RECLAMATION
Managing Water in the West

Lower Nason
Assessment of Geomorphic and Ecologic Indicators
Nason Creek, Wenatchee Subbasin

Chelan County, Washington

U.S. Department of the Interior
Bureau of Reclamation
Pacific Northwest Region
Pacific Northwest Regional Office, Boise, Idaho

April 2011

U.S. DEPARTMENT OF THE INTERIOR

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.

MISSION OF THE BUREAU OF RECLAMATION

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.

Cover Photo: View to the north looking at middle channel scour pool forced by large wood - Nason Creek, Washington – Bureau of Reclamation.

Date: September 15, 2010 Photo by: E. Lyon

RECLAMATION
Managing Water in the West

Lower Nason
Assessment of Geomorphic and Ecologic Indicators
Nason Creek, Wenatchee Subbasin

Chelan County, Washington

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

U.S. Department of the Interior
Bureau of Reclamation
Pacific Northwest Region
Pacific Northwest Regional Office, Boise, Idaho

April 2011

This page intentionally left blank

Table of Contents

List of Figures

List of Tables

EXECUTIVE SUMMARY

The Bureau of Reclamation (Reclamation) and Bonneville Power Administration contribute to the implementation of salmonid habitat improvement projects in the Wenatchee subbasin to help meet commitments contained in the *2010 Supplemental Federal Columbia River Power System (FCRPS) Biological Opinion* (BiOp) (NOAA Fisheries 2010). The BiOp includes a Reasonable and Prudent Alternative (RPA), or a suite of actions, to protect listed salmon and steelhead across their life cycle. Habitat improvement projects in various Columbia River tributaries are one aspect of this RPA. Reclamation provides technical assistance to States, Tribes, Federal agencies, and other local partners for identification, design, and construction of stream habitat improvement projects that primarily address streamflow, access, entrainment, and channel complexity limiting factors. Reclamation's contributions to habitat improvement are all meant to be within the framework of the FCRPS RPA or related commitments. This assessment provides scientific information on the geomorphology and habitat condition within the lower 4.6 miles of Nason Creek that can be used to help future monitoring of fish habitat improvement projects and evaluate how these projects are addressing key limiting factors to protect and improve survival of salmon and steelhead listed under the Endangered Species Act (ESA).

Nason Creek is a tributary to the Wenatchee River in the State of Washington. There are three ESA-listed fish species (UCSRB 2007) that utilize the Wenatchee River subbasin as part of their life stages before returning to the Columbia River and to the Pacific Ocean. The statuses of these listed species, based on biological indicators, were as follows: (1) all biological indicators for spring Chinook salmon are currently in unacceptable condition; (2) biological indicators for steelhead are in unacceptable condition for life history, diversity and isolation, and persistence and genetic integrity indicators; and (3) the subpopulation size biological indicator for bull trout is in unacceptable condition (USFS 1998b; 2006a).

At the reach scale, this report documented physical features and analyzed riverine processes that may affect the overall health of the system. Anthropogenic disturbances to channel-floodplain interactions through the construction of roads with elevated road grades have disconnected about 29 percent (132.7 acres) of historic channel paths and floodplain area. The channel was re-routed in several locations for road construction and has resulted in channel shortening, increased channel gradient, and decreased channel sinuosity. Impacts on physical processes were (1) an increase in streampower and sediment transport capacity, which may have resulted in a reduction of sediment and wood retention that would have contributed to formation of diverse habitat types (i.e. pool-run-riffle sequences); and (2) isolation of historic channel paths and floodplain areas that are no longer hydraulically connected to the stream and no longer contribute as much to the transfer of energy (i.e. food web), riparian vegetation health and maintenance, and ecological connectivity.

Bank protection (riprap) has been placed to protect the roadways and campgrounds. The bank protection artificially restricts lateral channel migration and floodplain reworking. This negatively impacts geomorphic channel processes that include (1) reduction in sediment and wood inputs into the channel, (2) maintenance of the channel's gradient, planform, geometry, and variability; (3) creation and maintenance of complex habitat types; and (4) maintenance of riparian vegetation that provides appropriate aquatic and terrestrial connectivity and diversity.

Anthropogenic disturbances have resulted in the clearing of riparian vegetation for infrastructure and development. These disturbances have changed the vegetation structure and composition in some areas and have reduced channel boundary roughness, bank reinforcement, stream shading, wood recruitment, and nutrient inputs. Riparian vegetation also provides wood to the stream that influences pool formation and sediment deposition, lateral channel migration, side channel development, bank reinforcement, and biomass to the system.

The cumulative effects of anthropogenic disturbances have negatively impacted the physical and ecological processes necessary to create and maintain aquatic habitat complexity, quality, and variability. Riparian and channel-floodplain processes result from the driving variables that control reach scale responses that control channel morphology, habitat structure, thermal regime, energy transfer, and species assemblages (Beechie et al., 2010). Anthropogenic disturbances in the Lower Nason reach have negatively impacted the physical and ecological processes. These disturbances have reduced habitat quantity, quality, and variability for the ESA-listed salmonid species by disrupting the necessary processes that form and maintain channel morphology and habitat structure.

OVERVIEW

The Bureau of Reclamation (Reclamation) and Bonneville Power Administration contribute to the implementation of salmonid habitat improvement projects in the Wenatchee River subbasin to help meet commitments contained in the 2010 Supplemental Federal Columbia River Power System (FCRPS) Biological Opinion (BiOp) (NOAA Fisheries 2010). The BiOp includes a Reasonable and Prudent Alternative (RPA), or a suite of actions, to protect listed salmon and steelhead across their life cycle. Habitat improvement projects in various Columbia River tributaries are one aspect of this RPA. Reclamation provides technical assistance to States, Tribes, Federal agencies, and other local partners for identification, design, and construction of stream habitat improvement projects that primarily address streamflow, access, entrainment, and channel complexity limiting factors. Reclamation's contributions to habitat improvement are all meant to be within the framework of the FCRPS RPA or related commitments.

INTRODUCTION

This geomorphic and ecologic indicators assessment provides scientific information on the geomorphology and habitat condition of the lower 4.6 miles of Nason Creek, a tributary of the Wenatchee River in the State of Washington (Figure 1). The data presented in this assessment can be used to help future monitoring of fish habitat improvement projects and evaluate how these projects are addressing key limiting factors to protect and improve survival of salmon and steelhead listed under the Endangered Species Act (ESA).

There are three ESA-listed fish species (UCSRB 2007) that utilize the Wenatchee River subbasin as part of their life stages before returning to the Columbia River and to the Pacific Ocean. In 1998 and 2006, biological assessments were conducted in the Nason Creek watershed by the Wenatchee-Okanogan National Forest (USFS 1998b; USFS 2006a) to establish baseline conditions on the status of these listed species. A summary of these reports is provided in the Status of Wenatchee River Subbasin Listed Species section of this report.

At the watershed scale, several factors that are affecting the species of concern in the Nason Creek watershed were identified in the Limiting Factors Analysis (Andonaegui 2001) and the Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan (UCSRB 2007), referred to as the Recovery Plan. To further understand the hydrology, geology, sediment inputs and routing, vegetation structure, and anthropogenic disturbances that affect the riverine processes in the Lower Nason subwatershed (Whitepine Creek at about river mile [RM] 14.3 to RM 4.6), Reclamation conducted a Tributary Assessment (Reclamation 2008). To further refine anthropogenic impacts to riparian and floodplain-channel interactions, three Reach Assessments were conducted between RM 14.3 to 4.6 (Reclamation 2009a;

Reclamation 2009b; Reclamation 2009c). From RM 4.6 to the confluence with the Wenatchee River, Chelan County contracted with Jones & Stokes to evaluate potential actions that could be implemented to improve rearing habitat (Jones & Stokes 2004). Chelan County reconnected two historic channel paths analyzed by Jones & Stokes to Nason Creek by placing culverts through State Route 207 road embankment in 2007 and 2009.

The focus of this assessment is to document present (2010) riverine conditions from RM 4.6 to the Wenatchee River confluence. The analysis was based on the riparian and channel-floodplain processes as recommended by Beechie et al. (2010), and the method used was an evaluation of reach-based ecosystem indicators (REI) which provides an understanding of how geomorphic and ecologic processes are currently functioning. Results and summaries are presented at the reach and channel segment scales to capture localized impacts and trends. The discussion of results and summarization of interpretations are provided at the reach scale.

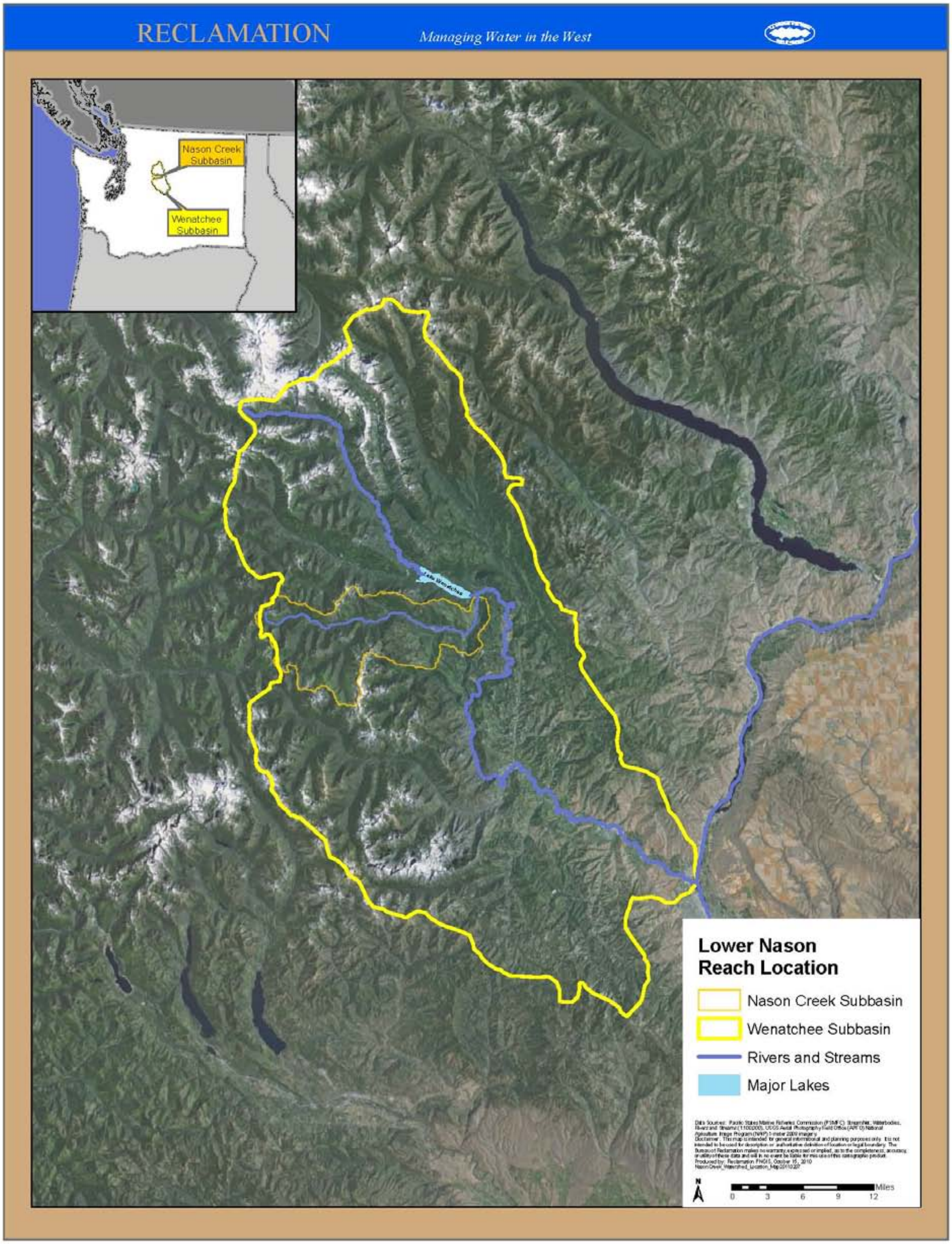

Figure 1. Location of Nason Creek watershed within the Wenatchee subbasin

Status of Wenatchee River Subbasin Listed Species

There are salmonid species that occur in the Wenatchee Subbasin in Washington that are included in the ESA Threatened and Endangered list. These species of concern include Upper Columbia River (UCR) spring Chinook salmon (*Oncorhynchus tshawytscha*), UCR steelhead (*Oncorhynchus mykiss*), and Columbia River bull trout (*Salvelinus confluentus*) (UCSRB 2007).

Based on biological information collected by the Wenatchee-Okanogan National Forest, the statuses of these listed species are summarized in Table 1. Information on the functional condition of subpopulation size, growth and survival, life history and diversity, and persistence and genetic integrity for the species of concern are as follows: (1) all biological indicators for spring Chinook salmon are currently in unacceptable condition; (2) biological indicators for steelhead are in unacceptable condition for life history, diversity and isolation, and persistence and genetic integrity indicators; and (3) the subpopulation size biological indicator for bull trout is in unacceptable condition (USFS 1998b; 2006a).

Table 1. Summary condition of biological indicators and species of concern (USFS 1998b; USFS 2006a)

Watershed Scale	Biological Indicator	Species	Condition
Wenatchee Subbasin - Status of Listed Species	Subpopulation Size	Bull Trout	Unacceptable
		Steelhead	At Risk
		Spring Chinook	Unacceptable
	Growth and Survival	Bull Trout	At Risk
		Steelhead	At Risk
		Spring Chinook	Unacceptable
	Life History, Diversity and Isolation	Bull Trout	At Risk
		Steelhead	Unacceptable
		Spring Chinook	Unacceptable
	Persistence and Genetic Integrity	Bull Trout	At Risk
		Steelhead	Unacceptable
		Spring Chinook	Unacceptable

Purpose of Assessment

This assessment refines the scientific understanding of geomorphic and ecologic processes occurring within Nason Creek. Several causal factors have been identified at the watershed scale that were believed to be limiting for ESA-listed fish species. The primary limiting factors are identified in the Recovery Plan. These factors included water quality, passage barriers, channel stability, habitat diversity, and fine sediment that could be affecting abundance, productivity, spatial structure, and diversity of the species.

Causal factors included (1) warm water temperatures which may create a thermal barrier that impedes upstream migration to natal spawning and rearing habitat; (2) road and railroad grades that obstruct access to tributaries and off-channel habitats; (3) fine sediment from roads and timber harvests that may have increased siltation in gravel dominated riffles used for spawning and in cobble dominated riffles used for rearing and fish cover; and (4) the channel has been artificially stabilized due to road and railroad construction, stream channelization, and bank protection (UCSRB 2007; USFS 2006).

This report documents physical features and analyzes riverine processes that may affect the overall health of the system at the reach scale (Lower Nason reach between RM 4.6 and the Wenatchee River confluence).

Assessment Methods

At the reach scale, physical habitat dynamics are primarily a function of sediment and water inputs that drive channel shape, sediment transport and storage characteristics, and formation of hydraulic features such as pools and riffles (Beechie et al., 2010). To understand how the riverine ecosystem dynamics are functioning, riparian processes and channel-floodplain interactions were analyzed using a matrix of reach-based ecosystem indicators (REI). The REI was based on the "Matrix of Diagnostics/Pathways and Indicators" as recommended by the U. S. Fish and Wildlife Service (USFWS 1998). Thresholds used to determine the condition of each indicator rating were vetted through a group of scientists working in the Upper Columbia Basin in order to accurately capture conditions observed east of the Cascades Range. A condition rating was determined for each indicator based on REI criteria, geomorphic constraints, and professional judgment.

The Lower Nason assessment area REI is provided in Appendix A of this report. The objectives of the REI analysis were to identify root causes of degradation and the driving processes that create and maintain habitat conditions. For example, vegetation composition and structure on the floodplain influences the delivery of wood to the channel, bank reinforcement, nutrient cycling, and thermal regimes. In addition, an appropriately functioning floodplain influences water quality, hyporheic interactions, and terrestrial connectivity.

Nason Creek Watershed and Assessment Area

Nason Creek watershed is part of the Wenatchee Subbasin located along the eastern side of the Cascade Range. The creek has a dendritic drainage pattern with a drainage density of about 0.9 and drains about 109 $miles^2$. Basin relief of about 6,160 feet with a maximum elevation of about 8,030 feet along the Chiwaukum Mountains and a minimum elevation of about 1,870 feet at the confluence with the Wenatchee River. Precipitation ranges from 30 to 90 inches annually with an average precipitation of 63 inches per year. About 84 percent of the basin receives 50 to 80 inches per year (USFS 1996). The hydrology is a snowmelt dominated system with runoff occurring between April and June with periodic rain-on-snow events occurring from October through November.

The Nason Creek drainage is divided into two 5th Field Hydrologic Unit Code (HUC) subwatersheds. The Upper Nason (HUC #170200110601) covers the headwaters to Whitepine Creek near RM 14.3, and the Lower Nason (HUC #170200110602) covers from Whitepine Creek to the Wenatchee River confluence. This report covers the section of Nason Creek from RM 4.6 near Coles Corner to the Wenatchee River confluence (Figure 2).

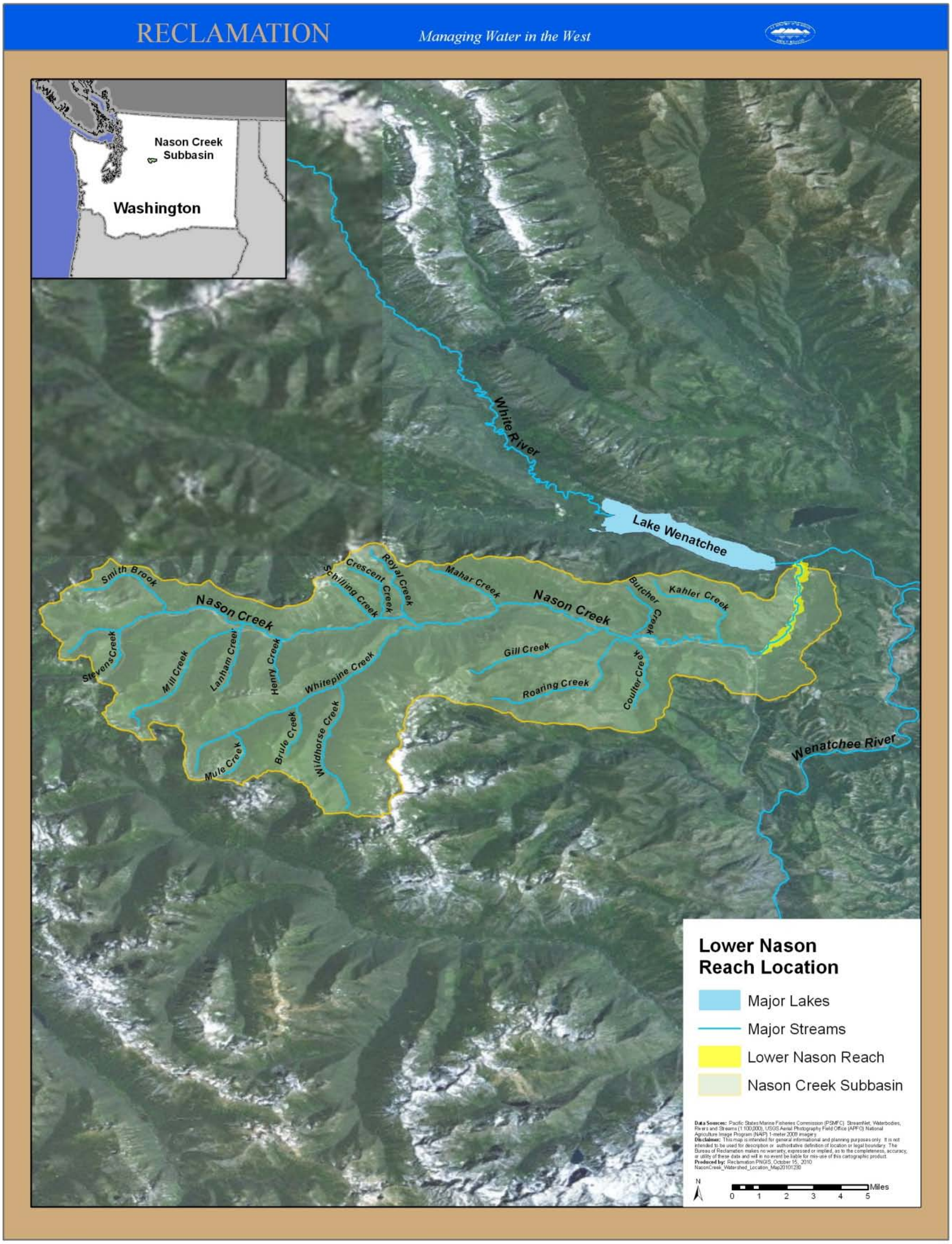

Figure 2. Nason Creek watershed and Lower Nason reach location map

REGIONAL SETTING

Nason Creek watershed is within the Northern Cascade Mountains section of the Cascade-Sierra Mountains physiographic province. The ecoregion is within the Eastern Cascades section of the Cascade Mixed Forest-Coniferous Forest-Alpine Meadow Province (Bailey classification), and the Chiwaukum Hills and Lowlands (Omernik classification).

The geology of the watershed is complex with three fault-bounded geologic rocks that are markedly different from their adjoining neighbors, also known as tectono-stratigraphic terranes. These terranes include the Nason Terrane, Ingalls Tectonic Complex, and the Chiwaukum Graben (Figure 3). The Nason Terrane and Ingalls Tectonic Complex are comprised of predominantly metamorphic rocks, and the Chiwaukum is formed by predominantly sedimentary rocks of the Chumstick Formation (USGS 1987).

Four alpine glacial cycles in the Northern Cascades were correlated by Waitt (1977) based on studies conducted in the Yakima Valley (Porter 1976), Peshastin Valley (Hopkins 1966), and Wenatchee Valley (Page 1939; Porter 1969). In the Nason Valley, Nimick (1977) mapped glacial deposits that are most likely correlative to those studied by Waitt (1977). Alpine glacial advances probably occurred in Nason Valley about 135 ky BP, 18 ky BP, 14.5 ky BP, and 11.5 ky BP (Waitt 1977) assuming these glacial cycles happened throughout the Northern Cascades. Advances of these alpine glaciers carved broad U-shaped valleys with over-steepened valley walls; whereas their retreats constructed high terraces along the valley margins and filled the valleys with alluvium creating broad outwash plains. Streams have since been reworking the glacial deposits left behind along the valley floor as they laterally migrate and develop their floodplains.

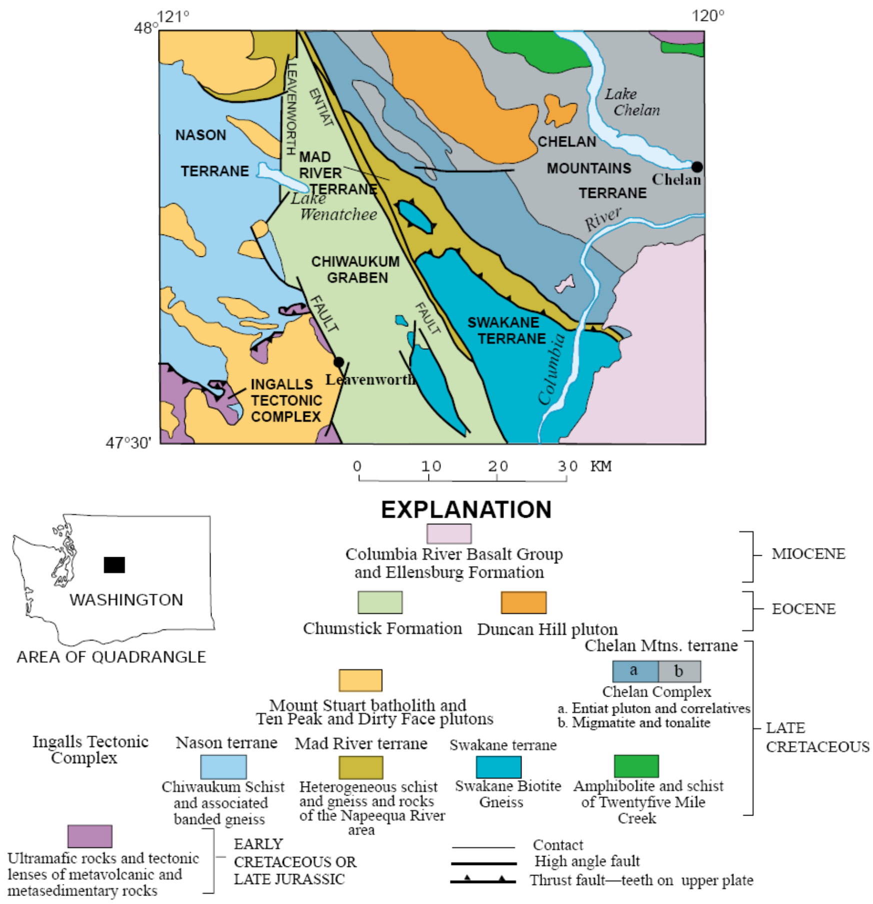

Figure 3. Generalized geologic map of the Chelan 30' X 60' quadrangle, central Washington (USGS 1987). Nason Creek watershed is located directly south of Lake Wenatchee

WATERSHED CONDITIONS

About 78 percent of the Nason Creek watershed is federally owned with the remaining 22 percent in private ownership, predominantly in the lower 15 miles of floodplain and along Kahler and Coulter Creek subwatersheds. Public lands are managed as non-designated recreational forest (about 51 percent) and designated Alpine Lakes Wilderness Area (about 21 percent). Private land uses include residential and commercial developments and tracts of commercial timber lands (USFS 1996).

The Wenatchee-Okanogan National Forest completed two biological assessments of the watershed (USFS 1998b; updated USFS 2006a). At the watershed scale, the current biological assessment documents 2006 baseline conditions derived from trend analysis from 1989 to 2006, based on analysis of seventeen sources and professional judgment. Their assessment divided the Nason Creek watershed into three subwatersheds (Table 2). The analysis used the "Matrix of Diagnostics/Pathways and Indicators" as recommended by the U.S. Fish and Wildlife Service (USFWS 1998).

Table 2. Nason Creek mainstem subwatershed divisions based on USFS (1998b)

Division	Location
Nason Headwaters	Above Mill Creek
Upper Nason	Mill Creek to Whitepine Creek
Lower Nason	Whitepine Creek to Mouth

The updated biological assessment (USFS 2006a) concluded that anthropogenic impacts included upland timber harvests in tributaries (i.e., Gill, Roaring, Coulter, Butcher, Kahler, Mill creeks) and mainstem subwatersheds; vegetation clearing along high voltage powerlines; railroad grade bisecting the floodplain in several areas creating artificial valley and channel confinement, and loss of floodplain connectivity; improved road grades that also bisect the floodplain in several areas with similar results as the railroad grade; and development of the floodplain that has impacted vegetation composition and structure and channel-floodplain function (USFS 1998b).

Wenatchee-Okanogan National Forest fisheries biologists concluded that anthropogenic disturbances in the watershed have altered the upslope processes, mainstem channel processes, quantity and timing of flows (hydrograph); and sediment and large wood recruitment (USFS 1998b). Based on thresholds contained in the Reach-based Ecosystem Indicators (REI) matrix (Appendix A), 80 % of the watershed general indicators were interpreted to be **At Risk** with the exception of habitat access that was **Adequate** (Table 3). Lower Nason subwatershed was found to be the most impacted, and overarching concerns included the following: (1) the Lower Nason mainstem is the access corridor for anadromous Chinook salmon and steelhead, and adfluvial bull trout; (2) this subwatershed contains all known Chinook spawning habitat in the Nason Creek watershed; and (3) it is also a key corridor for connectivity between subwatersheds (USFS 1998b).

Table 3. Summary of condition ratings for the watershed indicators (USFS 1998b)

Spatial Scale	General Indicator	Specific Indicator	Specific Indicator Condition	General Indicator Condition
Watershed Condition	Watershed Road Density and Effective Drainage Network	Watershed Road Density	At Risk	At Risk
		Effective Drainage Network	At Risk	
	Disturbance Regime	Disturbance Regime	At Risk	At Risk
	Flow/Hydrology	Flow	At Risk	At Risk
		Hydrology	At Risk	
	Water Quality	Water Quality	At Risk	At Risk
	Habitat Access	Mainstem Physical Barriers	Adequate	Adequate
		Tributary Physical Barriers	Adequate	

REACH CHARACTERIZATION

The objective of this section is to provide context for the physical and ecological processes occurring at the reach scale. The reach scale processes include channel-floodplain interactions and riparian processes (Beechie et al., 2010). Controlling these processes are (1) geologic controls that provide valley constraints that restrict the channel's ability to laterally migrate across the valley floor, (2) active channel and floodplain interactions, and (3) channel gradient that influences streampower and sediment transport capacity. Changes to the reach scale processes could adversely impact habitat quantity and quality, channel complexity and variability, and energy transfer that sustain ESA-listed species.

Surficial Geology

The surficial geology of Lower Nason reach was refined based on aerial photographs, topography, limited in-field observations, and incorporated USGS (1987) geologic mapping. Bedrock geology includes sedimentary rocks of the Chumstick Formation and metamorphic rocks of the Nason Terrane. Surficial geology includes predominantly glacial and alluvial deposits derived from glaciers scouring and plucking metamorphic rocks associated with the Nason Terrane. These rocks were eroded by alpine glaciers and the loose stones were transported downvalley by glacial and alluvial processes to the Lower Nason reach. These metamorphic stones are hard and more resistant to chemical and mechanical weathering than the sedimentary rocks (sandstone) of the Chumstick Formation which crops out in the Lower Nason reach. The glaciers deposited gravels and cobbles as ice-marginal terrace gravels (terraces along the margin of the glacier, found high along the valley walls); as glacial outwash forming higher terraces along the valley floor; and as glacial drift (undifferentiated glacial deposits). Alluvial deposits are primarily derived from the reworking of glacial deposits by Nason Creek to form lower floodplain terraces and the active channel deposits; and by tributaries along the valley walls that deposit alluvial fans on the valley floor. Table 4 contains the geologic map units and descriptions; and a surficial geologic map has been provided as Figure 4. The surficial geologic map also contains the 2010 wetted channel, based on field observations and 2009 aerial photography.

Table 4. Lower Nason reach geologic map units and descriptions

Geologic Unit	Geologic Deposits	Description
Qs	Quaternary sediment	Alluvium comprised predominantly of gravels and cobbles with sand, silt, and boulders. Generally derived from the reworking of floodplain and glacial deposits along the active channel.
Qht	Quaternary high terrace	Alluvium comprised predominantly of gravels and cobbles with sand and silt. These surfaces are higher than the Qs unit and are sometimes flooded when adjacent to the active channel. These deposits are interpreted to be associated with glacial outwash.

Geologic Unit	Geologic Deposits	Description
Qls	Quaternary landslide	Landslides comprised of gravel, cobbles, boulders, sand, and silt, sometimes occur along the active river channel. Colluvium and glacial deposits that mantle the bedrock (Tc) are generally unstable when they become saturated and/or oversteepened by fluvial erosion.
Qaf	Quaternary alluvial fan	Alluvial fans comprised of gravel, cobbles, boulders, sand, and silt are present along the valley margins and contribute sediment and wood to the system where the river is in contact with the fans.
Qtg	Quaternary terrace gravel	Alluvium comprised predominantly of gravel, cobbles, sand, and silt, deposited by glacial outwash processes. Material deposited along the margins of an alpine glacier during the Pleistocene epoch.
Qgd	Quaternary glacial drift	Glacial deposits (undifferentiated) comprised predominantly of cobbles, gravel, boulders, sand and silt, generally related to glacially constructed landforms (i.e., moraines). Material deposited during the Pleistocene epoch by alpine glaciations.
Tc	Tertiary Chumstick Formation	Chumstick Formation (bedrock) comprised predominantly of sandstone conglomerate and shale. Material deposited during the Eocene epoch as fans and floodplain deposits within a structural basin (known as the Chiwaukum Graben) bounded by faults (USGS 1987).

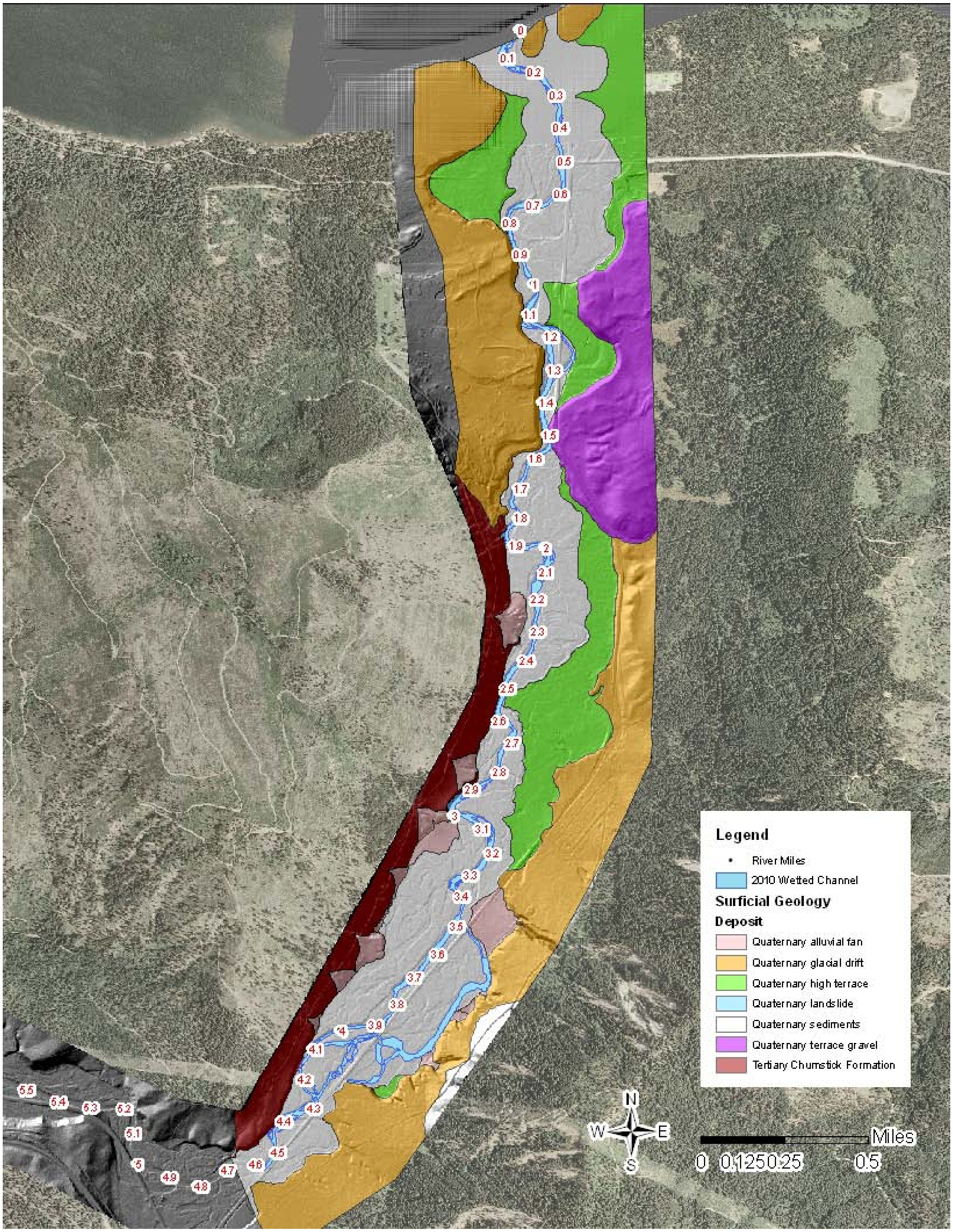

Figure 4. Surficial geologic map of the Lower Nason reach

Geologic Valley Confinement

The Lower Nason reach valley bottom-type is classified as a U-shaped trough (U1) with a valley bottom gradient of less than 3 percent and a predominantly unconstrained, moderately sinuous channel (Naiman et al. 1992). The stream type is predominantly entrenched with a moderate width to depth ratio and moderate sinuousity (F-type channel [Rosgen 1996]) in the moderately confined geomorphic channel segments and slightly entrenched with moderate to high width to depth ratio and high sinuousity (C-type channel [Rosgen 1996]) in the unconfined geomorphic channel segments. Channel bedforms consist of pools, riffles, and runs with a dominant substrate comprised of gravel and cobbles with sand. Boulders are frequent in the more confined sections of the stream, generally associated with bedrock, areas of artificial bank protection (rip rap), and artificial channel confinement.

Geologic valley confinements were based on the surficial geologic mapping conducted for this assessment. Average valley widths were measured using geologic controls to define valley bottom widths. Average channel widths were measured from the 2006 light detection and ranging (LiDAR) hillshade elevation model based on bank/channel slope scarps. All measurements were made using geographical information system (GIS) technology. Valley confinement was based on the ratio of average valley bottom width to average channel width. Unconfined segments have a ratio greater than 4:1; moderately confined segments were between 4:1 and 2:1; and confined segments had less than 2:1 (Hillman 2006). Table 5 contains the valley confinement determinations.

Table 5. Lower Nason reach valley confinement determinations by river miles

River Miles	Valley Confinement	Average Valley Bottom Width	Average Channel Width	Geologic Controls
RM 4.60-2.53	Unconfined	1,090 feet	115 feet	Bedrock (Tc), glacial drift (Qgd), alluvial fans (Qaf), and higher terraces (Qht)
RM 2.53-2.50	Confined	110 feet	90 feet	Bedrock (Tc) and higher terrace (Qht)
RM 2.50-1.52	Unconfined	1,080 feet	95 feet	Bedrock (Tc), glacial drift (Qgd), terrace gravels (Qtg), higher terrace (Qht), and alluvial fan (Qaf)
RM 1.52-1.00	Moderately Confined	380 feet	115 feet	Glacial drift (Qgd) and higher terrace (Qht)
RM 1.00-0	Unconfined	1,520 feet	100 feet	Higher terraces (Qht) and glacial drift (Qgd)

Geomorphic channel segments were identified based on geologic valley constrictions. The channel segment divisions (breaks) are located within the geologic constrictions or where there were geologic valley constraints. Based on the geologic constraints, a relative rating of the potential for overall lateral channel migration and floodplain reworking is presented. Channel segments that were unconfined were rated “high” and moderately confined were rated “moderate” (Table 6). No confined channel segments were identified which would have had a “low” rating. The locations of the four geomorphic channel segments identified in the Lower Nason reach are provided in Figure 5.

