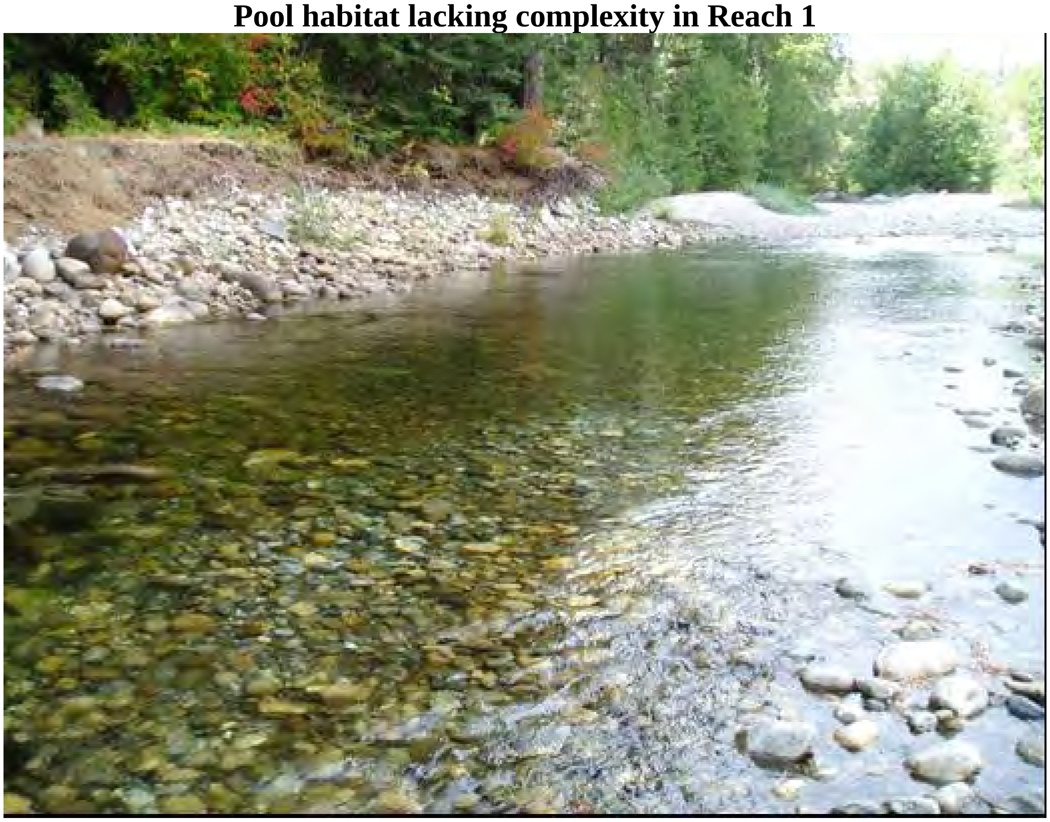
●**Bankfull Data:** A total of seven bankfull width measurements were taken in the reach. The bankfull width averaged 95', with a range of 82' to 120'. The average width/depth ratio in the reach was 44:1. The floodprone width varied from 92' (at the end of the reach) to greater than 500' in the middle of the reach. The lower five floodprone widths measured in the reach agree with the low surface elevations estimated by the BOR (at RM 4.8, 5.4, 6.3, 7.1 and 7.5). The upper two floodprone widths we measured (at RM 8.1 and 8.5) show a constricted channel, while BOR low surface elevations show that this segment of the channel is mainly unconstricted. The average wetted width in the stream reach at low flow is about 60'.

●**Stream Temperatures:** We did not install temperature monitors in Nason Creek during this survey. The Wenatchee River Ranger District and the Washington Department of Ecology have recorded extensive temperature data for several years. Summer temperatures typically exceed WDOE water quality standards in the lowest flows during late summer. This may have occurred naturally prior to development in low flow years because of natural conditions. We suspect channel alteration, harvest, and subsequent channel adjustments have exacerbated natural temperature exceedences.

Nason Creek alongside Highway 2 in Reach 1

Bank erosion from power line crossing at RM 6.2

Pool habitat lacking complexity in Reach 1



II. HABITAT ASSESSMENT: NASON CREEK REACH 2 (BOR Reach NC2)
From where the creek becomes constricted at RM 8.9 to the bridge crossing at RM 9.4

Summary of Habitat Data:

●**Reach Description:** This 0.5 mile reach is a straight, low gradient (1%) channel segment with about equal amounts of pool and riffle habitat. The channel is naturally confined throughout the reach. The reach is mainly a F3 channel type under Rosgen's channel classification system, with a small amount of F4 channel at the top of the reach.

●**Habitat Area:** The habitat area in the reach is about 18,000 square yards (32,000 square yards per mile), consisting of about 54% pool habitat and 46% riffle and run habitat. There is no side channel habitat in the reach.

●**Large Wood:** Large wood is very scarce in the 0.5 mile segment of stream, likely due both to wood removal upstream for road and railroad construction and to the high energy, straight channel, which is transporting wood downstream. About 10.6 pieces of wood per mile greater than 35' long with a diameter of at least 12" counted in the reach (about the same as Reach 1). Smaller pieces of wood in this reach (>20', >6" diameter) were about 66% higher than in Reach 1. No log jams were found in the reach. The recruitment potential for large wood is fair to good, with conifers found above both banks.

●**Pool Habitat:** About 54% of the total habitat area in the main channel consisted of pools. Pool habitat in the reach was more shallow than in the other four reaches, due mainly to the lack of wood in the pools which deepens scour. About 10.5 pools per mile were counted in the reach, about 33% higher than in Reach 1. The number of pools may be near natural levels in this reach, although pools lack complexity (no wood). Pools were formed mainly at the bends in the creek and by the bridge at the end of the reach. Boulders provide some hiding cover in pools in the lower half of the reach.

●**Riffle Habitat:** About 46% of the total habitat area in the main channel consisted of riffles. Hiding cover in the riffles was fair in the higher gradient riffles found in the lower half of the reach, with boulders and large cobble providing pocket pools and cover for fish. Hiding cover was poor in the riffles that did not have large substrate as there was almost no large wood, the channel bottom was uniform and there was little overhead cover above the stream. The average thalweg depth in the riffles was 1.25', providing good passage for fish migration.

●**Side Channel and Off-Channel Habitat:** No side channel habitat exists in the reach due to the constricted channel. A large pond (human constructed, enhanced by beaver) above the left bank at the end of the reach may not be accessible to fish, as the dam is four feet high. No other off-channel habitat exists in the reach.

●**Fish Spawning Habitat:** Excellent fish spawning habitat is found in the gravel-dominated upper half of this reach. A total of 12 spring Chinook salmon redds were observed in the reach, all in the upper half of the reach. The redds were located above a bedrock constriction in the middle of the reach. Upwelling in the area of the bedrock may make this area attractive to spawning salmon. The 21.6 redds per mile was by far the highest number of redds per mile in the surveyed segment of Nason Creek. Pools greater than 450' long and about 4.5' deep are found at the upper and lower end of the spawning area.

●**Juvenile Salmonid Rearing Habitat:** Fish rearing habitat is limited in the reach due to the lack of off-channel habitat, lack of side channels, and lack of fish hiding cover (lack of wood). Some rearing habitat exists among the boulders in the slower water in the lower half of the reach.

●**Substrate and Fine Sediment:** Substrate consisted almost entirely of cobbles and gravels in the upper half of the reach, ideal for anadromous fish spawning. Substrate was too coarse in the lower half of the reach for anadromous fish spawning. One pebble count was conducted in the reach during the survey, about half way through the reach, where the substrate size is transitioning from cobble dominated to gravel dominated. Surface fine sediments were below the 12% threshold established by USFWS for good fish habitat. Substrate embeddedness did not appear to be a problem in the reach, as very little of the coarse gravel/small cobble substrate was judged to be embedded by the surveyors.

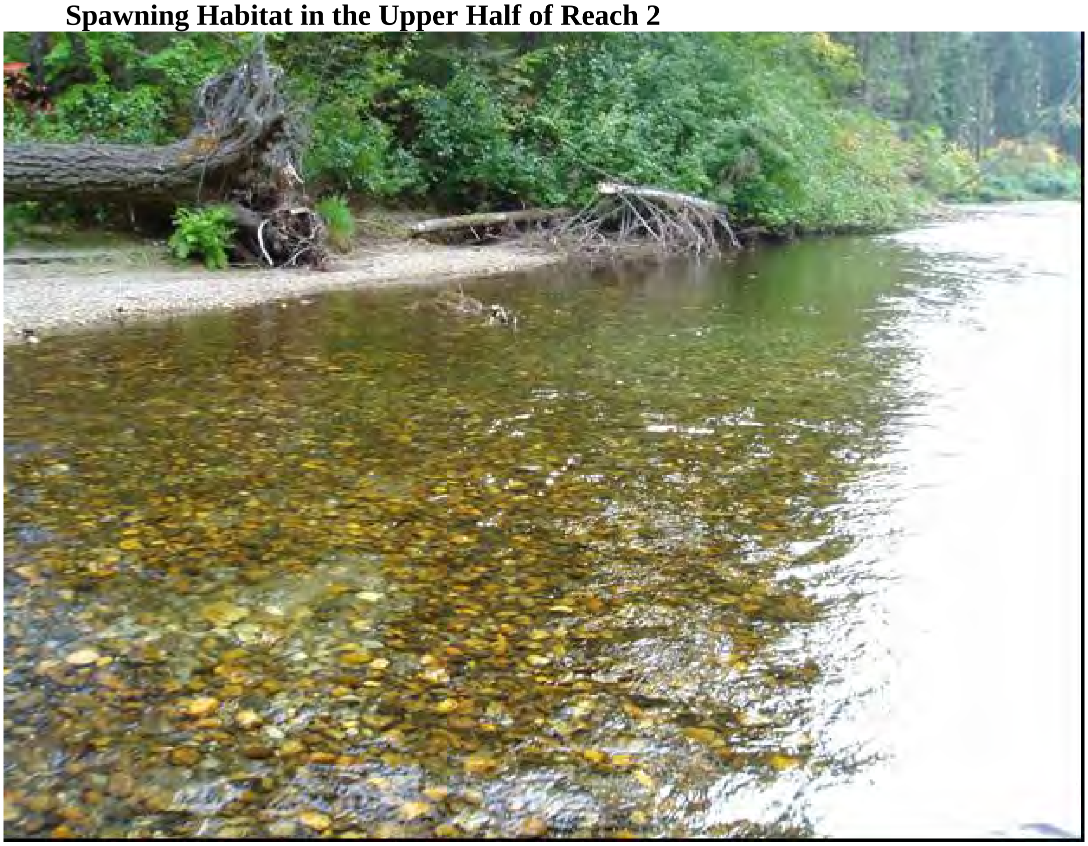
●**Bank Erosion:** About 7% of the stream banks are actively eroding, about the same as Reach 1. Nearly all of the bank erosion is from natural causes (bends in the constricted stream channel). Bank erosion in the reach does not appear to be affecting spawning habitat.

●**Bankfull Data:** Two bankfull width measurements were taken in the constricted reach. The bankfull width averaged 75' and the bankfull width/depth ratio averaged 27:1. The floodprone width was only 90', with steep slopes above both banks. Floodprone widths in the reach agree with the low surface elevations estimated by the BOR that show that the reach is naturally constricted. The average low flow wetted width is 54' in the reach.

●**Stream Temperatures:** We did not install temperature monitors in Nason Creek during this survey. The Wenatchee River Ranger District and the Washington Department of Ecology have recorded extensive temperature data for several years. Summer temperatures typically exceed WDOE water quality standards in the lowest flows during late summer. This may have occurred naturally prior to development in low flow years. We suspect channel alteration, harvest, and subsequent channel adjustments have exacerbated natural temperature exceedences.

●**Fish Passage:** There are no fish passage barriers in the reach.

Spawning Habitat in the Upper Half of Reach 2



III. HABITAT ASSESSMENT: NASON CREK REACH 3
From the bridge crossing at RM 9.4 to where the creek becomes constricted at RM 11.75

Summary of Habitat Data:

●**Reach Description:** This 2.35 mile reach is a moderately sinuous, very low gradient (< 0.5%) channel segment comprised mainly of pools. U.S. Highway 2 parallels the left bank of the creek and the railroad bed parallels the right bank of the creek throughout the entire reach. The railroad bed has cut off the creek from its floodplain. Segments of the stream from RM 10.1 to 10.7 and from RM 11 to 11.5 are unconfined and gravel dominated (Rosgen C4 channel type). The railroad bed, power line right of way and (to a lesser extent) highway 2 has confined most of the channel throughout the rest of the reach. The confined segments of the reach are an F4 Rosgen channel type.

●**Habitat Area:** The habitat area in the reach is about 79,000 square yards (32,500 square yards per mile), consisting of about 29% riffle and run habitat, 70% pool habitat, and 1% side channel habitat. (See page 19 for a summary of attributes by reach).

●**Large Wood:** Large wood is very scarce in the 2.35 mile segment of stream, likely due to the past removal of wood from the stream for flood control and during the construction of Highway 2, the railroad bed and the power lines. A total of 38 pieces of wood (15.7 pieces per mile) greater than 35' long with a diameter of at least 12" were counted in the reach. Almost half of this wood is found in a huge log jam at a bend in the river at RM 11.2. About 8.7 pieces of large wood per mile is found in the rest of this reach (without the jam), a very low amount of wood in such a low gradient, depositional stream segment. Large pieces of wood have been cabled or placed in the channel to prevent bank erosion at RM 9.5 and RM 10.3. Chinook redds were observed in areas of the reach that had pieces of wood. The future recruitment potential for large wood is very poor in this reach. Trees in the reach were harvested during the construction of the railroad bed and power lines, and are cut down on a regular basis to prevent damage to power lines and the railroad.

●**Pool Habitat:** The number of pools per mile and the % pool habitat is higher in this reach than any of the other reaches in the surveyed segment of Nason Creek. A total of 42 pools were counted (17.4 per mile). Although some deep pool habitat exists in the reach, pools generally do not have a lot of cover and lack complexity (due mainly to the lack of wood). A total of 11 pools greater than five feet deep were observed in the reach (4.5 pools per mile). Six of the 11 deep pools were formed by large wood.

●**Riffle Habitat:** About 29% of the total habitat area consisted of riffles and runs. Hiding cover in the riffles was poor as there was almost no large wood, the channel bottom was uniform and there was little overhead cover above the stream surface. The average thalweg depth in the riffles was about a foot deep, and considered adequate for fish migration.

●**Side Channel and Off-Channel Habitat:** Very little side channel and off-channel habitat exist in the reach as the railroad bed has cut off much of the floodplain on the south side of the creek. About 1.1% of the total habitat area at low flow consists of side channel habitat, which is very low for such a low gradient channel. A wetted side channel/wetland on the north side of the creek at river mile 11.3 was disconnected from the creek on both the upper and lower ends at low flow. A four foot berm at the mouth of the side channel prevented connection to the main channel. Some backwater pools were observed in the reach, usually at the tops of pools at bends in the creek.

●**Fish Spawning Habitat:** A total of 17 spring Chinook salmon redds were observed in the reach (7 per mile). Many of the redds were associated with pieces of large wood. Redds were observed in riffles and at pool crests near pools that had good hiding cover from wood. This reach likely had historically high numbers of spawning fish.

●**Juvenile Salmonid Rearing Habitat:** Fish rearing habitat is limited in the reach due to the lack of off-channel habitat, lack of side channels, and lack of fish hiding cover (lack of wood). Salmonid juveniles were observed in the pool under the huge log jam at RM 11.2. Hundreds of half inch long fish fry (non-salmonid) were observed in a small side channel along the right bank at RM 10.3. The rip-rap protecting the railroad bed may provide some cover for fish rearing.

●**Substrate and Fine Sediment:** One pebble count was conducted in the reach. About 11% of the substrate at the pebble count site consisted of fine sediments < 6 mm, which is considered functioning appropriately in USFWS Matrix of Pathways and Indicators (12% to 20% surface fine sediments < 6 mm is considered at risk; the MPI does not have a standard for surface fines). Substrate embeddedness did not appear to be a problem in the reach, as very little of the coarse gravel/small cobble substrate was judged to be embedded by surveyors. Fine sediment does not appear to be negatively affecting spawning habitat in this reach.

●**Bank Erosion:** The amount of bank erosion is highest in this reach, with about 10% of the banks actively eroding in the reach. About 75% of the total bank erosion in the reach appeared to be naturally occurring. The remaining 25% of the bank erosion appeared to have been caused by the removal of vegetation for the construction of the railroad bed, houses and the power line right of way. Over 500' of meadow on the left bank of the creek is rapidly eroding above the huge log jam at RM 11.2. Large chunks of sod are falling into the creek bed.

●**Bankfull Data:** A total of 3 bankfull width measurements were taken in the reach. A bankfull width of 87 feet and floodprone width of 100 feet was measured at RM 9.6, where the channel has been constricted along the right bank by the railroad bed. The width/depth ratio at this location was about 45:1. The other two bankfull widths were measured at RM 10.4 and RM 11.3, where the channel is unconfined. The two bankfull widths averaged 105' wide, with a width/depth ratio of about 50:1. The floodprone width was greater than 500 feet at both of the upper sites. Floodprone widths at the upper two bankfull sites in the reach agree with the low surface elevations estimated by the BOR (channel is unconfined). BOR low surface elevation data shows less confinement at RM 9.6 than we measured using the stream survey protocol. The average wetted width in the stream reach at low flow is about 55'.

●**Stream Temperatures:** We did not install temperature monitors in Nason Creek during this survey. The Wenatchee River Ranger District and the Washington Department of Ecology have recorded extensive temperature data for several years. Summer temperatures typically exceed WDOE water quality standards in the lowest flows during late summer. This may have occurred naturally prior to development in low flow years. We suspect channel alteration, harvest, and subsequent channel adjustments have exacerbated natural temperature exceedences.

Nason Creek from top of Railroad Grade

Cabled Logs in Pool at RM 10.3

Riffle Habitat in Reach 3

IV. HABITAT ASSESSMENT: NASON CREK REACH 4
From RM 11.75 to where the creek has been channeled at RM 13.4

Summary of Habitat Data:

●**Reach Description:** This 1.6 mile reach is a moderately sinuous, low gradient (< 1%) channel segment comprised mainly of pools. U.S. Highway 2 parallels the left bank of the creek and the railroad bed parallels the right bank of the creek throughout the entire reach. While much of the channel in the lower segment of the reach (below RM 12.5) is confined by human features, most of the upper channel above RM 12.5 appears to be moderately naturally confined, with an entrenchment ratio of about 1.65 (Rosgen B3c channel type).

●**Habitat Area:** The habitat area in the reach is about 47,000 square yards (27,700 square yards per mile), consisting of about 27% riffle and run habitat, 72% pool habitat, and 1% side channel habitat. (See table page 19 for a summary of attributes by reach.).

●**Large Wood:** Amounts of large wood were higher in this reach than in any other stream segment within the surveyed area, with about 26 pieces per mile greater than 35' long with a diameter of at least 12". Wood is likely far below natural levels due to the past removal of wood from the stream for flood control and during the construction of Highway 2, the railroad bed and the power lines. Two log jams were observed in the channel in the reach, at RM 12.9 and RM 13.1. Both jams were at bends in the stream and both jams created deep pool habitat. Four of the eight Chinook redds observed in the reach were near the log jams. Although the future recruitment potential for large wood has been reduced in the reach by Highway 2, houses and power lines, the future wood recruitment potential is greater than in Reach 3.

●**Pool Habitat:** About 15 pools per mile were counted in the reach, higher than in any reach except Reach 3, which had 17 pools per mile. Pools were deeper than in any other reach in the surveyed stream segment, with an average maximum depth of 4.6' and an average residual depth of 3.6' (max depth minus depth at pool crest). Pool habitat generally lacked complexity below RM 12.8, but deep, complex pool habitat was observed in a half mile segment of the reach located between RM 12.8 and RM 13.3. A pool at least seven feet deep at RM 11.8 was formed at a stream bend and by rip-rap that protects houses and the bridge that spans Nason Creek at the town of Merritt. An 800 foot long, six foot deep pool formed by the constricted channel along Highway 2 (RM 12.4 to 12.6) lacked habitat complexity (no wood), although boulders (rip-rap) and depth in segments of the pool provide rearing habitat. A total of nine pools at least five feet deep were observed in the reach (5.3 pools per mile). Six of the nine pools were formed by or deepened by large wood.

●**Riffle Habitat:** About 27% of the total habitat area consisted of riffles and runs. Hiding cover in the riffles was generally poor as there was almost no large wood, the channel bottom was uniform and there was little overhead cover above the stream surface. The average thalweg depth in the riffles was about 1.1 feet deep, adequate passage for fish migration.

●**Side Channel and Off-Channel Habitat:** Very little side channel and off-channel habitat exist in the reach (at low flow), due both to human impacts (dikes, rip-rap, road fill) and to a naturally constricted channel in the upper half of the reach. A large wetland complex formed by beaver dams above the left bank at the end of the reach connects to the creek at higher flows. Much of this wetland complex has been cut off from the creek below RM 13.3 by a large dike built to protect power lines. A small side channel (3' wide) on the left bank at RM 12 could not be walked due to deep silt in the channel. The loose silt substrate was measured at 2.6 feet deep! The side channel appears to be storing large amounts of fine sediment and likely contributing to the higher fine sediment count in this reach.

●**Fish Spawning Habitat:** A total of eight spring Chinook salmon redds were observed in the reach (4.7 per mile). Four of the redds were near the two log jams in the reach. This reach likely had historically high amounts of fish spawning.

●**Juvenile Salmonid Rearing Habitat:** Fish rearing habitat is limited in the reach due to the lack of off-channel habitat, lack of side channels, and lack of fish hiding cover (lack of wood). Some good juvenile rearing habitat was observed in the pools formed by log jams and in the boulders (rip-rap) in the lower half of the reach.

●**Substrate and Fine Sediment:** One pebble count was conducted in the reach. About 19% of the substrate at the pebble count site consisted of fine sediments < 6 mm, which is considered at risk in USFWS Matrix of Pathways and Indicators (12% to 20% surface fine sediments < 6 mm is considered at risk; the MPI does not have a standard for surface fines). Substrate embeddedness did not appear to be a problem in the reach, as very little of the coarse gravel/small cobble substrate was judged to be embedded by surveyors. Although fine sediment does not appear to be negatively affecting spawning habitat in this reach, surface fine sediments are more abundant in this reach and could be more abundant in spawning gravels.

●**Bank Erosion:** The amount of bank erosion is low in this reach, with only 4% of the banks actively eroding. Much of the banks in the reach are armored with rip-rap to protect U.S. Highway 2 and houses at the town of Merritt.

●**Bankfull Data:** A total of three bankfull width measurements were taken in the reach. The bankfull width of 54 feet was measured in the lower segment of the reach (just above Merritt, next to Highway 2). Bankfull widths of 87 feet and 93 feet were taken in the upper half of the reach. The floodprone zone (elevation of two times the maximum bankfull depth), measured 142' and 153' in the upper half of the reach. The width/depth ratio at the bankfull site just above Merritt was 19:1. The width/depth ratio in the upper two sites averaged 48:1. Floodprone widths at the lower bankfull site (RM 12) and upper bankfull site (RM 13.2) in the reach agree with the low surface elevations estimated by the BOR, channel is confined (lower site) and moderately confined (upper site). BOR low surface elevation data shows less confinement at RM 12.7 than we measured using the stream survey protocol. The average wetted width in the stream reach at low flow is about 47 feet, narrower than downstream reaches, mainly due to channel constrictions.

●**Stream Temperatures:** We did not install temperature monitors in Nason Creek during this survey. The Wenatchee River Ranger District and the Washington Department of Ecology have recorded extensive temperature data for several years. Summer temperatures typically exceed WDOE water quality standards in the lowest flows during late summer. This may have occurred naturally prior to development in low flow years. We suspect channel alteration, harvest, and subsequent channel adjustments have exacerbated natural temperature exceedences.

●**Fish Passage:** There are no fish passage barriers in the reach.

Log jam and deep pool habitat in Reach 4

Pool formed by wood in Reach 4

V. HABITAT ASSESSMENT: NASON CREK REACH 5
From RM 13.4 to Railroad Bridge Crossing at RM 14.2

Summary of Habitat Data:

●**Reach Description:** This 0.8 mile reach is a straight, channeled segment of the stream comprised mainly of riffles and one ¼ mile long pool. This segment of the creek was moved from its original stream bed during construction of the railroad in the 1940s. The right bank consists of the railroad bed and the left bank has been rip-rapped to protect power lines. Both banks of Nason Creek have been cut off from its floodplain.

●**Habitat Area:** The habitat area in the reach is about 22,400 square yards (25,400 square yards per mile), consisting of 63% riffle and run habitat, 36% pool habitat, and 1% side channel habitat. (See table on page 19 for a summary of attributes by reach.).

●**Large Wood:** Large wood is nearly absent from the channel in the lower ¾ miles of the reach. A log jam at the top of the reach diverts flow into the one side channel in the reach (just above the channeled segment of stream). Future wood recruitment potential from the adjacent riparian corridor is poor due to the railroad grade and power lines. Wood delivered to the valley bottom from debris slides likely would not reach the current channel because of revetments in much of this section.

●**Pool Habitat:** Only three pools exist in the 0.8 miles of stream. A 1,350 foot long pool is found near the beginning of the reach, formed by the constricted channel. Pool habitat quality is poor, with little or no wood in the pools. No spawning gravel exists at the pool crests. This reach is not properly functioning for pools or for wood.

●**Riffle Habitat:** About 63% of the total habitat area consisted of riffles and runs. Nearly the entire reach above the 1,350 foot long pool consists of straight, deep riffle habitat. No spawning habitat exists in the riffles. Hiding cover is limited due to rip-rap along the sides of the channel, and to boulders in the upper half of the reach. The average thalweg depth in the riffles was about 1.5 feet deep (deepest in the survey) due to the narrow channel width.

●**Side Channel and Off-Channel Habitat:** One side channel exists in the reach, formed by a log jam on the right bank just below the railroad bridge. Juvenile salmonids were observed rearing in the pools in the side channel at the time of the survey (two, 2 foot deep pools were seen in the side channel). A wetland complex beyond the left bank of Nason Creek has been cut off from the creek by a dike built to protect the power lines.

●**Fish Spawning Habitat:** No spring Chinook salmon redds were observed in the reach. The reach has very little, if any, spawning habitat.

●**Juvenile Salmonid Rearing Habitat:** Fish rearing habitat is limited in the reach due to the lack of off-channel habitat, lack of side channels, and lack of fish hiding cover (lack of wood). Some rearing habitat exists in the rip-rap along the channel margins in the lower half of the reach and among the pocket pools created by boulders in the upper half of the reach.

●**Substrate and Fine Sediment:** One pebble count was conducted, a little more than half way through the reach. About 7% of the substrate at the pebble count site consisted of fine sediments < 6 mm. Fine sediments in the higher gradient upper half of the reach are being transported and deposited in the long pool at the bottom of the reach (and downstream reaches).

●**Bank Erosion:** Both banks are hardened, which prevents erosion. No notable erosion was observed in the reach.

●**Bankfull Data:** Two bankfull width measurements were taken in the reach. The average of the two bankfull width measurements was 47 feet; the average of the two width/depth measurements was 18:1. The entrenchment ratio (floodprone width divided by bankfull width) was 1.20. Floodprone widths in the reach agree with the low surface elevations estimated by the BOR that show that the reach is constricted. The average wetted width in the stream reach at low flow is about 43 feet, narrower than downstream reaches due to the constricted channel.

●**Stream Temperatures:** We did not install temperature monitors in Nason Creek during this survey. The Wenatchee River Ranger District and the Washington Department of Ecology have recorded extensive temperature data for several years. Summer temperatures typically exceed WDOE water quality standards in the lowest flows during late summer. This may have occurred naturally prior to development in low flow years. partly to natural conditions. We suspect channel alteration, harvest, and subsequent channel adjustments have exacerbated natural temperature exceedences.

●**Fish Passage:** There are no fish passage barriers in the reach.

●**Habitat above the Railroad Bridge:** The channel is constricted by bedrock and the road to the bridge crossing several hundred feet upstream. The channel is higher gradient in this area; a series of step pools was observed above the railroad bridge. No habitat was observed above the road crossing.

