Design Report

Nason Creek Oxbow Reconnection Project ■ Chelan County Natural Resource Department
July 2006

Jones & Stokes

Nason Creek Oxbow Reconnection Project
Design Report

Prepared for:

Chelan County Natural Resource Department
316 Washington Street, Suite 401
Wenatchee, WA 98801
Contact: Mike Kaputa, Director

Prepared by:

Jones & Stokes

11820 Northup Way, Suite E300
Bellevue, WA 98005
Contact: John M. Soden
425/822-1077

July 2006

This document should be cited as:
Jones & Stokes. 2006. Nason Creek Oxbow Reconnection Project- Design Report. July. Prepared for the Chelan County Natural Resource Department (J&S 05750.05) Bellevue, WA.

Table of Contents

List of Tables

List of Figures

Appendices

Chapter 1. Introduction

This report presents the 35% construction plans and supporting analysis for the Nason Creek Oxbow Reconnection Project (Nason Oxbow Project) as proposed by the Chelan County Natural Resource Department (CCNRD). The purpose of this project is to improve habitat for salmonid species listed under the federal Endangered Species Act (ESA) which occur in the Wenatchee River watershed by addressing those limiting biological and habitat factors that persist there. The 35% plans are intended to present sufficient detail in grading plans, planting schemes, and habitat structural placement, and to provide an understanding of project details.

Past construction of the two-lane State Route (SR) 207 redirected a portion of Nason Creek, physically and hydrologically disconnecting a large oxbow. The Nason Oxbow Project proposes to install two 12-foot diameter fish-friendly culverts within SR 207 to reconnect 34.51 acres of historic Nason Creek aquatic habitat to the Nason Creek main channel. This area includes, including 21.7 acres of off-channel refuge, rearing, and over-wintering habitat for juvenile salmonids and other species plus an additional 12.81 acres of forested and shrub-wetland located along side the oxbow.

This project is funded by CCNRD and a Salmon Recovery Fund Board (SRFB) grant. This habitat restoration project incorporates recommendations from Wenatchee watershed planning and regional salmon recovery planning efforts and is part of a regional commitment by Chelan County to initiate long-term habitat protection and restoration efforts within the Wenatchee River subbasin for ESA-listed species. No other actions or activities are connected or otherwise associated with this habitat restoration project.

This document will be presented to local, state, and federal permitting agencies to describe this restoration project. Revisions to this document will be incorporated during meetings with state and local permitting agencies and as additional data is collected to support more detailed construction plans and specifications.

This report provides the following analysis:

- A discussion of the existing biological, hydrologic, and geomorphic site conditions (Chapter 2);
- Detailed analysis of the proposed action (Chapter 3);
- Design and construction details (Chapter 4); and

- 35% construction plans (Appendix A).

The following chapters include discussions outlining the project history and purpose, which precede a detailed description of existing conditions.

The following table lists points of contact for the permitting agencies and for the project proponent.

Table 1-1. Contacts

Agency/Firm	Role	Contact Name	Phone/e-mail	Address
Chelan County Natural Resource Department	Project Proponent	Mike Kaputa	509-667-6584 mike.kaputa@co.chelan.wa.us	411 Washington St. Wenatchee, WA 98801
Jones & Stokes	Design, report preparation	John Soden (project manager), Chris Soncarty (fisheries biologist)	425-893-6405 jsoden@jsanet.com 425-893-6407 csoncarty@jsanet.com	11820 Northup Way Suite E300 Bellevue, WA 98005
Washington State Department of Transportation	Project Review	Bill Gould, P.E. Assistant Planning Engineer	509.667.2909 gouldw@wsdot.wa.gov	P.O. Box 98 Wenatchee, WA 98807

1.1. Project History

In the late 1990s, three fish species which depend upon habitats within the Wenatchee River subbasin (Watershed Resource Inventory Area 45) were listed as threatened or endangered under the federal ESA. They are:

- The Upper Columbia River Spring-Run Chinook Salmon Evolutionarily Significant Unit (ESU) (endangered);
- The Upper Columbia River Summer-Run Steelhead ESU (endangered); and
- The Columbia River Bull Trout Distinct Population Segment (DPS) (threatened).

CCNRD currently administers watershed planning and salmon recovery efforts in Chelan County, including efforts in the Wenatchee River watershed. In 2001, CCNRD was awarded a grant from the SRFB to conduct the lower Wenatchee River Channel Migration Zone Study (CMZ Study) (Jones & Stokes 2004). The purpose of the CMZ Study was to provide the technical foundation to allow the selection and prioritization of salmonid habitat restoration, enhancement, and preservation project.

The Nason Oxbow Project site was one of 26 project sites identified for potential restoration, enhancement, or preservation actions in the CMZ Study (Jones & Stokes 2004a). At the request of CCNRD, Jones & Stokes conducted a site prioritization of the top 10 CMZ Study project sites based upon design and construction feasibility and risk factors (Jones & Stokes 2004b). Subsequently, the Nason Oxbow Project site ranked number one among these sites based upon the high design feasibility, very low risk to infrastructure, cost, and biological benefit. Thus, the Nason Oxbow Project has become the top priority within CCNRD for salmonid restoration within lower Nason Creek.

As a result of these factors, an agreement between the Washington State Department of Transportation (WSDOT) and CCNRD was reached which allows CCNRD to begin work on construction plans for the installation of two culverts to reconnect partial flows and allow full fish access from Nason Creek to the historic oxbow habitat; this access is currently cut off by SR 207.

1.2. Project Purpose

The purpose of this project is to provide juvenile salmonid (Chinook, steelhead, and sockeye) high-flow refuge and year-round foraging habitat, as well as deep-water overwintering habitat. The Nason Oxbow Project will result in the reconnection of off-channel oxbow habitat by hydrologically connecting an existing oxbow to the main channel of Nason Creek. This project will directly address the habitat limiting factors affecting salmonid production in Nason Creek as described below.

Within the lower Nason Creek, the largest impact on fish has been from human activities occurring outside of the main channel. The construction of roads, highways, and railroads has resulted in the disconnection of off-channel habitat and floodplain, and an increase in instream sedimentation (Andonaegui 2001).

The confinement of Nason Creek through roads, highways, and railroads has cut off approximately 400 acres of side channels and oxbows, and altered channel form (width:depth), resulting in a semi-braided system with severe aggradation. In addition, it has reduced large woody debris (LWD) input, instream cover, instream habitat complexity, streambank stability, and temperature regulation. Today, Nason Creek has approximately 25% as much side-channel habitat as nearby reference reaches (Andonaegui 2001), and within the lower 4 miles of Nason Creek, only 3% of the historic off-channel habitat remains (e.g., ponds, sloughs, and standing water). There has also been an 11% loss of riparian floodplain habitat and a 21% loss of backchannel connectivity (Jones & Stokes 2003, Northwest Hydraulic Consultants 2003, Jones & Stokes 2004a, Andonaegui 2001).

Guidance from the Wenatchee Watershed Habitat Subcommittee and the other sources cited above led to a determination that the priority actions within the Nason Creek watershed are:

- to protect remaining floodplain and riparian habitat;
- restore channel migration to historical function, and if restoration is not possible;
- improve fish access to oxbows and historical side channels (UCRTT 2003).

Chapter 2. Existing Conditions

2.1. Location and Driving Directions

The project site is located in lower Nason Creek, at approximately RM 3.4, in Township 26 North, Range 17 East, Section 9, Willamette Meridian (Figure 1).

Traveling east or west on Highway 2, turn north on Highway 207 at Coles Corner. Travel approximately 1 mile on Highway 207 to a gravel turnoff on the west side of the highway. A pond at the gravel turnoff on the east side of the highway marks the upstream (southern) end of the project site. Approximately 0.5 mile north on Highway 207 is a culvert under Highway 207 marking the downstream (northern) extent of the project.

2.2. Ownership and Land Use

The Nason Oxbow Project site is owned by multiple entities. WSDOT owns the SR 207 right-of-way, within which the proposed oxbow connections will be constructed. The greater oxbow habitat is owned primarily by the U.S. Department of Agriculture (USDA), although WSDOT maintains the right-of-way to SR 207.

2.3. Overview of Fish Species in the Nason Creek Watershed

Several species of anadromous and resident salmonids occur within Nason Creek including steelhead, Chinook salmon, sockeye salmon, coho salmon, bull trout, cutthroat trout, and rainbow trout, as well as mountain whitefish (Wydowski and Whitney 2003). Three of these species are listed under the federal ESA, including the Upper Columbia River Spring-run Chinook Salmon ESU, Upper Columbia River Summer-Run Steelhead , and the Columbia River Bull Trout DPS.

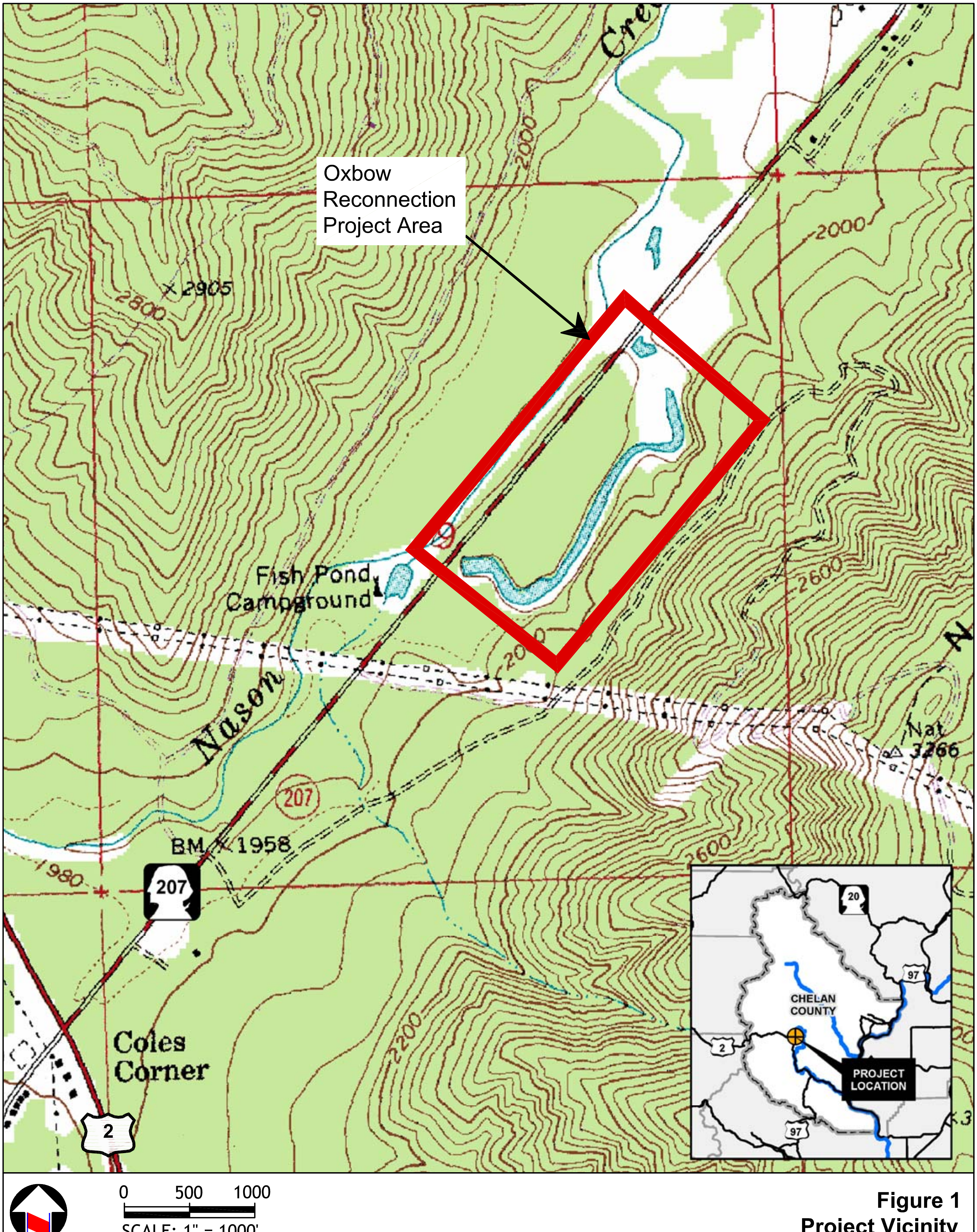


Figure 1
Project Vicinity

Jones & Stokes

Nason Creek Oxbow Reconnection Project

Chinook salmon are listed as endangered, steelhead and bull trout are listed as threatened. Table 2-1 lists the salmon, steelhead, and bull trout use within Nason Creek.

Table 2-1. Salmon, Steelhead and Bull Trout Use in Nason Creek.

Life-History Stage	Spring Chinook Salmon	Summer/Fall Chinook Salmon	Summer Steelhead	Sockeye Salmon	Bull Trout
Spawning	X		X	X	X
Rearing	X		X	X	X
Migration	X		X	X	X

The total juvenile salmonid densities in Nason Creek are limited primarily by the availability of high-flow refuge habitat for post-emergent fry and the degradation of spawning habitat (Andonaegui 2001, Upper Columbia Regional Technical Team [UCRTT] 2002). While neither steelhead, Chinook salmon, nor bull trout make extensive use of off-channel habitat, reconnecting this remnant oxbow of Nason Creek provides a unique opportunity to restore historic habitat, thus addressing a primary limiting factor to salmonid productivity.

2.4. Oxbow Habitat Assessment

The existing oxbow follows the geomorphic form of the historic Nason Creek channel; it was disconnected from direct creek flows after construction of SR 207. The oxbow is currently connected to the Nason Creek main channel only at the downstream end (Figure 2) (see photos in Appendix B).

2.4.1. Oxbow Habitat

Within the oxbow are 6.09 acres of open water and 28.42 acres of vegetated wetland habitat (Figure 2). Within the open water habitat, water depths average 3 to 6 feet. Dense mats of aquatic vegetation (water-milfoil) occur within the large ponded area at the upstream end of the oxbow. The oxbow substrate consists of 6 to 12 inches of muck/silt/sand overlying the historic Nason Creek gravel streambed. Existing woody debris in the oxbow is of moderate abundance, providing good overhead cover and habitat complexity.

Palustrine emergent, scrub-shrub, and forested wetland dominates the riparian and historic floodplain areas of the oxbow. Approximately 15.61 acres of the total 28.42 acres of wetland habitat are permanently or seasonally ponded and connected to the greater open water habitats of the oxbow. The wetland vegetation is mature and dominated by red osier dogwood, alder, birch, willow, grand fir, Douglas-fir, and ponderosa pine.

2.4.2. Current Fish Utilization of the Oxbow

On June 30, 2006 Jones & Stokes performed a snorkel survey of the Nason Creek oxbow to determine whether fish are present within the oxbow, the extent of potential fish presence, and the species of fish present within the oxbow. This survey coincided with high flows in the Nason Creek main channel (approximately 1,000 cubic feet per second [cfs]) which maintained a wetted connection between the downstream section of the oxbow and the main channel. No netting or capturing of any fish occurred during this survey.

Several schools of redside shiners were identified within the oxbow. One juvenile rainbow/steelhead was observed with a school of redside shiners just upstream of the downstream-most beaver dam (see Figure 3, Beaver Dam 1). Two other juvenile salmonids (believed to be rainbow/steelhead) were observed further upstream in the oxbow, but in the same pond area as the first rainbow/steelhead. These two juvenile salmonids were not observed with schools of redside shiners. The three salmonids observed upstream of Beaver Dam 1 were approximately 70 to 100 millimeters (mm) in length.

Downstream of Beaver Dam 1, several (>25) salmonid fry were observed both upstream and downstream of the SR 207 culvert. These fish were approximately 40 to 50 mm. in length, and were not identified to species.

As observed during the snorkel survey, juvenile salmonids can enter the oxbow from the downstream outlet culvert during spring flood flows. Fish access is limited due to high water velocities flowing through this culvert during high water, which minimizes the number of fish that may enter the oxbow below Beaver Dam 1. During late summer, this culvert is typically dewatered (see photos in Appendix B), which traps any remaining salmonids within the oxbow.

2.5. Nason Creek and Oxbow Geomorphology

The geomorphic assessment identifies the geomorphic processes operating within Nason Creek and the oxbow. The purpose of this section is to identify potential geomorphic effects such as sedimentation and scour, which affect project design or occur as a result of project activities.

Fieldwork for the geomorphic assessment was conducted on November 17, 2005. The entire side channel at the upstream oxbow connection and main channel at the downstream oxbow connection were visually investigated (Figure 3). Please refer to Appendix B for photos of the project area.

Figure 2
Existing Conditions

Nason Creek Oxbow
Reconnection Project

LEGEND

Open Water
(6.09 ac)

Palustrine Forest & Palustrine Scrub-Shrub Wetland

With permanently inundated aquatic habitat (15.61 ac)

Without aquatic habitat (12.81 ac)

Historic Channel

Rip Rap

Total Oxbow Length: 4,600 lf

0 175 350
SCALE: 1" = 350'

Jones & Stokes

Source: WA Department of Transportation, 1988

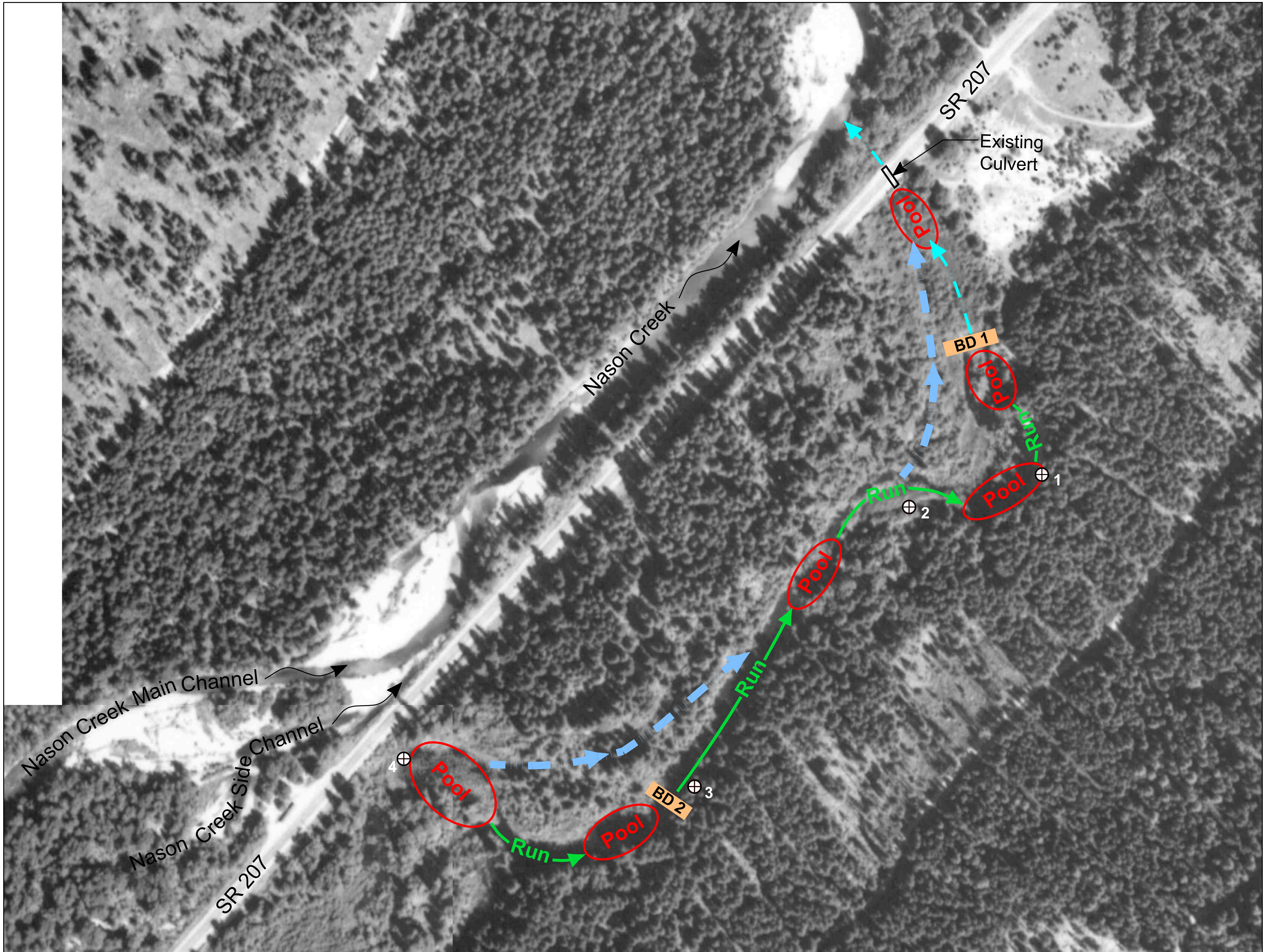


Figure 3
Geomorphic Characteristics of the Oxbow

Nason Creek Oxbow Reconnection Project

LEGEND

Run	Run
Pool	Pool
Low Flow Channel	
Secondary High Flow Channel	
Beaver Dam	BD 1
Data Point	⊕2

0 150 300
SCALE: 1" = 300'

Jones & Stokes

Source: WA Department of Transportation, 1988

2.5.1. Nason Creek Channel Geomorphology

Based on field observations and the stream classification methodology of Montgomery and Buffington (1998), Nason Creek, in the vicinity of the project area as well as further downstream, is an alluvial valley segment that transitions from a reach dominated by plane-bed and pool-riffle sequences, into a braided reach, then back to a reach dominated by plane-bed and pool-riffle sequences.

The construction of SR 207 originally created the oxbow and is responsible for helping to establish the braided reach on the main channel that parallels the length of the oxbow. The former channel length, originally about 3,300 feet when the oxbow was part of the main channel, decreased to about 2,200 after the construction of the road. As such, the main channel of Nason Creek adjusted its bed morphology by establishing a steeper, braided reach within the vicinity of the upstream oxbow connection; this reach is capable of transporting sediment at a variety of flows. Upstream and downstream of the braided reach of the main channel, however, Nason Creek still possesses its original geomorphic character—a single thread reach dominated by plane-bed and pool-riffle sequences.

Plane-bed and pool-rifle reaches are generally transport-limited. Therefore, Nason Creek in the vicinity of the project area behaves as an area of response and transport, adjusting its bed morphology to water or sediment upstream and downstream of the oxbow connections, and transporting sediment efficiently along the reach parallel to the oxbow.

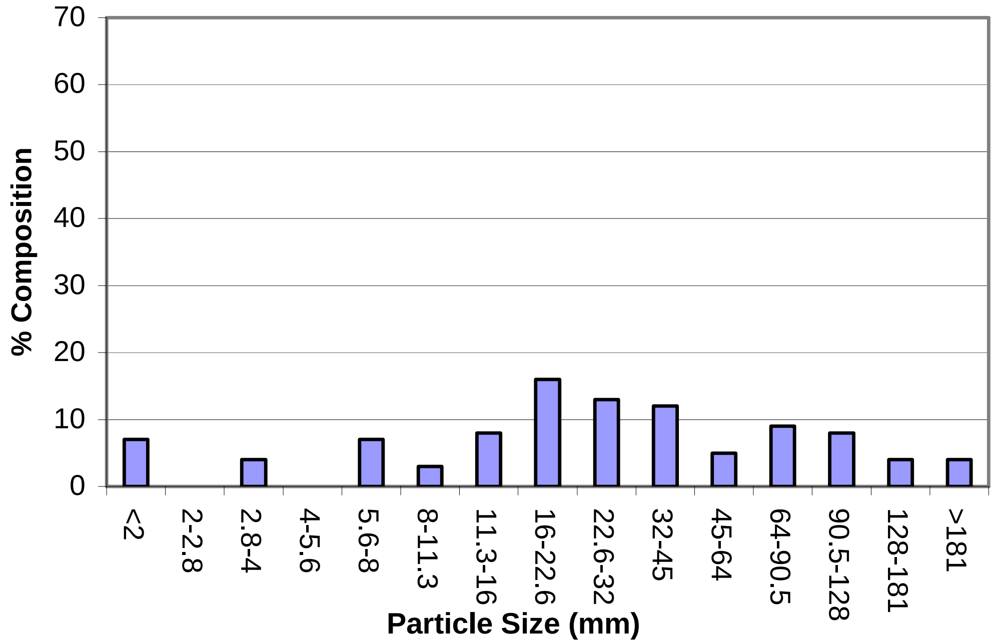
The channel in the vicinity of the upstream connection is split into a main channel on river-left and a side channel on river-right (Figure 2). The side channel, near the location of the proposed oxbow connector, has a bankfull width of approximately 40 feet and a depth of 4 feet. One substrate composition and embeddedness measurement was taken in the side channel on Nason Creek near the potential upstream oxbow connection. Sediment size ranges from sand to boulder, dominated by gravels and pebbles (see Figure 4). The D_{50}[1] for Nason Creek is 26 millimeters (mm) (coarse gravel). Embeddedness is generally low[2].

---

[1] The D_{50} is defined as the particle size that has 50% finer and greater particle sizes than that value (i.e., the median grain size).

[2] See Appendix C for detailed definitions of the geomorphic indicators used in this analysis.

Figure 4. Nason Creek Substrate Composition (N=100)



At the upstream oxbow connection, riparian conditions along the right bank of the Nason Creek side channel are very high along SR 207 (Figure 2), with a variety of native trees and shrubs present. The right streambank is very stable with significant vegetative cover and very low streambank heights and angles; the riparian condition is very high. Left streambanks are potentially unstable lateral bars formed within the braided channel system. Although these bars are densely vegetated, lateral movement may occur during high-flow events. High amounts of wood are located in jams upstream of the proposed connection where the main channel splits.

The riprap section along SR 207 at the upstream connection has steep slopes, with the thalweg of the side channel located at the toe of the road prism. Visual observations and hydraulic modeling (see Section 3.3) determined that this reach experiences high-velocity and sheer-stress conditions as the flows of the side channel are directed at the roadway.

At the downstream connection, an existing outlet channel already discharges flows from the oxbow into Nason Creek. Within this reach, Nason Creek has formed into a single-thread main channel. Riparian condition is very high, with dense streambank tree and shrub vegetation. Both left and right banks are stable upstream of a large high-flow gravel bar on river-left below the outlet channel. The average channel width within this reach is 95 feet, with a thalweg depth of 3 feet. Bankfull discharge channel width at the downstream oxbow outlet channel is 150 feet with a depth of 4 feet; this is wider than typical measurements of the reach upstream of the outlet channel due to the formation of the large gravel bar on the left bank. LWD is found in moderate amounts within this run-dominated reach.

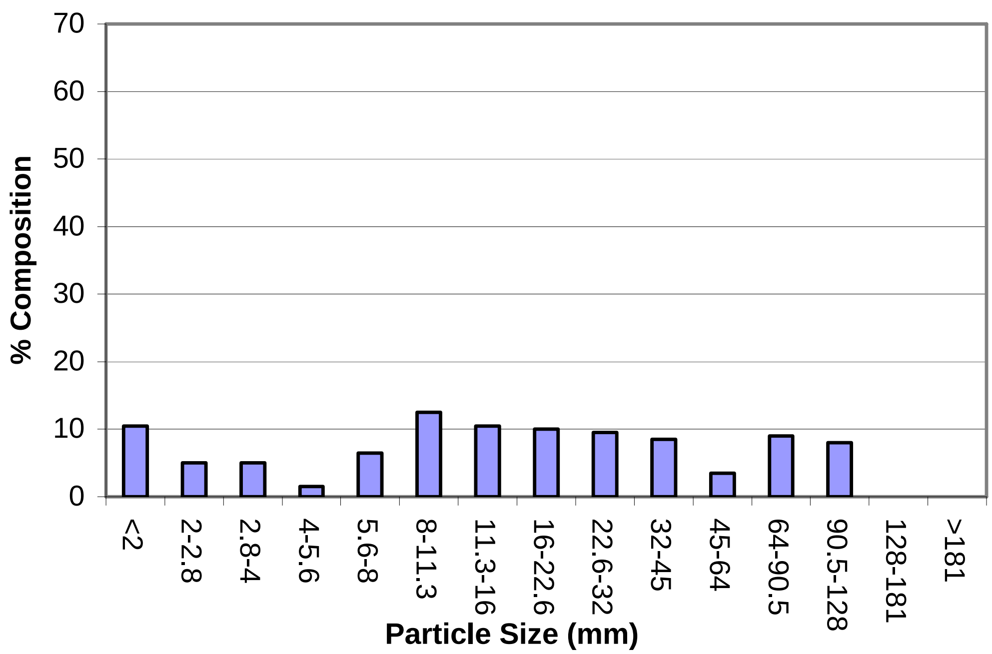
2.5.2. Oxbow Geomorphology

No surface flows from Nason Creek currently enter the oxbow. Inflow is through overland runoff and groundwater discharge, resulting in areas of permanently ponded water throughout the oxbow (Figure 3). No culvert connection exists at the upstream end of the oxbow, while an existing 3-foot-diameter cement culvert allows oxbow discharge to Nason Creek at the downstream end to the oxbow. The existing downstream culvert becomes perched during summer low flows. Flows within the oxbow are very slow and are impeded by two beaver dams (Figure 3).

Aquatic habitats within the oxbow are characterized by muck/silt/sand-filled runs. The layer of muck/silt/sand typically ranges from about 6 to 12 inches deep, below which there is noticeable larger sediment deposition. Total quantity of fine sediments within the oxbow could not be calculated with the limited data collected.

Two substrate composition and embeddedness measurements were taken in the oxbow below this muck layer (Figure 5). Sediment size ranges from sand to cobble, dominated by gravels and pebbles. The D_{50} for the entire oxbow is 15 mm (medium gravel). Embeddedness is very high. The "kick tests" in the most upstream and downstream pools qualitatively confirmed these values.

Figure 5. Oxbow Substrate Composition below Accumulated Fines (N=200)



Compared to the oxbow, Nason Creek has larger sediments and lower embeddedness. Table 2-2 displays the most commonly examined diameters of interest for both the oxbow and Nason Creek.