Table 6. Channel segments identified for Lower Nason reach

Geomorphic Channel Segment	River Miles	Geologic Valley Confinement	Potential for Overall Lateral Channel Migration and Floodplain Re-working
Channel Segment A	RM 4.6-2.5	Unconfined	High
Channel Segment B	RM 2.5-1.5	Unconfined	High
Channel Segment C	RM 1.5-1.0	Moderately Confined	Moderate
Channel Segment D	RM 1.0-0	Unconfined	High

The valley length was determined by measuring a longitudinal profile between the upper reach boundary at RM 4.6 and the lower reach boundary to RM 0. The profile end points were located about equidistant horizontally between the geologic valley constraints. Valley length was about 19,613 feet and the elevation change was about 88 feet based on channel survey elevations from 2006 LiDAR hillshade elevation model (Reclamation 2008). Based on these measurements the valley gradient was calculated to be about 0.45 percent (Table 7).

Channel planforms were traced from the channel migration zone study for the 1981, 1992, and 1998 channel alignments (Jones & Stokes 2004). The 2006 channel alignment was mapped for this assessment and two hypothetical historical channel alignments were interpreted from channel paths visible on the 2006 LiDAR hillshade elevation model. Elevation change was held constant at 88 feet in order to compare potential channel gradient differences. Channel sinuosity was calculated using the length of the channel alignment divided by the valley length. Results are summarized in Table 8.

Table 7. Reach scale valley gradient calculation

River Miles	Valley Length	Elevation Change	Valley Gradient
RM 4.6-0	19,613 feet	88 feet	0.45 percent

Table 8. Reach scale historical channel gradient and sinuosity

Year	Channel Length	Elevation Change (Constant)	Change Gradient	Channel Sinuosity
1981	23,623 feet	88 feet	0.37 percent	1.20
1992	23,765 feet	88 feet	0.37 percent	1.21
1998	23,759 feet	88 feet	0.37 percent	1.21
2006	23,635 feet	88 feet	0.37 percent	1.21
Hypothetical Channel A	29,397 feet	88 feet	0.30 percent	1.50
Hypothetical Channel B	28,579 feet	88 feet	0.31 percent	1.46

Hypothetical channels A and B represent the possible channel alignments prior to re-routing of the channel during construction of State Route 207. This analysis suggests that historically Nason Creek had a gradient of about 0.30 percent with a sinuosity of about 1.4 to 1.5. Following the construction of State Route 207, the channel has a gradient of about 0.37 percent with a sinuosity of about 1.2. Re-routing the stream has shortened the channel length by about 5,000 feet which increased the channel gradient by about 19 percent and reduced channel sinuosity by about 17 percent.

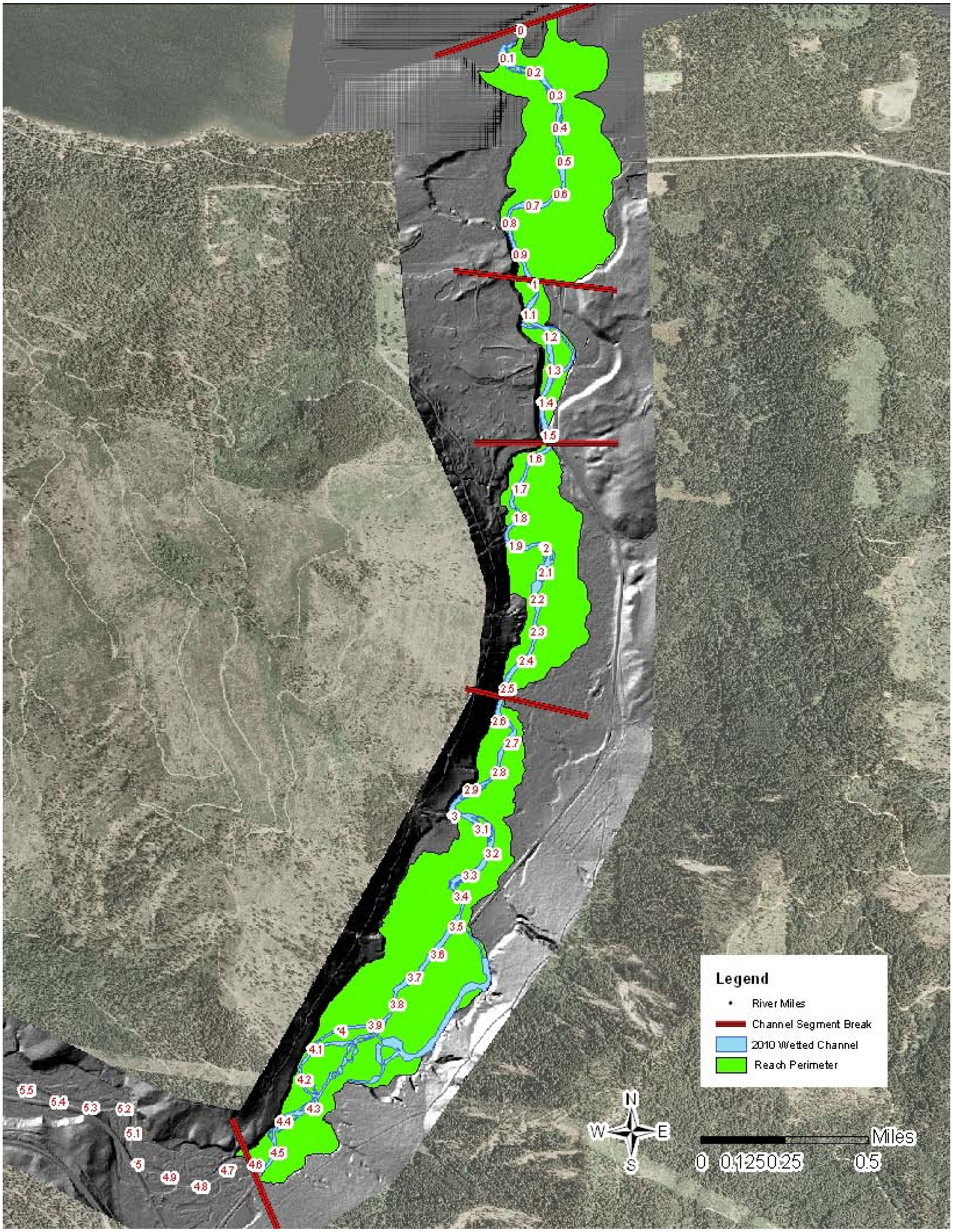

Figure 5. Lower Nason reach geomorphic channel segment delineations

Active Channel and Floodplain Designations

Geomorphic channel segments were identified based on valley confinement, geologic controls, and topography. These channel segments were further subdivided into the active channel and floodplain areas in order to describe localized channel controls, variability, and connectivity. Active channel areas are where channel forming flows re-work lower elevation surfaces (i.e. poorly vegetated gravel bars) and where lateral channel migration has deposited sediment (i.e. point bars). Floodplain areas are where the river goes out-of-bank and flows over higher surfaces (i.e. terraces). In general, floodplain areas that are adjacent to the active channel are more frequently flooded. The flood effects are reduced as flows are dispersed away from the channel over a larger cross sectional area.

Areas where active channel and floodplain interactions occur unimpeded by topographic features are considered hydraulically "connected". Conversely, areas where these interactions are impeded are referred to as hydraulically "disconnected". In general, the disconnected areas are associated with anthropogenic disturbances that have created elevated topographic features (i.e., road grades) that hydraulically disconnect active channel and floodplain interactions. Table 9 summarizes the connectivity by geomorphic channel segment and Figure 6 provides a visual reference of the overall connectivity within the reach.

Table 9. Summary of active channel and floodplain connectivity by geomorphic channel segments

Geomorphic Channel Segment	Total Acreage	Connected Acreage	Disconnected Acreage (Percent)
Segment A	217.9 acres	163.5 acres	54.4 acres (25%)
Segment B	85.0 acres	84.8 acres	0.2 acres (<1%)
Segment C	27.3 acres	23.9 acres	3.4 acres (12%)
Segment D	125.0 acres	50.3 acres	74.7 acres (60%)
Totals	455.2 acres	322.5 acres	132.7 acres (29%)

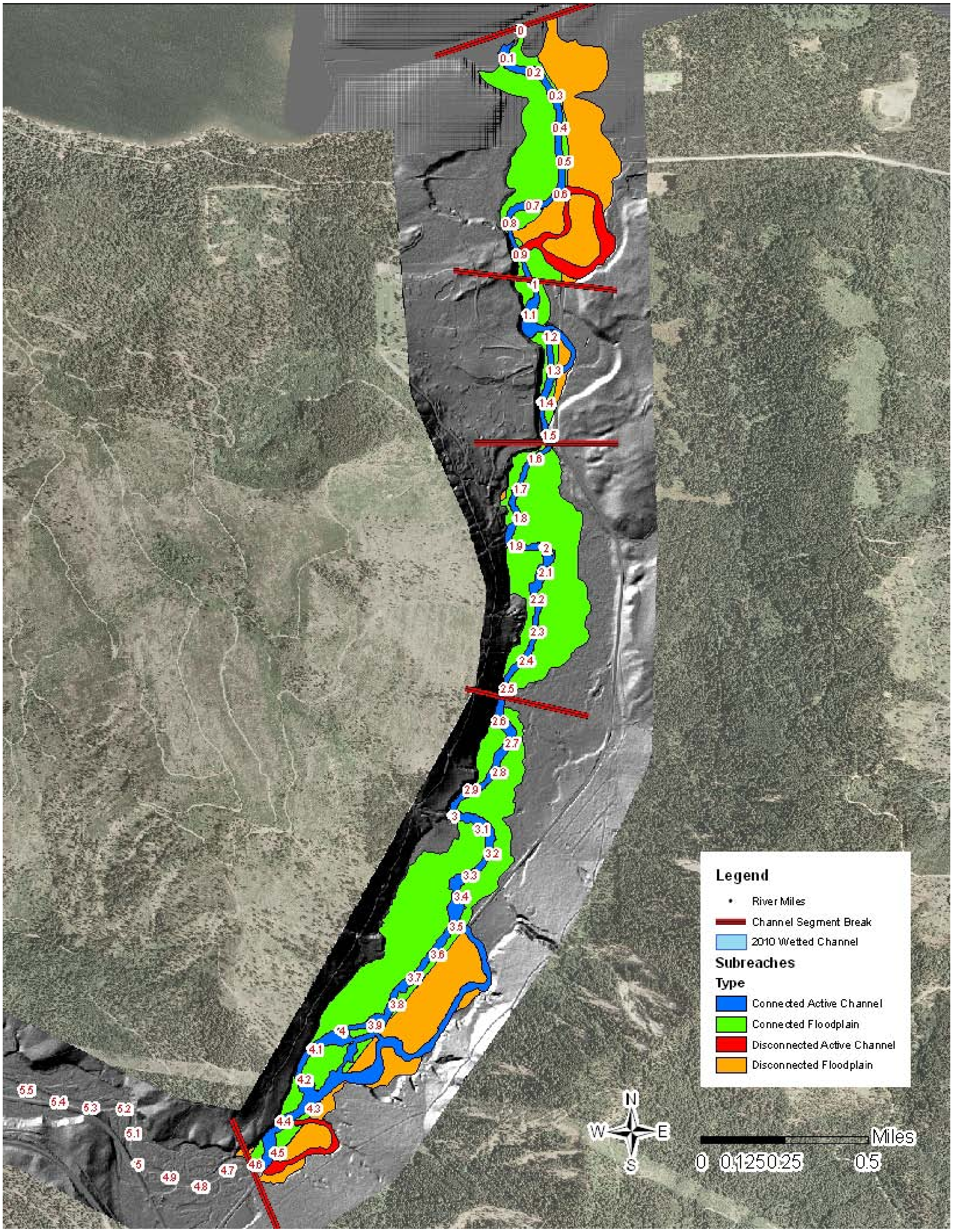

Figure 6. Hydraulic connectivity between the active channel and floodplain areas

Channel Gradient Determinations

A longitudinal channel profile was generated using the 2006 LiDAR data collected during the Tributary Assessment (Reclamation 2008) when streamflows were about 40 cfs. The LiDAR used does not penetrate the water, but does capture hydraulic controls along the channel alignment (i.e. riffles and rapids). The surface water channel profile was generated to determine the channel gradient from about Whitepine Creek to the confluence with the Wenatchee River. This report uses the results from this analysis (Figure 7) and based on the raw data determined the channel gradients for each of the geomorphic channel segments.

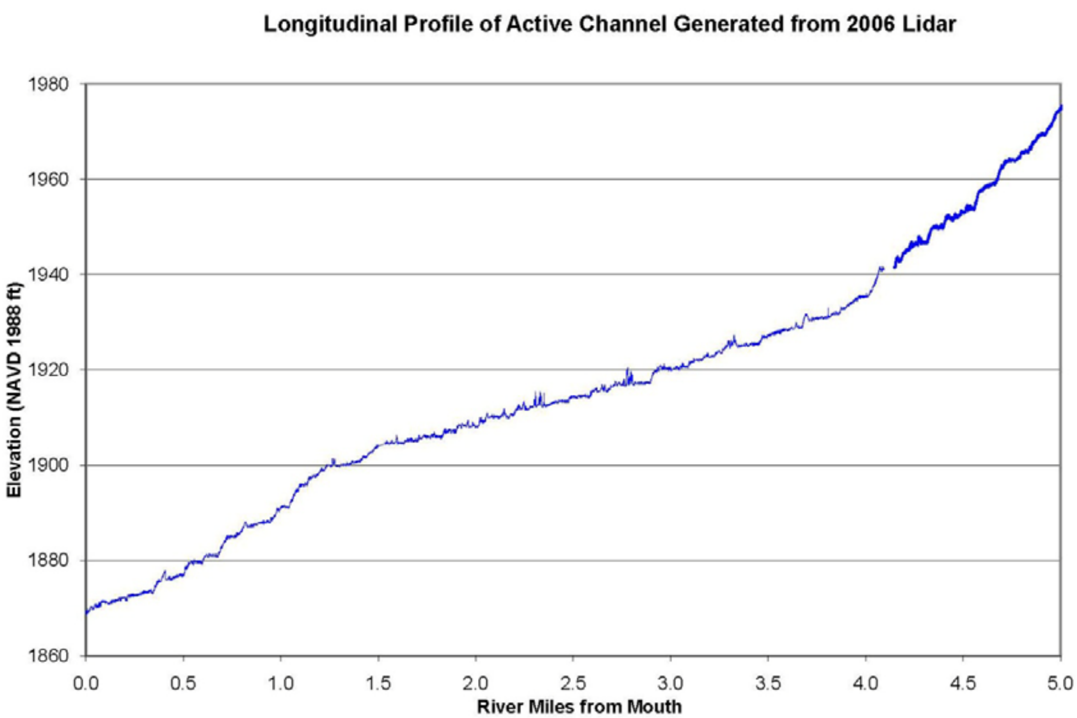

Figure 7. Lower Nason reach longitudinal channel profile (2006) from Reclamation (2008)

The raw data was analyzed using the river miles at the endpoints of the 2009 channel alignment and the average channel slope was calculated for each channel segment (Table 10). The average channel slopes ranged from 0.13 percent to 0.45 percent for the unconfined channels segments, and 0.48 percent for the moderately confined channel segment. Unconfined Channel Segment B had a 0.13 percent slope and does not have any anthropogenic channel controls. Conversely, the other two unconfined channel segments (Segment A and Segment D) have significant anthropogenic disturbances and artificial channel controls that have shortened the channel's lengths (i.e. channelization). These anthropogenic disturbances and features, and their impacts on physical and ecologic process are further discussed in the Channel Segment Characterization section of this report.

Table 10. Channel planform calculations based on 2006 LiDAR and 2009 aerial photographs

Geomorphic Channel Segment	River Miles	Valley Confinement	Elevation Change	Distance	Avg. Channel Slope (percent)	Sinuosity
Segment A	RM 4.60-2.53	Unconfined	46 feet	10,864 feet	0.42%	1.25
Segment B	RM 2.53-1.52	Unconfined (Constriction @ RM 2.53-2.50)	7 feet	5,234 feet	0.13%	1.22
Segment C	RM 1.52-1.00	Moderately Confined	14 feet	2,888 feet	0.48%	1.07
Segment D	RM 1.00-0	Unconfined	21 ft	4,663 feet	0.45%	1.19

REACH SCALE PHYSICAL INDICATORS

In this report, landscape processes were briefly discussed in the Regional Setting section and watershed-scale processes were summarized in the Watershed Characterization section. At the reach scale, physical habitat dynamics are primarily a function of sediment and water inputs that drive channel shape, sediment characteristics, and formation of habitat features such as pools and riffles (Beechie et al., 2010). To understand how the riverine ecosystem dynamics are functioning, riparian processes and channel-floodplain interactions were analyzed using a matrix of reach-based ecosystem indicators (REI). The condition rating determined for each indicator is based on REI criteria, geomorphic constraints, and professional judgment. Condition ratings of the indicators help identify watershed-scale systemic problems, reach-scale channel and floodplain functional problems, and evaluation of processes that benefit the riverine ecosystem. The REI for the Lower Nason assessment area is provided in Appendix A and the following section discusses the condition rating of each specific and general indicator.

Reach-based Ecosystem Indicators (REI) Summary

The condition of the reach-based ecosystem specific indicators informs how the general indicators (or pathways) are functioning. General indicators are used to evaluate riverine dynamics. Based on thresholds listed in the REI (Appendix A), conditions for general indicators are as follows:

- Water Quality and Quantity were **At Risk** due to the following: water temperature was found to be unacceptable for salmon spawning, core summer salmonid habitat, rearing and migration (USFS 2006), and classified as a Category 4a waterbody that was included in the Wenatchee River Watershed Temperature TMDL that was approved by the EPA on August 3, 2007; WDOE moderate quality finding for turbidity which may be exacerbated by anthropogenic disturbances; and a overall WDOE Water Quality Index rating of 70 (moderate water quality) for this Class AA waterbody suggests a potential systemic water quality and/or quantity problem occurring in the watershed.

- Habitat Access was **Adequate** because there are no mainstem barriers that prevent fish passage to the upper watershed or tributaries in this reach.

- Habitat Quantity was **Adequate** due to the following: channel substrate was comprised of gravels and small cobbles that are being transported from upstream to this reach; fine sediment deposition appears to be transient and fluctuating through time; large wood frequency exceeded the adequate REI criteria and vegetation structure was adequate for both long- and short-term recruitment potential; pool frequency (11 pools per mile) exceeded the REI criteria and had cover provided by wood, canopy cover, and depth; and off-channel habitat was present as side channels with low energy that were accessible and had cover.

- Channel Condition and Dynamics was **At Risk** due to the following: improved roads that have disrupted floodplain connectivity and channel-floodplain; bank hardening has restricted lateral channel migration; and anthropogenic disturbances have changed channel gradient and that may have increased streampower.

- Riparian/Upland Vegetation was **At Risk** due to the following: road construction, timber harvests, and floodplain development have altered the vegetation structure; channel-floodplain interactions have been disrupted in about 29 percent of the reach and may have altered vegetation composition; most of the woody vegetation along a 30-meter buffer zone adjacent to the active channel was available for recruitment; and canopy cover, based on vegetation structure along a 10-meter buffer zone, was comprised of about 92 percent woody vegetation that provides appropriate stream cover for thermal shading, leaf litter inputs, and connectivity between physical and ecological processes.

Table 11 contains the summary of condition ratings for each of the specific and general indicators contained in the REI. Channel and floodplain interactions have been reduced by anthropogenic disturbances. These disturbances include the loss of riparian habitat due to vegetation clearing, loss of mainstem habitat due to channel shortening, loss of floodplain connectivity due to road embankments, and reduction in lateral channel migration due to bank protection.

Physical, vegetation, and aquatic biota processes functioning at the reach spatial and temporal scales have been negatively impacted. Channel migration and floodplain reworking processes influence creation and sustainability of complex habitat (Beechie et al., 2010). About 29 percent of the floodplain has been disconnected by road embankments that are protected with riprap where the active channel interacts with the structure. Bank protection was also placed along the stream to protect campground areas. This has reduced the channel's ability to migrate laterally across its historic floodplain thus reducing the potential abundance of various habitat types (i.e., pools, riffles, bars, and side channels).

Vegetation processes involve the creation and maintenance of appropriate riparian vegetation composition and structure (Beechie et al., 2010). Many riparian vegetation species are dependent on disturbance regimes (i.e., floods and lateral channel migration) in order to colonize bars and islands, and maintain healthy stands (i.e., cottonwoods). Clearing riparian vegetation for floodplain development and infrastructure, and/or disconnecting channel-floodplain interactions negatively impact the health, structure, and composition of these riparian species.

Aquatic biota processes involve population dynamics including habitat selection and trophic dynamics (Beechie et al., 2010). Selection of habitat and species competition influence survival of individuals and their population dynamics. Physical and ecological connectivity are essential components to sustaining energy transfer and a viable food web necessary for the survival of many aquatic and terrestrial species. Disruptions to channel-floodplain interactions by anthropogenic features can disconnect aquatic and terrestrial interactions such as the transfer of organic matter to the stream that supports macroinvertebrate production, sustains the appropriate vegetation necessary to complete the life cycle of some aquatic insects (i.e. mayflies and stoneflies), and maintains an abundance of food available for foraging salmonids.

The physical and ecological processes have been impaired in the Lower Nason reach, and the resulting habitat complexity, diversity, and connectivity have been negatively impacted. These processes and features could be further rehabilitated which would improve needed habitat to support various life stages of ESA-listed fish species.

Table 11. REI condition ratings for indicators

Spatial Scale	General Indicator	Specific Indicator	Specific Indicator Condition	General Indicator Condition
Reach Characteristics	Water Quality and Quality	Water Temperature	Unacceptable	At Risk
		Turbidity	At Risk	
		Chemical Contamination/Nutrients	At Risk	
	Habitat Access	Main Channel Physical Barriers	Adequate	Adequate
	Habitat Quality	Channel Substrate	Adequate	Adequate
		Turbidity	At Risk	
		Large Wood	Adequate	
		Pools	Adequate	
		Off-channel Habitat	Adequate	

Spatial Scale	General Indicator	Specific Indicator	Specific Indicator Condition	General Indicator Condition
	Channel Condition and Dynamics	Floodplain Connectivity	At Risk	At Risk
		Bank Stability/Channel Migration	At Risk	
		Vertical Channel Stability	Adequate	
	Riparian/Upland Vegetation	Vegetation Structure	At Risk	At Risk
		Vegetation Disturbance	Adequate	
		Vegetation Canopy Cover	Adequate	

CHANNEL SEGMENT CHARACTERIZATION

Geomorphic channel segments were identified based on geologic valley constrictions. The channel segment divisions (breaks) are located within the geologic constrictions and where the channel was moderately confined. Subreaches were delineated based on interpretations from aerial photographs, 2006 LiDAR hillshade elevation model, topographic maps, and field observations. The objective was to identify areas where channel-floodplain interactions historically occurred prior to anthropogenic disturbances. In order to quantify the areas where anthropogenic disturbances disconnected the channel-floodplain interactions, the subreach was divided into smaller areas or “parcels”, and these subreaches are referred to as subreach complexes. Subreach complexes may include both connected and disconnected areas due to anthropogenic disturbances. The objective of these parcel subdivisions is to understand the physical connectivity of the channel-floodplain interactions and vegetative processes. These interactions are necessary to create and maintain appropriate channel morphology, habitat structure, thermal regime, water chemistry, species assemblage, and connectivity between physical and biotic processes (Beechie et al., 2010).

The floodplain vegetation was evaluated by mapping the overstory, middle story, understory vegetation, and areas with no vegetation using the 2006 aerial photographs. Overstory vegetation was predominantly in a Large Trees Condition that was commonly mixed deciduous and coniferous species. Middle story vegetation was in a shrub/seedling to Small Trees Condition that was comprised predominantly of deciduous species. Understory vegetation was in a Grass/Forbs Condition or had no vegetation due to anthropogenic disturbances that required clearing for development.

Channel units were mapped in the field based on observed physical characteristics and then each unit was redrawn on rectified aerial photographs (2009) in ArcGIS. “Channel units” are hydraulic features and should not be confused with “habitat units” that are a measure of habitat type and quantity available at low flows. For example, the habitat assessment includes the long pool tail-out in the “glide-pools” as pool habitat even though this area of the pool is functioning as a run hydraulically. For the channel unit mapping the pools (area of pool scour) and runs are spatially defined and mapped separately as geomorphic channel units.

Channel Segment A

Channel Migration

Located between RM 4.6 and 2.5, Channel Segment A contains a total area of 217.9 acres of historic active channel and floodplain areas. This segment is an artificially confined pool-riffle type system. Bedrock controls the extent of westward lateral channel migration near RM 4.45 and restricts both lateral and vertical channel migration near RM 4.15 (Figure 8). The horizontal orientation observed in the channel at RM 4.15 suggests bedrock may extend some distance to the east and influence lateral channel migration processes. This vertical restriction may translate into a faster rate of channel migration across the floodplain due to the thin veneer of alluvium mantling the bedrock which allows the channel to rework the floodplain more frequently than areas where thicker alluvial valley fill are present.

Figure 8. Channel Segment A: View looking at bedrock (Chumstick Formation (Tc)) outcrop near RM 4.15 that restricts lateral and vertical channel migration. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 15, 2010.

Aerial photographs were used to evaluate channel alignments for a period of about thirty-years. This channel alignment time series was after the re-routing of the channel during the construction of an improved road (State Route 207). To understand historic channel alignments and lateral migration prior to the road construction, a channel alignment was interpreted and traced from the 2006 LiDAR hillshade elevation model (Figure 9). Based on these channel alignments the following geomorphic channel changes are estimated to have occurred: (1) the channel length has been reduced by about 2,000 feet, (2) the channel gradient has been increased by about 17 percent, and (3) the channel sinuosity has decreased about 17 percent (Table 12).

Channelization and constraints on lateral channel migration have changed the geomorphology of the channel and have resulted in increased streampower and increased sediment transport capacity. These channel changes have reduced channel-floodplain interactions and may have degraded the long-term physical and ecological processes that create and sustain appropriate habitat complexity, connectivity, and variability.

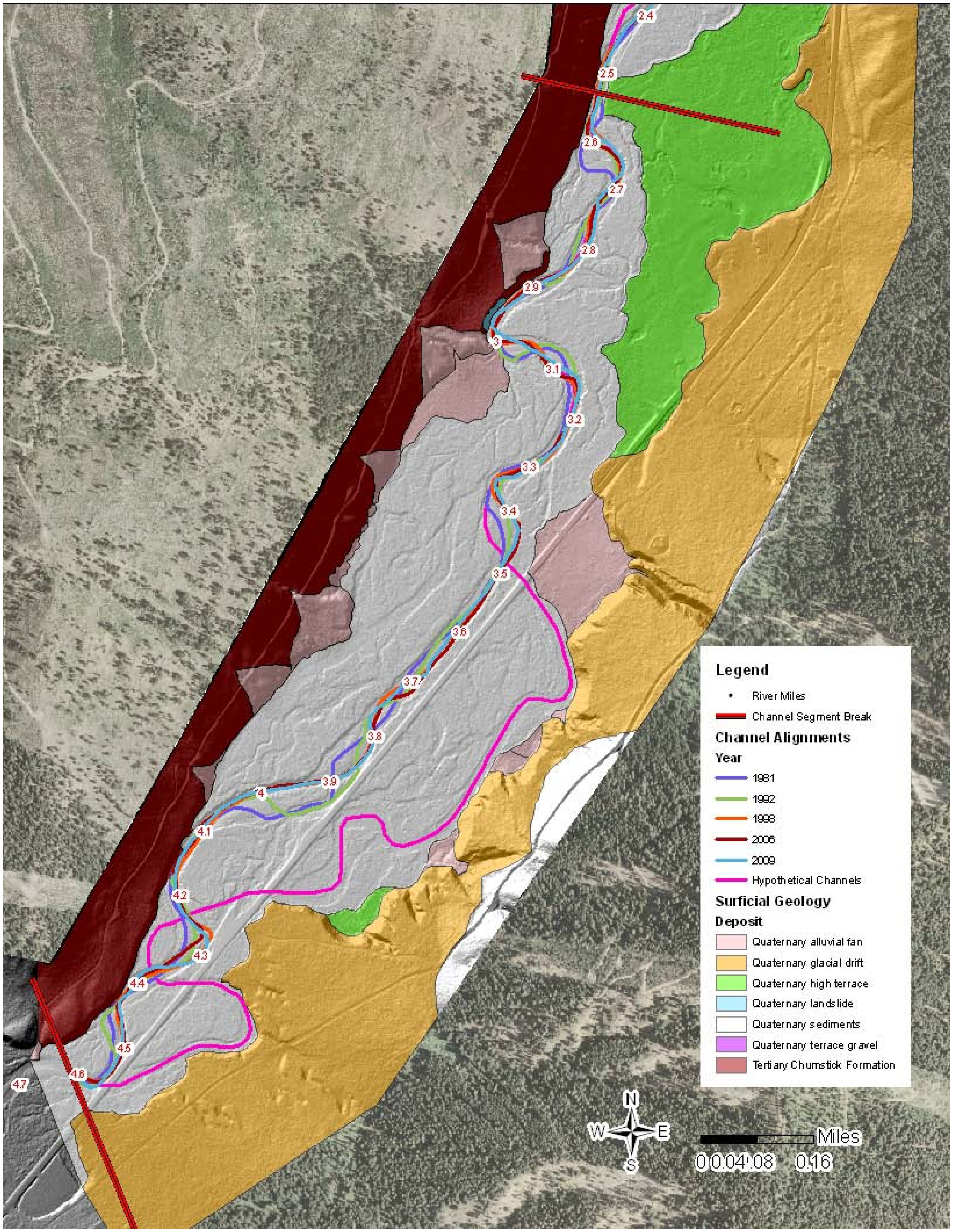

Figure 9. Channel Segment A: Historical channel alignments and hypothetical channel alignment interpreted from 2006 LiDAR hillshade

Table 12. Channel Segment A: Historic channel alignments and geomorphic channel metrics

Channel Alignment Year	Length	Elevation Change	Gradient (percent)	Sinuosity
1981	10,785 feet	46 feet	0.43%	1.24
1992	10,985 feet	46 feet	0.42%	1.26
1998	10,923 feet	46 feet	0.42%	1.25
2006	10,823 feet	46 feet	0.43%	1.24
2009	10,864 feet	46 feet	0.42%	1.25
Hypothetical Channel	13,075 feet	46 feet	0.35%	1.50

Hydraulic Connectivity

Connectivity between the active channel and floodplain are essential to maintaining the physical and ecological processes that create and sustain appropriate channel morphology, riparian vegetation composition, and energy transfer processes (i.e. food web). About 163.5 acres (75 percent) of the channel segment have appropriate connectivity between the active channel and floodplain. However, about 54.4 acres (25 percent) of the channel segment does not have these interactions due to elevated anthropogenic features that disconnect these processes (Table 13).

Table 13. Channel Segment A: Active channel and floodplain hydraulic connectivity

Channel Segment	River Miles	Subreach	Total Acres	Connected Acres	Disconnected Acres
Segment A	**RM 4.60-2.50**	LN-IZ-1 Complex	54.1	49.5	4.6
		LN-DOZ-1	2.5	0	2.5
		LN-OZ-2 Complex	2.0	1.4	0.6
		LN-OZ-3 Complex	8.7	2.2	6.5
		LN-OZ-4	2.5	2.5	0
		LN-OZ-5 Complex	3.2	0.6	2.6
		LN-OZ-6	6.8	6.8	0
		LN-OZ-7 Complex	4.0	1.4	2.6
		LN-DOZ-8	5.3	0	5.3
		LN-OZ-9	60.7	60.7	0
		LN-OZ-10	0.9	0.9	0
		LN-OZ-11 Complex	32.5	4.0	28.5
		LN-DOZ-12	1.2	0	1.2
		LN-OZ-13	28.1	28.1	0
		LN-OZ-14	5.4	5.4	0
Total Acres			**217.9**	**163.5**	**54.4**

In order to delineate the areas (and calculate acreage) where channel-floodplain interactions are either connected or disconnected, some subreaches had to be subdivided into smaller units, referred to as parcels. The subreaches that were subdivided are referred to as subreach complexes. The most significant anthropogenic impact was from an improved road (State Route 207) that longitudinally bisects the floodplain. State Route 207 has disconnected about 4.6 acres of historic channel and about 49.2 acres of floodplain. The total area disconnected by the road was about 53.8 acres or about 25 percent. Table 14 summarizes the subreaches and parcels that are disconnected by State Route 207 and their associated acreages.

Table 14. Channel Segment A: Summary of active channel and floodplain areas disconnected by improved road

Anthropogenic Feature	Geomorphic Impact	Subreach	Parcel	Acreage
Improved Road (State Route 207)	Disconnected Active Channel and Floodplain Areas	LN-IZ-1 Complex	LN-DIZ-1b	4.6 acres
		LN-DOZ-1	---	2.5 acres
		LN-OZ-3 Complex	LN-DOZ-3b	6.5 acres
		LN-OZ-5 Complex	LN-DOZ-5b	2.6 acres
		LN-OZ-7 Complex	LN-DOZ-7b	2.6 acres
		LN-OZ-8 Complex	LN-DOZ-8	5.3 acres
		LN-OZ-11 Complex	LN-DOZ-11b	28.5 acres
		LN-DOZ-12	---	1.2 acres

Other anthropogenic features such as unimproved roads, riprap, and powerline right-of-way impact physical processes to a lesser degree. Along the powerline right-of-way, vegetation near RM 4.25 has been cleared which reduces bank stability and channel boundary roughness, but otherwise does not affect floodplain connectivity. Unimproved roads in subreach LN-OZ-13 are not elevated and do not impede floodplain connectivity. Riprap placed along the State Route 207 may affect channel hydraulics and geometry, streampower, and lateral channel migration. In general, the relatively smooth hydraulic surface created by riprap decreases channel boundary roughness and maintains or increases streampower and can result in localized scour and downstream impacts. Anthropogenic features identified in this assessment are categorized by feature type and assigned a metric (i.e., measured or tabulated). A summary of the anthropogenic features and metrics are provided in Table 15 and their locations are shown in Figure 10.

Table 15. Channel Segment A: Anthropogenic features and metrics

Subreach/Parcel	Feature Type	Metric
LN-IZ-1a	Riprap	550 feet
	Improved Road	160 feet
	Culverts	3
LN-DIZ-1b	Improved Road	370 feet
LN-DOZ-3b	Improved Road	750 feet
LN-DOZ-5b	Improved Road	670 feet
	Unimproved Road	80 feet
LN-OZ-7a	Unimproved Road	230 feet
LN-DOZ-7b	Improved Road	700 feet
LN-DOZ-11b	Improved Road	2,100 feet
LN-OZ-13	Unimproved Road	1,200 feet
	Structure	1

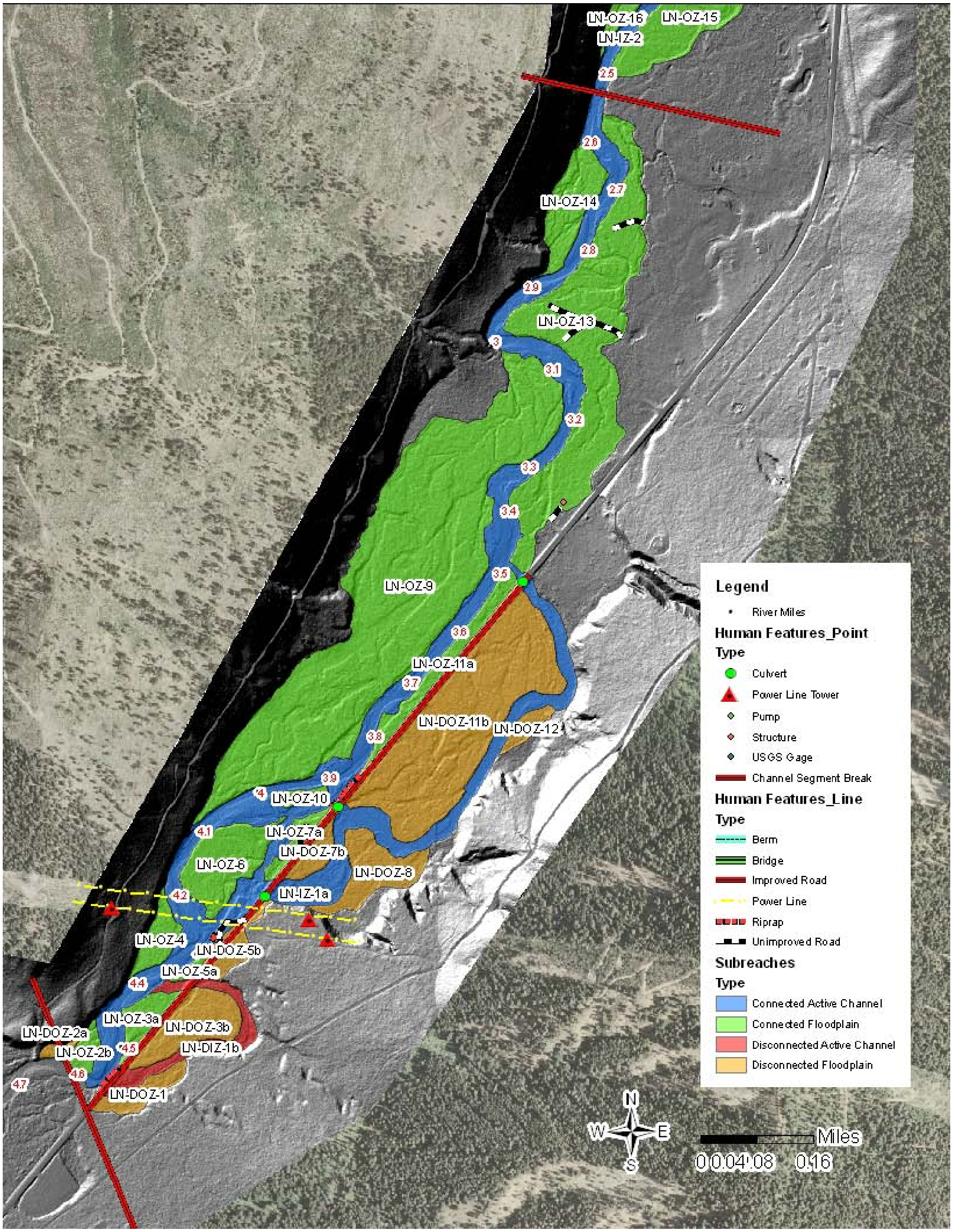

Figure 10. Channel Segment A: Active channel and floodplain connectivity and anthropogenic features

Vegetation Structure

Most of the floodplain within the channel segment is in a Large Trees Condition and compositions of individual stands are coniferous deciduous or mixed, dependent on their location and elevation with respect to the active channel (Figure 11). Areas that are in a Shrub/Pole or Small Trees Condition are typically along the margins of the active channel or along side channels where ground disturbing flows occur. Most of the areas in a Grass/Forb Condition or with no vegetation are associated with anthropogenic disturbances. These disturbances include clearing along the powerline right-of-way, State Route 207, and residential and agriculture development (Figure 12).