Nason Creek in channelized Reach 5

APPENDIX A: STREAM CONDITION ASSESSMENT

A statistical analysis (USFS 1998) of stream survey data within the Wenatchee Highlands Land Type Association found that a subset of fifth field watersheds within the Wenatchee Highlands subsection were relatively similar to each other. This relatively homogenous group included streams within the White, Little Wenatchee, Chiwawa, Nason, and Icicle watersheds. The analysis was conducted to determine if geomorphic, vegetative, climatic and/or channel variables could serve as predictive associations of pool and LWD abundance to identify "reference" parameter values (a natural range of stream condition). The ultimate goal of the analysis was the creation of categories, with reduced variation within category.

The tables below (Table 1 and Table 2) show the results of the analysis and the categories that can be used to assist in determining relative stream health. In Table 3, Nason Creek data is compared to a selected data set from relatively unimpacted streams within the fifth field watershed subset to consider how Nason Creek ranks within the pool and LWD categories.

Table 1. Channel categories for LWD.

LWD Size	Channel Type	Typical Range*	Mean	Median	Percentiles				Sample Size
					10th	25th	75th	90th	
LWD >12"	Pool-riffle	75-200	75	72	21	39	97	134	23
	other	25-200	65	60	24	37	81	110	47
	bedrock	15-200	59	40	10	19	97	164	17
	<10 ft. wide	5-100	33	18	5	10	64	72	5
LWD >20"	All other channels	15-100	31	25	8	16	43	66	56
	Bedrock	0-50	22	13	1	3	31	60	18
	No large riparian	0-35	12	9	0	1	21	32	34

Table 2. Channel categories for percent riffle area.

Channel Type	Typical Range*	Mean	Median	Percentiles				Sample Size
				10th	25th	75th	90th	
Pool-riffle	25-65	43	42	24	32	58	64	23
Low gradient plane-bed	45-70	61	61	47	48	67	88	19
Bedrock	55-95	72	69	57	59	82	94	18
Other	60-99	80	84	68	75	89	96	45

* 'Typical' was a subjective determination which took management history into account.

Table 3. NASON Creek LWD and pool data compared to 'unimpacted' river segments within the Wenatchee Highlands subsection.

	Nason Creek: RM 4.6 to RM 14.2	Little Wenatchee: RM 10.5 to 12.2	Chiwawa River: RM 13.8 to RM 17.5	Chiwawa River: RM 25.7 to RM 33.1
Est. Beginning Elevation of Reach	1960	2300	2400	2544
Est. Ending Elevation of Reach	2240	2330	2544	2772
Estimated Channel Gradient	0.5%	0.3%	0.2%	0.7%
Channel Type:	Pool-riffle	Pool-riffle	Pool-riffle	Pool-riffle
Rosgen Channel Type	C3, F3	C4	C4	C4
Habitat Area:				
% Pool	47%	34%	49%	34%
% Riffle and Glide	52%	61%	47%	51%
% Side Channel	1%	1%	4%	6%
Pools:				
Pools per mile in main channel	10.6	10.0	24.6	14.0
Pools > 3' deep per mile	9.0	10.0	24.6	13.5
Large Wood per Mile:				
>6 inches	23.8	51	238	116
>12 inches	10	39	35	16
>20 inches	5	31	6	3

NASON CREEK STREAM SURVEY DATA SUMMARY
Bend at RM 4.56 to Railroad Bridge at RM 14.20
09-17-07 to 09-19-07 AND 09-26-07 to 09-27-07

	Reach 1	**Reach 2**	**Reach 3**	**Reach 4**	**Reach 5**	**Total**
Reach Mileage Boundaries (BOR maps)	RM 4.56 to 8.90	RM 8.90 to 9.42	RM 9.42 to 11.75	RM 11.75 to 13.37	RM 13.37 to 14.20	RM 4.56 to 14.20
Reach Length (BOR maps)	4.34	0.52	2.33	1.62	0.83	9.64
Reach Length (measured miles)	4.37	0.56	2.42	1.70	0.88	9.93
Average Wetted Width:	61’	54’	55’	47’	43’	55’
Average Thalweg Depth (riffles):	1.32’	1.25’	1.01’	1.08’	1.46’	1.25’
Average Thalweg Depth (runs):	1.55’	1.40’	1.16’	1.25’	1.43’	1.38’
Habitat Area:						
% Pool	28.6%	54.3%	69.8%	72.6%	36.0%	46.9%
% Riffle	57.5%	35.1%	21.6%	22.3%	48.8%	41.8%
% Runs (non-turbulent riffles)	12.4%	10.6%	7.4%	4.6%	13.8%	10.1%
% Side Channel	1.5%	-	1.2%	0.5%	1.4%	1.2%
Pools:						
Pools per Mile	8.0	10.6	17.4	15.3	5.7	10.6
Pools > 3’ deep per mile	6.9	7.1	11.6	14.1	3.4	9.0
Total # of Pools > 1 meter deep	23	3	21	23	3	73
Pools > 1 meter deep per mile	5.2	5.3	8.7	13.5	3.4	7.4
Pools > 4’ deep per mile	3.2	5.3	7.4	11.7	1.1	5.6
Pools > 5’ deep per mile	1.8	0	4.5	5.3	1.1	2.9
Avg. Pool Maximum Depth	4.1’	3.5’	4.2’	4.6’	3.8’	4.1’
Avg. Pool Residual depth	**2.9’**	2.4’	3.4’	3.6’	**2.3’**	**3.1’**
Riffle to Pool Ratio	2.44 to 1	0.84 to 1	0.42 to 1	0.37 to 1	1.74 to 1	1.11 to 1
Large Wood per Mile:						
Small (>20’ Long, > 6” diameter)	18.1	30.1	21.9	37.6	26.2	23.8
Medium (>35’Long, 12-20” diam.)	8.7	8.8	10.3	12.3	9.1	9.8
Large (>35’ Long, >20” diameter)	1.8	1.8	5.4	13.5	5.7	5.0
Total Large and Medium (>35’ L)	10.5	10.6	15.7	25.8	14.8	14.8
Bank Erosion:						
Total Bank Erosion (both banks)	3,100’	400’	2,585’	695’	0’	6,780’
Linear Length per Mile	710’	708’	1,068’	408’	0’	682’
% Eroding Banks (both banks)	6.7%	6.7%	10.1%	3.9%	0%	6.5%
Bankfull Data:[1]						
-# Bankfull Measurements in Reach	7	2	3	3	2	
-Avg. Bankfull Width	95’	75’	99’	78’	47’	
-Avg. Bankfull Depth (avg. of 7 measurements per bankfull width)	2.15’	2.85’	2.07’	2.16’	2.59’	
-Avg. W/D Ratio	44.0	27.3	47.7	36.0	18.1	
-Avg. Entrenchment ratio[2]	2.38	1.20	4.55	1.55	1.20	

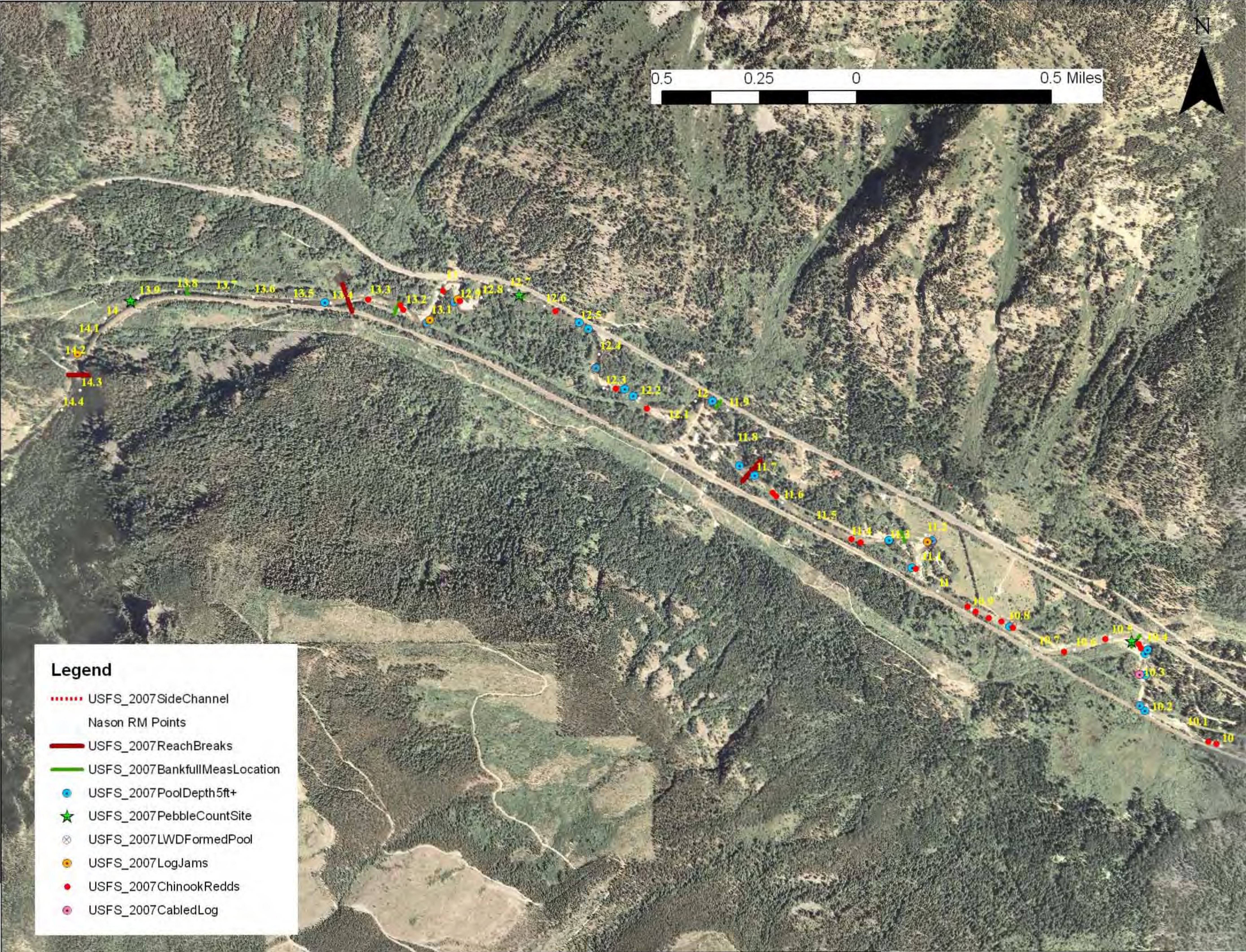
Nason Creek Survey Data page 2	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Total
Sinuosity (estimated from maps)	> 1.30	1.05	1.20	1.30	1.15	
Gradient (estimated)	1%	1%	< 0.5%	< 0.5%	1%	
Substrate (Pebble Count Data):						
-# of Pebble Counts in Reach	2	1	1	1	1	
-% Surface Fines < 6 mm	13%	11%	11%	19%	7%	
-D35	71	45	32	40	118	
-D50	123	103	47	58	171	
-D84	311	325	84	126	415	
Substrate % (Ocular Estimate)						
% Sand	10%	10%	10%	15%	15%	
% Gravel	25%	30%	57%	35%	15%	
% Cobble	40%	35%	30%	35%	40%	
% Boulder	25%	25%	3% (rip-rap)	15% (incl. rr)	30% (incl rr)	
Primary Rosgen Channel Types in Reach:	C3, F3	F3	C4, F4	F3, B3c	F3	
# of Chinook Salmon Redds	17	12	17	8	0	54
# Chinook Salmon Redds per mile	3.9	21.4	7.0	4.7	0	5.4

[1]Rough estimate, two to seven bankfull measurements were taken per reach.
[2]Floodprone width divided by bankfull width.

NASON CREEK POOL QUALITY BY AREA
September 2007 Survey

River Mileage	Length (Miles)	Description of Stream Segment	Pools per Mile	Pools > 5' Deep per Mile	Residual Depth	LWD per mile (pools)[1]	Assessment
4.6 to 5.3	0.70	Sinuous, bar formation, well-vegetated	12.8	2.85	2.4'	19, 5, 9	**At risk** due to lack of wood.
5.3 to 5.75	0.45	Straight channel, few bars, road above right bank	4.4	0	1.7'	45, 0, 0	**At unacceptable risk**
5.75 to 7.75	2.00	Sinuous, largely unconfined, some bar formation, ends at end of BOR subreach	6.0	1.5	3.3'	36, 25, 0	**At risk**
7.75 to 8.9	1.15	Very sinuous, well vegetated, ends at reachbreak.	10.4	2.6	3.0'	8, 3, 0	**At risk** due to lack of wood.
8.9 to 9.42	0.52	Confined, straight, away from road and railroad, ends at reachbreak.	10.6	0	2.4'	31, 9, 0	**At risk**.
9.42 to 10.2	0.78	Straight channel is locked against right back (railroad grade on right bank)	11.5	1.3	2.4'	12, 10, 0	**At unacceptable risk** due to lack of cover (lacks wood).
10.2 to 10.6	0.40	Sinuous, unconfined, large bars.	20.0	12.5	4.3'	20, 12, 5	**Adequate**, lots of deep pool habitat.
10.6 to 11.0	0.40	Straight channel is locked against right bank (railroad grade on right bank)	10.0	2.5	3.1'	18, 4, 0	**At unacceptable risk,** lack of wood.
11.0 to 11.35	0.35	Sinuous, unconfined, large bars, large log jam in channel.	20.0	8.5	3.5'	68, 38, 28	**Adequate**, lots of wood, deep pools.
11.35 to 11.7	0.35	Straight channel locked against R bank.	14.2	0	1.9'	5, 0, 5	**Unacceptable risk**
11.7 to 12.8	1.10	Moderately sinuous, well-vegetated, deep channel, starts just below town of Meritt. Deep pools from constrictions.	15.4	7.3	3.8'	22, 5, 8	**At risk** due to lack of large wood.
12.8 to 13.3	0.50	Sinuous, moderately confined, bars.	20.0	4.0	3.2'	59, 19, 24	**Adequate**
13.3 to 14.25	0.95	Straight, confined, altered channel.	5.7	1.1	2.3'	17, 6, 3	**Unacceptable risk**
Total	**9.65**		**10.6**	**2.9**	**3.1'**	**26, 11, 6**	**At Risk**

[1]Small, medium, and large size class, respectively, in table. Calculation is large wood per mile of pool habitat.



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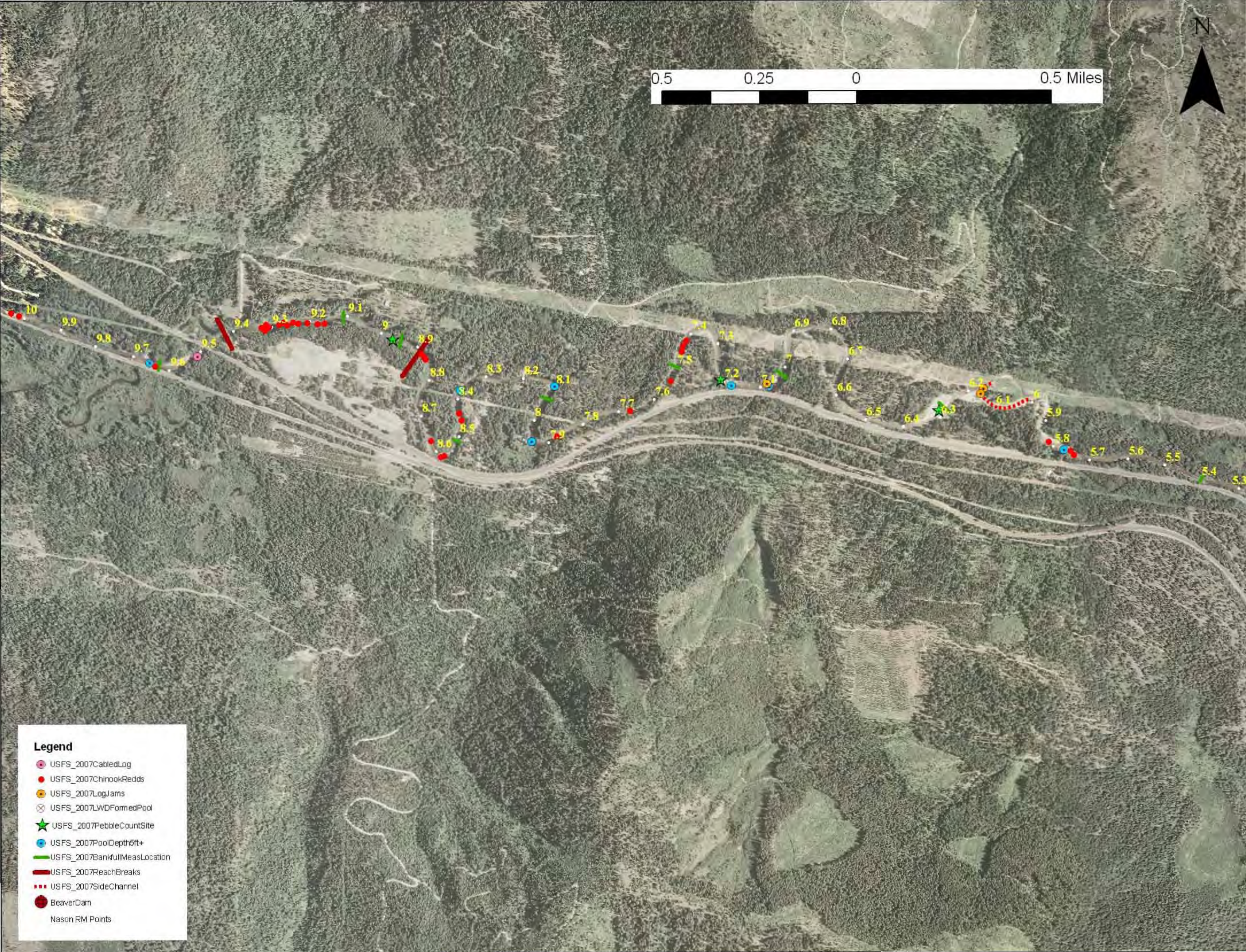
Nason RM Points
USFS_2007ReachBreaks
USFS_2007BankfullMeasLocation
USFS_2007PoolDepth5ft+
USFS_2007PebbleCountSite
USFS_2007LWDFormedPool
USFS_2007LogJams
USFS_2007ChinookRedds
USFS_2007CabledLog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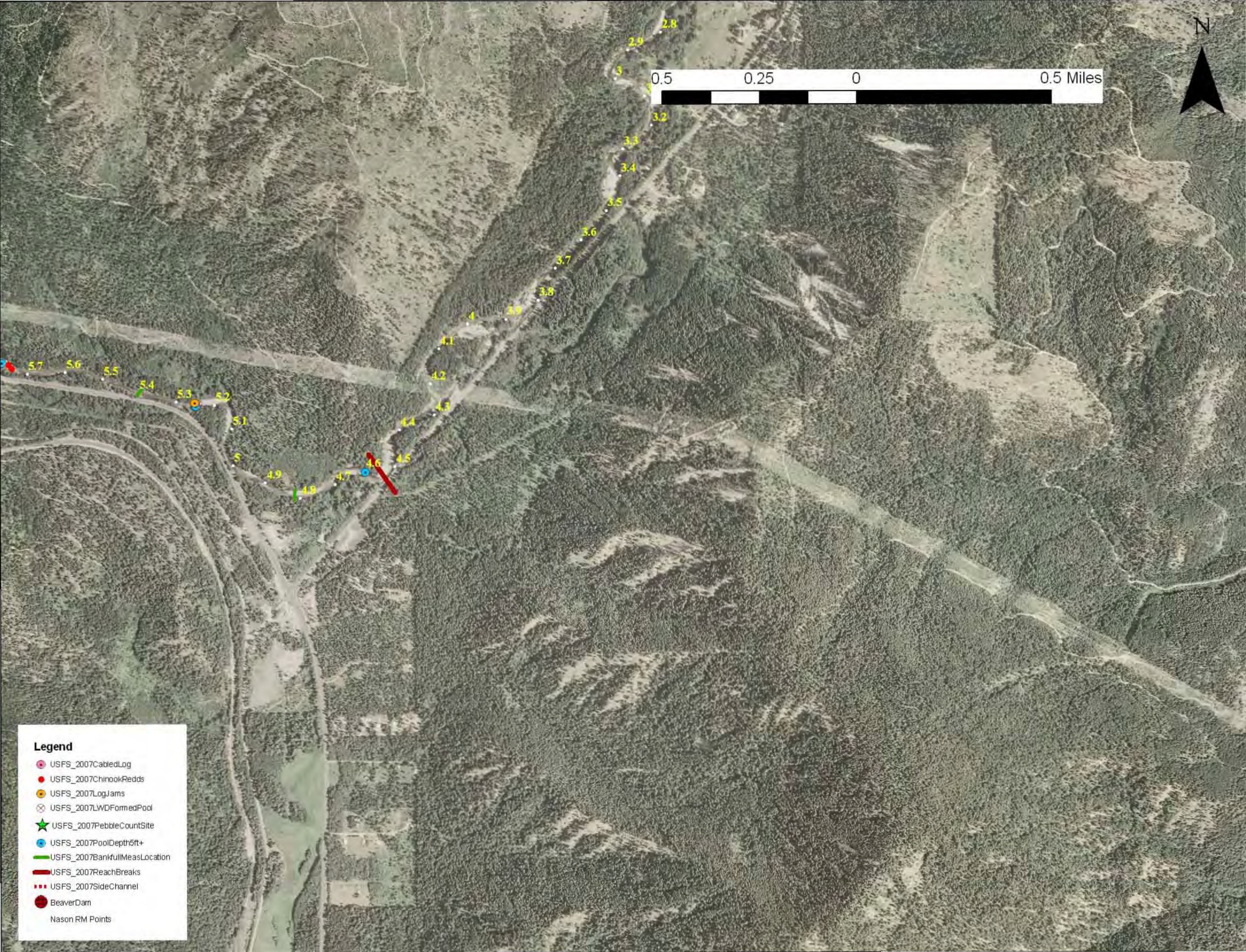
USFS_2007SideChannel
BeaverDam
Nason RM Points



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BeaverDam
Nason RM Points

RECLAMATION
Managing Water in the West

Technical Memorandum 86-68220-08-05

2007 Nason Creek Floodplain Vegetation Assessment

U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Environmental Applications and Research
Denver, Colorado

April 2008

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

BUREAU OF RECLAMATION
Technical Service Center, Denver, Colorado
Environmental Applications and Research (86-68220)

Technical Memorandum 86-68220-08-05

2007 Nason Creek Floodplain Vegetation Assessment

Prepared for:

Bureau of Reclamation
Technical Service Center
Sedimentation and River Hydraulics in Support of Geomorphic Assessments for the PN Regional Office

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U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Environmental Applications and Research
Denver, Colorado

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Contents

Tables

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Executive Summary

The objective of the 2007 riparian vegetation assessment is to provide an understanding of the present vegetation conditions to be utilized for U.S. Bureau of Reclamation's Nason Creek tributary- and reach-scale assessments. A team of ecologist conducted field sampling and GIS analyses of remotely sensed data to create a GIS file containing polygons of vegetation units. Data from the vegetation assessment, along with other components of the geomorphic assessment, will be used for planning and prioritizing salmon recovery efforts in Nason Creek between river miles (RM) 4 and 14.

In August 2007 riparian vegetation was sampled throughout the assessment reach. Data collected included canopy cover and height for overstory and understory species and herbaceous species. These data were used in a GIS along with aerial photography and Light Detection and Ranging data to interpret riparian vegetation and create vegetation units within the reach. The vegetation units were classified into the Oregon/Washington U.S. Forest Service vegetation units for consistency with previous mapping available for lower Nason Creek RM 0 to 4.

Utilizing GIS, vegetation units were analyzed for the potential contribution of riparian vegetation for healthy salmon habitat. Analyses included natural species presence (potential natural community), large woody debris (LWD) trees, and shading (see table below). Areas of presently functioning vegetation were identified for potential easement or protection strategies. Presently functioning was generally defined as areas with native vegetation species that were at least several decades old (most areas were historically logged). Acres of LWD-sized trees—trees over 40 feet (12 meters) tall—from the riparian vegetation mapping were compiled for the entire floodplain and for an 82-feet (25-meters) buffer adjacent to the stream. Potential for thermal shading by the riparian vegetation within the 82-feet (25-meters) buffer was also quantified. Vegetation units were also ranked based on professional judgment for the level of effort needed to restore vegetation to a hypothesized natural condition.

The riparian vegetation along Nason Creek is generally in good health, and species are of potential naturally occurring species. Douglas-fir and grand fir are typically co-dominant in the canopy with vine maple being the common understory species. Black cottonwoods are present along the river and along abandoned river channels. Sand-bar willows and black cottonwood are present on gravel bars and cobble bars. Pacific willow and some alder species are found in wet areas. Limited amounts of western red cedar are mixed throughout the reach. Old growth (legacy) trees are absent from the reach and were most likely logged. A large amount of logging of the floodplain and log drives down the river

Summary of Nason Creek vegetation analysis results by geomorphic reach

Reach	Area (acres)	Presently impacted[1] (acres)	Natural species[2] (acres)	% Natural	% Impacted	LWD potential area[3] (acres)	% LWD potential area	% shaded[4]
1	334.9	54.69	280.1	84%	16%	206.2	62%	80%
2	13.6	0	13.6	100%	0%	9.2	68%	96%
3	607.6	128.27	479.3	79%	21%	255.4	42%	77%

[1] Impacted areas which are not potential natural community riparian vegetation but are anthropogenic land cover including railroad rights-of-way, roads, power line corridors, private and commercial property.
[2] Riparian areas which contain potential natural communities.
[3] Areas where the over 50 percent is covered by canopy of trees of LWD height [trees over 40 ft (12 m) tall] which could be potentially recruited into Nason Creek by either high flows or active river migration.
[4] Percent of main channel which is presently shaded by vegetation. Note that this estimate is based on a buffer width along the stream of 82 ft (25 m).

occurred along Nason Creek in the early 1900s, but the exact extent and impact is not documented. The riparian forest appears to be recovering back to the historic grand fir forest. Ponded areas containing wetland indicator plants were observed in the reach; however, wetlands delineation was not a part of this scope. A limited amount of mammalian herbivory was observed, most likely from deer. Tree diseases were not evaluated but do not appear to be a limiting factor for healthy riparian vegetation. The majority of the forest is recovering and appears to be trending back to historical conditions. However, localized areas of the floodplain vegetation have been completely cleared due to construction of the highway, railroad, power lines, and commercial and residential development. Active residential development is also occurring in the reach and would further impact the riparian vegetation if it continues to expand. Noxious weeds were found in limited areas such as under power lines and may increase over time if not controlled.

Where riparian forest vegetation is present along the river, trees of adequate LWD size are available for future and immediate recruitment into the river if river migration processes are restored. Although cleared areas adjacent to the river had inadequate shading, aerial photography shows the majority of the river was shaded by tall trees. Further analyses should be completed to determine if the riparian vegetation provides adequate shading for the river. Large historical channel and floodplain areas presently cut off by the railroad and highway are now ponded. For example, the area to the south of the railroad between RM 9 and 11 is now disconnected from the river and contains several wetland-type species and naturally broken-off stumps where tall trees used to be present. This area might require major vegetation restoration efforts to restore it to historical conditions on a short timeframe of years.

High energy floods are also a concern in the reach, and have impacted vegetation adjacent to the river channel, reducing regrowth of trees and shrubs along with the presence of LWD in the main channel. In artificially confined reaches, there is limited bar development or floodplain surfaces for vegetation to establish. Most banks in these areas are riprap.

Additional analyses may be needed at project level scale to further develop riparian restoration strategies. More field measurements of tree age and species health may be of particular use at these smaller scales. High water temperatures are a concern on the river, and further study is recommended to better understand the contribution of riparian vegetation to the thermal regulation of the river.

2007 Nason Creek Floodplain Vegetation Assessment

Background/Objectives

The Nason Creek watershed is located on the eastern slope of the Cascade Mountains in central Washington. The headwaters of Nason Creek are at the crest of the Cascades Mountain Range and flow east for approximately 21 miles (34 kilometers) and then turn north for another 5 miles (8 kilometers) before emptying to the Wenatchee River at Lake Wenatchee. Past U.S. Forest Service (USFS) vegetation assessments indicated that the watershed is a vegetative transition zone, stretching from high elevation sub-alpine forest to dry forest environments.