Table 2-2. Particle Size Distribution for the Oxbow and Nason Creek

	Particle Size Distribution (mm)				
Location	D_{16}	D_{25}	D_{50}	D_{75}	D_{84}
Oxbow	2.9	6.6	15.2	37.6	66.5
Nason Creek	7.2	13.4	25.8	64.0	90.5

In general, riparian condition is very high, with a variety of trees, shrubs, and grasses present on each bank. All of the tree vegetation is native and includes alder, dogwood, ponderosa pines, grand firs, and Douglas-firs. Left streambanks are very stable with significant vegetative cover and very low streambank heights and angles. Right streambanks are stable with significant vegetative cover. The right canyon wall serves as the right streambank, and there are a few unvegetated areas contributing sediment to the oxbow along the right streambank/canyon wall. Nonetheless, the overall bank stability for the right streambank is high.

There are approximately 4 runs and 6 pools in the oxbow (Figure 3); variability in channel or habitat units is relatively high. There are also two active beaver dams present on the oxbow (Figure 3). These beaver dams trap sediment and impede flows.

Woody debris influence is generally moderate in and near the oxbow channel (i.e., on the streambanks). Oxbows, by definition, are cut off from their main channel and, as such, do not receive the same amount of woody debris from upstream sources as main channels. The Nason Creek oxbow does receive woody debris from windthrow processes on the stream banks. Most of the woody debris associated with the Nason Creek oxbow is derived from the right canyon wall and is typically situated in the center of the channel.

No present-day bar development was observed in the oxbow. However, historic point bars (now covered in either the aforementioned layer of muck/silt/sand or other vegetation) were observed on the outer bends of the oxbow across from present-day pools.

Bankfull width is approximately 100 to 120 feet, and bankfull depth is approximately 6 to 8 feet. Average width is approximately 50 to 70 feet, and average depth is approximately 3 to 6 feet. The oxbow is not incised and is in very stable condition. The oxbow is characterized by a sinuous channel planform (sinuosity of 1.5).

2.5.3. Oxbow Soil Contamination

At the recommendation of the UCRTT, concentrations of diesel-range total petroleum hydrocarbons and lube-oil range total petroleum hydrocarbons were measured in the oxbow (Appendix D). The purpose of this analysis is to identify potential contaminants in the oxbow sediments which would be mobilized into the Nason Creek main channel following the oxbow reconnection.

Both types of petroleum-based hydrocarbons were detected in the oxbow and the main channel. The majority of samples from the main channel and oxbow showed concentrations below the screening-level criteria for human health protection and ecological indicators.

Within the oxbow, lube-oil based petroleum hydrocarbons were detected at levels slightly exceeding the ecological indicator limits for soil biota, but falling well below the limits for wildlife and human health (Appendix D). Measured concentrations of petroleum were only detected at the upstream end of the oxbow adjacent to SR 207. Over 50 years of stormwater draining from the roadway into the oxbow likely contributed trace concentrations of crankcase oil, lube oil, diesel oil, and weathered gasoline. The level of contamination detected supports the conclusion that the contaminants are the result of highway stormwater runoff. As the measured concentrations are well below the “wildlife” criterion and only slightly above the conservatively low “soil biota” criterion, it is reasonable to conclude that fuel hydrocarbons in the oxbow have not adversely affected biological functions, and would not adversely impact biological functions within the main channel if mobilized.

2.5.4. Oxbow Water Temperatures

Water temperatures within the oxbow during spring runoff are generally 2 to 3 degrees higher (Celsius [C]) than that of the main channel, and well within target temperatures for juvenile salmonids and trout (10 to 14°C). Data is not yet available for summer oxbow water temperatures, but due to the current lack of inflow, water temperatures are assumed to reach above 24 to 25°C, and may cause mortality in trapped fish.

Jones & Stokes is currently monitoring oxbow water temperatures for the spring and summer of 2006, and will then evaluate the effect of the proposed inflows on current conditions.

2.6. Conclusions and Habitat Enhancement Recommendations

Given the relative absence of side-channel habitat in the lower Nason Creek watershed, it is likely that juvenile salmonids and trout, as well as other species of fish, will utilize the oxbow for rearing, forage, and overwintering. In particular, access to this habitat will benefit juveniles during flooding by providing high-flow refugia, as well as overwintering and foraging habitat.

The main channel currently maintains the historic channel planform, has excellent riparian vegetation, moderate levels of LWD, deep pools (3 to 6 feet in depth), and long runs. As modeled in Section 3.3 below, reconnected flows will expose gravel, cobble, and boulder substrate which are present beneath the fine mud and detritus substrate (approximately 6 to 12 inches in depth).

The primary habitat concerns associated with the current oxbow habitat, as identified by Jones & Stokes and the RTT are:

- High potential for fish stranding and,
- High summer water temperatures.

As mentioned above, low summer flows within the oxbow currently dewater the downstream culvert and likely trap juvenile salmonids within the oxbow. The lack of inflow into the oxbow may also contribute to high summer water temperatures (>24°C), resulting in mortality to trapped juvenile salmonids and trout.

Immediate habitat enhancement will focus on preventing fish stranding through improved fish access at the downstream culvert and installation of an upstream culvert, and increased inflow to lower water temperatures. Habitat enhancements to the remnant oxbow, such as placement of large boulders and LWD, could provide additional cover for rearing habitat conducive to steelhead, Chinook salmon, and bull trout.

Chapter 3. Description of the Proposed Action

This chapter presents analysis of the proposed action for the Nason Oxbow Project. The project will reconnect of a portion of the main channel to the oxbow via two 12-foot diameter corrugated metal pipe (CMP) culverts under SR 207 (Figure 6). The complete Alternatives Analysis is provided in Appendix E.

The following sections present the goals and objectives of the project, details of the two culverts to be installed, the supporting hydraulics and hydrology analysis, and the resulting habitat benefits. Detailed 35% design plans are presented in Chapter 4, with construction plans located in Appendix A.

3.1. Project Goals and Objectives

The project will reconnect of flows and restore fish access into the oxbow, while maintaining current habitat conditions on the Nason Creek main channel. Based upon feedback from the RTT, the following are project guidelines used in development of the culvert designs:

- Maintain a year-round wetted connection between the oxbow and main channel at both upstream and downstream connections to avoid fish stranding.
- In order to maintain current habitat conditions on the main channel, the diversion of flows into the oxbow should not alter the current main channel sediment transport regime.
- Oxbow inflow should mobilize fine sediments to expose the historic streambed while maintaining oxbow bank stability.

The following goals and objectives reflect the overall project guidelines listed above. These goals and objectives were used to develop and select the most feasible and appropriate design alternative (Appendix E), and were used as guidance during the development of the 35% construction plans. In addition, these goals and objectives provide the foundation for the monitoring approach detailed in Chapter 5.

The overall project goals and objectives include the following:

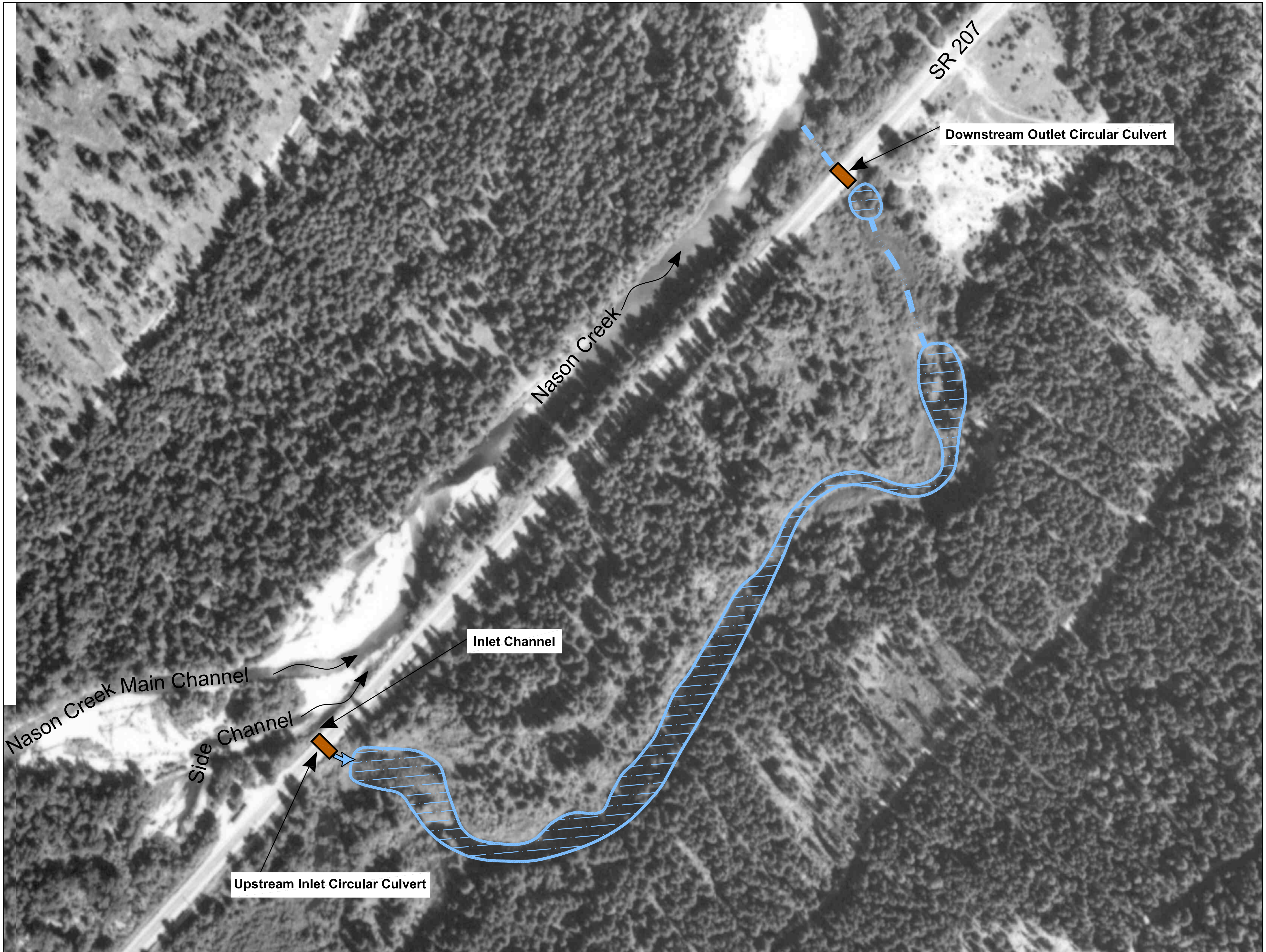
- Goal 1 – The Nason Oxbow Project will address the primary salmonid habitat-limiting factors within Nason Creek (i.e., the reduction of off-channel habitat).
  - Objective 1.1 – Connect the existing oxbow to the Nason Creek main channel to create 21.7 acres of off-channel fish habitat.
- Goal 2 – Connection structures will be designed to be hydraulically stable and require minimal future maintenance.
  - Objective 2.1 – Construct the upstream and downstream oxbow connections in locations that are hydraulically stable, and install structures that provide for the long-term stability of the channel openings and minimize sediment deposition.
- Goal 3 – The off-channel oxbow habitat will provide access to fish during high- and low-flow conditions.
  - Objective 3.1 – Construct the upstream and downstream oxbow connections to meet velocity and water-depth criteria per Washington State Department of Fish and Wildlife's (WDFW) Design of Road Culverts for Fish Passage.
- Goal 4 – Maintain oxbow channel stability and minimize the mobilization of fine and coarse oxbow channel materials.
  - Objective 4.1 – Maintain peak sheer-stress and water velocities within the oxbow below those able to cause channel avulsion.
- Goal 5 – Vegetation planting will create an integrated, functional riparian complex that is associated with aquatic habitat.
  - Objective 5.1 - Establish diverse native riparian vegetation including trees, shrubs, and grasses at the two culvert locations to provide shade, habitat complexity, and soil/streambank stability.

3.2. Overview of the Proposed Action

The Hydraulic Engineering Center – River Analysis System (HEC-RAS) hydraulic model of the two culvert connections, the oxbow, and the main channel was used to assess flow conditions and modify the project design (Appendix F). The results of this analysis is presented below in Sections 3.3, 3.4, and 3.5. Design and construction details for both culverts are provided in Chapter 5.

Figure 6
Preliminary Site Design

Nason Creek Oxbow Reconnection Project



LEGEND

Proposed Culvert

Proposed Inlet Channel

Existing Open Water

Existing Low-Flow Channel

0 150 300
SCALE: 1" = 300'

Jones & Stokes

Source: WA Department of Transportation, 1988

3.2.1. Upstream Inlet Culvert Overview

The upstream oxbow inlet connection will be a 12-foot diameter 90-foot-long CMP culvert. This culvert will be countersunk 6 feet. The key design features of the upstream inlet connection are as follows:

- The culvert will be installed upstream of where the Nason Creek side channel directly abuts the SR 207 road prism to avoid high sheer stress on the proposed structure.
- To maintain the existing sediment transport processes in the main channel, the upstream culvert will not allow greater than 10% of the total Nason Creek flows into the oxbow.
- An excavated inlet channel will connect the culvert to the side channel of Nason Creek.
- Log and rock structures will be used to reinforce the inlet channel opening.
- No skew is proposed for the new outlet culvert.
- The culvert invert elevation will be maintained by a concrete sill on the oxbow side.

3.2.2. Downstream Outlet Culvert Overview

The downstream oxbow outlet connection is similar to the upstream inlet connection and will also be a 12-foot diameter 90-foot-long CMP culvert and will be countersunk 6 feet. The key features of the downstream oxbow outlet connection are as follows:

- The new structure will replace an existing 3-foot-diameter concrete culvert.
- Flows will exit the new culvert into an existing outlet channel connecting to Nason Creek.
- No skew is proposed for the new outlet culvert.
- The outlet culvert will be set at a lower invert elevation than the existing culvert to prevent fish stranding and to maintain a year-round wetted connection to the main channel.
- The outlet channel is modeled to remain stable with minimal scour and without reinforcement (e.g., riprap); however, willow plantings will be installed to protect newly graded channel slopes.

3.3. Hydraulic and Hydrologic Analysis

Post-project flow conditions in the main channel and oxbow were evaluated by assessing historic streamflows and developing an HEC-RAS hydraulic model of the project area. A detailed discussion of this analysis is provided in Appendix F, and a summary of the model results are presented below.

3.3.1. Flow Data

The Washington State Department of Ecology (Ecology) has operated a gage near the mouth of Nason Creek from June 2002 to the present. While valuable for gathering information on seasonal Nason Creek flow trends, the period of record is currently too short to support predictive analysis of long-term mean daily and peak annual flows.

The United States Forest Service (USFS) has developed regression equations to predict mean daily streamflows on Nason Creek . A review of these synthetic flows indicates that there is greater than a 90% likelihood of more than 50 cfs in Nason Creek between November and August, and greater than a 75% likelihood of more than 50 cfs in Nason Creek in September and October; 50 cfs was therefore selected as the lowest modeled flow (20 cfs was also modeled to determine minimum culvert water depths).

The USFS regression equations were designed for determination of mean daily flows, and were not found to successfully predict peak annual flows. Standard United States Geologic Survey (USGS) regression equations for Washington State were used instead to determine peak annual flows. The 2-year peak discharge was estimated to be about 1,800 cfs, and the 100-year peak discharge was estimated to be about 4,300 cfs.

It should be noted that the Ecology gage on Nason Creek has recorded peak annual flows greater than 3,000 cfs in four of the last five years, suggesting that peak annual flow estimates based on the USGS regression equations may be underestimated.

3.3.2. Hydraulic Model Results

An HEC-RAS model of Nason Creek was developed from surveys of the main channel and the oxbow (Figures F-1 and F-2 in Appendix F), and the hydraulic characteristics of a series of flows ranging from 20 cfs to about 4,300 cfs were evaluated. The inlet and outlet culvert connections each comprised a 90-foot long, 12-foot diameter culvert, countersunk 6 feet. The inlet culvert elevation was set at 1930.6 feet, while the outlet culvert elevation was set at 1922.8 feet (approximately 1.7-feet lower than existing).

Simulated oxbow inflows were typically less than 10% of the total Nason Creek flow. A summary of several representative Nason Creek flows and oxbow inflows is provided in Table 3-1.

Table 3-1. Simulated Nason Creek and Oxbow In-Flows

Total Nason Creek Flow (cfs)	Oxbow Inflow (cfs)	Percent of Total
20	0.9	4.5
40	3	7.5
50	4	8.0
100	10	10.0
500	51	10.2
1,000	79	7.9
2,000	167	8.4
2,933	217	7.4
4,299	282	6.6

3.4. Fish Passage

Velocities in the culverts ranged from 0.4 feet per second to 7.8 feet per second. The inlet culvert experienced generally higher velocities than the outlet culvert. Velocities in the culverts exceed the WDFW (WDFW 2003) passage criteria for adult Chinook, coho and steelhead of 6.0 ft/s when flows are around 2,500 cfs in the main channel, or at slightly greater than a 2-year event. The maximum recommended velocities for passage of juvenile salmonid fry and fingerlings is 1.1 to 1.3 ft/s, and were typically exceeded in both culverts at flows that occur over 50% to 75% of the year. The velocity restrictions would only be applicable to juvenile salmonids attempting to enter the oxbow from the main channel through the downstream outlet culvert or exit the oxbow through the upstream inlet culvert. As juveniles are still able to enter and exit oxbow habitat in the direction of flow during large events, this criterion should not be a factor in assessing habitat access.

Both culverts are expected to maintain a wetted connection to the main channel during low-flow conditions. However, minimum culvert flow depths can affect fish access to the oxbow. Adult fish passage requires a 1-foot depth (WDFW 2003), and this is achieved at flows greater than 100 to 300 cfs in the main channel for both upstream and downstream culverts. Flows of this magnitude are typically exceeded during the majority of the year (see Appendix F). Minimum water depths may not be met for adult passage during late September and October low-flow events. For the upstream culvert, at 40 cfs water depth is expected to be 0.4-feet, and at extreme low flow (20cfs) the water depth is expected to be 0.2-feet. For the downstream culvert, minimum water depth at 20 cfs is expected to be 0.5-feet deep. As adult salmonids and trout will not depend upon the oxbow for spawning success, this criteria is not critical to the success of the project. However, by maintaining a wetted connection between the oxbow and the main channel during all flow conditions, the design allows fish to enter and exit the oxbow as needed.

3.5. Evaluation of Sediment Transport

Installation of an upstream culvert and the reintroduction of flows into the oxbow raise concerns about potential changes to sediment transport along the Nason Creek main channel, and mobilization of fine and coarse-grained sediments within the oxbow. This section summarizes the anticipated effects of changes in flow distribution due to construction of the proposed action on sediment transport within both the main channel and the oxbow.

3.5.1. Main Channel

Bed material in the Nason Creek main channel ranges from sand to boulders, with a D_{50} of about 26 mm (coarse gravel) and low embeddedness. The corresponding critical shear stresses necessary to initiate bed mobilization ranges from 0.03 to over 2.0 pounds per square foot (lbs/sq ft), with a shear stress of about 0.7 lbs/sq ft required to mobilize the D_{50}.

During a simulated low flow (50 cfs), mobilization of sediments less than or equal to 26 mm occurred at only CX 3127 (Appendix F, Figure F-2); as flows increased to 1,000 cfs, mobilization of coarse gravel occurred at almost every section. Calculated shear stress values indicate mobilization of larger sediments such as cobbles during only the largest simulated flows (50- to 100-year return periods).

The oxbow inlet culvert is currently designed to capture about 7% to 10% of the total flow within Nason Creek at the project site. A typical flow of 1,000 cfs in the main channel would correspondingly be reduced to about 900 cfs. An HEC-RAS run comparing these two flows indicates almost no difference in shear stress values: 0.33 lb/sq ft for 900 cfs and 0.35 lb/sq ft for 1,000 cfs at CX 500. The small reduction in flows in the main channel created by the oxbow reconnection is therefore not expected to alter sediment transport characteristics of the main channel.

This conclusion is important as it indicates that the flows diverted into the oxbow will not alter the bed material composition within the main channel. As the main channel is known to support salmonid spawning habitat, it was essential that the modifications to flows due to the project not alter habitat conditions within the main channel.

3.5.2. Oxbow

Streambed material in the oxbow consists of a 6- to 12-inch layer of silt and sand over a surface of much larger diameter substrate. Sediment in the lower surface ranges from sand to cobble, with high embeddedness and an approximate D_{50} of 15 mm (medium gravel). Shear stress values generated by the HEC-RAS model were used to evaluate the mobility of sediment in these two distinct layers.

Fine-Sediment Mobilization

The top layer of silt and sand in the oxbow will likely be mobilized when shear stress exceeds 0.005 lb/sq ft to 0.03 lb/sq ft, corresponding to a D_{50} of 0.2 mm to 2 mm. A review of the HEC-RAS results indicates that the upper value of 0.03 lb/sq ft is exceeded throughout the majority of the oxbow at virtually every simulated flow. Simulated shear stress values at two locations in the oxbow, CX 781 and CX 2644 (Appendix F, Figure F-2), were close to zero and mobilization of fine-grained silts is only expected at higher flows.

Oxbow inflows and associated shear-stress values would be capable of mobilizing the silt and sand layer when flow in the oxbow is greater than 50 cfs. Based on available flow information, the oxbow will experience a flow of 50 to 170 cfs almost every year once it is reconnected. It is therefore likely that a portion of the fine sediment in the oxbow would be mobilized every year.

During lower flows (50 to 2,000 cfs in Nason Creek), the fine sediments would probably move in discrete pulses. Once a pulse of sediment encountered a beaver dam in the oxbow, it would most likely be deposited behind it. During higher flows (greater than 2,000 cfs in Nason Creek), the fine sediments would probably move as a discrete slug along the oxbow and through the outlet culvert toward the main channel of Nason Creek. Both beaver dams would probably breach, and debris would likely be mobilized within the oxbow during large flow events. The 12-foot diameter culvert will provide enough conveyance to pass most debris generated in the oxbow, although risk of a debris jam from larger debris remains a possibility.

It is highly likely that most of the fine sediment will move out of the oxbow within 1 to 2 years. However, most of this sediment would remain in suspension during high-velocity flood flows in the Nason Creek main channel because it has a highly organic content; it is not expected to substantially increase sedimentation in Nason Creek or be of a chronic nature.

Large-Sediment (Historic Streambed) Mobilization

The historic streambed layer in the oxbow will likely be mobilized when shear stress exceeds about 0.3 lb/sq ft to 1.5 lb/sq ft, corresponding to a D_{50} range of 15 mm to 75 mm. Simulated shear stress values are greater than 0.3 lb/sq ft at several sections within the oxbow when Nason Creek flows increase beyond 3,500 to 3,900 cfs, suggesting that movement of sands is possible during larger flows. The larger oxbow sediments will likely mobilize when shear stress values exceed 1.5 lb/sq ft. The HEC-RAS simulation results indicate that shear stress values at the downstream face of the inlet culvert and at CX 2023 in the middle of the oxbow are near or greater than 1.5 lb/sq ft for Nason Creek flows greater than 2,000 to 3,000 cfs.

These results suggest that relatively large flows on Nason Creek (greater than 3,500 cfs) would likely send enough discharge into the oxbow to mobilize sands in portions of the channel. In addition, scour is likely to occur at the downstream side of the inlet culvert and possibly in the vicinity of CX 2023. The amount of large-sediment movement would vary depending on the duration and magnitude of the flow, and on the highly embedded nature of the larger sediments, which may decrease sediment mobilization.

It is assumed that there will be minimal larger sediment contribution to the oxbow, and that large oxbow sediment will be gradually mobilized over time. Because of this, the oxbow may experience some degradation at CX 2023 or other locations through loss of larger material. However, the channel section is expected to adjust, and sediment transport is expected to decrease as the channel and reach attain a new equilibrium.

3.5.3. Channel Stability

The overall stability of the oxbow is not expected to alter significantly under any modeled representative flow. However, some areas of existing bank instability could be weakened by increasing water depths (i.e., stage level rises). Furthermore, increased fine sediment input to the main channel of Nason Creek from the oxbow is a temporary possibility under higher flow events. It is likely, however, that this sediment would not aggrade at the confluence of the oxbow and the Nason Creek main channel, and would easily be transported away by the flow of the main channel. Localized aggradation would most likely be temporary as the fine sediments are ultimately flushed through by subsequent flows. As mentioned above, much of this finer material would be transported in suspension.

3.6. Habitat Benefits

The project is intended to provide benefits to spring Chinook salmon, summer steelhead, bull trout, and resident fish in Nason Creek. The primary benefits of this project are as follows:

- The two new culverts would provide fish access and exit at upstream and downstream locations, thus greatly increasing access during both low and high flows, and reducing the potential for fish stranding.

- The addition of the upstream culvert will provide approximately 10% of the total Nason Creek flow to the oxbow, flushing out fine sediments, and lowering summer water temperatures.

The sections below discuss these benefits in detail.

3.6.1. Effects to Oxbow Habitats

The project would provide beneficial effects to substrate quality and oxbow water quality under all modeled representative flows. The modeled inflows would be beneficial to the aquatic habitat of the oxbow because it would help expose the larger substrates below the muck/silt/sand layer. Substrate quality and oxbow water clarity would increase, and water temperature would likely decrease from current conditions during summer months. Other geomorphic benefits include the exposure of interstitial spaces between the larger sediments throughout the oxbow. This exposure would reduce their extremely embedded nature, and allow aquatic organisms to take advantage of the interstitial space between the rocks. Finally, secondary high-flow channels would produce variable aggradation and degradation, promoting habitat diversity and complexity.

It is also assumed that the increased inflow from the upstream culvert will lower oxbow water temperatures. In addition, the new culverts will allow fish to exit the oxbow during summer high water temperatures. The resulting change from a somewhat static channel condition to a dynamic-equilibrium condition is considered an appreciable improvement in channel function, which is the primary goal of reconnecting off-channel habitat to the main channel.

3.6.2. EDT Analysis of Benefits to Spring Chinook Salmon

To quantify the benefit of the project, the proposed oxbow reconnection was analyzed for spring Chinook salmon using the Ecosystem Diagnosis and Treatment (EDT) model (Lestelle, et al. 2004) This analysis provides an estimate of the potential benefits of the project in terms of the change in abundance of returning adult spring Chinook to Nason Creek. The project was assessed by comparing the current habitat potential of Nason Creek for spring Chinook salmon, to the habitat potential if the oxbow was reconnected. A detailed discussion of this analysis is provided in Appendix G.

As discussed in Chapter 2, the reconnected oxbow would provide limited spawning habitat in the glides, and relatively large amounts of rearing and overwintering habitat. Adult Chinook salmon do not typically spawn in off-channel habitat features, but interior stocks make some use of off-channel ponds and side channels for juvenile rearing and overwintering. As a result of increased habitat quantity from the oxbow reconnection, the spring ***Chinook salmon abundance potential in Nason Creek increased by 4.7 percent***. This is roughly the same as the increase in length of total stream miles available to Chinook in Nason Creek with the oxbow. The relative productivity of spring Chinook in Nason Creek increased slightly with the oxbow, reflecting the change in distribution of habitat types while all other habitat quality attributes (wood, temperature, water quality, etc.) remained the same in the main channel and oxbow segments.

Chapter 4. Design and Construction Details

The results of the hydrologic and geomorphic analysis presented in Section 3.3 allowed for the preparation of detailed construction plans for the upstream inlet and downstream outlet oxbow connections. These construction plans should be considered 35% complete and are subject to revision following discussions with permitting agencies.

Detailed discussions of the following are presented below:

- Siting of the upstream inlet and downstream outlet oxbow connections
- Stabilization structures
- Site preparation
- Grading and earthwork
- Planting plans
- Monitoring approach

Please refer to Appendix A for construction plans and specifications.

4.1. Upstream Culvert Details

The upstream 12-foot diameter, 90-foot long CMP culvert will be installed in the existing SR 207 roadway where no culvert currently exists. Both ends of the culvert will have mitered concrete headwalls with no wingwalls. An inlet channel will be constructed from the existing Nason Creek main channel to the inlet of the culvert on the west side of SR 207. The culvert will discharge directly to water within the oxbow.

4.1.1. Upstream Inlet Connection

The location of the upstream end of the oxbow determined the general location of the inlet culvert, while the planform and geomorphology of the Nason Creek side channel dictated the specific culvert location (Figure 6). The right Nason Creek side channel shifts from west to east in the vicinity of the upstream end of the oxbow, ultimately running along the toe of the highway prism (see photos in Appendix B). Flow velocities and shear stress are high along the main channel, so the inlet culvert was sited at a location where the overbank was about 15 feet wide; this allowed the culvert to be set back from the right Nason Creek main channel and out of the high-velocity flows.

The culvert will be countersunk by 6-feet, filled with select gravels from the excavation, then covered with 2 feet of streambed gravel. The culvert invert elevation will be approximately 0.5-feet higher than the thalweg depth of the Nason Creek side channel. As discussed in Section 3.3 above, this elevation will allow approximately 10% of the total Nason Creek discharge to enter the oxbow. At higher flows, the oxbow inflow rate decreases to 7 to 9% of the total Nason Creek discharge. At no flow is the culvert expected to become dewatered. This invert elevation will also match the inside oxbow elevation at the culvert discharge point. See Figure 7 for 100-year, 2-year, and low-flow water elevations within the proposed arch culvert.