Figure 11. Channel Segment A: View looking downstream at riparian buffer zone near RM 3.70. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 15, 2010.

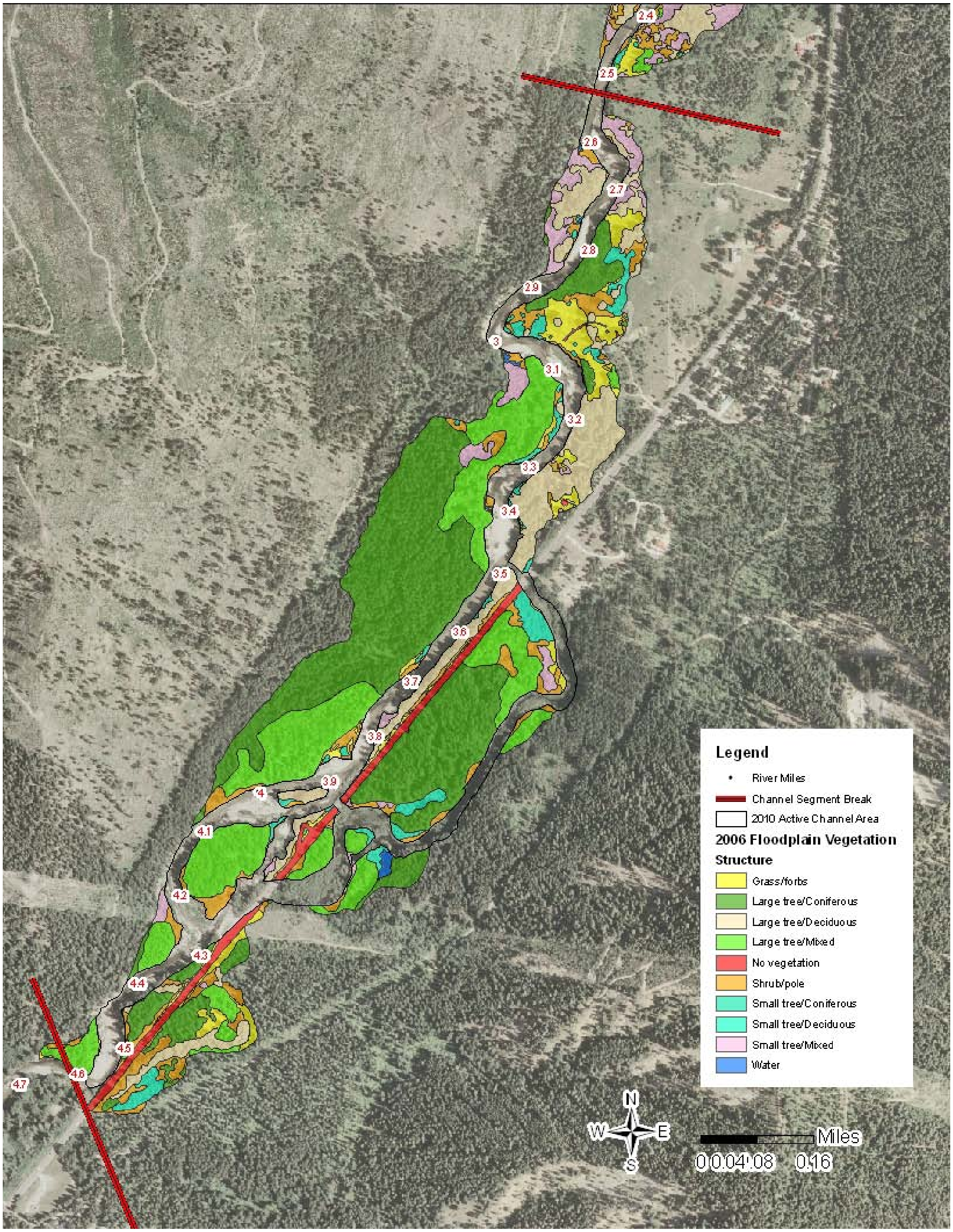

Figure 12. Channel Segment A: Vegetation structure adjacent to the active channel and within the floodplain

Aquatic Habitat

Channel unit area (in acres) was evaluated to determine the percent of each unit present within the wetted channel (Table 16 and graphically illustrated in Figure 13).

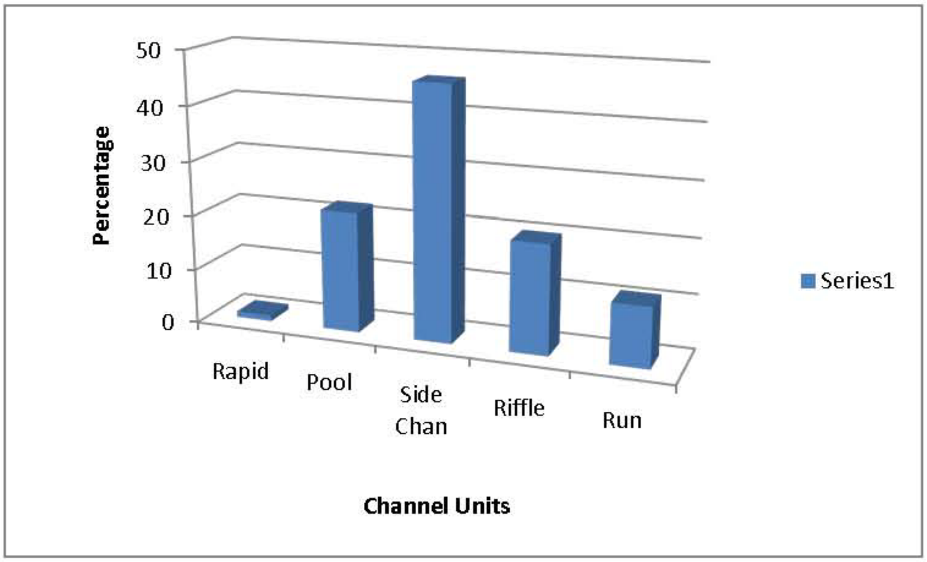

Figure 13. Channel Segment A: Chart of mapped geomorphic channel units (Side Chan - side channels)

Table 16. Channel Segment A: Channel unit percentages

Rapids	Pools	Side Channels	Riffles	Runs
1 percent	22 percent	46 percent	20 percent	11 percent

This channel segment has a high percentage of side channels because a historic channel path was reconnected for off-channel habitat in 2007 by the Chelan County Natural Resources Department. The reconnected channel path (SC_3.48_R) provides about 6.61 acres of off-channel habitat and represents about 57 percent of the total side channel units (Figure 14).

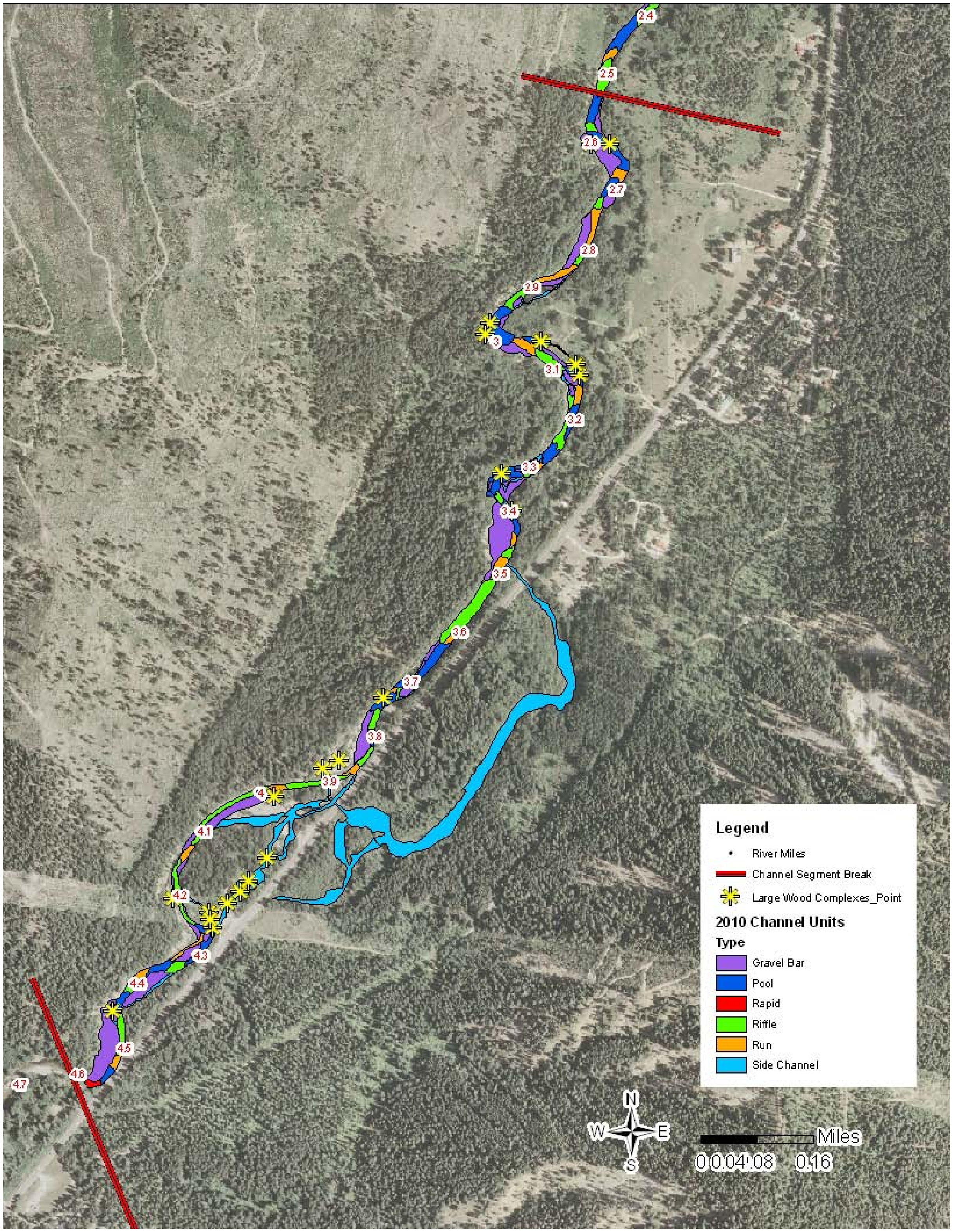

Figure 14. Channel Segment A: Visual representation of channel units and their association with large wood complexes

As part of this assessment, side channels were mapped as a separate channel unit, given a unique identifier (SC_4.44_L as an example is a side channel at RM 4.44 on river left) and classified as either a gravel bar- or floodplain-type side channel (Table 17). Gravel bar-type side channels are associated with unvegetated bars and channel braids that are not well established; whereas floodplain-type side channels are established side channels associated with vegetated islands and floodplain areas. Fourteen side channels were mapped totaling about 11.60 acres. About 11.05 acres or 95 percent of the side channels were classified as floodplain-type side channels which typically provide complex micro-habitat and ecological function. The remaining side channels, about 0.55 acres or 5 percent, were classified as gravel bar-type side channels which generally provide spawning and rearing habitat. In 2007, the Chelan County Natural Resources Department (CCNRD) reconnected a historic channel path that created a floodplain-type side channel (SC_3.48_R) to provide additional off-channel habitat.

Table 17. Channel Segment A: Side channel identifiers, types, and acreage

Channel Segment	River Miles	Side Channel	Side Channel Type	Acres
Segment A	**RM 4.60-2.50**	SC_4.44_L	Gravel Bar	0.08
		SC_4.34_R	Gravel Bar	0.17
		SC_4.20_R	Floodplain	0.16
		SC_3.98_R	Floodplain	0.61
		SC_3.88_R	Floodplain	1.50
		SC_3.86_R	Floodplain	1.96
		SC_3.68_R	Gravel Bar	0.07
		SC_3.48_R	Floodplain	6.61
		SC_3.32_R	Gravel Bar	0.07
		SC_3.27_L	Gravel Bar	0.05
		SC_3.12_L	Gravel Bar	0.08
		SC_3.17_R	Floodplain	0.11
		SC_2.92_R	Gravel Bar	0.03
		SC_2.85_R	Floodplain	0.10
Total Acres by Side Channel Type:	**Floodplain-Type:**	**11.05 acres**		
	Gravel Bar-Type:	**0.55 acres**		
Total Side Channel Acres:	**11.60 acres**			

About 20 wood complexes were observed in the mainstem as small log jams; along meander bend apexes; throughout natural side channels; and on the active floodplain. The wood influences channel morphology by providing a forcing agent that contributes to pool and side channel creation, channel switching, and island formation.

Side channel SC_3.86_R on river right near RM 4.3 is a good example of the importance of wood in this channel segment. The photograph in Figure 15 shows the wood complex (left of center in photograph) at the head of the side channel. Based on aerial photograph interpretation, the wood complex covered about 0.44 acres in 2006. However, by 2009 the wood complex had nearly doubled in acreage to about 0.90 acres. The wood complex has contributed to the development of several smaller side channels adjacent to the complex that provide spawning and rearing habitat, fish cover and provides biomass that benefits macroinvertebrate production.

Figure 15. Channel Segment A: View to the northeast looking downstream at lateral scour pool near RM 4.30 along river right and large wood complex. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 16, 2010.

By reconnecting the historic channel path that was isolated by State Route 207 (Figure 16), available off-channel habitat was increased (Figure 17) and sediment transport capacity in the mainstem may have been reduced as flows are distributed over a larger cross sectional area. However, lateral channel migration remains restricted and most of the floodplain remains disconnected due to the road grade.

Figure 16. Channel Segment A: View looking at culvert placed through State Route 207 near RM 3.90 that reconnects historic channel path (side channel SC_3.48_R). Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 15, 2010.

Figure 17. Channel Segment A: View looking downstream at reconnected historic channel path near RM 3.90 (side channel SC_3.48_R). Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 16, 2010.

Summary

Channel migration has been negatively impacted due the location of an improved road (State Route 207). In several areas the road grade is protected by riprap that restricts channel migration processes. Analysis of channel alignments shows the channel was re-routed for construction of the improved road that has reduced the channel length by about 2,000 feet which resulted in an increased channel slope of about 17 percent and a decrease in channel sinuosity of about 17 percent. In addition, State Route 207 has an elevated grade that disrupts active channel-floodplain interactions and has disconnected about 25 percent (54.4 acres) of active channel and floodplain areas.

The floodplain vegetative structure was predominantly in a Large Trees Condition comprised of coniferous, deciduous, or mixed coniferous and deciduous stands based on interpretation of 2006 aerial photographs. The composition of each stand was dependent on their disturbance history and their location and elevation with respect to the active channel. Vegetation along the active channel provides appropriate shading, recruitment potential, and ecological connectivity.

Wood complexes were observed in the mainstem as small log jams; along meander bend apexes; throughout side channels; and on the active floodplain. The wood influences channel morphology by providing hydraulic diversity that alters the energy profile and contributes to creation of pools and side channels, and contributes to gravel sorting and island formation.

Fourteen side channels were identified that provide about 11.60 acres of available off-channel habitat available at varying flows. About 95 percent (11.05 acres) of the side channels were classified as floodplain-type (or established) side channels. The remaining side channels, about 5 percent (0.55 acres), were classified as gravel bar-type (or braid) side channels.

Channel Segment B

Channel Migration

Geomorphic Channel Segment B is located between about RM 2.5 and 1.5 and contains a total area of 85 acres of active channel and floodplain areas. This segment is an unconfined pool-riffle type system. Analysis of historic channel alignments (~30 year period) and a hypothetical channel alignment interpreted from 2006 LiDAR (Figure 18) were evaluated in conjunction with the locations of geologic constraints. No anthropogenic channel constraints were identified in this segment. The channel is able to adjust vertically and laterally to distubances with a channel gradient range of 0.11 to 0.13 percent and a channel sinuosity range of 1.19 to 1.53 (Table 18).

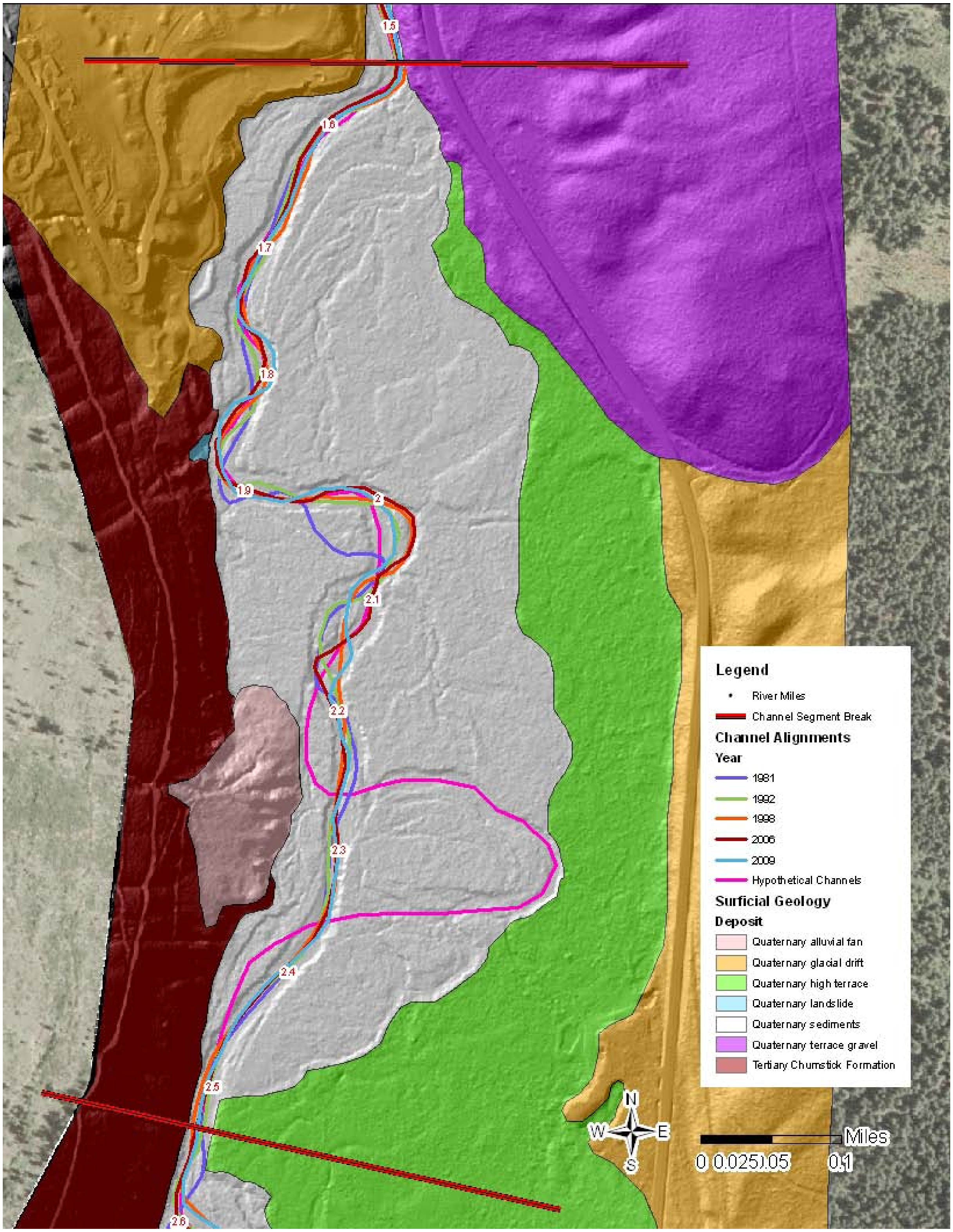

Figure 18. Channel Segment B: Historical channel alignments and hypothetical channel alignment interpreted from 2006 LiDAR hillshade

Table 18. Channel Segment B: Historical geomorphic channel changes

Channel Alignment Year	Length	Elevation Change	Gradient (percent)	Sinuosity
1981	5,096 feet	7 feet	0.14%	1.19
1992	5,148 feet	7 feet	0.14%	1.20
1998	5,227 feet	7 feet	0.13%	1.22
2006	5,286 feet	7 feet	0.13%	1.23
2009	5,234 feet	7 feet	0.13%	1.22
Hypothetical Channel	6,557 feet	7 feet	0.11%	1.53

Hydraulic Connectivity and Anthropogenic Features

About 84.8 acres (almost 100 percent) of the channel segment have appropriate connectivity between the active channel and floodplain. Only about 0.02 acres (less than 1 percent) of floodplain was considered disconnected (Table 19).

Table 19. Channel Segment B: Active channel and floodplain hydraulic connectivity

Channel Segment	River Miles	Subreach	Total Acres	Connected Acres	Disconnected Acres
Segment B	**RM 2.50-1.52**	LN-IZ-2	11.5	11.5	0
		LN-OZ-15	57.3	57.3	0
		LN-OZ-16	11.7	11.7	0
		LN-OZ-17	0.1	0.1	0
		LN-OZ-18 Complex	4.4	4.2	0.2
Total Acres			**85.0**	**84.8**	**0.2**

There are no significant anthropogenic impacts that disconnect either ecological or physical processes. One anthropogenic feature (berm) was identified in parcel LN-OZ-18b. The berm appears to impound a pond, possibly a retention or stock pond, which disconnects less than 1 percent of floodplain near the valley margin and has a negligible impact on floodplain processes (Table 20). The locations of subreaches, subreach complex, and anthropogenic feature are provided in Figure 19.

Table 20. Channel Segment B: Summary of floodplain disconnected by berm

Anthropogenic Feature	Geomorphic Impact	Subreach	Parcel	Acreage	Metric
Berm	Disconnected Floodplain	LN-OZ-18 Complex	LN-DOZ-18b	0.2 acres	180 feet

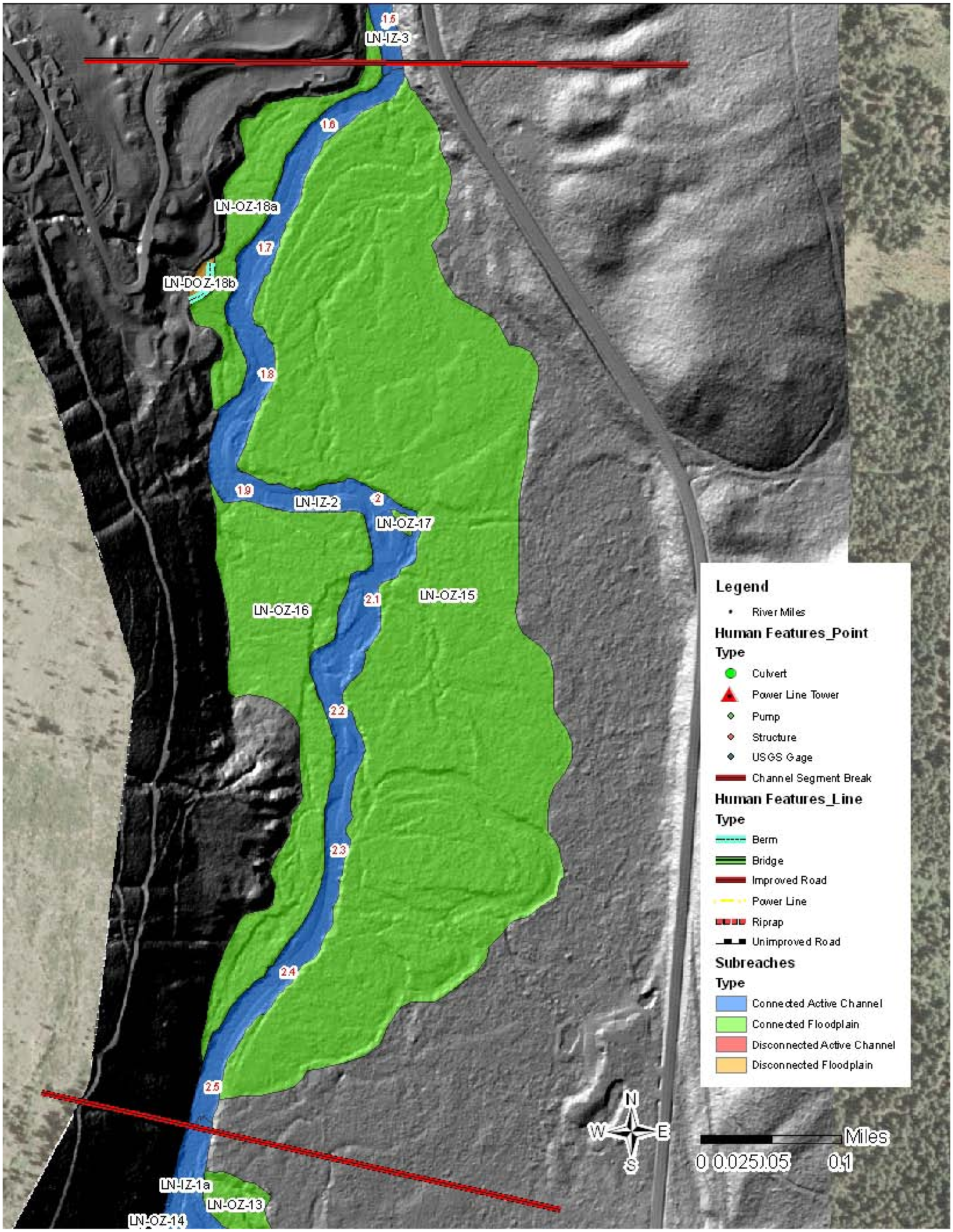

Figure 19. Channel Segment B: Active channel and floodplain connectivity and anthropogenic features

Vegetation Structure

Floodplain vegetation was predominantly in a Large Trees Condition and a majority of stands had a mixed coniferous and deciduous composition (Figure 20). Vegetation structure was a mosaic comprised of individual stands in a Grass/Forbs to Small Trees Condition where the channel has reworked the floodplain and where some vegetation clearing has occurred (presumed for livestock grazing). There were a couple of areas with no vegetation that were associated with State Route 207 and an impoundment pond (Figure 21).

Figure 20. Channel Segment B: View looking downstream at riparian buffer zone and wood complex near RM 2.25. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 14, 2010.

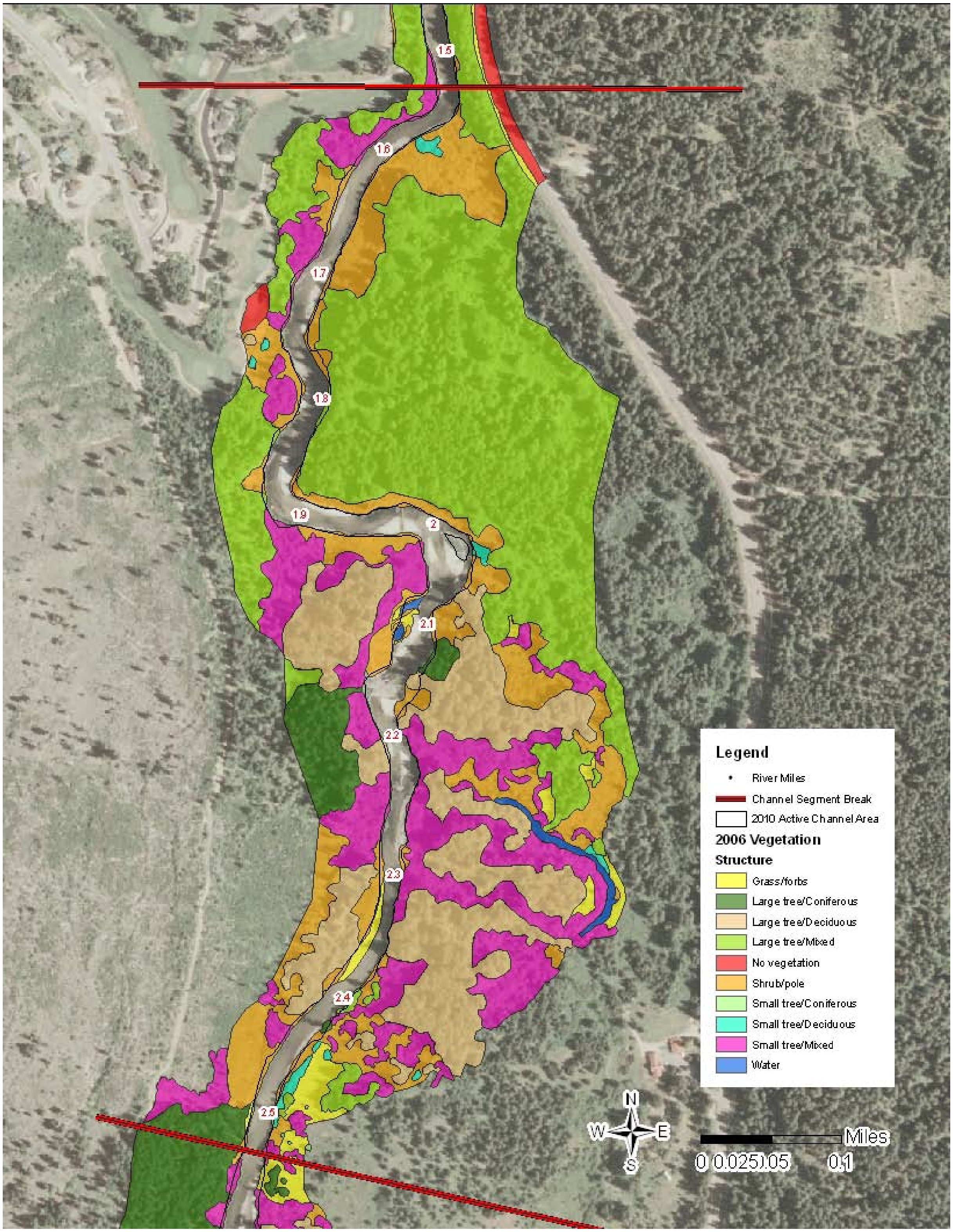

Figure 21. Channel Segment B: Vegetation structure adjacent to the active channel and within the floodplain

Aquatic Habitat

Channel Segment B has not been significantly impacted by anthropogenic disturbances that directly influence active channel-floodplain interactions. The channel can migrate laterally across its floodplain that has appropriate riparian vegetation structure. The interaction between the physical and ecological processes provides the appropriate combination for creating and sustaining quality aquatic habitats.

The intact physical and ecological processes may represent the appropriate type and quality of habitat that was present in the other geologically unconfined channel segments in this reach (Table 21 and graphically illustrated in Figure 22). Large wood was readily available for recruitment, and once incorporated into the channel contributes to the creation of in-stream complexity and diverse hydraulic habitats (Figure 23).

Table 21. Channel Segment B: Channel unit percentages

Rapids	Pools	Side Channels	Riffles	Runs
0 percent	51 percent	5 percent	24 percent	20 percent

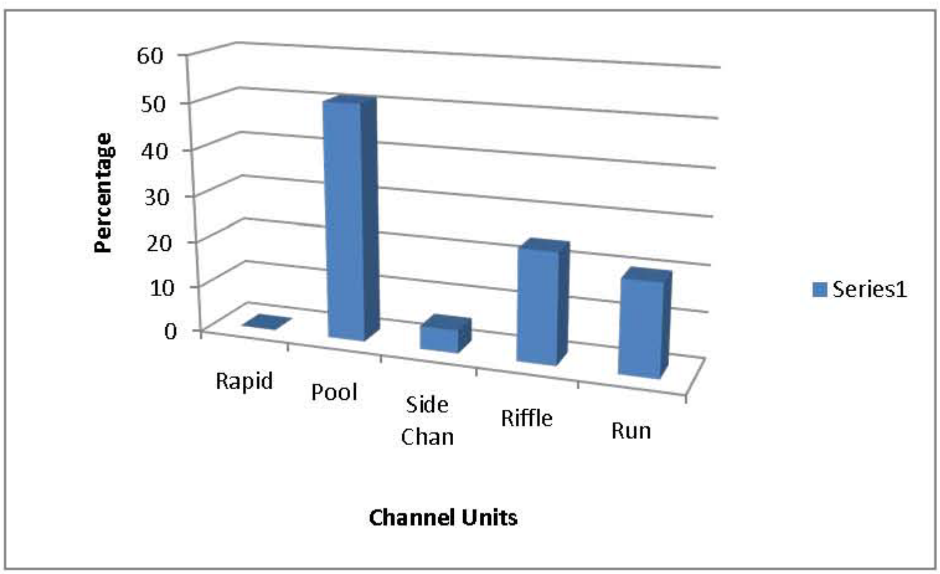

Figure 22. Channel Segment B: Chart of mapped geomorphic channel units (Side Chan - side channels)

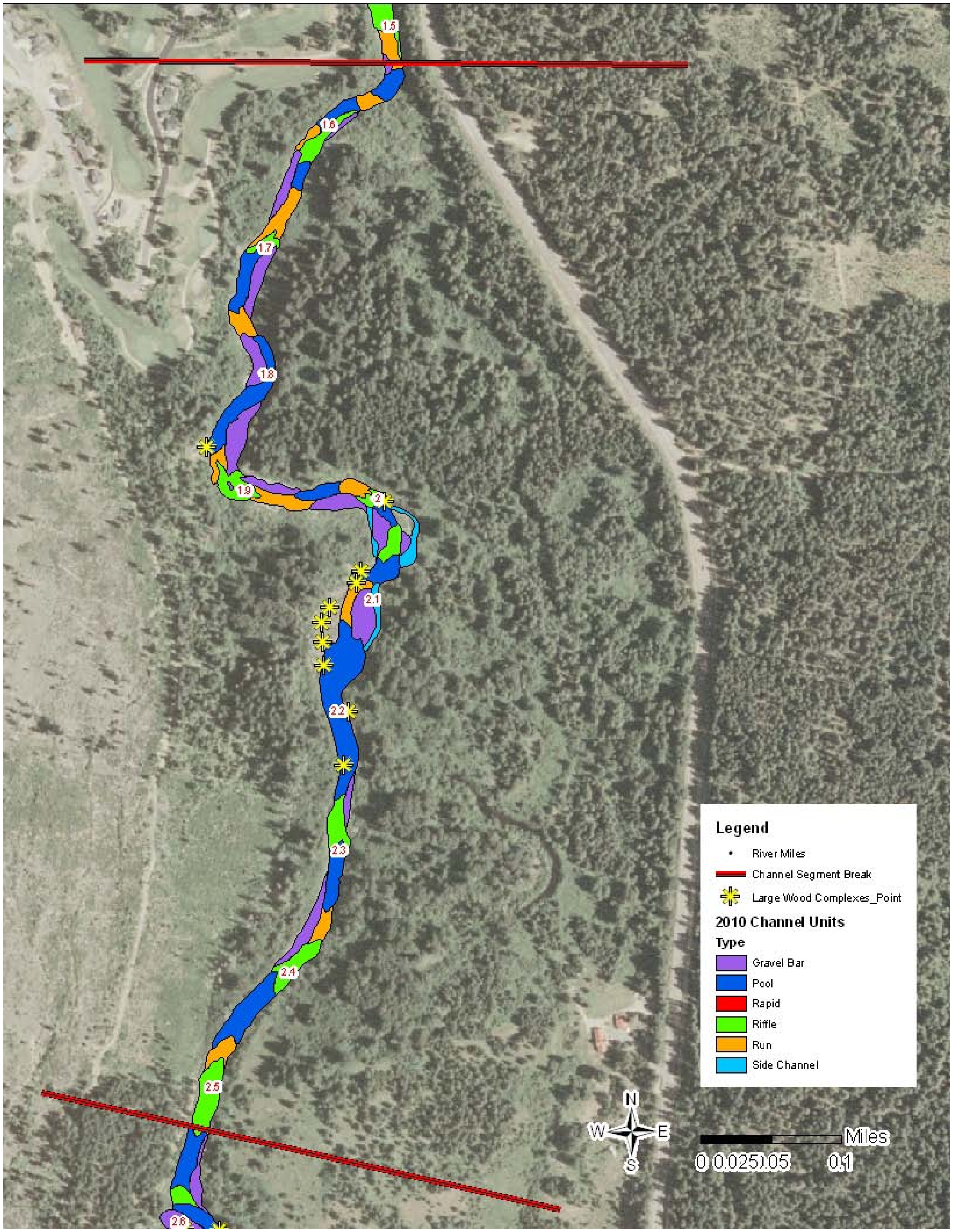

Figure 23. Channel Segment B: Visual representation of channel units and their association with large wood complexes

Wood complexes were primarily observed as a channel spanning log jam near RM 2.2 that creates a backwater debris pool and a middle channel scour pool underneath the structure (Figure 24); along meander bend apexes where the wood contributed to the formation of lateral scour pools; and as small log jams that contribute small, pocket pools and riffles.

The channel spanning log jam near RM 2.2 covered about 0.85 acres in 2006, and by 2009 had increased to about 1.48 acres based on interpretation of aerial photographs (Figure 25 and Figure 26). A backwater (or debris dam) pool was created by the log jam and a middle channel scour pool has formed beneath the jam as flows scour underneath the jam. The log jam has contributed to the creation of macro-habitat in the form of large, deep pools and a mosaic of micro-habitats within the jam and along its margins.

Figure 24. Channel Segment B: View looking downstream at channel spanning wood complex near RM 2.20. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 14, 2010.

Figure 25. Channel Segment B: 2009 aerial photograph of large wood complex near RM 2.2

Figure 26. Channel Segment B: 2006 aerial photograph of large wood complex near RM 2.2

Three side channels were mapped totaling about 0.35 acres (Table 22). About 0.18 acres (51 percent) were classified as gravel bar-type side channels and about 0.17 acres (49 percent) were classified as floodplain-type side channels (Figure 27).