The Nason Creek floodplain is currently occupied by sucessional coniferous forest. A mean annual precipitation of over 60 inches (1.5 meters) a year supports a grand fir/vine maple series as defined by Lillybridge et al. 1995. Douglas-fir and grand fir are typically co-dominant in the canopy with vine maple being the common understory species. Black cottonwood is present along the creek and along abandoned creek channels. Western red cedar is mixed throughout the floodplain. Ponderosa pine is scattered in the upstream portion of the watershed and becomes more dominate in the downstream direction. Monotypic ponderosa stands exist on higher and drier sites adjacent to the floodplain. A smaller percentage of the riparian vegetation is composed of riparian non-forest habitats consisting of hardwood stands, shrubs, wetlands, and meadow.

The objective of the 2007 vegetative assessment was to fill data gaps on U.S. Bureau of Reclamation's (Reclamation) Nason Creek tributary and reach assessments (two stages of analysis) in the vegetation component for river mile (RM) 4 to 14 (Coles Corner to White Pine Campground). For these analyses, the following vegetation products were needed:

1) Vegetation composition and structure of present (2006 to 2007) site conditions within the area of active channel migration and floodplain processes (low surface)
    a. Utilize initial vegetation mapping for Nason Creek by the USFS done solely with aerial photography
    b. Refine and expand USFS vegetation mapping to cover the newly mapped low surface
    c. Include mapping of impacted or cleared areas (e.g., power lines, developments, etc.), and of ponded and river areas

2) A conceptual model (hypothesis) of historic vegetation conditions prior to European settlement in the late 1800s for comparison to present conditions.
3) Identification of riparian reserves—defined as areas of functioning or at least semi-functioning vegetation that could provide a good source of shade, cover, and potential large woody debris (LWD).
4) Potential for the present vegetation to serve as a LWD source if eroded into the river through channel migration processes or windfall along Nason Creek.
5) Ranking of vegetation condition in terms of shade and cover along a defined buffer zone of 98 feet (30 meters) along the present main channel
6) Restoration recommendations and quantification of level of effort for restoration to be used in ranking and prioritizing of potential projects.

Data collected included information on LWD, LWD recruitment, diameter of LWD, types of conifers and deciduous trees, percentage of canopy coverage and relative foliage coverage in specific non-assessed area. The 2007 vegetation assessment covered low surface sites utilizing both 2006 GPS vegetation mapping (orthophotos and hardcopy aerial photographs) and LiDAR Detection and Ranging (LiDAR) data. In addition, field validations (ground truthing) were conducted to verify vegetation on GPS maps and photographs based on LiDAR technology.

Methods

A limited field inventory and mapping project was conducted to collect data on riparian vegetation for Nason Creek. Field assessments were conducted from August 6 to August 10, 2007, and from October 1 to October 4, 2007. Interpretation of aerial photographs and LiDAR data were used to create a GIS vegetation community map. Data will be used for analyses and project areas ranking within the assessment area for salmon recovery efforts.

Vegetation community classification

A classification system was selected which would best assess riparian vegetation for ecosystem health, creation, and restoration. This classification is based on various studies done by Robert D. Ohmart (Hink and Ohmart 1984). The classification method included categorizing vegetation polygons into community types and structure classes using an alphanumeric descriptive code. Each woody riparian plant species was assigned a letter code (the species code). The classification code (described in Figure 1) consisted of species codes for the canopy layer, species codes for the understory layer, and a number signifying the height of the canopy and thickness of the understory. This detailed classification was rolled into the more general USFS classification used for the lower Nason Creek study (RM 0 to 4) which was completed by Jones and Stokes for Chelan County (2003). See Figure 2 showing example map.

Example:

Canopy Layer / Understory Layer+Type Number (1-4)

Example: PP-GF/VM1

Ponderosa pine dominant with grand fir in overstory with understory of vine maple

Type Definitions:

Type 1- Tall trees with well developed understory. Tall or mature to mixed-aged trees [**>40 feet (12 meters)**] with canopy covering **>50 percent of area** of the community (polygon) **and** understory layer [**5 to 40 feet (1.5 to 12 meters)**] with covering **>25 percent of area** of the community (polygon).

Type 2 – Tall tree canopy with little or no understory vegetation. Tall or mature trees **[>40 feet (12 meters**)] with canopy covering **>50 percent of area** of the community (polygon) **and** understory layer [**5 to 40 feet (1.5 to 12 meters)**] with covering **<25 percent of area** of the community (polygon).

Type 3 – Intermediate-sized canopy with dense understory vegetation. Intermediate-sized trees [**(15 to 40 feet (4.6 to 12 meters)]** with canopy covering **>50%** of area of the community (polygon) **with** understory layer [**(5 to15 feet (1.5 to 4.5 meters)]** with canopy covering **>25 percent** of the area of the community (polygon).

Type 4 –Intermediate-sized trees openly spaced with little understory. Intermediate-sized trees [**15 to 40 feet (4.6 to 12 meters)]** with canopy covering > **50 percent** of the area of the community (polygon) understory [**5 to 15 feet (1.5 to 4.5 meters)**] layer covering **< 25 percent** of the area of the community (polygon).

Figure 1. Alphanumeric descriptive code and type definitions used to categorize vegetation polygons**.**

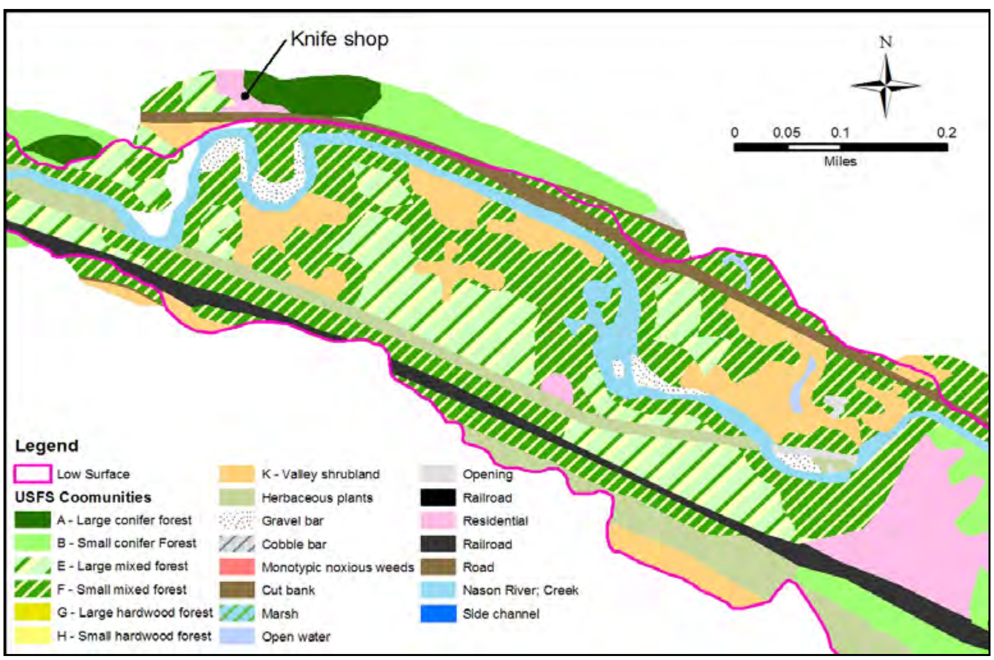

Figure 2. Example map showing USFS vegetation classes.

Preparatory field work

Prior to going to the field, orthophotos from October 2006 and hardcopy aerial photos were used to select vegetation data collection sites. Sites were selected which appeared to represent all possible vegetation communities, and focus was on areas which showed potential for reconnection of the floodplain to the creek. Coordinates for the points were generated using ArcGIS and loaded into GPS devices for use in the field.

Field work

During the August field work, an attempt was made to navigate as close as possible to each point using GPS and hardcopy aerial photos. An evaluation form (Figure 3) was completed to document percent cover, heights, and species of the canopy, herbaceous understory, woody debris and litter, wetland features, and hydrologic indicators. At each field site a photograph(s) was taken to document the vegetation species and structure. Table 1 lists the vegetation species observed and designated species code. In some instances where access was not possible due to thick vegetation, open water, and private lands, evaluations were conducted from a high overlook or from public roads.

Field data were entered in a spreadsheet (Appendix 1) for later use in developing alphanumeric classification codes. Plant species were recorded according to the relative abundance of the species cover within two layers. Species within a layer were separated by a “-”. Canopy and understory layers were separated by a “/”. Typically one or two species were recorded for each layer, but as many species as qualified (up to four) were recorded. For a species to be recorded in the code, they had to have 25-percent relative abundance. Plant species dominance (or relative abundance) was determined by visual estimation. Tree and shrub height, as well as plant cover, were also determined by visual estimates.

This detailed vegetation community class was rolled into the Oregon/ Washington/USFS watershed analysis model vegetation units (Table 2). The authors added additional fields for other land areas such as gravel bars, etc. Using this classification maintains consistency with the lower Nason Creek mapping done in 2003 for Chelan County. This classification was linked to the polygons in the GIS and added as an attribute field.

During the October 2007 field assessment, 2 days were spent measuring tree diameters at breast height (DBH) and tree heights for a sampling of the largest cottonwoods and conifers. Tree height was measured using a TruPulse Professional Laser Rangefinder (Laser Technology, Inc.). A meter tape was used to measure circumference from which the diameter was calculated. Tree height information was used in the interpretation of the tree LiDAR data to determine trees that had the required diameter for LWD potential. Thirty-eight trees were measured for DBH and 14 trees for height from various GPS locations.

Veg Classification Form						
Date						
Recorder, Phone #						
Polygon ID				**Photo Number**		
UTM WGS84 Coordinates	**X**					
	Y					
Waypoint #			**Time**			
Riparian Vegetation						
Species Codes	**Canopy**	**Height and Cover**				
		Canopy Cover	>40 Ft	1-25%	25-75%	75-100%
			20-40 Ft	1-25%	25-75%	75-100%
		%Dead	1-25%	25-50%	50-75%	75-100%
		Species (Relative foliage cover) - Circle one for each species				
			1-25%	25-50%	50-75%	*75-100%*
			1-25%	25-50%	50-75%	*75-100%*
	Understory	**Height and Cover**				
		Height	5-15 Ft	1-25%	25-75%	75-100%
			<5 Ft	1-25%	25-75%	75-100%
		%Dead	1-25%	25-50%	50-75%	75-100%
		Species (Relative foliage cover) - Circle one for each species				
			1-25%	25-50%	50-75%	*75-100%*
			1-25%	25-50%	50-75%	*75-100%*
			1-25%	25-50%	50-75%	*75-100%*
Ground Litter			1-25%	25-50%	50-75%	*75-100%*
Notes						
Wetland						
CM- Cattail Marsh		OW-Open Water		GM - Grass Meadow		
Other						
OA - Open Area		Ag-Agricultural			Road	
Hydrology Indicators (circle all that apply)						
Surface water present		Debris in vegetation			Watermarks on vegetation	
Sediment deposits		Drainage patterns			Back channel	

Figure 3. Evaluation form for Nason Creek vegetation assessments.

Table 1. Vegetation inventory from 2007 Nason Creek field assessment

Conifer/Deciduous Tree	**Scientific Name**	**Species Code**
Aspen	*Populus tremuloides*	A
Black cottonwood	*Populus balsamifera*	BC
Big Leaf maple	*Acer macrophyllum*	BM
Douglas-fir	*Pseudotsuga menziesii*	DF
Englemann spruce	*Picea engelmannii*	ES
Grand fir	*Abies grandis*	GF
Ponderosa pine	*Pinus ponderosa*	PP
Red cedar	*Thuja plicata*	RC
Sita alder	*Alnus crispa* spp.	SA
Shrubs/Terrestrial		
Bitter cherry	*Prunus emarginata*	BC
Black elderberry	*Sambucus racemosa* spp	BE
Black hawthorn	*Crataegus douglasii*	BH
Red-Osier dogwood	*Cornus stolonifera*	RD
Snowbrush	*Ceanothus velutinus*	NU*
False solomon	*Smilacina racemosa*	NU
Hardhack	*Spiraea douglasii*	Hh
Ocean spray	*Holodiscus discolor*	NU
Oxeye daisy	*Chrysanthemum leucanthemum* L.	NU
Sand bar willow	*Salix ssp.*	SBW
Pacific willow	*Salix lucida* spp. *lasiandra*	PW
Scouler willow	*Salix scouleriana*	SW
Skunk cabbage	*Lysichiton americanum*	NU
Timbleberry	*Rubus parviflorus*	NU
Vine maple	*Acer circinatum*	VM
Riparaian/Emergent Plants		
Duckweed	*Lemna* spp.	NU
Pondweeds	*Potomogeton* spp	NU
Vallsinera	*Vallisneria* spp.	NU
Reed canarygrass	*Phalaris arundinacea* L.	NU
Sedges	Family Cyperaceae	NU
Various grasses		NU

* NU=Not Used

Table 2. Oregon/Washington/USFS vegetation type unit descriptions for Nason Creek

Designation	Unit Name	Description
A	Large conifer forest	Mean DBH greater than 12 inches (30.4 centimeters). Mixed stands often include Douglas-fir, ponderosa pine, western red cedar, grand fir, or western larch. Crown closure usually greater than 50 percent
B	Small conifer forest	Same as large conifer forest but with smaller trees
E	Large mixed forest	Mean DBH greater than 12 inches (30.4 centimeters). Stand dominants almost always black cottonwood and mixed conifers, with an understory of smaller trees and shrubs
F	Small mixed forest	Same as large mixed forest but with smaller trees
G	Large hardwood forest	Mean DBH greater than 12 inches (30.4 centimeters). Nearly always consists of black cottonwood stands
H	Small hardwood forest	Comparable to large hardwood forest but with smaller trees
K	Valley shrub land	Dominated by deciduous woody vegetation (usually willows) less than 40 feet (12 meters) tall
Additional fields identified by Reclamation (authors)		
Co	Cobble bar	Riverine bar dominated by cobble sized material
Creek	Nason Creek	Main stem Nason Creek
Cutbank	Cutbank	Large bank cut by the creek during high flows
Go	Gravel bar	Gravel bar with less than 25 percent shrub cover
Garish	Gravel bar/shrub	Gravel bar with more than 25 percent scattered willow stands
Herb	Herbaceous	Dominated by herbaceous vegetation
MHz	Marsh	Wetted area containing marsh plants
NN	Noxious weeds	Area dominated by noxious weeds
Op	Opening	Open area, usually cleared areas adjacent to residential or commercial development
OW	Open water	Open water, usually ponded areas, which are now disconnected from the river by either the road or railroad
Railroad	Railroad	Railroad tracks and associated embankment
Res	Residential	Dominated by residential development
Riprap	Riprap	Bank dominated by riprap along the river
Road	Road	Highway
Side-Channel	Side channel	Creek side channel which contains, or may contain, water during high flows

Measurements of tree height were limited by denseness of tree stands, making it difficult to see both the top and the lower portions of trees. In addition, rain interfered with the laser rangefinder and limited the number of measurements taken.

Post field work aerial photograph and LiDAR data interpretation

Aerial photography was flown for the project in October 2006 and then orthorectified for the project (average flow in river of 40 cfs). LiDAR data were captured in October 2006, and first and second returns were used to create a grid containing tree height values. The LiDAR data and color aerial photography were used in GIS to interpret map vegetation not mapped in the field. The October aerial photos were useful for delineating hardwoods because yellow foliage was visible.

In ArcGIS 9.2, a 300-foot (91-meter) buffer from the rivers edge (as seen October 2006 photography) was created and merged with the geologic low surface provided by Reclamation hydrologists to create the study area polygon. The existing vegetation (provided by USFS) was incorporated. LiDAR data were grouped into height classifications, made semi-transparent, and overlain on 2006 aerial photography (Figure 4). Polygons of dominate canopy cover were created using heads-up (on screen) digitizing. Field assessment points were overlain on the photography. Data and detailed vegetation classification from the field assessments were tied to the polygons and used to visually interpret the areas not field assessed. Polygons were attributed with USFS unit and LWD categories (trees, small trees and shrubs, and low vegetation/openings) (Figure 4). Approximately 20 percent of the study area was assessed in the field, and the remaining 80 percent was visually interpreted using aerial photography and LiDAR data.

LWD and shading interpretation methods

Thirty-foot-long (9.1-meter-long) logs are the generally accepted minimum size for LWD in the stream. Forty feet (12 meters) was used in this study as a minimum size which, with accounting for some breakage of the tree or the small size of the top 5 feet (1.5 meters) of the trees, would provide LWD to the stream.

LiDAR data were symbolized to group vegetation into areas with greater than 50-percent canopy cover of:

- Trees with potential LWD tree size over 40 feet tall (12 meters) = T
- Small trees and shrubs 5 to 40 feet (1.5 to 12 meters) tall = S
- Low vegetation (crops, herbaceous, low shrubs and open areas) 1 to 5 feet (30.4 centimeters to 1.5 meters) tall. = O

Polygons were attributed with the appropriate letter to be used in analysis.

In order to estimate shading and short-term (decades) LWD contribution of the riparian vegetation adjacent to the river, a buffer of 82 feet (25 meters) was

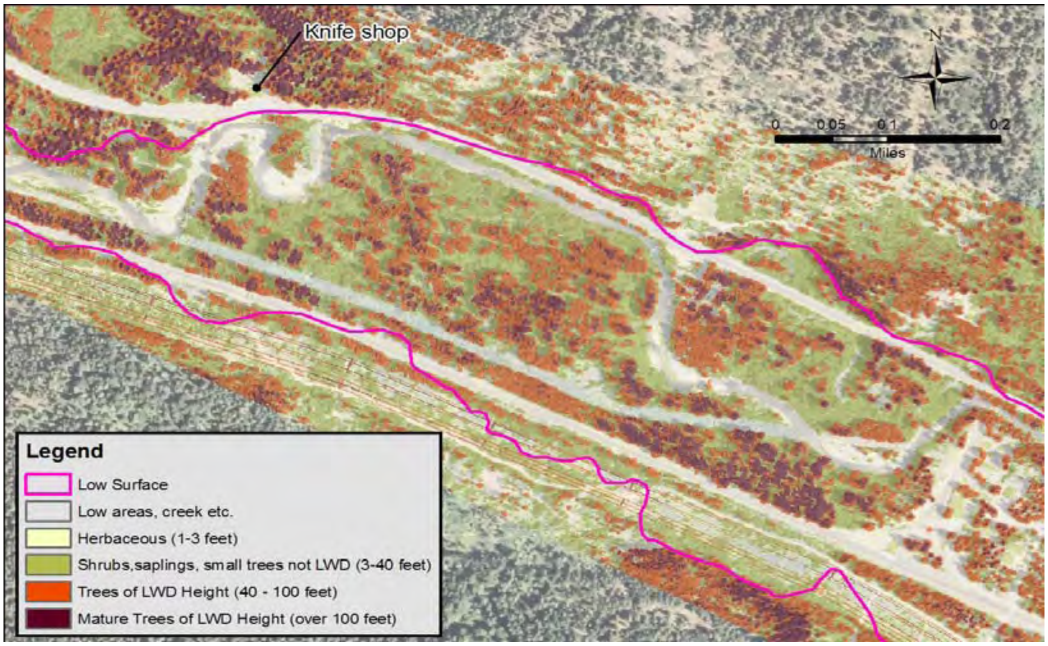

Figure 4. Example map showing LiDAR data shaded for tree heights and overlain on aerial photography.

chosen. McDade et al. (1990) used a 82-foot (25-meter) buffer as the minimum distance from the river that trees contributed LWD to the river. An 82-foot (25-meter) buffer from the river was created in GIS and intersected with the vegetation classification. Acres were calculated for all polygons and added as an attribute. The attribute table was exported to an excel file. The excel file was then imported into an Access database for summary reporting by reach. The summary reports were exported to an excel spreadsheet for distribution and formatting for reports.

Vegetation Summary and Results

The vegetation along Nason Creek is heavily influenced by the Cascade Mountains. Douglas-fir and grand fir are typically co-dominant in the canopy with vine maple being the common understory species. Black cottonwoods are present along the river and along abandoned river channels. Sand-bar willows and black cottonwood are present on gravel bars and cobble bars. Pacific willow and some alder species are found in wet areas. Limited amounts of western red cedar are mixed throughout the reach. Old growth (legacy) trees are absent from the reach and were probably logged in the 1900s for the railroad and for the fruit industry. The forest appears to be recovering back to the historic grand fir forest. Ponded areas containing wetland indicator plants were observed in the reach; however, wetlands delineation was not a part of this scope. A very limited amount of mammalian herbivory was observed, mostly likely from deer. Few deer tracks and limited amounts of deer scat were observed. One set of moose tracks was observed near White Pine. Signs of bear were observed at three locations during field surveys. Limited beaver activity was observed in the reach. Table 3 shows the acres of each USFS unit type for each reach (see Nason Creek tributary assessment).

Table 3. Acres of USFS units (See Table 2 for USFS type description)

USFS Unit	Reach N1	N2	N3
A	46	6	14
B	88	4	27
E	15	0	33
F	25	0	120
G	13	0	6
H	20	0	56
K	32	0	164
Herb	16	0	39
Marsh	0	0	6
Gravel bar	5	0.2	7
Gravel bar/shrub	2	0.2	3
Noxious weed	4	0	2
Op	5	0	5
Railroad	0	0	20
Res	10	0	38
Co	4	0	0
Cutbank	1	0	0

Nason geomorphic reach 3

The forest in the low surface of reach 3 has good vertical and lateral complexity in the sites visited. Douglas-fir, ponderosa pine and grand fir are often mixed in the canopy. The understory is dominated by vine maple. Few high flow channels were observed in this area. Black cottonwood and aspen are found in abandoned river channels.

Nason geomorphic reach 2

In reach 2, the geology constrains the floodplain, keeping it narrow and in places where the soils are relatively dry. The dominate conifer tree is ponderosa pine, but in general the presence of vegetation is limited.

Nason geomorphic reach 1

The riparian vegetation in reach 1 tends to have less lateral and vertical complexity than in reach 3. The forest adjacent to the low surface at the meander at RM 6.6 has low vertical structural complexity due to dry soil conditions, and the dominate conifer trees is the ponderosa pine. The two meanders at RM 5.1 and 5.9 near Coles Corner contain older average age class trees including intermediate to mature grand fir, black cottonwood, and red cedar resulting in approximately 75 percent canopy closure. Young and intermediate age class trees were lacking, which may have been stripped in the 1990 flood. At those two sites there was extensive evidence of a high flow event forming many high flow channels. Piles of large woody debris were observed on the downstream portion of the meander.

Floodplain cut-off areas

Areas of floodplain presently cut off by railroad and highway embankments or other manmade features were specifically evaluated for vegetation condition. The majority of these areas are located in reach 3. Many of these areas contain small-to-medium size wetlands (in the former main channels) and are dominated by large shrubs extending in some cases up to 25 feet (7.6 meters) in height. Conifers, which at one time did exist in this area, have died (visual observations) because they do not tolerate the wet and standing water conditions. These shrubs are found either occupying the channel within the oxbows or found at the edge of open water (pond or oxbow) where they could potentially provide some shading. Shrubs and wetlands that currently exist in the cutoff areas would not contribute to short-term LWD recruitment if these areas are reconnected and accessed by the river. However, over longer time periods, riparian vegetation would be expected to re-establish if natural migration processes are restored, reconnecting these areas to the presently accessible channel and floodplain. Riparian and aquatic vegetation found in and surrounding these sites included equisetum, bulrush, pondweed species, vallisneria, duckweed, and grasses. At higher elevations on the perimeters of some of these moist sites are mature to intermediate deciduous and conifer trees.

There are additional moist sites outside the low surface, which were cut off by channelization. These areas are fed by seepage and groundwater flows where there are intermediate to mature conifers and deciduous trees including black cottonwood and grand fir. Understory in these areas is comprised mainly of various types of shrubs including vine maple up to 15 feet (4.5 meters) in length. In one particular area, there was a large monoculture of spyrea ranging up to 6 feet (1.8 meters) in height which was surrounded mainly by Pacific willow.

Power line corridors

Power and transmission lines run nearly parallel to the channel throughout the Nason assessment area, and often cross the main channel. Floodplain vegetation within these corridors and the vegetation adjacent to the corridors have been severely impacted by consistent clearing done to maintain the access right-of-way. Vegetation tends to be monocultures of differing species depending on the sites. Some areas are dominated by non-native and noxious weeds such as spotted knapweed and less desirable native plants such as common tansy. Other areas on the edges of these corridors have native vegetation such as black cottonwoods and aspen that are being limited in height by mowing to allow access into these corridors for operation and maintenance of the power lines. These trees are generally intermediate in height and are density packed (dog hair stands) which are an unnatural condition limiting diameter and tree height. In some areas dense shrub growth is found to the edge of the river but do not extend substantially over the river to provide adequate shading for fish.

Soils in these corridors appear more xeric with more cobble due to removal of endemic soils for the development of the corridor and right-of-way. This results in encroachment by non-native plants which were potentially transferred to the area from heavy equipment or by some other vector. These drier sites do not appear to be sustaining shrubs and tree growth. On the edge of the river within the power line corridor there are some areas that have limited amounts of LWD that could be recruited. Overall, when the power line corridor passes over Nason Creek potential LWD recruitment has been greatly reduced as is shading on the river.

IS Analysis of Natural Community, Potential LWD Sources and Shading

This report section documents methods used to accomplish GIS-based vegetation and LWD analysis needed to help populate a reach-based ecosystem indicator (REI) table, presented in a separate report.

Potential natural community (REI structure criteria)

Riparian vegetation which is consistent with its potential natural community is the desired condition for the riparian area. The potential natural community is a biotic community that would be established if all sucessional sequences were completed without the interference of human activities (Winward 2000). Table 4 shows the acres of the riparian area of potential natural community (natural species) and the acres of impacted areas which are anthropogenic land cover such as railroad rights-of-way, roads, power line corridors, and private and commercial property.

Table 4. Potential natural community vegetation analysis results by geomorphic reach

Reach	Area (acres)	Natural Species (acres)	% Natural	Impacted (acres)	% Impacted
1	334.9	280.1	84%	54.69	16%
2	13.6	13.6	100%	0	0%
3	607.6	479.3	79%	128.27	21%

LWD contribution and shading

Two important components riparian vegetation contributes to salmon habitat are large wood debris (LWD) and shading for the river channel. LWD creates and maintains spawning, rearing, and holding habitat for salmon and is part of the nutrient exchange necessary in a river system. Shading of the river channel has been shown to contribute by reducing water temperatures during hot summer months, particularly during low flow conditions.

These data were generated from the GIS analysis:

- Trees which could be **potentially** recruited into the stream and provide LWD by active river meanders accessing the trees at some point in the future (acres of polygons classified as dominated by trees within the low surface - **LWD potential analysis)**
- LWD which is **accessible** to the stream in the short-term because they are within a close proximity to the present river channel; the impact on present river channel migration rates due to levees, riprap, etc., was not taken into account in this analysis [acres of trees within 82 feet (25 meters) of the wetted river on 2006 aerial photography - **LWD accessible analysis**]
- Shading by trees and shrubs adjacent to the river [acres within 82 feet (25 meters) of the wetted river on 2006 aerial photography - **shading analysis**]

LWD potential analysis

A map (Figure 5) was produced with LWD classification of all vegetation in the study area.

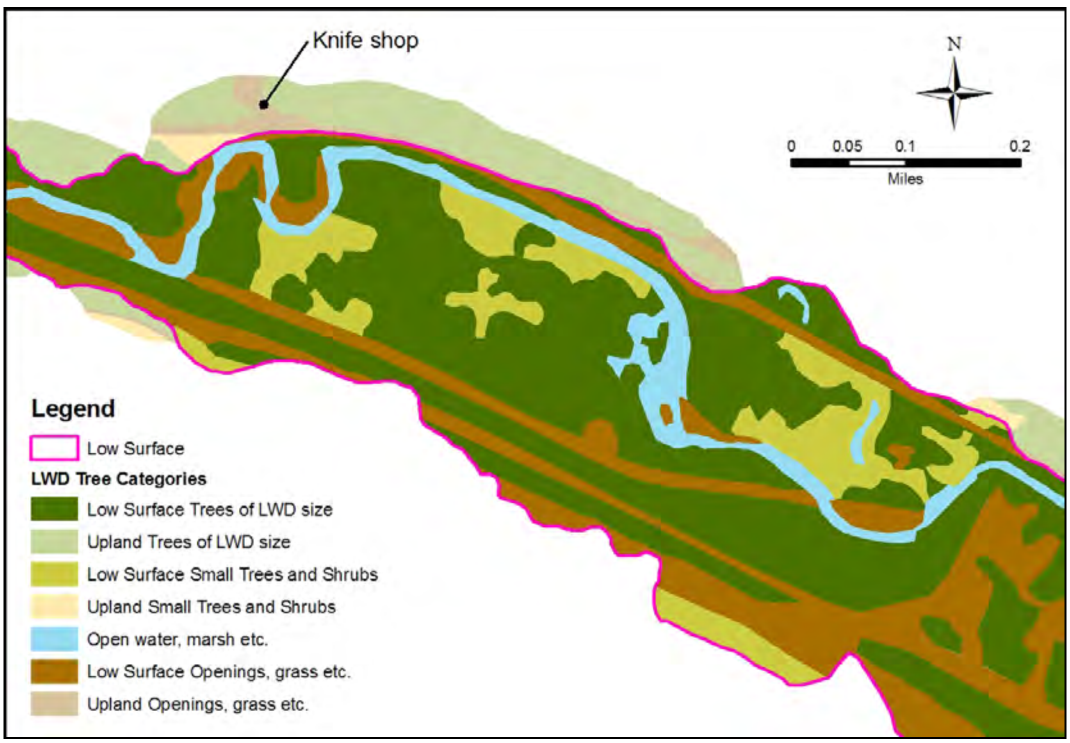

Figure 5. Example map showing LWD tree classifications.