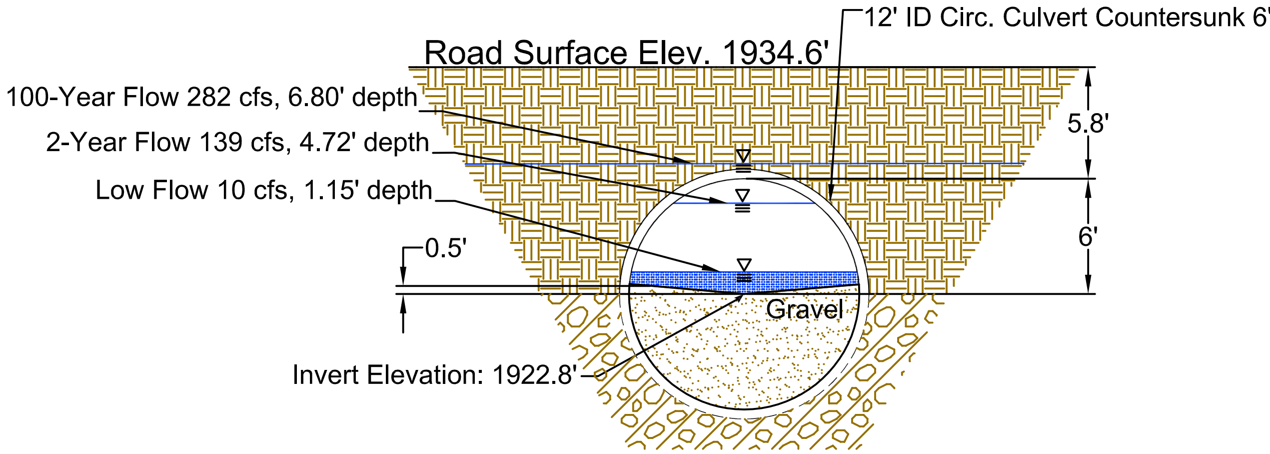
4.1.2. Culvert Inlet at the Upstream Connection

The culvert placement requires the construction of a inlet in the Nason Creek floodplain near the entrance of the proposed culvert (Appendix A). Maintaining a channel to provide fish access and hydraulic connection to the oxbow is vital to the success of the project. Stabilization of the channel slope and longitudinal profile are key in providing overall integrity/stability for the inlet channel system. The inlet channel will be anchored with 18-inch to 24-inch diameter riprap (Appendix A). This riprap will be tied into the existing riprap associated with the SR 207 road prism in order to create a seamless and stable transition from the inlet channel mouth to the road prism.

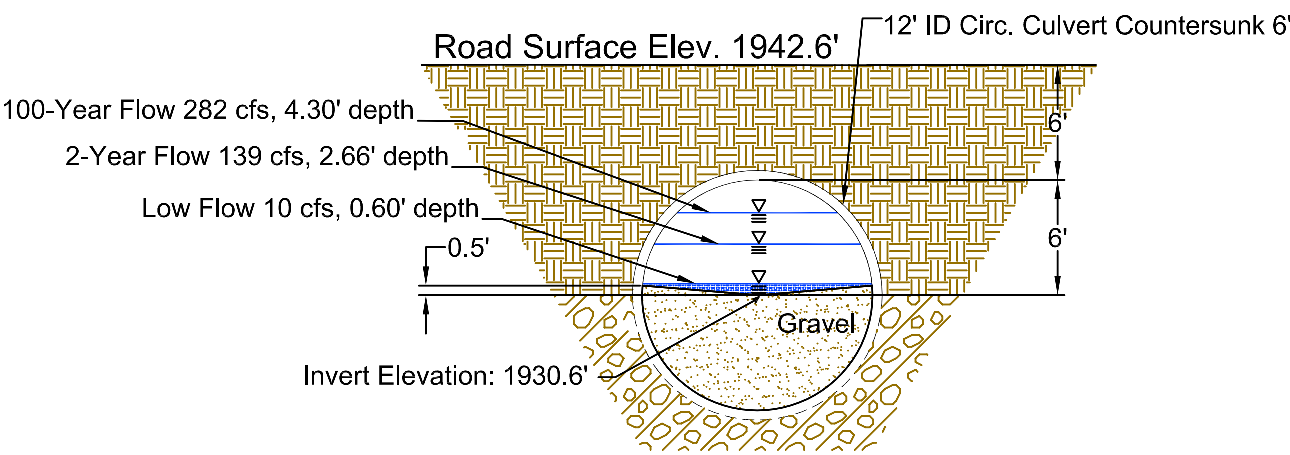
The woody structures will be tied into 18- inch to 24-inch-diameter riprap. Three anchored rootwads will also be placed on the upstream banks of the inlet channel to provide habitat elements at the mouth of the culvert. The rootwads will typically be single 12- to 24-inch-diameter log, with a 4- to 5-foot-diameter root bole (refer to structure details in Appendix A).

The woody structures and riprap will be interplanted with native willow and dogwood stakes (see Section 4.6). These shrubs will eventually provide the majority of the erosion protection along the banks near the inlet. While the plants are maturing, the wood structures and riprap will provide a stable environment for plant establishment and continue to provide long term bank stability.

Downstream Outlet Circular Culvert



Upstream Inlet Circular Culvert



Scale: 1"=10'

Figure 7
Downstream Outlet and Upstream Inlet Culvert Capacity

Jones & Stokes

Nason Creek Oxbow Reconnection Project

To avoid potential impacts to instream aquatic habitats, all inlet channel grading and bank stabilization will occur within the existing floodplain and not within the main channel.

To further reduce the risk of a high-flow headcut near the culvert, a buried concrete sill will be constructed to maintain the existing bank alignment at the low-flow connection point at the inlet channel (Appendix A). The addition of a concrete sill on the oxbow side of the inlet culvert will maintain the culvert invert for the life of the structure. The sill will have a low-flow V notch to maintain fish passage and provide a stable thalweg within the inlet channel and culvert bottom.

Five 3-foot diameter habitat boulders will be placed within the culvert. These boulders will provide habitat complexity within the culvert.

Sedimentation of the inlet channel is minimized through the design of stable channel side slopes, structural reinforcement, the installation of the buried concrete sill, and planting for stabilization and fish refugia. The designed structures in the inlet channel and culvert (i.e., concrete sill and habitat boulders) also provide local scour potential to maintain the conveyance of the connection channel thalweg. The designed placement of the structures is intended to ensure the connection of the local scour pockets to maintain positive drainage.

4.2. Downstream Culvert Details

The downstream 12-foot diameter, 90-foot long CMP culvert will be installed in the existing SR 207 roadway to replace the existing 3-foot diameter cement culvert. The culvert inlet will be directly connected to oxbow discharges. The culvert outlet will discharge directly to an existing outlet channel that will carry flows to the Nason Creek main channel.

4.2.1. Siting the Downstream Oxbow Outlet Connection

The proposed downstream outlet culvert was sited in the same location as the existing outlet culvert (Figure 6). This location provides the best connection between the downstream end of the oxbow and Nason Creek because the existing culvert is set about 90 feet back from the main Nason Creek channel and has a well-defined and stable outlet connection channel.

4.2.2. Stabilization at the Downstream Oxbow Outlet Connection

This culvert will also be countersunk by 6-feet, filled with select gravels from the excavation, then covered with 2 feet of streambed gravel.. The sizing and placement of this downstream culvert is expected to pass high flows and potential woody debris which may be mobilized during flood events. The proposed culvert invert outlet will be 1.7-feet lower than the existing invert outlet in order to better match the lower pond elevation immediately upstream of the current culvert. The new culvert invert elevation will not create a substantial elevation difference between the receiving channel thalweg and the culvert invert.

The outlet channel will be graded to taper to the existing channel connection and match the thalweg of the main channel. Minor scour of the existing connection channel to Nason Creek is expected as discharge flows are increased; however, there is a natural forested buffer that is expected to maintain the creek alignment and minimize the risk of bank erosion and potential head cutting into the oxbow (see photos in Appendix B). Two anchored pieces of LWD will be placed within the outlet channel to provide overhead cover. In addition, five 3-foot diameter habitat boulders will be placed within the culvert. These boulders will provide habitat complexity within the culvert.

See Figure 7 for 100-year, 2-year, and low-flow water elevations within the proposed arch culvert. Riparian plantings (Section 4.6) will be installed to further stabilize the graded areas associated with the culvert installation and provide riparian cover.

4.3. Oxbow Habitat Enhancement

Direct restoration of the existing oxbow habitat is not proposed at this time. Aquatic habitat elements, such as riparian cover and LWD, already exist in significant quantities within the oxbow (Section 2.5). Pools of greater than 6 feet in depth occur in six locations, and additional fish access is available to 15.6 acres of permanently and seasonally ponded off-channel wetland area without any channel modifications.

As discussed in Section 3.3, fine sediments present in the oxbow are expected to be mobilized during low- and high-flow events. As the oxbow achieves equilibrium between increased inflow and the mobilization of fine sediments, deeper pools will be formed, and original gravel channel substrates will be exposed, thus improving fish foraging, refuge, and overwinter habitat.

4.4. Site Preparation

Site preparation activities will include:

- Creating a staging area and site access;
- Clearing and grubbing the site; and
- Protecting native vegetation.

4.4.1. Staging Area and Site Access

A staging area and site access will be established by CCNRD and the contractor, and will be used to accommodate storage of equipment and supplies.

4.4.2. Clearing and Grubbing

Clearing and grubbing activities include removing existing debris and vegetation within the project footprint and beyond the project footprint as necessary to construct the project. Native woody material removed during clearing and grubbing activities will be incorporated as part of the project as practicable or may be incorporated into another restoration project or disposed of off-site.

4.4.3. Protect Native Vegetation

Protection of native vegetation includes the installation of perimeter fencing to delineate the extent of clearing activities and identify the vegetation to be preserved. Additional vegetation surveys may be necessary to determine the number of trees to be preserved. It will be the responsibility of the contractor to maintain the perimeter fencing throughout the construction of the project to ensure protection of vegetation.

4.5. Grading and Earthwork

The following is a summary of predicted grading activities. As detailed plans and specifications are prepared, revisions to the discussion below may be necessary. Grading activities include:

- Excavating the upstream inlet channel and road prism at both connection locations;
- Installing instream structures in the upstream inlet channel;
- Dewatering construction areas to allow excavations in dry areas when feasible;
- Installation of the upstream and downstream culverts; and
- Placing excavated materials on-site where feasible and stabilizing the material.

A net total of 940 cubic yards of native and road prism materials will remain following the construction of the upstream and downstream culverts. Hauling and placement of this material will be determined by CCNRD and the contractor.

4.5.1. Construction Sequencing

Construction is planned for the low-flow months of late summer and early autumn. Due to the shallow groundwater table and proximity to the Nason Creek main channel, some in-water work is likely to be necessary. To avoid and minimize the potential for sediments to be carried into Nason Creek during construction, as much of the grading and earthwork as possible will be done inside an area separated from Nason Creek by coffer dams. Only the final excavation of the inlet channel connection will occur outside the coffer dam. The downstream oxbow outlet connection will be constructed first, followed by the upstream inlet connection. In-water work that affects the main channel of Nason Creek (i.e., the connection of the upstream inlet channel) will be conducted within the U.S. Army Corps of Engineers (Corps)/WDFW-approved in-water work window.

4.5.2. Temporary Erosion and Sediment Control Plan

Temporary erosion and sediment control consists of implementing standard erosion control Best Management Practices (BMPs) to minimize the input of sediment into Nason Creek and adjacent wetlands. Typical BMPs for the site include the installation of silt fencing along the downhill edge of the clearing limits for the project, covering exposed soil with straw mulch, and hydroseeding with native grass seed mix. Temporary impoundment structures, commonly referred to as coffer dams, will be placed at the inlet and outlet at each culvert between the extents of channel grading at the culvert and the existing water (the creek or the wetted oxbow) to keep water from entering the active construction area.

As part of the construction contract, the contractor will be required to develop a site specific Temporary Erosion and Sediment Control (TESC) plan that conforms to WSDOT standards. The person who prepares the plan and is responsible for implementing and maintaining all BMPs will be required to possess valid WSDOT TESC certification.

4.5.3. Traffic Plan

Potential detour routes for traffic during construction of the culverts were investigated and no acceptable route could be identified. Traffic will remain on SR 207 during construction and a minimum of one lane will remain open for traffic throughout construction activities. A detailed traffic control plan in accordance with WSDOT requirements will be developed as part of the final plans and submitted to WSDOT for approval.

4.6. Vegetation Planting Plan

The vegetation planting plan is designed to provide bank stability, instream cover, and enhance the existing riparian vegetation within the floodplain at both the upstream inlet and downstream outlet structures (Appendix A).

Plant species selected are based on observations of existing native species growing in Nason Creek riparian areas and from guidance from WDFW. Table 4-1 lists the proposed plants.

Table 4-1. Proposed Plant Species for the Nason Creek Oxbow Reconnection Project

Scientific Name	Common Name
Live Stakes	
Cornus stolonifera	Red-osier dogwood
Salix exigua	Coyote willow
Riparian Shrub	
Lonicera involucrata	Black twinberry
Salix exigua	Coyote willow
Upland Shrub	
Acer glabrum douglassii	Douglas maple
Rosa woodsii	Woods rose
Salix scouleriana	Scouler's willow
Symphoricarpus albus	Snowberry

The project design incorporates existing native vegetation and avoids the removal of mature (>12-inch diameter at breast height [dbh]) trees.

Construction of the upstream and downstream culverts will require excavation of surface and subsurface soils. Therefore, the plants will be planted in the sand and gravel subsurface soils along the channel banks and within the interstitial spaces of the riprap. Plant species used for this planting are adapted for growth in nutrient-poor, coarse-textured, alluvial soils typical of the Nason Creek floodplain.

The planting plan will be implemented during the dormant season, after site preparation and grading/earthwork has been completed. Plant assemblages will be used to create a vegetation structure for the different planting zones as described below and detailed in Appendix A.

4.6.1. Live Stakes

This community will consist of a dense planting of willow and dogwood stakes along the wood structures and riprap used to stabilize the banks at the upstream inlet channel.

Planting willow stakes on slopes and within the interstitial spaces of the riprap will help prevent erosion, promote structure stability, and provide aquatic and terrestrial habitat. Rapid growth of willows will provide overhead cover and allochthonous inputs for the inlet channel, main channel, and outlet channel. The lower elevation of the Live Stake planting area corresponds to the limits of shrub growth within the

Nason Creek riparian area as identified in the field. Based on the hydraulic model, it is anticipated that this planting zone will be inundated periodically during periods of moderate to high flows (March through July). Based upon the modeled stream hydrology, native willows and dogwood have been selected for planting due to their tolerance of seasonal flooding and subsequent dry season.

4.6.2. Riparian Shrub

The lower elevation of the Riparian Shrub planting area corresponds to the limits of shrub growth within the Nason Creek riparian area as identified in the field. The Riparian Shrub area will be planted with a variety of native shrub species that will provide bank stabilization and functioning riparian habitat. The Riparian Shrub planting zone will be inundated during higher flows, typically during peak-flow events between May and June, remaining above the water surface during the majority of the growing season. Species selected are those that can tolerate some inundation during the growing season, are able to grow in coarse-grained soils, and will generate more plant cover through new shoots. This planting area will also be seeded with a riparian seed mix to help stabilize the graded areas.

4.6.3. Upland Shrub

Graded areas above and adjacent to the proposed culvert structures will be planted with a mix of upland shrub species to stabilize slopes and provide riparian habitat. Deciduous species will be the primary species installed. The Upland Shrub planting area has been designed to begin above either the 2-year flood elevation or at a delineated wetland boundary, and is thus designed to include species able to tolerate predominantly dry conditions. This planting area will also be seeded with an upland seed mix to help stabilize the graded areas.

In addition to plants that provide shade cover, selected plant assemblages are intended to provide benefits to local wildlife species by producing fruit, buds, leaves, and twigs for wildlife consumption. These plants will also provide cover for invertebrates, resident and migratory birds, and small mammals.

4.6.4. Upland Seed Mix

A 10-foot buffer between the roadway and the Upland Shrub planting area will remain free of trees and shrubs. Within this buffer, an unplanted and unseeded “Roadside Clearzone” will extend three feet from the edge of the pavement. A zone extending seven feet beyond the edge of the clearzone will be the Roadside Buffer seeding area and will be seeded with the Upland seed mix (See Appendix A for seed mix). The entire Upland Shrub planting area will be seeded with the same seed mix.

4.6.5. Riparian Seed Mix

The Riparian Shrub planting area and areas graded below the Riparian Shrub planting area will be seeded with the Riparian seed mix. This seed mix will be placed under a biodegradable coconut fiber erosion control blanket which will be located below the 2-year flood elevation or edge of wetland boundary (see Appendix A). The lower boundary of the Riparian seed mix area corresponds to the elevation of late summer low-flow as calculated using the HEC-RAS model.

Chapter 5. Project Monitoring

CCNRD will perform implementation monitoring and Level 1 effectiveness monitoring using methods developed by the Upper Columbia Salmon Recovery Board (UCSRB) (Hillman 2005). CCNRD will work with the UCSRB and the state and federal permitting agencies to draft performance standards and a monitoring plan applicable to this oxbow reconnection project. Ultimately, permit conditions will dictate monitoring procedures.

The purpose of monitoring the project site is to ensure that design goals are achieved. The project site will be monitored for a period of 5 years to ensure that the project functions as designed. The 5-year monitoring period will begin after the installation of the culverts, and after the planting program has been completed. As-built drawings of the project site showing topographic contours, habitat features, and planting areas, will be prepared immediately after the full planting program is complete.

Prior to project construction, photo-points will be established at both culvert locations, along the main channel, and at 3 locations within the oxbow. The presence/absence of target fish and life stage will also be documented, as well as oxbow bank stability, and water temperature.

A 5-year monitoring plan will be implemented to assess the degree to which objectives and performance standards are achieved. Monitoring may be conducted by volunteers, through coordination by biologists and CCNRD, prior to project construction, and once every year for five years following construction.

A minimum of five photographic points will be established at the project site to develop a pictorial history of the progress and development of the project site. Photographs will be taken each year monitoring is scheduled.

Table 5-1 presents the objectives, performance standards, and monitoring methods used to determine successful achievement of project objectives. The monitoring methods will explicitly address the objectives for the construction of the culverts, fish passage, oxbow stability, and vegetation. If success criteria are not being met, data collected will be useful for determining if remedial action is appropriate.

Table 5-1. Summary of Goals, Objectives, Performance Standards, and Monitoring Methods

Goal 1 – The Nason Oxbow Project will address the primary salmonid habitat-limiting factors within Nason Creek (i.e., the reduction of off-channel habitat).		
Objective	Performance Standard	Monitoring Method
Objective 1.1 – Connect the existing oxbow to the Nason Creek main channel to create 21.7 acres of off-channel fish habitat.	The culverts and inlet/outlet channels will be constructed to proposed elevations and dimensions.	(Implementation Monitoring) Conduct as-built survey to determine obtain acreage from surveyed boundaries using AutoCAD. Survey again in Year 5 to document any changes from as-built conditions.

Goal 2 – Connection structures will be designed to be hydraulically stable and require minimal future maintenance.		
Objective	Performance Standard	Monitoring Method
Objective 2.1 – Construct the upstream and downstream oxbow connections in locations that are hydraulically stable, and install structures that provide for the long-term stability of the channel openings and minimize sediment deposition	The culverts and inlet/outlet channels will be constructed to proposed elevations and dimensions.	(Implementation Monitoring) Conduct as-built survey to determine obtain acreage from surveyed boundaries using AutoCAD.
	Accumulated silt and sediments within the culverts will not prevent fish access during low summer flows.	(Effectiveness Monitoring) Conduct a monitoring visit each spring and summer (Years 1, 3, and 5) during a high flow event (>3000 cfs and <50 cfs), to document whether silts and sediments block fish access.

Goal 3 - The off-channel oxbow habitat will provide access to fish during high- and low-flow conditions.		
Objective	Performance Standard	Monitoring Method
Objective 3.1 – Construct the upstream and downstream oxbow connections to meet velocity and water-depth criteria per WDFW's Design of Road Culverts for Fish Passage.	Water depth and velocity will meet WDFW Design of Road Culverts for Fish Passage.	(Effectiveness Monitoring) Install a staff gage at the inlet and outlet culverts. Conduct a monitoring visit during a high flow (>3000 cfs) and low flow (<100 cfs) event in Years 1, 3, and 5, to document whether water levels are present per design criteria. Water velocity will be measured at both inlet and outlet culverts using a calibrated water-velocity meter. Fish presence and absence will be documented in the oxbow by species and life history stage through snorkel survey or visual observations from the bank.

Goal 4 – Maintain oxbow channel stability and minimize the mobilization of fine and coarse oxbow channel materials.		
Objective	Performance Standard	Monitoring Method
Objective 4.1 – Maintain peak sheer-stress and water velocities within the oxbow below those able to cause channel avulsion.	Oxbow banks will remain stable and vegetated. The oxbow banks will experience less than a 10% increase in erosion over baseline condition.	(Effectiveness Monitoring) Assess bank stability along the banks of the oxbow before and after project construction. Visually estimate the percentage of the lineal distance that is actively eroding.

Goal 5 – Vegetation planting will create an integrated, functional riparian complex that is associated with aquatic habitat.		
Objective	Performance Standard	Monitoring Method
Objective 5.1 - Establish diverse native riparian vegetation including trees, shrubs, and grasses at the two culvert locations to provide shade, habitat complexity and soil/streambank stability	Document that the total average survival of shrubs and trees shall be at least 80% per planting zone by Year 5; minimum survival rate for woody live stakes will be at least 40% by Year 5. The intent is not to guarantee 80/40 percent survival for each species planted but instead to document an average survival rate of 80/40 percent for all species (i.e., some species will exceed 80/40 percent survival while others will be below this). The survival of planted species is expected to be variable from area to area, as well as from year to year, dependent upon a variety of factors (e.g., site conditions, wildlife depredation, plant competition). Document areas of active erosion.	(Implementation Monitoring) Document number and location of plants installed. (Effectiveness Monitoring) Monitor vegetation along randomly located, permanent transects stratified by planting zone. Vegetation will be sampled within either permanent plots placed randomly along each transect or as point intercepts along the transects. The permanent plots will be adjusted at placement, whenever necessary, to exclude surface structure unsuitable for establishment of herbaceous species (e.g., large rocks). The endpoints of the transects and the sample plot locations will be permanently marked. The number of transects established within each planting zone will depend upon the size and shape of the zones, and the number of transects or plots required to adequately sample the planting zone. Assess bank stability along the banks of the constructed inlet and outlet channels. Visually estimate the % of the lineal distance that is actively eroding.

5.1. Construction Monitoring

A qualified restoration biologist will monitor construction operations regularly (at least weekly). The biologist will monitor construction activities to ensure that work occurs only in those areas designated. Vegetation clearing, excavation, and placement of fill will be monitored regularly to ensure that work is completed as planned.

5.2. Contingency Planning

If monitoring results demonstrate that site conditions fail to meet performance standards, contingency measures will be implemented. Contingency measures are dependant upon the acquisition of additional project funds. If a contingency measure must be implemented, CCNRD will work with potential funding partners (e.g., SRFB) to secure those funds. Examples of conditions that may require contingency measures include, but are not limited to:

- Hydrology is not as anticipated – Contingency will involve evaluating design of outlet and pond invert elevations to either increase or decrease the range of surface water elevations, as appropriate.
- In-stream structures do not remain in place as designed – Contingency will involve evaluating causes of structure failure and developing appropriate engineering design to keep material in place.
- Unsuccessful plant survival or growth – Contingency may involve selecting a different suite of plant species for a specific planting zone, based on the soils and hydrology of the site. Willow cuttings can be inserted into shallow water to help establish plant cover.

If a performance standard is not met for any given year CCNRD will present a proposed corrective action. Even if all performance standards are met, corrective actions may still be implemented if monitoring identifies deficiencies that could lead to poor performance or future problems. Descriptions of such problems and corrective actions recommended and/or taken to solve them will be included in the monitoring reports.

5.3. Reporting

Monitoring reports will include all data necessary to address the performance standards. Beyond general introductory and background information, monitoring reports will include:

- A brief discussion of the monitoring objectives and success criteria.

- An overview of all significant activities for each year;
- A brief description of the monitoring methods;
- A discussion of the vegetation, hydrology, and in-water habitat conditions as they relate to corresponding success criteria;
- A discussion of problems, recommendations, and contingency measures taken; and,
- A chronological photographic summary and comparison of photographs from established photo points.

Each monitoring report will focus on data for that year. To the extent that trends in biological conditions become apparent or problems persist from one year to the next, these too will be described. Monitoring reports will be submitted for each monitoring year. Monitoring years will consider the growing season and the following rain season (i.e., generally from July of one year through June of the following year). Monitoring reports will be submitted by the end of the year.

5.4. Maintenance and Contingency

CCNRD will be responsible for maintenance activities associated with the project site, including monitoring and preparation of reports. Coordination with WDFW will occur throughout the life of the project. In the event the site fails to meet any of the success criteria, CCNRD will promptly notify the WDFW and any other participating agencies to discuss potential corrective actions.

CCNRD will take corrective action as necessary, following the completion of planting, and following the receipt of additional project funding specific to the necessary action(s). Corrective actions may include but are not limited to, grading to adjust site hydraulics, additional plantings, control of invasive vegetation, and/or reseeding during the 5 years following plant establishment, as necessary.

Chapter 6. References

Andonaegui, C. 2001. *Salmon, Steelhead and Bull Trout Habitat Limiting Factors for the Wenatchee Subbasin (WRIA 45) and Portions of WRIA 40 within Chelan County (Squilchuck, Stemilt and Colockum Drainages).* Washington State Conservation Commission.

Hillman, Tracy W. 2005. Project Monitoring: A Guide for Sponsors in the Upper Columbia Basin. Draft Report. November 1. Prepared for Upper Columbia Salmon Recovery Board and the HCP Tributary Committees.

Jones & Stokes. 2004a. *Chelan County Natural Resource Program, Final Wenatchee River Channel Migration Zone Study – Phase II*. April 16. (J&S 01243.01) Bellevue, WA. Prepared for the Chelan County Natural Resource Program, Wenatchee, WA.

Jones & Stokes. 2004b. *Project Site Feasibility Study and Prioritization*. December. (J&S 04609.04 300) Bellevue, WA. Prepared for the Chelan County Natural Resource Program, Wenatchee, WA.

Jones & Stokes. 2005. Nason Creek Oxbow Reconnection Project, Design Report and Alternatives Analysis. December. Bellevue, WA. Prepared for the Chelan County Natural Resource Department, Wenatchee, WA.

Lestelle, L., L. Mobrand, and W. McConnaha. 2004. Information structure of Ecosystem Diagnosis and Treatment (EDT) and habitat rating rules for Chinook salmon, coho salmon and steelhead trout. Mobrand Biometrics, Inc., Vashon, WA,50 pages

Montgomery, D.R., and J.M. Buffington. 1998. Channel Processes, Classification, and Response. In: Naiman, R., and R. Bilby (eds.), R*iver Ecology and Management*. Springer-Verlag, New York, pp 13–42.

Northwest Hydraulic Consultants (nhc). 2003. *Wenatchee River Channel Migration Zone Stud*y. Draft Technical Memorandum. Tukwila, WA.

Upper Columbia Regional Technical Team (UCRTT). 2002. A Biological Strategy to Protect and Restore Salmon Habitat in the Upper Columbia Region, A Report to the Upper Columbia River Salmon Recovery Board. June. Available from the Upper Columbia Salmon Recovery Board, Chelan, WA.

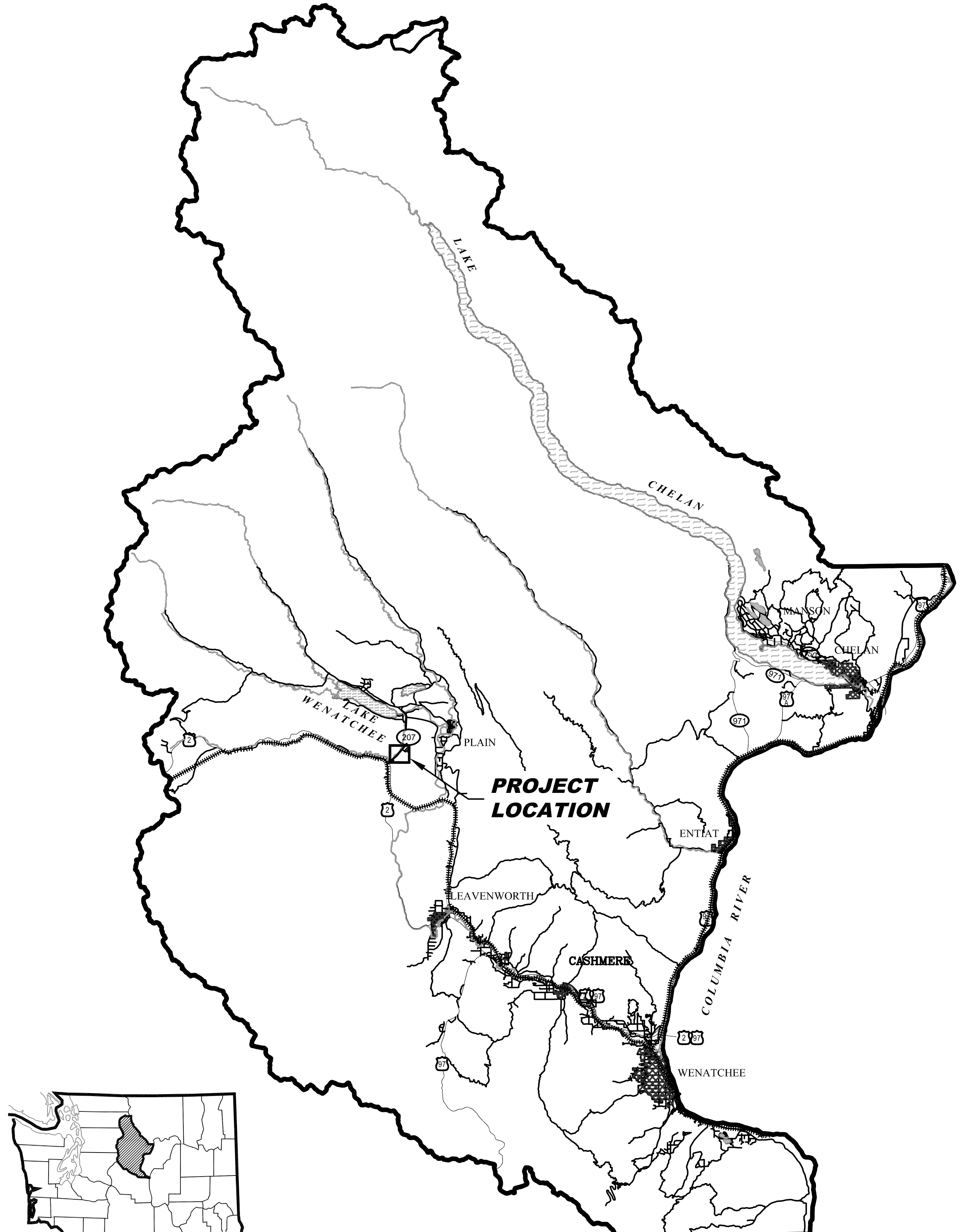
Upper Columbia Regional Technical Team (UCRTT). 2003. *A Plan to Protect and Restore Salmon Habitat within the Wenatchee River Subbasin (WRIS 45)*. February. Available from the Upper Columbia Salmon Recovery Board, Chelan, WA.