Table 22. Channel Segment B: Side channel identifiers, types, and acreage

Channel Segment	River Miles	Side Channel	Side Channel Type	Acres
Segment B	**RM 2.50-1.52**	SC_2.07_R	Gravel Bar	0.12
		SC_2.01_R	Floodplain	0.17
		SC_1.99_L	Gravel Bar	0.06
Total Acres by Side Channel Type:	**Floodplain Type:**	**0.17 acres**		
	Gravel Bar Type:	**0.18 acres**		
Total Side Channel Acres:	**0.35 acres**			

Figure 27. Channel Segment B: View looking upstream at a floodplain type side channel (SC_2.01_R) along river right near RM 2.00. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 14, 2010.

Summary

No anthropogenic features were identified that could restrict lateral channel migration. The channel is able to adjust vertically and laterally to disturbances with a channel gradient range of 0.11 to 0.13 percent and a channel sinuosity range of 1.19 to 1.53.

Active channel-floodplain interactions that affect the connectivity of ecological and physical processes are not significantly impacted. There was a berm that was located near the valley margin which has a negligible impact on floodplain processes.

Anthropogenic disturbances have not significantly impacted the floodplain vegetation structure. Mosaics of vegetation structures ranging from Grass/Forbs to Small Trees conditions were present along the active channel margin and along a historic channel path. The compositions of the floodplain vegetation stands were deciduous and mixed deciduous and coniferous species that were appropriate based on their location and elevation with respect to the active channel. Vegetation along the active channel was providing shading, potential for wood recruitment, and ecological connectivity.

Wood complexes were primarily observed as a channel spanning log jam near RM 2.2 that creates a backwater, debris pool and a middle channel scour pool; racked wood along meander bends apexes that contribute to lateral scour pool creation; and as small log jams that contribute to the creation of pocket-pools and riffles.

Three side channels were identified that provide about 0.35 acres of off-channel habitat available at varying flows. About 51 percent (0.18 acres) of side channels were classified as gravel bar-type side channels and the remaining 49 percent (0.17 acres) were classified as floodplain-type side channels.

Channel Segment C

Channel Migration

Geomorphic Channel Segment C is located between about RM 1.5 and 1.0 and contains a total area of 27.3 acres of active channel and floodplain. This segment is a moderately confined poot-riffle to plane-bed type system. Aerial photograph analysis of historic channel alignments recorded lateral channel migration after re-routing of the channel during construction of an improved road (State Route 207). A hypothetical channel alignment was used to understand the channel alignment prior to the road construction (Figure 28). Based on these channel alignments the following geomorphic channel changes have occurred: (1) the channel length has been reduced by about 200 feet; (2) the channel gradient has been increased by about 10 percent; and (3) the channel sinuosity has decreased about 10 percent (Table 23).

These channel changes in combination with placement of riprap to protect a campground may have resulted in an increase in streampower resulting in increased sediment transport capacity. The anthropogenic changes may have degraded the long-term physical and ecological processes that sustain and maintain habitat complexity, connectivity, and variability.

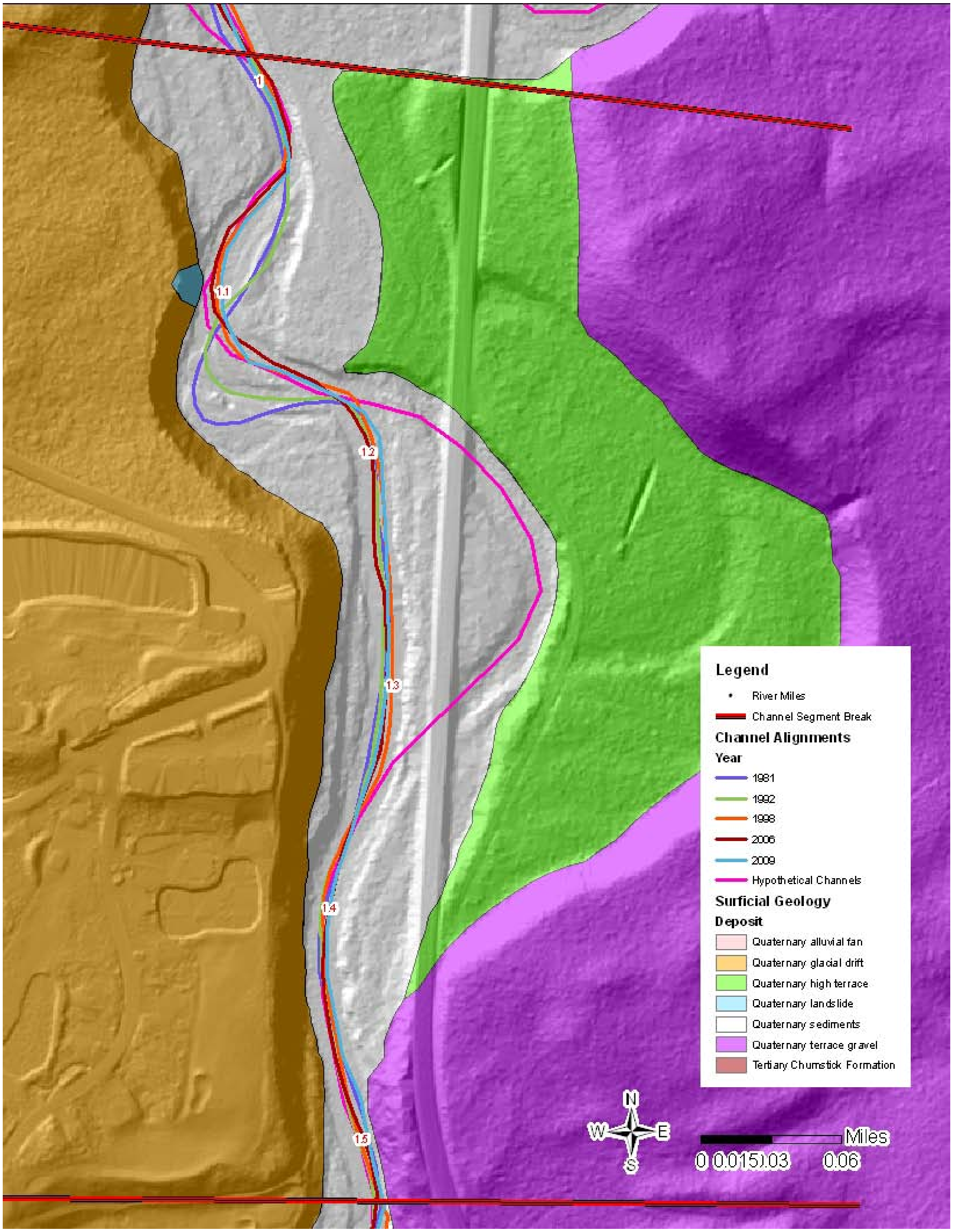

Figure 28. Channel Segment C: Historical channel alignments and hypothetical channel alignment interpreted from 2006 LiDAR hillshade

Table 23. Channel Segment C: Historic channel alignments and geomorphic channel metrics

Channel Alignment Year	Length	Elevation Change	Gradient (percent)	Sinuosity
1981	3,066 feet	14 feet	0.46%	1.13
1992	2,972 feet	14 feet	0.47%	1.10
1998	2,880 feet	14 feet	0.49%	1.06
2006	2,870 feet	14 feet	0.49%	1.06
2009	2,888 feet	14 feet	0.48%	1.07
Hypothetical Channel	3,268 feet	14 feet	0.43%	1.21

Hydraulic Connectivity and Anthropogenic Features

About 23.9 acres (88 percent) of the channel segment have appropriate connectivity between the active channel and floodplain. However, active channel-floodplain interactions are lacking on about 3.4 acres (12 percent) of the channel segment due to elevated anthropogenic features that disconnect these processes (Table 24).

Table 24. Channel Segment C: Active channel and floodplain hydraulic connectivity

Channel Segment	River Miles	Subreach	Total Acres	Connected Acres	Disconnected Acres
Segment C	**RM 1.52-1.00**	LN-IZ-3	9.8	9.8	0
		LN-OZ-19 Complex	3.0	1.6	1.4
		LN-OZ-20	1.9	1.9	0
		LN-OZ-21 Complex	2.6	1.1	1.5
		LN-OZ-22 Complex	7.4	6.9	0.5
		LN-OZ-23	2.6	2.6	0
Total Acres			**27.3**	**23.9**	**3.4**

The most significant anthropogenic impact is from State Route 207 that longitudinally bisects the floodplain. The road has disconnected about 3.4 acres of floodplain or about 12 percent (Table 25).

Improved roads in the campground area (LN-OZ-22a) do not have elevated road grades and don’t impede floodplain connectivity (Table 26). Riprap placed along the streambank to protect the campground area may be affecting channel hydraulics and geometry, streampower, and lateral channel migration. The riprap decreases channel boundary roughness and maintains or increases streampower that can result in localized scour downstream impacts (Figure 29).

Table 25. Channel Segment C: Summary of active channel and floodplain areas disconnected by improved road

Anthropogenic Feature	Geomorphic Impact	Subreach	Parcel	Acreage
Improved Road	Disconnected Floodplain	LN-OZ-19 Complex	LN-DOZ-19b	1.4 acres
		LN-OZ-21 Complex	LN-DOZ-21b	1.5 acres
		LN-OZ-22 Complex	LN-DOZ-22b	0.5 acres

Table 26. Channel Segment C: Anthropogenic features and metrics

Subreach/Parcel	Feature Type	Metric
LN-IZ-3	Riprap	850 feet
	Improved Road (State Route 207)	260 feet
	Culverts	2
LN-DOZ-19b	Improved Road (State Route 207)	400 feet
LN-DOZ-21b	Improved Road (State Route 207)	470 feet
LN-OZ-22a	Improved Road (State Route 207)	1,570 feet

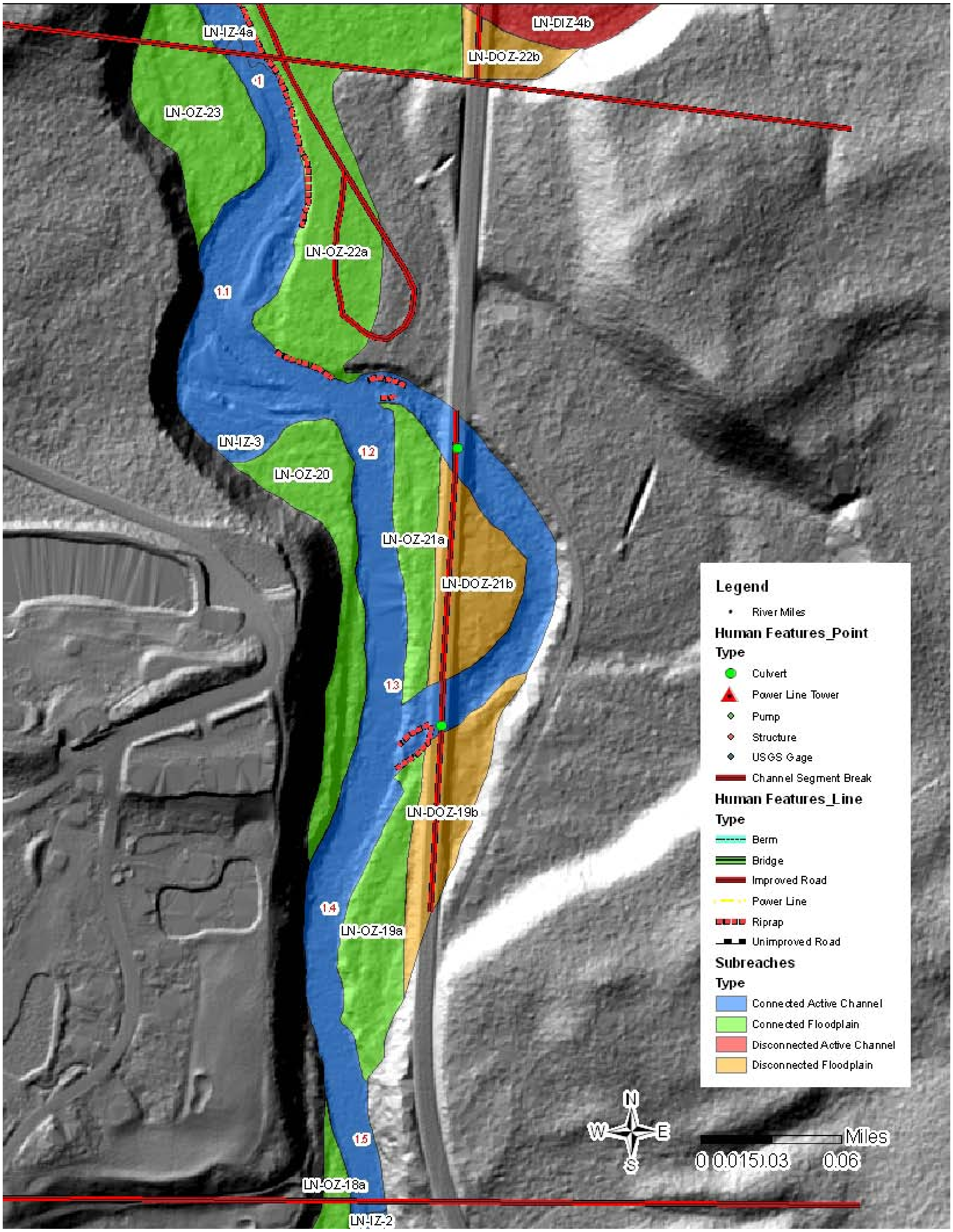

Figure 29. Channel Segment C: Subreaches and subreach complexes

Vegetation Structure

Much of the floodplain is in a Large Trees Condition and the predominant compositions of individual stands are mixed deciduous and coniferous species (Figure 30). Areas that are in a Shrub/Pole to Small Trees Condition are typically along the margins of the active channel and along side channels where ground disturbing flows occur. Anthropogenic disturbances associated with the campground and State Route 207 are in a Grass/Forbs Condition or have no vegetation (Figure 31).

Figure 30. Channel Segment C: View to the north looking downstream at riparian buffer zone near RM 1.52 that is in a large trees condition. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 14, 2010.

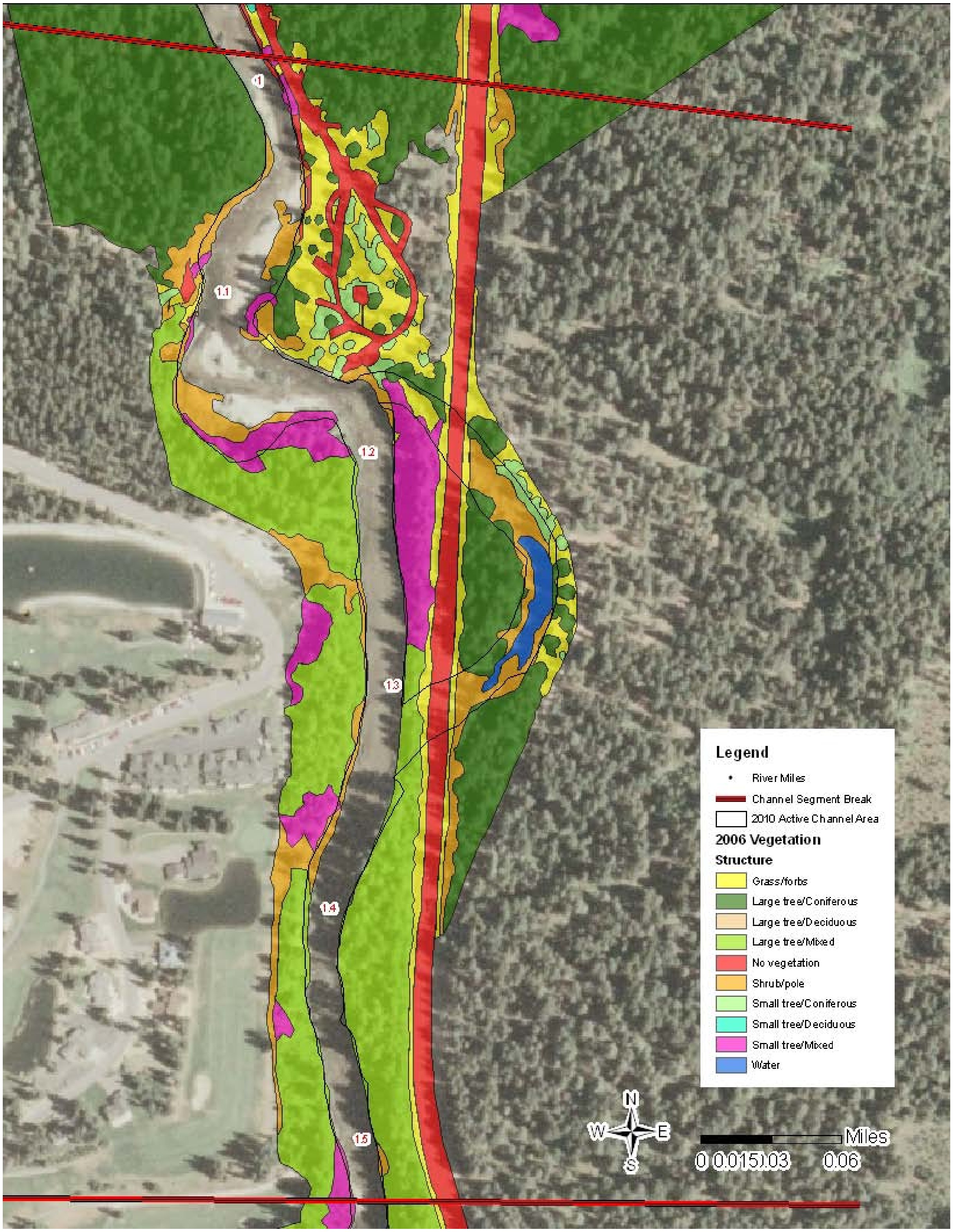

Figure 31. Channel Segment C: Vegetation structure adjacent to the active channel and within the floodplain

Aquatic Habitat

Channel Segment C has a relatively high percentage of side channel area for a moderately confined channel segment (Table 27 and graphically illustrated in Figure 32). This is partially because a historic channel path was reconnected for off-channel habitat in 2009 by the Chelan County Natural Resources Department. The reconnected channel path (SC_1.17_R) provides about 0.85 acres of off-channel habitat and represents about 77 percent of the total side channel units (Figure 33).

Table 27. Channel Segment C: Channel unit percentages

Rapids	Pools	Side Channels	Riffles	Runs
0 percent	14 percent	20 percent	40 percent	26 percent

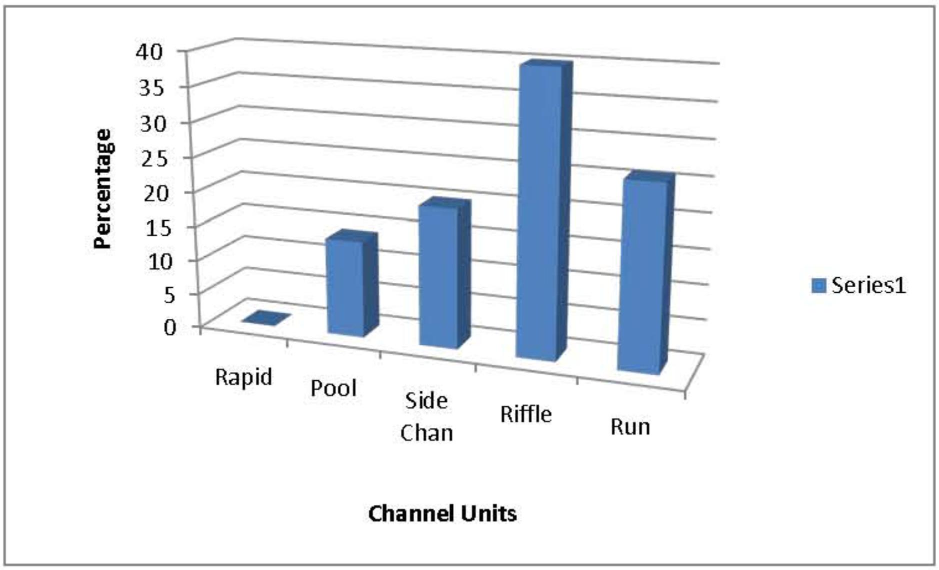

Figure 32. Channel Segment C: Chart of mapped geomorphic channel units (Side Chan - side channels)

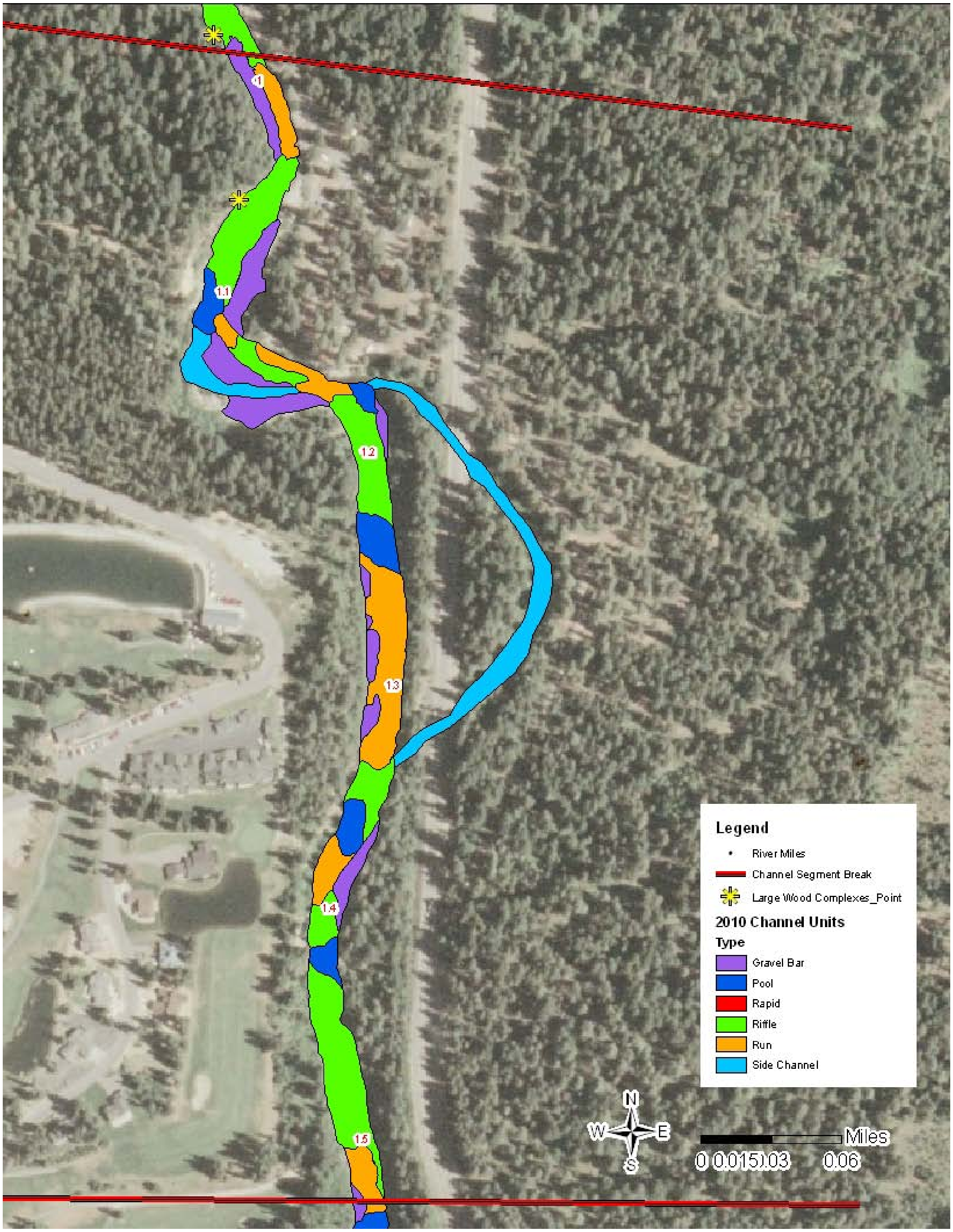

Figure 33. Channel Segment C: Visual representation of channel units and their association with large wood complexes

One wood complex was observed in the mainstem near RM 1.05 along the left bank. The wood was most likely recruited from an active landslide upstream of the complex. This channel segment was moderately confined by geologic constraints and floods would be focused within the channel and would not be dispersed over a broad floodplain. Therefore, wood would not be anticipated to accumulate or be retained except along the channel margins or high on gravel bars.

Two side channels were mapped totaling about 1.11 acres. One side channel about 0.85 acres or 77 percent of off-channel habitat was classified as a floodplain-type side channel (Table 28). The stream was re-routed for construction of State Route 207 and disconnected a historic channel path. In 2009, CCNRD reconnected the historic channel path using culverts that created a floodplain-type side channel (SC_1.17_R) to provide additional off-channel habitat and potentially reduce sediment transport capacity during floods (Figure 34). However the road grade still restricts lateral channel migration and floodplain processes. The other side channel was a gravel bar-type side channel that covered about 0.26 acres or 23 percent of available off-channel habitat and provides spawning and rearing habitat.

Table 28. Channel Segment C: Side channel identifiers, types, and acreage

Channel Segment	River Miles	Side Channel	Side Channel Type	Acres
Segment C	**RM 1.52-1.00**	SC_1.17_R	Floodplain	0.85
		SC_1.12_L	Gravel Bar	0.26
Total Acres by Side Channel Type:	**Floodplain Type:**	**0.85 acres**		
	Gravel Bar Type:	**0.26 acres**		
Total Side Channel Acres:	**1.11 acres**			

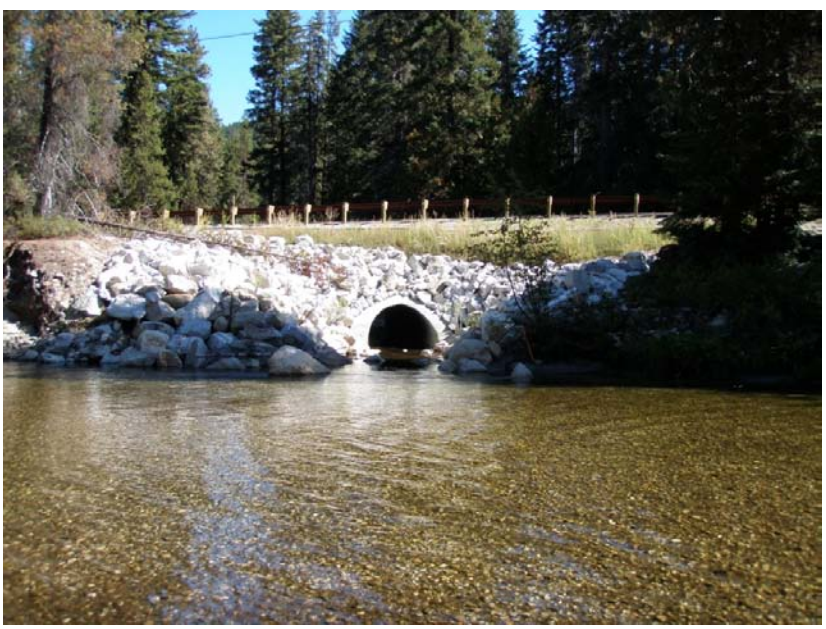

Figure 34. Channel Segment C: View looking at a culvert placed through the embankment of State Route 207 that reconnects a historic channel path (SC_1.17_R) near RM 1.30. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 14, 2010.

Summary

This channel segment contains a total area of 27.3 acres of active channel and floodplain. It is located in a moderately confined section of the stream where lateral channel migration is limited by geologic controls. The construction of State Route 207 re-routed the channel and reduced the channel length by about 200 feet, increased the channel gradient by about 10 percent; and decreased channel sinuosity by about 10 percent. These geomorphic channel changes in combination with placement of riprap to protect a campground may have resulted in an increase in streampower resulting in an increase sediment transport capacity.

About 23.9 acres (88 percent) of the channel segment have appropriate connectivity that provides active channel-floodplain interactions. However, about 3.4 acres (12 percent) of the floodplain has been disconnected due to the elevated road grade along State Route 207.

Much of the floodplain was in a Large Trees Condition that is comprised of mixed deciduous and coniferous species. Along the margins of the active channel where ground disturbing flows occur the vegetation was in a Shrub/Pole to Small Trees Condition. Floodplain areas in a Grass/Forbs Condition or have no vegetation are primarily associated with anthropogenic disturbances associated with the campground and State Route 207.

Two side channels were mapped totaling about 1.11 acres. One floodplain-type side channel was reconnected by CCNRD in 2009 along a historic channel path which accounts for about 77 percent (0.85 acres) of available off-channel habitat. However, the road grade still restricts lateral channel migration and floodplain processes. The other mapped side channel was a gravel bar-type side channel that represents about 23 percent (0.26 acres) of the remaining available off-channel habitat.

Channel Segment D

Channel Migration

Located between RM 1.0 and 0 (confluence with Wenatchee River), Channel Segment D contains a total area of 125.0 acres of active channel and floodplain areas, and is located along a geologically unconfined section of the stream. This segment is an artificially confined pool-riffle to plane-bed type system. Aerial photograph analysis of historic channel alignments recorded lateral channel migration after re-routing of the channel for construction of State Route 207. Hypothetical channel alignments based on LiDAR data and U.S. Geological Survey topographic maps were used to understand the channel alignments prior to the road construction (Figure 35). Based on these channel alignments the following geomorphic channel changes have occurred: (1) the channel length has been reduced by about 1,000 feet to 1,500 feet; (2) the channel gradient has been increased by about 22 percent; and (3) the channel sinuosity has decreased about 23 percent (Table 29). In addition, following the construction of State Route 207 the Nason Creek Campground Road was constructed and the stream was constrained by a bridge crossing near RM 0.83.

Channelization and constraints on lateral channel migration have changed the geomorphology of the channel and have resulted in increased streampower and increased sediment transport capacity (Figure 36). These channel changes have reduced channel-floodplain interactions and may have degraded the long-term physical and ecological processes that create and sustain appropriate habitat complexity, connectivity, and variability.

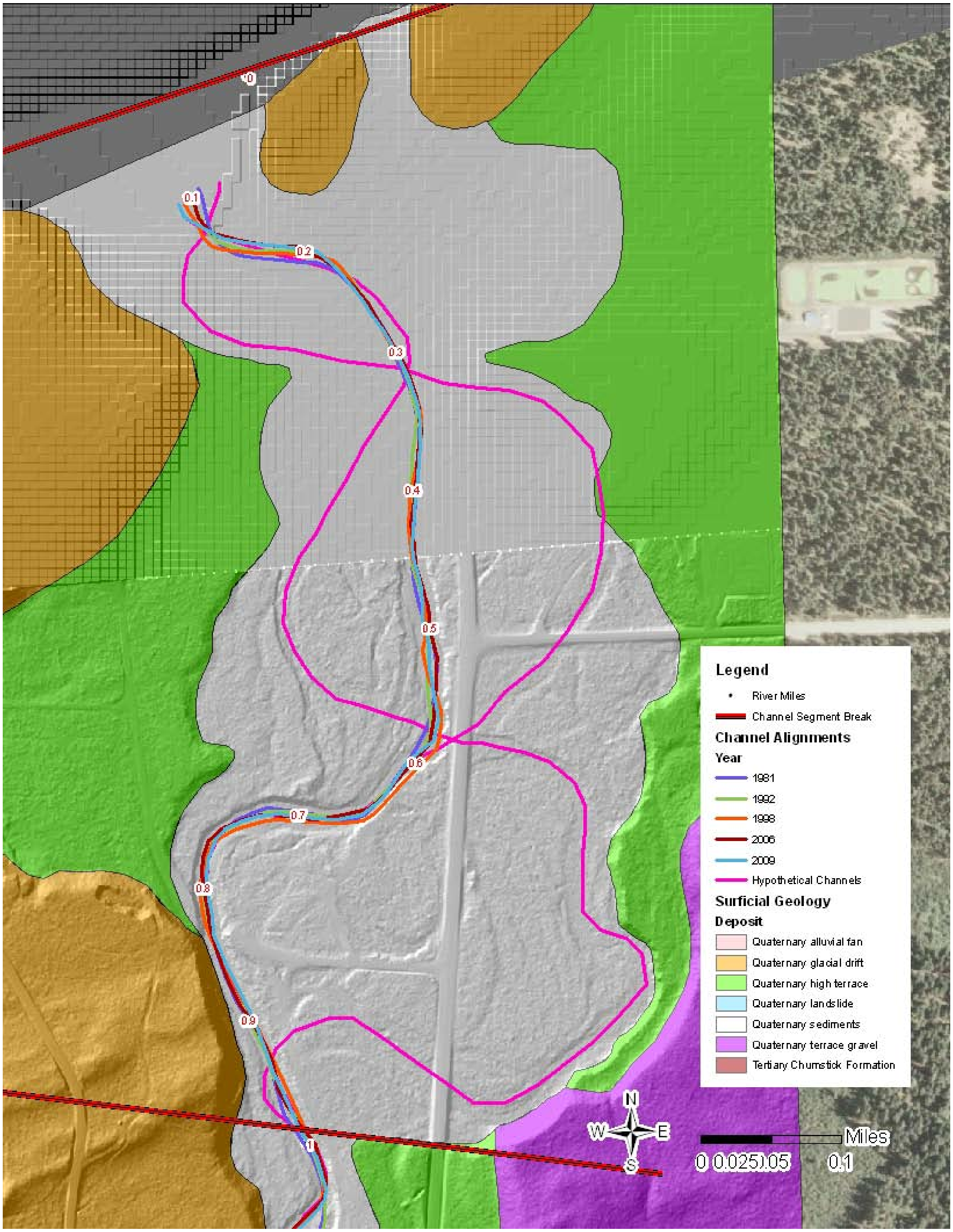

Figure 35. Channel Segment D: Historical channel alignments and hypothetical channel alignment (LN_HypoChanAlign) interpreted from 2006 LiDAR hillshade and USGS topographic map

Table 29. Channel Segment D: Historic channel alignments and geomorphic channel metrics

Channel Alignment Year	Length	Elevation Change	Gradient (percent)	Sinuosity
1981	4,676 feet	21 feet	0.45%	1.20
1992	4,660 feet	21 feet	0.45%	1.19
1998	4,729 feet	21 feet	0.44%	1.21
2006	4,656 feet	21 feet	0.45%	1.19
2009	4,663 feet	21 feet	0.45%	1.19
Hypothetical Channel (D1)	6,497 feet	21 feet	0.32%	1.66
Hypothetical Channel (D2)	5,679 feet	21 feet	0.37%	1.45

Figure 36. Channel Segment D: View looking downstream where the channel has been re-routed and confined by State Route 207 near RM 0.50. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 16, 2010.

Hydraulic Connectivity and Anthropogenic Features

About 50.3 acres (40 percent) of the channel segment have appropriate connectivity between the active channel and floodplain. The remaining historic channel paths and floodplain areas, about 74.7 acres (60 percent), were disconnected by elevated road grades along State Route

207 and Nason Creek Campground Road. The most significant anthropogenic impacts in the channel segment are from improved roads that longitudinally and laterally bisect the historic channel paths and floodplain areas. The improved roads disconnect 60 percent (74.7 acres) of channel and floodplain area that was historically available to the stream (Table 30). Subreaches and parcels are summarized in Table 31.

Table 30. Channel Segment D: Active channel and floodplain hydraulic connectivity

Channel Segment	River Miles	Subreach	Total Acres	Connected Acres	Disconnected Acres
Segment D	**RM 1.00-0**	LN-IZ-4 Complex	23.9	11.5	12.4
		LN-OZ-24	13.2	0	13.2
		LN-OZ-25 Complex	9.2	2.3	6.9
		LN-OZ-26	31.4	31.4	0
		LN-OZ-27 Complex	47.3	5.1	42.2
Total Acres			**125.0**	**50.3**	**74.7**

Table 31. Channel Segment D: Summary of active channel and floodplain areas disconnected by improved road

Anthropogenic Feature	Geomorphic Impact	Subreach	Subreach/Parcel	Acreage
Improved Road	Disconnected Floodplain	LN-IZ-4 Complex	LN-DIZ-4b	12.4 acres
		LN-DOZ-24	LN-DOZ-24	13.2 acres
		LN-OZ-25 Complex	LN-DOZ-25b	6.9 acres
		LN-OZ-27 Complex	LN-DOZ-27b	42.2 acres

Other anthropogenic features that may affect physical processes include local utility lines, commercial and residential structures, unimproved roads, and riprap (Table 32; Figure 37). The utility lines provide electricity to commercial and residential structures, and may have impacts on floodplain roughness and vegetation structure. For the most part, unimproved roads do not have elevated grades and do not impede floodplain connectivity, but do have impacts on vegetation structure. Riprap placed along the streambank does not impede floodplain connectivity, but does affect lateral channel migration and may affect channel hydraulics and geometry, and streampower. In general, riprap does not provide appropriate channel boundary roughness and maintains or increases streampower than can result in localized scour and downstream effects (Figure 38).