Fifty-six percent of the assessment area (Table 5) has polygons which are dominated by LWD sized-trees. Polygons classified as LWD trees contain an

Table 5. Summary of vegetation classification for study area

Acres LWD trees	Acres small trees/ shrubs	Acres low vegetation/ openings	Total acres*
476	196	185	857
56%	23%	22%	100%

*Wetted areas including the river were not included in total acres.

average of 40 trees per acre. In areas cut-off from the river by the railroad shrubs dominated areas make up 23 percent of the study area. Twenty-two percent of the study area is classified as low vegetation/openings. Much of this area is private land.

LWD potential analysis by reach

Table 6 shows acres of trees that are currently of adequate size to provide LWD within the low surface (floodplain) for each reach. This represents the acres of LWD-sized trees that could be recruited if the river accessed them either through lateral erosion, flooding, or wind throw. Reach 2 is a very short, narrow reach and is constrained by the geology.

Table 6. Acres and percent of area of LWD-sized trees within the low surface by reach

Reach	LWD Trees (acres)
N1	208
N2	9
N3	259

LWD accessible analysis

The LWD accessibility analysis includes three general spatial areas: vegetation within 82 feet (25 meters) of the river centerline, the remaining low surface, and areas outside the low surface but still within a 300-foot (91-meter) distance from the river centerline. These areas could provide trees which could be recruited into the stream (Figure 6).

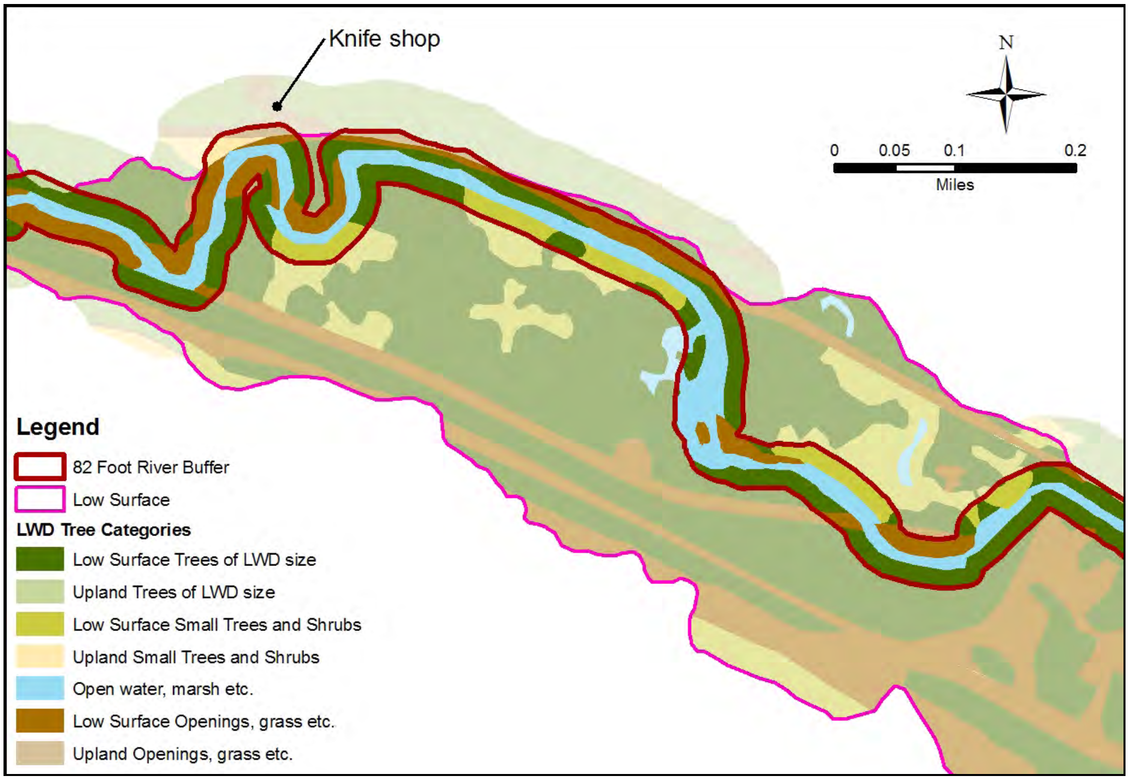

Figure 6. Example map showing buffer adjacent to the river and LWD tree categories.

LWD-sized trees adjacent to the river could be recruited into the river in the short term. Table 7 shows acres for each reach. Some acres are larger than the low surface LWD trees because of area outside the low surface, but within 82 feet (25 meters) of the river.

Table 7. Acres of LWD-sized trees within 82 feet (25 meters) of the river by reach within 82 feet (25 meters) of the river

Reach	LWD Trees (acres)
N1	64
N2	10
N3	51

Shading analysis

Seventy-eight (672 acres) percent of the study area is shaded by the riparian vegetation. The majority of this shading is by shadows of tall trees falling across the river. Table 8 shows the percent of the strip 82 feet (25 meters) wide along both sides of the river which contains trees and/or shrubs and which could provide shade to the river. Trees and shrubs outside the low surface, but within 82 feet (25 meters) are included.

Table 8. Percent of stream shaded by trees/shrubs by reach

Reach	% of stream shaded
N1	80%
N2	96%
N3	77%

Limitations and Future Work Recommendations

Future work should include more ground assessments to increase GIS mapping accuracy. If desired, measurements of large down wood per cubic/foot would yield information of the riparian area's ability to provide filtering of sediment and nutrients to the river. Additional analyses are needed to better understand the linkage between shading along the river by the riparian vegetation and influence on water temperature. Aerial photography or field surveys could be completed during the hottest times of the year, and measurements of actual shading by the vegetation would enhance the understanding of the contribution of the vegetation for thermal cover for the fish. Continued monitoring of vegetation structure could be done on a decadal scale to track recovery of logging from the turn of the century. Additional, more detailed vegetation mapping and monitoring may be important at a project scale as part of restoration actions and adaptive management.

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APPENDIX 1

Appendix 1. Field Form Data

SurveyPt	Photo	Comments	Canopy Avg Hight	Canopy % Cover	% Canopy Dead	Canopy Species 1	Canopy 1 Species % abundance	Canopy Species 2	Canopy 2 Species % abundance	Canopy Species 3	Canopy 3 Species % abundance	Canopy Species 4	Canopy 4 Species % abundance	Understory Avg Height	% understory cover	% understory dead	Recruitment species	understory species 1	% understory species 1 abundance	understory species 2	% understory species 2 abundance	understory species 3	% understory species 3 abundance	understory species 4	% understory species 4 abundance	understory species 5	% understory species 5 abundance	understory species 6	% understory species 6 abundance	understory species 7	% understory species 7 abundance	understory species 8	% understory species 8 abundance	understory species 9	% understory species 9 abundance	Wetted area plants	Wetted area characteristics
01A	DSCN1275.JPG	Black Cottonwood, Intermediate age	>40 FT	25-75%	1-25%									5-15 FT	25-75%	1-25%		D.W.		Willow		black cottonwood															
01B	DSCN1278.JPG	Underneath Power Lines, no trees, brush species, area approx. 200 yds long x 40 yds wide, spotted knapweed and grasses found underneath power lines. Small bc, maples dw and elderberry												5-15 FT	1-25%	1-25%		BC	25-50%	Vine Maple	25-50%	D.W.	1-25%	Spotted Knapweed	75-100%	grasses	25										
02A	DSCN1280.JPG	Looking downstream, Mixed conifers, mixed shrubs, this view some cottonwoods taller than conifers	>40 FT	75-100%	1-25%	DF	25-50%	BC	25-50%																												
02B	DSCN1283.JPG	Looking upstream, Mixed conifers, mixed shrubs, this view conifer taller than cottonwoods	>40 FT	75-100%	1-25%	BC	25-50%	BC																													
03A	DSCN1288.JPG	G.F., BC site, Intermediate, Moist	>40 FT	75-100%	1-25%	GF	25-50%	BC	25-50%					5-15 FT	25-75%	1-25%		VM																			
03B	DSCN1305.JPG	Looking north to 03A site, open water, tall grasses, moist soils, dead trees			1-25%																															grasses	open pond
04A	DSCN1292.JPG	Good BC recruitment in creek channel. Intermediate age BC both side of creek	>40 FT	75-100%	1-25%	BC	50-75%	PP	25-50%	DF	25-50%			5-15 FT	25-75%	1-25%		S.W.	25-50	Dogwood	25-50																
04B	DSCN1298.JPG	BC lining both sides of right of way, BC approx 40-60 year old	>40 FT	75-100%	1-25%	BC	50-75%	GF	1-25%	BC	1-25%	Aspen	1-25%	5-15 FT	75-100	1-25%																					
05A	DSCN1302.JPG	Open area 2 acres approx. with dense spyrea shrubs up to 6 ft tall, area wet														1-25%		Spyrea	75-100%	Pacific Willow	25-50%	Hawthorne	1-25%														
05B	DSCN1307.JPG	Oxbow on north side of road with pondweed(P.S), standing water	>40 FT	75-100%	1-25%	E.S.	25-50%	PP	25-50%	GF	1-25%	BC	1-25%	5-15 FT	75-100%	1-25%		VM	25-50%	Dogwood	25-50%	Hawthorne	1-25%	Spyrea	1-25%												
06A	DSCN1313.JPG	Site appears to flood periodically, with cobble and woody debris BC recruitment high for this area	>40 FT	75-100%	1-25%	BC	75-100%	GF	1-25%	PP	1-25%			5-15 FT	75-100%	1-25%		Willow Sandbar	25-50%	VM	25-50%	D.W.	1-25%														
06B	DSCN1315.JPG	Oxbow evaluated from high point on south side, looking east	>40 FT	1-25%	1-25%	BC	1-25%	DF	1-25%	PP	1-25%	GF	1-25%	5-20 FT	75-100%	1-25%		S. Willow	50-75%	VM	25-50%	BC	1-25%	Hawthorne	1-25%											grasses, PS, wildflowers	
07A	DSCN1320.JPG	Looking west to oxbow, photo from high overlook on south side of oxbow	>40 FT	25-75%	1-25%	BC	25-50%	GF	1-25%	E.S.	1-25%	DF	1-25%	5-20 FT	75-100%	1-25%		VM	25-50%	Dogwood	25-50%	Bitter Cherry	1-25%	Willow (P.S)	1-25%											grasses, PS, wildflowers	
07B	DSCN1321.JPG	Looking north into woods from Highway 2, some dead LWD, private property	>40 FT	25-75%	1-25%	BC	50-75%	BC	1-25%	Aspen	1-25%			5-15 FT	75-100%	1-25%		Dogwood	50-75%	BC	25-50%	Spyrea	1-25%	Aspen	1-25%												
08A	DSCN1323.JPG	Standing water between Highway 2 and dirt road to the north	>40 FT	1-25%	1-25%	BC	25-50%	PP	25-50%	DF	1-25%			5-15 FT	75-100%	1-25%		Dogwood	1-25%	Hawthorne	1-25%															grasses, PS, wildflowers	open pond
08B	DSCN1326.JPG	Dense tree and shrub growth, tree young intermediate, ferns	>40 FT	25-75%	1-25%	BC	25-50%	VM	25-50%	BC	1-25%	Aspen	1-25%	5-15%	25-75%	1-25%		VM	50-75%	Ferns	25-50%	Wild Rose	1-25%	False Solomon Seal	1-25%												
09A	DSCN1328.JPG	Open pond area, riparian plants on edge, trees & shrubs on west, north, east	>40 FT	25-75%	1-25%	PP	50-75%	BC	1-25%	GF	1-25%			5-15 FT	25-75%	1-25%		Dogwood	25-50%	VM	25-50%	Hawthorne	1-25%	False Solomon Seal	1-25%	Spyrea	1-25%									grasses, equisetum, reed canarygrass, bulrush	Yes, open pond, 1 acre
09B	DSCN1329.JPG	Looking at WP 168 (9A) from paved road, looking north from Highway 2	NA & 9B same site																																		
10A	DSCN1331.JPG	site off of gravel bar, mature BC, dead BC, young bc recruitment area	>40 FT	25-75%	1-25%	BC	25-50%	Aspen	25-50%					5-15 FT	25-75%	1-25%		BC	25-50%	VM	25-50%	aspen	1-25%	Red elderberry	1-25%	snow Berry	1-25%	Ferns	1-25%	Tansy	1-25%	Fireweed	1-25%	golden rod	1-25%		
10B	DSCN1332.JPG	Oxbow to south of wypt, off of RR	>40 FT		1-25%	BC	50-75%	BC	1-25%	PP	1-25%	GF	1-25%	5-15 FT	50-75%	1-25%		Willow(P)	50-75%	Dogwood	1-25%	BC	1-25%	hawthorne	1-25%	spyrea	1-25%									grasses, equisetum, PS, cat tails	Yes, open pond
11A	DSCN1336.JPG	Old beaver dam, dense monotypic willow,	>40 FT	1-25%	1-25%	BC	1-25%							5-15 FT	75-100%	1-25%		Willow (P)	75-100%	Spyrea	1-25%	Hawthorne	1-25%													PS	Yes, standing water
11B	DSCN1337.JPG	Decommissioned bridge,	20-40 FT	25-50%	1-25%	PP	25-50%	BC	1-25%					5-15 FT	1-25%	1-25%	Willow on sandbar	Willow (P)	25-50%	Alder(white, mountain)	1-25%	BC	25-50%	spyrea	1-25%	dogwood	1-25%	hawthorne	1-25%								
12A	DSCN1340.JPG	BO2 Bridge	>40 FT	1-25%	1-25%	PP	25-50%	GF	25-50%					5-20 FT	25-75%	1-25%		VM	25-50%	Willow(S)	25-50%	Dogwood	25-50%														
12B	DSCN1341.JPG	LBC	>40 FT	50-75%	1-25%	PP	50-75%	BC	25-50%	DF	1-25%	BC	1-25%	5-15 FT	75-100%	1-25%		VM	75-100%	Oregon Grape	1-25%	Snowberry	1-25%														
13A	DSCN1344.JPG	Power line cutting across Nason Cr, large mature aspens	>40 FT	25-75%	1-25%	PP	50-75%	BC	25-50%	DF	1-25%	GF	1-25%	5-15 FT	25-50%	1-25%		dogwood	30-50%	VM	30-50%	hawthorne	1-25%	ferns	1-25%	black elderberry	1-25%	snowberry	1-25%								
13B	DSCN1346.JPG	LWD (BC), Moist site	>40 FT	50-75%	1-25%	DF	50-75%	BC	25-50%	Aspen	1-25%	GF	1-25%	5-25 FT	25-75%	1-25%		VM	75-100%	Giant Skunk Cabbag	1-25%	willow(S)	1-25%	dogwood	1-25%	snowberry	1-25%										yes
14A	DSCN1348.JPG	Shrub area, moist site, trees in semi circle	>40 FT	75-100%	1-25%	PP	75-100%	DF	25-50%					5-20 FT	50-75%	1-25%		willow(P)	50-75%	Alder(white, mountain)/ 5-50%	1-25%	Hawthorne	1-25%	service berry	1-25%	spyrea	1-25%										
14B	DSCN1350.JPG	Wypt on edge of creek, cobble, sand	>40 FT	50-75%	1-25%	PP	50-75%	BC	50-75%	Aspen	1-25%	GF	1-25%	5-20 FT	25-50 %	1-25%	Willow on sandbar	Dogwood	25-50%	VM	1-25%	willow(S)	1-25%	alder	1-25%	black elderberry	1-25%	BC	1-25%								
15A	DSCN1354.JPG	West wypt to island, LBC	>40 FT	25-50%	1-25%	BC	25-50%	PP	25-50%	DF	1-25%			5-25 FT	25-75 %	1-25%		Willow (P)	25-50 %	Alder	50-75%	Dogwood	1-25%														
15B	DSCN1356.JPG	Under power lines, n & s views	>40 FT	1-25%	1-25%	PP	25-50%	DF	25-50%	BC	1-25%			5-20 FT	75-100%	1-25%		Sitka Alder	50-75%	Willow (P)	50-75%	Dogwood	1-25%	VM	1-25%	snowberry	1-25%	mares tail	1-25%								
16A	DSCN1360.JPG	wypt174 looking north from northside of N.C., significant amounts of cobble on site	>40 FT	25-75%	1-25%	PP	50-75%	BC	50-75%	DF	1-25%	BC	1-25%	5-15 FT	25-75%	1-25%		G.F.	50-75%	Dogwood	1-25%	Service berry	1-25%	VM	1-25%	BC	1-25%										
16B	DSCN1361.JPG	Wypt looking sw to island, c.s.w. through island, open ground on island, plants among stones	>40 FT	25-75%	1-25%	PP	50-75%	BC	25-50%	DF	1-25%			5-20 FT	25-75%	1-25%		Sitka Alder	50-75%	BC	25-50%	Dogwood	1-25%	PP	1-25%	Tansy	1-25%	Bitter Cherry	1-25%	Ocean Spray	1-25%						
17A	DSCN1368.JPG	Trees, shrubs on south side of power line, dry high flow channel, little gd cover in low site	>40 FT	50-75%	1-25%	DF	25-50%	PP	25-50%					5-15 FT	1-25%	1-25%	Potential for Willow		0 1-25%	Kinnikinick	1-25%	[illegible]	1-25%	DF	1-25%												
17B	DSCN1369.JPG	Wypt taken underneath power line, looking north, decline of large BC, potential BC recruitment	> 40 FT	25-75%	1-25%	PP	25-50%	BC	25-50%	DF	1-25%			5-20 FT	25-75%	1-25%	?	Sitka Alder	25-50%	Dogwood	25-50%	Spyrea	1-25%	Willow(S)	1-25%	BC	1-25%	VM	1-25%								
18A	DSCN1373.JPG	old channel on west side of creek, willow, BC intermediate tree growth	>40 FT	25-75%	1-25%	PP	25-50%	BC	25-50%	DF	1-25%			5-20 FT	25-75%	1-25%		VM	1-25%	BC	1-25%	Dogwood	1-25%	Willow (S)	1-25%	Ferns	1-25%										
18B	DSCN1377.JPG	Some grass, fairly bare below shrub/tree canopy, LWD on inside of stream curve, willow recruitment	>40 FT	50-75%	1-25%	PP	25-50%	BC	25-50%	GF	1-25%			5-15 FT	50-75%	1-25%	Potential for Willow	Sitka Alder	25-50%	Dogwood	25-50%	Willow(S, P?)	1-25%	VM	1-25%	Spyrea	1-25%	Service Berry	1-25%	BC	1-25%						
19A	DSCN1380.JPG	Site a mixture of PP and DG and ground cover predominately service berry and snowberry	>40 FT	25-75%	1-25%	PP	50-75%	DF	25-50%	Aspen	1-25%	BC	1-25%	5-15 FT	25-75%	1-25%		Service berry	25-50%	Snowberry	25-50%	Wild Rose	1-25%	False Solomon Seal	1-25%												
19B	DSCN1381.JPG	Site contains signif amounts of down woody debris, IAM BC. Site of potential recruitment of BC &DF, older side canal-like during runoff photo 1383?	>40 FT	25-75%	1-25%	PP	25-50%	DF	25-50%	BC	25-50%	Aspen	1-25%	5-20 FT	50-75%	1-25%		Sitka Alder	50-75%	Dogwood	25-50%	BC	25-50%	Spyrea	1-25%	Black elderberry	1-25%	DF	1-25%	PP	1-25 %	snowberry	1-25%				

Appendix 1. Field Form Data

SurveyPt	Photo	Comments	Canopy Avg Hight	Canopy % Cover	% Canopy Dead	Canopy Species 1	Canopy 1 Species % abundance	Canopy Species 2	Canopy 2 Species % abundance	Canopy Species 3	Canopy 3 Species % abundance	Canopy Species 4	Canopy 4 Species % abundance	Understory Avg Height	% understory cover	% understory dead	Recruitment species	understory species 1	% understory species 1 abundance	understory species 2	% understory species 2 abundance	understory species 3	% understory species 3 abundance	understory species 4	% understory species 4 abundance	understory species 5	% understory species 5 abundance	understory species 6	% understory species 6 abundance	understory species 7	% understory species 7 abundance	understory species 8	% understory species 8 abundance	understory species 9	% understory species 9 abundance	Wetland area plants	Wetland area characteristics
20A	DSCN1305.JPG	Major old meander (wet site), thickly covered with shrubs, standing water in meander.	>40 FT	25-75%	1-25%	DF	25-50%	GF	25-50%	PP	1-25%	BC	1-25%	5-15 FT	50-75%	1-25%		VM	25-50%	Dogwood	25-50%	Sitka Alder	25-50%	Fern	1-25%	snowberry	1-25%									water hemlock,equisetum, cattail	yes
20B	DSCN1306.JPG	Major old meander (same site), thickly covered with shrubs, standing water in meander. Large dia alders (8 inch)	>40 FT	25-75%	1-25%	DF (I)	50-75%	PP(I)	25-50%					5-25 FT	25-75%	1-25%		Sitka Alder	25-50%	Spyrea	1-25%	Water Hemlock	1-25%	Skunk Cabbage	1-25%	bulrush	1-25%	Equisetum	1-25%	VM	1-25%					water hemlock, equisetum,cattail	yes
21A	DSCN1307.JPG	Site contains signif amounts of down wood limbs and tree trunks, lots of woody debris from flooding, very little undergrowth	>40 FT	50-75%	1-25%	GF (I&M)	25-50%	B.C (I&M)	1-25%	RC(I&M)	1-25%	DF	1-25%	5-20 FT	25-75%	1-25%		VM	25-50%																		
21B	DSCN1303.JPG	Young GF/PP /DF on edge of river, I&M BC, old bridge structure at this site.	>40 FT	25-50%	1-25%	BC	25-50%	PP	25-50%					5-20 FT	25-75%	1-25%		Sitka Alder	50-75%	Willows(?)	25-50%	BC	1-25%	Tansy	1-25%	Spyrea	1-25%										
22A	DSCN1296.JPG	Broken standing PP &BC trees close to water one dead (DF) fairly tall, some bank erosion, small sub	>40 FT	25-75%	1-25%	BC	50-75%	PP	50-75%	GF	1-25%	DF	1-25%	5-15 FT	75-100%	1-25%		Dogwood	25-50%	Sitka Alder	25-50%	VM	1-25%	BC	1-25%	Bitter Cherry	1-25%										
22B	DSCN1297.JPG	I &M BC, wet soil at this site, a sign amount of young willow, dense vegetation	>40 FT	25-75%	1-25%	BC	25-50%	GF	1-25%	DF	1-25%	BC	1-25%	5-20 FT	50-75%	1-25%		Sitka Alder	50-75%	Willow (P&S)	25-50%	Skunk Cabbage	1-25%	VM	1-25%	Fern	1-25%	snowberry	1-25 %	service berry	1-25%	Thimble berry	1-25%				
						I = Intermediate																															
						M=Mature																															

PEER REVIEW DOCUMENTATION
PROJECT AND DOCUMENT INFORMATION

Project Name: Wentachee Watershed Plan

WOID: WEWAP

Document: 2007 Nasson Creek Floodplain Vegetation Assessment

Date: March 26, 2008 Date Transmitted to March Client: March 27,2008

Team Leader: David Sisneros Leadership Team Member___________
(Peer Reviewer of Peer Review/QA Plan)

Document Author(s)/Preparer(s):David Sisneros, John Boutwell, Debra Callahan

Peer Reviewer: Denise Hosler

REVIEW REQUIREMENT

Part A: Document Does Not Require Peer Review

Explain____

Part B: Document Requires Peer Review: SCOPE OF PEER REVIEW
Peer Review restricted to the following Items/Section(s): Reviewer:
Entire ___________
Entire ___________

REVIEW CERTIFICATION

Peer Reviewer - I have reviewed the assigned Items/Section(s) noted for the above document and believe them to be in accordance with the project requirements, standards of the profession, and Reclamation policy.

Reviewer: Denise M Hosler Review
Date: March 26, 2008 Signature

Reviewer:_____________________ Review
Date:_____________________ Signature

Preparer - I have discussed the above document and review requirements with the Peer Reviewer and believe that this review is completed, and that the document will meet the requirements of the project.

Team Member: David Sisneros
Date: April 2, 2008 Signature

UCRTT
UPPER COLUMBIA REGIONAL TECHNICAL TEAM

Draft Memorandum

To: MaryJo Sanborn, Wenatchee Habitat Subcommittee
From: Casey Baldwin, RTT Chair (509-664-3148; baldwcmb@dfw.wa.gov)
Date: 04/11/2008
Subject: Nason Creek Biological Benefit Assessment

The RTT appreciated the opportunity to work on the biological benefit portion of the Nason Creek prioritization and we look forward to continuing to assist with this process. As you know, the USBR has developed a very detailed geomorphic assessment of approximately 2/3 of the anadromous zone of Nason Creek (RM 4.6-14.3). Due to the impressive quantity and quality of information provided by the USBR, and the complexities of the social aspects and considerations outlined in the *Draft Prioritization Framework for Nason Creek Restoration Projects* (herein referred to as the *Prioritization Framework*), the RTT has developed a phased approach to evaluating the biological benefits of potential restoration actions in Nason Creek. In this memo, we outline our recommendations from Phase I of the biological benefit assessment and our intended approach to Phase II of the assessment.

The USBR assessment provided information at multiple spatial scales: 1) three Geomorphic Reaches 2) nine Project Areas and 3) 84 Project Subareas. We realize that the ultimate goal may be to have a single prioritized list of the 84 Project Subareas; however, due to the variability of the conditions and the interconnectedness of the information provided by USBR within each Project Area the RTT did not believe that we could effectively rank all of the Project Subareas at this time. Our approach was to evaluate the project types independently, beginning with the channel reconnection projects.

Phase I

Project Type Prioritization

There are four basic project types that are considered a priority in Nason Creek, protection, channel reconnection (including floodplain), and habitat diversity, and riparian restoration. The first three actions were rated as Tier 1 in the RTT *Biological Strategy* so we certainly believe all three should occur and all three are of very high importance to the recovery and long-term viability of salmonids in Nason Creek. Riparian planting was considered a Tier 2 action in the RTT *Biological Strategy*, making it still very important to accomplish, but not as high a priority as the other actions in Nason Creek.

Protection certainly needs to occur in Nason Creek to be sure that the functional areas remain functional and that impacted areas are allowed to heal and recover from past land management practices. An effort needs to be undertaken to identify the areas in Nason Creek that are at the greatest risk and therefore in the greatest need of protection. We believe that is a separate task from what has been asked of us at this time. Its possible that Phase II of this assessment could include an RTT prioritization of the protection areas in Nason Creek. The USBR assessment goes a long way towards identifying areas that need to be protected, but we think that the lower 4.6 miles of Nason Creek also need to be included in an analysis of risks and benefits for the entire anadromous section.

The RTT supports the concept from the *Prioritization Framework* that states "habitat diversity projects should not proceed prior to connectivity projects unless the main channel of the stream is unconstrained" and we would add that the risks of failure for the complexity project should be relatively low. Additionally, we recommend looking at the proportion of each project area that is disconnected from the channel migration zone and floodplain as a course filter for where habitat complexity projects may be appropriate (Table 1). Project Areas 13.3, 8.9, and 7.75 are all less than 10% disconnected from their channel migration zone and floodplain and may be appropriate areas to consider habitat complexity actions.