Washington Department of Fish and Wildlife (WDFW). 2003. *Design of Road Culverts for Fish Passage*. Olympia, WA. 110p.

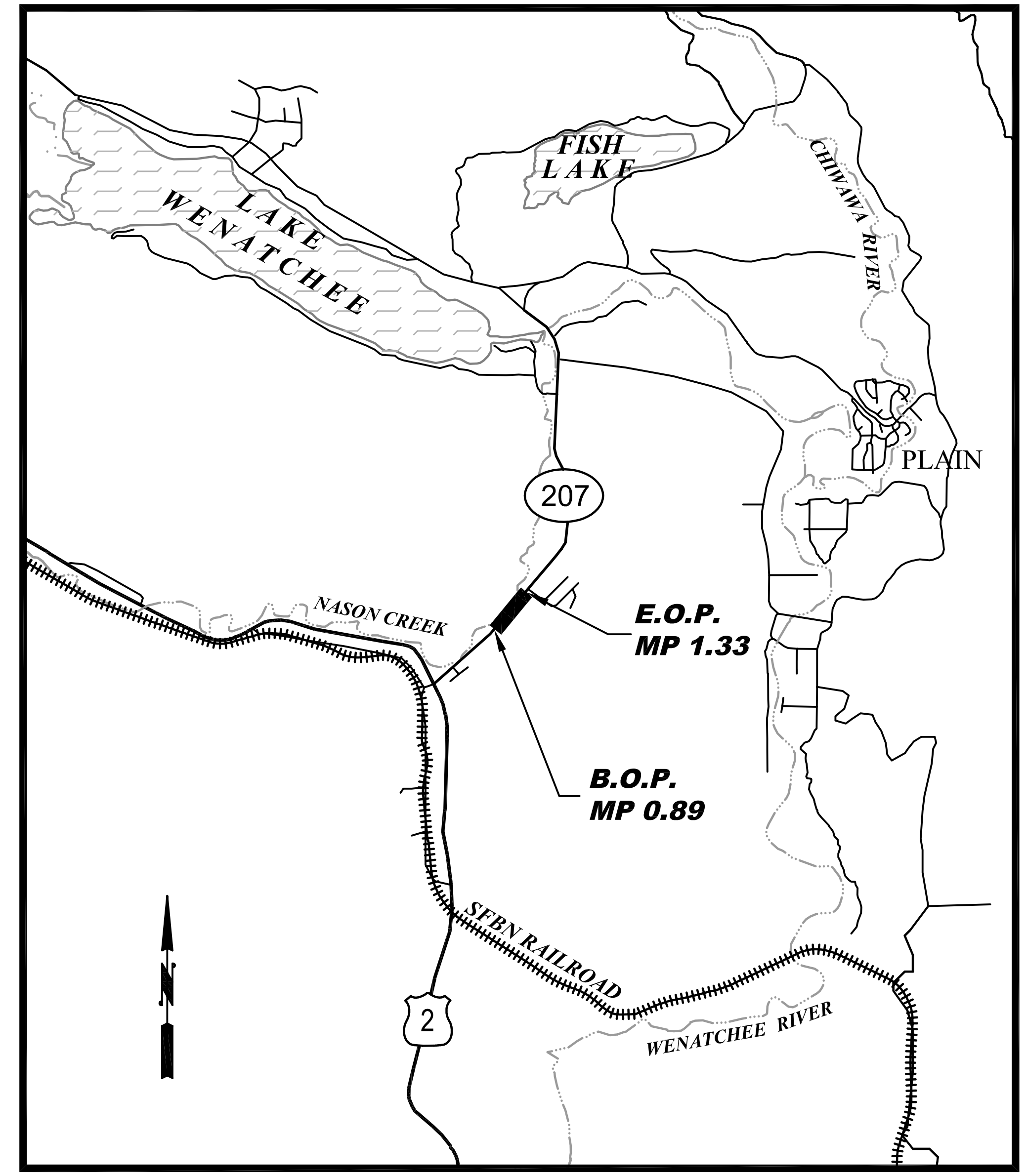
Wydowski, R.S., and R.R. Whitney. 2003. *Inland Fishes of Washington*. Second Edition. University of Washington Press, Seattle, WA, and American Fisheries Society, Bethesda, MD.

Appendix A

Design Sheets



CHELAN COUNTY, WASHINGTON



VICINITY MAP

NOT TO SCALE

Nason Creek

Oxbow Reconnection Project

C.R.P. ###

Design:	REVISIONS		
	Date:	Description:	Made by:
Drawn by:			
Project Inspector:			
Survey Crew:			
Plot Date: 7-24-2006	As-Built Date:	by:	

Jones & Stokes
11820 Northup Way, Suite E300, Bellevue, WA 98005

Approved Board of County Commissioners

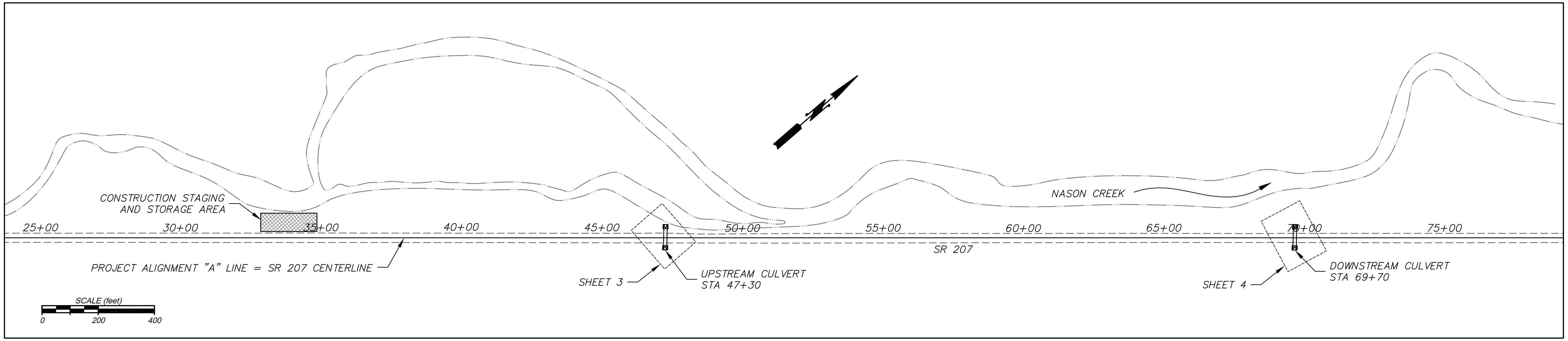
Date

Chelan County
Natural Resource Department
316 Washington Street, Suite 401
Wenatchee, Washington, 98801
Phone: (509) 667-6567
Website: www.co.chelan.wa.us

Nason Creek
Oxbow Reconnection Project

Sheet 1 of 8 | *C.R.P. nnn*

G:\PNWProjects\Chelan County\05750.05 - Nason Creek Oxbow\04 Resources\CAD\60%_ConstructionDrawings\1_CoverSheet.dwg



PROJECT OVERVIEW

SHEET INDEX

LEGEND

- EXISTING EDGE OF PAVEMENT
- EXISTING EDGE OF WATER
- OP — EXISTING OVERHEAD POWER
- UT — EXISTING UNDERGROUND TELEPHONE
- EXISTING ROAD CENTERLINE
- 1935 — EXISTING CONTOUR, INDEX
- 1931 — EXISTING CONTOUR, INTERMEDIATE
- PROPOSED CONTOUR
- 47+00 — CONSTRUCTION ALIGNMENT
- PROPOSED GUARDRAIL
- CUT CUT — LIMITS OF GRADING (CUT)
- CONTROL POINT
- LWD BANK PROTECTION STRUCTURE
- LWD HABITAT STRUCTURE

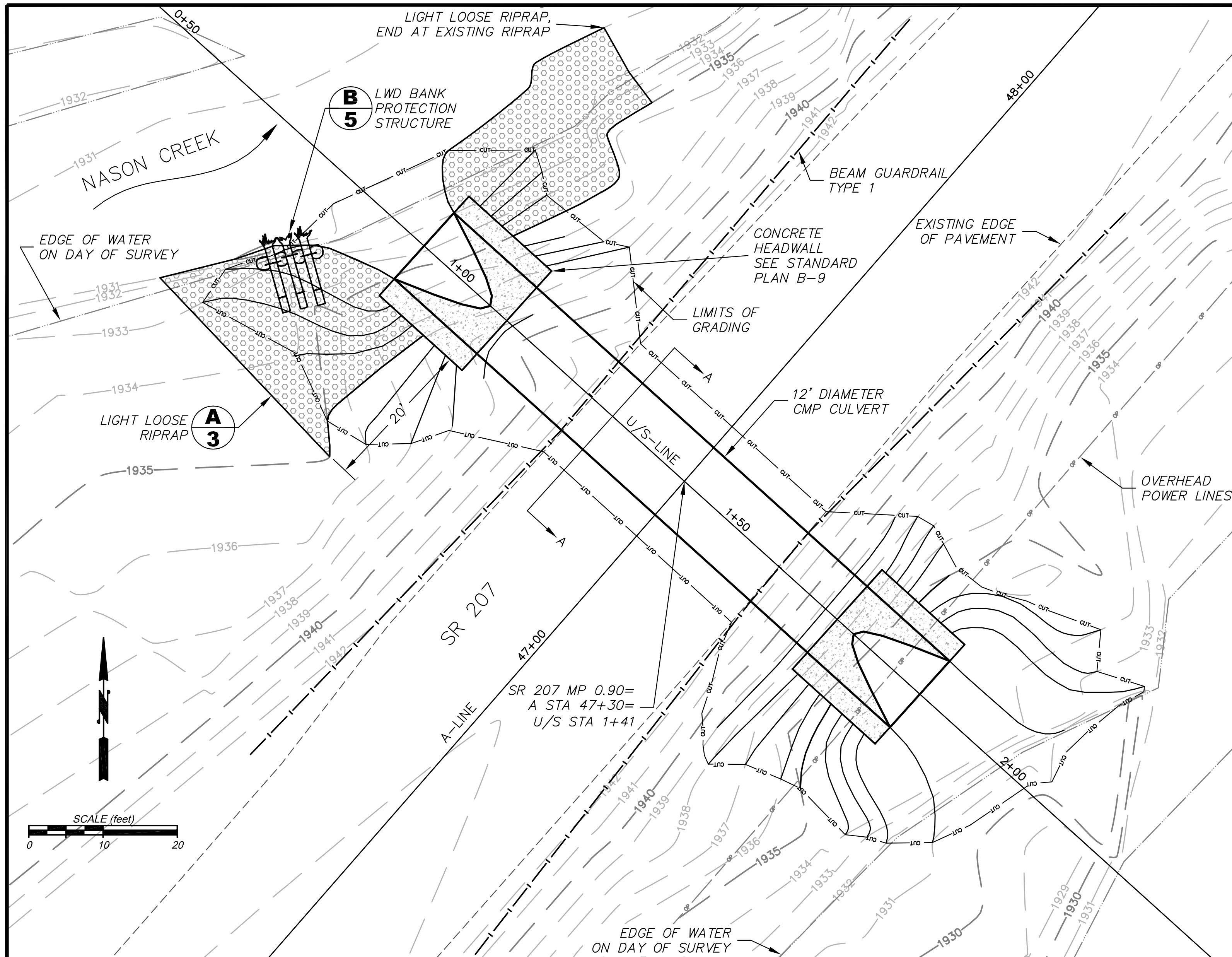
Design:	REVISIONS		
Drawn by:	Date:	Description:	Made by:
Project Inspector:			
Survey Crew:			
Plot Date: 7-24-2006	As-Built Date:	by:	

Jones & Stokes
11820 Northup Way, Suite E300, Bellevue, WA 98005

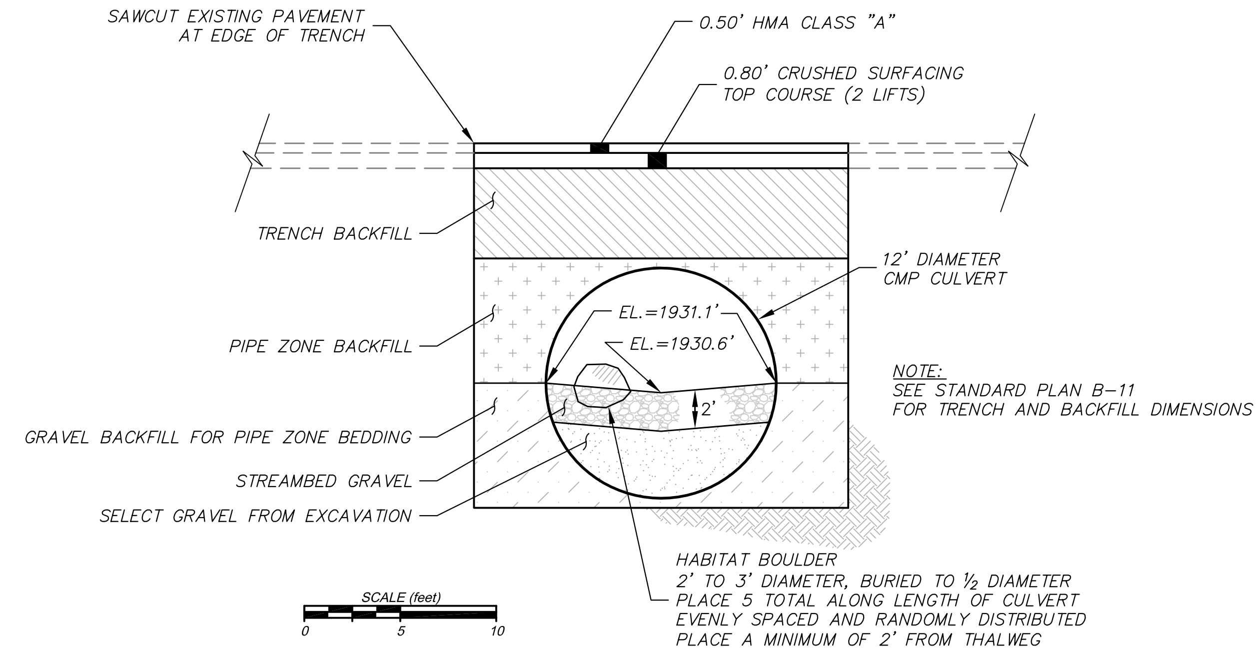
Chelan County
Natural Resource Department
316 Washington Street, Suite 401
Wenatchee, Washington, 98801
Phone: (509) 667-6567
Website: www.co.chelan.wa.us

Index, Overview, and Legend

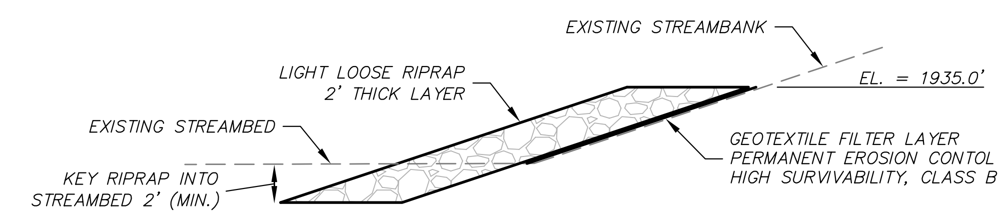
Nason Creek
Oxbow Reconnection Project



UPSTREAM CULVERT - PLAN

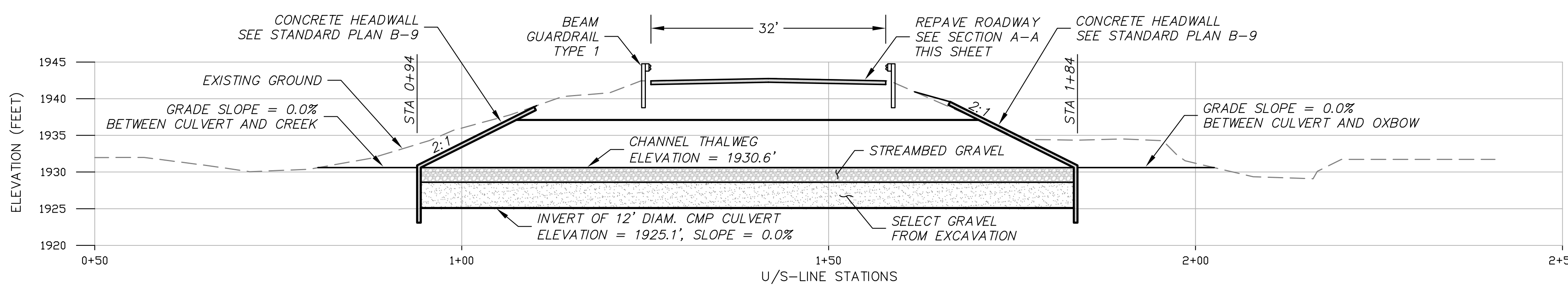


SECTION A-A



A **RIPRAP BANK PROTECTION - TYPICAL SECTION**

Scale: 1" = 5'



UPSTREAM CULVERT - PROFILE

Design:	REVISIONS		
	Date:	Description:	Made by:
Drawn by:			
Project Inspector:			
Survey Crew:			
Plot Date: 7-24-2006	As-Built Date:	by:	

Jones & Stokes
11820 Northup Way, Suite E300, Bellevue, WA 98005

Chelan County
Natural Resource Department
316 Washington Street, Suite 401
Wenatchee, Washington, 98801
Phone: (509) 667-6567
Website: www.co.chelan.wa.us

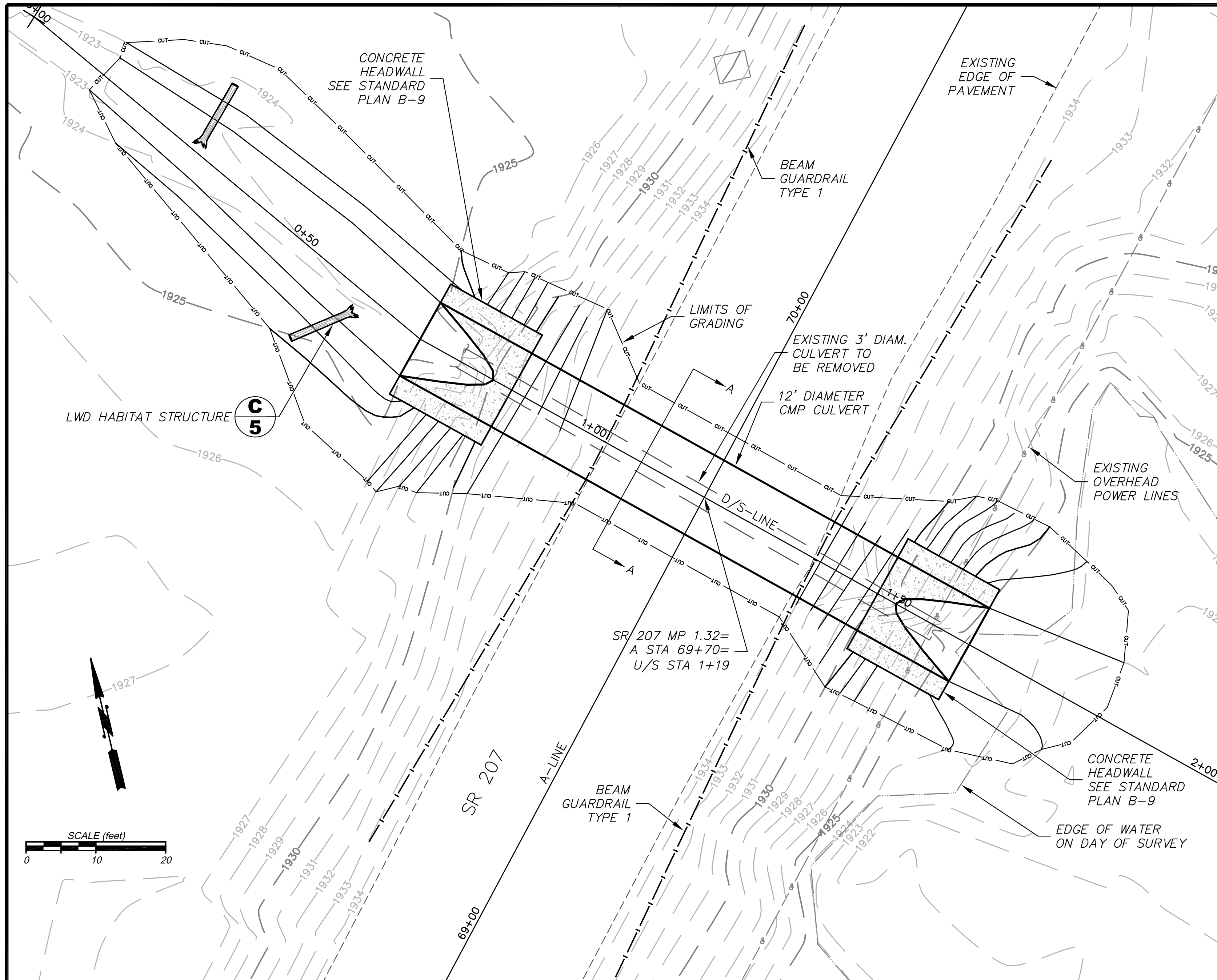
Grading Plan
Upstream Culvert

PRELIMINARY PLANS SUBJECT TO REVISION

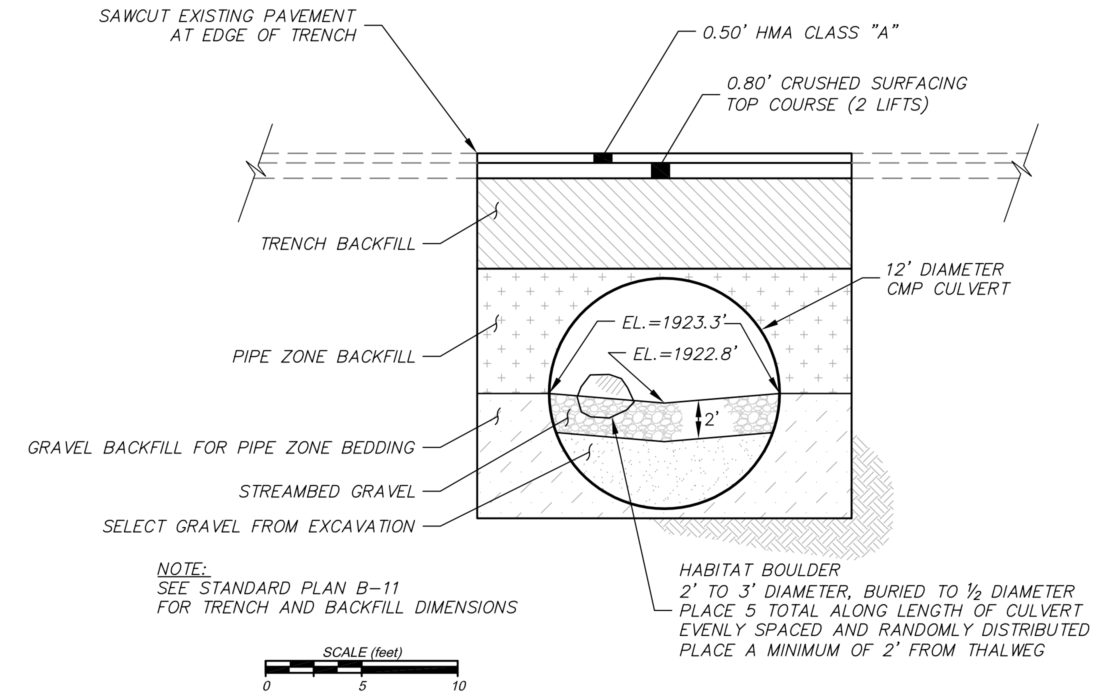
Nason Creek
Oxbow Reconnection Project

Sheet 3 of 8 | C.R.P. nnn

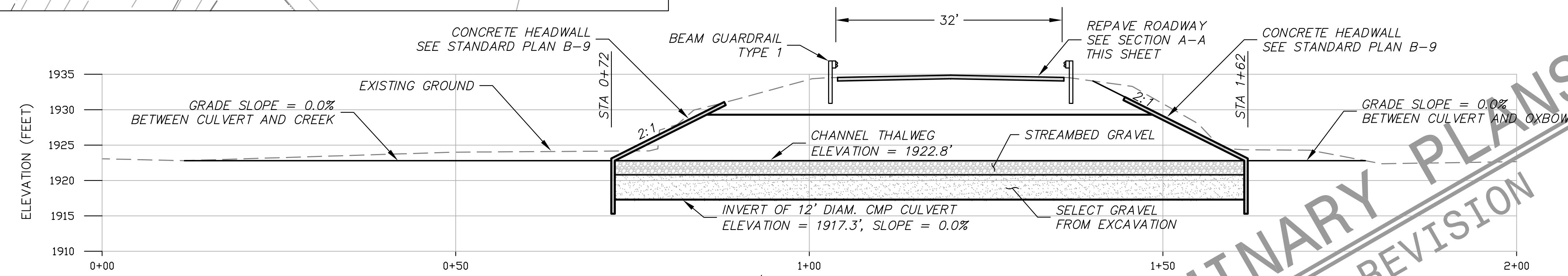
G:\PNWProjects\Chelan County\05750.05 - Nason Creek Oxbow\04 Resources\CAD\60%_ConstructionDrawings\3-4_Grading.dwg



DOWNSTREAM CULVERT - PLAN



SECTION A-A



DOWNSTREAM CULVERT - PROFILE

PRELIMINARY PLANS SUBJECT TO REVISION

Design:	REVISIONS		
	Date:	Description:	Made by:
Drawn by:			
Project Inspector:			
Survey Crew:			
Plot Date: 7-24-2006	As-Built Date:	by:	

Jones & Stokes
11820 Northup Way, Suite E300, Bellevue, WA 98005

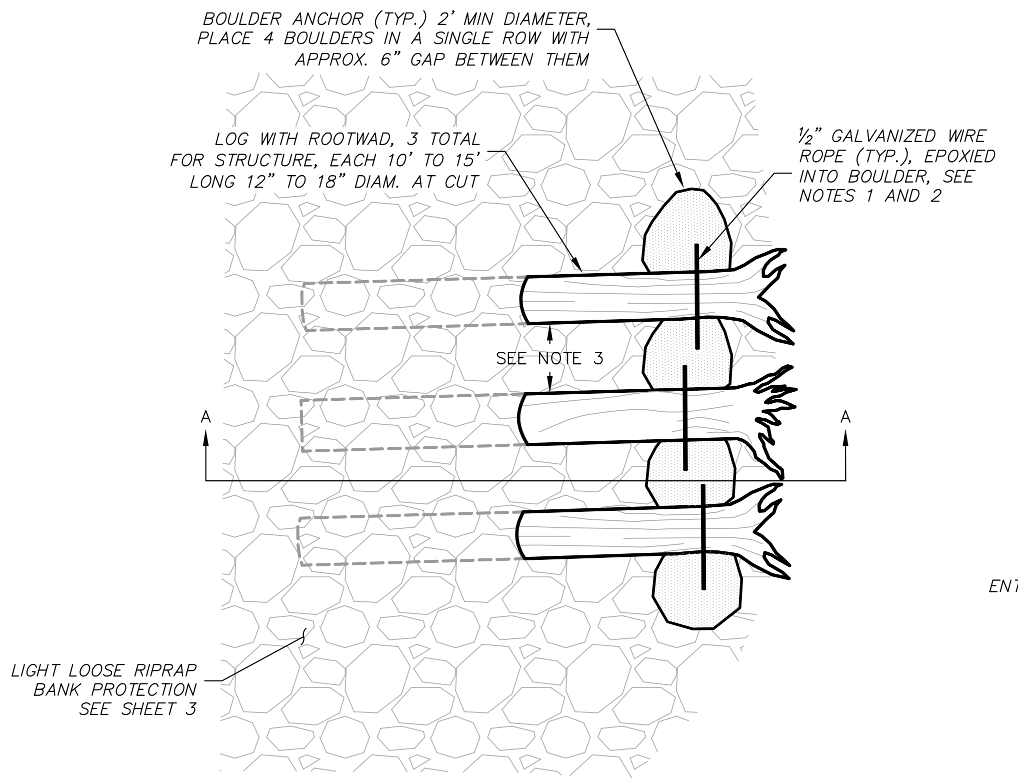
Chelan County
Natural Resource Department
316 Washington Street, Suite 401
Wenatchee, Washington, 98801
Phone: (509) 667-6567
Website: www.co.chelan.wa.us

Grading Plan
Downstream Culvert

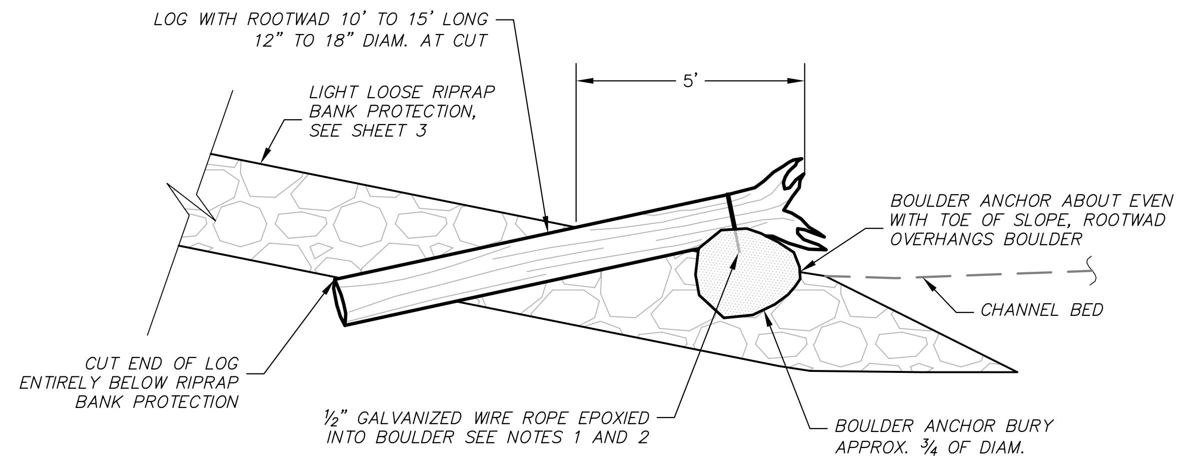
Nason Creek
Oxbow Reconnection Project

Sheet 4 of 8 | C.R.P. nnn

G:\PNWProjects\Chelan County\05750.05 - Nason Creek Oxbow\04 Resources\CAD\60%_ConstructionDrawings\3-4_Grading.dwg



PLAN



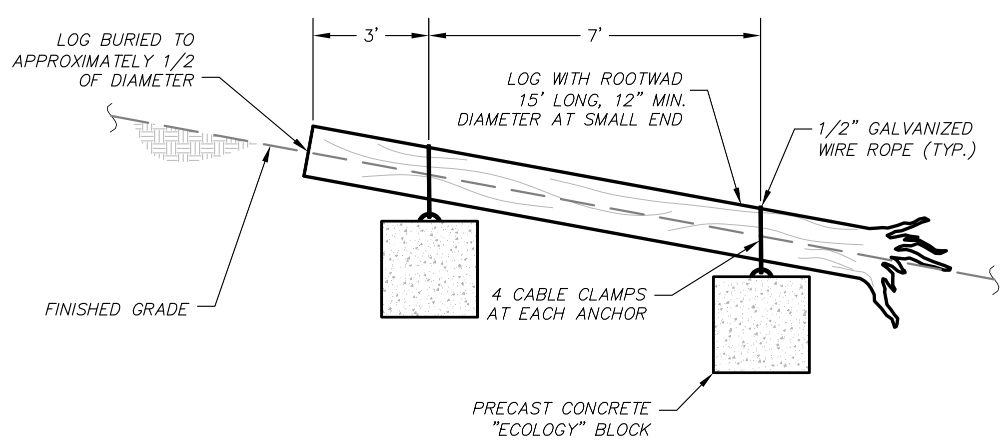
SECTION A–A

NOTES:

1. MINIMUM DIAMETER FOR BOULDER IS 2 FEET. EPOXY WIRE ROPE INTO ONE BOULDER, WRAP OVER TOP OF LOG. AND EPOXY INTO THE ADJACENT BOULDER. DRIVE TWO 2" GALVANIZED STEEL STAPLES OVER THE WIRE ROPE AND INTO THE LOG AFTER BOTH ENDS OF WIRE ROPE ARE EPOXIED INTO BOULDERS. PROVIDE A MINIMUM OF 6" BETWEEN STAPLES.
2. DRILL A 6" DEEP ¾" DIAMTER HOLE INTO BOULDER ORIENTED TOWARDS THE CENTER OF THE BOULDER. USE HILTE RE500 EPOXY ADHESIVE (OR APPROVED EQUIVALENT) PER MANUFACTURER'S INSTRUCTIONS TO ANCHOR WIRE ROPE INTO HOLE. WIRE ROPE MUST EXTEND INTO HOLE TO WITHIN ½" OF THE BOTTOM OF THE HOLE.
3. LOGS ARE SHOWN AS SPACED APPROXIMATELY 2' ON CENTER WITH 1' GAPS BETWEEN LOGS; HOWEVER, LOGS USED IN PROJECT MAY BE LARGER OR HAVE LARGE ROOTWADS. ADJUST SPACING OF LOGS AS NECESSARY TO ACCOMMODATE THE MATERIAL DELIVERED AND TO CREATE A CONTINUOUS WALL–LIKE FACING FROM THE ROOTWADS.
4. SOME TRIMMING OF ROOTS IS ALLOWABLE TO FIT THE LOG DIRECTLY AGAINST THE BOULDER ANCHORS WITHOUT EXCAVATING THE CREEK CHANNEL TO ACCOMODATE THE ROOTS.