Table 32. Channel Segment D: Anthropogenic features and metrics

Subreach/Parcel	Feature Type	Metric
LN-IZ-4a	Riprap	1,830 feet
	Bridge	110 feet
	Pump	1
	USGS Gaging Station	1
LN-DIZ-4b	Improved Road	1,585 feet
	Unimproved Road	440 feet
LN-DOZ-22b	Improved Road	140 feet
LN-DOZ-24	Improved Road	750 feet
LN-DOZ-25b	Improved Road	650 feet
	Unimproved Road	450 feet
LN-DOZ-27b	Improved Road	3,060 feet
	Unimproved Road	2,420 feet
	Structures	7
	Culvert	1
LN-OZ-27a	Unimproved Road	170 feet

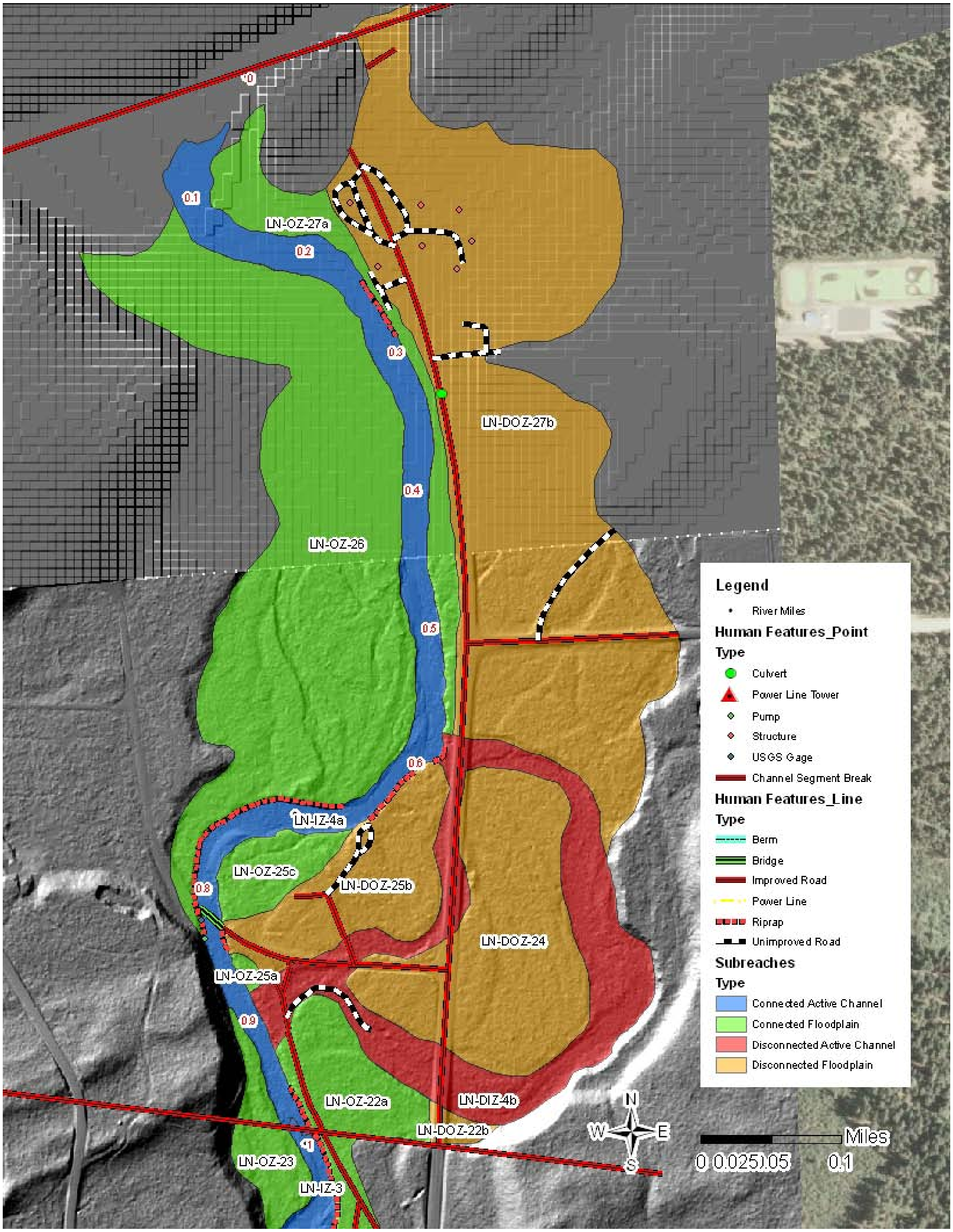

Figure 37. Channel Segment D: Active channel and floodplain connectivity and anthropogenic features

Figure 38. Channel Segment D: View looking from Nason Creek Campground Road bridge at riprap protecting campground along river left near RM 0.80. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 13, 2010.

Vegetation Composition

Much of the floodplain within the channel segment is in a Large Trees Condition and compositions of individual stands are predominantly coniferous and mixed coniferous and deciduous, dependent on their location and elevation with respect to the active channel (Figure 39). Areas that are in a Shrub/Pole to Small Trees Condition are typically along the margins of the active channel. However, much of the floodplain has been disconnected and developed in the downstream, eastern section of the channel segment and has a mosaic of vegetation in a Grass/Forbs to Small Trees Condition intermixed with a Large Trees Condition and no vegetation. The vegetation disturbances are clustered around the Nason Creek confluence with the Wenatchee River between east of State Route 207 and north of State Route 209 where residential and commercial development is concentrated.

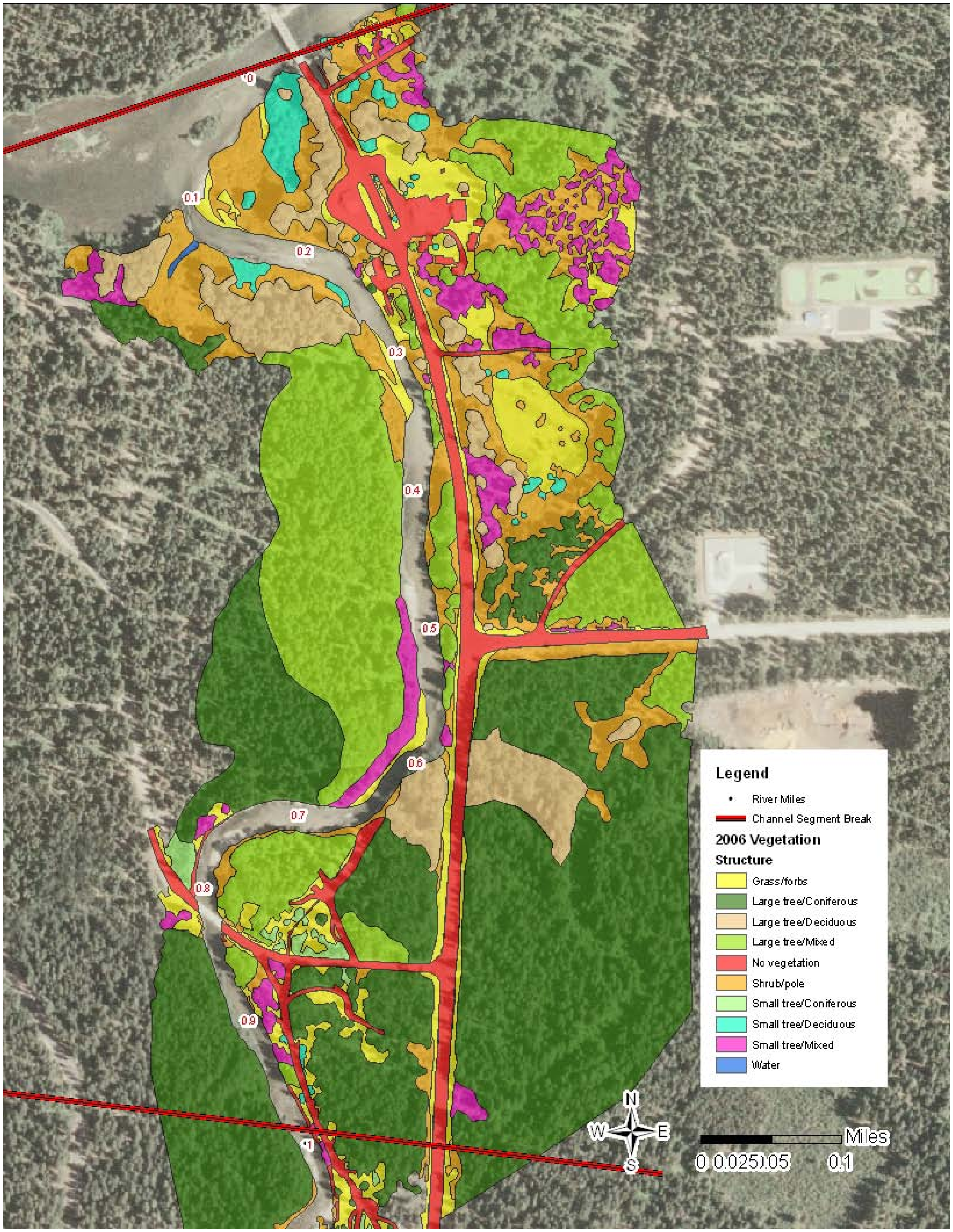

Figure 39. Channel Segment D: Vegetation structure adjacent to the active channel and within the floodplain

Aquatic Habitat

Historically, the channel was unconfined and able to migrate laterally and rework the floodplain. Wood that could contribute to pool formation and gravel bar deposition would have been readily available as it was being transported downstream and from recruitment by the channel via lateral channel migration. The simplification of the channel has changed the physical and ecological processes that create and maintain in-stream habitat. The predominant channel units observed were riffles (47 percent) constructed of mostly cobble size material and runs (27 percent) (Table 33 and graphically illustrated in Figure 40). There was a lack of wood complexes that would provide hydraulic diversity and contribute to development of complex habitat (Figure 41).

Table 33. Channel Segment D: Channel unit percentages

Rapids	Pools	Side Channels	Riffles	Runs
0 percent	19 percent	19 percent	47 percent	27 percent

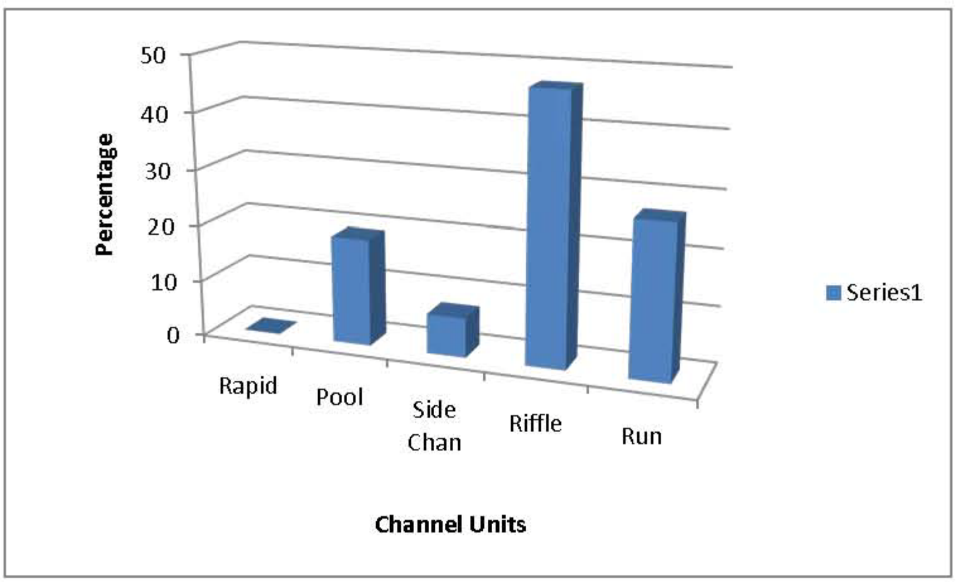

Figure 40. Channel Segment D: Chart of mapped geomorphic channel units (Side Chan - side channels)

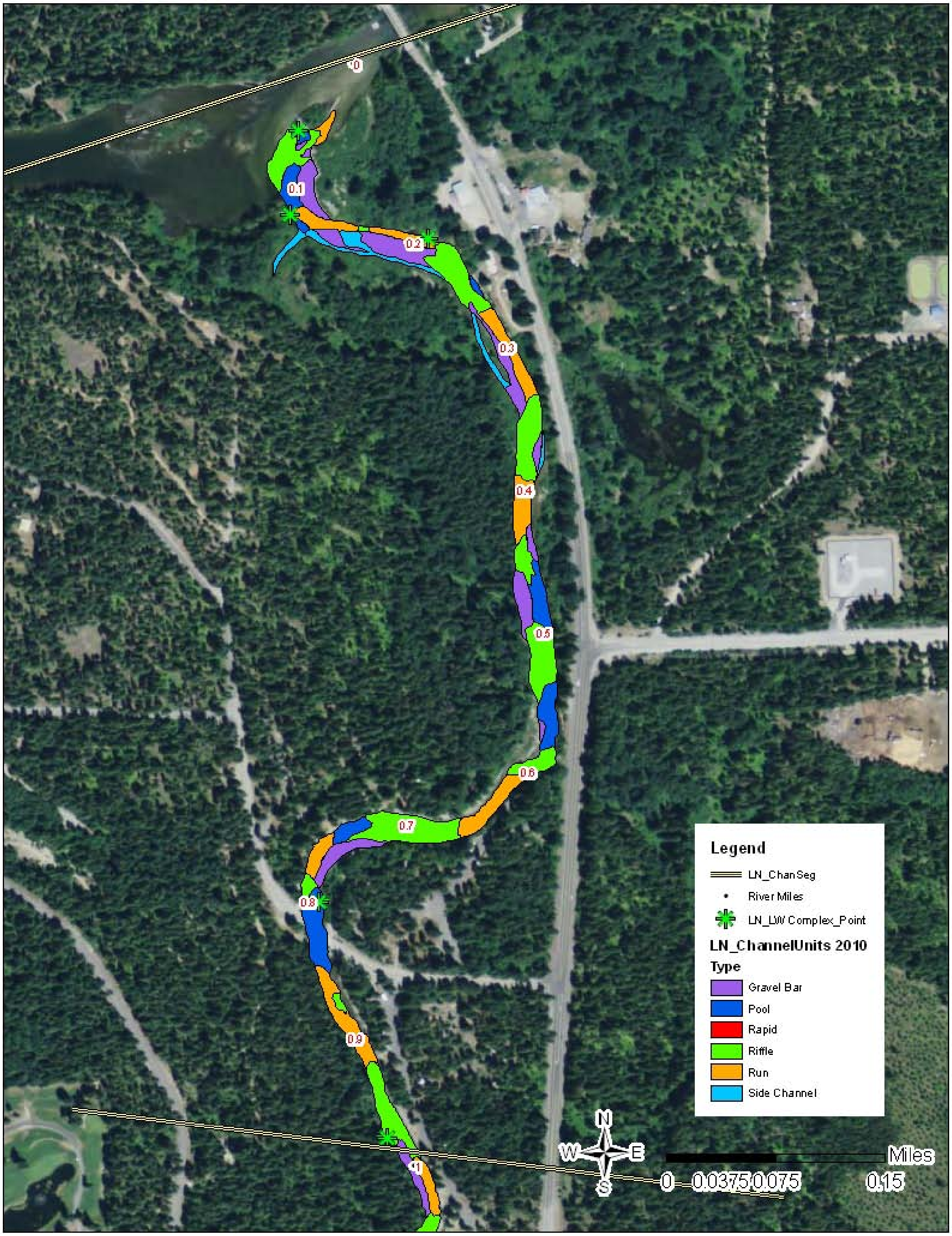

Figure 41. Channel Segment D: Visual representation of channel units and their association with large wood complexes

Wood complexes were observed along the channel margins and at the confluence with the Wenatchee River. Although this channel segment was historically unconfined, it has been artificially confined by anthropogenic features and energy associated with floods is focused within the channel and instead of dispersed over a broad floodplain. As a result of these changes, wood is not anticipated to accumulate or be retained except along the channel margins or at the stream's convergence with the Wenatchee River.

Four side channels were mapped totaling about 0.53 acres. Three of the side channels were gravel bar-type side channels that covered about 0.44 acres or 83 percent of available off-channel habitat (Table 34). The other side channel was classified as a floodplain-type side channel and covered about 0.09 acres or 17 percent of available off-channel habitat. This side channel (SC_0.13_L) was a spring-fed system where signs of beaver activity (i.e., chewed willows) were observed (Figure 42).

Table 34. Channel Segment D: Side channel identifiers, types, and acreage

Channel Segment	River Miles	Side Channel	Side Channel Type	Acres
Segment D	**RM 1.00-0**	SC_0.36_R	Gravel Bar	0.04
		SC_0.26_L	Gravel Bar	0.12
		SC_0.13_L	Gravel Bar	0.28
		SC_0.13_L	Floodplain (Spring)	0.09
Total Acres by Side Channel Type:	**Floodplain Type:**	**0.09 acres**		
	Gravel Bar Type:	**0.44 acres**		
Total Side Channel Acres:	**0.53 acres**			

Figure 42. Channel Segment D: View looking upstream at spring-fed floodplain type side channel (SC_0.13_L) near RM 0.13. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 16, 2010.

Summary

This channel segment contains a total area of 125.0 acres of active channel and floodplain areas. It is located in a geologically unconfined section of the stream where lateral channel migration would have occurred over a broad floodplain near the Wenatchee River confluence. However, the construction of State Route 207 re-routed the channel and reduced the channel length by about 1,000 feet to 1,500 feet, increased the channel gradient by about 22 percent, and decreased the channel sinuosity by about 23 percent. In addition, following the construction of State Route 207 the Nason Creek Campground Road was constructed and the creek was constrained by a bridge crossing near RM 0.83. These channel changes have reduced channel-floodplain interactions, most likely degrading physical and ecological processes that create and sustain appropriate habitat for the species of concern.

About 50.3 acres (40 percent) of the channel segment have appropriate connectivity that provides active channel-floodplain interactions. However, about 74.7 acres (60 percent) of the floodplain has been disconnected due to the elevated road grade along State Route 207, Nason Creek Campground Road, and State Route 209. Much of the floodplain was in a Large Trees Condition and compositions of individual stands were predominantly coniferous and mixed coniferous and deciduous. Areas in a Shrub/Pole to Small Trees Condition were typically along the channel margins. However, much of the floodplain was disconnected and developed, and had a mosaic of vegetation in a Grass/Forbs to Small Trees Condition intermixed with a Large Trees Condition and areas with no vegetation. Vegetation disturbances clustered near the confluence east of State Route 207 and north of State Route 209 where there was residential and commercial development.

Four side channels were mapped totaling about 0.53 acres. Three side channels were gravel bar-type side channels and provided about 83 percent (0.44 acres) of available off-channel habitat. The other side channel was classified as a floodplain-type side channel and provided about 17 percent (0.09 acres) of available off-channel habitat. This floodplain-type side channel (SC_0.13_L) was spring-fed and had signs of beaver activity.

CONCLUSIONS

The purpose of this assessment was to provide scientific information on the geomorphology and habitat condition of the lower 4.6 miles of Nason Creek, a tributary to the Wenatchee River in the State of Washington.

At the reach scale, this report documents physical features and analyzes riverine processes that may affect the overall health of the system.

Anthropogenic disturbances have disconnected the channel-floodplain interactions by constructing roads with elevated road grades that have disconnected about 29 percent (132.7

acres) of historic channel paths and floodplain area. The channel was re-routed in several locations for road construction resulting in channel shortening, increased channel gradient, and decreased channel sinuosity. Impacts on physical processes are (1) an increase in streampower and sediment transport capacity, which may have resulted in a reduction of sediment and wood retainion that would contribute to formation of diverse habitat types; and (2) isolation of historic channel paths and floodplain areas that are no longer hydraulically connected to the stream that wouldcontribute to the transfer of energy (i.e. food web), riparian vegetation health and maintenance, and ecological connectivity.

Bank protection (riprap) has been placed along several sections of the roads and to protect campground areas. The bank protection artificially restricts lateral channel migration and floodplain reworking and results in negative impacts to geomorphic channel processes.

The overall cumulative effects of anthropogenic disturbances have negatively impacted the physical and ecological processes necessary to create and maintain aquatic habitat complexity, quality, and variability. Anthropogenic disturbances in the Lower Nason reach have negatively impacted the physical and ecological processes by (a) artificially disconnecting the floodplain, (b) restricting lateral channel migration, and (c) clearing and altering riparian vegetation structure and composition. These disturbances have reduced habitat quantity, quality and variability by disrupting the necessary processes that form and maintain channel morphology and habitat structure.

This page intentionally left blank

LIST OF PREPARERS

Name	Organization	Contribution
Edward W. Lyon, Jr., L.G.	Bureau of Reclamation Pacific Northwest Regional Office Boise, Idaho	Principal Author River Systems Analysis Group Geomorphologist
Terril Stevenson, L.G.	Bureau of Reclamation Pacific Northwest Regional Office Boise, Idaho	Peer Reviewer River Systems Analysis Group Manager
Kristin Swoboda	Bureau of Reclamation Pacific Northwest Regional Office Boise, Idaho	GIS Peer Reviewer Geographic Information System Geodatabase
Steve Kolk	Bureau of Reclamation Pacific Northwest Regional Office Boise, Idaho	Peer Reviewer Wenatchee Subbasin Liaison
Kelly Vick	Bureau of Reclamation Pacific Northwest Regional Office Boise, Idaho	Natural Resources Natural Resources Writer

This page intentionally left blank

LITERATURE CITED

Parenthetical Reference	Bibliographic Citation
Andonaegui 2001	Washington State Conservation Committee. 2001. *Salmon, steelhead and bull trout habitat limiting factors for the Wenatchee Subbasin (Water Resource Inventory Area 45) and portions of WRIA 40 within Chelan County (Squilchuck, Stemilt and Colockum drainages*. Olympia, Washington.
Beechie et al., 2010	Beechie, T., Sear, D., Olden, J., Pess, G., Buffington, J., Moir, H., Roni, P., and Pollock, M. 2010. *Process-based Principles for Restoring River Ecosystems*. BioScience, Vol. 60 No. 3, p. 209-222.
CCPUD 1998	Chelan County Public Utility District. 1998. *Aquatic species and habitat assessment: Wenatchee, Entiat, Methow, and Okanogan watershed*. Chelan County Public Utility District Number 1, Wenatchee, Washington. 100 p.
Craig and Suomela 1941	Craig, J.A. and Suomela, A.J. 1941. *Time of appearance of the runs of salmon and steelhead trout native to the Wenatchee, Entiat, Methow, and Okanogan rivers*. Unpublished Master Thesis. U.S. Fish and Wildlife Service. 35 p. plus 18 affidavits and accompanying letters of corroboration.
English et al. 2001	English, K.K., Sliwinski, C., Nass, B., and Stevenson, J.R. 2001. *Assessment of Adult Steelhead Migration through the Mid-Columbia River Using Radio-Telemetry Techniques, 1999-2000*. Final report for Public Utility District No. 1 of Chelan County, Wenatchee, Washington.
Fraley and Shepard 1989	Fraley, J.J. and Shepard, B.B. 1989. "Life history, ecology, and population status of migratory bull trout (Salvelinus confluentus) in the Flathead Lake River System, Montana." *Northwest Science* 63 (4); pp. 133-143.
Hillman 2006	Hillman, T. 2006. *Monitoring strategy for the Upper Columbia Basin, second draft report, August 2006*. Prepared for the Upper Columbia Salmon Recovery Board, Bonneville Power Administration, and National Marine Fisheries Service: BioAnalysts, Inc., Boise, Idaho. 98 pp.
Hopkins 1966	Hopkins, K. 1966. *Glaciation of Ingalls Creek valley, east-central Cascade Range, Washington* [M.S. thesis]. University of Washington, Seattle, Washington. 79 p.
Jones & Stokes 2004	Jones & Stokes. 2004. *Chelan County Natural Resource Program, Wenatchee River, Final Channel Migration Study – Phase II*. (J&S 01243.01), Bellevue, Washington. Prepared for the Chelan County Natural Resource Program, Wenatchee, Washington. April 16, 2004.

Parenthetical Reference	Bibliographic Citation
Kauffman et al. 1997	Kauffman, J., et al. 1997. "An Ecological perspective of riparian and river restoration in the western United States." *Fisheries* 22(5):12-14.
Mosey and Murphy 2000	Mosey, T., and Murphy, L. 2000. *Spring and summer chinook spawning ground surveys on the Wenatchee River Basin*. Chelan County Public Utility District, Fish and Wildlife Operations, Wenatchee, Washington.
Naiman et al. 1992	Naiman, R.J., Lonzarich, D.G., Beechie, T.J., and Ralph, S.C. 1992. "General principles of classification and the assessment of conservation potential in rivers." Pages 93-123 in: P.J. Boon, P. Calow, and G.E. Petts, editors. *River conservation and management*. John Wiley and Sons, New York, New York.
Nimick 1977	Nimick, D. 1977. *Glacial Geology of Lake Wenatchee and Vicinity, Washington* [Thesis]. University of Washington, Seattle, Washington. 52 p.
NOAA Fisheries 2010	National Marine Fisheries Service. 2010. *Supplemental Consultation on Remand for Operation of the Federal Columbia River Power System, 11 Bureau of Reclamation Projects in the Columbia Basin and ESA Section 10(a)(1)(A) Permit for Juvenile Fish Transportation Program*. May 20, 2010, F/NWR/2010/0209.
ODFW 2002	Oregon Department of Fish and Wildlife. 2002. *The adverse reproductive consequences of supplementing natural steelhead populations in Oregon with hatchery fish (Draft).* Oregon Department of Fish and Wildlife, Portland, Oregon.
Page 1939	Page, B. 1939. "Multiple alpine glaciation in the Leavenworth area, Washington." *The Journal of Geology*, November-December 1939, v. XLVII, no. 8, p. 785-815.
Porter 1969	Porter, S. 1969. "Pleistocene geology of the east-central Cascade Range, Washington." *Guidebook for Third Pacific Coast Friends of the Pleistocene Field Conference*. 54 p.
Porter 1976	Porter, S. 1976. "Pleistocene glaciation in the souther part of the North Cascade Range, Washington." *Geological Society of America Bulletin*, v. 87. p. 61-75.
Pratt 1992	Pratt, K.L. 1992. "A review of bull trout life history." Howell, P.J.; Buchanan, D.B., eds. *Proceedings of the Gearhart Mountain bull trout workshop*. Gearhart Mountain, Oregon, Corvallis, Oregon: Oregon Chapter of the American Fisheries Society: 5-9 pp. August 1992.
Reclamation 2008	Bureau of Reclamation. 2008. *Nason Creek Tributary Assessment, Chelan County, Washington*. U.S. Department of the Interior, Bureau of Reclamation, Technical Service Center, Denver, Colorado and Pacific Northwest Regional Office, Boise, Idaho. 123 p.

Parenthetical Reference	Bibliographic Citation
Reclamation 2009a	Bureau of Reclamation. 2009. *Upper White Pine Reach Assessment, Nason Creek, Chelan County, Washington*. U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Boise, Idaho. 84 p.
Reclamation 2009b	Bureau of Reclamation. 2009. *Lower White Pine Reach Assessment, Nason Creek, Chelan County, Washington*. U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Boise, Idaho. 114 p.
Reclamation 2009c	Bureau of Reclamation. 2009. *Kahler Reach Assessment, Nason Creek, Chelan County, Washington.* U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Boise, Idaho. 116 p.
Rieman and Allendorf 2001	Rieman, B.E., and Allendorf, F.W. 2001. "Effective population size and genetic conservation criteria for bull trout." *North American Journal of Fisheries Management*, 21. 756-764.
Rieman et al. 1997	Rieman, B.E., Lee, D.C., Chandler, G., and Myers, D. 1997. "Does wildfire threaten extinction for salmonids: responses of redband trout and bull trout following recent large fires on the Boise National Forest." *Proceedings of the Conference on Wildfire and Threatened and Endangered Species and Habitats, November 13-15, 1995, Coeur d'Alene Idaho*. International Association of Wildland Fire, Fairfield, Washington. pp.47-57.
Rosgen 1996	Rosgen, D. 1996. *Applied river morphology*. Wildland Hydrology, Pagosa Springs, Colorado.
UCRTT 2007	Upper Columbia Regional Technical Team (UCRTT). 2007. *A biological strategy to protect and restore salmonid habitat in the Upper Columbia Region*. A report to the Upper Columbia Salmon Recovery Board, Wenatchee, Washington.
UCSRB 2007	Upper Columbia Salmon Recovery Board. 2007. *Upper Columbia spring Chinook salmon, steelhead, and bull trout recovery plan*. Upper Columbia Salmon Recovery Board, Wenatchee, Washington. 300 pp. Web site: http://www.ucsrb.com/plan.asp
USFS 1993	U.S. Forest Service. 1993. *Demographic and habitat requirements for conservation of bull trout.* U.S. Department of Agricultuer, Forest Service, General Technical Report, INT-302.
USFS 1995	U.S. Forest Service. 1995. *Integrated survey assessment of habitat condition and response to flooding: three case studies in two earstern Cascades geomorphic landunits* (subsections): U.S. Department of Agriculture, Wenatchee National Forest, Wenatchee, Washington. 18 p.

Parenthetical Reference	Bibliographic Citation
USFS 1996	U.S. Forest Service. 1996. *Nason Creek watershed analysis*. U.S. Department of Agriculture, Lake Wenatchee Ranger District, Wenatchee National Forest. 96 p.
USFS 1998a	U.S. Forest Service. 1998. *Wenatchee National Forest desired future condition project, July 1998*. U.S. Department of Agriculture, Wenatchee National Forest, Wenatchee, Washington.
USFS 1998b	U.S. Forest Service. 1998. *Biological assessment for steelhead, spring Chinook, bull trout and cutthroat trout in Nason Watershed, baseline condition and effects of ongoing activities, including recreation, effective December 1998*: U.S. Department of Agriculture, Wenatchee National Forest, Wenatchee, Washington. 47 p.
USFS 2006a	U.S. Forest Service. 2006. *Draft - Fisheries Biological Assessment: Natapoc Ridge Forest Restoration Project, December 22, 2006*. U.S. Department of Agriculture, Okanogan-Wenatchee National Forests, Wenatchee, Washington. 71 p.
USFS 2006b	U.S. Forest Service. 2006. *Stream Inventory Handbook, Level I & II*. U.S. Department of Agriculture, Pacific Northwest Region, Region 6. Version 2.8. 114 p.
USFS 2008	U.S. Forest Service. 2008. *Draft Nason Creek focused watershed action plan, (HUC 5th)*. U.S. Department of Agriculture, Wenatchee River Ranger District, Okanogan-Wenatchee National Forest, Wenatchee, Washington. September 2008.
USFWS 1992	U.S. Fish and Wildlife Service. 1992. *Production and habitat of salmonids in Mid-Columbia River tributary stream*. U.S. Fish and Wildlife Service. Monograph 1.
USFWS 1998	U.S. Fish and Wildlife Service. 1998. *A framework to assist in making Endangered Species Act determinations of effect for individual or grouped actions at the Bull Trout subpopulation watershed scale*. U.S. Fish and Wildlife Service. 49 p.
USFWS 2005	U.S. Fish and Wildlife Service. 2005. *Movement patterns of adult bull trout in the Wenatchee River Basin, Washington*. U.S. Fish and Wildlife Service, Leavenworth, Washington. 58 pp.
USGS 1987	U.S. Geological Survey. 1987. *Geologic map of the Chelan 30-minute by 60-minute quadrangle, Washington*. U.S. Geological Survey Map I-1661.

Parenthetical Reference	Bibliographic Citation
Waitt 1997	Waitt, R., Jr. 1977. *Guidebook to Quaternary geology of the Columbia, Wenatchee, Peshastin, and Upper Yakima Valleys, West-Central Washington*. Geological Society of America, 1977 Annual Meeting (Seattle), Field Trip No. 13, 10-11 November, 1977; Open-file Report 77-753, 25 p.
WDFW 1992a	Washington Department of Fish and Wildlife. 1992. *Run size outlook for Columbia River sockeye salmon in 1992, Columbia River Progress Report No. 92-16*. Washington Department of Fisheries, Battle Ground, Washington. 16 p.
WDFW 1992b	Washington Department of Fish and Wildlife. 1992. *Draft management guide for the bull trout, Salvelinus confluentus (Suckley) on the Wenatchee National Forest*. Washington Department of Fish and Wildlife, Wenatchee, Washington.
WDOE 2010a	Washington State Department of Ecology. 2010a. Website http://www.ecy.wa.gov/apps/watersheds/riv/station.asp?
WDOE 2010b	Washington State Department of Ecology. 2010b. Website: http://www.ecy.wa.gov/programs/wq/tmdl/overview.html

This page intentionally left blank

GLOSSARY

Some terms in the glossary appear in this reach assessment report.

TERM	DEFINITION
action	Proposed protection and/or rehabilitation strategy to improve selected physical and ecological processes that may be limiting the productivity, abundance, spatial structure or diversity of the focal species. Examples include removing or modifying passage barriers to reconnect isolated habitat (i.e. tributaries), planting appropriate vegetation to reestablish or improve the riparian corridor along a stream that reconnects channel-floodplain processes, placement of large wood to improve habitat complexity, cover and increase biomass that reconnects isolated habitat units.
adfluvial	Fish that migrate between lakes and rivers or streams. These fish may also be called lacustrine and are sometimes further characterized as to whether they spawn in outlet tributaries (allacustrine) or inlet tributaries (lacustrine-adfluvial).
alluvial fan	An outspread, gently sloping mass of alluvium deposited by a stream, esp. in an arid or semiarid region where a stream issues from a narrow canyon onto a plain or valley floor. Viewed from above, it has the shape of an open fan, the apex being at the valley mouth.
alluvium	A general term for detrital deposits made by streams on river beds, floodplains, and alluvial fans; esp. a deposit of silt or silty caly laid down during time of flood. The term applies to stream deposits of recent time. It does not include subaqueous sediments of seas and lakes.
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.
anthropogenic	Caused by human activities.
bedrock	The solid rock that underlies gravel, soil or other superficial material and is generally resistant to fluvial erosion over a span of several decades, but may erode over longer time periods.
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; a measure of water flows

TERM	DEFINITION
channel forming flow	Sometimes referred to as the effective flow or ordinary high water flow and often as the bankfull flow or discharge. For most streams, the channel forming flow is the flow that has a recurrence intermal of approximately 1.5 years in the annual flood series. Most channel forming discharges range between 1.0 and 1.8. In some areas it could be lower or higher than this range. It is the flow that transports the most sediment for the least amount of energy, mobilizes and redistributes the annually transient bedload, and maintains long-term channel form.
channel morphology	The physical dimension, shape, form, pattern, profile and structure of a stream channel.
channel planform	The two-dimensional longitudinal pattern of a river channel as viewed on the ground surface, aerial photograph or map.
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 raising or lowering the elevation of the streambed.
channel units	Morphologically distinct areas within a channel segment that are on the order of at least one to many channel widths in length and are defined by distinct hydraulic and geomorphic conditions within the channel (i.e. pools, riffles, and runs). Channel unit locations and overall geometry are somewhat stage dependent as well as transient over time, and observers may yield inconsistent classifications. To minimize the inconsistencies, channel units are interpreted in the field based on the fluvial processes that created them during channel forming flows, then mapped in a geographic information system (GIS) to provide geospatial reference.
channelization	The straightening and deepening of a stream channel, to permit the water to move faster, to reduce flooding, or to drain marshy acreage.
control	A natural or human feature that restrains a streams ability to move laterally and/or vertically.
degradation	Transition from a higher to lower level or quality. A general lowering of the earth's surface by erosion or transportation in running waters. Also refers to the quality (or loss) of functional elements within an ecosystem.
diversity	Genetic and phenotypic (life history traits, behavior, and morphology) variation within a population. Also refers to the relative abundance and connectivity of different types of physical conditions or habitat.
ecosystem	An ecologic system, composed of organisms and their environment. It is the result of interaction between biological, geochemical and geophysical systems.
floodplain	that portion of a river valley, adjacent to the channel, which is built of sediments deposited during the present regimen of the stream and is covered with water when the river overflows its banks at flood stages.

TERM	DEFINITION
fluvial	Produced by the action of a river or stream. Also used to refer to something relating to or inhabiting a river or stream. Fish that migrate between rivers and streams are labeled "fluvial".
fluvial process	A process 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.
general indicator	Reach, valley segment, watershed, and basin scale indicators (i.e., water quality) that are 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). Sometimes referred to as pathways.
geomorphic reach	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 resulting from streamflow and sediment transport.
geomorphology	The science that treats the general configuraion of the earth's surface; specif. the study of the classification, description, nature, origin and development of landforms and their relationships to underlying structures, and the history of geologic changes as as recorded by these surface changes.
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 connectivity	Suitable aquatic and/or terrestrial conditions that are linked together and needed to provide the physical and ecological processes necessary for the transfer of energy (i.e. food web) to maintain all life stages of species that are dependent on the riverine ecosystem.
habitat unit	A channel-wide segment of a stream which has a distinct set of characteristics. Habitat units and channel units are used interchangeably in the literature, however, habitat units are identified and measured during low-flows and sometimes include several channel units. For example, "pool habitat" is measured from the head of the pool scour to the crest of the pool tailout, which technically includes the following "channel units", pool, run, and riffle.
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.

TERM	DEFINITION
inner zone (IZ)	Area where ground-disturbing flows take place; characterized by the main river channel, may include 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.
large woody debris (LWD)	Large downed trees or parts of trees that are transported and depositied 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, landslides, debris flows, or human-induced activities. Generally refers to the woody material in the river channel and floodplain with a diameter of at least 20 inches and has a length greater than 35 feet in eastern Cascade streams (USFS 2006b).
limiting factor	Any factor in the environment that limits a population from achieving complete viability with respect to any Viable Salmonid Population (VSP) parameter.
outer zone (OZ)	Area that may become inundated at higher flows, but does not experience regular ground-disturbing flows; generally coincidental with the historic channel migration zone unless the channel has been modified or incised leading to the abandonment of the floodplain.
parcel	A smaller unit within a subreach that has differing impacts on physical and/or ecological processes than an adjacent unit, and the need to sequence or prioritize potential rehabilitation actions within the context of the subreach and reach.
reach-based ecosystem indicators (REI)	Qualitative and/or quantifiable physical and/or biological indicators that are referenced to watershed characteristics and reach characteristics.
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
riparian area	An area adjacent to a stream, wetland, or other body of water that is transitional between terrestrial and aquatic ecosystems. Riparian areas usually have distinctive soils and vegetation community/composition resulting from interaction with the water body and adjacent soils.
riprap	Materials (typically large angular rocks) that are placed along a river bank to prevent or slow erosion.
river mile (RM)	Miles measured in the upstream direction beginning from the mouth of a river or its confluence with the next downstream river.
side channel	A distinct channel with its own defined banks that is not part of the main channel, but appears to convey water perennially or seasonally/ephemerally. May also be referred to as a secondary channel.

TERM	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 and 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 Middle Fork John Day River subbasin.
subreach	Distinct areas 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.
subreach complex	A subreach that has been subdivided, or parceled, into smaller areas due to complicated anthropogenic impacts and the need to sequence implementation actions.
terrace	A relatively stable, planar surface formed when the river abandons its floodplain. It often parallels the river channel, but is high enough above the channel that it rarely, if ever, is covered by over-bank river water and sediment. The deposits underlying the terrace surface are primarily alluvial, either channel or overbank deposits, or both. Because a terrace represents a former floodplain, it may 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).
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 channel migration	Movement of a stream channel in a vertical direction; the filling and raising or the removal or erosion of streambed material that changes the elevation of the overall streambed over an entire reach or subreach.
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 (ICBTRT 2007).

TERM	DEFINITION
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.

APPENDICES

This page intentionally left blank

APPENDIX A

Reach-based Ecosystem Indicators

This page intentionally left blank

Appendix A

Reach-based Ecosystem Indicators (REI)

Version 1.2

The reach-based ecosystem indicators table has been compiled from literature review, data obtained from the U.S. Forest Service (USFS 2006, USFS 2010) and new data collected during this assessment. The ranges of criteria presented here are not absolute and should be adjusted to each unique subbasin as data become available. Edward W. Lyon, Jr. compiled the data for the Reach-based Ecosystem Indicators (REI) matrix.