Reach Level Prioritization

The RTT utilized the Interior Columbia Technical Recovery Team's evaluation of intrinsic potential (ICTRT 2007) to determine if there would be greater biological benefits to working in one reach of Nason Creek over the other reaches. To evaluate intrinsic potential, the ICTRT developed a model to predict areas of high quality habitat based on empirically derived relationships between salmon spawner densities and channel characteristics (i.e. gradient, stream width, valley width, and confinement).

The RTT took a qualitative look at the intrinsic potential maps for spring Chinook (Figure 1) and steelhead (Figure 2) to determine which reaches had the most intrinsic potential. From this analysis, it was evident that the lower 4.6 miles and reaches 1 (rm 4.6 to 8.9) and 3 (9.4 to 14.3) all had similar high levels of intrinsic potential. Reach 2 (rm 8.9 to 9.4) has a higher gradient and is naturally confined and is therefore the only reach that stands out as having lower restoration potential. Due to the course scale of the intrinsic potential analysis the RTT did not believe that it could be used to further prioritize between reaches, but that it was a useful analysis to evaluate if there was a reach scale justification for biological benefit prioritization. The RTT did not try to further differentiate the priority between reaches but recommends that prioritizations occur at the smaller spatial scales of the Project Areas and Project Subareas.

Channel Connectivity

We believe that, over the long term, channel reconnection projects will achieve the greatest improvements to biological benefits to listed salmonids in Nason Creek. Protection projects will help maintain what is currently functioning and secure that form and function for the future, but improvements to juvenile survival and habitat capacity are needed in order to recover listed salmonids. Restoring natural processes, channel form, and floodplain function will allow for the natural recruitment of spawning gravels, large woody debris complexes, and pool formation that are so critical to all life stages of salmonids. This concept is already well imbedded in both the *Prioritization Framework* as well as the Technical Sequencing section of the USBR *Draft Findings and Restoration Concepts for Nason Creek Between RM 4.6 to 14.4.*

The USBR Assessment describes two levels of channel connection, the historic channel migration zone (HCMZ) and the floodplain. The HCMZ is the area within the valley bottom where the main river channel typically migrated when unimpeded by human impacts. The floodplain is the remainder of the low elevation valley bottom that was (and should be) accessed during high water events.

Project Area Prioritization

We evaluated the data provided by the USBR regarding the quantity of each habitat type (HCMZ and floodplain) that has been altered by manmade features (Figure 3). Biological benefit preference was not given to one habitat type (HCMZ vs. floodplain) over the other. From this evaluation, it became evident that Project Area 11.62 has, by far, the greatest quantity (227 acres) of disconnected habitat (Table 1). The five largest Project Subareas in the USBR assessment (33.8 to 80.2 acres) fall within this project area. The project areas with the next highest quantity of disconnected habitat were Project Areas 14.3 and 12.47 with approximately 53 acres each (Figure 3, Table 1). We concluded that the connectivity actions outlined by the USBR within these Project Areas that recapture the greatest quantity of HCMZ and floodplain habitat would have the greatest biological benefit for the restoration of Nason Creek. We also recommend generally following the technical sequencing suggested by the USBR within each Project Area. Within this first group of Project Areas, we recommend conducting a course scale social, economic, and feasibility assessment to narrow down the options and possibilities in terms of specific projects in each of the Project Subareas. After sequencing the list within this first group of project areas we recommend revisiting the biological benefit assessment during phase II.

A second group of project areas with substantial opportunity for channel connection include Project Area 6.6 with 31 acres, Project area 5.2 with 16 acres, Project Area 13.3 with 9 acres, Project Area 8.9 with 7 acres, and Project Area 7.75 with 6 acres (Table 1). After sequencing the list within this second group of project areas, we recommend revisiting the biological benefit assessment during phase II.

Table 1. Summary of the total and currently disconnected Historic Channel Migration Zone (HCMZ) and Floodplain in Nason Creek between river mile 4.6 and 14.3. Data generated by the USBR Nason Creek Geomorphic Reach Assessment.

Reach	Project Area Name	Qty of HCMZ	Qty HCMZ disconnected	% HCMZ disconnected	Qty Floodplain	Qty Floodplain disconnected	% floodplain disconnected	Sum of disconnected HCMZ and floodplain	% floodplain and HCMZ disconnected
3	PrjArea_14.3	40.9	31.1	76%	66.1	22.3	34%	53.4	50%
3	PrjArea_13.3	30.7	3.2	10%	65.6	5.9	9%	9.1	9%
3	PrjArea_12.47	45.1	14.6	32%	100.2	37.8	38%	52.4	36%
3	PrjArea_11.62	167.8	90.0	54%	372.2	136.9	37%	226.9	42%
2	PrjArea_9.42	10.1	0.0	0%	13.6	0.05	0%	0.1	0%
1	PrjArea_8.9	45.0	7.0	16%	86.3	0	0%	7.0	5%
1	PrjArea_7.75	42.2	6.2	15%	57.7	0	0%	6.2	6%
1	PrjArea_6.6	52.2	9.6	18%	122.1	21.2	17%	30.8	18%
1	PrjArea_5.2	38.5	3.2	8%	68.9	12.3	18%	15.5	14%
	Sum =	472.5	164.9	35%	952.7	236.5	25%		28%
	Mean =	52.5	18.3		105.9	26.3			
	Median =	42.2	7.0	16%	68.9	12.3	17%		14%

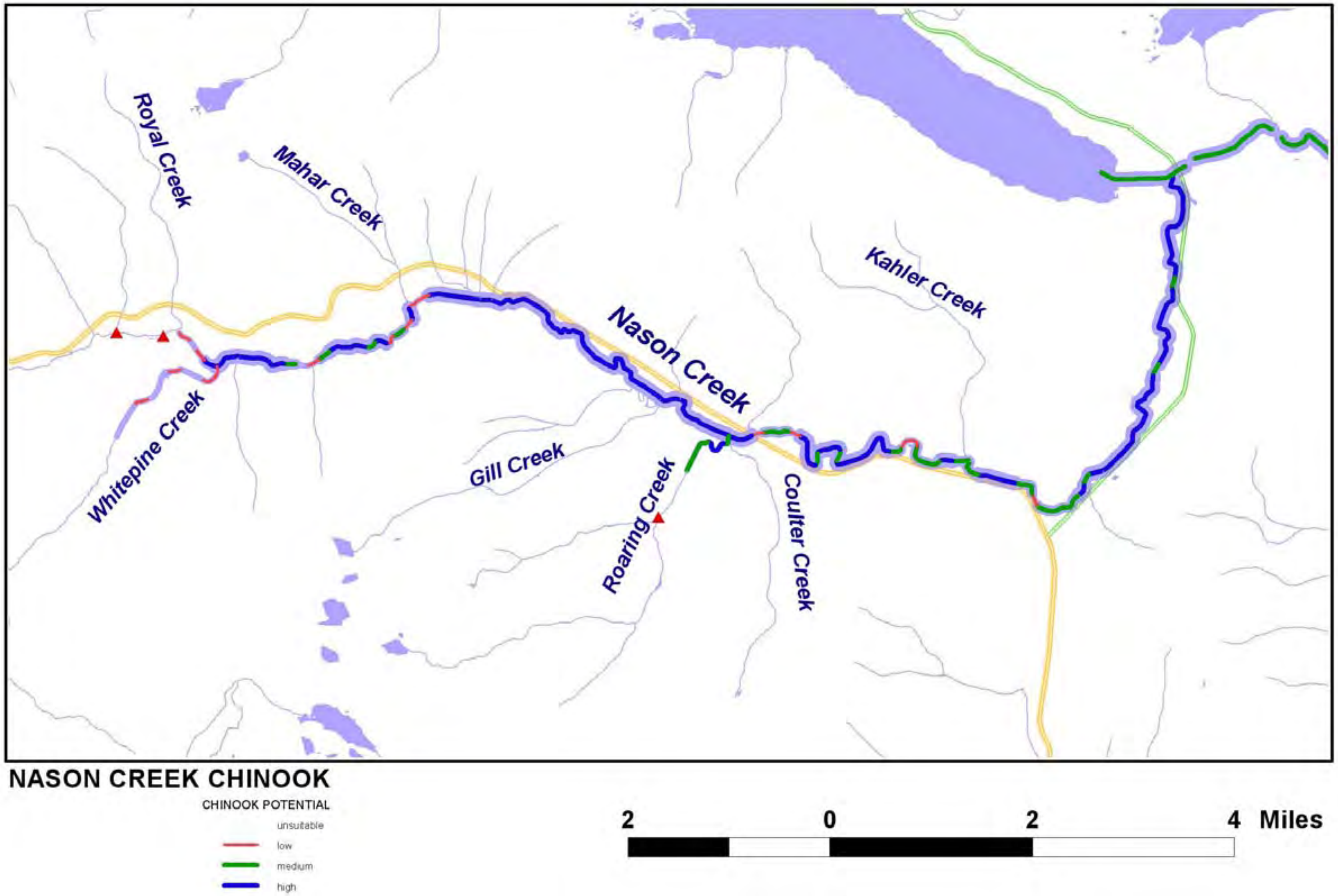

Figure 1. Map of spring Chinook habitat Intrinsic Potential (ICTRT 2007) in Nason Creek, Washington.

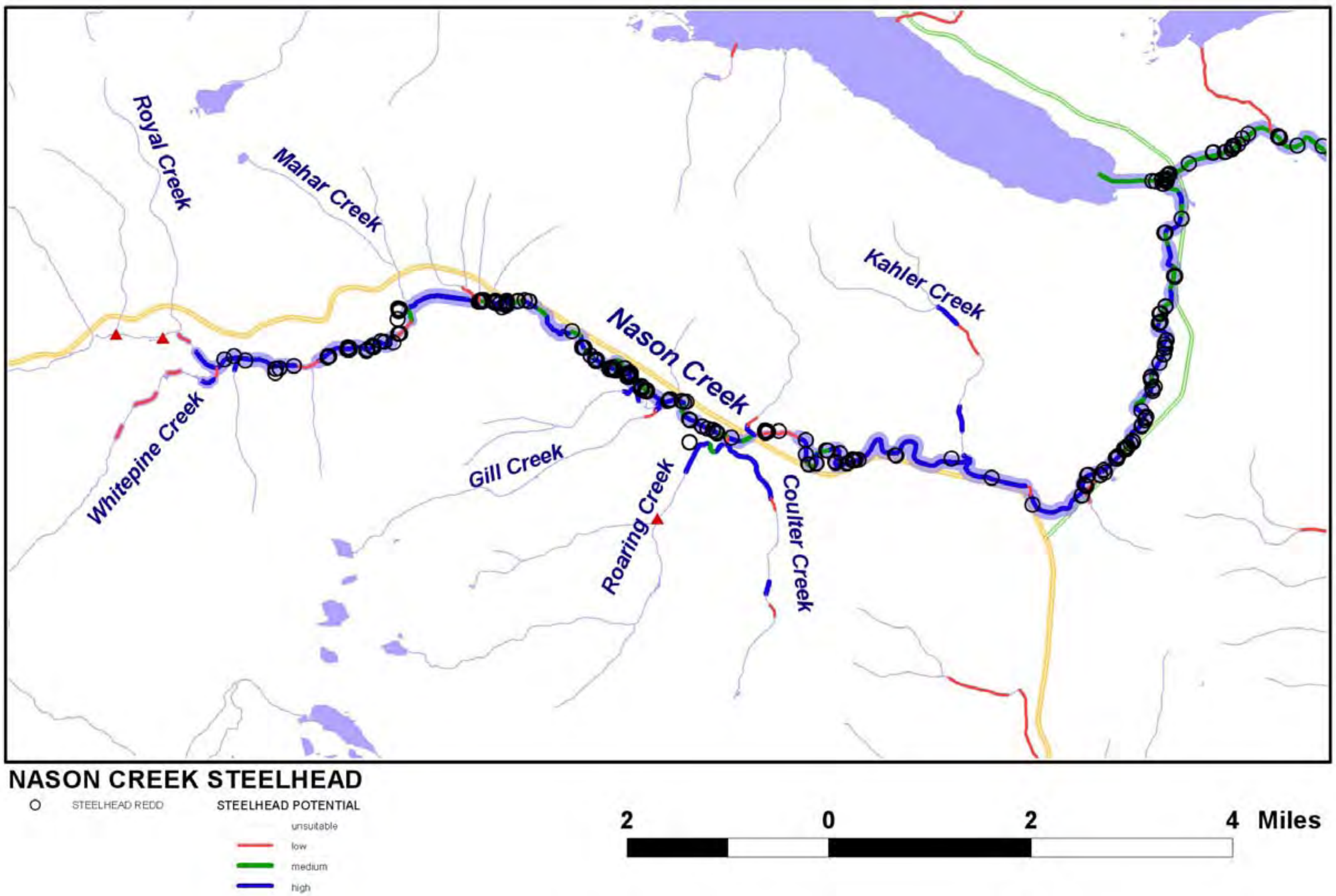

Figure 2. Map of steelhead habitat Intrinsic Potential (ICTRT 2007) and steelhead redd locations (2004-2005?) in Nason Creek.

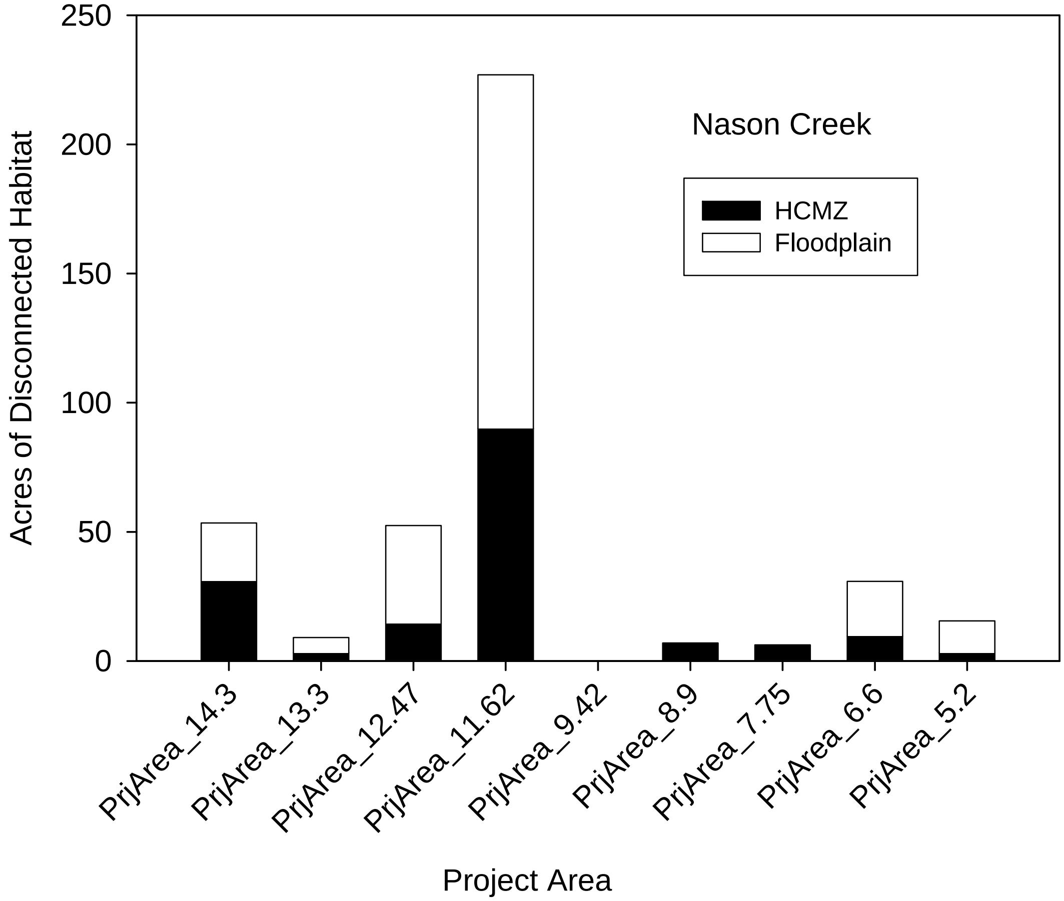

Figure 3. Quantity of historic channel migration zone (HCMZ) and floodplain disconnected within each Project Area of Nason Creek between river mile 4.6 and 14.3. Data source: USBR *Draft Findings and Restoration Concepts for Nason Creek Between RM 4.6 to 14.4.*

Phase II.

Project Subarea Prioritization

The RTT has not yet conducted a comprehensive evaluation of all the Project Subareas.

After the initial course screen feasibility is applied from the Prioritization Framework and there are Project Subareas of similar size and feasibility then we would consider:

1) Quality of the habitat in the reconnected floodplain. Quality is defined by:
   a) The density and complexity of sidechannels.
      a. Complexity of floodplain interaction with sidechannels versus total area (is it locked in an incised sidechannel?)
   b) If there is upwelling or other cold water inputs (tributary streams) into the area. *This will be determined using the FLIR surveys from 2001 and 2003 and by evaluating the quantity of standing water in the recaptured floodplain*.
   c) The quality of existing riparian condition in the recaptured floodplain.
   d) Existing instream diversity

2) Relationship to secondary and tertiary opportunities in the Project Area

APPENDIX F

HYDRAULICS AND SEDIMENT ANALYSIS

This appendix includes the methodology for development of a two-dimensional (2D) numerical hydraulic model applied to the assessment area and an analysis of relative sediment transport capacity among reaches. The 2D model was developed using existing topography and topography with human features removed. The removed human features removed from the modeling surface prevent flow from accessing the floodplain in localized portions of the floodplain. The objective of the hydraulic modeling effort was to assist with delineation of the geologic floodplain and historical channel migration zone, and evaluate flow connectivity impacts from embankments or other man-made constructs that prevent channel – floodplain connectivity. Additionally, relative sediment capacity among geomorphic reaches is compared. The model was based solely on 2006 LiDAR data collected at 40 cfs and is most applicable for drawing conclusions regarding off-channel and floodplain connectivity at near bankfull and higher flows. If localized channel hydraulics or sediment predictions are needed, particularly at low flows, additional modeling should be employed that incorporates survey data below the water surface elevation corresponding to a discharge of 40 cubic feet per second (cfs). The type of model needed at project scales will be dependent on the project level questions of interest, and could potentially range from a one-dimensional to three-dimensional numerical model, a physical model, or a channel migration model.

CONTENTS

Tables

Figures

1. INTRODUCTION

The two dimensional (2D) numerical model, SRH-W v1.1 (Lai 2006; http://www.usbr.gov/pmts/sediment/model/srh2d/index.html), was used for hydraulic and sediment analysis on Nason Creek from river mile[1] (RM) 4.6 to 14.3. A 2D model was utilized for its improved representation of complex hydraulic flow features and its ability to determine hydraulic conditions on a continuum. Examples of complex flow features are lateral overtopping onto adjacent floodplains and interaction between the main channel and side channels. Both conditions can result in non-uniform flow distribution (Figure 1). A 1D HEC-RAS model (built with GEORAS in ARCGIS) was also used for visualization of topography in cross-section format and for generating boundary conditions for the 2D model (Figure 2). Limited calibration data was available that included water surface elevation at 40 cfs, ground photographs during a spring snowmelt flood that did not overtop the active channel banks, anecdotal accounts during a 1990 and 1996 flood that did overtop the active channel banks, and FEMA floodplain boundaries. Steady flows modeled ranged from 2,500 to 15,000 cfs, which includes the range of estimated 2- to 100-year flood values between RM 4 to 14.

The following is a list of major features of SRH-W (Lai 2006):

- SRH-W solves the 2D depth-averaged form of the diffusive wave or the dynamic wave equations. The dynamic wave equations are the standard St. Venant depth-averaged shallow water equations;
- Both the diffusive wave and dynamic wave solvers use the implicit scheme to achieve solution robustness and efficiency;
- Both steady or unsteady flows may be simulated;
- All flow regimes, i.e., subcritical, transcritical, and supercritical flows, may be simulated simultaneously without the need of a special treatment;
- Solution domain may include a combination of main channels, side channels, floodplains, and overland;
- Solved variables include water surface elevation, water depth, and depth averaged velocity. Output information includes above variables, plus flow inundation, Froude number, and bed shear stress.

[1] All river miles in this appendix refer to the centerline length along the 2006 active, unvegetated channel starting at river mile 0 at the mouth of Nason Creek where it enters the Wenatchee River.

- A development version of the code was also utilized to compute sediment capacity, Shields number, and incipient motion for a limited number of model runs.

The 2D model was applied to existing topographic conditions and to topographic conditions with human features removed that block flow access within the floodplain. The objective was to assist with delineation of the geologic floodplain and historical channel migration zone, and evaluate flow connectivity impacts from embankments or other human features that prevent the channel from interacting with the floodplain at bankfull discharges and higher. Additionally, sediment capacity between geomorphic reaches is compared. The model was based solely on 2006 LiDAR data collected at 40 cfs and is most applicable for looking at off-channel and floodplain connectivity at near bankfull and higher flows.

All data presented in this report are in the horizontal projection of Washington State Plane North, NAD 1983 feet and vertical projection of NAVD 1988 feet. Model results are available in ASCII (comma delimited) format for each model run, SMS format (a post processing software), and also as ARCGIS shape files.

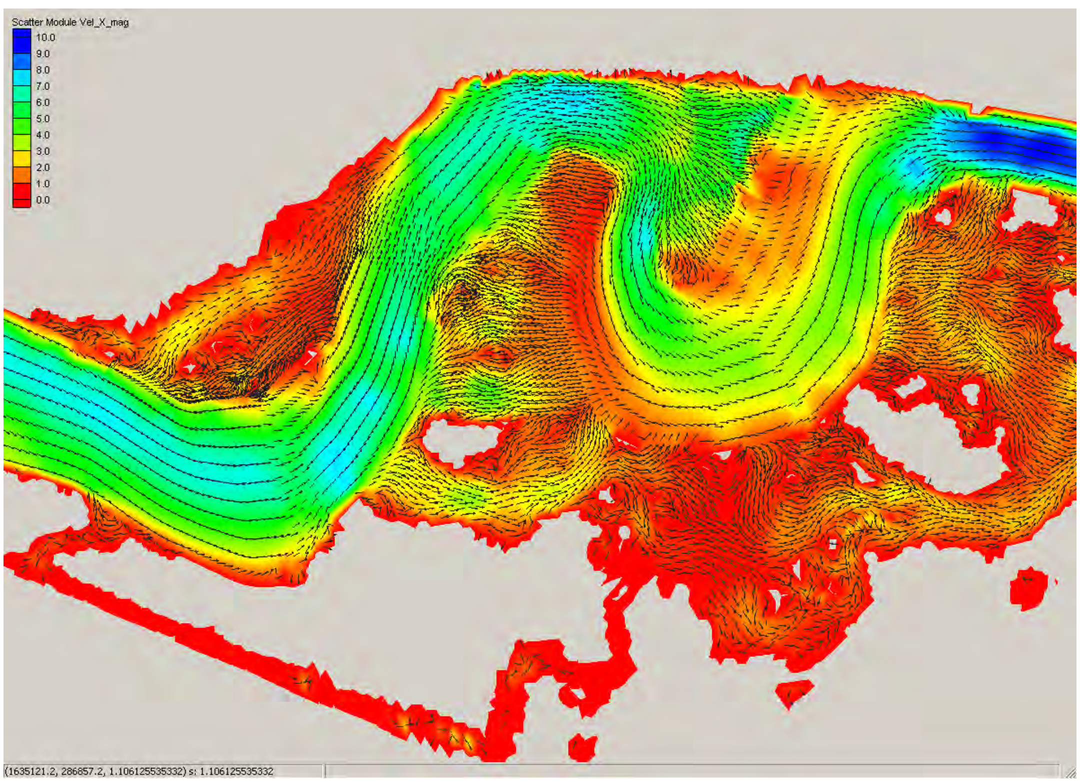

Figure 1. Example of 2D model velocity vectors (black arrows) and magnitude (color coded legend in ft/s) results around RM 12.7 to 13.3 where flow path along channel and floodplain differ.

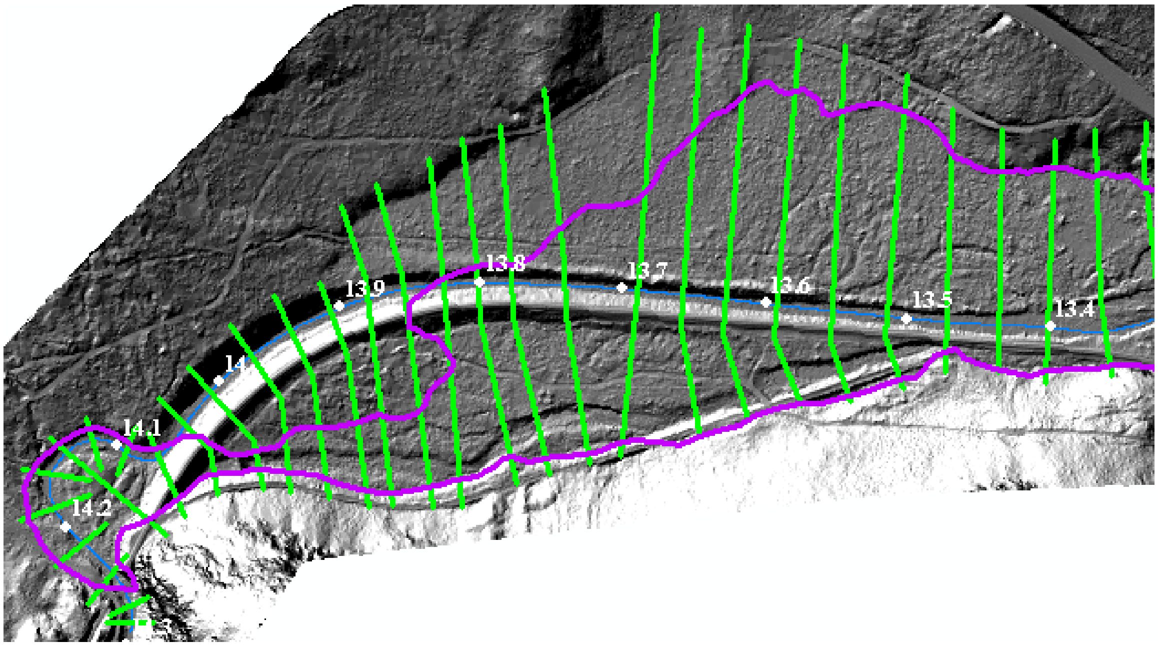

Figure 2. Example of 1D model cross-sections generated (green lines) along with geologic floodplain boundary (purple) for RM 13.4 to 14.3 shown on hillshade from 2006 LiDAR.

2. MODEL SETUP

Hydraulic analysis includes the following steps:

1. Selection of the solution domain (model boundaries)
2. Mesh generation for the solution domain
3. Delineation of Manning's roughness parameters on mesh
4. Topographic representation of the mesh (transforms mesh to a "grid" by applying elevations of input survey data)
5. Selection of computation parameters and boundary conditions

2.1 Solution Domain (Model Boundaries)

Two independent model meshes were generated to capture each of the two geomorphic reaches 1 and 3 that contain complex off-channel areas and floodplain (Table 1). LiDAR data was available from RM 0 to 14.4. The upstream and downstream boundaries were chosen where there is a naturally confined section with fairly uniform hydraulics. The exception was the downstream end of the reach 1 model, where the floodplain was more extensive. Because there was not an ideal location to cutoff the model, the model boundary went slightly downstream of the geomorphic reach boundary to help eliminate any errors associated with the boundary. The lateral boundaries of the solution domain were selected based on geologic features that limit the extent of flood inundation such as alluvial fans, terraces, bedrock, etc.

Table 1. Summary of solution domains for both 2D models.

Geomorphic Reach Represented	1D and 2D Model Extent	Upstream Boundary	Downstream Boundary	Model Reference Name
1 (RM 4.6 to 8.9)	RM 4.3 to 9.4 (5.1 miles)	Naturally confined section (geomorphic reach 2)	Moderately confined section with highway embankment	RM 5 to 9 Model
3 (RM 9.4 to 14.3)	RM 9.2 to 14.3 (5.1 miles)	Bedrock constriction just upstream of White Pine Bridge	Naturally confined section (geomorphic reach 2)	RM 9 to 14 Model

2.2 Mesh Generation

SRH-W uses a combination of structured and unstructured mesh cells. For Nason Creek, a combination of quadrilateral and triangular meshes was utilized. A pre-processor program SMS (version 8.1) was used to generate the mesh for existing and human feature removed conditions. The following web site link provides more information for the software: www.scientificsoftwaregroup.com. The SRH-W user’s manual (Lai 2006) provides an in-depth discussion on how to use SMS to prepare a 2D mesh for use by SRH-W.