B LWD BANK PROTECTION STRUCTURE

Scale: 1" = 2'



NOTES:

1. MINIMUM SIZE (VOLUME) FOR ECOLOGY BLOCK IS ½ CUBIC YARD.
2. FOUR CABLE CLAMPS ARE REQUIRED FOR EACH ANCHOR. THREAD WIRE ROPE THROUGH REBAR OR CABLE EYE ON TOP OF ECOLOGY BLOCK AND SECURE WIRE ROPE TO ITSELF USING TWO CABLE CLAMPS. BACKFILL ECOLOGY BLOCKS, PLACE LOGS, WRAP WIRE ROPE TWO FULL TURNS AROUND LOG AND SECURE WIRE ROPE TO ITSELF USING TWO CABLE CLAMPS. AT THE CUT END OF THE WIRE ROPE, A MINIMUM OF 6" OF WIRE ROPE SHALL EXTEND BEYOND THE CABLE CLAMPS.

C LWD HABITAT STRUCTURE

Scale: 1" = 2'

PRELIMINARY PLANS
SUBJECT TO REVISION

Design:	REVISIONS		
	Date:	Description:	Made by:
Drawn by:			
Project Inspector:			
Survey Crew:			
Plot Date: 7-24-2006	As-Built Date:	by:	

Jones & Stokes
11820 Northup Way, Suite E300, Bellevue, WA 98005

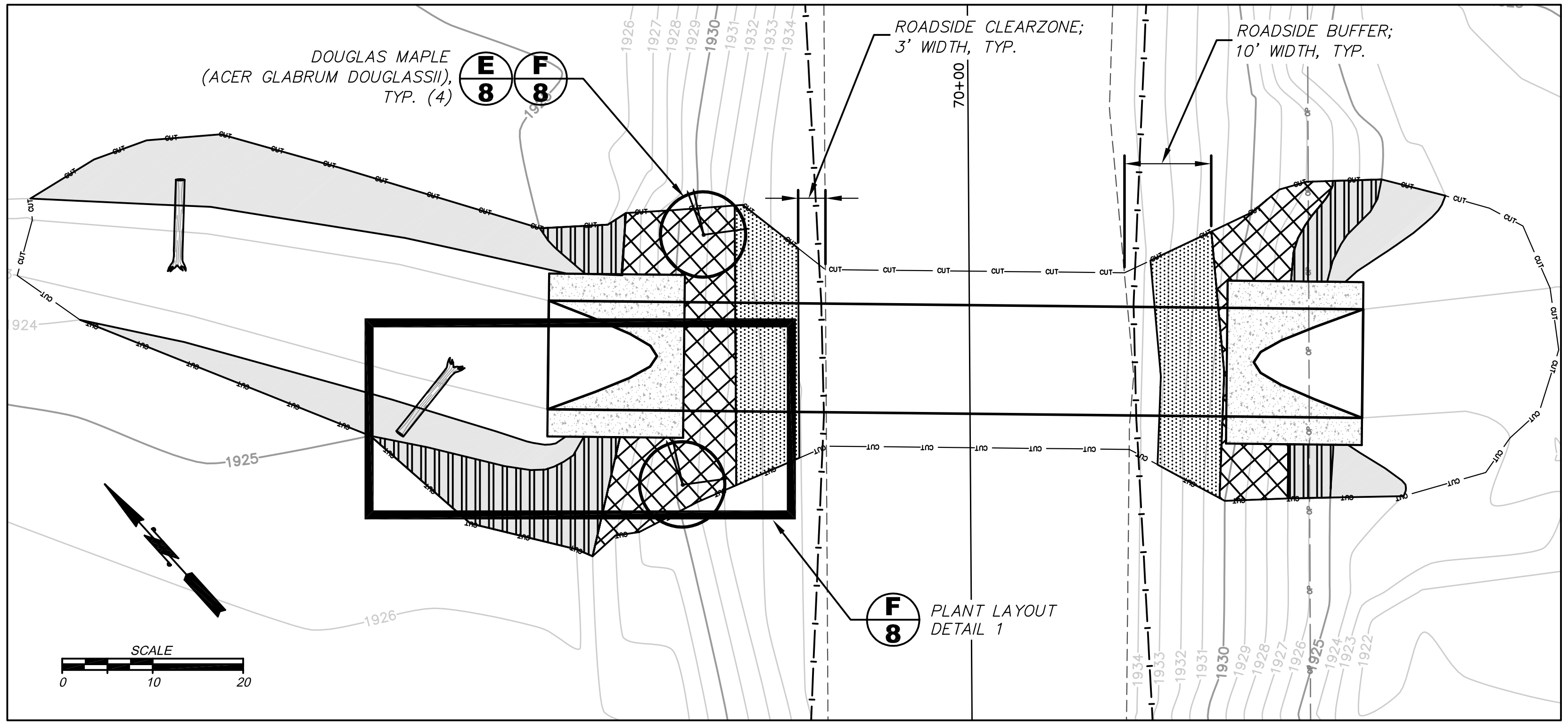
Chelan County
Natural Resource Department
316 Washington Street, Suite 401
Wenatchee, Washington, 98801
Phone: (509) 667-6567
Website: www.co.chelan.wa.us

Grading Details

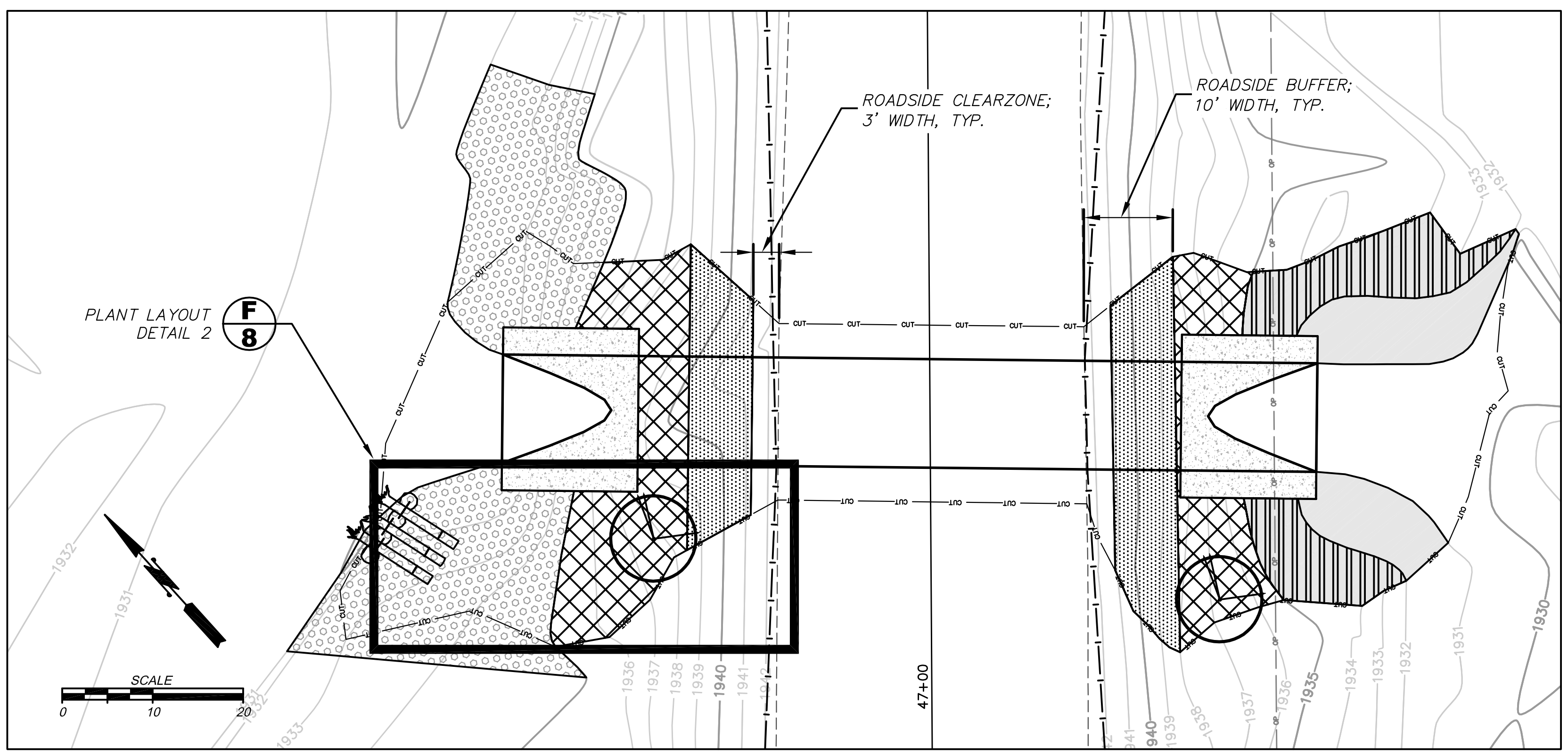
Nason Creek
Oxbow Reconnection Project

Sheet 5 of 8 | C.R.P. nnn

G:\PNWProjects\Chelan County\05750.05 - Nason Creek Oxbow\04 Resources\CAD\60%_ConstructionDrawings\5_Gradingdetails.dwg



DOWNSTREAM CULVERT - PLAN



UPSTREAM CULVERT - PLAN

LEGEND

(symbol)	EROSION CONTROL BLANKET

PLANTING AREAS

SYMBOL	PLANTING AREA	AREA (sf)	DETAIL
	UPLAND SHRUB PLANTING AREA	1,032	D/8 E/8 F/8
	RIPARIAN SHRUB PLANTING AREA	597	D/8 E/8 F/8
	LIVE STAKE PLANTING AREA	906	D/8 F/8

SEEDING AREAS

SYMBOL	SEEDING AREA	SEED MIX	AREA (sf)	DETAIL
	UPLAND SHRUB PLANTING AREA	UPLAND	1,032	F/8
	ROADSIDE BUFFER SEEDING AREA	UPLAND	838	F/8
	RIPARIAN SHRUB PLANTING AREA	RIPARIAN	597	F/8
	EROSION CONTROL BLANKET SEEDING AREA	RIPARIAN	1,456	F/8

NOTES

1. SEE PLANT SCHEDULE (SHEET 7) FOR PLANT SPECIES, QUANTITIES, AND MINIMUM SPACING. SEE PLANTING DETAILS (SHEET 8) FOR INSTALLATION AND LAYOUT DETAILS.
2. BOUNDARIES OF PLANTING AREAS TO BE STAKED BY ENGINEER.
3. PLANT LAYOUT TO BE APPROVED BY ENGINEER PRIOR TO INSTALLATION.
4. NO SEEDING OR PLANTING WITHIN THE 3-FOOT WIDTH ROADSIDE CLEARZONE BETWEEN EDGE OF PAVEMENT AND ROADSIDE BUFFER SEEDING AREA.
5. CONTRACTOR TO RESEED WITH UPLAND SEED MIX ALL AREAS DISTURBED BY CONSTRUCTION ACTIVITIES OUTSIDE LIMITS OF WORK.
6. EROSION CONTROL BLANKET SHALL BE WOVEN, BIODEGRADEABLE COIR FABRIC.

PRELIMINARY PLANS
SUBJECT TO REVISION

Design:	REVISIONS		
	Date:	Description:	Made by:
Drawn by:			
Project Inspector:			
Survey Crew:			
Plot Date: 7-24-2006	As-Built Date:	by:	

Jones & Stokes
11820 Northup Way, Suite E300, Bellevue, WA 98005

Chelan County
Natural Resource Department
316 Washington Street, Suite 401
Wenatchee, Washington, 98801
Phone: (509) 667-6567
Website: www.co.chelan.wa.us

Planting Plan

Nason Creek
Oxbow Reconnection Project

C.R.P. nnn

DOWNSTREAM CULVERT PLANT SCHEDULE

PLANTING AREA		SPECIES		MIN. SPACING	QUANTITY	SIZE	NOTES
UPLAND SHRUB	456 sf						
Location: Between 1927' elevation and Roadside Buffer seeding area.		Acer glabrum douglassii	Douglas maple	10'	1	1 gal	
		Rosa woodsii	Woods rose	4'	6	1 gal	
		Salix scouleriana	Scouler's willow	4'	9	72" ht.	Live stake
		Symphoricarpus albus	Snowberry	4'	9	1 gal	
RIPARIAN SHRUB	302 sf						
Location: Between 1925' elevation and Upland Shrub planting area.		Lonicera involucrata	Black twinberry	4'	10	1 gal	
		Salix exigua	Coyote willow	4'	10	60" ht.	Live stake

UPSTREAM CULVERT PLANT SCHEDULE

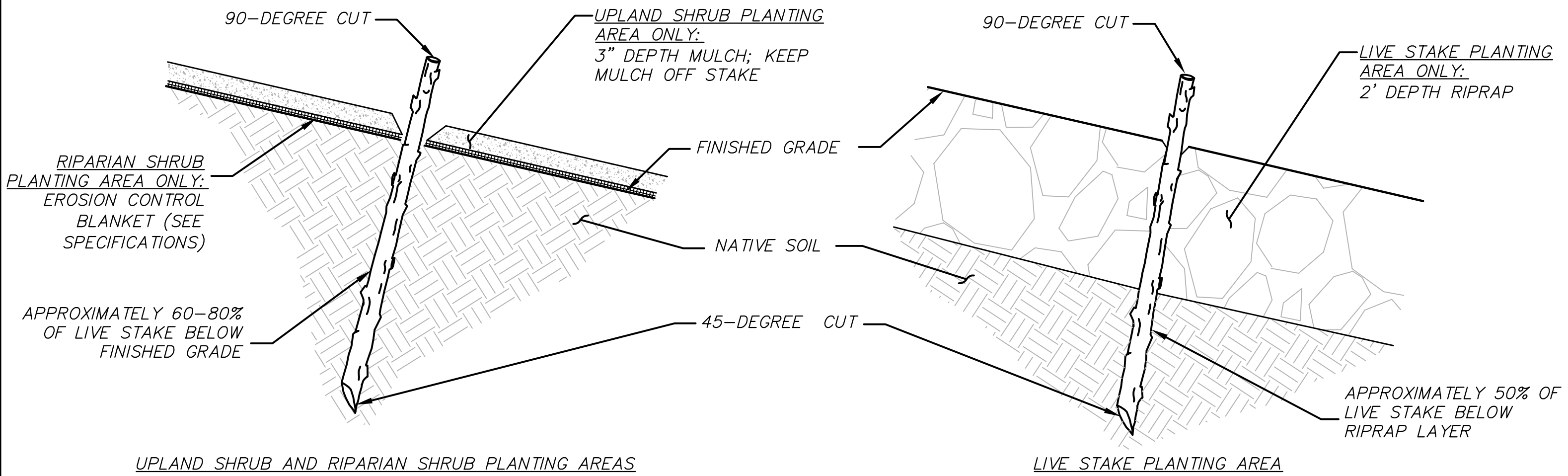
PLANTING AREA		SPECIES		MIN. SPACING	QUANTITY	SIZE	NOTES
UPLAND SHRUB	576 sf						
Location: Between riprap and Roadside Buffer seeding area at culvert inlet and between 1935' elevation and Roadside Buffer seeding area at culvert outlet.		Acer glabrum douglassii	Douglas maple	10'	1	1 gal	
		Rosa woodsii	Woods rose	4'	8	1 gal	
		Salix scouleriana	Scouler's willow	4'	12	72" ht.	Live stake
		Symphoricarpus albus	Snowberry	4'	12	1 gal	
RIPARIAN SHRUB	295 sf						
Location: Between 1932' and 1935' elevation at the culvert outlet.		Lonicera involucrata	Black twinberry	4'	10	1 gal	
		Salix exigua	Coyote willow	4'	10	60" ht.	Live stake
LIVE STAKE	906 sf						
Location: Joint planting in riprap at culvert inlet.		Cornus stolonifera	Red osier dogwood	4'	19	72" ht.; 1.5" min. diam.	Live stake
		Salix exigua	Coyote willow	4'	19	72" ht.; 1.5" min. diam.	Live stake

NOTES

1. SEE PLANTING DETAILS (SHEET 8) FOR INSTALLATION AND LAYOUT DETAILS.
2. SEED MIXES TO CONTAIN MINIMUM 95% PURE LIVE SEED.

SEED MIXES

SEEDING AREA	SPECIES		% MIX BY WEIGHT
UPLAND			
Location: Upland Shrub planting areas, Riparian Buffer seeding areas (between Upland Shrub plantinga areas and Roadside Clearzone) and all unplanted areas disturbed by construction activities.	Agropyron spicatum	Bluebunch wheatgrass	25
	Poa sandbergii	Sandberg bluegrass	25
	Festuca idahoensis	Idaho fescue	30
	Orzopis hymenoides	Indian ricegrass	20
RIPARIAN			
Location: Between 1924' and 1927' at inlet and outlet of downstream culvert. Between 1931' and 1935' at outlet of upstream culvert. (Corresponds with limits of Erosion Control Blanket and includes all Riparian Shrub planting areas.)	Deschampsia caespitosa	Tufted hairgrass	25
	Glyceria occidentalis	Western mannagrass	25
	Agropyron riparium	Streambank wheatgrass	20
	Festuca idahoensis	Idaho fescue	30

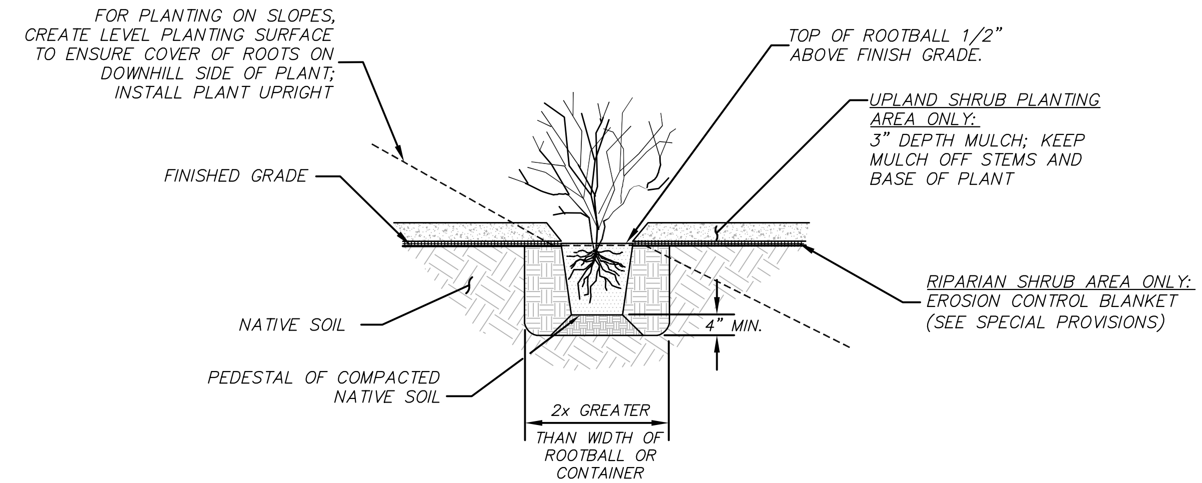


NOTES:

1. PLANT STAKES DURING THE DORMANT SEASON.
2. PRIOR TO PLANTING, MAKE 45-DEGREE CUT AT BUTT-END. CUT GROWING TIP SQUARE.
3. CREATE PILOT HOLE IN SOIL AT PLANTING SITE WITH PILOT BAR OR HAND AUGER.
4. PLANT STAKE AT 90-DEGREES TO FINISHED GRADE. GENTLY PUSH CUTTING BUTT-END DOWN INTO PILOT HOLE. A MINIMUM OF 3-5 BUD SCARS SHALL BE ABOVE FINISHED GRADE.
5. BACKFILL HOLE WITH NATIVE SOIL. FIRM SOIL AROUND STAKE TO AVOID AIR POCKETS AND SOIL SETTLEMENT.
6. INSTALL PROTECTIVE CAGES AROUND STAKES ACCORDING TO THE MANUFACTURER'S SPECIFICATIONS FOR PURPOSES OF CONTROLLING DAMAGE BY WILDLIFE BROWSE.

D LIVE STAKE INSTALLATION

Not to Scale

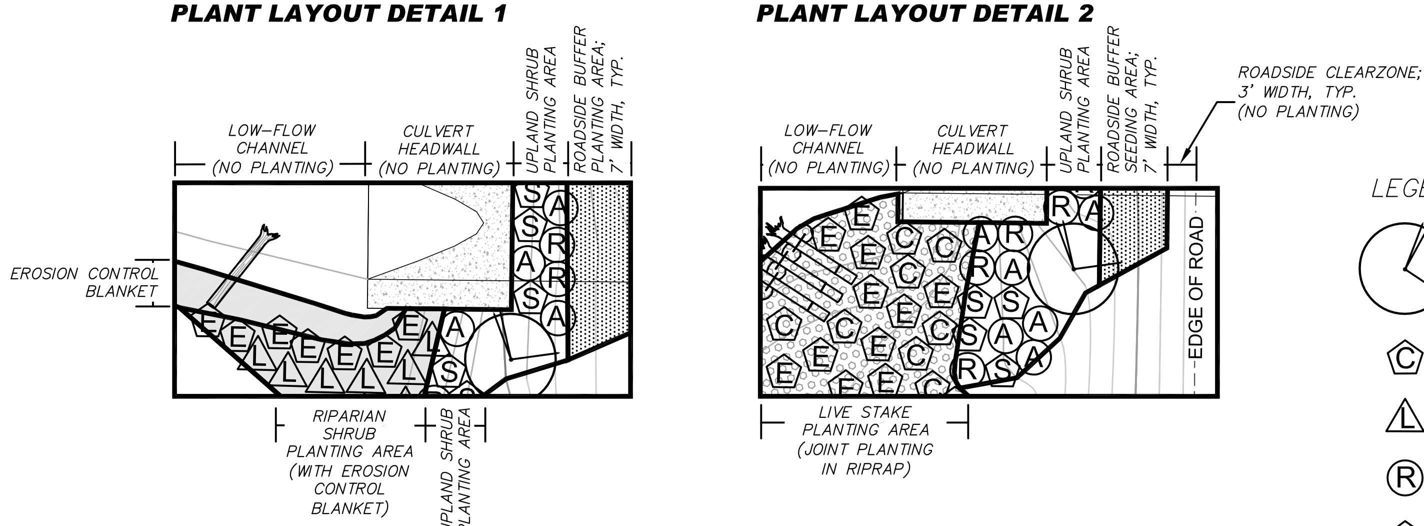


NOTES:

1. PLANTING PIT SHALL BE TWICE THE WIDTH OF THE ROOTBALL OR CONTAINER. SCARIFY SIDES OF PIT IF GLAZED.
2. PLACE ROOTBALL ON PEDESTAL (4" MINIMUM HEIGHT) OF COMPACTED NATIVE SOIL. TOP OF ROOTBALL SHALL BE 1/2" ABOVE FINISHED GRADE. SPREAD ROOTS OUT TO SIDES OF PIT.
3. INSTALL PROTECTIVE CAGES AROUND PLANTS ACCORDING TO THE MANUFACTURER'S SPECIFICATIONS FOR PURPOSES OF CONTROLLING DAMAGE BY WILDLIFE BROWSE.

E 1 GALLON CONTAINER PLANTING

Not to Scale



LEGEND:

- DOUGLAS MAPLE (ACER GLABRUM DOUGLASSII)
- C RED OSIER DOGWOOD (CORNUS STOLONIFERA)
- L BLACK TWINBERRY (LONICERA INVOLUCRATA)
- R WOODS ROSE (ROSA WOODSII)
- E COYOTE WILLOW (SALIX EXIGUA)
- S SCOULER'S WILLOW (SALIX SCOULERIANA)
- A SNOWBERRY (SYMPHORICARPUS ALBUS)

NOTES:

1. PLANT LAYOUT DETAILS ARE INTENDED FOR DIAGRAMMATIC PURPOSES ONLY AND SHOULD NOT BE USED AS A LAYOUT TEMPLATE.
2. PLANT LAYOUT DETAILS DO NOT SHOW ALL SPECIFIC PLANTING SITES REQUIRED FOR COMPLETE INSTALLATION OF PLANTINGS.
3. PLANT PLACEMENT SHALL BE VARIED TO ENSURE RANDOM LAYOUT.
4. SEE PLANTING PLAN (SHEET 6) FOR PLANTING LOCATIONS OF DOUGLAS MAPLES (ACER GLABRUM DOUGLASSII).
5. WITHIN RIPARIAN SHRUB PLANTING AREA, PLANT 75% OF TOTAL COYOTE WILLOW (SALIX EXIGUA) PLANTS AT LOWER ELEVATION THAN BLACK TWINBERRY (LONICERA INVOLUCRATA) PLANTS.

F PLANT LAYOUT DETAILS

Scale: 1"=10'

PLANTING NOTES:

1. SEE PLANT SCHEDULE (SHEET 7) FOR SPECIES, QUANTITIES, AND MINIMUM PLANT SPACING.
2. PLANT LAYOUT SHALL BE APPROVED BY ENGINEER PRIOR TO INSTALLATION.
3. ALL PLANTINGS SHALL BE INSTALLED ACCORDING TO THE CONSTRUCTION DRAWINGS AND SPECIFICATIONS. NO REPLACEMENTS WILL BE PERMITTED WITHOUT APPROVAL OF ENGINEER.
4. THE CONTRACTOR SHALL BE RESPONSIBLE FOR PROTECTING NEW PLANTINGS FROM DAMAGE FOR PERIOD SPECIFIED IN CONTRACT AND WILL REPLACE ALL DEAD OR DAMAGED PLANTS DURING THE MAINTENANCE PERIOD.

Design:	REVISIONS		
	Date:	Description:	Made by:
Drawn by:			
Project Inspector:			
Survey Crew:			
Plot Date: 7-24-2006	As-Built Date:	by:	

Jones & Stokes
11820 Northup Way, Suite E300, Bellevue, WA 98005

Chelan County
Natural Resource Department
316 Washington Street, Suite 401
Wenatchee, Washington, 98801
Phone: (509) 667-6567
Website: www.co.chelan.wa.us

Plant Details

Nason Creek
Oxbow Reconnection Project

 C.R.P. nnn

Appendix B

Site Photos

Photo 1. Upstream Connection Side Channel Flowing towards SR 207 (Summer)

Photo 2. Upstream Connection Side Channel Flowing towards SR 207 (Winter)

Photo 3. Upstream Connection Side Channel in Foreground

Photo 4. Location of the Upstream Connection Adjacent to SR 207

Photo 5. Existing Riprap and Side Channel Below Upstream Connection

Photo 6. Upstream Connection Oxbow Pool

Photo 7. Pool Formed Upstream of the Existing Downstream Oxbow Culvert

Photo 8. Highway 207.

