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

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

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October 15, 2007

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May 28, 2008

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

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

-Reach 1: A 4.3 mile segment of creek located from a major bend in the creek at RM 4.6 to where the channel becomes constricted at RM 8.9 (BOR Reach NC1).

-Reach 2: A 0.5 mile segment in a naturally constricted area of the creek located between RM 8.9 and a bridge crossing located 0.1 miles below the Highway 2 bridge crossing (BOR Reach NC2).

-Reach 3: A 2.3 mile segment of the creek located from the bridge crossing at RM 9.4 to where the creek is constricted at RM 11.8 (just below the town of Merritt).

-Reach 4: From RM 11.8 to where the creek has been channelilzed to protect the railroad (river right bank) and power lines (left bank) at RM 13.4.

-Reach 5: From RM 13.4 to the railroad bridge crossing at RM 14.2.

Reaches 3 to 5 comprise BOR Reach NC3.

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

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

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

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

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

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

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

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

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

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

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

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

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

NASON CREEK HABITAT ASSESSMENT OVERVIEW

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

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

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

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

pebble counts, spaced throughout the survey. The MPI standard for an appropriately functioning stream is < 12% surface fines < 6 mm. Surface fine sediments < 6 mm averaged about 12% in the six Wolman pebble counts, with a range of 7% to 19% surface fine sediments < 6 mm. Nason Creek appears to be properly functioning for substrate and fine sediments in most of the surveyed segment of the stream.

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

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

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

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

Summary of Habitat Data:

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

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

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

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

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

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

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

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

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

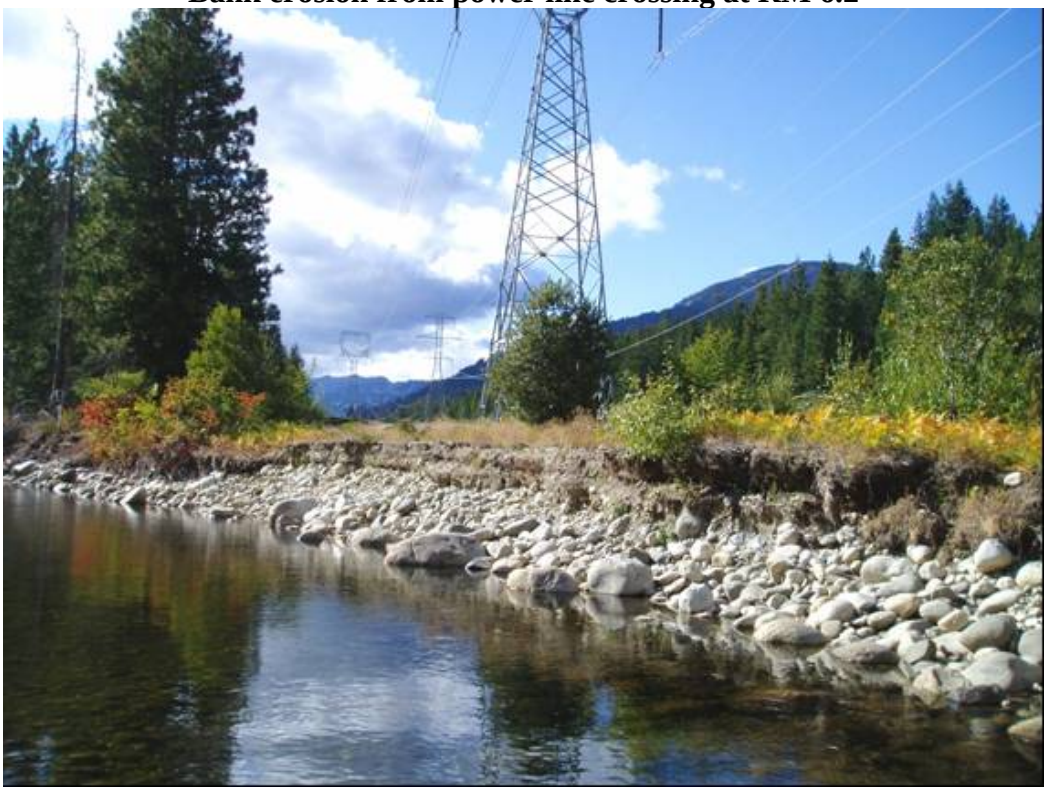
●**Bank Erosion:** About 7% of the banks are actively eroding in the reach. While about half of the erosion appears to be naturally occurring, the remaining erosion is caused by the removal of vegetation for the construction/maintenance of power line corridors, private property development (home construction,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

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

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

Nason Creek alongside Highway 2 in Reach 1

Bank erosion from power line crossing at RM 6.2



Pool habitat lacking complexity in Reach 1

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

Summary of Habitat Data:

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

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

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

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

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

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

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

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

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

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

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

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

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

Spawning Habitat in the Upper Half of Reach 2

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

Summary of Habitat Data:

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

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

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

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

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

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

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

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

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

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

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

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

Nason Creek from top of Railroad Grade

Cabled Logs in Pool at RM 10.3

Riffle Habitat in Reach 3

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

Summary of Habitat Data:

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

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

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

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

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

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

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

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

juvenile rearing habitat was observed in the pools formed by log jams and in the boulders (rip-rap) in the lower half of the reach.

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

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

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

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

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

Log jam and deep pool habitat in Reach 4

Pool formed by wood in Reach 4

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

Summary of Habitat Data:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Nason Creek in channelized Reach 5

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

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

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

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

APPENDIX A: STREAM CONDITION ASSESSMENT

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

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

Table 1. Channel categories for LWD.

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

Table 2. Channel categories for percent riffle area.

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

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

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

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