The mesh was broken into unique polygons based on an iterative procedure. Polygons were initially based on roughness variations (e.g., main channel, vegetated floodplain, and unvegetated floodplain). Polygons were then further sub-divided to allow proper representation of flow lines, such as in meander bends. The final iteration was to sub-divide polygons in areas where tighter mesh cell density was needed such as along road and railroad embankments where it was important to capture absolute maximum elevations that could impact flow connectivity within the floodplain. The existing conditions mesh was also utilized to represent the human features removed conditions.

The mesh has the following features:

- Combined structured and unstructured mesh with quadrilateral and triangular element configurations
- Number of elements
  - 118,349 elements (mesh cells) for RM 5 to 9
  - 296,441 elements (mesh cells) for RM 9 to 14
- Number of nodes
  - 110,711 nodes for RM 5 to 9
  - 161,580 nodes for RM 9 to 14
- 20 cells generally used across active, unvegetated 2006 channel
- Tightest density of cells used in channel areas and areas with rapid changes in elevation with respect to horizontal distance
- Lesser density of cells was used in floodplain areas where there is less elevation change (topographic relief)

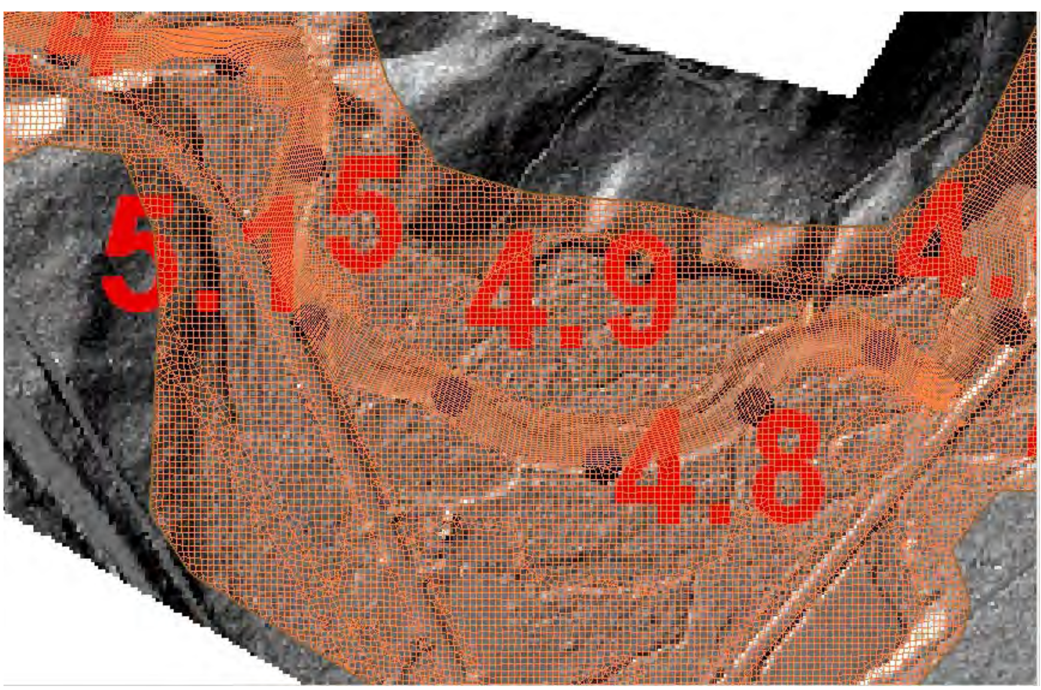

Figure 3. Example of mesh solution with river miles shown in red text and brown circles (background is 2006 LiDAR hillshade).

2.3 Roughness Delineation

Flow resistance is quantified in SRH-W using the Manning's roughness coefficient, and as such is one of the model inputs. Manning's coefficient is usually distributed spatially, according to the surface roughness type in the solution domain. Delineation of roughness polygons was done in ARCGIS version 9.2 using a 2006 aerial photograph generated from the U.S. Department of Agriculture "National Agriculture Imagery Program" (NAIP), 2006 aerial photography collected by Watershed Sciences for this geomorphic effort, and a vegetation model from 2006 LiDAR data illustrating canopy heights. Because the model objectives are focused on off-channel and floodplain connectivity and each model is 5-miles in length, roughness polygons were broken into four general categories: 1) unvegetated channel area, 2) cleared, 3) densely vegetated floodplain, and 4) sparsely vegetated floodplain (example shown in Figure 4 and Figure 5). Roughness value selection is discussed in the calibration section of the report.

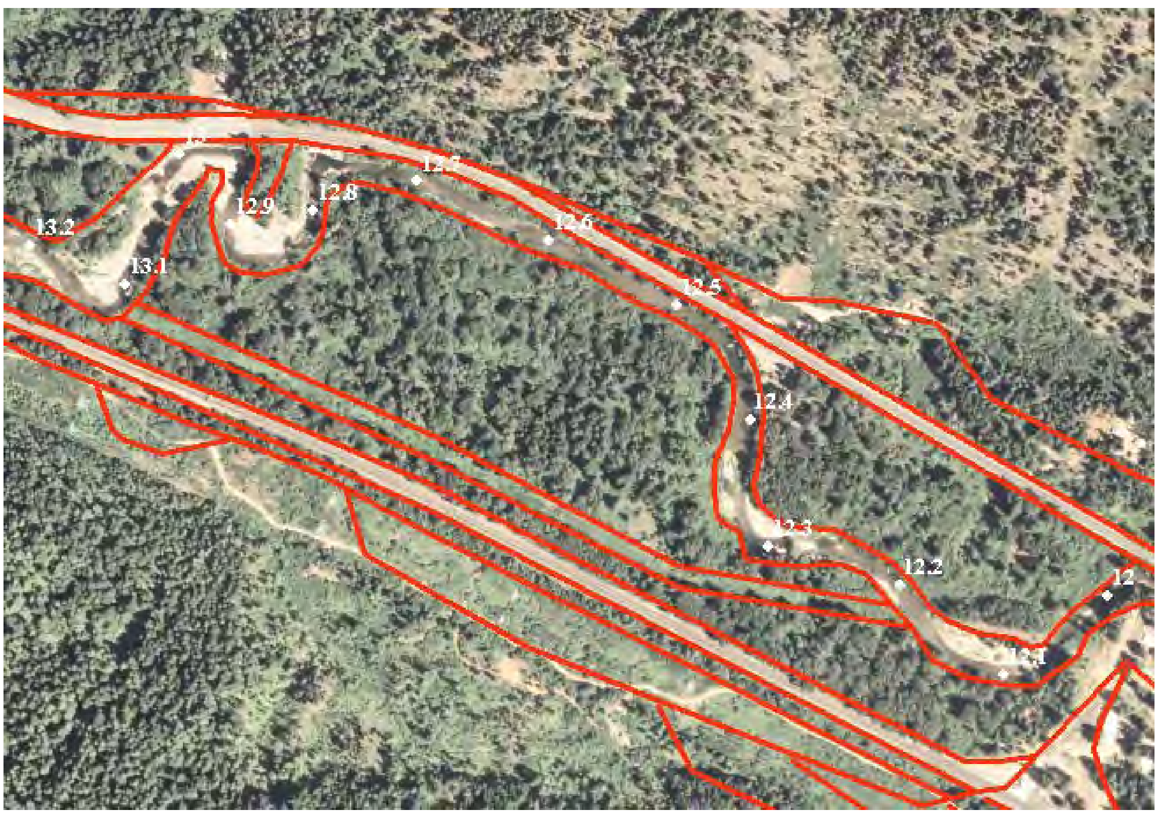

Figure 4. Example of roughness delineation for 2D model mesh for the extent of the model boundary.

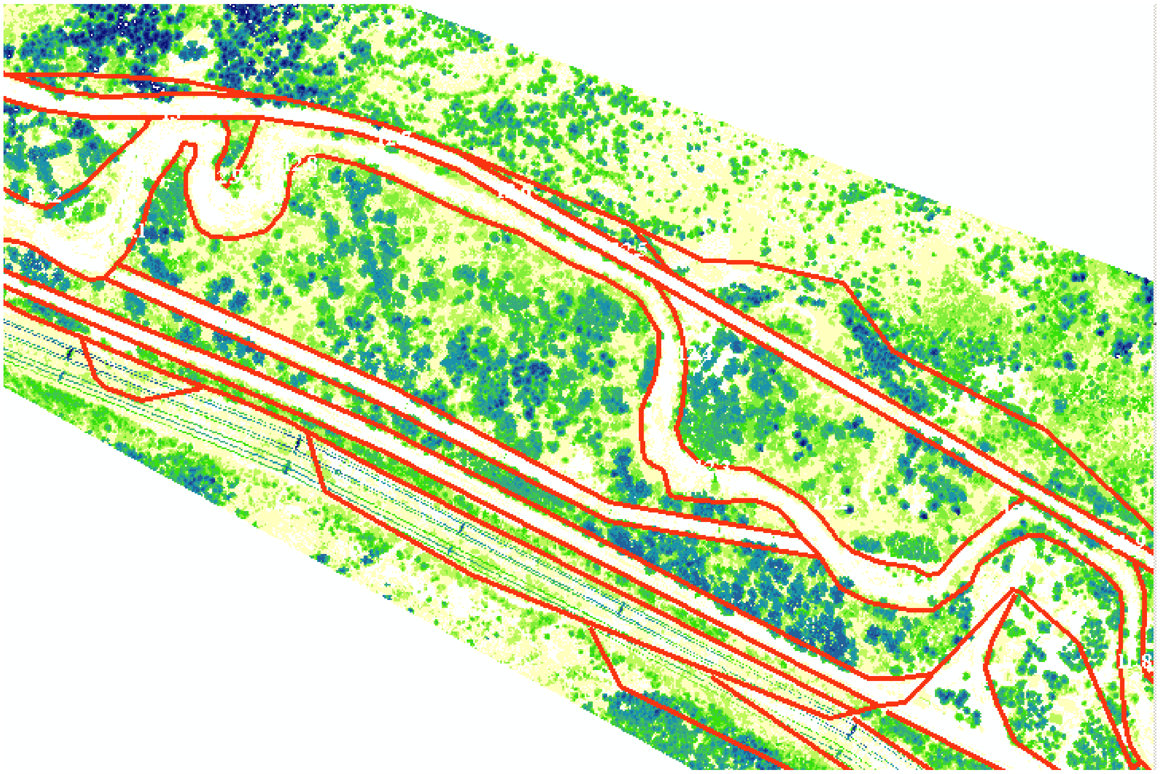

Figure 5. Example of vegetation height model from 2006 LiDAR data used for roughness delineation.

2.4 Topographic Representation of Mesh

The terrain grids generated for 2D modeling of geomorphic reaches 1 and 3 are listed in Table 2. Topography data used to populate the existing conditions grid with elevations was a 10-foot grid derived from bare-earth 2006 LiDAR data collected at a flow of 40 cfs. The bare-earth LiDAR elevation points had to be reduced from a 3.3-foot grid to a 10-foot grid to accommodate processing limitations of SMS, a program used to develop the mesh and grid for input to SRH-W. In the RM 9 to 14 grid, embankment areas were supplemented with original LiDAR data to ensure crest heights of embankments that limit flow connectivity were captured correctly. For the human features removed grid, features were removed that were raised above the nearby ground such that they would impact flow connectivity between the main channel and floodplain (e.g. levees, road embankments, railroad embankments). Houses, infrastructure, and features such as power line poles were not removed.

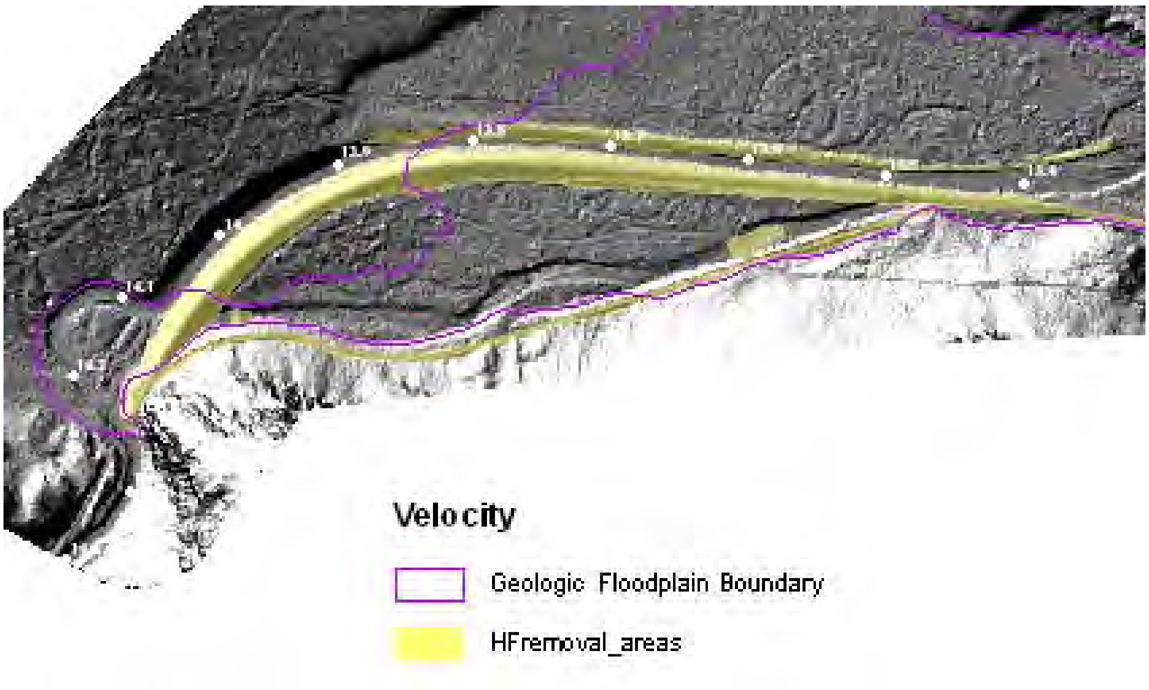

Figure 6. Example of human features removed that impede flow connectivity within the geologic floodplain boundary.

Bare-earth LiDAR data does not represent the true ground elevation of wetted areas during the survey (Figure 7); however, bed elevations in very shallow portions of the river such as riffles were determined to be properly represented because a significant portion of the bed material was exposed in these areas. A longitudinal profile of the channel bottom (thalweg) was later surveyed by foot (combination of RTK GPS and total station) in 2007 and could be incorporated into the grid development for future modeling efforts. A comparison of the LiDAR and ground surveys in very shallow areas indicates that elevations are within one foot of each other. More details of this comparison can be found in Appendix G (Channel Slope and Survey Data). No ground elevation data were collected in ponded areas outside of the main channel during the 2007 ground survey. In deep pools the LiDAR is unreliable for determining bed elevations due to the inability of red light to penetrate the water column. Even though the thalweg is not represented in deep pools, the hydraulic controls that have the greatest impact on water surface elevations (riffles) are properly represented, thus the water surface elevations and off-channel and floodplain connectivity is well represented in model results at discharges greater than 40 cfs. Although the water surface elevations are within a few tenths of a foot in pool areas, localized model results for depth, velocity, Froude number, and shear stress are not well represented. Due to the lack of detailed channel bottom data, model results at discharges less than 40 cfs will be unreliable.

Table 2. List of grids created for 2D modeling.

Reach	Scenario	Grid Name	Topographic Data Notes	Elevation Range (NAVD 88 ft)
RM 5 to 9 (Geomorphic Reach 1)	Existing	NC_RM5to9_Existing.2dm (Figure 8)	10 foot grid from bare earth 2006 LiDAR data	1946 to 2256
RM 5 to 9 (Geomorphic Reach 1)	Human Features Removed	NC_RM5to9_HFRemoved.2dm (Figure 9)	Delineated human features in ARCGIS where elevations are higher than natural ground (e.g. levees, roads, railroad); removed these elevation points from model input data and allowed the tin to connect natural ground from either side of the feature to create new surface	1946 to 2256
RM 9 to 14 (Geomorphic Reach 3)	Existing	NC_RM9to14_Existing4.2dm (Figure 10)	10 foot grid from bare earth 2006 LiDAR data; delineated human features in GIS where elevations are higher than natural ground (e.g. levees, roads, railroad); supplemented 10 ft grid in these areas with original 1 m bare earth LiDAR data to capture crest heights of features; used for higher flows to ensure overtopping was correctly captured	2132 to 2468
RM 9 to 14 (Geomorphic Reach 3)	Human Features Removed	NC_RM9to14_HFRemoved3.2dm (Figure 11)	Delineated human features in ARCGIS where elevations are higher than natural ground (e.g. levees, roads, railroad); removed these elevation points from model input data and allowed the tin to connect natural ground from either side of the feature to create new surface	2132 to 2468
RM 9 to 14 (Geomorphic Reach 3)	Human Features Removed and Channel Modifications	NC_RM9to14_ChanMod3.2dm (Figure 12and Figure 13)	Modified channel to fill in engineered channel areas and reconnect historical main channel to present channel at RM 13.3 to 14.3 and RM 10.7 to 11;	2132 to 2468

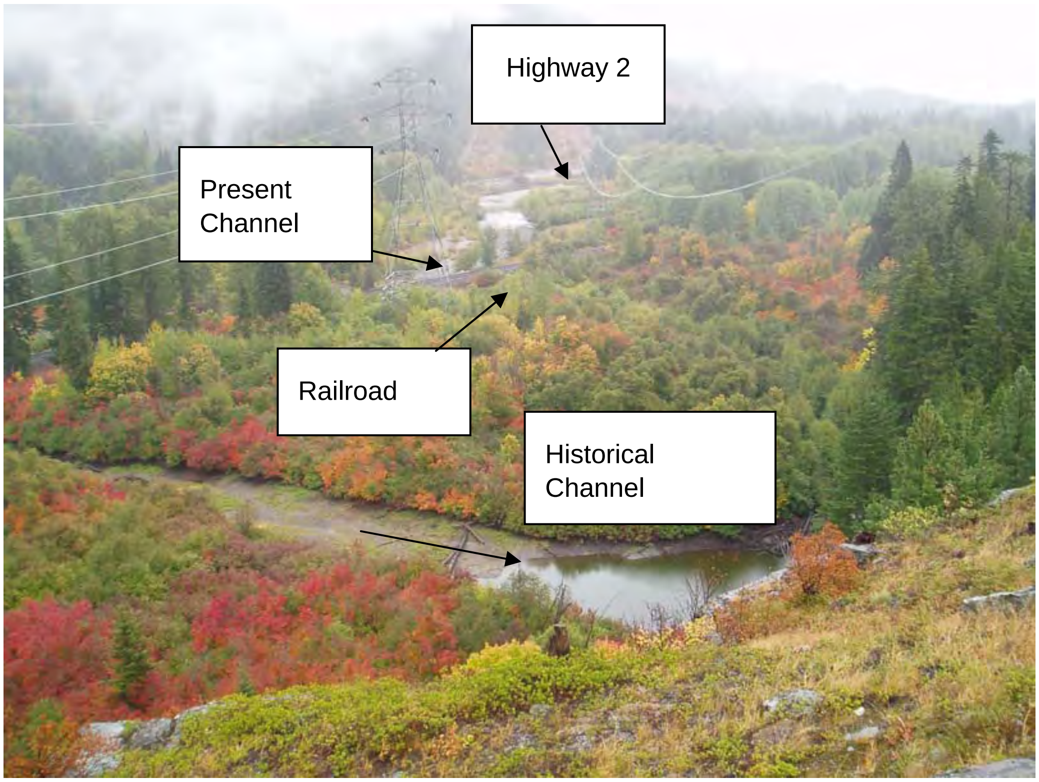

Figure 7. Example showing wetted channel and ponded areas where underwater elevations are not represented in 2D model grid.

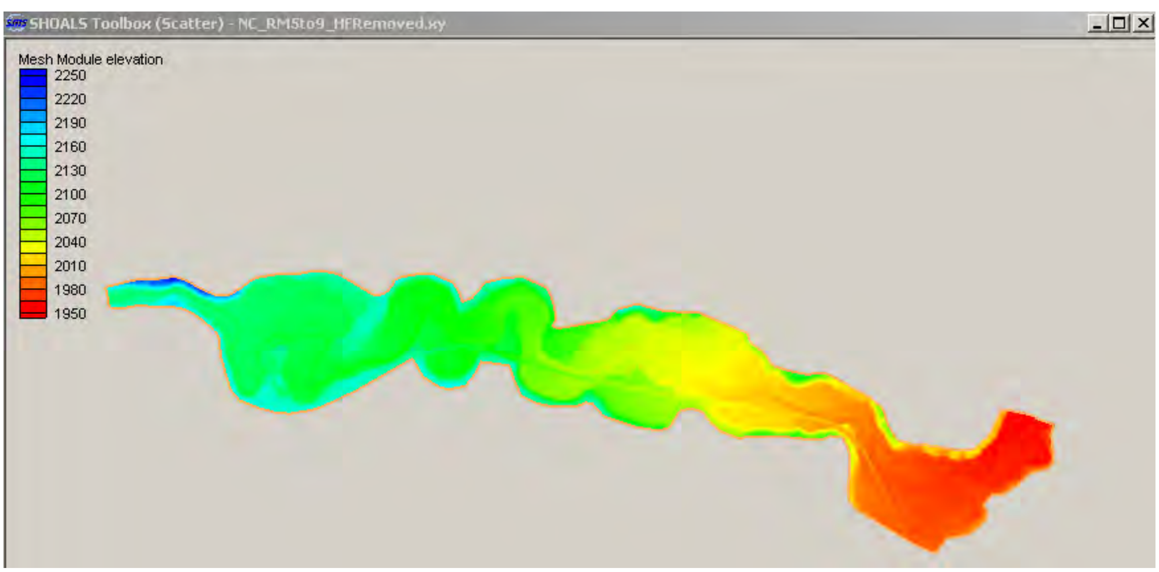

Figure 8. Existing conditions grid for RM 5 to 9.

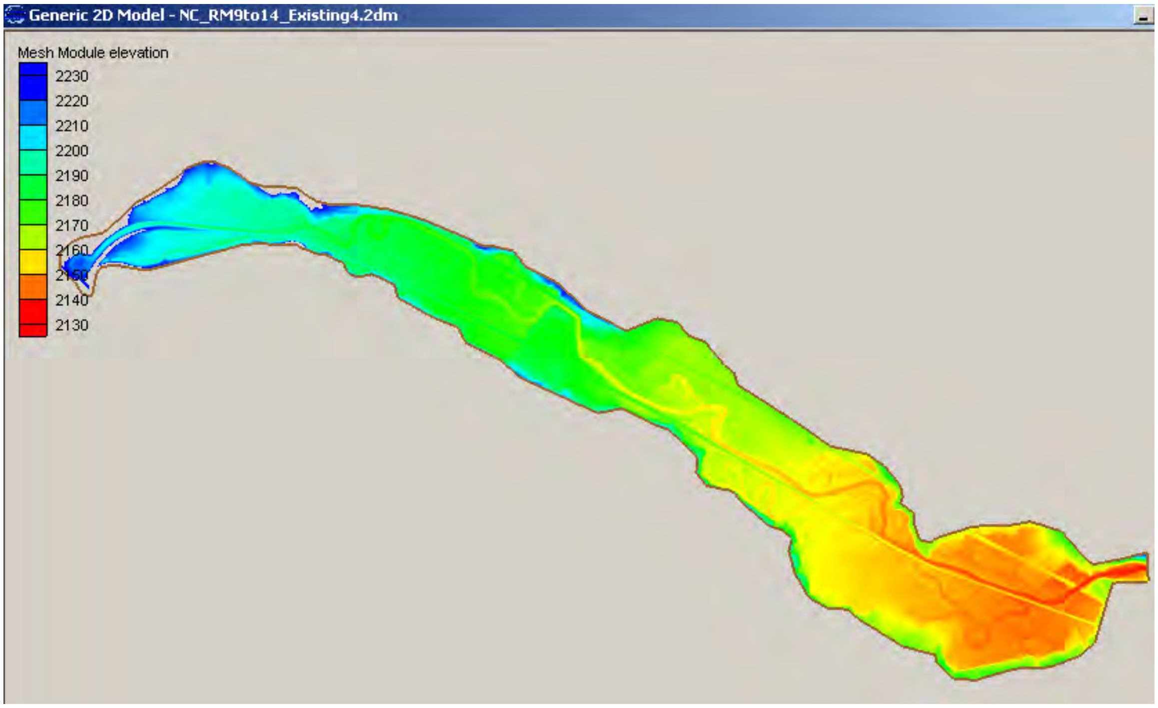

Figure 9. Existing conditions grid for RM 9 to 14.

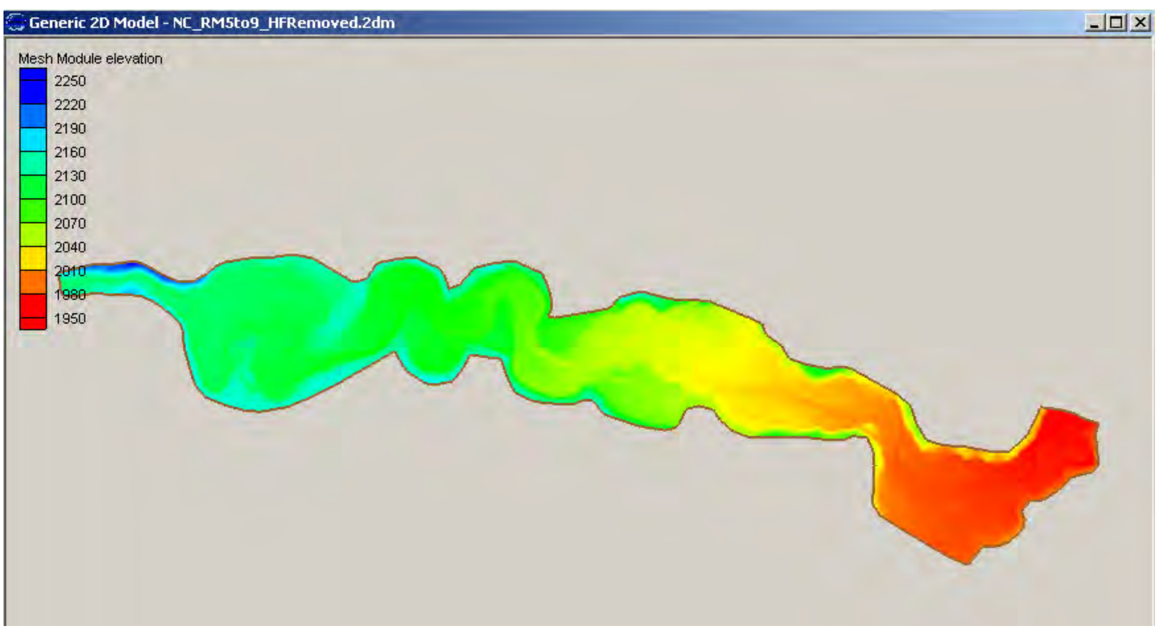

Figure 10. Human features removed grid for RM 5 to 9.

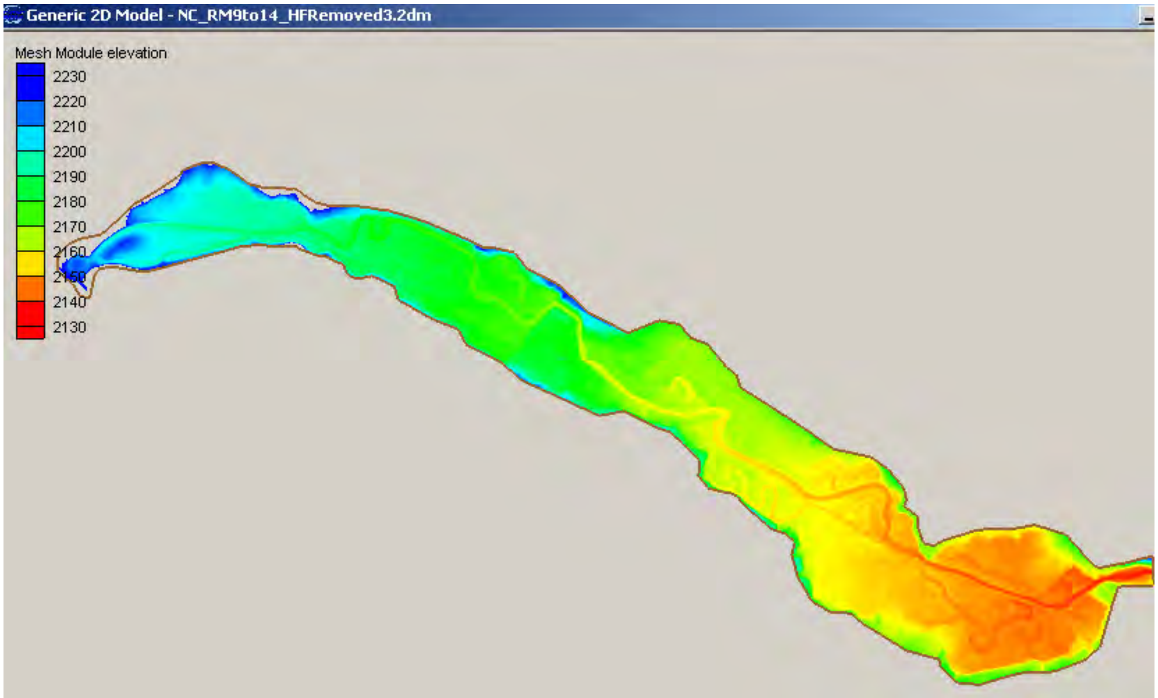

Figure 11. Human features removed grid for RM 9 to 14.