Photo 9. Downstream Outlet Channel Connection to Nason Creek during Winter Flows.

Photo 10. Downstream Outlet Channel Connection to Nason Creek during Spring Flood Flows.

Photo 11. Existing Downstream Culvert Perched During Low Summer Flows.

Photo 12. Oxbow Pool Immediately Upstream of Beaver Dam 1

Photo 13. Beaver Dam 2

Photo 14. Oxbow Run Below Beaver Dam 2 Facing Downstream

Photo 15. Oxbow Run Below Beaver Dam 2 Facing Upstream

Photo 16. Oxbow Run Near Data Point 3

Photo 17. Shallow Oxbow Crossing in Run Below Beaver Dam 2

Photo 18. Scour caused by groundwater scour at the proposed upstream connection point within the oxbow. Note gravel substrate.

Photo 19. Example of the Construction of CMP (Chumstick Highway).

Photo 20. Example of the finished countersunk CMP (Chumstick Highway). The Nason Oxbow Project proposes a mitered concrete headwall.

Appendix C

Geomorphic Survey Indicator Definitions

Riparian Condition

Riparian condition refers to a description of the general health of the riparian area, focusing on the amount and type of vegetative cover. Riparian condition was described as low (0-25 % vegetative cover), moderate (25-50 % vegetative cover), high (50-75 % vegetative cover), or very high (75-100 % vegetative cover).

Substrate Composition and Embeddedness

Substrate composition and embeddedness refer to the size of the substrate materials on the channel bed of the oxbow, and the degree to which these materials are embedded. Substrate composition and embeddedness were measured at various sampling points. Typically, riffles are the best habitat or channel units to determine substrate composition and embeddedness; however, due to the lack of any identifiable riffles in the oxbow, one substrate composition and embeddedness measurement was taken on a historic point bar and one was taken on a run. Substrate composition and embeddedness was also crudely measured in other locations along the oxbows by using random "kick tests" along the channel bed.

Two sampling methods were used for determining substrate composition and embeddedness. On the two areas described above, substrate composition and embeddedness were measured using the methods described by Bunte and Abt (2001). This method, commonly referred to as the pebble count method, provides an objective, repeatable method that is more sensitive to changes in fine sediment than others, such as the Bain (1999) method (Jones & Stokes 2003). This method involved the establishment of a 5 by 5 ft grid in the middle of the habitat or channel unit. A metal pin, held vertically above a sampling point, was lowered until it contacted the substrate. The first particle touched by the metal pin was selected. The selected particle was picked up and its composition (i.e., size in millimeters [mm]) and embeddedness was measured. 50 values were recorded.

Dominant substrate composition fell into one of five classes: sand (< 2 mm), gravel (2-16 mm), pebble (17-64 mm), cobble (65-256 mm), and boulder (> 256 mm)

The embeddedness of gravel-sized and larger particles (>2 mm) was measured as the percentage of the total vertical extent of a particle below the bed surface. Embeddedness was scored as negligible (<5%), low (5–25%), moderate (25–50%), high (50–75%), or very high (>75%).

The second method, the "kick test", is a crude way of determining substrate composition whereby the approximate size and amount of substrate was determined by kicking up the sediment on the channel bottom and quantifying it by feel. The "kick test" method was employed in the most upstream and downstream pools.

Bank Instability and Bank Characteristics

The term 'bank instability' refers to streambanks that are either actively retreating or have the potential to retreat in the near future. In brief, weakening processes are any bank or near-bank processes that act to erode or prepare streambanks for further erosion (Lawler 1992).

Bank instability was qualitatively assessed in all of the four surveyed locations. The purpose of assessing this indicator was to identify fluvial erosion (erosion associated with flowing water) and bank failure (erosion associated with gravitational forces and weakening processes). Fluvial erosion is closely related to boundary shear stress, which can be loosely approximated by unit stream power variations, and bank failure is collapse of all or part of the streambank in situ (Lawler 1995).

Bank stability is defined as the natural streambank that has stable groundcover. Stable ground cover includes rooted trees, shrubs, herbaceous plants, and naturally occurring rocky substrates. The terms defined in Table C-1 were used to describe observed bank stability conditions. Only potentially unstable and currently unstable streambanks were recorded in the field and analyzed.

Table C-1.	Terms Used to Describe Bank Stability Conditions [a]

Category	Term	Definition
Streambanks	Stable streambank	Has 75% or more cover of live plants and/or other stability elements that are not easily eroded and has no instability elements
	Potentially unstable streambank	Has 75% or more cover but has 1 or more instability element(s)b
	Unstable streambank	Has less than 75% cover of live plants and/or other stability elements and/or 1 or more instability element(s) (unstable streambanks are often bare or nearly bare streambanks composed of noncohesive soil that is susceptible to fluvial erosion; particle size may vary depending on streambank material)
Stability elements	Live plants	Perennial herbaceous species, such as grasses, sedges, rushes; woody shrubs, such as willows; broadleaf trees, such as cottonwood and alder; conifer trees; and plant roots that are on or near the surface of the streambank and provide substantial binding strength to the streambank material
	Rock	Boulders, bedrock, and cobble/boulder aggregates that are combined to form a stable mass
	Downed wood	Logs firmly embedded in streambanks
	Erosion-resistant soil	Hardened conglomerate or cohesive clay/silt streambanks
Instability elements	Bank height	Moderately high to high bank height relative to surrounding streambanks
	Fracturing, blocking, or slumping	Cracks near the top of the streambank, slumping streambanks, and blocks of soil/plant material that have fallen off or slid down the streambank
	Mass movement	Bank failure from landslides and gravity erosion of oversteepened streambank slopes

Category	Term	Definition
	Undercutting	Frequent or continuous scour; significant to severe undercutting

[a] Based on definitions of streambank conditions in the U.S. Forest Service Region 5 Stream Condition Inventory Guidebook.

[b] Exception: Streambank will be classified as stable if bank height is the only instability element present.

Once a stream streambank was determined as potentially currently unstable or unstable, the following information was collected:

- streambank location (left or right);
- length of unstable area (horizontal distance);
- height of unstable area (defined as height from point of deepest scour adjacent to streambank to top of the streambank); and

  reference photographs.

Habitat or Channel Unit Type

Habitat or channel unit type encompasses the distribution of habitat or channel units, such as pools, riffles, and runs. Basic channel or habitat units were delineated along the entire reach of the oxbow according to standard habitat mapping descriptions. The purpose of delineating habitat or channel units was to identify areas that would possibly transport or aggrade a potential input of increased sediment, either from Nason Creek or the oxbow itself, delivered via higher velocities.

Channel or habitat units were defined as:

- Pool: Slow water, length and width at least one-half the bankfull channel width and a 10-inch minimum residual pool depth (Schuett-Hames et al. 1994). Subcategories define the general type of pool and include scour (lateral, channel, channel confluence, plunge), dam, and backwater as defined by Overton et al. (1997).
- Riffle: Swiftly flowing, turbulent water; some partially exposed substrate; substrate cobble and/or boulder dominated (McCain et al. 1990).
- Run: Wide, uniform channel volume, low to moderate water velocity, little surface agitation. Encompasses any areas that do not qualify as pool or riffle.

Woody Debris Influence

Woody debris influence refers to the amount of woody debris in the riparian area that has direct interaction with the channel, either through promotion of shade or influence on channel form. Woody debris pieces are defined as logs at least 6 feet long and at least 10 inches in diameter (Schuett-Hames et al. 1999, WFPB 1997) or rootwads of any size. Woody debris influence was described as low (0-25 %), moderate (25-50 %), high (50-75 %), or very high (75-100 %) for logs at least 3 feet long and at least 5 inches in diameter.

Bar Development

Bar development refers to the formation of any significant channel bar bedforms, such as mid-channel bars and point bars. No present-day bar development was encountered in the surveyed areas.

Bankfull Width and Depth

Bankfull width and depth measurements were recorded to assess the hydraulic capacity of the channels in the surveyed areas. Specifically, a geomorphic or effective bankfull surface was identified in the field. The geomorphic bankfull or effective surface is the surface that gets inundated by the discharge that performs the most geomorphic work on a system, typically a flow that occurs every 1.5-2 years (Knighton 1999). This discharge, known as the geomorphic bankfull discharge, is defined as that water discharged when stream water just begins to overflow into the active floodplain. The geomorphic bankfull or effective surface was identified based on the methodology of Harrelson et al. (1994) and Hauer and Lamberti (1996). Once this surface was recognized, width and depth measurements were recorded. Average bankfull depth was measured with a marked rod throughout the channel or habitat unit surveyed.

Average Width and Depth

Similar to bankfull width and depth measurements, average width and depth measurements were recorded. Specifically, an average wetted surface was identified in the field. The average wetted surface is the surface that is inundated most of the time and is closely related to the low flow surface (Knighton 1999). Once this surface was recognized, width and depth measurements were recorded. Average bankfull depth was measured with a marked rod throughout the channel or habitat unit surveyed.

Degree of Incision

The degree to which the channel in a particular area of the survey was incised was recorded. Degree of incision was qualitatively analyzed using the following criteria:

- Identification of any Quaternary landforms on the floodplain (e.g., terraces, low floodplain, fan, etc.). Terraces typically have steep streambanks and the channel may not necessarily be incised. Steep, unstable streambanks adjacent to a low floodplain surfaces, however, typically indicate incision.

- Identification of bedforms downstream of the site where and if the channel is less incised. Bed and streambank material from incised channels will typically be deposited downstream in somewhat uncharacteristically large deposits on the channel bed (downstream aggradation).

- Recognition of base level changes downstream. Dams and other barriers can create upstream changes in channel bed elevation (i.e., headward migration of incision).

- Visual survey of channel bed at the site. Channel or habitat sequences, such as pool-riffle sequences, are rare in incised channels, and those that do exist do so for only limited time intervals. Additionally, the increased depth of flow associated with incision, coupled with an increased flashy regime, results in bed armoring and a decreased frequency of bed mobilization.

- Determination of the health of the riparian and floodplain plant species. Plants that are found in similar, un-incised reaches are usually not present in incised reaches. No vegetation at all is an indicator of no hydrologic interaction between the floodplain and the channel and therefore incision.

- Identification of recent evidence of overbank deposition of fine sediment, plant debris, or other organic matter. A channel that floods its streambanks frequently will typically have splay (i.e., sand) deposits and vegetation with a smoothed, flooded appearance in the downstream direction. Natural levee development is also an indication of frequent flooding.

Degree of incision was recorded as negligible, low, moderate, high, or very high.

Channel Pattern

Channel pattern was not directly identified in the field. Rather, aerial photographs and other maps were used to assess whether channel pattern was straight, meandering, braided, or anabranching.

References

Bain, M.B. 1999. Substrate. Pages 95–103 in Bain, M.B., and N. J. Stevenson (eds.), *Aquatic Habitat Assessment: Common Methods, 1999*. Bethesda, MD: American Fisheries Society.

Bunte, K., and S.R. Abt. 2001. *Sampling Surface and Subsurface Particle-size Distributions in Wadable Gravel- and Cobble-bed Streams for Analyses in Sediment Transport, Hydraulics, and Streambed Monitoring.* General Technical Report RMRS-GTR-74. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Harrelson, C.C., C.L. Rawlins, and J.P. Potyondy. 1994. *Stream Channel Reference Sites: An illustrated Guide to Field Technique.* General Technical Report RM-245. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, 61 p.

Hauer, F.R., and G.A. Lamberti (eds.). 1996. *Methods in Stream Ecology*. Academic Press, San Diego, 6,474 pp.

Jones & Stokes. 2003. *Water Quality and Aquatic Resources Monitoring Program for the Ralston Sediment Management Project: 2002 Annual Report.* September. (J&S 01-335) Sacramento, CA. Prepared for Placer County Water Agency, Foresthill, CA.

Knighton, A.D. 1998. *Fluvial Forms and Processes: A New Perspective*. John Wiley and Sons, New York, 383 pp.

Lawler, D.M. 1992. Process Dominance in Bank Erosion Systems. In: Carling, P.A., and Petts, G.E. (eds.), *Lowland Floodplain Rivers: Geomorphological Perspectives*. John Wiley and Sons, Chichester, pp. 117–143.

Lawler, D.M. 1995. The Impact of Scale on the Processes of Channel-Side Sediment Supply: A Conceptual Model. In: Osterkamp, W.R. (ed.), *Effects of Scale on Interpretation and Management of Sediment and Water Quality*. IAHS Publication 226, pp. 175–184.

McCain, M., D. Fuller, L. Decker, and K. Overton. 1990. *Stream Habitat Classification and Inventory Procedures for Northern California*. FHC Currents. No.1., U.S. Department of Agriculture. Forest Service, Pacific Southwest Region.

Overton, C.K., S.P. Wollrab, B.C. Roberts, and M.A. Radko. 1997. *R1/R4 (Northern/Intermountain Regional) Fish and Fish Habitat Standard Inventory Procedures Handbook.* Gen. Tech. Rep. INT-GTR-346. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station.

Schuett-Hames, D.A. Pleus, L. Bullchild, and S. Hall. 1994. *Timber-Fish-Wildlife Ambient Monitoring Program Manual.* TFW-AM9-94-001 Northwest Indian Fisheries Commission. Olympia WA.

Schuett-Hames, D.A. Pleus, J. Ward, M. Fox, J. Light. 1999. *Method Manual for the Large Woody Debris Survey*. TFW-AM9-99-004 Northwest Indian Fisheries Commission. Olympia WA.

Washington Forest Practices Board (WFPB). 1997. *Watershed Analysis Manual*. Volume 4.0. Olympia, WA.

Appendix D

Soil Test Results

Jones & Stokes

Technical Memorandum

Date: July 14, 2006

To: John Soden

From: Jim Wilder

Subject: Fuel Contamination in Soil at Nason Creek Oxbow

Objective

This memorandum evaluates the measured concentrations of diesel-range total petroleum hydrocarbons (TPH-D) and lube-oil range total petroleum hydrocarbons (TPH-O) measured in surface soil at the Nason Creek Oxbow restoration site. The measured concentrations are compared to two sets of soil cleanup criteria established by the Washington state Model Toxics Control Act (MTCA) cleanup regulation (WAC 173-340):

- Conservatively low screening-level human health risk-based cleanup standards defined by MTCA Method A (MTCA Table 740-1) based on unrestricted human access.

- Conservatively low screening-level ecological indicator cleanup standards defined by MTCA Table 749-3, assuming the restoration site is ecologically sensitive and therefore subject to site-specific indicator criteria.

Methodology

Jones & Stokes is conducting an ecological restoration of a formerly abandoned oxbow along Nason Creek. The oxbow is adjacent to Highway 2. Stormwater draining from the roadway into the oxbow likely contains trace concentrations of crankcase oil, lube oil, diesel oil, and weathered gasoline. To assess potential accumulation of soil contaminants in the oxbow, Jones & Stokes collected four soil samples from within the oxbow in June 2006. Two regional background samples were collected at the same time from nearby Nason Creek. The samples were sent to the TestAmerica laboratory in Bothell, Washington and analyzed for fuel hydrocarbons using Washington state Method NWTPH-Dx. The analysis categorized the measured hydrocarbon concentrations into two ranges: diesel-range hydrocarbons (TPH-D) and lube oil-range hydrocarbons (TPH-O).

11820 Northup Way, Suite E300 • Bellevue, WA 98005-1946 • tel. 425 822.1077 • fax 425 822.1079
www.jonesandstokes.com

Analytical Results

Table D-1 summarizes the results of the TPH-D and TPH-O analyses for each sample, and presents the arithmetic averages for the oxbow samples and the Nason Creek background samples.

Table D-1. Summary of Analytical Results

Sample	**Hydrocarbon Type**	**Soil Concentration (mg/Kg)**
Oxbow US 1	TPH-D	146
	TPH-O	555
Oxbow US 2	TPH-D	ND(< 78 Method Reporting Limit)
	TPH-O	386
Oxbow Mid 1	TPH-D	ND(< 15)
	TPH-O	ND(< 37)
Oxbow DS 1	TPH-D	ND(< 61)
	TPH-O	ND(< 152)
Nason US 1	TPH-D	15
	TPH-O	44
Nason DS 1	TPH-D	62
	TPH-O	148
Arithmetic Average of Oxbow Samples	***TPH-D***	***55***
	TPH-O	***259***
Arithmetic Average of Nason Creek Samples	***TPH-D***	***39***
	TPH-O	***96***

Note: to calculate the arithmetic average, non-detect values were set equal to ½ the Method Reporting Limit.

Quality control samples consisted of field blanks, duplicate samples, and laboratory matrix spikes. The blank samples exhibit concentrations below the Method Reporting Limits, and the matrix spikes exhibited recoveries between 83% to 119%.

Comparison to MTCA Cleanup Standards

Table D-2 compares the arithmetic averages of the measured concentrations to the conservatively low screening-level criteria for human health protection and ecological indicators. With one exception, the measured concentrations are less than the screening-level criteria. The exception is lube oil-range hydrocarbons (TPH-O) measured in the oxbow, where the arithmetic average (259 mg/kg) slightly exceeded the presumed ecological indicator criterion for soil biota (200 mg/kg). Note the TPH-O concentration (259 mg/kg) is only a small fraction of the ecological criterion for “wildlife” (6,000 mg/kg).

The exceedance of the TPH-O criterion for "soil biota" does not necessarily mean that soil within the oxbow is toxic to soil biota. The MTCA rule emphasizes that exceedances of the screening-level criteria do not indicate ecological damage and the need for soil remediation. Instead, an exceedance indicates a possible need for additional, more refined assessment to evaluate whether the soil contamination has actually stunted biological functions within the site. Because the measured concentrations are well below the "Wildlife" criterion and only slightly above the conservatively low "Soil Biota" criterion, it is reasonable to conclude fuel hydrocarbons in the oxbow have not adversely affected biological functions, and would not adversely impact the restoration project. However, that conclusion is not 100% supported based solely on the results of this study.

Table D-2. Comparison to MTCA cleanup Standards

Sample	**Fuel Type**	**Soil Conc. (mg/Kg)**	**Method A Human Health Based Cleanup Standard (mg/kg)**	**Ecological Indicator Limits from MTCA Table 749-3 (mg/kg)**		
				Plants	**Soil Biota**	**Wildlife**
Oxbow Arithmetic Average	THP-D	55	2,000	None listed	200	6,000
	TPH-O	**259**	2,000	None listed	**200** (No listed value; assumed same as TPH-D)	6,000 (No listed value; assumed same as TPH-D)
Nason Creek Arithmetic Average	THP-D	39	2,000	None listed	200	6,000
	TPH-O	96	2,000	None listed	200 (No listed value; assumed same as TPH-D)	6,000 (No listed value; assumed same as TPH-D)

Note: Underlined values indicate exceedance of screening-level criterion

Appendix E

Alternatives Analysis

Technical Memorandum

Date: June 6, 2006

To: Mike Kaputa, CCNRD

From: John Soden

cc: Joy Juelson, Alan Schmidt, Martin Fisher

Subject: Nason Creek Oxbow Reconnection Project Design Alternatives Analysis

Alternatives

At the request of the Chelan County Natural Resource Department and Regional Technical Team (RTT), Jones & Stokes has conducted an analysis of project design alternatives for the Nason Creek Oxbow Reconnection Project (Nason Project). Based upon feedback from the RTT on May 10, 2005, we have examined five design alternatives. These five design alternatives are as follows:

- Alternative 1 – Remove SR 207 from the Nason Creek channel migration zone.
- Alternative 2 – Redirect Nason Creek into the existing oxbow using two 200-foot bridge structures.
- Alternative 3 – Reconnect partial Nason Creek flows to the oxbow with two 12-foot CMP culverts.
- Alternative 4 – Reconnect partial Nason Creek flows to the oxbow with two 36-foot CMP culverts.
- Alternative 5 – Reconnect partial Nason Creek flows to the oxbow with one 12-foot CMP culvert at the downstream oxbow connection.

As shown in Table E-1, these alternatives were compared through overall salmonid habitat benefit, construction feasibility, cost, and the potential for funding based upon project cost.

Based upon this analysis, the CCNRD proposes to construct Alternative 3; the partial reconnection of the oxbow to Nason Creek via two 12-foot CMP culverts. This Alternative directly address the limiting habitat factors within Nason Creek, is practical to construct, has comparatively low cost, and meets typical financial limits of current funding sources.

Table E-1. Comparison of the Five Nason Project Alternatives.

Alternative	Habitat Benefits	Construction Feasibility	Cost	Funding Potential	Overall
Alternative 1 Remove SR 207 from the Nason Creek channel migration zone.	High Additional 47 acres of rearing habitat. Additional 1,100 l.f. spawning habitat. Restore channel migration zone.	Moderate Feasible highway alignment available. WSDOT opposes highway realignment due to safety concerns. Project could be constructed in stages to avoid highway closure.	High $6.4 million Large uncertainty due to unknown real estate costs.	Low Project meets the goals of the Biological Strategy. Cost exceeds the historic SRFB and Tributary Fund budgets for Chelan County projects.	Alternative Rejected Project meets biological goals, but WSDOT opposes highway realignment, high potential of condemnation of private property, high cost, and low likelihood of available project funds.
Alternative 2 Redirect Nason Creek into the existing oxbow using two 200-foot bridge structures.	High Additional 37.5 acres of rearing habitat. Additional 1,100 l.f. spawning habitat. SR 207 road prism remains in CMZ and continues to restrict natural channel migration.	Moderate Bridges not preferred by WSDOT due to increased maintenance requirements. Significant amount of in-channel work required. Traffic control during construction could be difficult and expensive.	High $6.3 million.	Low Project meets the goals of the Biological Strategy. Cost exceeds the historic SRFB and Tributary Fund annual budgets for Chelan County projects.	Alternative Rejected Project meets biological goals, but cooperation from WSDOT unlikely, high cost, and low likelihood of available project funds.
Alternative 3 Reconnect partial Nason Creek flows to the oxbow with two 12-foot CMP culverts.	High 34.5 acres of year-round off-channel rearing habitat SR 207 road prism remains in CMZ and continues to restrict natural channel migration.	High WSDOT supports culvert alternative. No significant in-water work.	Moderate $500,000	Moderate Project meets the goals of the Biological Strategy. Cost falls within historic range for SRFB and Tributary Fund annual budgets for Chelan County projects.	Preferred Alternative Project meets biological goals, has WSDOT support, and cost is within limits of local funding sources.
Alternative 4 Reconnect partial Nason Creek flows to the oxbow with two 36-foot CMP culverts.	High 34.5 acres of year-round off-channel rearing habitat SR 207 road prism remains in CMZ and continues to restrict natural channel migration.	High WSDOT supports culvert alternative. No significant in-water work.	High $1.2 million	Low Project meets the goals of the Biological Strategy. Cost exceeds the historic SRFB and Tributary Fund annual budgets for Chelan County projects.	Alternative Rejected Project meets biological goals, and has WSDOT support. Biological benefit is similar to Alternative 3, but is 2.5 times more costly.
Alternative 5 Reconnect partial Nason Creek flows to the oxbow with one 12-foot CMP culvert at the downstream oxbow connection.	Moderate 34.5 acres of seasonally restricted off-channel rearing habitat. SR 207 road prism remains in CMZ and continues to restrict natural channel migration.	High WSDOT supports culvert alternative. No significant in-water work.	Moderate $375,000	Moderate Project meets the goals of the Biological Strategy. Cost falls within historic range for SRFB and Tributary Fund annual budgets for Chelan County projects.	Alternative Rejected Project has WSDOT support, and cost is within limits of local funding sources. Project costs are similar to Alternative 3 but provides less habitat benefit.

A brief description of each alternative along with the assumptions made during this analysis is presented below and on the following pages. A matrix that compares costs and benefits for each alternative follows the description of the alternatives.

Alternative 1: Remove SR 207 from the Nason Creek Channel Migration Zone

Alternative 1 would relocate approximately 1.35 miles of SR 207 from the channel migration zone (CMZ) to the adjacent hillside east of the existing highway alignment (Figure 1). This alternative would restore natural riverine processes to a 0.75-mile reach of lower Nason Creek by removing the existing highway from the CMZ. This would allow natural creek processes to dictate future channel conditions.

While removing the highway will allow the creek to reach ultimate equilibrium with an expanded CMZ, in-channel work would be performed to train the existing channel into the oxbow. These measures are necessary insure that the project results in the creek occupying the abandoned oxbow thus providing a maximum of habitat benefit. This work would require a minimum of 3,000 linear feet of creek realignment. Due to the braided planform of the existing creek channel, the creek realignment would require new channel construction, bank hardening, and flow redirection (e.g. barbs, and cross vanes) beginning upstream of the BPA powerlines.

The cost for this project was estimated using a generalized design for the new SR 207 alignment. This Alternative proposes only to move SR 207 in the 1.35-mile vicinity of the Nason Oxbow Project Site, because the highway is not within the CMZ downstream of river mile (RM) 3.0.

This project would result in the reconnection of 42 acres of salmonid rearing habitat. By ensuring that the main channel will relocate to the historic oxbow channel, this alternative would also result in an increase of 1,100 l.f. of spawning habitat. The expansion of floodplain capacity and instream habitat would provide a long-term benefit to spawning and rearing for both chinook and steelhead. This alternative would also provide five acres of off-channel high-flow rearing habitat in the abandoned main channel.

Alternative 2: Redirect Nason Creek into the Existing Oxbow Using Two 200-Foot Bridge Structures

Alternative 2 would redirect Nason Creek into the existing oxbow (Figure 2). This alternative would place Nason Creek back into its historic alignment thereby increasing the channel length by approximately 1,100 linear feet. The active channel averages 200-feet in width at the location of the upstream connection point, thus a bridge with a span of 200 feet is proposed for this alternative. A similar bridge would be required at the downstream end. In-channel work would be necessary to train the existing creek to enter the oxbow at the new upstream bridge. To redirect the creek, a minimum of 3,000 linear feet of creek realignment would be required. Due to the braided planform of the existing creek channel, the creek realignment would require new channel construction, bank hardening, and flow redirection (e.g. barbs, and cross vanes) beginning upstream of the BPA powerlines. To protect the downstream bridge structure from potential debris jams, accumulated sediments and large wood would be removed from the oxbow prior to reconnection.

For the purposes of this alternative, the existing reach of main channel located between the proposed upstream and downstream oxbow connections would be blocked from direct flows and converted into an off-channel backwater habitat. Excavation and habitat enhancement in the remnant main channel would incorporate shallow groundwater discharge to provide seasonal high-flow off-channel habitat (3 acres [1,500 l.f.]) accessed by juvenile salmonids from downstream only.

We considered maintaining this channel as a high flow channel via the installation of a sill at the upstream end of the reach. But diverting high flows at the upstream bridge results in a high likelihood of causing a sedimentation problem either at the bridge structure or inside the new creek alignment (the current oxbow). This would increase bridge maintenance and degrade spawning habitats in the new channel. Therefore, the option to maintain the existing channel as a high flow habitat has been rejected.

This project would result in the reconnection of 34.5 acres of rearing habitat, and an additional 1,100 l.f. of spawning habitat in the realigned main channel. The existing mainstem would also provide 3 acres of seasonal off-channel rearing habitat. The expansion of floodplain capacity and instream habitat would provide a long-term benefit to spawning and rearing for both chinook and steelhead.

Alternative 3: Reconnect Partial Nason Creek Flows to the Oxbow with Two 12-foot CMP Culverts

Alternative 3 is the preferred Alternative for the Nason Project. This alternative would install two 12-foot diameter CMP culverts to reconnect partial flows to the oxbow habitat (Figure 3). This Alternative was described in detail in the *Nason Creek Oxbow Reconnection Project - Alternatives Analysis and Design Report* (Jones & Stokes 2005). The preferred method is to install two 12-foot diameter culverts, one at the upstream end and one at the downstream end of the oxbow, to reconnect fish access and flows and maintain the oxbow as off-channel habitat. No in-channel work would be performed upstream or downstream of the culvert connections. No habitat enhancement would be performed within the existing oxbow.

As simulated with a numerical hydraulic model in Jones & Stokes 2005, the 12-foot culvert allows about 25% of the flow in the river-right Nason Creek side channel to enter the oxbow, which corresponds to about 10% of the total Nason Creek discharge. At the highest simulated flows, this oxbow inflow rate decreases to 13% of the right side channel discharge, or 5% of the total discharge. Above a flow of about 1,700 cfs in the right channel, oxbow inflows reach a maximum near 218 cfs. This alternative would allow flows and fish passage during high and low-flow conditions, resulting in very low risk to fish stranding, and lower water temperatures in summer months.

This project would result in the reconnection of 34.5 acres of year-round off-channel rearing aquatic habitat, while maintaining the current main channel alignment and spawning habitat (2,200 l.f.). This project would directly address the limiting salmonid habitat factors in the Nason Creek subbasin by immediately providing fish access to year-round off-channel rearing and foraging habitat.

Alternative 4: Reconnect Partial Nason Creek Flows to the Oxbow with Two 36-foot CMP Culverts

Alternative 4 would install two 36-foot diameter CMP culverts to reconnect partial flows to the oxbow habitat (Figure 3). This Alternative was described in detail in the *Nason Creek Oxbow Reconnection Project - Alternatives Analysis and Design Report* (Jones & Stokes 2005). The two 36-foot CMP culverts, would be installed at the upstream and downstream end of the oxbow, to reconnect fish access and flows and maintain the oxbow as off-channel habitat. No in-channel work would be performed upstream or downstream of the culvert connections. No habitat enhancement would be performed within the existing oxbow.

As simulated with a numerical hydraulic model in Jones & Stokes 2005, the upstream 36-foot culvert allows about 50% of the flow in the river-right Nason Creek side channel to enter the oxbow, which corresponds to about 20% of the total Nason Creek discharge. At the highest simulated flows, this oxbow inflow rate decreases to 35% to 38% of the right side channel discharge, or 14% to 15% of the total discharge. Above a flow of about 1,700 cfs in the right channel, oxbow inflows reach a maximum near 619 cfs. This alternative would allow flows and fish passage during high and low-flow conditions, resulting in very low risk to fish stranding, and lower water temperatures in summer months.