General Regional Characteristics

At the regional spatial scale, characteristics evaluated include the following information: ecoregion, drainage basin, valley segments, and channel segments that inform planners and evaluators on the regional setting where the assessment occurred. These regional characteristics are recommended in the *Monitoring Strategy* (Hillman 2006), and by NOAA Fisheries and U.S. Fish and Wildlife Service (1998).

Watershed Characteristics

At the watershed/subwatershed spatial scales several tributary-based ecosystem indicators are evaluated as general indicators to inform planners and evaluators on the condition of the watershed/subwatershed. At this scale an overall watershed/subwatershed condition can be addressed to determine if deficiencies at the reach-scale are symptomatic of a larger problem that should be addressed that impact the sustainability and effectiveness of implemented habitat actions in the Upper and Lower Nason subwatersheds.

Reach Characteristics

At the reach spatial scale individual reach-based ecosystem indicators are evaluated to inform planners and evaluators on the condition of the indicators. Condition ratings are assigned as Adequate, At Risk or Unacceptable based on criteria presented in the Lower Nason reach REI between river mile (RM) nd the Wenatchee River confluence.

GENERAL REGIONAL CHARACTERISTICS

REGIONAL SETTING

Ecoregion	Bailey Classification	Eastern Cascades Section of the Cascade Mixed Forest-Coniferous Forest-Alpine Meadow Province
	Omernik Classification	Chiwaukum Hills and Lowlands
	Physiography	Northern Cascade Mountains section of the Cascade-Sierra Mountains Province
	Geology	Metamorphic, Igneous and Sedimentary rocks of Cascade Range

DRAINAGE BASIN CHARACTERISTICS

Geomorphic Features	Basin Area	Basin Relief	Drainage Density	Hydrologic Unit Code (6th Field)	Strahler Stream Order	Land Ownership
Nason Creek Watershed	109 miles^2	6,160 feet	0.9	170200110302	4	78% Public 22% Private

VALLEY SEGMENT CHARACTERISTICS

Valley Characteristics	Location	Valley Bottom Type	River Miles	Average Valley Bottom Width	Average Channel Width	Valley Confinement[1]
Lower Nason Creek Subwatershed	Whitepine Creek to Wenatchee River Confluence	U-shaped Trough (*U1*)	RM 4.60-2.53	1,090 feet	115 feet	Unconfined
			RM 2.53-2.50	110 feet	90 feet	Confined
			RM 2.50-1.52	1,080 feet	95 feet	Unconfined
			RM 1.52-1.00	380 feet	115 feet	Moderately Confined
			RM 1.00-0	1,520 feet	100 feet	Unconfined

[1]Valley confinement was based on the ratio of average valley bottom width to average channel width (unconfined for greater than 4:1; moderately confined if 4:1 or less and greater than 2:1; confined for less than 2:1) (Hillman 2006)

CHANNEL SEGMENT CHARACTERISTICS

Channel Characteristics	Channel Segment	River Miles	Geologic Confinement	Elevation Change	Distance	Channel Gradient	Channel Sinuosity
	Segment A	RM 4.6-2.5	Unconfined	46 feet	10,864 feet	0.42%	1.25
	Segment B	RM 2.5-1.5	Unconfined	7 feet	5,234feet	0.13%	1.22
	Segment C	RM 1.5-1.0	Moderately Confined	14 feet	2,888 feet	0.48%	1.07
	Segment D	RM 1.0-0	Unconfined	21 feet	4,663 feet	0.45%	1.19

WATERSHED CHARACTERISTICS

GENERAL INDICATOR: EFFECTIVE DRAINAGE NETWORK AND WATERSHED ROAD DENSITY

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

General Characteristics	General Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Watershed Condition	Effective Drainage Network and Watershed 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.

Watershed Road Density

Upper Nason (HUC #170200110601) covers the headwaters to Whitepine Creek near RM 14.3, and the Lower Nason (HUC #170200110602) covers from Whitepine Creek to the Wenatchee River confluence. Analysis of the road densities for Upper Nason were 1.1 mi/mi^2 (headwaters to RM 12.2) and 3.88 mi/mi^2 for Lower Nason (RM 12.2-mouth) (USFS 2008; Reclamation 2008). Watershed road densities have increased as a result of increased logging and access roads, and private and public roads due to development (USFS 1996). Road related impacts include the following: (1) disruption of channel-floodplain interactions, (2) restricted lateral channel migration, (3) isolation of tributaries and off-channel habitat areas, (4) decrease in infiltration rates (impervious surfaces), and (5) increase in surface runoff and erosion (USFS 1996).

Effective Drainage Network

U.S. Forest Service (1998) determined the only significant increase in drainage network was from elevated road grades (and railroad grades). The trail network in the watershed had no significant impacts. Their conclusion was that effective drainage network rating should be the same as the road density ratings.

Narrative:

A watershed road density condition rating for Nason Creek was At Risk in the Upper Nason and Unacceptable in the Lower Nason. The Forest Service concluded that the effective drainage network should be the same as the road density ratings and concluded that the Upper Nason was At Risk and the Lower Nason was Unacceptable (USFS 1998). Based on the current data, the overall condition rating for road density and effective drainage network for the watershed is **At Risk**.

GENERAL INDICATOR: DISTURBANCE REGIME (NATURAL/HUMAN)

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

General Characteristics	General Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Watershed Condition	Disturbance Regime	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.

About 78 percent of the Nason Creek watershed is federally owned with the remaining 22 percent in private ownership. Private ownership is predominantly in the lower 15 miles of floodplain and along Kahler and Coulter Creek subwatersheds. Public lands are managed as non-designated recreational forest (about 51 percent) and designated Alpine Lakes Wilderness Area (about 21 percent). Private land uses included residential and commercial developments, and tracts of commercial timber lands (USFS 1996).

The watershed vegetation was comprised of about 30 percent in an early successional stage, 29 percent in a middle successional stage, and 23 percent in a late successional comprised predominantly by coniferous forest vegetation. Within the 68,164 acre watershed, 18 percent of the total acreage was composed of non-forest habitat such as hardwood stands and shrubs, wetlands, alpine meadows, rock, and water (USFS 1996).

At the 5th HUC, disturbance history in the Lower Nason was At Risk (USFS 2006) due to multiple clearcuts and logging roads that have been constructed over the last 50 year. Timber harvest activity increased between 1985 and 1992 and mass erosion became more evident (USFS 1996; Golder 2003). Fifty-four site damage reports associated with debris flows from the 1990 flood were recorded in the Nason Creek watershed (USFS 1996).

Narrative:

Anthropogenic disturbances included timber harvest and construction of logging roads, infrastructure construction, and floodplain development. Mass erosion became more frequent including debris flows from the 1990 flood. Debris flows have occurred in several parts of the watershed primarily due to vegetation clearing that has destabilized the soils and logging road construction on steep slopes. Improved roads and floodplain development have increased the amount of impervious surfaces that reduce infiltration rates and increase surface runoff rates. The cumulative effects of vegetation clearing that can destabilize hillslopes and increase the rate of runoff, increased logging roads and improved roads that may have changed the effective drainage network and increased impervious surfaces, and floodplain development along the stream and tributaries most likely have changed the disturbance regime. These anthropogenic disturbances may have had a negative effect on the resiliency of the system. Based on the available data, the overall condition rating for the disturbance regime indicator is **At Risk**.

GENERAL INDICATOR: FLOW / HYDROLOGY

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

General Characteristics	General Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Watershed Condition	Flow/hydrology	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.

Flow

Figure 1 is the 2009 to 2010 hydrograph from WDOE Water Monitoring Gage 45J070 located near RM 1 at elevation 1,740 feet (latitude 47.8001; longitude 120.7165) near the Nason Creek Campground Road bridge crossing (WDOE 2010a). Hydrology of the watershed is a snowmelt dominated system with runoff occurring between April and June with periodic rain-on-snow events occurring from October through December. Reclamation (2008) calculated discharges at each river mile through RM 14 for the 2-, 5-, 10-, 25-, 50- and 100-year recurrence intervals. No impact on the magnitude, timing, duration, or frequency of flows was detected in Nason Creek.

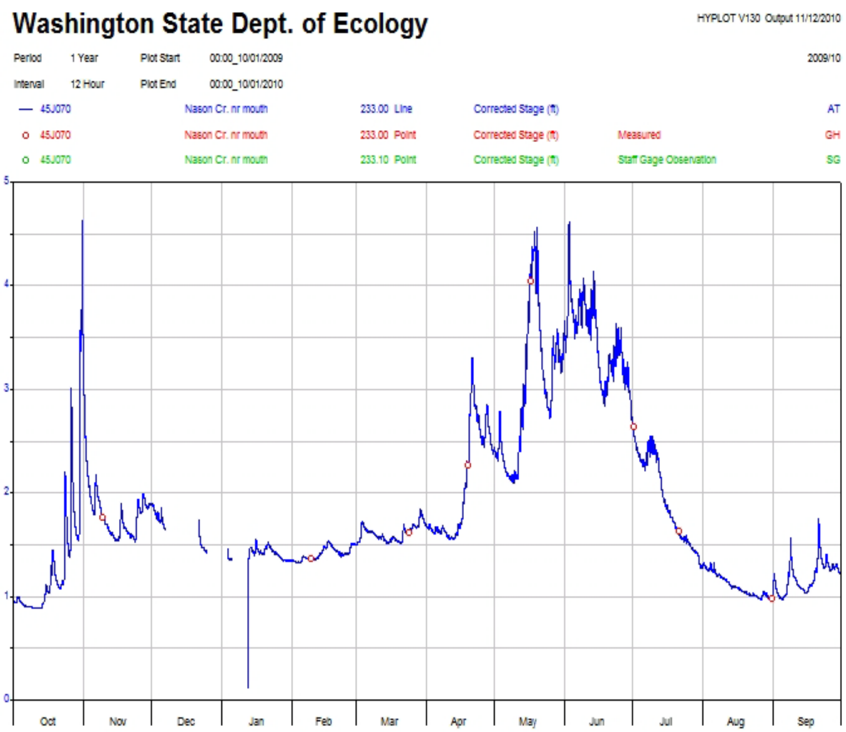

Figure 1. Hydrograph of WDOE monitoring station 45J070 from October 2009 to September 2010 (WDOE 2010a). The downward "spike" in January is most likely due to icing.

Hydrology

Anthropogenic disturbances have likely affected the effective drainage network, upland and riparian vegetation structure, and water storage on the floodplain. Road and railroad grades affect the routing and rates of runoff, timber harvests affect water infiltration rates, and development within the floodplain affects water storage. The cumulative effect of anthropogenic disturbances has not been quantified in the watershed, however, based on the known anthropogenic disturbances, changes to the effective drainage network, vegetation structure, and floodplain development have likely resulted in a negative cumulative effect on the watershed hydrology.

Narrative:

No changes on the magnitude, timing, duration, or frequency of flows in Nason Creek were detected during the Tributary Assessment (Reclamation 2008). Although no changes were detected, the anthropogenic disturbances could have negatively impacted the system prior to installation of the stream gages.

Cumulative effects of anthropogenic disturbances have not been quantified in the watershed. However, known anthropogenic disturbances have likely changed the effective drainage network, vegetation structure, and floodplain development, negatively impacting watershed hydrology. The condition rating for flow and hydrology is based on professional judgment. The flow/hydrology indicator for the Nason Creek watershed is **At Risk** because there is some indirect evidence that the timing and duration of peak flows may have been changed.

GENERAL INDICATOR: WATER QUANTITY AND QUALITY

Criteria: The following criteria were adapted and modified from the USFWS (1998) and Washington State Department of Ecology.

General Characteristics	General Indicators	Adequate Condition	At Risk Condition	Unacceptable Condition
Water Quantity and Quality	Quantity/Temperature/Chemical Contamination/ Nutrients	Adequate instream flows for habitat, low levels of water quality impairments from landuse sources, no excessive nutrients, no CWA 303d designated reaches. Or, Washington State Department of Ecology standards – 173-201A-200.	Inadequate instream flows for habitat, moderate levels of water quality impairments from landuse sources, some excess nutrients, CWA 303d designated reaches.	Inadequate instream flows for habitat, high levels of water quality impairments from landuse sources, high levels of excess nutrients, CWA 303d designated reaches.

*Water quality assessment categories (http://www.ecy.wa.gov/programs/wq/303d/WAAssessmentsCats.html).

- Category 1 – Meets tested standards for clean waters.
- Category 2 – Waters of concern.
- Category 3 – Insufficient data.
- Category 4 – Polluted waters that do not require a TMDL.
    - Category 4a – has a TMDL
    - Category 4b – has a pollution control program.
    - Category 4c – is impaired by a non-pollutant.
- Category 5 – Polluted waters that require a TMDL.

Water Quantity

Flows and hydrology may have been impacted by anthropogenic disturbances that could have negatively affected groundwater recharge. However, it is unclear if there has been a reduction in groundwater recharge that has negatively affected baseflows to the stream. In addition, Nason Creek has not been listed by WDOE as having inadequate instream flows that would limit available habitat.

Water Quality

The following is a brief explanation of the Washington State Department of Ecology's Water Quality Index (WDOE 2010b).

"The Water Quality Index is designed to rate general water quality based on monitoring conducted by Ecology's Freshwater Monitoring Unit. Monitoring results from monthly grab samples have been converted to scores ranging from 1 to 100 following a fairly complex methodology. In general, scores less that 40 indicate water quality did not meet expectations or was poor. Scores of 40 through 79 indicate moderate quality, and scores of 80 and greater indicate water quality met expectations and is good."

The index values below (Figure 2) include data through September 2008. The overall water quality at this station (Monitoring Station 45J070) is of moderate concern based on water-year 2008 summary. Constituents that earned moderate quality scores include oxygen, suspended solids, temperature, total persulf nitrogen, and turbidity.

1 **WQI scores for the most recent completed water year (2008)**

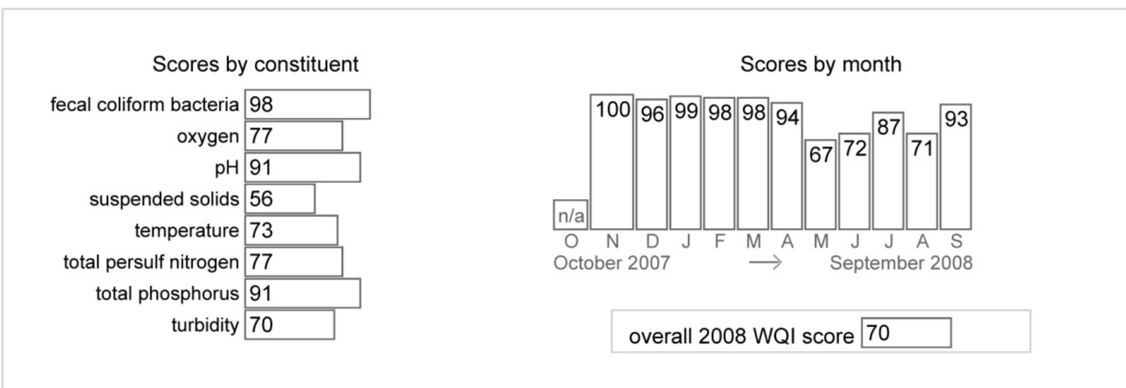

Figure 2. **(WDOE 2010a)** http://www.ecy.wa.gov/apps/watersheds/riv/station.asp

Nason Creek was listed in 2004 as a Category 5 waterbody considered to have polluted waters that require a Total Maximum Daily Load (TMDL) or Water Quality Improvement Project. The listing was primarily due to water temperature (see Listing Identifier (ID) Nos. 39376 and 8425 below).

Listing ID No. 39376:

Okanogan and Wenatchee National Forest unpublished data (submitted by Sonny O'Neal on January 17, 2003) show a maximum daily temperature of 22.3° C from continuous measurements collected in 2001 at a station called "Nason Creek near the mouth". The unpublished data show a 7-day mean of maximum daily temperature of 20.6° C, with a maximum daily temperature of 21.4° C from continuous measurements collected in 2000. The unpublished data also shows a 7-day mean of maximum daily temperature of 17.5° C, with a maximum daily temperature of 18.2° C from continuous measurements collected in 1999.

The Okanogan and Wenatchee National Forest unpublished data show excursions beyond the criterion from measurements collected in 2000 and 2001.

Listing ID No. 8425:

Department of Ecology's Wenatchee River TMDL continuous monitoring data, station 45NC00.3, shows between May 13, 2003 and September 24, 2003 there were 69 occurrences in which the 7-day mean of daily maximum value exceeded the temperature criterion for this waterbody; the maximum exceedance during this period was 21.94° Celsius for the 7-day period ending August 1, 2003.

Numerous excursions beyond the criterion sampled at the mouth by Wenatchee National Forest (submitted by Bella Patheal of U. S. Environmental Protection Agency [EPA] on December 1, 1995) during 1994.

Figure 3 shows water temperature data collected by WDOE from October 2009 to September 2010 at Monitoring Station 45J070 (Nason Creek near mouth). The water temperatures are generally highest in July and August during the low flow periods as would be expected. The Water Quality Improvement Project (also referred to as Total Maximum Daily Loads (TMDL)) establishes limits on pollutants that can be discharged to a waterbody and still allow state standards to be met (WDOE 2010b). In 2008, Nason Creek was listed as a Category 4a waterbody and was included as part of the Wenatchee River Watershed Temperature TMDL that was approved by the EPA on August 3, 2007.

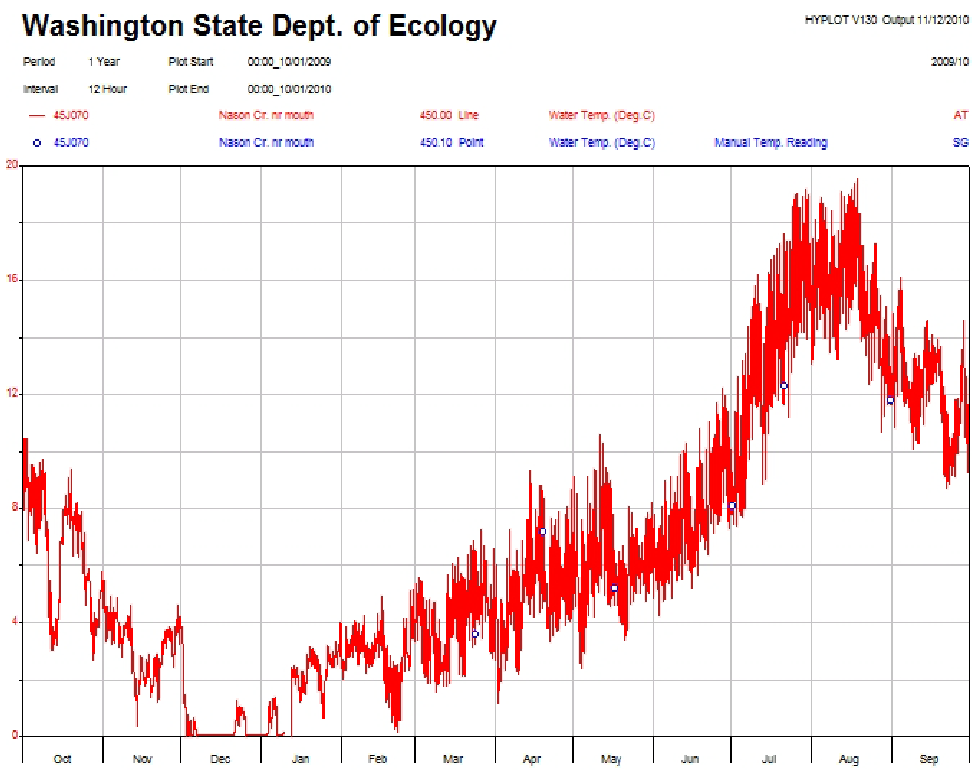

Figure 3. Water temperature data at Monitoring Station 45J070 (WDOE 2010b).

Three of twenty values of dissolved oxygen (DO) and one of twenty of pH failed to meet state water quality standards at the Lower Nason Creek monitoring site (Station 45J070) near RM 0.5. At the Upper Nason Creek, temporary monitoring site near Berne (downstream of Henry Creek near about RM18) five of twenty DO readings and one pH reading failed to meet state water quality standards.

Narrative:

Nason Creek has not been listed by the WDOE for inadequate flows that limit habitat quantity. Water quality was considered “good” based on WDOE’s Water Quality Index for fecal coliform bacteria, pH, and total phosphorous. However, water quality was considered “moderate” for oxygen, suspended solids, water temperature, total persulf nitrogen and turbidity (WDOE 2010b). Water temperature did not meet the WDOE’s standards and was listed as a Category 4a waterbody and included in the Wenatchee River Watershed Temperature TMDL that was approved by the EPA on August 3, 2007. Based on monitoring conducted by WDOE and USFS, Nason Creek is **At Risk** for water quantity and quality due to moderate levels of water quality impairments and being listed as a Catergory 4a waterbody.

GENERAL INDICATOR: HABITAT ACCESS

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

General Characteristics	General Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Habitat Access	Main Channel Physical Barriers	No manmade barriers present in the mainstem that limit upstream or downstream migration at any flow.	Manmade barriers present in the mainstem that prevent upstream or downstream migration at some flows that are biologically significant.	Manmade barriers present in the mainstem that prevent upstream or downstream migration at multiple or all flows.

Mainstem Physical Barriers

There are two naturally occurring falls on Nason Creek that appear to block upstream passage to Chinook, steelhead, and bull trout. The lower falls, just above Whitepine Creek near RM 14.3, is believed to block upstream passage of Chinook to upper Nason and the headwaters. The upper falls, just below Smith Brook, is believed to block upstream passage of steelhead and bull trout to the Nason headwaters (USFS 1998).

In Lower Nason, juvenile passage into oxbows, wetlands, side channels, and other key habitat areas have been significantly reduced because of habitat isolation from the mainstem. These areas are disconnected or poorly connected because of railroad grades and road corridors (USFS 1998).

Tributary Physical Barriers

Natural barrier falls that are believed to block upstream passage of Chinook, steelhead, and bull trout occur in Roaring, Gill, Mill, Smith Brook, and Whitepine creeks (USFS 1996).

Narrative:

There are no manmade barriers on Nason Creek between RM 16.8 (natural falls) to the mouth. Nason Creek has been channelized in some areas for the construction of the railroad and improved roads, and these anthropogenic disturbances have created passage barriers into historic channel paths in the Lower Nason and to some tributaries (i.e. Coulter Creek) that may have been utilized by ESA-listed fish. While these disturbances may be affecting passage to off-channel habitat, the habitat access on the main Nason Creek channel is in **Adequate** condition.

REACH CHARACTERISTICS

GENERAL INDICATOR: WATER TEMPERATURE

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

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Water Quality	Water Temperature	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 (WDOE): 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%

The Wenatchee River from the Wenatchee National Forest boundary (RM 27.1) to its headwaters is considered Class AA. Class AA waterbodies are defined as extraordinary waters for salmon and trout spawning, core rearing, and migration; extraordinary primary contact recreation; and all other water supply and miscellaneous uses) (WDOE website). Because Nason Creek discharges to the Class AA portion of the Wenatchee River, it is considered Class AA as well. Nason Creek was listed as part of the Wenatchee River Watershed Temperature TMDL that was approved by EPA on August 3, 2007.

At the 5th HUC scale, the reach in Lower Nason Creek with the most sustained longitudinal heating occurred between RM 10.6 and 3.5 (Watershed Sciences 2003). Recorded temperatures in the tributaries were below the temperature measured in Nason Creek, indicating the temperature problem is related to Nason Creek (Table 1). Stream shading has been reduced through vegetation clearing and riprap of banks (USFS 2006). Water temperature measurements conducted at Coles Corner near RM 4.6 and the mouth showed water temperatures approaching the threshold of 20.6º C (303d Listing; WDOE Website). Water temperatures pertaining to salmonids life stages in the Lower Nason reach are summarized in Table 2.

Table 1. The following information was obtained through a literature review of USFS unpublished data (USFS 2008) and Wenatchee River Temperature Total Maximum Daily Load Study (WDOE 2005). WDOE website data: http://www.ecy.wa.gov/ecyhome.html

Location	Agency	Year	7-day mean of maximum daily temperature	Maximum daily temperature
Above Whitepine Creek	WDOE	2003	17.9° C	18.4° C
Ben 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	USFS	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

Table 2. Washington Department of Ecology water quality indicators were used to determine the water temperature condition for the Kahler reach assessment (Reclamation 2009).

Life Stage	Condition Rating
Salmon spawning	Unacceptable
Core summer salmonid habitat	Unacceptable
Salmonid spawning, rearing and migration	Unacceptable
Salmonid rearing and migration only	Unacceptable

Narrative:

Nason Creek was listed in 2008 as part of the Wenatchee River Watershed Temperature TMDL approved by EPA on August 3, 2007. Water temperatures in Lower Nason were unacceptable for salmon spawning, core summer salmonid habitat, rearing, and migration (USFS 2006). Solar heating of the stream in the Lower Nason may have been exacerbated by re-routing surface flows that now parallel State Route 207, removal of vegetation along road had decreased shading, and surface water heating associated with disconnected channels and oxbows. Historically the channel was able to migrate laterally and the stream's channel orientation ranged from east-west to north-south which would have provided appropriate stream shading. The Lower Nason reach meets the **Unacceptable** criteria for water temperature.

GENERAL INDICATOR: TURBIDITY

Criteria: The performance standard for this indicator is from Hillman and Giorgi (2002), and Washington State Department of Ecology.

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Water Quality	Turbidity	Nephelometric Turbidity Units (NTU)	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.

Turbidity is measured in Nephelometric Turbidity Units (NTU) which is a measure of the cloudiness of the water caused by suspended solids. Exceeding a criterion does not necessarily mean the water quality standard has been violated according to the Environmental Protection Agency.

Turbidity is of moderate quality in Nason Creek based on WDOE water quality standards (refer to Figure 2) with a rating of 70 (scores of 40 through 79 indicate moderate quality, and scores of 80 and greater indicate water quality met expectations and is good (WDOE 2010a). In the Lower Nason assessment area the stream flows against bedrock (Chumstick Formation) that is a sedimentary rock comprised predominantly of silt to gravel. As the sedimentary rock “breaks down”, or weathers, it releases fine sediment which becomes accessible to the stream. Therefore, Lower Nason may have a relatively high background level of fine material that is transported by the stream in suspension which directly influences the turbidity measurements. However, there has been timber harvesting and construction of logging roads in the watershed that may have destabilized soils that flush to Nason Creek during runoff and thunderstorms. In addition, the Lower Nason has a high road density (3.88 mi/mi^2) and the Upper Nason has a moderate road density (1.1 mi/mi^2) that may also provide fine sediment inputs to the stream.

Narrative:

Turbidity was found to be of moderate quality in Nason Creek (WDOE 2010a). Weathering of sedimentary rocks in contact with the stream provides a fine sediment source to the stream that naturally provides a relatively high background level of fine sediment. Anthropogenic disturbances in the watershed that may exacerbate fine sediment inputs and influence water turbidity include timber harvests and logging road building and increased road densities. Based on WDOE moderate quality finding for turbidity and anthropogenic disturbances that may exacerbate fine sediment inputs to the stream, water turbidity for the Lower Nason reach is **At Risk**.

GENERAL INDICATOR: CHEMICAL CONTAMINATION / NUTRIENTS

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

General Characteristics	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.

The Water Quality Index is designed to rate general water quality based on monitoring conducted by Ecology's Freshwater Monitoring Unit. Monitoring results from monthly grab samples have been converted to scores ranging from 1 to 100 following a fairly complex methodology. In general, scores less than 40 indicate water quality did not meet expectations or was poor. Scores of 40 through 79 indicate moderate quality, and scores of 80 and greater indicate water quality met expectations and is good.

For temperature, pH, fecal coliform bacteria, and dissolved oxygen, the index expresses results relative to levels required to maintain beneficial uses (based on criteria in Washington's Water Quality Standards, WAC 173-201A). For nutrient and sediment measures, where standards are not specific, results are expressed relative to expected conditions in a given region (http://www.ecy.wa.gov/apps/watersheds/riv/station.asp?).

Chemical Contamination/Nutrients

Water sampling in 2008 by the WDOE (2010a) at Monitoring Station 45J070 near the bridge along the Nason Creek Campground Road determined the following Water Quality Index scores:

1. fecal coliform bacteria score was 98 or a "good" water quality rating
2. total phosphorus score was 91 or a "good" water quality rating
3. total persulf nitrogent was 77 or a "moderate" water quality rating

Overall Water Quality Index score at this monitoring station was 70 or “moderate” water quality. There is a wastewater return from a Class IV Advanced Wastewater Treatment Plant (tertiary treatment with alum addition) that services a ski resort area and discharges to Nason Creek (WDOE 2006). Other factors that may affect water quality include the following: location of improved roads adjacent to the stream where road runoff is input into the stream, contaminants from areas developed within the floodplain and adjacent to the stream, and surface water diversions and withdrawals that reduce water quantity available to dilute any contaminants or nutrients entering the stream.

Narrative:

The overall Water Quality Index score for the Lower Nason reach was 70 or of “moderate” water quality (WDOE 2010a). There are low levels of chemical contaminants or nutrients from point sources. Non-point sources have not been studied or monitored and may be contributing contaminants or nutrients to the stream. Surface water diversions and withdrawals reduce have reduced stream flows (quantity of water withdrawals is unknown) that may exacerbate water quality problems due to possible increases in contaminant or nutrient concentrations (lack of water dilution). Based on the moderate Water Quality Index rating for Nason Creek and anthropogenic disturbances, the stream is **At Risk** for chemical contamination or from nutrients.

GENERAL INDICATOR: HABITAT ACCESS

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

General Characteristics	General Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Habitat Access	Main Channel Physical Barriers	No manmade barriers present in the mainstem that limit upstream or downstream migration at any flow.	Manmade barriers present in the mainstem that prevent upstream or downstream migration at some flows that are biologically significant.	Manmade barriers present in the mainstem that prevent upstream or downstream migration at multiple or all flows.

Narrative:

There are no manmade barriers on Nason Creek between RM 16.8 (natural falls) to the mouth. The stream has been channelized in some areas for the construction of the improved roads, and these anthropogenic disturbances have disrupted channel-floodplain interactions but have not created passage barriers into natal tributaries. In addition, the quantity of available off-channel habitat was found to be more than adequate (refer to Off-channel Habitat indicator), unlike upstream of this reach where the location of the railroad grade has impeded or prevented fish passage into natal tributaries. There are no mainstem barriers that prevent habitat access to the upper watershed or tributaries in this reach. Nason Creek is **Adequate** for habitat access.

GENERAL INDICATOR: CHANNEL SUBSTRATE

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

General Characteristics	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.

Channel Substrate

The dominant substrate in the lower Nason was predominantly gravel and cobble with fine sand. Coarse substrate (gravel to boulder size) are mostly from the Nason Terrane comprised of metamorphic rocks that crop out upstream of the assessment area and were transported to their present location by the stream. Most of the finer substrates (silt to fine sand size) are from the Chumstick Formation comprised of sedimentary rocks that are adjacent to and underlying the stream within the assessment area.

Sediment inputs from upstream sources provide appropriate substrate size materials for spawning and providing rearing habitat cover. Artificial channel confinement by improved roads, bank protection, and an overall increase in channel gradient may have increased streampower and sediment transport capacity in areas where the stream has been re-routed for road construction. This may have reduced retention of fine-to-medium size gravels in localized areas.

Substrate Embeddedness

There was no quantitative data on juvenile rearing habitat substrate embeddedness in Nason Creek watershed. The percent embeddedness measured in some stream surveys was gravel embeddedness and not embeddedness of cobble and boulder substrates that are used for juvenile rearing habitat. Lacking additional information on embeddedness, USFS (1998) extrapolated that fine sediment found in spawning substrate indicated there was a potential for embeddedness of coarse substrate used for juvenile rearing.

Fine Sediment

McNeil sampler, which is comprised of a coring cylinder and collection cylinder was used to collect sediment samples in spawning gravels to a depth of about 10 inches from three riffles in the lower 5 miles of Nason Creek in 1993. The grain size distribution on the three riffles ranged from 19.3 to 27.8 percent fine sediment (less than 1mm in diameter), with a mean of 22.7 percent. The Lower Nason was re-sampled in 2005 (Wenatchee River Ranger District, unpublished data) and the average percentage of fines less than 1 mm was 12.7 percent. The Forest Service (USFS 2006) concluded that fine sediment accumulation was variable over time.

As previously discussed, the stream flows through sedimentary rocks of the Chumstick Formation that is comprised of predominantly fine sand in this reach. Erosion and weathering of the sedimentary rocks likely produce relatively high background levels of fine sediment. Anthropogenic disturbances such as timber harvest and logging road construction may exacerbate fine sediments reaching the stream.

Narrative:

The channel substrate indicator describes the dominant material that makes up the substrate composition along the streambed in spawning and rearing areas (Hillman 2006). Gravel and cobble are being transported from upstream to this reach, and fines and sand are being incorporated primarily within this from erosion and weathering of sedimentary rocks. Substrate embeddedness of rearing habitat areas (i.e. cobble and boulder substrate) were not directly measured, but extrapolated to be at risk based on fine material percentages found in spawning gravels. Fine sediment sampling within spawning gravels in Lower Nason were variable over time and fluctuated between adequate and at risk thresholds. The dominant substrate within this reach appears to be **Adequate**. Fine sediment inputs that may negatively affect spawning gravels and cause embeddedness of rearing habitat appear to be transient suggesting fine sediment inputs are not a chronic problem.

GENERAL INDICATOR: LARGE WOOD

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

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Habitat Quality	Large Wood	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.

The large wood numbers are approximately the same for the reach for the period between 1996 and 2010 based on stream surveys conducted by the U.S. Forest Service (USFS 2010). Different wood size classifications were used in the two surveys so the large wood numbers are not directly comparable. The large wood pieces that were counted in the 1996 survey had a minimum length of 25 feet from the large end while in the 2010 survey the large wood pieces had a minimum length of 35 feet from the large end. This increase of 10 feet in length would result in fewer pieces counted in 2010 compared to 1996. More of the large wood was found in side channels in 2010 than in 1996 (Table 3). In both surveys much of the large wood was found in a few large logjams. Large wood observed in four jams during the 2010 survey represented about 56 percent of the total large wood counted in the reach. In the unconstrained portions of the reach that were away from roads and campgrounds, large wood was being recruited through bank erosion. In one location several recently toppled large trees were observed that span the entire channel, creating the potential for another channel spanning logjam to develop.

Table 3. Pieces of large wood per mile observed during the 1996 and 2010 stream surveys (USFS 2010)

Year	Pieces of Large Wood Per Mile (>12 inches)	Percent Large Wood in Side Channels
2010	88	30%
1996	100	9%

Narrative:

In both the 1996 and 2010 stream surveys conducted by the U.S. Forest Service pieces of large wood per mile exceeded the adequate criteria. Much of the large wood was imported from upstream into the reach based on limited areas where active bank erosion was occurring in the reach. Vegetation structure and composition was adequate for both long- and short-term recruitment potential. Large wood counts per mile and wood recruitment potential meet the REI criteria for **Adequate**.

GENERAL INDICATOR: POOLS

Criteria: The following criteria were adapted from USFWS (1998) and Montgomery and Buffington (1993).

General Characteristics	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 For channel widths greater than 100 feet, pool spacing for an alluvial valley type that are moderately confined to unconfined with a channel slope <2% is generally a pool for every 5-7 channel widths (Montgomery and Buffington (1993). 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.

The 2010 stream survey (USFS 2010) found that the overall pool area in the reach increased from 60 percent to 72 percent of the main channel area while the average length of individual pools increased from 305 feet to 360 feet (15 percent) (Table 4). The average maximum depth for pools was not comparable between the 1996 and 2010 stream surveys because the 1996 surveyors did not try to estimate maximum pool depth if it was deeper than 4 feet, while in 2010 they made estimates of maximum depth. Riffles decreased in average length, and total number and percent of the main channel area they occupied. The data indicates that the total habitat variability and complexity has increased since the 1996 survey.

Table 4. Habitat unit dimensions 1996 and 2010 for RM 4.23 – 0 (USFS 2010).

Year	Unit Type	Average Length	Number	Average Wetted Width	Average Maximum Depth	Average Thalweg Depth
2010	Pool	360 feet	47	56 feet	5.3 feet	---
	Riffle	258 feet	21	71 feet	2.4 feet	1.5 feet
	Total	328 feet	68	61 feet	4.4 feet	----
1996	Pool	305 feet	49	55 feet	4.4 feet	---
	Riffle	293 feet	26	72 feet	3.1 feet	1.4 feet
	Total	301 feet	75	61 feet	3.9 feet	---

Pool Frequency

Stream surveys are typically conducted during low flow conditions when streams are wadable and instream habitat units can be measured. The stream survey in 1996 observed 12 pools per mile and in 2010 they observed 11 pools per mile. Channel widths ranged from 119 feet (1996) to 90 feet (2010). The REI criteria are 4 pools per mile with good cover and cool temperatures for streams with channel widths ranging from 65 to 100 feet. Pools per mile observed in both 1996 and 2010 stream surveys exceeded the pool frequency criteria. Wood and vegetation provided appropriate cover for most pools, and pools associated with bedrock outcrops provide cover due to average depths greater than about 5 feet.

Large Pools

Most of the pools observed in the reach were greater than 3 feet deep and were formed as lateral and middle channel scour pools associated with logjams and bedrock outcrops. Pool depth and cover appeared to be appropriate based on the physical processes that formed the pools.

Narrative:

Pool frequency (11 pools per mile) exceeded the criteria of 4 pools per mile with appropriate cover provided by wood, canopy cover, and depth. Pool habitat in this reach is **Adequate**.

GENERAL INDICATOR: OFF-CHANNEL HABITAT

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

General Characteristics	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.

Comparison of the 1996 and 2010 stream surveys conducted by the U.S. Forest Service (USFS 2010) found the number of side channels had increased by one with an increase of wetted side channel area (as a percent of wetted main channel area) of 8 percent (Table 5). Geomorphic channel unit mapping conducted by Reclamation for this assessment identified 13 gravel bar-type side channels covering about 1.43 acres and 10 floodplain-type side channels covering 12.16 acres for a total of 13.59 acres of available off-channel habitat (Table 6). Two historic channel paths were reconnected by placing culverts through the road embankment of State Route 207 in 2007 and 2009 by the Chelan County Natural Resources Department. These reconnections were mapped as floodplain-type side channels because the culverts limit the stream from fully accessing the historic channel paths. About 7.46 acres (or 55 percent of total acres) of side channels were made available as off-channel habitat for rearing.