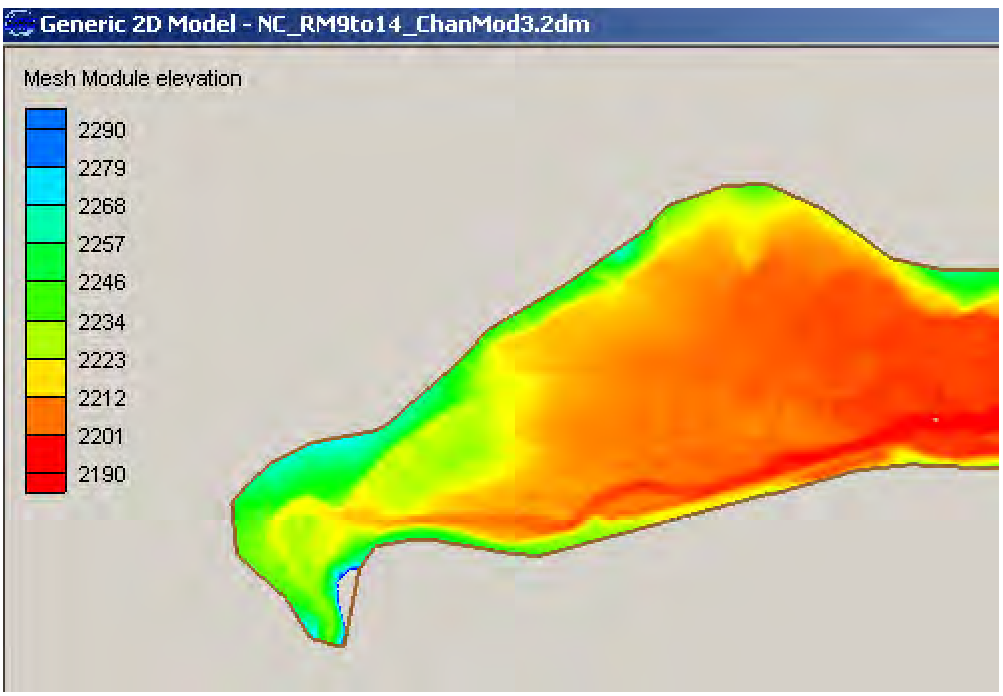

Figure 12. RM 13.3 to 14.3 where present channel was filled in to evaluate flow connectivity if only historical channel were inundated.

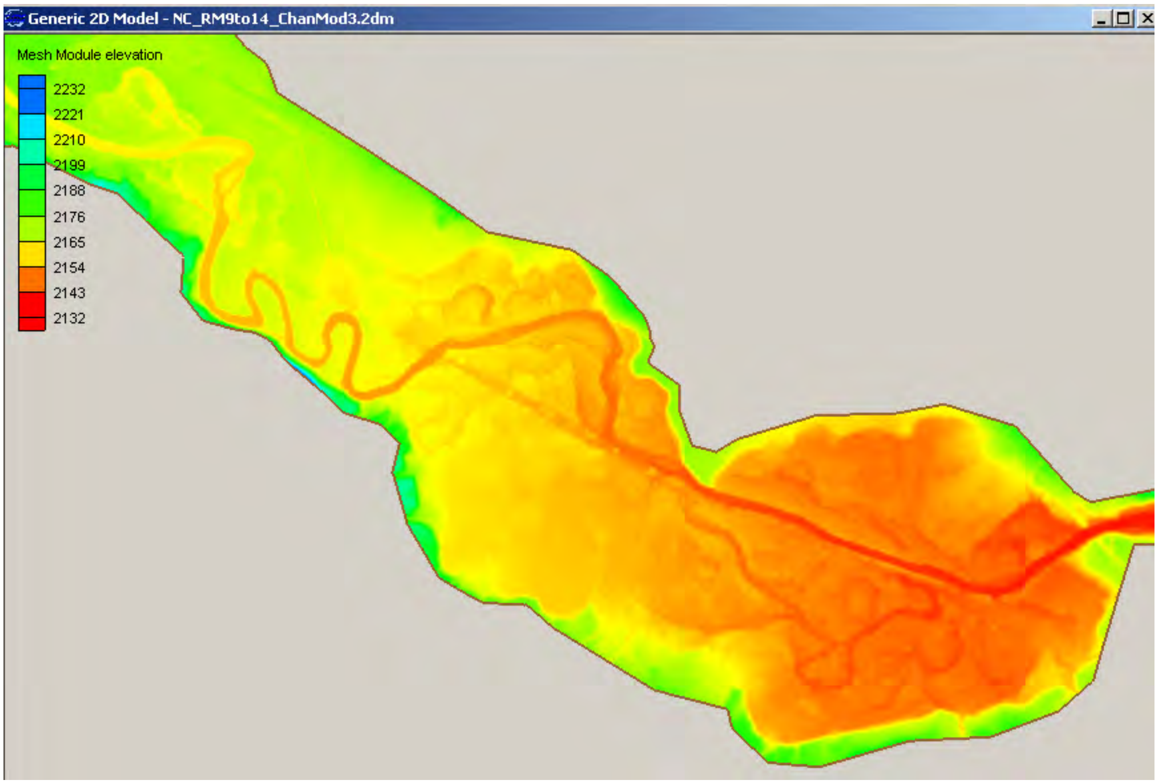

Figure 13. RM 10.7 to 11.0 where present channel was filled in to evaluate flow connectivity if only historical channel were inundated.

2.5 Computation Parameters and Boundary Conditions

A time step, total computation time, upstream boundary condition of discharge, and downstream boundary water surface elevation must be input to SRH-W prior to running a simulation. Selection of these parameters is discussed in this section.

2.5.1 Time Step and Duration

A time step of 5 seconds was chosen and initially ran for 86,400 time steps (432,000 seconds or 120 hours). Model results were output at intervals of 900 or 1800 time steps, which equals every 1.25 to 2.5 hours. A computation time duration was chosen that was long enough such that results appeared to be hydraulically stable and were not significantly changing with additional computation time. A hydraulically stable result was defined as having no unrealistic values of velocity or Froude number from both an absolute magnitude and relative to location in the main channel or floodplain (e.g., smaller velocities in shallow overbank areas, higher velocities around outside of meander bends, etc.). To test the model run times, results were compared for a flow of 2,500 and 15,000 cfs in the RM 5 to 9 reach for existing conditions at different durations (example comparison shown in Figure 14). The results were nearly identical at half the total computation time, so subsequent runs were often shortened to be more efficient in computer processing time.

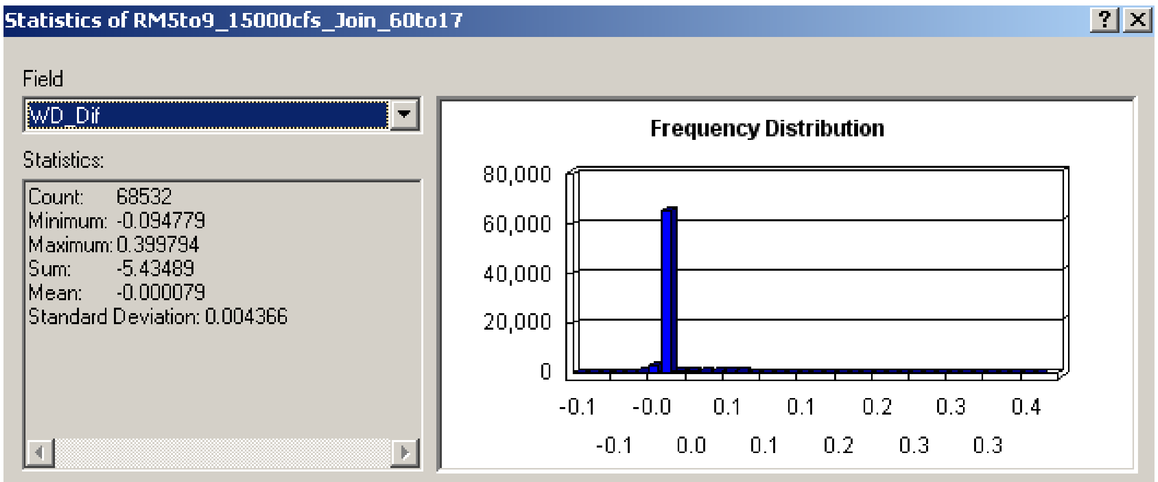

Figure 14. Comparison of model results at two computation intervals for 15,000 cfs for RM 5 to 9 existing conditions grid.

2.5.2 Modeled Discharges

USGS gage data from Icicle Creek and the Washington Department of Ecology (DOE) gage data at RM 0.8 was used to develop flood frequency values to help choose the discharges modeled. However, flow data at this gage has only been collected since 2002, which provides about 5 years of data. The highest flow recorded was slightly less than 10,000 cfs. Additionally, discharge varies with drainage area and generally increases in the downstream direction, so that a 100-year flood value at RM 0.8 is much different than at the upper end of the 2D modeling near RM 14. Upstream flow reduction for each flood frequency value was estimated using a relationship of flow and drainage area (see Hydrology appendix for methods; Figure 15). Because modeling was done with steady flows and not hydrographs, a series of flows were used in 5,000 cfs increments ranging from 2,500 to 15,000 cfs, which covers the range of 2- to 100-year estimated flood values for RM 4 to 14.

The DOE suggests that the margin of error is 5 percent for flows measured below 1,200 cfs and 15 percent for flows measured above 1,200 cfs; stage measurements are noted to have a 0.02 foot margin of error (Springer 2005). Additionally, the flood frequency values also have uncertainty of up to 30 percent for the 100-year flood because of limited gage data available on Nason Creek (Appendix D – Hydrology). Therefore, a combination of model results should be used when thinking of a 10- or 100-year flood result depending on the location.

For comparison, the 100-year flood reported in the 1980s FEMA study for Nason Creek was 6,200 cfs near RM 6, and about 4,100 cfs at the White Pine railroad bridge (RM 14.3) (Figure 16). These flood frequency values were not based on any gage data from the Nason Creek watershed, and are lower than values updated with DOE gage data. The DOE gage at RM 0.8 (107.8 sq miles) has estimated values for the following peak flows;

- Water Year 2007: November 2006, 9,940 cfs instantaneous peak (peak under review at DOE and may be changed; as of June 2008 new November peak listed as 4,960 cfs)
- Water Year 2006: May 2006, 6,440 cfs instantaneous peak (estimated value)
- Water Year 2005: January 2005, 4,950 cfs instantaneous peak (estimated value)
- Water Year 2004: November 2003, 3,150 cfs estimated instantaneous peak
- Water Year 2003: January 2003, 5,780 cfs instantaneous peak (estimated value)

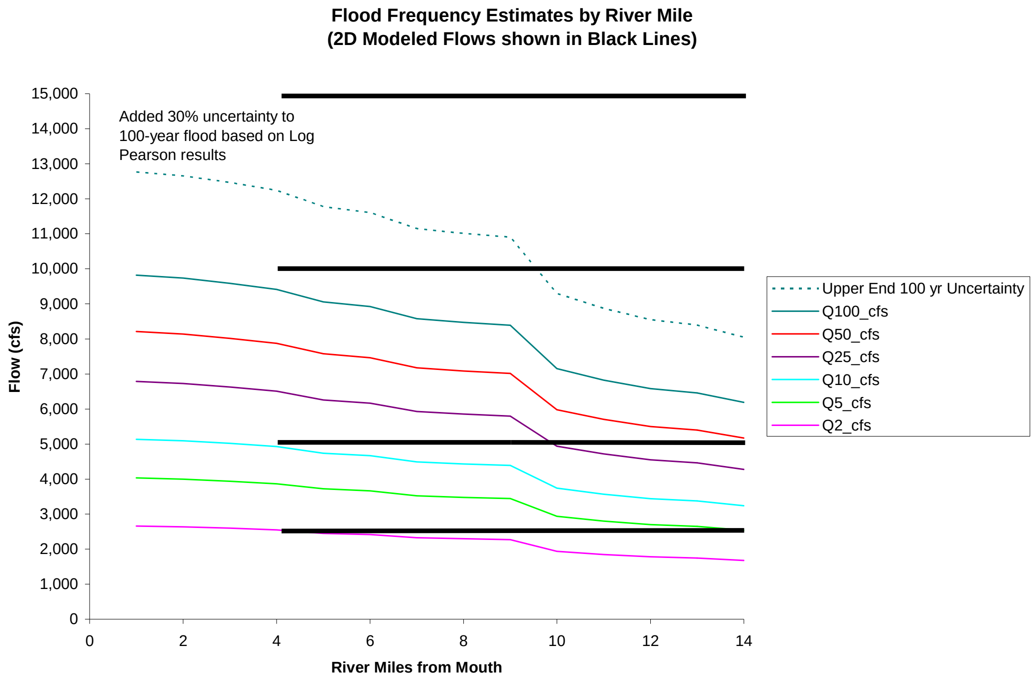

Figure 15. Comparison of modeled flows of 2,500, 5,000, 10,000, and 15,000 cfs (black lines) for RM 4 to 14 versus computed flood frequency estimates (e.g. Q 100_cfs is 100-year flood) that change longitudinally by river mile.

Table 1. Summary of Discharges

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second (cfs)) 10-Year	50-Year	100-Year	500-Year
Wenatchee River					
At Monitor Gage	1,301	26,500	38,500	48,700	82,000
At Dryden Gage	1,155	25,700	36,863	46,372	78,289
At Peshastin Gage	1,000	24,300	34,000	42,300	71,800
At South Line S34, T26N, R17E	606	17,600	21,500	23,000	26,000
At Plain Gage	591	17,500	26,500	34,100	62,800
At Lake Gage	273	10,000	12,100	13,000	14,800
Mission Creek					
At Southern City Limits of Cashmere	82	660	1,780	2,600	5,700
Peshastin Creek					
At Mouth	143	1,980	3,210	3,790	5,130
Icicle Creek					
At Mouth	213	7,930	11,000	12,360	15,650
Chumstick Creek					
At Mouth	82	900	1,430	1,720	2,810
At Eagle Creek Road	50	560	900	1,200	1,820
At Cross Section AP	41	470	760	930	1,520
At Sunitsch Canyon Road	31	400	640	770	1,250
Chiwawa River					
At Mouth	190	4,900	6,500	7,200	8,800
Nason Creek					
At Kahler Creek Bridge	98.6	4,270	5,860	6,590	8,250
Above Kahler Creek Confluence	91.2	3,990	5,490	6,170	7,720
Below Butcher Creek Confluence	87.5	3,850	5,290	5,960	7,460
Below Roaring Creek Confluence	76.3	3,430	4,720	5,320	6,670
Above Gill Creek Confluence	70.8	3,220	4,440	5,000	6,260
At Merritt	67.5	3,090	4,270	4,810	6,020
At Burlington Northern RR Bridge	64.2	2,960	4,090	4,610	5,780

Figure 16. Flood frequency values reported in 1980s FEMA analysis on Nason Creek.

2.5.3 Downstream Boundary Water Surface Elevation

A downstream boundary condition of water surface elevation is needed for each upstream boundary of discharge (Table 3). Preferably, a known rating curve of water surface elevation versus discharge is used for the downstream boundary, but was not available in this case except at RM 0.8 at a gaging station which is too far downstream to be used for either model. For the RM 9 to 14 model boundary, the output results from the RM 5 to 9 2D model were used to generate a downstream water surface elevation value. The boundary for the RM 5 to 9 model had to be generated from a 1D model as described below. Because both models had estimated boundary conditions, model results in the vicinity of the boundaries may not be accurate and should be used with caution.

Table 3. Boundary conditions for modeling.

Upstream Flow Input (cfs)	RM 5 to 9 Downstream Boundary Water Surface Elevation		RM 9 to 14 Downstream Boundary Water Surface Elevation	
	(m)	(ft)	(m)	(ft)
40	593.69	1947.79	650.53	2134.30
2500	594.96	1951.98	651.74	2138.25
5000	595.38	1953.34	652.80	2141.73
5666	595.45	1953.59	653.74	2144.81
10000	595.84	1954.85	654.01	2145.70
15000	596.20	1956.03	654.98	2148.90

The water surface elevation for the RM 5 to 9 model was based on a normal depth assumption using a 0.0067 slope derived from the water surface elevation slope (Appendix G – Channel Slope and Survey Data). A downstream boundary of water surface elevation is needed for the 2D model, so this slope assumption was input into a 1D HEC-RAS model also created from the 2006 LiDAR data. The 1D model was used to generate a water surface elevation for input to SRH-W. A 1D HEC-RAS model was also available from a previous effort funded by Chelan County with topography based on cross-section data. Because the LiDAR data was utilized to generate the grid for the 2D model, it was assumed the new 1D model based on LiDAR would be more accurate to develop downstream boundary conditions. To improve the accuracy of the downstream boundary input data, the 1D model could be extended so its boundary was at the DOE gage. The established discharge-elevation rating curve at the gage could be used for the boundary of the 1D model instead of slope, and then the computed elevation at the point of interest used for the 2D model downstream boundary.

A sensitivity analysis was performed for the RM 5 to 9 model at 5,000 cfs (near bankfull) with the boundary raised and lowered an arbitrary value of 1 foot to estimate the extent of influence on model results. At 5,000 cfs, the extent of river where the water surface elevation differed by more than 0.1 feet was limited to about 1/10 of a mile upstream from the downstream boundary. Other discharges were not tested.

3. MODEL CALIBRATION AND VALIDATION

Calibration of the model is an iterative process used to adjust roughness parameters and the topographic representation of the grid (if needed) to match measured data at a range of flows and scenarios. The measured data typically represents existing (or very recent) conditions, but in some cases may represent historical conditions with a different grid. Measured data can include water surface elevations, inundation boundaries, velocities, or water depths. The calibrated model is then validated by running at one or more flows with additional measured data not used in the calibration process. Both processes should cover the range of flows of interest.

Within the Nason Creek modeling boundaries, limited hydraulic data was available to either calibrate or validate the hydraulic model results. Additionally, the discharge is estimated to change longitudinally, and is only measured at RM 0.8, downstream of both models. Measured water surface elevation and depth was collected in 2007 at a low flow of 40 cfs, but this flow does not represent the majority of flows modeled (2,500 to 15,000 cfs). Additionally, because the 2D model grid was based on LiDAR and did not incorporate the 2007 channel thalweg, the modeled water surfaces are slightly higher in elevation than measured values (because the channel bottom is approximately modeled as water surface elevation at 40 cfs). The only data available to calibrate with were six photographs taken during May 2006 which are described in Section 3.2. No data was available to validate the model.

3.1 Selection of Roughness Values

Roughness values were based on past modeling experience in similar channel environments. A slightly higher roughness value was used in the channel for 40 cfs because of the shallower depths where coarse sediment would have more influence. For comparison purposes, the FEMA report documents Manning's n values for the Nason Creek 1D modeling in the 1980s ranged from 0.038 to 0.050 for the channel and 0.080 to 0.100 for overbank areas (FEMA 2004).

Table 4. Roughness values selected for 2D modeling.

Description	40 cfs	2,500 to 15,000 cfs
Unvegetated Main Channel	0.05	0.04
Cleared Overbank	0.03	0.03
Densely Vegetated Overbank	0.08	0.08
Sparsely Vegetated Overbank	0.06	0.06

3.2 Inundation Comparison during May 2006 Snowmelt Runoff

Six high flow photographs were available that show inundation from a May 19, 2006 spring snowmelt flood at RM 0.8 (location not modeled), 5.5, 6.6, 10.5, 13.2, and 14.2 (Table 5). The estimated mean daily flow at the DOE gage (RM 0.8) on the day of the photographs was 5,650 cfs, which is between a 10- and 25-year flood (Appendix D – Hydrology). The flood started on May 15 and went into June. Estimates of flow reduction by river mile were made for the May 19th flood based on a drainage area relationship with discharge (Appendix D – Hydrology). This approach suggests the flow was approximately 4,900 cfs at RM 9, and only 3,600 cfs at RM 14.

Model inundation results from 5,000 cfs were reasonably matched with the photographs between RM 5 to 9 (Figure 17 and Figure 18). For the sites above RM 9, the 5,000 cfs model results showed more inundation than observed in the field, and the 2,500 cfs model results showed less inundation. This would be expected given the predicted reduction in flow. Further calibration of roughness should be done using additional field measured water surface elevation data at higher flows if possible for future modeling efforts.

Table 5. Summary of model observations versus field notes for ground photographs during May 2006 flood.

Photograph	Approximate RM	Estimated Q based on drainage area	2,500 cfs model notes	5,000 cfs model notes	Field Notes
N6	0.85	5,600	No data	No data	Flow almost as high as bridge deck near DOE gage;
N1	5.5	5,200		Flow contained in banks; about 2 feet of freeboard to top of right bank	Flow contained in banks; can't see any backchannels

Photograph	Approximate RM	Estimated Q based on drainage area	2,500 cfs model notes	5,000 cfs model notes	Field Notes
N2	6.6	5,100		Less than 0.5 feet flow on parts of island; did not overtop Hwy 2	Flow partially inundating island in split flow; does not overtop Hwy2
N3	10.5	4,100	Gravel bar partially wet	Gravel bar wet	Gravel bar not inundated in photos
N4	13.2	3,700	Gravel bar dry	Gravel bar wet	Gravel bar not inundated in photos; can't see back channels
N5	14.2	3,600	Flow confined to banks	Flow confined to banks	Confined under RR bridge; looks like going into backchannel beyond log jam but hard to see

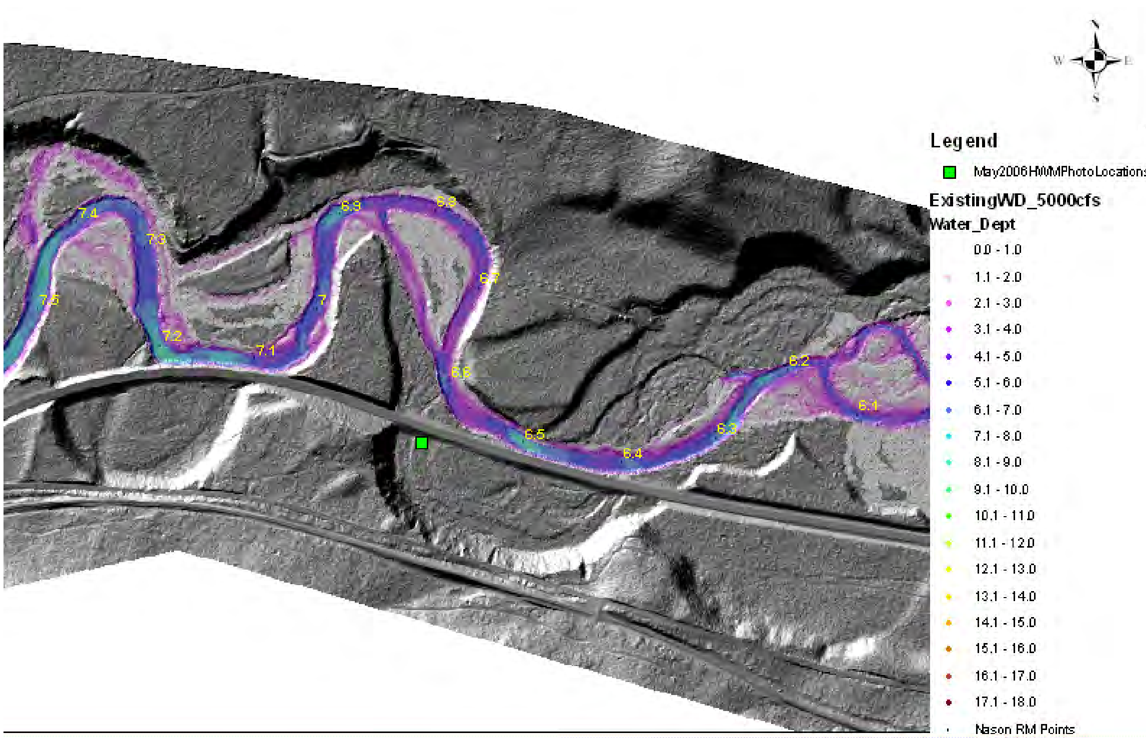

Figure 17. Existing conditions grid with modeled flow of 5,000 cfs for comparison to ground photograph (green square) during May 2006 flood. Flow on the island between the split flow was typically less than 0.5 foot.

Figure 18. Looking upstream at May 2006 flood from locations shown in previous figure (near RM 6.6).

3.3 Comparison with FEMA Floodplain

For comparison, the 100-year flood inundation boundary reported in the 1980s FEMA 1D model study for Nason Creek was compared to 2D model results. The FEMA study reported the 100-year flood as 6,200 cfs near RM 6, and about 4,100 cfs at the White Pine railroad bridge (RM 14.3) (see Figure 16). The model result of 5,000 cfs fell in the middle of these values and was used for comparison. Some areas were very close, but other areas were different. The main differences in results are attributed to use of a dense topographic data set and 2D model approach compared with a 1D model utilizing only cross-section data that may have missed hydraulic controls such as riffles and rapids. Results from the 2D model were based on existing conditions and did not account for backwater through culverts or tributary inflow. The FEMA floodplain boundary between RM 9 to 14 has several areas that show inundation for existing conditions due to backwater from culvert openings or tributary input that is blocked by embankments from reaching the mainstem river.

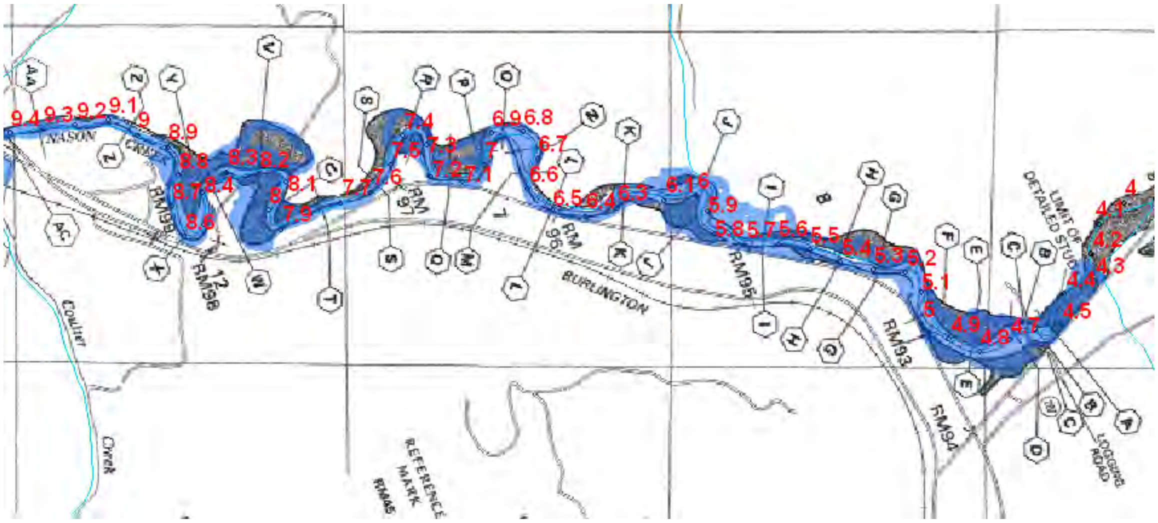

Figure 19. Inundation comparison in geomorphic reach 1 (RM 5 to 9) of 2D model results with FEMA 1D model result.