This project would result in the reconnection of 34.5 acres of year-round off-channel rearing aquatic habitat, while maintaining the current main channel alignment and spawning habitat (2,200 l.f.). Similar to Alternative 3, this project would directly address the limiting salmonid habitat factors in the Nason Creek subbasin by immediately providing fish access to year-round off-channel rearing and foraging habitat.

Alternative 5: Reconnect Partial Nason Creek Flows to the Oxbow with One 12-foot CMP Culvert at the Downstream Oxbow Connection

Alternative 5 proposes to replace the existing 3-foot diameter concrete culvert currently located under SR 207 at the downstream end of the oxbow (Figure 4) with a 12-foot CMP culvert. The current culvert is perched and creates a seasonal (low-flow) fish passage barrier. The new culvert would be installed with a lower invert elevation to improve fish passage.

No in-channel work would be performed on the main channel upstream or downstream of the culvert connection. Very limited fish passage currently exists through the oxbow channel between the main creek channel and the 3-foot diameter culvert. There is an open water connection consisting of a shallow seasonal 1 to 2-foot wide channel that does not convey flow during summer months. To improve fish passage between the open water in the oxbow and the main creek channel, a wider and deeper channel would be excavated between the culvert and the main oxbow habitat. While this measure would improve fish passage during both high and low flows, extreme summer low-water would likely leave this excavated channel dewatered and result in fish stranded in the oxbow.

This project would result in the seasonal reconnection of 34.5 acres of off-channel rearing aquatic habitat, while maintaining the current main channel alignment and spawning habitat (2,200 l.f.). This project would directly address the limiting salmonid habitat factors in the Nason Creek subbasin by immediately providing fish access to off-channel rearing and foraging habitat. Fish access to the oxbow would be seasonally restricted by low oxbow discharge in the summer months. This will likely lead to fish stranding and potential mortality due to high water temperatures in the oxbow.

Work Plan

The following is the CCNRD work plan for completing construction on Alternative 3 of the Nason Project during 2007. This schedule is subject to change based upon project funding, and permitting.

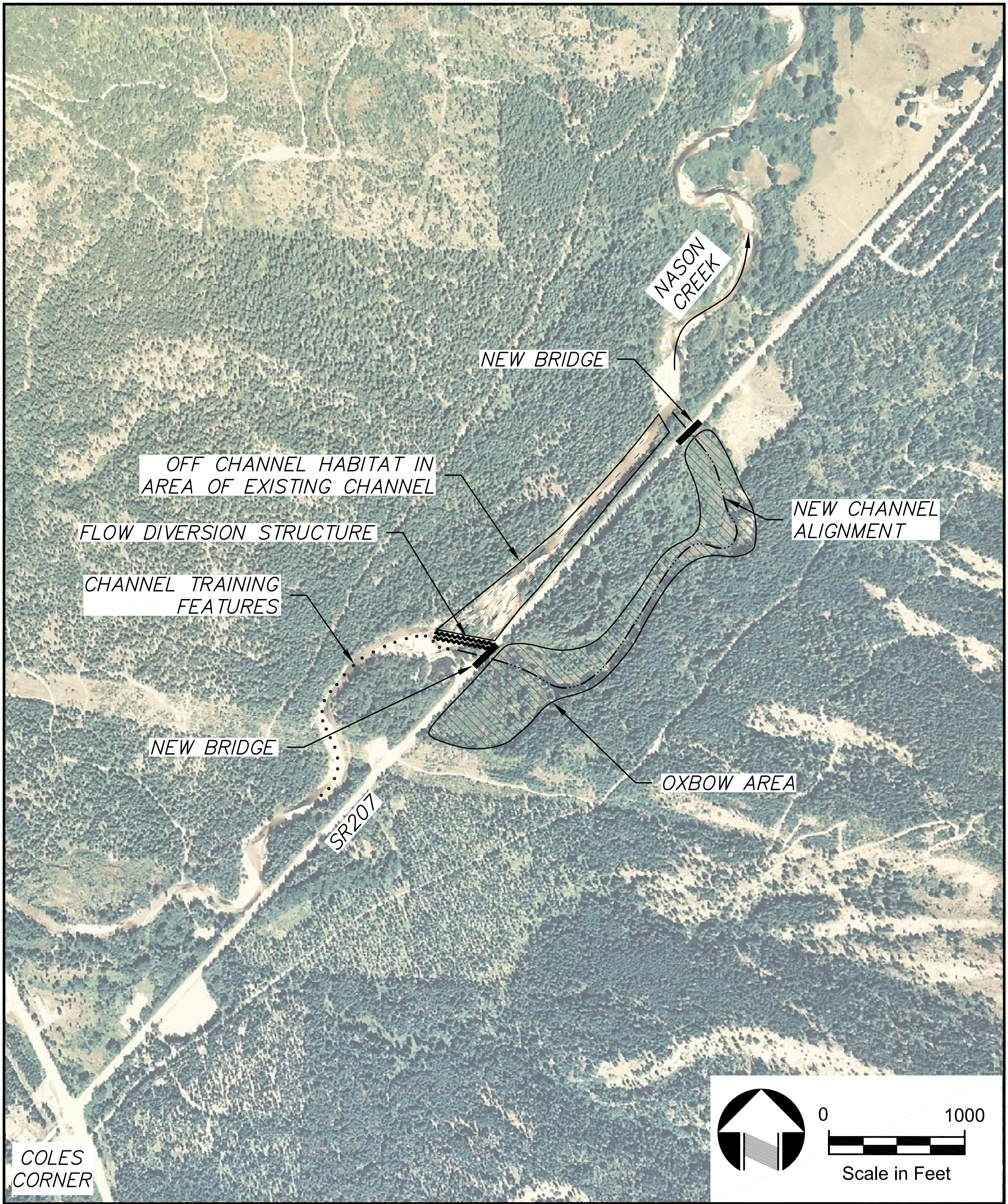
Time	Task
Summer 2006	Conduct geotechnical borings at the proposed culvert locations.
	Collect and analyze oxbow sediments for toxins.
	Collect oxbow water temperatures and model changes to water temperatures with proposed alternative.
	Collect additional river cross-sections and refine the hydraulics and hydrology model to meet WSDOT modeling and reporting standards.
	Collect additional topography data at the proposed culvert locations.
Fall 2006	Refine 35% design plans for the 12-foot CMP culvert alternative (Alternative 3).
Winter 2006–2007	Complete permit applications and coordinate with permit agencies.
Spring 2007	Complete 100% plans and specifications incorporating agency comments and recommendations.
Summer 2007	Conduct pre-construction monitoring.
	Project construction

References

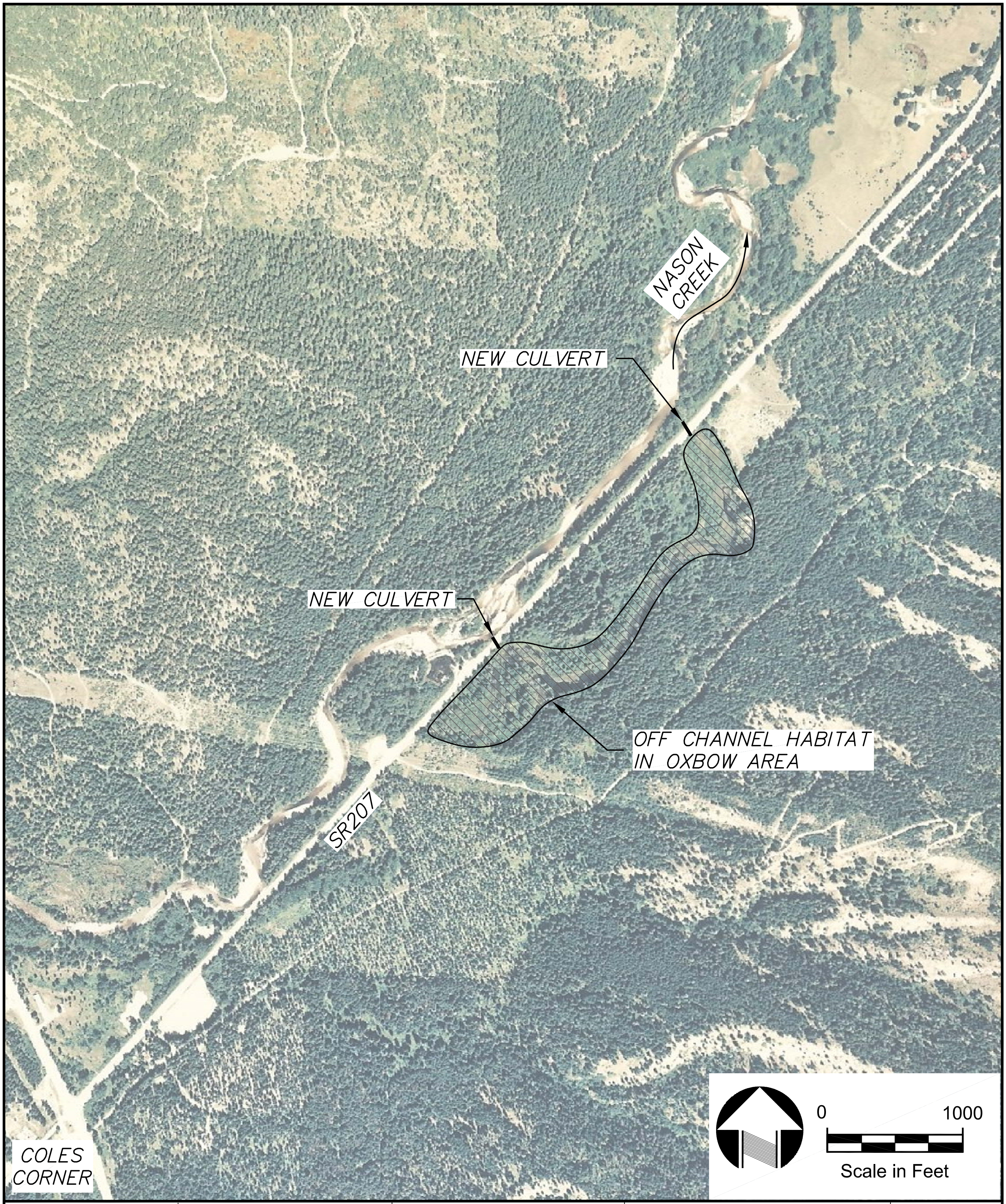
Jones & Stokes. 2005. Nason Creek Oxbow Reconnection Project, Design Report and Alternatives Analysis. December. Bellevue, WA. Prepared for the Chelan County Natural Resource Department, Wenatchee, WA.

Appendix E Figures

Jones & Stokes 11820 Northup Way, Suite E300 Bellevue, WA 98005	Alternative 1 Realignment of SR 207 and Channel	Nason Creek Oxbow Reconnection Project	CHELAN COUNTY NATURAL RESOURCE DEPARTMENT 316 Washington Street, Suite 401 Wenatchee, WA 98801	FIGURE NO. 1 PROJECT NO. 05750.05



Jones & Stokes 11820 Northup Way, Suite E300 Bellevue, WA 98005	Alternative 2 Two Bridges and Channel Realignment	Nason Creek Oxbow Reconnection Project	CHELAN COUNTY NATURAL RESOURCE DEPARTMENT 316 Washington Street, Suite 401 Wenatchee, WA 98801	FIGURE NO. 2 PROJECT NO. 05750.05



Jones & Stokes
11820 Northup Way, Suite E300
Bellevue, WA 98005

Alternatives 3 and 4

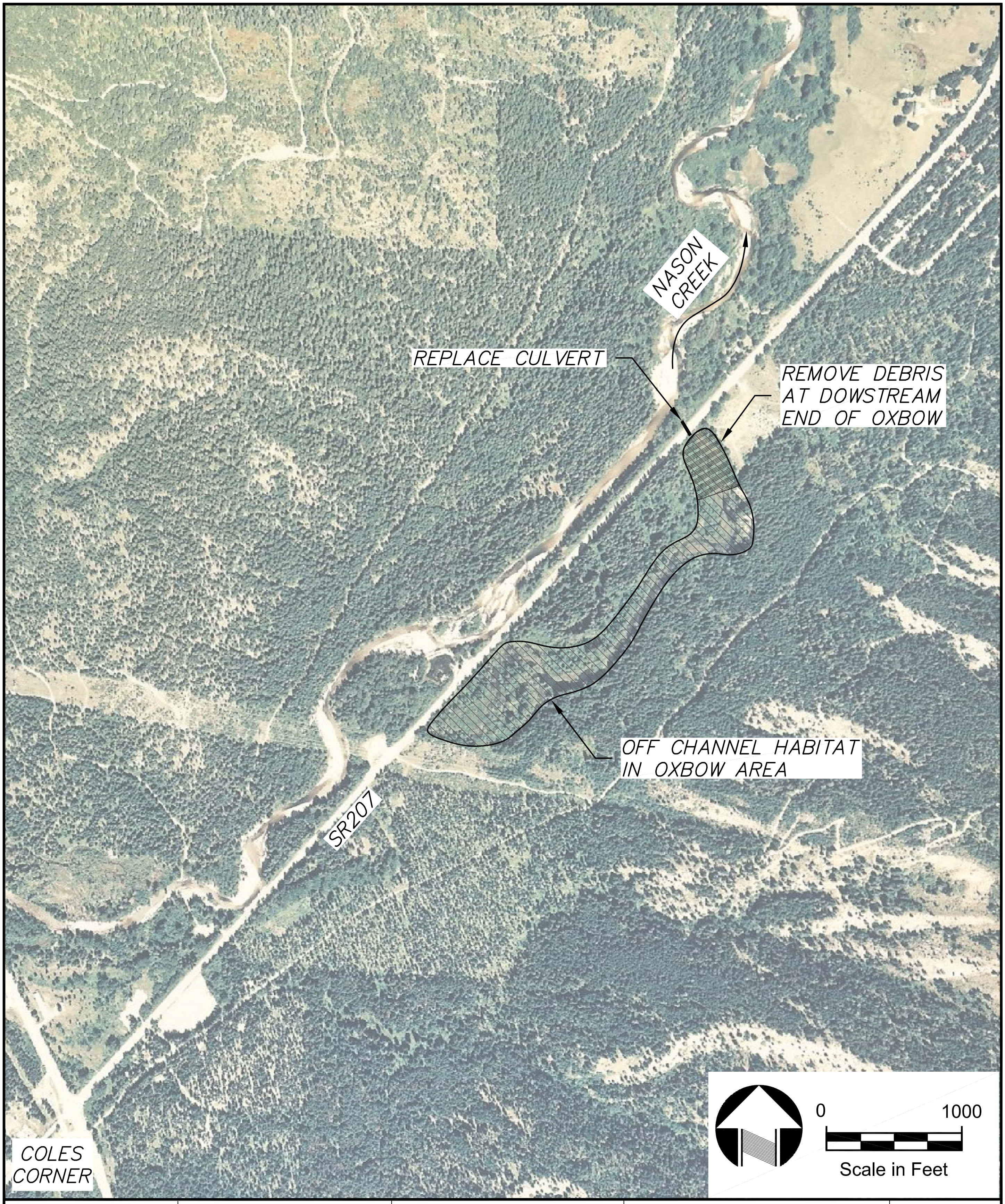
Culverts at Upstream and Downstream Ends of Oxbow

Nason Creek Oxbow Reconnection Project

CHELAN COUNTY
NATURAL RESOURCE DEPARTMENT
316 Washington Street, Suite 401
Wenatchee, WA 98801

FIGURE NO.
3

PROJECT NO.
05750.05



Jones & Stokes
11820 Northup Way, Suite E300
Bellevue, WA 98005

Alternative 5

Replace Culvert at Downstream End of Oxbow

Nason Creek Oxbow Reconnection Project

CHELAN COUNTY
NATURAL RESOURCE DEPARTMENT
316 Washington Street, Suite 401
Wenatchee, WA 98801

FIGURE NO.

4

PROJECT NO.
05750.05

Appendix F

Hydraulic and Hydrologic Analyses

Nason Creek Hydraulic and Hydrologic Analyses

The hydraulic effects of the proposed oxbow reconnection preferred alternative were analyzed through development of a Hydrologic Engineering Center-River Analysis System (HEC-RAS) hydraulic model (Corps 2002). Jones & Stokes evaluated available flow data, surveyed channel cross-sections and site topography, constructed a stream model and simulated a range of flows to determine oxbow inflows and velocities under various seasonal conditions. A description of this analysis and summary of the model results are provided below.

1.1. Flow Data

The Washington Department of Ecology (Ecology) has operated a stream gage on Nason Creek near its mouth since June 2002. The gage records both 15-minute interval and instantaneous maximum and minimum flow data. These gage data constitute the only available record of flows on Nason Creek, but the short recording period precludes frequency analysis of flows.

Mean daily and peak annual discharge flows were determined using the results of recent hydrologic analysis performed by the U.S. Forest Service (USFS) and standard U.S. Geological Survey (USGS) regression equations. USFS recently developed regression equations for flows at five ungaged locations within the Wenatchee River watershed, including Nason Creek near its mouth. Ecology's Nason Creek gage record was correlated to the USGS gage on the Wenatchee River at Plain, which has an 84-year partially continuous flow record beginning in October 1910. The following regression equation was developed by the USFS for mean daily flows in cubic feet per second (cfs) at the two gages:

Nason Creek Q = 0.1946*Wenatchee River at Plain Q – 33.378

This equation has a coefficient of determination (R^2) of 0.826, indicating a reasonably good fit to the data. Jones & Stokes applied this equation to the full Wenatchee River at Plain record to develop a corresponding long-term mean daily average flow record for Nason Creek.

Ecology's gage site on Nason Creek is located approximately 3 miles downstream of the project site. Given that the difference in drainage areas at the two locations is relatively minor in comparison to the total watershed area, the long-term synthetic record generated at the Ecology gage site was utilized for the current project. An exceedance analysis was performed on the synthetic Nason Creek record on both an annual and a monthly basis. The results of this analysis are presented in Table F-1. Values reported in the annual column represent flows that exceeded the corresponding percentage of days per year. For example, a flow of 60 cfs corresponds to the 10th percentile, which means that it is exceeded 90% of the total number of days per year, on average. Reported monthly flows follow the same approach but were analyzed on a monthly basis instead of an annual basis.

Evaluation flows were selected to represent the range of flows typically seen in the river and flows that are of interest for the analysis of fish habitat and riparian vegetation. Water surface elevations, depths, velocities, and shear stress were simulated for daily average flows ranging from 50 cfs (a relatively low flow that is close to the 10th percentile for late fall through early winter) up to 2,000 cfs (a high flow that typically occurs for a few days every spring). The flow percentiles that correspond to the selected flows are shown in Table F-1. The annual exceedance (Table F-2) values represent the long-term average percentage of days per year that each flow is exceeded, while the monthly exceedance values represent the long-term average percentage of days per month that each flow is exceeded.

In order to assess streamflow characteristics under flood conditions, it was necessary to establish instantaneous peak 2-, 10-, 25-, 50-, and 100-year discharges. The validity of generating peak-flow estimates based on the USFS Nason Creek regression equation developed for mean daily flows was checked by comparing calculated peak flows for 2003 and 2004 against measured peak flows. The synthetic flows were significantly different from the measured flows (greater than +/-100%), suggesting that the USFS Nason Creek regression equation is not applicable for calculation of peak instantaneous discharges. This is not surprising because peak flows are likely driven by different hydrologic conditions on Nason Creek than on the Wenatchee River at Plain.

Peak flows on Nason Creek were therefore generated using an alternative approach. The USGS has developed regression equations for peak flows in nine regions of Washington based on analysis of data from numerous streamflow gages (Sumioka et al. 1998). The project site is located in Region 4, and the following regression equations were applied to develop peak flows:

$$Q_2 = 0.025A^{0.880}P^{1.70}$$

$$Q_{10} = 0.179A^{0.856}P^{1.37}$$

$$Q_{25} = 0.341A^{0.850}P^{1.26}$$

$$Q_{50} = 0.505A^{0.845}P^{1.20}$$

$$Q_{100} = 0.703A^{0.842}P^{1.15}$$

In the above equations, “A” is the watershed area in square miles, and “P” is the average annual precipitation in inches within the watershed

Table F-1. Percentiles of Synthetic Mean Daily Flows (cfs) for Nason Creek near Mouth, WY 1911–1979, 1990–2004

Percentile	Annual	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
10th	60	32	58	57	54	57	76	177	533	554	194	75	41
25th	100	50	89	89	79	81	103	268	700	803	309	104	56
50th	200	86	152	148	126	118	150	426	986	1,138	533	154	82
75th	530	179	270	253	214	204	255	626	1,372	1,508	870	249	120
90th	1,095	315	488	436	346	366	397	881	1,786	1,903	1,249	375	169
99th	2,110	823	1,523	1,325	875	914	768	1,401	2,691	2,886	1,800	780	366

Table F-2. Percent Occurrence of Selected Flows in the Record of Synthetic Mean Daily Flows for Nason Creek near Mouth

		Monthly Percent Occurrence											
Flow (cfs)	Annual Percent Occurrence	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
50	94	75	92	92	91	93	99	100	100	100	100	98	83
100	75	44	70	70	64	61	76	99	100	100	99	77	37
200	50	21	35	35	28	26	35	86	100	100	89	35	7
500	26	3	10	8	4	5	5	39	92	93	54	5	<1
800	16	1	4	3	1	1	<1	14	66	75	28	<1	*
1,000	12	<1	3	2	<1	<1	<1	6	49	61	19	<1	*
1,500	4	<1	1	<1	<1	<1	*	<1	19	25	4	*	*
2,000	1	*	<1	<1	<1	<1	*	<1	6	8	<1	*	*

* No flows of this magnitude generated in synthetic record.

A contributing watershed area of 103.4 square miles at the project site was determined from USGS quad maps, and an average annual rainfall of 65.7 inches was determined from a Natural Resource Conservation Service precipitation map. The results of this analysis are presented in Table F-3.

Table F-3. Estimated Peak Discharges at Project Site on Nason Creek

Return Interval	Flow (cfs)
2-year	1,822
10-year	2,933
25-year	3,429
50-year	3,860
100-year	4,299

The estimated peak discharges were compared to Ecology's Nason Creek gage record. A peak flow of about 2,400 cfs was recorded in 2002, and peak flows greater than 3,000 cfs were recorded in 2003 through 2006; each of these peak flows occurred during the early summer snowmelt season. Although the gage is located 3 miles downstream of the project site, no significant additional tributaries join Nason Creek below the project site. Based on this comparison to recorded gage data, the USGS-based peak-flow estimates may be somewhat low. No long-term gage record is available to establish more precise peak-flow estimates, however; the USGS peak discharges were therefore used for this analysis.

1.2. Survey Data

A total of eight cross-sections were surveyed on November 17 and 18, 2004, and April 26, 2006 (Figure F-1). Five cross-sections were established perpendicular to SR 207, extending across both the existing Nason Creek channel and the abandoned oxbow areas. Three additional cross-sections were surveyed across the oxbow channel.

In addition to collecting stream channel cross-sections, Jones & Stokes performed topographic surveys of the areas surrounding the proposed upstream and downstream oxbow connection locations (Figure F-1). These surveys were performed using a TopCon Total Station, and the land-surveying firm Erlandsen & Associates was contracted to establish horizontal and vertical control. Survey data are reported in Washington State Plane North Zone NAD 83 feet (horizontal) and NGVD 29 feet (vertical).

1.3. Model Development

Surveyed cross-sections and topography along the main channel and oxbow were used to construct a one-dimensional, steady-state HEC-RAS hydraulic model (Figure F-2). This model was created to analyze post-project flow conditions over a range of seasonal discharges with the connection culverts in place (12-foot diameter, countersunk six feet).

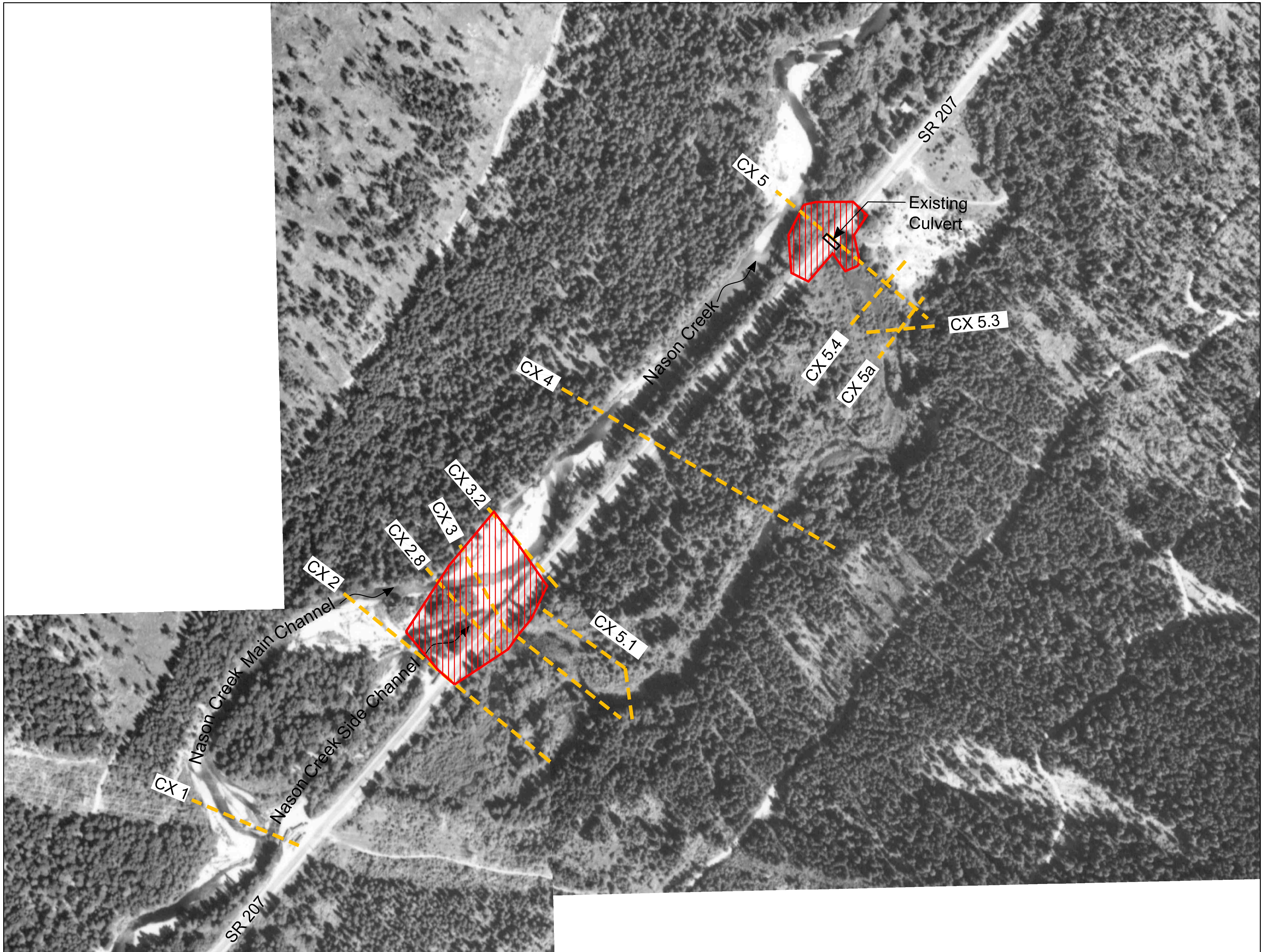


Figure F-1
Cross-Section & Topographic Survey Locations

Nason Creek Oxbow Reconnection Project

LEGEND

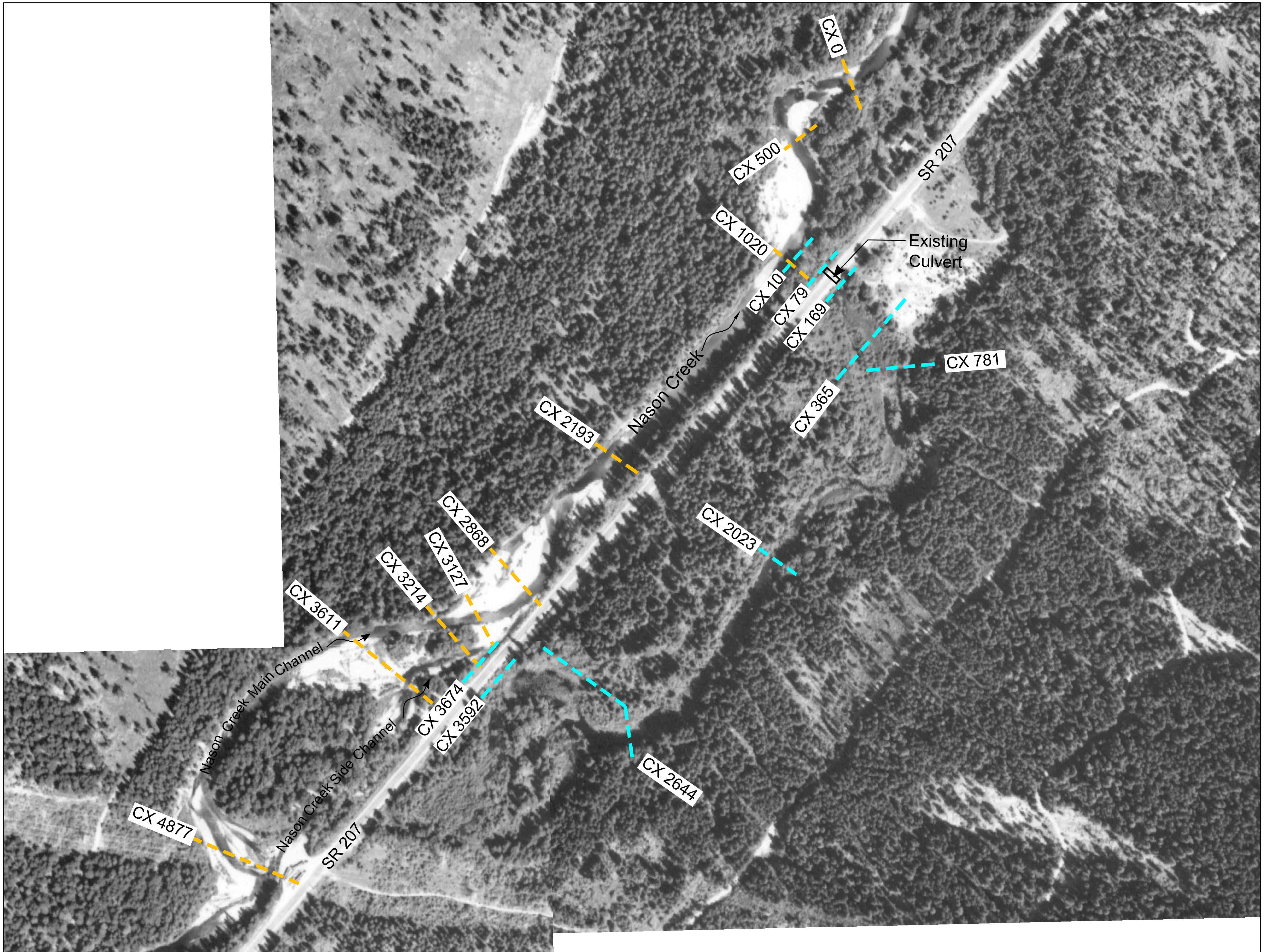
Cross-Section Locations CX 1

Topographic Survey Areas

0 200 400
SCALE: 1" = 400'

Jones & Stokes

Source: WA Department of Transportation, 1988



Source: WA Department of Transportation, 1988

Figure F-2
Modeled Cross-Section Locations

Nason Creek Oxbow Reconnection Project

LEGEND

Stream Cross-Sections CX 0

Oxbow Cross-sections CX 0

0 200 400
SCALE: 1" = 400'

Jones & Stokes

The model results provide information about velocities and depths within the connection culverts; oxbow inflow rates; and velocities, depths, and shear-stress forces along the oxbow channel. The discussion below details assumptions used in establishing the HEC-RAS model and the results of the proposed conditions analysis.