Table 5. Side channel areas observed during the 2010 stream survey (USFS 2010)

Year	Side Channel Area as Percent of Main Channel Area	Side Channel Length as Percent of Main Channel Length	Number of Side Channels
2010	10%	39%	10
1996	2%	17%	9

Table 6. Mapped geomorphic side channel units

Side Channel Identifier	Gravel Bar-type (Acres)	Floodplain-type (Acres)
SC_4.44_L	0.08	---
SC_4.34_R	0.17	---
SC_4.20_R	---	0.16
SC_3.98_R	---	0.61
SC_3.88_R	---	1.50
SC_3.86_R	---	1.96
SC_3.68_R	0.07	---
SC_3.48_R	---	6.61 (Reconnected 2007)
SC_3.32_R	0.07	---
SC_3.27_L	0.05	---
SC_3.12_L	0.08	---
SC_3.17_R	---	0.11
SC_2.92_R	0.03	---
SC_2.85_R	---	0.10
SC_2.07_R	0.12	---
SC_2.01_R	---	0.17
SC_1.99_L	0.06	---
SC_1.17_R	---	0.85 (Reconnected 2009)
SC_1.12_L	0.26	---
SC_0.36_R	0.04	---
SC_0.26_L	0.12	---
SC_0.13_L	0.28	---
SC_0.13_L	---	0.09
Total	**1.43 acres**	**12.16 acres**

Narrative:

Two historic channel paths remain disconnected by improved roads covering about 17.0 acres total acres. Reconnecting these channel paths using culverts would more than double the total acreage available as off-channel habitat. However, the streams geomorphology and hydrology suggest side channels were not abundant in this reach. Prior to channel re-routing to construct improved roads which have disconnected historic channel paths, the stream had a flatter gradient, more sinuosity and the channel-floodplain interactions were not disconnected. Geomorphically, the riverine processes would have been more conducive to pool formation and gravel bar deposition. Side channels probably would have represented about 5-10 percent of the overall channel units (refer to Channel Segment B that has appropriate channel-floodplain interactions and riparian vegetation). The REI criterion emphasizes many off-channel areas with cover and low energy side channels with no manmade barriers present to prevent access to off-channel areas. There are manmade barriers that prevent access to historic channel paths, but not side channels. Side channels are plentiful and accessible as rearing habitat and have appropriate cover. Interpretation of stream morphology and channel-floodplain interactions suggests this reach has Adequate off-channel habitat.

SPECIFIC INDICATOR: FLOODPLAIN CONNECTIVITY

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

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Channel 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.

Channel-floodplain interactions have been disconnected by construction of improved roads, most notable State Route 207, improved campground roads, and State Route 209. These roads have disconnected about 29 percent (132.7 acres) of historic channels and floodplain areas (Table 7 : refer to Channel Segment Characterization of report for locations and further discussion). The most impacted areas occur in geologically unconfined Channel Segment D where about 74.7 acres have been disconnected by State Route 207, improved campground roads, and State Route 209; and Channel Segment A where about 53.8 acres have been disconnected by State Route 207 (Table 8).

Table 7. Summary of connected and disconnected areas in lower Nason reach.

Channel Segment	Total Acreage	Connected Acreage	Disconnected Acreage (Percent)
Segment A	217.9 acres	163.5 acres	54.4 acres (25%)
Segment B	85.0 acres	84.8 acres	0.2 acres (<1%)
Segment C	27.3 acres	23.9 acres	3.4 acres (12%)
Segment D	125.0 acres	50.3 acres	74.7 acres (60%)
Totals	455.2 acres	322.5 acres	132.7 acres (29%)

Table 8. Summary of subreaches and parcels that have disconnected historic channels or floodplain area

Channel Segment	Subreach/Parcels	Anthropogenic Feature	Metric	Disconnected Acreage
Segment A	LN-DIZ-1b	Improved Road	370 feet	4.6 acres
	LN-DOZ-1			2.5 acres
	LN-DOZ-3b	Improved Road	750 feet	6.5 acres
	LN-DOZ-5b	Improved Road	670 feet	2.6 acres
	LN-DOZ-7b	Improved Road	700 feet	2.6 acres
	LN-DOZ-8			5.3 acres
	LN-DOZ-11b	Improved Road	2,100 feet	28.5 acres
	LN-DOZ-12			1.2 acres
Segment C	LN-DOZ-19b	Improved Road	400 feet	1.4 acres
	LN-DOZ-21b	Improved Road	470 feet	1.5 acres
Segment D	LN-DIZ-4b	Improved Road	1,585 feet	12.4 acres
	LN-DOZ-24	Improved Road	750 feet	13.2 acres
	LN-DOZ-25b	Improved Road	650 feet	6.9 acres
	LN-DOZ-27b	Improved Road	3,060 feet	42.2 acres

* Culverts placed through improved roads to reconnect historic channel paths limit the flows into these areas. For this assessment, the historic floodplain areas adjacent to these reconnected channels are not reworked or inundated as would be expected during flood events. Therefore, they are considered disconnected.

Narrative:

Improved roads have significantly disrupted channel-floodplain interactions; reducing linkage between wetland areas, floodplains and riparian areas. Overbank flows have been reduced due to artificial confinement by road grades and there has been degradation of riparian areas associated with development and infrastructure. The disruptions between the active channel and historical channel paths and floodplain areas are not considered severe because over 70 percent of the reach remains hydrologically connected to the active channel. Based on the REI criterion the reach is considered **At Risk**.

SPECIFIC INDICATOR: BANK STABILITY/CHANNEL MIGRATION

Criteria: The criteria for bank stability/channel migration are a relative condition of the specific indicator developed by Reclamation.

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Channel 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.	Little or no channel migration is occurring because of human actions preventing reworking of the floodplain; or channel migration is occurring at an accelerated rate such that channel width has at least doubled, possibly resulting in a channel planform change, and sediment supply has noticeably increased from bank erosion.

Bank erosion was measured during the 1996 and 2010 stream inventory surveys conducted by the U.S. Forest Service. About 18 percent of the streambanks were observed eroding in the 1996 survey and 3 percent were observed in the 2010 survey. The change in bank erosion between the two surveys was probably not due to an actual change in erosion rates, but rather a different interpretation on what constitutes bank erosion (Table 9). In 1996 any bare bank with fines in it was tallied as eroding, but in 2010 if a bare bank was vertical with no accumulation of fines at the base then it was not considered eroding. In addition areas observed in the 1996 survey may have already been colonized with vegetation by the 2010 survey (USFS 2010).

Table 9. Summary of bank erosion between 1996 and 2010 stream inventory surveys (USFS 2010)

Year	Bank Erosion Percentage of Both Banks
2010	3%
1996	18%

Anthropogenic disturbances were mapped during this assessment including bank protection (riprap) and artificial channel constrictions (bridge) (Table 10). About 3,230 linear feet of riprap was observed providing bank protection the restricted lateral channel migration. In addition, one bridge spanning about 110 feet (average channel bankfull channel width was about 90 feet) constrained the channel from lateral channel migration.

Table 10. Anthropogenic disturbances affecting bank stability and lateral channel migration

Channel Segment	Subreach/Parcels	Anthropogenic Feature	Metric
Segment A	LN-IZ-1a	Riprap	550 feet
Segment C	LN-IZ-3	Riprap	850 feet
Segment D	LN-IZ-4a	Riprap	1,830 feet
		Bridge	110 feet

In addition, historic channel paths and floodplain where lateral channel migration occurred has reduced the area available for lateral channel migration and dissipation of flood flows across the floodplain (Table 11).

Table 11. Summary of anthropogenic features effecting floodplain connectivity and lateral channel migration

Channel Segment	Subreach/Parcels	Anthropogenic Feature	Metric	Disconnected Acreage
Segment A	LN-IZ-1a	Riprap	550 feet	
	LN-DIZ-1b	Improved Road	370 feet	4.6 acres
	LN-DOZ-1			2.5 acres
	LN-DOZ-3b	Improved Road	750 feet	6.5 acres
	LN-DOZ-5b	Improved Road	670 feet	2.6 acres
	LN-DOZ-7b	Improved Road	700 feet	2.6 acres
	LN-DOZ-8			5.3 acres
	LN-DOZ-11b	Improved Road	2,100 feet	28.5 acres
	LN-DOZ-12			1.2 acres
Segment B	LN-DOZ-18b	Berm	180 feet	0.2 acres
Segment C	LN-IZ-3	Riprap	850 feet	
		Improved Road	260 feet	
	LN-DOZ-19b	Improved Road	400 feet	1.4 acres
	LN-DOZ-21b	Improved Road	470 feet	1.5 acres
Segment D	LN-IZ-4a	Riprap	1,830 feet	
		Bridge	110 feet	
	LN-DIZ-4b	Improved Road	1,585 feet	12.4 acres
	LN-DOZ-24	Improved Road	750 feet	13.2 acres
	LN-DOZ-25b	Improved Road	650 feet	6.9 acres
	LN-DOZ-27b	Improved Road	3,060 feet	42.2 acres

Narrative:

Bank erosion in this reach was about 3 percent of the streambanks suggesting that a minimal about of erosion was occurring. The rate of bank erosion has most likely been at a slower rate due to bank hardening from riprap placed along the streambanks that restricts lateral channel migration. About 3,230 linear feet of riprap was observed along the streambanks that protected improved roads and campgrounds from lateral channel migration. Historic channel paths and floodplain have been isolated and protected by elevated road embankments with bank protection that constrains lateral channel migration and creates artificially stable banks. Bank stability/channel migration in this reach meets the REI criterion for **At Risk**.

SPECIFIC INDICATOR: VERTICAL CHANNEL STABILITY

Criteria: The criteria for bank stability/channel migration are a relative condition of the specific indicator developed by Reclamation.

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Channel Condition	Channel Dynamics	Vertical Channel Stability	No measurable or observable trend of aggradation or incision and no visible change in channel planform.	Measurable or observable trend of aggradation or incision that has the potential to, but not yet caused, disconnect 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).

Significant anthropogenic disturbances in the reach consist of re-routing the channel for road construction, disrupting channel-floodplain interactions due to elevated road grades, and restricting lateral channel migration due to bank hardening to protect roads and campgrounds. Re-routing the stream has shortened the channel resulting in an increase in channel gradient, reduction in sinuosity, and reduction in lateral channel migration. Construction of roads with elevated road grades have disconnected historic channel paths and floodplain areas, reducing the cross sectional area available to dissipate floods and may result in an increase in streampower within the channel providing more shear stress along the channel bed.

Narrative:

Anthropogenic disturbances have affected channel gradient, channel-floodplain interactions, and lateral channel migration and may have increased streampower within the channel resulting in more shear stress along the channel bed. Following these anthropogenic disturbances, the channel has most likely reached a new state of dynamic equilibrium between sediment transport and deposition. Streampower and sediment transport capacity may have increased, and concurrently, the dominant channel substrate may have increased in size and mass.

No measurable trend of aggradation or incision has been documented or observed. There was a measurable change in the channel planform and gradient due to the stream being re-routed for road construction. These considerations are not “neatly” captured in the REI criterion for vertical channel stability, but based on overbank flows during spring high-flow events and floodplain area regularly accessed, this indicator was considered **Adequate**.

SPECIFIC INDICATOR: VEGETATION CONDITION (STRUCTURE)

Criteria: The criteria for riparian vegetation structure are a "relative" indication to the functionality of the specific indicator.

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Riparian/Upland Vegetation	Vegetation Condition	Vegetation 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.

The floodplain vegetation was evaluated by mapping the overstory, middle story, understory vegetation, and areas with no vegetation in GIS using the 2006 aerial photographs. Overstory vegetation was predominantly in a Large Trees Condition of mixed deciduous and coniferous species. Middle story vegetation was in a shrub/seedling to Small Trees Condition comprised predominantly of deciduous species. Understory vegetation was in a Grass/Forbs Condition or had no vegetation due to anthropogenic disturbances that required clearing for development. An analysis of the vegetation mapping was conducted using GIS to determine the floodplain vegetation structure, vegetation disturbances along a 30-meter buffer zone adjacent to the active channel, and canopy cover using a 10-meter buffer zone adjacent to the active channel. The results of the GIS analysis are included in the following specific indicator rating for vegetation structure, vegetation disturbance, and canopy cover.

Vegetation structure of the floodplain covering about 372.6 acres included about 67 percent in a Large Trees Condition, about 22 percent in a Shrub-to-Small Trees Conditions, and about 11 percent that had no vegetation to a Grass/Forbs Condition (Table 12). Vegetation structure and composition appears to be appropriate for the floodplain areas.

Table 12. Floodplain vegetation structure

Map Unit	Vegetation Class	Floodplain Acreage	Percent
WT	Water	1.1 acres	<1%
NV	No Vegetation	17.7 acres	5%
GF	Grass/Forbs Condition	22.0 acres	6%
SS	Shrub/Seedling-Sapling/Pole Condition	44.5 acres	12%
ST/D	Small Trees Condition/Deciduous	8.8 acres	2%
ST/C	Small Trees Condition/Coniferous	1.1 acres	<1%
ST/M	Small Trees Condition/Mixed	28.4 acres	8%
LT/D	Large Trees Condition/Deciduous	46.8 acres	13%
LT/C	Large Trees Condition/Coniferous	105.8 acres	28%
LT/M	Large Trees Condition/Mixed	96.4 acres	26%
Total Acreage	**372.6 acres**		

Narrative:

Floodplain vegetation structure and composition appears to be appropriate for areas that are hydrologically connected to the active channel, but about 29 percent of historical channels and floodplain areas within the reach have been disconnected by improved roads and are maintained by groundwater. Riparian vegetation has been cleared for infrastructure, commercial and residential development; and during floods (i.e. 10-year event) the surface water cannot flow over these areas. By disconnecting the historic floodplain areas, the hydrologic conditions have been altered which may have lowered the groundwater table resulting in drier soils. Disconnecting flood flow interactions and the possible lowering of the groundwater table would not be conducive to maintaining the appropriate riparian type “native community” as some of the riparian species rely on flood disturbances for regeneration and a higher soil moisture regime. These current conditions are probably more conducive for colonization of upland vegetation species. Based on available information, the floodplain vegetation structure and composition is **At Risk** since the “footprint” of anthropogenic disturbances and vegetation removal are greater than 20 percent of the floodplain areas.

SPECIFIC INDICATOR: VEGETATION CONDITION (DISTURBANCE)

Criteria: The criteria for riparian vegetation disturbance are a “relative” indication to the functionality of the specific indicator.

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Riparian/Upland Vegetation	Vegetation Condition	Vegetation Disturbance (Natural/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.

The vegetation structure along a 30-meter buffer zone adjacent to the active channel area was comprised of about 57 percent in a Large Trees Condition, about 31 percent in a Shrub/Pole-to-Small Trees Conditions, and about 12 percent with no vegetation or in a Grass/Forbs Condition (Table 13). Most of the woody vegetation (about 88 percent) along the buffer zone was available to the stream for recruitment. Areas with no vegetation or in a Grass/Forbs Condition had been disturbed primarily from road construction and campground development. Vegetation appeared to be appropriate where channel-floodplain interactions maintained vegetation structure and composition.

Table 13. Vegetation structure along 30-meter buffer zone

Map Unit	Vegetation Class	30-meter Buffer Acreage	Percent
WT	Water	0.5 acres	<1%
NV	No Vegetation	6.7 acres	5%
GF	Grass/Forbs Condition	8.2 acres	6%
SS	Shrub/Seedling-Sapling/Pole Condition	20.6 acres	16%
ST/D	Small Trees Condition/Deciduous	4.5 acres	4%
ST/C	Small Trees Condition/Coniferous	0.6 acres	<1%
ST/M	Small Trees Condition/Mixed	14.1 acres	11%
LT/D	Large Trees Condition/Deciduous	14.5 acres	11%
LT/C	Large Trees Condition/Coniferous	25.7 acres	20%
LT/M	Large Trees Condition/Mixed	33.3 acres	26%
Total	**128.7 acres**		

Narrative:

About 88 percent of the woody vegetation along the 30-meter buffer zone appears to have appropriate structure and composition, and most was available for recruitment by the stream, except where the streambank has been armored with riprap that restricts lateral channel migration. Almost all areas with no vegetation or that are in a Grass/Forbs Condition have experienced anthropogenic disturbances from road construction and development (i.e. campgrounds and residential). The vegetation along the 30-meter buffer zone meets the **Adequate** REI criterion for vegetation structure and composition, and recruitment potential by the stream.

SPECIFIC INDICATOR: VEGETATION CONDITION (CANOPY COVER)

Criteria: The criteria for riparian vegetation canopy cover are a “relative” indication to the functionality of the specific indicator.

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

Vegetation structure along a 10-meter buffer zone adjacent to the active channel was used as a surrogate to analyze canopy cover. The vegetation structure along the buffer zone was comprised of about 48 percent in a Large Trees Condition, about 44 percent in a Shrub/Pole-to-Small Trees Conditions, and about 8 percent with no vegetation or in a Grass/Forbs Condition (Table 14). About 92 percent of the vegetation provides appropriate stream cover, leaf litter inputs, and connectivity between terrestrial and aquatic environments that are necessary to complete some aquatic macroinvertebrate life cycles (i.e. mayflies and stoneflies).

Table 14. Vegetation structure along 10-meter buffer zone

Map Unit	Diameter Class	10-meter Buffer Zone Acreage	Percent
WT	Water	0.2 acres	1%
NV	No Vegetation	1.5 acres	3%
GF	Grassland/Forb Condition	2.2 acres	5%
SS	Shrub/Seedling-Sapling/Pole Condition	11.0 acres	24%
ST/D	Small Trees Condition/Deciduous	2.4 acres	5%
ST/C	Small Trees Condition/Coniferous	0.2 acres	1%
ST/M	Small Trees Condition/Mixed	5.8 acres	13%
LT/D	Large Trees Condition/Deciduous	5.0 acres	11%
LT/C	Large Trees Condition/Coniferous	7.0 acres	16%
LT/M	Large Trees Condition/Mixed	9.6 acres	21%
Total	**44.9 acres**		

Narrative:

The vegetation along the 10-meter buffer zone was comprised of about 92 percent woody vegetation that provides appropriate stream cover for thermal shading, leaf litter inputs, and connectivity between terrestrial and aquatic environments. Based on the criteria, the canopy cover was **Adequate** along the 10-meter buffer zone.

REFERENCES

Parenthetical Reference	Bibliographic Citation
Golder 2003	Golder and Associates. 2003. *Decision Framework for an Instream flow Workplan for Wenatchee Basin, Final Draft*.
Hillman 2006	Hillman, T. 2006. *Monitoring strategy for the Upper Columbia Basin, second draft report, August 2006*. Prepared for the Upper Columbia Salmon Recovery Board, Bonneville Power Administration, and National Marine Fisheries Service: BioAnalysts, Inc., Boise, Idaho, 98 pp.
Hillman and Giorgi 2002	Hillman, T. W. and A. E. Giorgi. 2002. *Monitoring protocols: effectiveness monitoring of physical/environmental indicators in tributary habitats*. BioAnalysts, Inc. Report to Bonneville Power Administration, Portland, Oregon.
Montgomery and Buffington 1993	Montgomery, D. R. and J. M. Buffington. 1993. Channel classification, prediction of channel response, and assessment of channel condition: Washington State Timber/Fish/Wildlife Agreement, TFW-SH10-93-002: Department of Natural Resources, Olympia, Washington.
Reclamation 2008	Bureau of Reclamation. 2008. *Nason Creek Tributary Assessment, Chelan County, Washington*. U.S. Department of the Interior, Bureau of Reclamation, Technical Service Center, Denver, Colorado and Pacific Northwest Regional Office, Boise, Idaho, 123 pp.
Reclamation 2009	Bureau of Reclamation. 2009. *Kahler Reach Assessment, Nason Creek, Chelan County, Washington*. U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Regional Office, Boise, Idaho, 116 pp.
USFS 1996	U.S. Forest Service. 1996. *Nason Creek watershed analysis*. U.S. Department of Agriculture, Lake Wenatchee Ranger District, Wenatchee National Forest, Wenatchee, Washington, 96 pp.
USFS 1998	U.S. Forest Service. 1998. *Biological assessment for steelhead, spring Chinook, bull trout and cutthroat trout in Nason Watershed, baseline condition and effects of ongoing activities, including recreation, effective December 1998*: U.S. Department of Agriculture, Lake Wenatchee Ranger District, Wenatchee National Forest, Wenatchee, Washington, 47 pp.
USFS 2006	U.S. Forest Service. 2006. *Draft – Fisheries Biological Assessment: Natapoc Ridge Forest Restoration Project, December 22, 2006*. U.S. Department of Agriculture, Lake Wenatchee Ranger District, Okanogan-Wenatchee National Forest, Wenatchee, Washington, 71 pp.

Parenthetical Reference	Bibliographic Citation
USFS 2008	U.S. Forest Service. 2008. *Draft Nason Creek focused watershed action plan (HUC 5th)*. U.S. Department of Agriculture, Lake Wenatchee Ranger District, Okanogan-Wenatchee National Forest, Wenatchee, Washington, September 2008.
USFS 2010	U.S. Forest Service. 2010. *Nason Creek Stream Survey RM 0-4.23*. U.S. Department of Agriculture, Okanogan-Wentachee National Forest, Wenatchee, Washington, December 2010.
USFWS 1998	U.S. Fish and Wildlife Service. 1998. "Matrix of physical/environmental pathways and indicators for east-side streams" in Hillman and Giogi, 2002, Appendix C.
WDOE 2005	Washington State Department of Ecology. 2005. Website: http://www.ecy.wa.gov/ecyhome.html
WDOE 2006	Washington State Department of Ecology. 2006. *Wenatchee River Basin dissolved oxygen, pH, and phosphorus Total Maximum Daily Load Study*.
WDOE 2010a	Washington State Department of Ecology. 2010a. Website: http://www.ecy.wa.gov/apps/watersheds/riv/station.asp?
WDOE 2010b	Washington State Department of Ecology. , 2010b. Website: http://www.ecy.wa.gov/programs/wq/tmdl/overview.html
Watershed Sciences 2003	Watershed Sciences. 2003. *Aerial surveys in the Wenatchee River Sub-Basin, Washington*. Report to Washington Department of Ecology, Olympia, Washington: Watershed Sciences, LLC, Corvallis, Oregon 20 p.

APPENDIX B

Stream Survey

This page intentionally left blank

2010 Nason Creek Stream Survey RM 0-4.23 funded by the BOR

12/30/2010

The first 4.23 miles of Nason Ck, (trib to the Wenatchee River) were surveyed from October 5-8, 2010, using the US Forest Service Region 6 stream survey protocol (USDA 2010). In 1996 a similar survey was conducted using essentially the same protocol. The 2010 and 1996 results are compared in table 1 and table 2 below:

Table 1. Nason Creek survey comparisons 1996 and 2010.

Year	Pool Area	Riffle Area	Side Channel Area as % of Main Channel Area	Side Channel Length as % of Main Channel Length	# Side Channels	Pieces LWD/Mile (>12"dia small end)	% LWD in side channels	Bank Erosion % (of both banks)	flow (cfs)	Survey Start Date
2010	72%	28%	10%	39%	10	88	30%	3%	69	5-Oct
1996	60%	40%	2%	17%	9	100	9%	18%	68	2-Aug

Table 2. Habitat unit dimensions 1996 and 2010 (units are feet).

Year	Unit Type	Av Length	Number	Av Wetted Width	Av Max Depth	Av Thalweg Depth
2010	P	360	47	56	5.3	
	R	258	21	71	2.4	1.5
	Total	328	68	61	4.4	
1996	P	305	49	55	4.4	
	R	293	26	72	3.1	1.4
	Total	301	75	61	3.9	

Table 3. Bankfull dimensions 1996 and 2010 (units are feet).

Year	Bankfull Width	Max BF Depth	Flood-prone Width	Entrench-ment Ratio	N
2010	90	3.7	148	1.7	3
1996	119	4.0	285	2.4	3

The stream has changed markedly over the 14 years between surveys. Pools and side channels have both increased in area. The stream has shifted portions of its channel, creating new side channels in the process. However most of the side channel increase is due to 2 restoration efforts over the last 7 years that reconnected approximately 5000' of old side channels/oxbows (side channels 2 and 8 in Figure 1) that had been cut off by Highway 207.

There were many uncountable riffles in the reach. A morphological unit needed to be longer than wide (except for plunge pools) to be countable. There were many instances where the riffle was oriented such that water flowing over the riffle was angled nearly 90 degrees to the bank. This resulted in riffles that might be 40' long and 135' wide, for example. A surveyor from the 1996 survey did not remember the same situation in 1996 so there may have been more such uncountable riffles in 2010 than in 1996. Table 2 compares pool/riffle dimensions between the 2 surveys.

Overall pool area increased from 60% to 72% of the main channel area while the average length of individual pools increased from 305' to 360'. The average max depth for pools is not comparable between years. In 1996 surveyors didn't try to estimate max pool depth if it was deeper than their 4' long measuring staff, while in 2010 they made estimates of max depth, the maximum of which was 10'in 5 pools. Riffles shrank in average length and total number and percent of the main channel area they occupied. The maximum riffle depth shows riffles shallowing between the 2 surveys but keeping the same average thalweg depth. The estimated widths are the same between years which is an indication of an unchanged wetted channel width at the same flows.

The large woody debris (lwd) numbers are approximately the same. A different lwd size classification was used in the 2 surveys so the lwd numbers are not directly comparable. The smallest sized piece that was counted in the 1996 had a minimum of a 12" diameter 25' from the large end while in 2010 the smallest size piece counted had a minimum of a 12" diameter 35' from the large end. This increase of 10' in length would result in fewer pieces counted in 2010 compared to 1996. More of the lwd was found in side channels in 2010. In both years a large portion of the lwd was found in a few huge jams, at least one of which was in the same location, possibly the same lwd pieces. In the largest jam in 2010 (labeled as "Megajam" in Figure 1 and the Arcmap project) almost all the 89 countable pieces (24% of the total lwd counted in the reach) were old and weathered enough that no bark remained. The lwd in 4 lwd jams represents 56% of the total lwd counted in the reach. In the unconstrained portions of the reach away from roads and campgrounds, lwd is being recruited through bank erosion toppling streamside trees. In one location several recently toppled huge trees span the entire channel, creating the potential for another channel spanning jam to develop.

The change in bank erosion between the 2 surveys is probably not due to an actual change but rather a different interpretation in what constitutes bank erosion. In 1996 any bare bank with fines in it was tallied as eroding, but in 2010 if a bare bank was vertical with no accumulation of fines at the base then it was not counted. There were thousands of feet of such vertical banks in 2010. In at least a few cases bare eroding areas in 1996 were being colonized with vegetation by 2010.

Given that only 3 bankfull measurements were taken each year in this reach, there is little confidence that bankfull channel geometry, shown in Figure 3, has actually changed.

Discussion

This reach of Nason Creek appears to be working through the sediment that was brought into the reach by the flood of record in 1995/1996. This process involves carving out much bigger (longer) pools and shrinking riffle area, average length and maximum depth. Average wetted width at the same flow has remained the same. Lwd abundance has remained approximately the same, with more of it found in side channels but still concentrated in a few habitat units. The biggest change is the dramatic increase in side channel length, most of which is the result of restoration work punching large culverts through Highway 207 to reconnect old channels.

Note: The property owner of the land bordering the lwd jam labeled “Channel spanning jam to be” in Figure 1 (also labled in the Arcmap project) should be contacted. There is an irrigation pump (labeled “Pump” in Figure 1 and Arcmap project) immediately upstream of the tangle of large channel spanning trees and many of the branches of the downed trees have already been trimmed off. We assume the property owner may be trimming branches to prevent pump damage or further property loss. Since the trees span the channel at a stream bend, further lwd accumulation and channel avulsion are likely to occur in the future if the downed trees remain in place. There may be an opportunity for the habitat committee to meet with the landowner and develop solutions that meet the landowner needs and maintain lwd function.

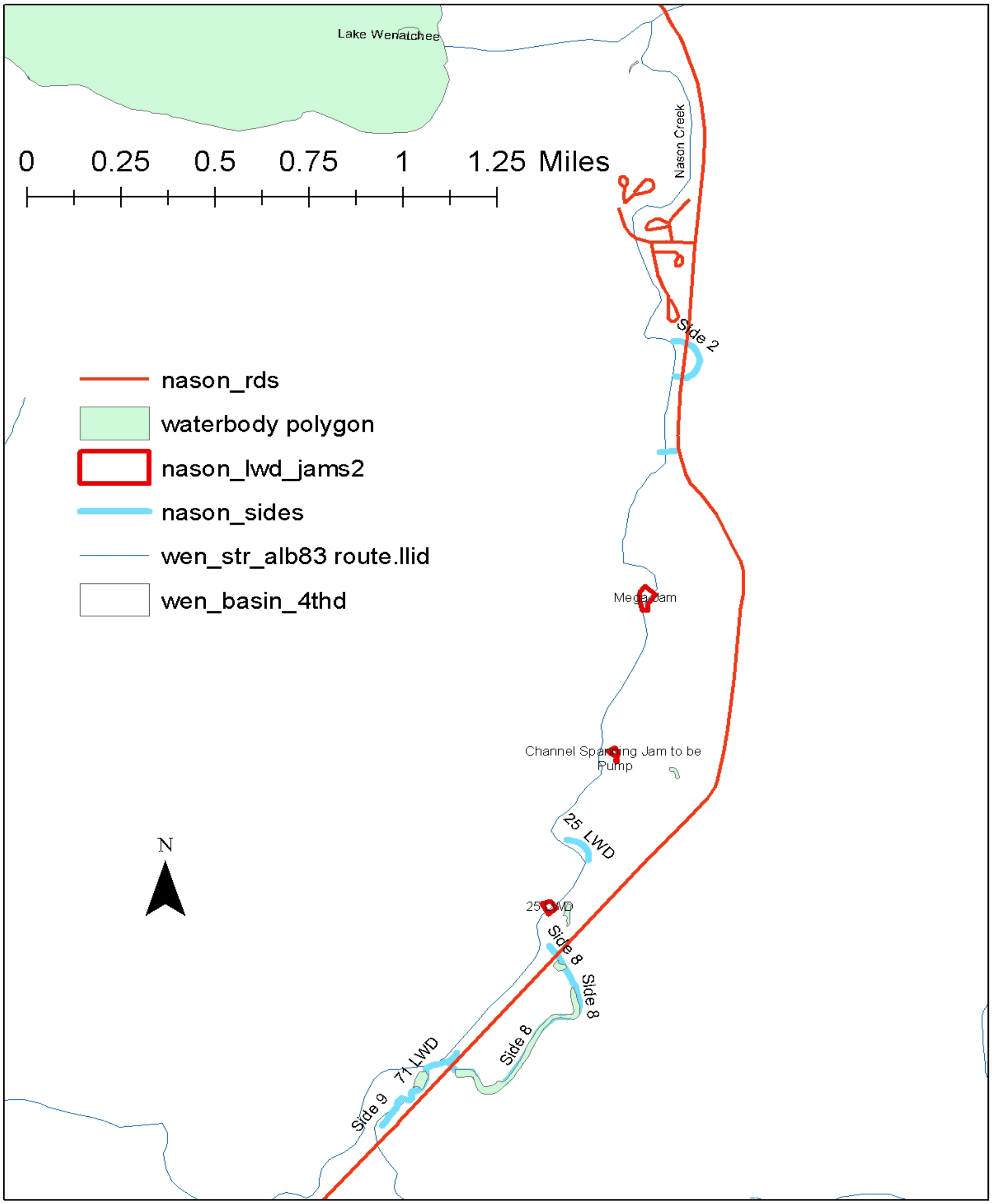

Figure 1. Map of 2010 surveyed portion of Nason Creek showing lwd accumulations, side channels and streamside roads.

APPENDIX C

Photographic Documentation

This page intentionally left blank

Appendix C

LOWER NASON PHOTOGRAPHIC LOG

Photographic documentation of the Lower Nason area was completed during the Fall 2010 in support of the document, *Lower Nason Assessment of Geomorphic and Ecologic Indicators, Nason Creek, Wenatchee Subbasin, Chelan County, Washington*. Photographs were taken in the field and their location and direction were noted on aerial photographs. The photopoints were then mapped using GIS and are provided in the Photograph Location Documentation section. Each photograph was then captioned including the direction of the photograph, subject matter, and date that are provided in the Photographic Documentation section.

PHOTOGRAPH LOCATION DOCUMENTATION

Aerial photographs showing photograph locations with respect to the subreaches and subreach complexes are provided in Figure 1 through Figure 5.

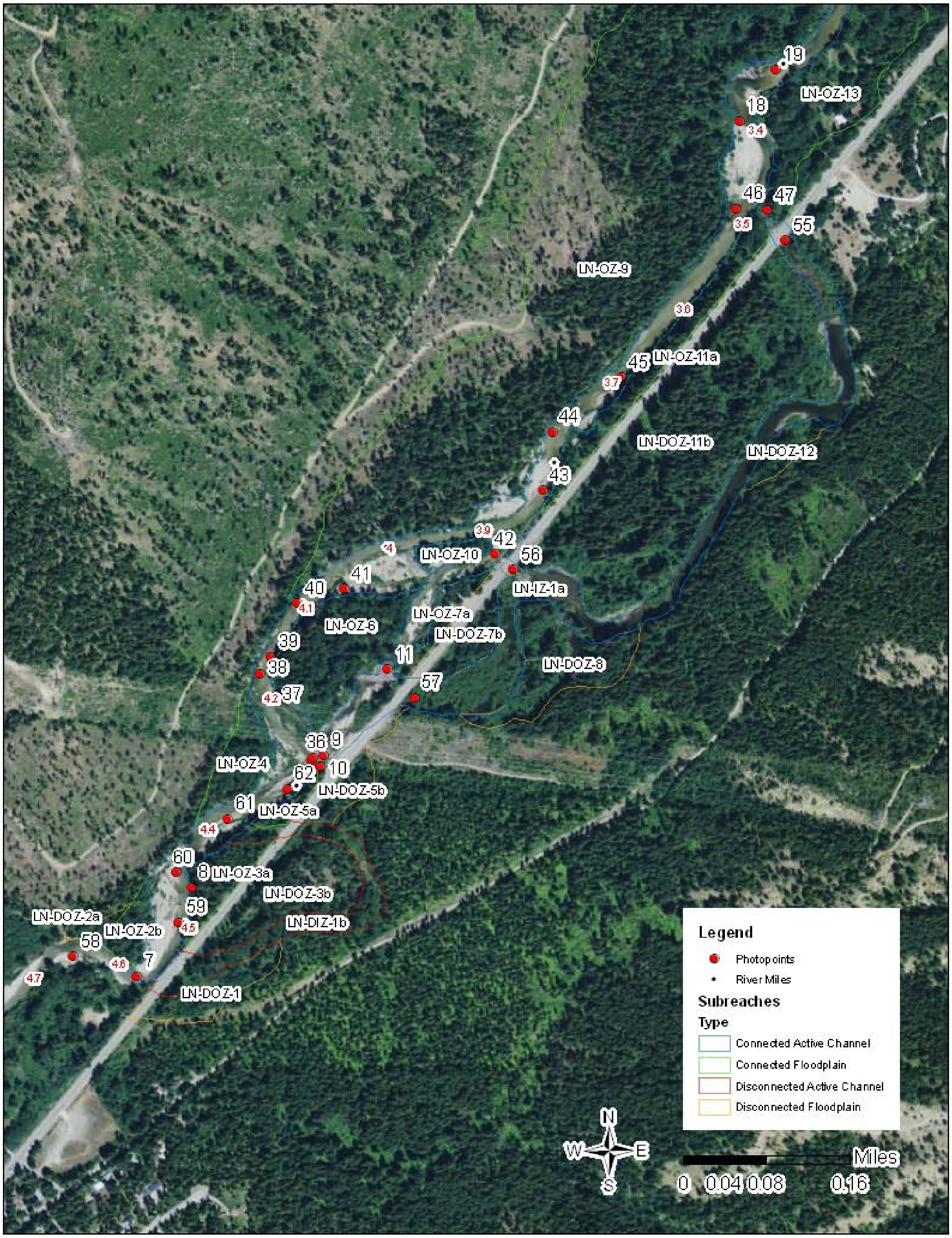

Figure 1. Photographic locations between RM 4.7 and 3.4.