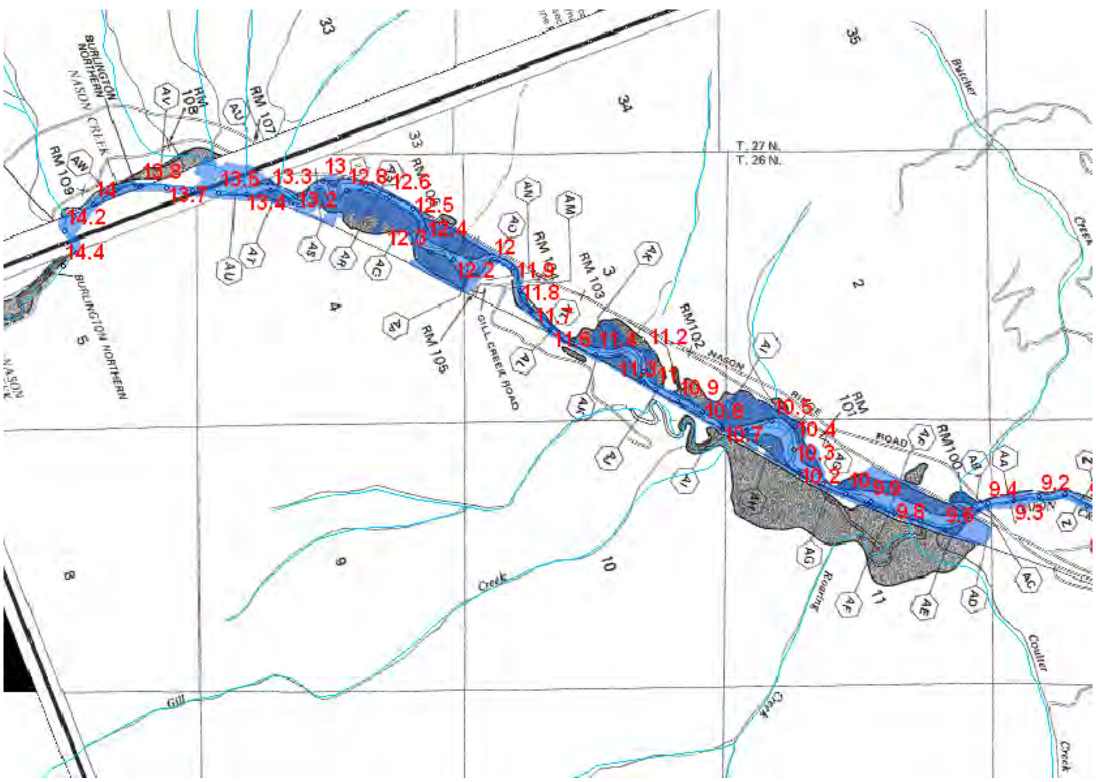

Figure 20. Inundation comparison in geomorphic reach 3 (RM 9 to 14) of 2D model result with FEMA 1D model result.

3.4 Roughness Uncertainty

The impact of uncertainty in roughness was examined by adjusting a Manning's n value of 0.04 by +/- 0.01. A flow of 5,000 cfs was used for the comparison, which is largely contained within the active channel. A change in roughness of +/- 0.01 resulted in a mean change in water surface elevation of +/- 0.3 foot for all inundated grid cells (based on comparison of 2d model result grids in GIS) (Figure 21). Inundation area was slightly larger with a larger roughness but would not change reach-level conclusions of off-channel and floodplain connectivity (Figure 22).

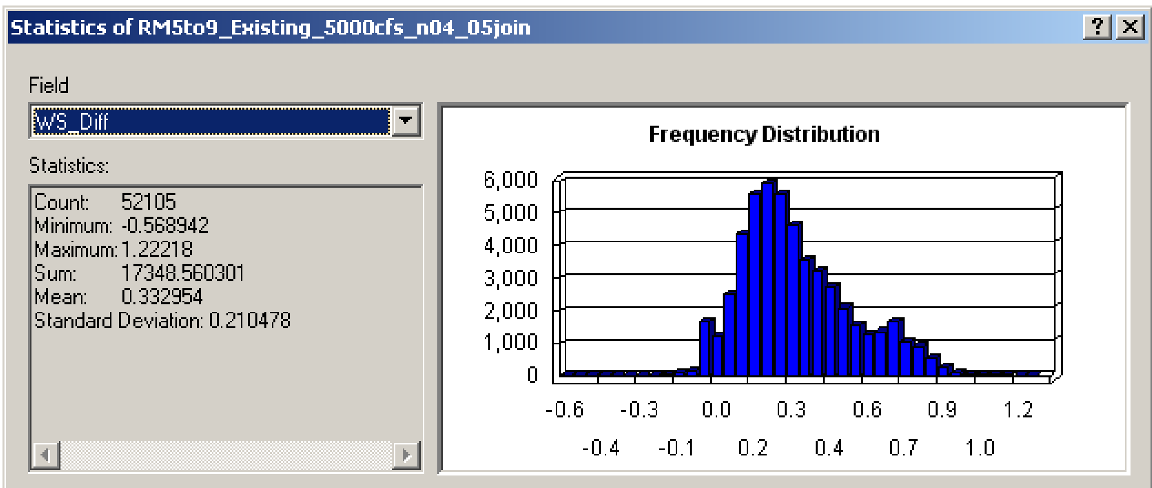

Figure 21. Comparison of water surface elevation difference between 5,000 cfs run with roughness of 0.04 versus 0.05.

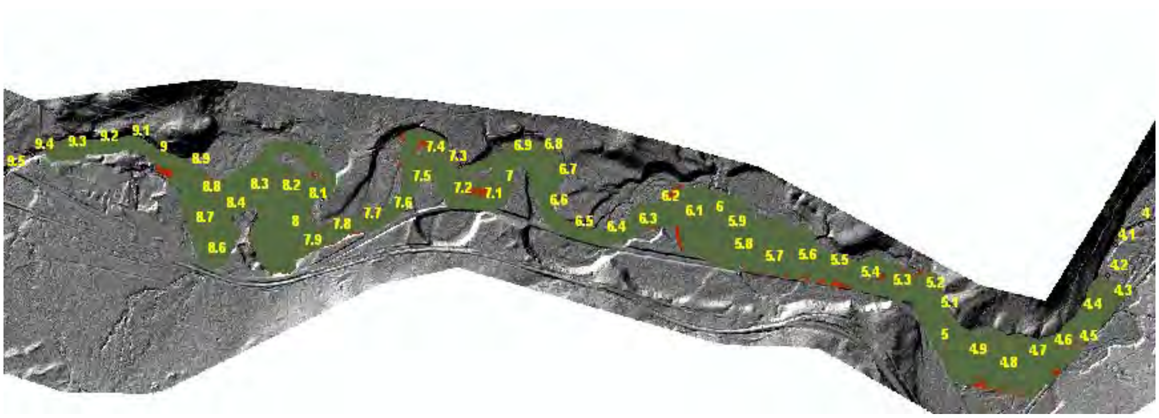

Figure 22. Inundation comparison of roughness of 0.04 (green) versus 0.05 (red) in geomorphic reach 1 for existing conditions. Areas in red represent the additional inundation caused by the higher roughness value in the active channel.

4. MODEL SCENARIOS AND OUTPUT

Two model grids were used that cover RM 5 to 9 (geomorphic reach 1) and RM 9 to 14 (geomorphic reach 3) independently (see Section 2). Modeling was done to represent existing conditions for a range of flows that cover near bankfull conditions to inundation of the majority of the geologic floodplain (Table 6). The purpose of modeling existing conditions was to evaluate current hydraulic conditions and relatively compare geomorphic reaches 1 and 3. Modeling was also done with all human features removed that are raised above the floodplain and block connectivity of flow between the main channel and off-channel and floodplain areas. One additional model run was done with the human features removed grid at 5,000 cfs in RM 9 to 14 that also has two sections of the artificial channel filled in. The purpose of this run was to assist with visualization of potential inundation and hydraulic characteristics if the historical channels and floodplain are reconnected.

Interpretation of inundation, backwater effects and sediment transport capacity results are documented in the main report so they can be integrated with conclusions from the geomorphic mapping. For each model run, a raw output file from SRH-W is available with results for all cells along with a GIS file containing results only in wetted cells.

Hydraulic model result files contain the following parameters:

1. X (easting position of cell value) (ft)
2. Y (northing position of cell value) (ft)
3. Bed elevation from input topography (ft)
4. Water surface elevation (ft)
5. Water depth (ft)
6. Velocity in the X-direction (ft/s)
7. Velocity in the Y-direction (ft/s)
8. Velocity magnitude (ft/s)
9. Froude number ($V/\sqrt{gh}$) (dimensionless)
10. Bed shear stress (lb_f/ft^2)

A few additional runs were done with a newer version of the SRH-W code that compute sediment capacity and incipient motion of sediment (Table 7). Additional model results obtained with the sediment code are:

1. Sediment capacity (lb/ft/s)
2. Critical D50 (mm)
3. Shields parameter

Table 6. List of 2D model runs for RM 5 to 9 (geomorphic reach 1) and RM 9 to 14 (geomorphic reach 3).

Scenario	Model Mesh Name	SRH-W Output File Name	GIS Output File name	Upstream Flow Input (cfs)
Existing	NC_RM5to9_Existing.2dm	RM5to9_Exist40cfs_SMS96.txt	RM5to9_Existing_40cfs	40
Existing	NC_RM5to9_Existing.2dm	RM5to9_Exist2500cfs_SMS96.txt	RM5to9_Existing_2500cfs	2,500
Existing	NC_RM5to9_Existing.2dm	RM5to9_Exist5000cfs04_SMS96	RM5to9_Existing_5000cfs	5,000
Existing	NC_RM5to9_Existing.2dm	RM5to9_Exist10000cfs_SMS73.txt	RM5to9_Existing_10000cfs	10,000
Existing	NC_RM5to9_Existing.2dm	RM5to9_Existing_15000cfs_SMS60.txt	RM5to9_Existing_15000cfs	15,000
HF Removed	NC_RM5to9_HFRemoved.2dm	RM5to9_HF40cfs_SMS96.txt	RM5to9_HF_40cfs	40
HF Removed	NC_RM5to9_HFRemoved.2dm	RM5to9_HF2500cfs_SMS96.txt	RM5to9_HF_2500	2,500
HF Removed	NC_RM5to9_HFRemoved.2dm	RM5to9_HF5000cfs_SMS96.txt	RM5to9_HF_5000	5,000
HF Removed	NC_RM5to9_HFRemoved.2dm	RM5to9_HF10000cfs_SMS36.txt	RM5to9_HF_10000	10,000
HF Removed	NC_RM5to9_HFRemoved.2dm	RM5to9_HF15000cfs_SMS45.txt	RM5to9_HF_15000	15,000
Existing	NC_RM9to14_Existing2.2dm	RM9to14_Exist40cfs_SMS96.txt	RM9to14_Exist40cfs	40
Existing	NC_RM9to14_Existing4.2dm	RM9to14_Exist2500cfs_SMS96.txt	RM9to14_Exist2500cfs	2,500
Existing	NC_RM9to14_Existing4.2dm	RM9to14_Exist5000cfs_SMS41.txt	RM9to14_Exist5000cfs	5,000
Existing	NC_RM9to14_Existing4.2dm	RM9to14_Exist7500cfs_SMS35.txt	RM9to14_Exist7500cfs	10,000
Existing	NC_RM9to14_Existing4.2dm	RM9to14_Exist10000cfs_SMS35.txt	RM9to14_Exist10000cfs	15,000
Existing	NC_RM9to14_Existing4.2dm	RM9to14_Exist15000cfs_SMS27.txt	RM9to14_Exist15000cfs	40
HF Removed	NC_RM9to14_HFRemoved3.2dm	RM9to14_HF2500cfs_SMS96.dat	RM9to14_Exist2500cfs	2,500
HF Removed	NC_RM9to14_HFRemoved3.2dm	RM9to14_HF5000cfs_SMS96.txt	RM9to14_Exist5000cfs	5,000
HF Removed	NC_RM9to14_HFRemoved3.2dm	RM9to14_HF10000cfs_SMS67.dat	RM9to14_Exist10000cfs	10,000
HF Removed	NC_RM9to14_HFRemoved3.2dm	RM9to14_HF15000cfs_SMS62.txt	RM9to14_Exist15000cfs	15,000

Table 7. List of 2D model runs with sediment capacity for RM 5 to 9 (geomorphic reach 1) and RM 9 to 14 (geomorphic reach 3).

Scenario	Model Mesh Name	SRH-W Output File Name	GIS Output File name	Upstream Flow Input (cfs)
Existing	NC_RM5to9_Existing.2dm	RM5to9_Exist2500SEDSRH_SMS48.txt	RM5to9_Exist2500SEDSRH	2,500
Existing	NC_RM5to9_Existing.2dm	RM5to9_Exist5000SEDSRH_SMS48.txt	RM5to9_Exist5000SEDSRH	5,000
Existing	NC_RM5to9_Existing.2dm	RM5to9_Exist10000SEDSRH_SMS48.txt	RM5to9_Exist10000SEDSRH	10,000
Existing	NC_RM9to14_Existing4.2dm	RM9to14_Exist2500SEDSRH_SMS48.txt	RM9to14_Exist2500SEDSRH	2,500
Existing	NC_RM9to14_Existing4.2dm	RM9to14_Exist5000SEDSRH_SMS48.txt	RM9to14_Exist5000SEDSRH	5,000
Existing	NC_RM9to14_Existing4.2dm	RM9to14_Exist10000SEDSRH_SMS48.txt	RM9to14_Exist10000SEDSRH	10,000

5. MODEL APPLICABILITY AND LIMITATIONS

The SRH-W model utilized is state-of-the-art and provides one of the best available methods to simulate river hydraulics. However, even the most advanced modeling has uncertainties due to assumptions related to the theoretical model development (e.g., depth-averaged flow equations used and numerical discretization errors) and the input data used (e.g., uncertainty in topography data and roughness values).

The results are applicable for looking at the relative change in hydraulics and flow distribution between the two geomorphic reaches 1 and 3. The model results are useful for looking at existing and potential off-channel and floodplain connectivity to historical areas currently cut-off (either partially or completely). The model results were also utilized to assist with refining boundaries of historical channel migration zone areas and floodplain areas based on the extent of inundation, depth, and velocity. The water surface elevations computed by the model have an estimated uncertainty of up to 1 foot at high flows based on professional experience.

Future model improvements should consider incorporating 2007 channel bottom data and obtaining additional underwater topography in areas where more accuracy is needed. Detailed hydraulic results at a project scale may require a denser grid than the 10-foot grid used at the reach scale. Model accuracy could be validated and potentially improved if more calibration and validation data is obtained to check against the model results. All of the models were run with steady flows (no hydrographs) and static beds. Additional modeling will be needed if channel migration rates, or bed scour and aggradation prediction is of interest.

6. SEDIMENT ANALYSIS METHODS

Sediment characteristics and the likelihood of future incision were addressed through an analysis of surrogate sediment transport parameters (stream power) and by comparing measured sediment sizes in the channel bed with incipient motion computations. Comparison with incipient motion indicates the ability of the river to mobilize the present channel bed and bars. The locations and general characteristics of sediment sources to the assessment reach were identified as part of the geologic investigation, but were not quantified or measured. Sensitivity of the channel bed to a change in sediment supply and/or sediment transport capacity as a result of construction of individual or multiple projects could be considered for future analysis if required. Field observations and channel survey comparisons suggested localized areas of a few feet of channel incision, particularly in areas where engineered straight channels had replaced historically meandering sections of river. The limitations of not using a predictive, quantitative sediment transport model in this assessment include losses in analysis resolution such as magnitude of incision or deposition of sediment, changes in bar and channel sediment storage as a result of proposed project construction, interactions of sediment supply and storage between proposed projects in close proximity, and changes in bed character.

Sediment transport capacity was also computed for 5,000 cfs existing conditions model runs to compare relative transport capacity between geomorphic reach 1 and 3. Sediment transport capacity was computed using the Meyer-Peter Muller equation in a version of SRH-W that computes sediment transport capacity at each grid cell based on hydraulic results for the input steady flow. In addition, the critical (largest) sediment size that can be mobilized for the modeled flow was computed using the Shields equation and the D_{50}, which had an average sediment size of 60 mm. These values were compared to sediment sizes measured on the bed surface to see if the typical bed sizes are mobilized within the range of potential flows.

Results are presented in the main report so they can be integrated with other information. Details on the stream power and pebble count methods are provided below.

6.1 Stream Power

Generally, discharge tends to increase in the downstream direction in river basins as additional tributaries and runoff provide more flow. Increasing discharge provides more potential energy to transport sediment and large woody debris if hydraulic conditions are otherwise comparable. Increasing the slope can also increase the river’s ability to transport sediment and large woody debris while decreasing the slope can reduce the transport capacity.

The total stream power computation shows how the combination of discharge and slope vary along the river from a reach-based perspective. The total stream power is computed by multiplying the product of discharge, slope and the specific weight of water for a given reach length (γQSX with units of power) (Bagnold 1966). Stream power is typically computed per unit length, X = 1. In this report, total stream power is simply computed as discharge multiplied by slope without the constant of specific weight of water or reach length. Discharge values were based on flood frequency output documented in the hydrology appendix D. Slopes were based on water surface slopes generated from hydraulic controls surveyed in 2007 (Appendix G – Channel Geomoety and Slope).

Total stream power is often used to indicate and compare the relative magnitude of sediment loads a stream is capable of transporting between reaches. It does not provide quantitative information as to the actual quantities or sizes transported. If the total stream power increases or decreases in a downstream direction, the sediment transport potential of the stream would also be expected to increase or decrease, respectively. Increases or decreases in sediment transport potential can indicate the likelihood of a reach to trend towards deposition or incision. If changes in slope and discharge are balanced out by the river, total stream power will remain relatively constant along the river's length and the reach would be expected to be in dynamic equilibrium. Computations utilized the 2- to 100-year discharge combined with bankfull slopes and did not differentiate between in-channel and floodplain flows.

The "unit stream power" is defined as the rate of potential energy expenditure per unit weight of water (Yang 1996). It is often used as an indicator of the relative energy required to transport a given sediment load among various cross-sections.

The unit stream power is computed by multiplying the friction slope and velocity (typically depth-averaged) for a given cross-section (VS with units of ft/s). Friction slope was computed by taking an average difference of the velocity head between model cell results for a given discharge along the centerline of the main channel. Velocity was the velocity magnitude output at a grid cell along the centerline of the active channel for a given discharge. Velocity incorporates the impact of channel geometry on sediment transport. Unit stream power provides a way to compare the relative ability of the stream to transport sediment at various cross-sections. By using a series of cross sections to represent a range of hydraulic conditions within each geomorphic reach, unit stream power can be used to look at relative comparisons of sediment transport capacity between reaches. It does not provide quantitative information as to the actual quantities or sizes transported. The depth-averaged velocity was computed using the normal depth assumption and did not differentiate between floodplain areas and the active channel.

6.2 Pebble Counts

Reclamation contracted with the USFS to collect pebble count samples during low flow periods at typical channel and bar sections located throughout the assessment reach. The sediment sample was collected with the intention of measuring surface coarse bed-material that must be mobilized by the river before the channel and bar sediment can be transported. This is the sediment sizes most closely linked with channel form, potential aggradation, and potential incision. In some channel areas the pebble count represents an armor layer on the channel bottom that may not be mobilized except for extremely high flood events. Ground photographs, particle size distributions, and field notes are available for each site. The D35, D50, and D90 at each site were computed (Figure 23, Figure 24, and Figure 25).

The method employed was to count 100 pebbles in approximately 1-foot intervals either across the wetted channel or along the unvegetated portions of sediment bars. Lines across channel sections were repeated if the channel width was less than 100 feet. Bar locations were chosen generally such that the grid was adjacent to the water edge and in the middle of the point or longitudinal bars (as opposed to upstream or downstream end). On bars, up to 4 lines were used in a grid format to capture the 100 piece count because most bars were less than 100 feet in width. Areas for pebble counts were chosen based on typical channel and bar sections without any localized influence that would cause local fining or coarsening of the sediment. Bank material was not included in the counts. If the bank sediment being eroded is coarse enough it will not be mobilized far from the erosion site and will be represented in the bar and channel samples. On the other hand, finer-sized sediment in the bank may be easily suspended and mobilized downstream and, therefore, would improperly skew the particle size distribution representing surface bed-material sizes.

The USFS crews noted the following regarding methods for collecting pebble counts:

- A written summary for each survey site was done, including whether the sample was located across the wetted channel or on a gravel bar.
- At sites where there was a river survey and grid survey performed, in some instances only one “largest substrate” measurement was taken. In this case the “largest substrate” was entered for both survey summaries for that site. If there were two “largest substrates” on the data sheets for river and grid surveys at one site, then two were entered in the database.
- The location of large wood was documented if it fell in a river or bar grid; if the wood spanned both areas, the location was based on whether it was mostly located in the river line or on a bar grid, but was never entered in both.

- Some "wetted widths" were recorded in feet with decimals, where others were recorded in feet and inches.
- In the ground photographs for each site, the following abbreviations were used: LB= left bank, RB= right bank, XS= cross-section.
- Grid type on the "pebble_count_bar" worksheet includes dimensions of the grid.
- At most sites several passes were made across a stream in order to gain 100 data points. These are designated by pass 1, 2, 3…etc., and #s meaning each unique data point gathered.

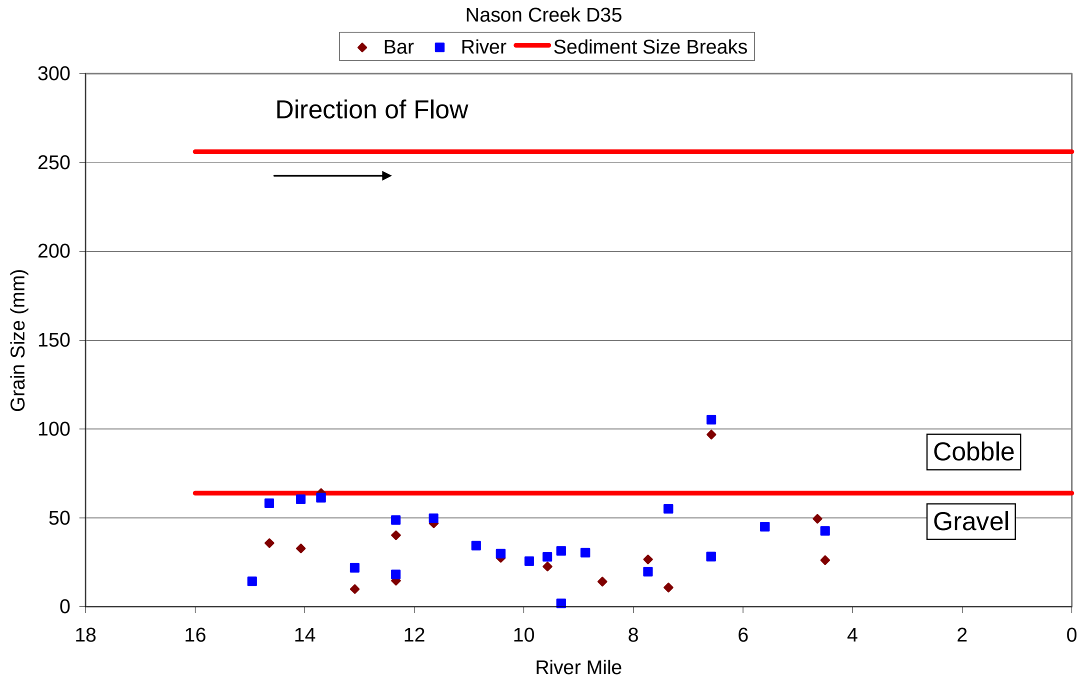

Figure 23. Results of D_{35} at pebble count sample sites.

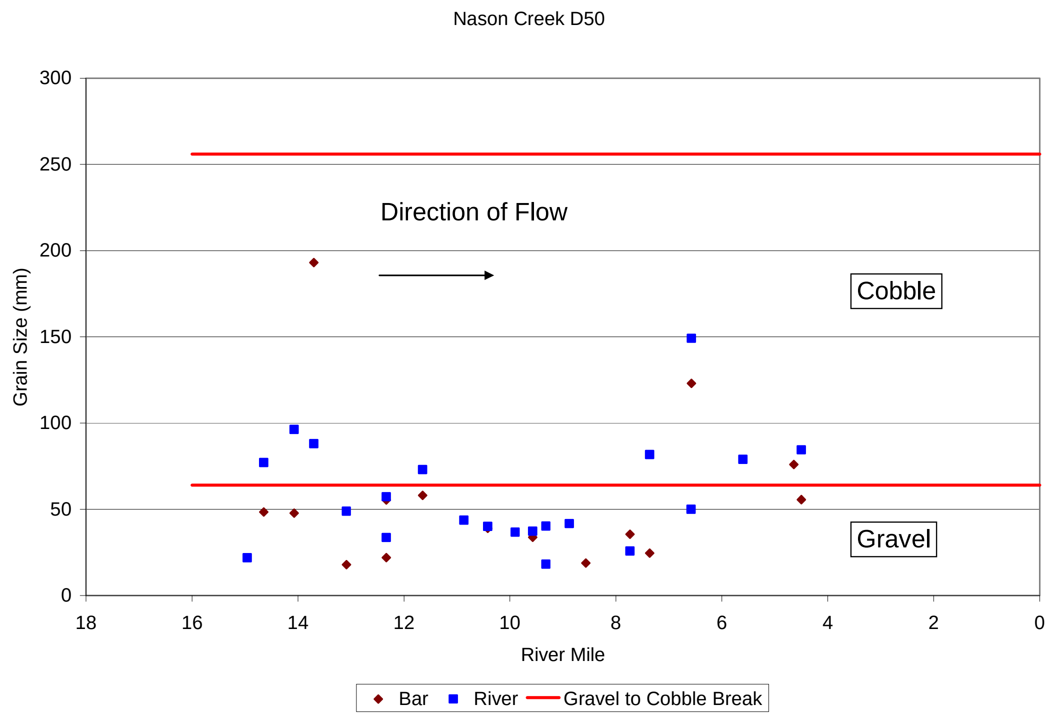

Figure 24. Results of D_{50} at pebble count sample sites.

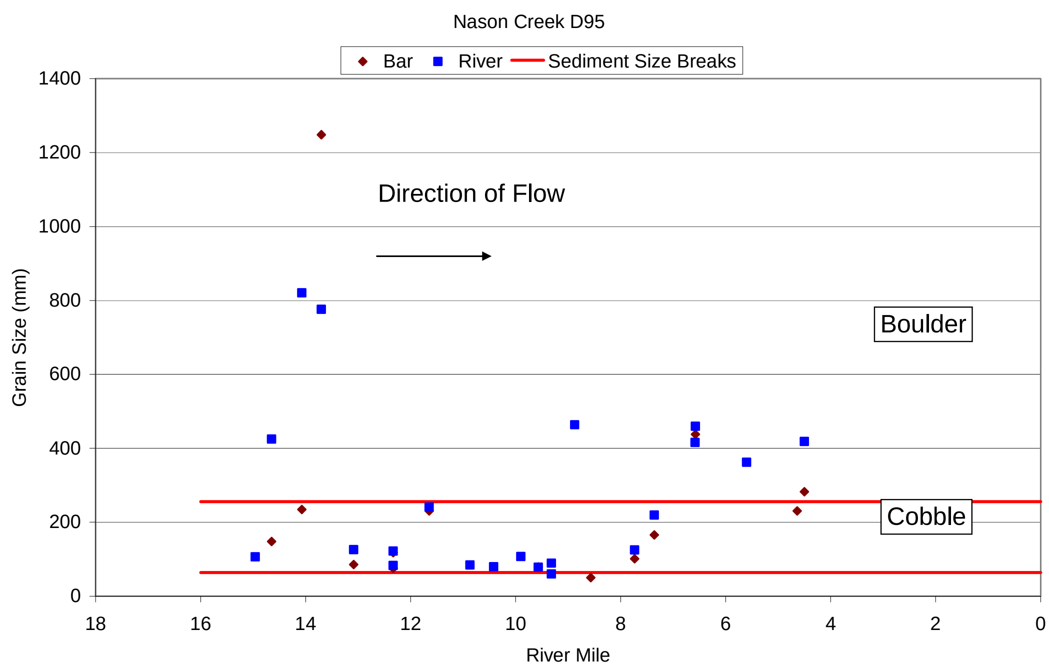

Figure 25. Results of D_{95} at pebble count sample sites.

7. REFERENCES

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