1.3.1. Model Geometry

The HEC-RAS model consists of two stream reaches: the main Nason Creek channel and the oxbow channel. The surveyed stream cross-sections formed the basis of the model geometry, with five sections located on the main Nason Creek channel and four sections located on the oxbow. Five supplementary cross-sections were also cut from the surveyed oxbow topography: one along each face of both the inlet and outlet culvert locations, and one across the oxbow outlet channel downstream of SR 207. Finally, two additional main channel sections were generated by copying the downstream-most surveyed section (CX 5 in Figure F-1) to two locations 500 and 1,000 feet farther downstream, respectively (Figure F-2). These sections were added to the model to ensure that starting water surface conditions were well established below the study reach. Ground elevations in these two sections were lowered by 1.18 feet and 2.37 feet, respectively, to reflect a stream gradient of 0.00237 along the lower portion of the study reach. The Nason Creek model reach extends a total of 4,877 feet, while the oxbow model reach extends a total of 3,694 feet.

Manning's n values of 0.04 and 0.07 were selected for the main channel and overbanks, respectively. These values were based on field observations of vegetation and stream conditions, as well as standard hydraulic references.

Downstream boundary conditions on the main Nason Creek channel were set by allowing the HEC-RAS model to calculate normal depth based on a stream slope of 0.00237. Downstream boundary conditions on the oxbow channel are automatically determined within HEC-RAS and are based on water surface elevations along the main channel.

1.3.2. Selected Flows

Two sets of flows were analyzed to provide information on flow distributions and sediment transport capacities over a range of conditions. The first set is the group of mean daily flows presented in the annual column of Table F-1, and the second set is the group of peak annual discharges presented in Table F-3. Together, these two sets of flows represent the full range of discharge conditions expected at the project site. The hydraulic characteristics of these flows were used to evaluate sediment transport capacity and are discussed in detail under Model Results, Section 3.3.

Nason Creek splits into two stream channels upstream of the proposed oxbow inlet culvert location. Flows in these two channels are hydraulically independent for all but the largest discharges. Flows in the right (east) Nason Creek side channel were therefore modeled separately through this portion of the reach to provide a more accurate representation of water surface elevations adjacent to the proposed upstream culvert location (CX 3214).

Detailed topography was not available to precisely determine the upstream flow split, so an assumption was made based on field observations that 40% of the total discharge enters the right side channel. Reduced flows were applied along the right channel only at CX 3611, CX 3214, and CX 3127 (Figure F-2); full flows were applied upstream and downstream of those sections where Nason Creek is confined to a single channel.

1.3.3. Culvert Connections

The preferred inlet and outlet culvert connections are 12-foot diameter structural plate culverts, countersunk six feet. The inlet culvert invert elevation is 1930.6 feet, while the outlet culvert invert elevation is 1922.8 feet.

The Nason Creek channel was connected to the oxbow reach in the HEC-RAS model with a lateral weir at the upstream end, leading to the proposed culvert. A lateral weir was chosen for the upstream end because the inlet connection is set off the main channel, and inflows will be driven by differences in water surface elevations rather than momentum. The lateral weir geometry was defined based on proposed oxbow inlet channel topography. Flows are automatically distributed between the Nason Creek side channel and the oxbow channel via the lateral weir based on hydraulic conditions. The flow optimization feature was applied within HEC-RAS to ensure that flows, water surface elevations, and energy grade lines are balanced between the two reaches.

A second culvert was placed at the downstream end of the oxbow and the oxbow channel was connected to the main channel using a flow junction.

Model Results

The HEC-RAS model was applied to evaluate hydraulic conditions over a range of discharges for the preferred alternative. The results of the model runs are presented below.

Flows

The model was run with two groups of flow data: mean daily flows and peak annual flows. The range of mean daily flows evaluated for this project varied from 50 cfs to 2,000 cfs, while the range of peak annual flows varied from 1,822 cfs to 4,299 cfs. These flows were applied along the main channel of Nason Creek, with flows reduced to 40% in the right side channel near the proposed oxbow inlet location. Inflows to the oxbow were automatically determined within the model by balancing energy grade lines and flows between the main channel and the oxbow.

During low flows (up to about 500 cfs total), the small connection culvert allows about 20% to 25% of the flow in the right Nason Creek side channel to enter the oxbow, which corresponds to about 10% of the total Nason Creek discharge. At the highest modeled flows, this oxbow inflow rate is about 20% of the right side channel discharge, or 8% of the total discharge. Table F-4 summarizes the distribution of flow into the oxbow for modeled mean daily flows, while Table F-5 summarizes the flow split for peak annual discharges.

Table F-4. Upstream Oxbow Inflows – Mean Daily Flows

Total Nason Creek Flow (cfs)	Right Side Channel Flow (cfs)	Oxbow Inflow (cfs)
50	20	4
100	40	10
200	80	22
500	200	51
800	320	68
1,000	400	79
1,500	600	114
2,000	800	167

Table F-5. Upstream Oxbow Inflows – Peak Annual Flows

Return Period	Total Nason Creek Flow (cfs)	Right Side Channel Flow (cfs)	Oxbow Inflow (cfs)
2-Year	1,822	729	139
10-Year	2,933	1,173	217
25-Year	3,429	1,372	243
50-Year	3,860	1,544	262
100-Year	4,299	1,720	282

Culvert Hydraulic Conditions and Fish Passage Criteria

Velocities through the inlet culvert range from 0.7 feet/second for the low-modeled oxbow inflow of 4 cfs to 7.8 feet/second for the high-modeled inflow of 282 cfs. Flows depths in the culvert vary from 0.4 feet during the low-modeled inflow to 3.6 feet during the largest modeled inflow. The upstream culvert does not experience pressure flows under any of the modeled flows. The full range of modeled velocities and depths are presented in Table F-6.

Table F-6. Modeled Inlet Culvert Velocities and Depths

Total Nason Creek Flow (cfs)	Oxbow Inflow (cfs)	Velocity (ft/s)	Depth (ft)
50	4	0.7	0.4
100	10	1.3	0.6
200	22	2.0	0.8
500	51	3.2	1.2
800	68	3.7	1.5
1,000	79	4.0	1.7
1,500	114	4.8	2.1
2,000	167	5.8	2.6
1,822	139	5.3	2.3
2,933	217	6.7	3.0
3,429	243	7.1	3.2
3,860	262	7.5	3.4
4,299	282	7.8	3.6

Velocities through the outlet culvert (flows exiting from the oxbow to the main channel) range from 0.4 feet/second for the low-modeled oxbow inflow of 4 cfs to 5.0 feet/second for the high modeled inflow of 282 cfs. Flows depths in the culvert vary from 0.8 feet during the low modeled inflow to 6.8 feet during the largest modeled inflow. The outlet culvert experiences pressure flow conditions when flow in Nason Creek is around 3,500 cfs.

The full range of modeled velocities and depths are presented in Table F-7.

Table F-7. Modeled Outlet Culvert Velocities and Depths

Total Nason Creek Flow (cfs)	Oxbow Inflow (cfs)	Velocity (ft/s)	Depth (ft)
50	4	0.4	0.8
100	10	0.7	1.2
200	22	1.1	1.6
500	51	1.8	2.5
800	68	1.9	3.1
1,000	79	2.0	3.6
1,500	114	2.5	4.3
2,000	167	3.3	4.9
1,822	139	2.8	4.7
2,933	217	3.9	5.7
3,429	243	4.3	6.1
3,860	262	4.6	6.5[1]
4,299	282	5.0	6.5[1]

[1] Culvert in pressure flow

The 12-foot diameter culvert generally meets WDFW fish passage standards. Per the Design of Road Culverts for Fish Passage (WDFW 2003), the maximum velocity to allow adult chinook, coho, or steelhead access through an 80-foot-long culvert (as proposed under this alternative) is 6.0 ft/sec. This would be exceeded in the upstream culvert during high-flow events greater than about 2,500 cfs in the main channel (>2-year event). Recommended maximum velocities for juvenile salmonid fry and fingerlings are 1.1 and 1.3 ft/sec, respectively. These velocities would be exceeded in both culverts during flows greater than about 100 to 200 cfs in the main channel, or approximately 50 to 75% of the time in normal years. Although these velocities would limit entry and exit of juveniles in the upstream direction (against the current), entry and exit in the downstream direction would be unaffected.

Important to the success of the oxbow reconnection is allowing juvenile salmonids access during low-flow conditions for foraging and overwintering opportunities. The minimum required flow depth of 1 foot for adult passage is achieved in the inlet culvert when flows are above approximately 300 cfs in the main channel and in the outlet culvert when flows are above approximately 100 cfs in the main channel. Based on the mean daily flows reported in Table F-1, Nason Creek flows exceed this range 90% of the time between April and July. At no time is either culvert expected to be dewatered, thus allowing juvenile ingress and egress at low flows. Although low Nason Creek flows occur during the late summer spawning season, at no time is either oxbow connection modeled to be dewatered, and they will always maintain a minimum water depth of 0.2 feet under low flow conditions (20 cfs). This criterion should therefore not be a factor in assessing adult salmonid access.

Oxbow Hydraulic Conditions

Potential water depths, velocities, and sheer stress within the oxbow are presented below. Additional detailed analysis of potential geomorphic effects to the oxbow resulting from these conditions is presented in Section 3.3.4.

Velocities and Depths

Flow velocities within the oxbow range from less than 0.1 feet/second to 7.7 feet/second for modeled mean daily flows. The limited capacity of the culvert creates upstream backwater conditions and reduces velocities at CX 365 as flows increase. Flow depths associated with mean daily flows range from 0.3 feet to about 7.5 feet. The shallowest depths occur in the middle of the oxbow reach, while the greatest depths occur near the downstream end of the oxbow.

Modeled annual peak flows generate velocities within the oxbow ranging from 0.2 to 9.1 feet/second, with highest velocities at the downstream side of the inlet culvert and lowest velocities at CX 781. Modeled depths in the oxbow range from 1.3 feet to 9.4 feet. The shallowest depths occur at CX 2023, while the greatest depths occur at CX 781.

The range of average velocities and maximum depths at each cross-section along the oxbow is presented in Table F-8 for both modeled mean daily and peak annual flows.

Table F-8. Hydraulic Characteristics of Oxbow Cross-Sections

Cross-Section Station	Cross-Section Description	Mean Daily Flows		Peak Annual Flows	
		Average Velocity Range (ft/s)	Maximum Depth Range (ft)	Average Velocity Range (ft/s)	Maximum Depth Range (ft)
10	Cut from topo	0.6 – 1.0	0.8 – 4.9	0.9 – 1.2	4.7 – 6.5
79	D/S face of outlet culvert	0.6 – 2.9	0.8 – 4.8	2.5 – 3.6	4.6 – 6.4
169	U/S face of outlet culvert	0.6 – 3.0	0.8 – 4.9	2.6 – 3.6	4.7 – 6.8
365	CX 5.4	0.5 – 1.5	3.3 – 6.9	0.4 – 0.5	6.6 – 8.8
781	CX 5.3	0.02 – 0.2	4.0 – 7.5	0.2 for all modeled flows	7.3 – 9.4
2023	CX 4	2.2 – 4.7	0.3 – 1.4	4.6 – 5.3	1.3 – 1.8
2644	CX 5.1	0.04 – 0.7	1.8 – 3.4	0.6 – 0.9	3.3 – 4.0
3592	D/S face of inlet culvert	2.4 – 7.7	0.4 – 2.1	7.2 – 9.1	1.9 – 2.8
3674	U/S face of inlet culvert	2.0 – 5.0	0.4 – 3.0	4.8 – 5.8	2.7 – 4.3

Note: D/S = downstream; U/S = upstream

Shear Stress

Calculated shear-stress values quantify the forces on bed material. Erosion is initiated when these forces exceed the threshold value for movement of sediment in the stream channel. Simulated shear-stress values are presented in Table F-9 at two cross-sections within the oxbow for selected mean daily and peak annual discharges: CX 2023 and CX 2644. CX 2023 was selected because it experiences the greatest modeled shear-stress values in the oxbow for this culvert configuration, while CX 2644 was selected because it experiences some of the lowest shear-stress values in the oxbow; results for these two sections bracket the range of possible values.

Shear-stress values at CX 2023 range from 0.42 to 1.34 lb/ft^2. Shear stress increases linearly with flow, and is greatest at a discharge of 282 cfs in the oxbow, or 4,299 cfs within Nason Creek. Based on the calculated shear stress values, the maximum bed material diameter that can be mobilized under the small culvert design is about 60 mm at a flow of 282 cfs. The highest shear stress values correspond to critical depth at CX 2023. It is unlikely that water surface elevations would remain at critical depth during a flow event for any length of time, however, because roughness elements in natural channels typically create localized turbulence that results in subcritical water surface elevations. Shear-stress values and minimum bed material mobilization diameters are therefore likely to be somewhat overestimated at this location.

Shear-stress values at CX 2644 vary from 0.00 to 0.03 lb/ft^2 for flows ranging from 4 to 282 cfs in the oxbow. A typical annual discharge of 2,000 cfs generates a shear stress of 0.02 lb/ft^2, which corresponds to mobilization of a maximum sediment size of about 1 mm. At the upper limit of flows, the 100-year discharge generates a shear stress of 0.03 lb/ft^2, which corresponds to mobilization of a maximum sediment size of about 2 mm.

Table F-9. Shear Stress at Representative Flows and Locations in Oxbow

Total Nason Creek Flow (cfs)	Oxbow Flow (cfs)	Shear Stress at Cross-Section 2023 (lb/ft^2)	Shear Stress at Cross-Section 2644 (lb/ft^2)
50	4	0.42	0.00
500	51	0.87	0.00
1,000	79	0.96	0.01
2,000	167	1.13	0.02
3,429	243	1.29	0.02
3,860	262	1.30	0.03
4,299	282	1.34	0.03

1.4. Data Gaps and Model Uncertainty

Survey data collected to date provides adequate information to construct a preliminary HEC-RAS model of the project reach. Collection of additional focused survey data would allow refinement of the model and more precise quantification of flows into the oxbow. Recommended additional survey data includes the following, in general order of importance:

- Cross sections defining channel split on main channel of Nason Creek upstream of inlet culvert location,
- Additional overbank/channel bank topography in the vicinity of the oxbow inlet culvert location,
- Control cross section within the oxbow downstream of inlet culvert,
- Verification of the channel profile and location of significant grade break along the oxbow,
- Two cross sections downstream of CX 5 on main channel Nason Creek to establish tailwater conditions, and
- One cross section within the oxbow outlet channel downstream of existing outlet culvert.

It is important to note that this additional data may result in recommended changes in the proposed project design.

LIDAR-based topographic data collection is currently being performed along the study reach as part of another project. It is expected that some of the information identified above will be obtained from the processed LIDAR data.

As noted under model development, the flow split on the main channel of Nason Creek above the proposed oxbow inlet culvert location is currently based on the assumption that 40% of the total flow enters the right (east) side channel. Incorporation of additional channel geometry data into the HEC-RAS model will allow quantitative analysis of the flow split over a range of discharges.

The hydraulic model represents existing stream morphologic conditions. The majority of Nason Creek currently flows in the left (west) channel, but if the main channel were to shift to the right (east) side channel, inflows to the oxbow would likely change. It is difficult to predict whether oxbow inflows would increase due to increased flows in the main channel or whether channel morphology would change and possibly reduce inflows to the oxbow.

Chapter 2. References

Sumioka, S.S., D.L. Kresch, and K.D. Kasnick. 1998. *Magnitude and Frequency of Floods in Washington*. Water Resources Investigations Report 97-4277. United States Geological Survey.

U.S. Army Corps of Engineers (Corps). 2002. HEC-RAS River Analysis System, Hydraulic Reference Manual. Version 3.1. Hydrologic Engineering Center. November.

Washington Department of Fish and Wildlife (WDFW). 2003. *Design of Road Culverts for Fish Passage*. Olympia, WA. 110p.

Appendix G

Ecosystem Diagnosis and Treatment Analysis

Jones & Stokes

Memorandum

Date: July 7, 2006

To: John M. Soden

From: Betsy Torrell

Willis E. McConnaha

Subject: Ecosystem Diagnosis and Treatment Analysis of the Nason Creek Oxbow Reconnection Project

Introduction

This memo describes the results of an analysis of the proposed reconnection of oxbow habitat in Nason Creek, a tributary to the Wenatchee River system. The project is intended to provide benefits primarily to spring Chinook salmon spawning in Nason Creek and will restore historical riverine and floodplain habitats (Jones & Stokes 2005). This analysis provides an estimate of the potential benefits of the project in terms of the change in abundance of returning adult spring Chinook to Nason Creek.

Methods

The proposed oxbow reconnection was analyzed for spring Chinook salmon using the Ecosystem Diagnosis and Treatment (EDT) model (Lestelle et al. 2004). The analysis built on an existing EDT assessment of the Wenatchee River developed by the Yakama Tribe and the Washington Department of Fish and Wildlife (referred to here as the WDFW/YIN data). The previous analysis provided the characterization of conditions outside the Nason Creek watershed that affect spring Chinook salmon abundance. Information on conditions within the Nason watershed was reviewed and refined as part of this assessment to characterize the current and historic potential of the stream to support spring Chinook salmon. The proposed oxbow reconnection was analyzed in regard to potential spring Chinook salmon productivity and abundance. The project was assessed by comparing the current habitat potential of Nason Creek for spring Chinook salmon to the habitat potential if the oxbow was reconnected.

Modifications to WDFW/YIN dataset

Review of the existing WDFW/YIN dataset indicated that the flow patterns were incorrect and not consistent with EDT documentation (Lestelle 2004). For this analysis, we started from a duplicate of the WDFW/YIN dataset and made appropriate modifications. The registered Wenatchee EDT dataset that remains on the EDT website is the WDFW/YIN dataset without modifications. The Nason Creek Oxbow data differs from the registered WDFW/YIN dataset only in regard to Nason Creek as described here.

In EDT, some attribute ratings, such as flow and width, are shaped throughout the year with a pattern. The pattern consists of a set of multipliers that when applied to the rating gives the condition of that attribute for each month. The flow patterns in the WDFW/YIN dataset were refined to reflect the estimated mean daily flows of Nason Creek near its confluence with the Wenatchee River (Jones & Stokes 2005). The flow patterns were derived using standard EDT procedures (Lestelle 2004). The width pattern, which applies to both the maximum and minimum width attributes, was based on the annual hydrograph. The high flow pattern was applied to the high flow, diel flow variation, intra-annual flow variation and bedscour attributes. The revised patterns were applied to all of the reaches within the Nason Creek watershed. Information in the WDFW/YIN dataset for the rest of the Wenatchee system was not altered for this analysis.

The standard EDT reference condition or Template was generated using the data in the WDFW/YIN dataset with flow pattern modifications described above.

The Nason Creek Oxbow Project

Reach and Population Structure

The oxbow reconnection project will occur adjacent to a 2,200-ft stream reach (Jones and Stokes 2005), beginning at approximately RM 3.4. In the WDFW/YIN dataset, the first reach of Nason Creek (Nas1) extended from the confluence with the Wenatchee River to Coulter Creek at RM 9.9. For this analysis, the first Nason Creek reach was split into 3 segments (Table G-1) in order to define the 2,200-ft stream section with the oxbow project as its own reach (Nas1_B_oxbow). All three segments initially had identical ratings for all EDT attributes. In the following discussion, Nas1_B_oxbow is referred to as the Project reach.

Channel morphology measurements were taken by JSA staff at five transects in the Project reach, as well as the disconnected oxbow in December 2004. Based on the measurements, the average wetted width at annual high and low flow was estimated as 225 feet and 85 feet, respectively. The EDT data was revised for the Project reach to reflect these measurements.

Spring Chinook salmon populations were defined in Nason Creek for the EDT analysis using life history information developed in the WDFW/YIN analysis. Populations in EDT do not imply a genetic affinity but instead represent spawning aggregations that characterize habitat potential in different portions of the watershed. A Nason Creek spring Chinook salmon population was defined as spawning in Nason Creek from its confluence with the Wenatchee River upstream to Gaynor Falls, a natural barrier to spring Chinook at RM 16.8.

Table G-1. Spring Chinook Salmon Spawning Reaches within Nason Creek in Ecosystem Diagnosis and Treatment (EDT) analysis.

Reach Name	Reach Length (mi)	Reach Description
Nas1_A	3.4	From mouth to RM 3.4. This reach subdivided to create oxbow reconnection reach.
Nas1_B_oxbow	0.417	From RM 3.4 to RM 3.7. Reach where historic oxbow may be reconnected as side channel.
Nas1_C	6.083	From oxbow reconnection at RM 3.7 to RM 9.9, confluence with Coulter Creek.
Nas2	6.9	Nason Creek, from Coulter Creek confluence to Gaynor Falls.

Oxbow Reconnection Scenario

The Nason Oxbow Project reconnects a 4,608-ft long oxbow to the main channel as a secondary channel. This oxbow was originally part of the river but was cut off by construction of state highway. The oxbow would be reconnected at the upstream and downstream ends of the Nason Creek project reach via fish-friendly culverts. Once connected, the oxbow would provide pool, beaver pond and glide habitat to spring Chinook salmon. Table G-2 indicates the amount of habitat available to spring Chinook salmon in the Project reach both currently and with the oxbow reconnected during low flow. For the oxbow reconnection scenario, the habitat types in the original dataset were modified accordingly.

Table G-2. Estimated stream habitat in the Nason Creek Project reach with and without the oxbow reconnection at low flow.

Scenario	Pools	Backwater Pools	Beaver Ponds	Glides	Small Cobble Riffles/ Pool Tailouts	Large Cobble Riffles
Current without oxbow connection (sqft)[1]	67,320	1,870	0	3,740	69,190	43,010
Oxbow (sqft)	86,028	0	42,372	102,000	0	0
Current with oxbow reconnection (sqft)	153,348	1,870	42,372	105,740	69,190	43,010
Current with oxbow reconnection (% of Project reach)	36.9	0.5	10.2	25.4	16.7	10.4

[1] Source: WDFW/YIN

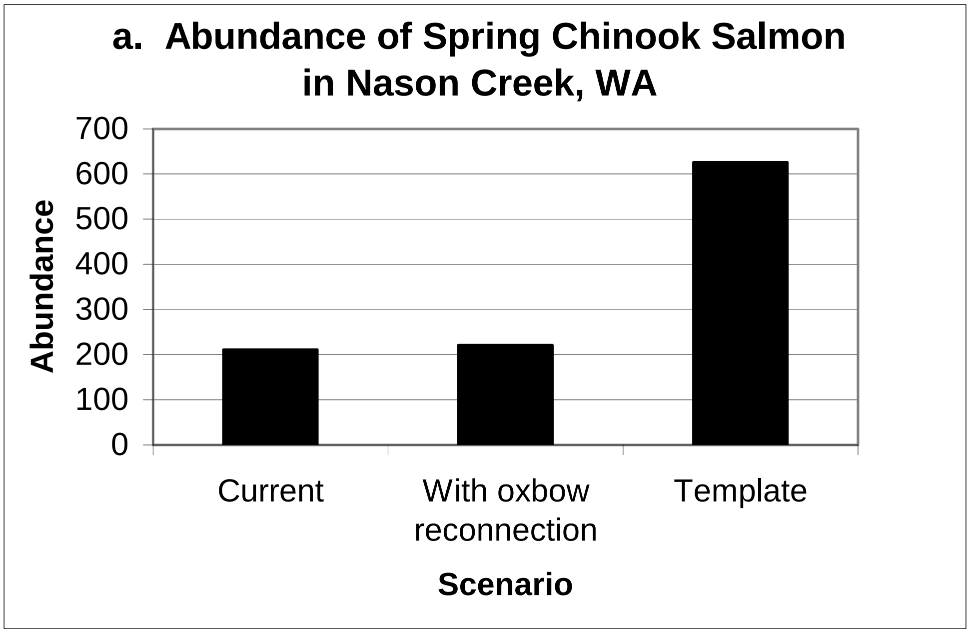
The average widths of the oxbow at high and low flows would be 70 ft and 50 ft, respectively (Jones & Stokes 2005). The maximum and minimum widths for the Project reach with the oxbow reconnected were determined by summing the amount of habitat (sq ft) in the Project reach and the oxbow and dividing the sum by the main channel length (2,200 ft). This accounts for all the additional amount of habitat that would be gained from the oxbow reconnection without altering the length of the main channel.

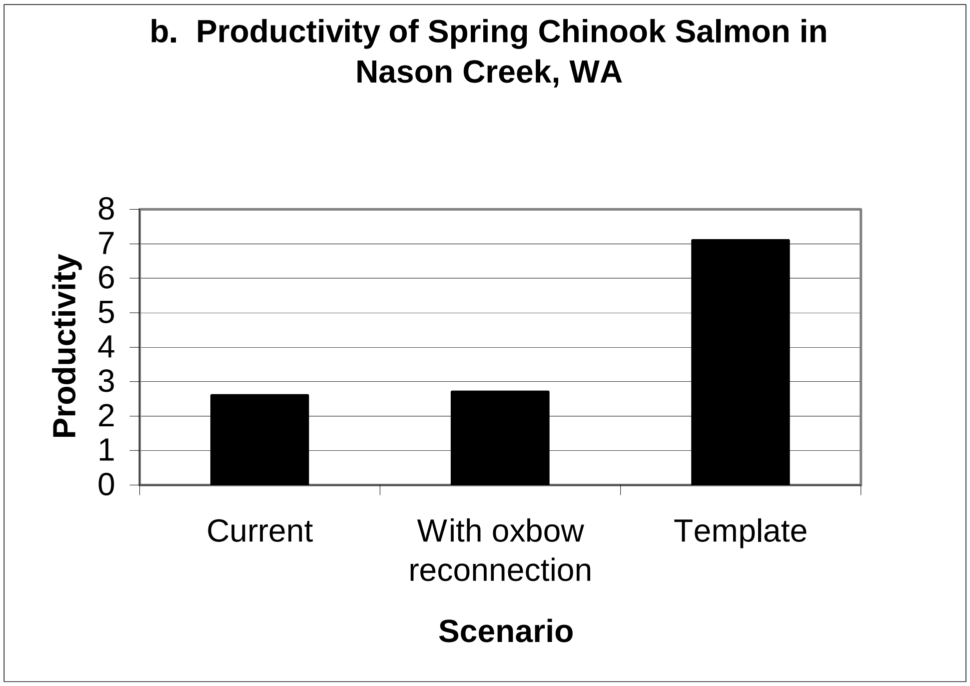
The remainder of the EDT attributes (wood, flow, temperature, etc.) in the oxbow were assumed to be the same as the current condition in the WDFW/YIN dataset. The oxbow substrate currently consists of a 6- to 12-inch layer of silt, sand and muck over the historic Nason Creek gravel streambed. We assumed that the fine sediment would be flushed out of the oxbow after reconnection. Thus, the major effect of the project was assumed to be an increase in total area and a shift in key habitat types as described in Table G-2.

Results and Discussion

The effect of the oxbow reconnection in Nason Creek on spring Chinook salmon was estimated using EDT. The reconnected oxbow would provide limited spawning habitat in the glides and relatively large amounts of rearing and overwintering habitat for spring Chinook salmon. As a result of increased habitat quantity from the oxbow reconnection, the spring Chinook salmon abundance potential in Nason Creek increased by 4.7 percent, (Figure G-1a). This is roughly the same as the increase in length of total stream miles available to Chinook in Nason Creek with the oxbow. The relative productivity of spring Chinook in Nason Creek increased slightly with the oxbow reflecting the change in distribution of habitat types while all other habitat quality attributes (wood, temperature, water quality etc.) remained the same in the main and oxbow segments (Figure G-1b).

Figure G-1. Estimated impact of oxbow reconnection on the biological performance of spring Chinook salmon in the Nason watershed. (a) abundance, (b) productivity.





References

Jones & Stokes. 2005. Nason Creek oxbow reconnection project alternatives analysis and design report. Prepared for Chelan County Natural Resources Department by Jones & Stokes Associates, Bellevue, WA,

Lestelle, L., L. Mobrand, and W. McConnaha. 2004. Information structure of Ecosystem Diagnosis and Treatment (EDT) and habitat rating rules for Chinook salmon, coho salmon and steelhead trout. Mobrand Biometrics, Inc., Vashon, WA,50 pages

Lestelle, L. C. 2004. Guidelines for Rating Level 2 Environmental Attributes in Ecosystem Diagnosis and Treatment. Mobrand Biometrics, Inc., Vashon, WA