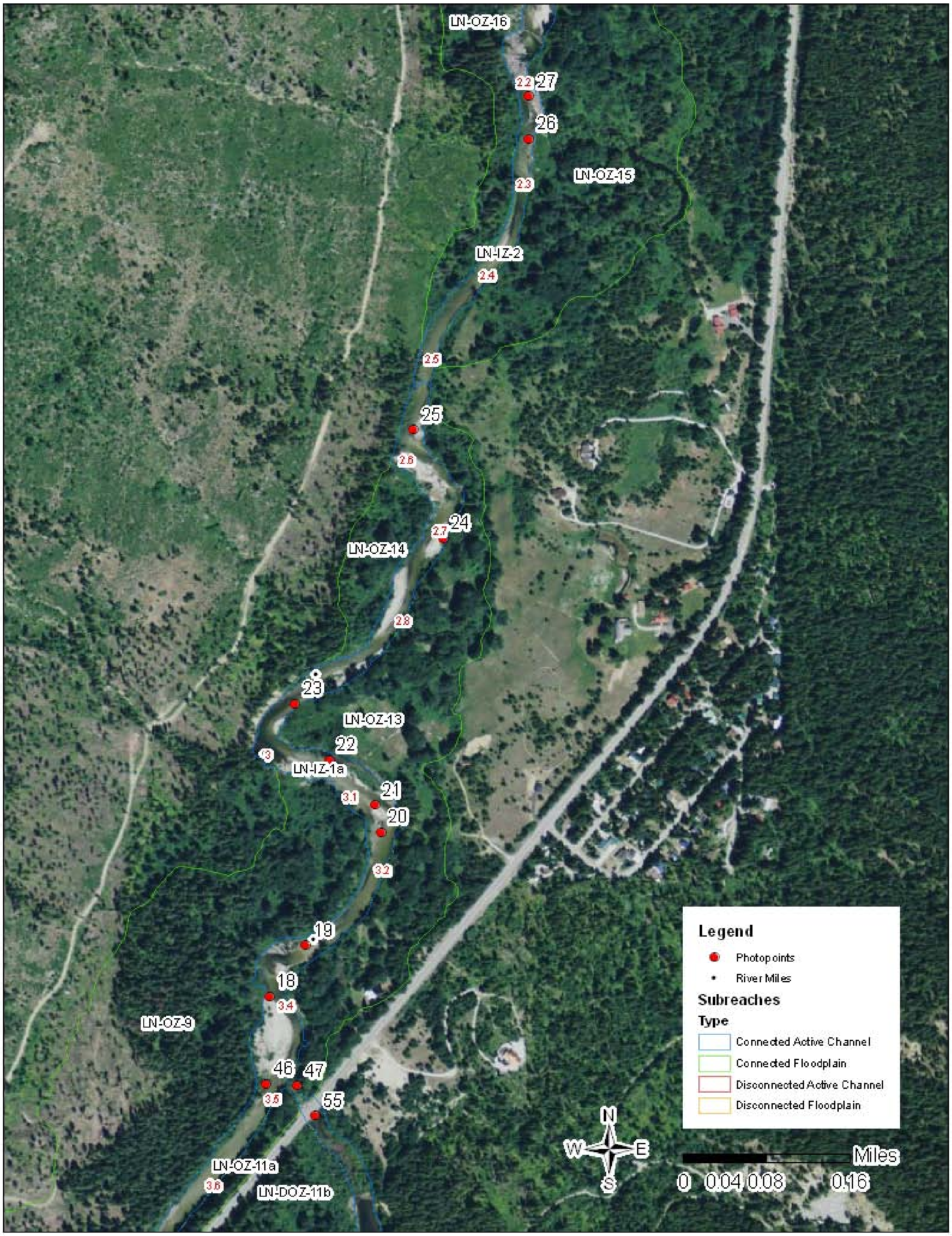

Figure 2. Photographic locations between RM 3.6 and 2.2.

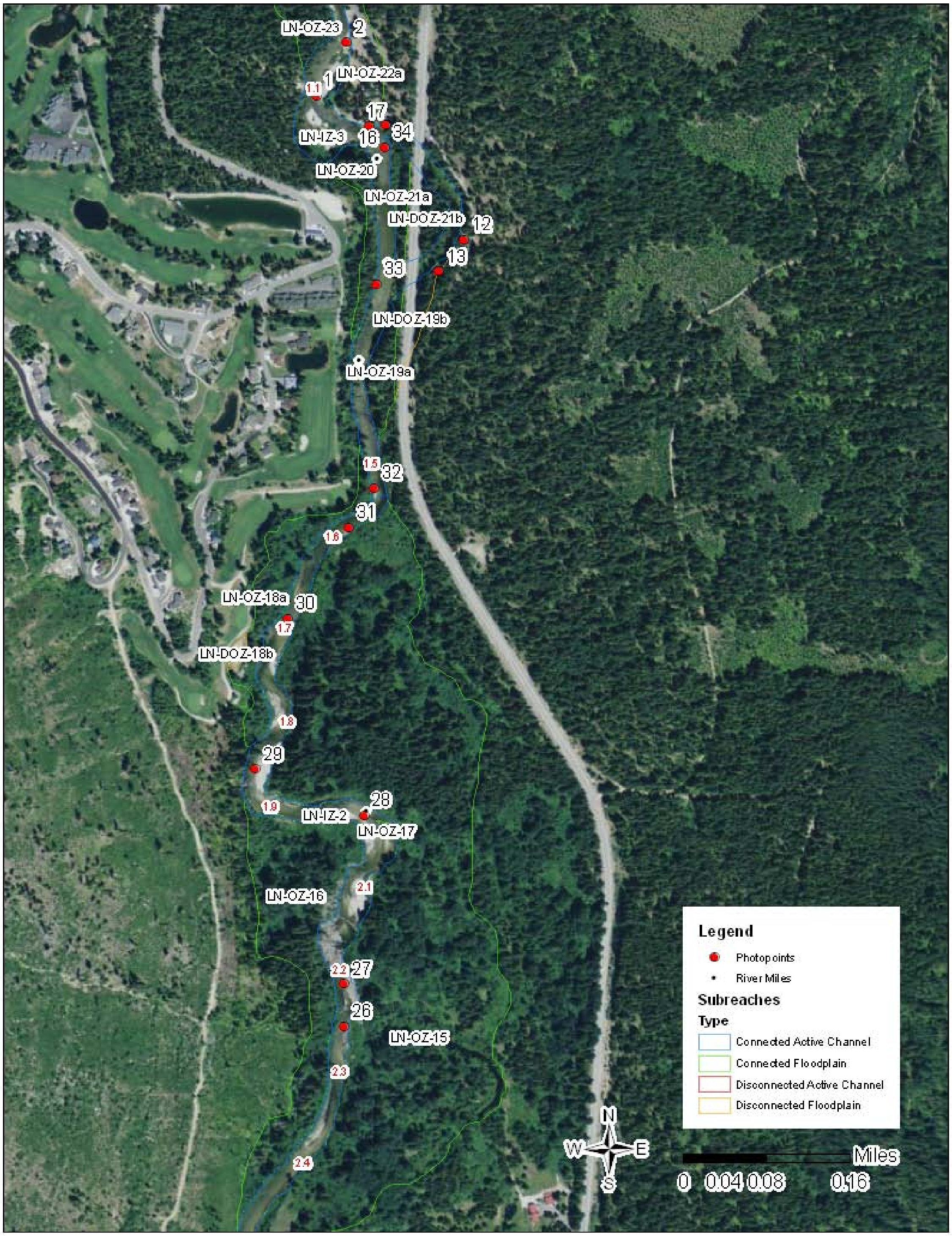

Figure 3. Photographic locations between RM 2.4 and 1.1.

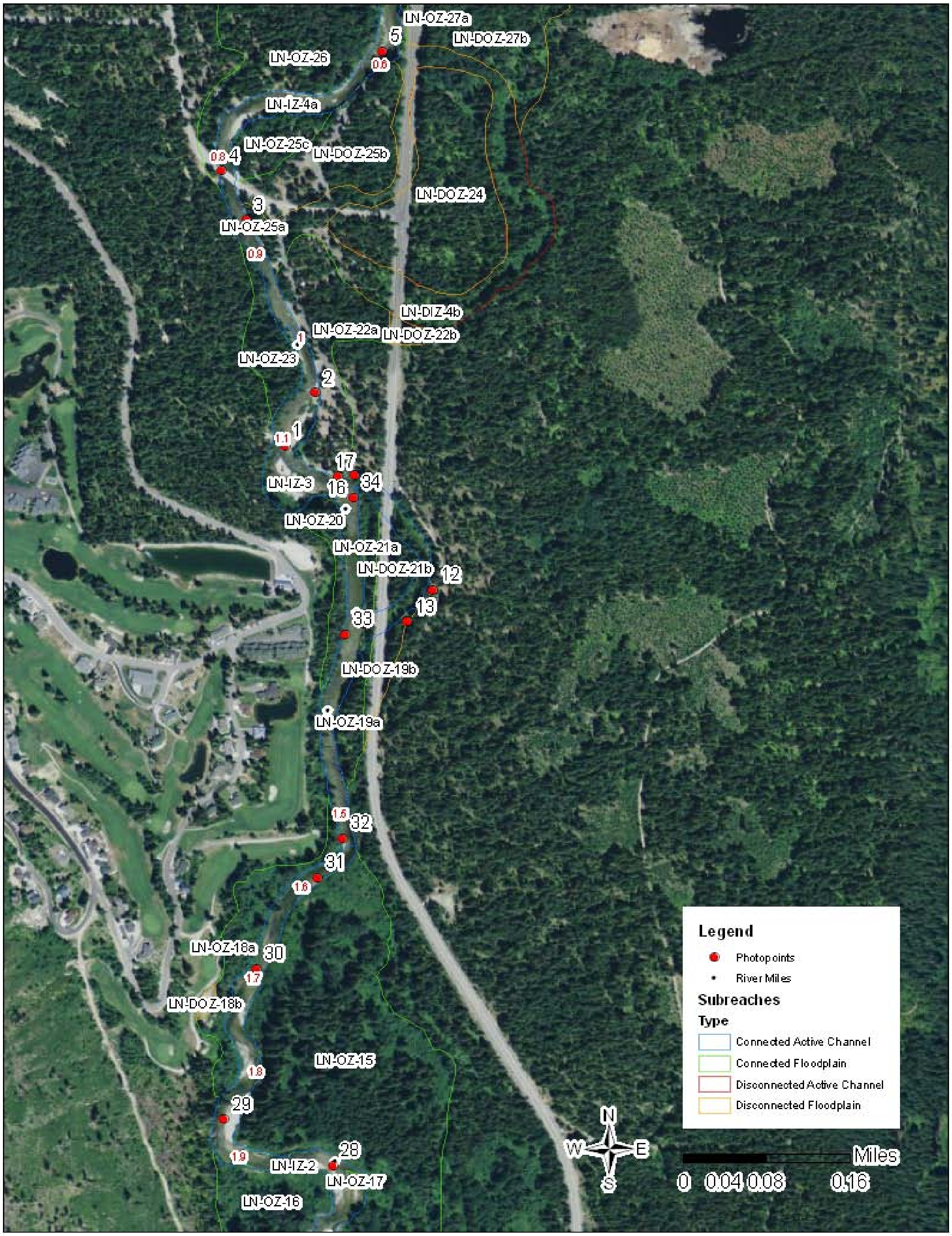

Figure 4. Photographic locations between RM 1.9 and 0.6.

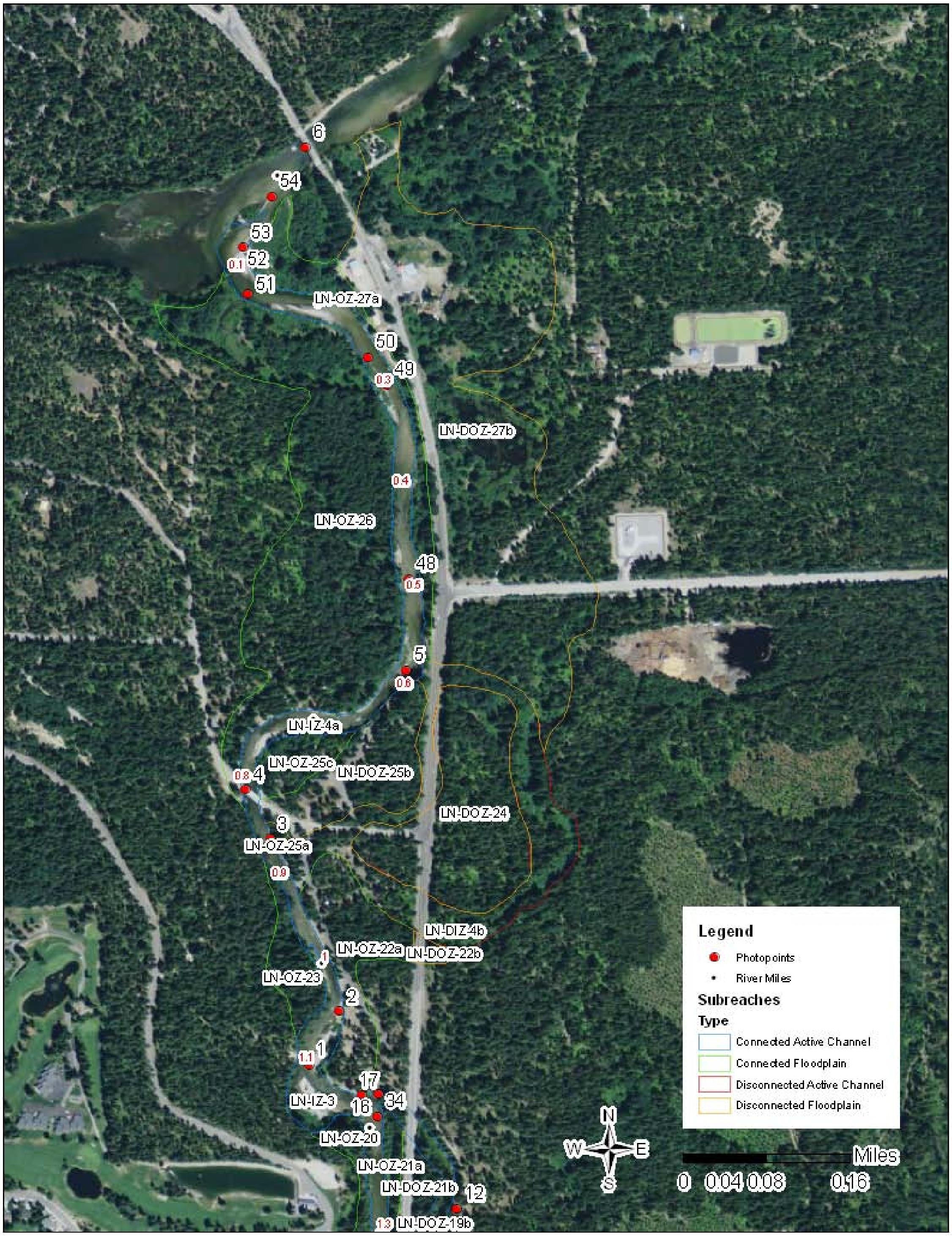

Figure 5. Photographic locations between RM 1.3 and 0.

PHOTOGRAPHIC DOCUMENTATION

Captioned photographs that correlate to the locations maps in the previous section are provided as Photograph No. 1 through Photograph No. 62.

Photograph No. 1. View to the northwest looking downstream at a slide contributing sand and gravel. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 13, 2010.

Photograph No. 2. View to the northeast looking downstream at riprap placed along river right. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 13, 2010.

Photograph No. 3. View to the north looking at bridge crossing with riprap protecting abutments and artificially confining the channel. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 13, 2010.

Photograph No. 4. View to the north looking from bridge crossing downstream at riprap protecting campground along river left. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 13, 2010.

Photograph No. 5. View to the northeast looking at bank erosion along river right that could threaten improved road. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 13, 2010.

Photograph No. 6. View to the southwest looking upstream at the confluence of Nason Creek and the Wenatchee River. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 13, 2010.

Photograph No. 7. View to the east looking downstream at riprap placed along river right protecting improved road. There is also a disconnected historic channel path behind the embankment. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 13, 2010.

Photograph No. 8. View to the north looking downstream at bedrock (Chumstick Formation) along river left that restricts lateral channel migration. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 13, 2010.

Photograph No. 9. View to the northeast looking downstream at large wood accumulating in side channel along river right. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 13, 2010.

Photograph No. 10. View to the northwest looking downstream where channel is deflected by large wood that is accumulating at the head of a side channel along river right. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 13, 2010.

Photograph No. 11. View to the southwest looking upstream at large wood accumulation in a side channel along river right. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 13, 2010.

Photograph No. 12. View to the northwest looking downstream at a reconnected side channel through an improved road embankment along river right. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 13, 2010.

Photograph No. 13. View to the west looking upstream at a culvert placed through improved road embankment to reconnect side channel along river right. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 13, 2010.

Photograph No. 14. View to the southwest looking at inlet to reconnected side channel through improved road embankment with redd and a spawning summer Chinook salmon. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 13, 2010.

Photograph No. 15. View to the east looking downstream at culvert placed through improved road embankment that reconnects side channel. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 13, 2010.

Photograph No. 16. View to the southeast looking upstream at culvert placed through improved road embankment that reconnects side channel. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 13, 2010.

Photograph No. 17. View to the south looking upstream from the outlet of reconnected side channel and pocket pool habitat along the mainstem of Nason Creek. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 13, 2010.

Photograph No. 18. View to the north looking downstream at a lateral scour pool forced by large wood accumulation along river left. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 14, 2010.

Photograph No. 19. View to the northeast looking downstream at a run and lateral scour pool forced by large wood accumulation along river left. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 14, 2010.

Photograph No. 20. View to the northeast looking downstream at a gravel bar-type side channel along river left. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 14, 2010.

Photograph No. 21. View to the northwest looking downstream at a gravel bar-type side channel along river left and eroding bank in the distance. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 14, 2010.

Photograph No. 22. View to the southeast looking upstream at a floodplain-type side channel along river right. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 14, 2010.

Photograph No. 23. View to the southwest looking upstream at an eroding glacial deposit overlying the Chumstick Formation along river left. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 14, 2010.

Photograph No. 24. View to the north looking at channel spanning large wood contributing to middle channel scour pool development. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 14, 2010.

Photograph No. 25. View to the north looking downstream at geologic confinement. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 14, 2010.

Photograph No. 26. View to the north looking downstream at large wood complex. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 14, 2010.

Photograph No. 27. View to the northwest looking downstream at a channel spanning large wood complex. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 14, 2010.

Photograph No. 28. View to the southeast looking upstream at a side channel along river right. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 14, 2010.

Photograph No. 29. View to the west looking at a landslide in glacial drift along river left. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 14, 2010.

Photograph No. 30. View to the northeast looking downstream at riffle and run channel units. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 14, 2010.

Photograph No. 31. View to the northeast looking downstream at glacial terrace on river right that restricts lateral channel migration. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 14, 2010.

Photograph No. 32. View to the north looking downstream at the confined channel segment that has a higher percentage of cobbles, boulders and gravel sediment. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 14, 2010.

Photograph No. 33. View to the east looking at a culvert that reconnects a historic channel path that was blocked by an improved road. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 14, 2010.

Photograph No. 34. View to the north looking downstream at pocket-pool habitat created by boulders. Also note riprap placed on the outside bend along river right in the distance. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 14, 2010.

Photograph No. 35. View to the southwest looking upstream at scour pool forced by large wood. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 15, 2010.

Photograph No. 36. View to the northeast looking downstream at large wood complex at head of side channel that may be contributing to bank erosion along river right. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 15, 2010.

Photograph No. 37. View to the southeast looking upstream at a floodplain-type side channel. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 15, 2010.

Photograph No. 38. View to the north looking downstream at bedrock (Chumstick Formation (Tc)) that restricts both lateral and vertical channel migration. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 15, 2010.

Photograph No. 39. View to the northwest looking at bedrock (Chumstick Formation (Tc)) in the channel that restricts vertical channel migration. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 15, 2010.

Photograph No. 40. View to the northeast looking downstream at cobble and boulder substrate downstream of bedrock control (refer to photographs 38 and 39). Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 15, 2010.

Photograph No. 41. View to the east looking at developing side channel. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 15, 2010.

Photograph No. 42. View to the east looking at culvert through improved road embankment that reconnects historic channel path. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 15, 2010.

Photograph No. 43. View to the north looking at lateral gravel bar and lateral scour pool along river right. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 15, 2010.

Photograph No. 44. View to the north looking at middle channel scour pool forced by large wood. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 15, 2010.

Photograph No. 45. View to the northeast looking at middle channel scour pool. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 15, 2010.

Photograph No. 46. View to the east looking at outlet of reconnected side channel. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 15, 2010.

Photograph No. 47. View to the east looking upstream at culvert through improved road embankment that reconnects historic channel path. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 15, 2010.

Photograph No. 48. View to the north looking downstream at riffle/pool sequence. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 16, 2010.

Photograph No. 49. View to the north looking downstream at riprap placed along river right. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 16, 2010.

Photograph No. 50. View to the south looking upstream at developing floodplain-type side channel. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 16, 2010.

Photograph No. 51. View to the north looking downstream at the confluence with the Wenatchee River. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 16, 2010.

Photograph No. 52. View to the west looking upstream along the Wenatchee River at the confluence with Nason Creek. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 16, 2010.

Photograph No. 53. View to the northeast looking at large wood complex along the Wenatchee River near the confluence with Nason Creek. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 16, 2010.

Photograph No. 54. View to the northeast looking at bridge crossing over the Wenatchee River downstream of the confluence with Nason Creek. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 16, 2010.

Photograph No. 55. View to the southeast looking upstream at reconnected historic channel path. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 16, 2010.

Photograph No. 56. View to the east looking downstream at reconnected historic channel path. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 16, 2010.

Photograph No. 57. View to the west looking at concrete culvert that poorly connects historic channel path through improved road embankment. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 16, 2010.

Photograph No. 58. View to the northwest looking at historic bridge abutment along river left. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 16, 2010.

Photograph No. 59. View to the north looking downstream at large wood and riffle. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 16, 2010.

Photograph No. 60. View to the north looking downstream at bedrock (Chumstick Formation (Tc)) that restricts both lateral and vertical channel migration. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 16, 2010.

Photograph No. 61. View to the northeast looking downstream at large wood complex in the distance. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 16, 2010.

Photograph No. 62. View to the northeast looking downstream at lateral scour pool along river right and large wood complex. Lower Nason Creek, Wenatchee Subbasin, Washington – Bureau of Reclamation Photograph by E. Lyon, September 16, 2010.

This page intentionally left blank

APPENDIX D

GIS Databases

Appendix D

GIS Databases

The Lower Nason Reach GIS (Geographic Information System) File Geodatabase was produced in support of the document, *Lower Nason Assessment of Geomorphic and Ecologic Indicators, Nason Creek, Wenatchee Subbasin, Chelan County, Washington*. More file geodatabases at the valley segment spatial scale are contained in the *Nason Creek Tributary Assessment, Chelan County, Washington (Reclamation, 2008)*.

The ***LN_BaselineAssessment*** File Geodatabase includes multiple feature classes:

Feature Classes	Description
LN_Geology	Surficial geology (polygon)
LN_ValleyBotWidth	Valley bottom width measurements (polyline)
LN_ChanSeg	Channel segment delineations (polyline)
LN_ChanWidth	Channel width measurements (polyline)
LN_Perimeter	Perimeter of assessment area (polygon)
LN_ActChanPerimeter	Perimeter of active channel (polygon)
LN_Vegetation 2006	Vegetation structure (2006) (polygon)
LN_Subreaches	Subreach and subreach complexes (polygon)
LN_2006ChanAlign	Channel alignment (2006) (polyline)
LN_2009ChanAlign	Channel alignment (2009) (polyline)
LN_2009WetChan	Wetted channel area (2009) (polygon)
LN_ChannelUnits 2010	Mapped channel units (2010) (polygon)
LN_Human Features_Line	Linear anthropogenic features (polyline)
LN_Human Features_Point	Location of anthropogenic features (point)
LN_LW Complex_Point	Location of wood complexes (point)
LN_LWC2006	Area of wood complexes (2006) (polygon)
LN_LWC2009	Area of wood complexes (2009) (polygon)
LN_Photopoint	Location of photographs (point)
Floodplain Vegetation 2006	Floodplain vegetation structure (2006) (polygon)
Vegetation 10m Buffer 2006	Vegetation 10m buffer zone (polygon)
Vegetation 30m buffer zone	Vegetation 30m buffer zone (polygon)
LN-ChanLength	Channel length (2009) (polyline)
LN_HypoChanAlign	Hypothetical channel alignment (polyline)
LN_ValleyLength	Valley length (polyline)

For more information or to request a copy of the ***LN_BaselineAssessment*** geodatabase and other pertinent geographic information system data (including USFS geodatabase ***LN_USFS Stream Inventory 2010*** for this assessment) on DVD, contact Reclamation GIS staff at the Reclamation's Pacific Northwest Regional Office, gen-PNR-GeoData@usbr.gov.

Lower Nason Assessment of Geomorphic and Ecologic Indicators, Geodatabase Files

Project Feature Classes

<u>Feature Class – LN_Geology</u>
Title – LN_Geology: This feature class was created for the *Lower Nason Environmental Baseline Assessment, Wenatchee Subbasin, Chelan County, Washington*
Keywords – Surficial Geology
Abstract – A composite map of prominent geologic features were mapped using a LiDAR hillshade elevation model. Data used for the map was from Tabor et al., 1987, Geologic map of the Chelan 30-minute by 60-minute quadrangle, Washington: US Geological Survey Map I1661, and field observations.

Surficial geology was mapped by Edward W. Lyon, Jr., L.G. (Pacific Northwest Regional Office, Boise, Idaho) using the citation listed above and incorporating them into GIS.

<u>Feature Class – LN_ValleyBotWidth</u>
Title – LN_ValleyBotWidth: This feature class was created for the *Lower Nason Environmental Baseline Assessment, Wenatchee Subbasin, Chelan County, Washington*
Keywords – Valley bottom width
Abstract – The valley bottom width was delineated in several strategic locations based on the geologic constraints (i.e., valley walls, alluvial fans, glacial terraces) in ArcGIS.

The valley bottom width was delineated by Edward W. Lyon, Jr., L.G. (Pacific Northwest Regional Office, Boise, Idaho) using the lower Nason geology shapefile (LN_Geology).

<u>Feature Class – LN_ChanSeg</u>
Title – LN_ChanSeg: This feature class was created for the *Lower Nason Assessment of Geomorphic and Ecologic Indicators, Nason Creek, Wenatchee Subbasin, Chelan County, Washington*
Keywords – Channel Segment
Abstract – The channel segments are delineated based on valley confinement. These are distinct areas comprised of the floodplain and active channel areas. They are delineated by lateral controls and processes with respect to position and elevation.

Geographic boundaries were mapped by Edward W. Lyon, Jr., L.G. (Pacific Northwest Regional Office, Boise, Idaho) using field observations and incorporating them into GIS.

<u>Feature Class – LN_ChanWidth</u>
Title – LN_ChanWidth: This feature class was created for the *Lower Nason Assessment of Geomorphic and Ecologic Indicators, Nason Creek, Wenatchee Subbasin, Chelan County, Washington*
Keywords – Channel Width

Abstract – The channel widths were remotely mapped on the 2006 LiDAR hillshade elevation model. The channel widths are used in conjunction with valley bottom widths to determine the degree of channel confinement.

The geographic boundaries were mapped by Edward W. Lyon, Jr., L.G. (Pacific Northwest Regional Office, Boise, Idaho).

<u>Feature Class – LN_Perimeter</u>
Title – LN_Perimeter: This feature class was created for the *Lower Nason Assessment of Geomorphic and Ecologic Indicators, Nason Creek, Wenatchee Subbasin, Chelan County, Washington*
Keywords – Perimeter
Abstract – Perimeter of the Lower Nason area. The geographic boundaries were mapped by Edward W. Lyon, Jr., L.G. (Pacific Northwest Regional Office, Boise, Idaho).

<u>Feature Class – LN_ActChanPerimeter</u>
Title – LN_ActChanPerimeter: This feature class was created for the *Lower Nason Assessment of Geomorphic and Ecologic Indicators, Nason Creek, Wenatchee Subbasin, Chelan County, Washington*
Keywords – Active channel
Abstract – The active channel perimeter of the assessment area. The geographic boundaries were mapped by Edward W. Lyon, Jr., L.G. (Pacific Northwest Regional Office, Boise, Idaho) using field observations and incorporating them into GIS.

<u>Feature Class – LN_Vegetation 2006</u>
Title – LN_Vegetation 2006: This feature class was created for the *Lower Nason Assessment of Geomorphic and Ecologic Indicators, Nason Creek, Wenatchee Subbasin, Chelan County, Washington*
Keywords – Vegetation
Abstract – The vegetation was evaluated by mapping the overstory, middle story, understory and areas with no vegetation using the 2006 aerial photographs.

The vegetation boundaries were mapped by Edward W. Lyon, Jr., L.G. (Pacific Northwest Regional Office, Boise, Idaho) remotely with very limited field observations.

<u>Feature Class – LN_Subreaches</u>
Title – LN_Subreaches: This feature class was created for the *Lower Nason Assessment of Geomorphic and Ecologic Indicators, Nason Creek, Wenatchee Subbasin, Chelan County, Washington*
Keywords – Subreaches
Abstract – The subreaches and subreach complexes are distinct areas comprised of the floodplain and active channel areas. They are delineated by lateral and vertical controls and processes with respect to position and elevation.

The geographic boundaries were mapped by Edward W. Lyon, Jr., L.G. (Pacific Northwest Regional Office, Boise, Idaho) using field observations and incorporating them into GIS.

Feature Class – LN_2006ChanAlign
Title – LN_2006ChanAlign: This feature class was created for the *Lower Nason Assessment of Geomorphic and Ecologic Indicators, Nason Creek, Wenatchee Subbasin, Chelan County, Washington*
Keywords – 2006 Channel Alignment
Abstract – The 2006 channel alignment was delineated using 2006 ortho-photographs and LiDAR hillshade elevation model. The 2006 channel alignment was drawn by Edward W. Lyon, Jr., L.G. (Pacific Northwest Regional Office, Boise, Idaho) using the lower Nason 2006 rectified aerial photographs.

Feature Class – LN_2009ChanAlign
Title – LN_2009ChanAlign: This feature class was created for the *Lower Nason Assessment of Geomorphic and Ecologic Indicators, Nason Creek, Wenatchee Subbasin, Chelan County, Washington*
Keywords – 2009 Channel Alignment
Abstract – The 2009 channel alignment was delineated using 2009 aerial photographs and LiDAR hillshade elevation model. The 2009 channel alignment was drawn by Edward W. Lyon, Jr., L.G. (Pacific Northwest Regional Office, Boise, Idaho) using the lower Nason 2009 rectified aerial photographs.

Feature Class – LN_2009WetChan
Title – LN_2009WetChan: This feature class was created for the *Lower Nason Assessment of Geomorphic and Ecologic Indicators, Nason Creek, Wenatchee Subbasin, Chelan County, Washington*
Keywords – 2009 Wetted Channel
Abstract – The 2009 wetted channel was drawn using 2009 aerial photographs and field observations in ArcGIS. The 2009 wetted channel was drawn by Edward W. Lyon, Jr., L.G. (Pacific Northwest Regional Office, Boise, Idaho) using the lower Nason 2009 rectified aerial photographs.

Feature Class – LN_ChannelUnits 2010
Title – LN_ChannelUnits 2010: This feature class was created for the *Lower Nason Assessment of Geomorphic and Ecologic Indicators, Nason Creek, Wenatchee Subbasin, Chelan County, Washington*
Keywords – Channel units
Abstract – Channel units are mapped in the field on the most recent available aerial photographs and the data is delineated in ArcGIS. Channel units are interpreted based on the fluvial processes that created them, regardless of the low-flow conditions in which they were observed in the field (modified from USDA, 2008). These geomorphic channel units differ from “habitat units” in that habitat units are interpreted in the field by biologists at low-flow conditions to document what habitat is available during these low-flow conditions. Habitat units typically describe physical attributes of channel units at one point in time based on biotic life stage needs. Geomorphic channel units describe those physical attributes related to the stream processes that create and maintain them over time. While the basic parameters are similar, the evaluation of the individual unit attributes is not the same nor is the applicability of the information to alternative development, evaluation and implementation. The habitat units describe the what and the geomorphic channel units represents the why and how.

The geographic boundaries were mapped by Edward W. Lyon, Jr., L.G. (Pacific Northwest Regional Office, Boise, Idaho) using field observations and incorporating them into GIS.

Feature Class – LN_Human Features_Line
Title – LN_Human Features_Line: This feature class was created for the *Lower Nason Assessment of Geomorphic and Ecologic Indicators, Nason Creek, Wenatchee Subbasin, Chelan County, Washington*
Keywords – Human features, Anthropogenic features
Abstract – Anthropogenic features are mapped in the field on the most recent aerial photographs and the data is delineated in ArcGIS. Feature class includes lines representing levees and roads, etc. The attribute table contains several fields including type of feature, length, etc. The geographic boundaries were mapped by Edward W. Lyon, Jr., L.G. (Pacific Northwest Regional Office, Boise, Idaho) using field observations and incorporating them into GIS.

Feature Class – LN_Human Features_Point
Title – LN_Human Features_Point: This feature class was created for the *Lower Nason Assessment of Geomorphic and Ecologic Indicators, Nason Creek, Wenatchee Subbasin, Chelan County, Washington*
Keywords – Human features, Anthropogenic features
Abstract – Anthropogenic features are mapped in the field on the most recent aerial photographs and the data is delineated in ArcGIS. Feature class includes points representing culvert locations, staff gages, pumps, etc. The geographic boundaries were mapped by Edward W. Lyon, Jr., L.G. (Pacific Northwest Regional Office, Boise, Idaho) using field observations and incorporating them into GIS.

Feature Class – LN_LW Complex_Point
Title – LN_LW Complex_Point: This feature class was created for the *Lower Nason Environmental Baseline Assessment, Wenatchee Subbasin, Chelan County, Washington*
Keywords – Large Wood Complexes
Abstract – Locations of large wood complexes were mapped remotely in ArcGIS on the most recent aerial photographs. The large wood complex locations were mapped by Edward W. Lyon, Jr., L.G. (Pacific Northwest Regional Office, Boise, Idaho) remotely using ArcGIS.

Feature Class – LN_LWC2006
Title – LN_LWC2006: This feature class was created for the *Lower Nason Assessment of Geomorphic and Ecologic Indicators, Nason Creek, Wenatchee Subbasin, Chelan County, Washington*
Keywords – Large Wood Complexes
Abstract – Aerial extent of large wood complexes near RM 2.2 and in a side channel on river right near RM 4.28 were mapped remotely in ArcGIS using 2006 ortho-photographs. The large wood complexes were mapped by Edward W. Lyon, Jr., L.G. (Pacific Northwest Regional Office, Boise, Idaho) remotely using ArcGIS.

<u>Feature Class – LN_LWC2009</u>
Title – LN_LWC2006: This feature class was created for the *Lower Nason Assessment of Geomorphic and Ecologic Indicators, Nason Creek, Wenatchee Subbasin, Chelan County, Washington*
Keywords – Large Wood Complexes
Abstract – Aerial extent of large wood complexes near RM 2.2 and in a side channel on river right near RM 4.28 were mapped remotely in ArcGIS using 2009 ortho-photographs. The large wood complexes were mapped by Edward W. Lyon, Jr., L.G. (Pacific Northwest Regional Office, Boise, Idaho) remotely using ArcGIS.

<u>Feature Class – LN_Photopoint</u>
Title – LN_LWC2006: This feature class was created for the *Lower Nason Assessment of Geomorphic and Ecologic Indicators, Nason Creek, Wenatchee Subbasin, Chelan County, Washington*
Keywords – Photopoint, Photograph locations
Abstract – Point locations of photographs taken during the field inventory are noted on the most recent available ortho-photographs and the locations are delineated in ArcGIS. Photographs are used to visually document baseline conditions and to provide basis for compliance monitoring. Each photograph is captioned and includes the direction of the photograph and the subject matter. The photographs and captions were done by Edward W. Lyon, Jr., L.G. (Pacific Northwest Regional Office, Boise, Idaho).

<u>Feature Class – Floodplain Vegetation 2006</u>
Title – Floodplain Vegetation 2006: This feature class was created for the *Lower Nason Assessment of Geomorphic and Ecologic Indicators, Nason Creek, Wenatchee Subbasin, Chelan County, Washington*
Keywords – Vegetation, Nason Creek
Abstract – The floodplain analysis was completed by “clipping” the Floodplain Vegetation 2006 shapefile to the LN_Vegetation 2006 shapefile. The resulting shapefile was then clipped using the LN_ActChanPerimeter shapefile to remove the active channel area. The attribute table from this resulting shapefile was used to determine acreage and percentages of floodplain vegetation. The analysis was done by Edward W. Lyon, Jr., L.G. with support from the Pacific Northwest Regional Office GIS Group (Boise, Idaho).

<u>Feature Class – Vegetation 10m Buffer 2006</u>
Title – Vegetation 10m Buffer 2006: This feature class was created for the *Lower Nason Assessment of Geomorphic and Ecologic Indicators, Nason Creek, Wenatchee Subbasin, Chelan County, Washington*
Keywords – Vegetation
Abstract – The vegetation 10m buffer zone analysis was completed by creating a 10 meter border around the active channel (LN_ActChanPerimeter) and then clipping to the LN_Vegetation 2006 shapefile. The attribute table from this resulting shapefile was used to determine acreage and percentages of the 10m buffer zone. The analysis was done by Edward W. Lyon, Jr., L.G. with support from the Pacific Northwest Regional Office GIS Group (Boise, Idaho).

<u>Feature Class – Vegetation 30m Buffer 2006</u>
Title – Vegetation 30m Buffer 2006: This feature class was created for the *Lower Nason Assessment of Geomorphic and Ecologic Indicators, Nason Creek, Wenatchee Subbasin, Chelan County, Washington*
Keywords – Vegetation
Abstract – The vegetation 30m buffer zone analysis was completed by creating a 30 meter border around the active channel (LN_ActChanPerimeter) and then clipping to the LN_Vegetation 2006 shapefile. The attribute table from this resulting shapefile was used to determine acreage and percentages of the 30m buffer zone. The analysis was done by Edward W. Lyon, Jr., L.G. with support from the Pacific Northwest Regional Office GIS Group (Boise, Idaho).

<u>Feature Class – LN_ChanLength</u>
Title – LN_ChanLength: This feature class was created for the *Lower Nason Assessment of Geomorphic and Ecologic Indicators, Nason Creek, Wenatchee Subbasin, Chelan County, Washington*
Keywords – Channel Length
Abstract – The 2009 channel alignment was mapped remotely using 2009 aerial photographs. The geographic alignment was mapped by Edward W. Lyon, Jr., L.G. (Pacific Northwest Regional Office, Boise, Idaho).

<u>Feature Class – LN_HypoChanAlign</u>
Title – LN_HypoChanAlign: This feature class was created for the *Lower Nason Assessment of Geomorphic and Ecologic Indicators, Nason Creek, Wenatchee Subbasin, Chelan County, Washington*
Keywords – Hypothetical Channel Alignments
Abstract – The hypothetical channel alignments were interpreted from the 2006 Light Detection and Ranging (LiDAR) hillshade elevation model and USGS topographic maps. This alignment was used to evaluate the possible historic alignment prior to anthropogenic disturbances. The hypothetical channel alignments were interpreted and drawn by Edward W. Lyon, Jr., L.G. (Pacific Northwest Regional Office, Boise, Idaho).

<u>Feature Class – LN_ValleyLength</u>
Title – LN_Valley Length: This feature class was created for the *Lower Nason Assessment of Geomorphic and Ecologic Indicators, Nason Creek, Wenatchee Subbasin, Chelan County, Washington*
Keywords – Valley Length
Abstract – The valley length was drawn near the centerline of the valley based on the geologic constraints (i.e. valley walls, alluvial fans, glacial terraces). The valley length was drawn by Edward W. Lyon, Jr., L.G. (Pacific Northwest Regional Office, Boise, Idaho).