NORTH WESTERN PACIFIC RAILROAD - STREAM CROSSING INVENTORY AND FISH PASSAGE EVALUATION WITHIN THE EEL RIVER BASIN

FINAL REPORT

By

Ross Taylor and Associates (RTA)

December 2011

Ross Taylor and Associates
1254 Quail Run Court
McKinleyville, CA 95519
(707)-839-5022
rossntaylor@sbcglobal.net

ACKNOWLEDGEMENTS

This project was funded by the California Department of Fish and Game (CDFG) **P0810307.**

Ross Taylor and Associates (RTA) would like to acknowledge the following persons and their assistance with the North Western Pacific Railroad (NWPRR) stream crossing inventory and fish passage evaluation project within the Eel River basin:

Tom Grey (RTA) – conducted field surveys, data entry, FishXing analyses and assisted with report preparation.

Tom Weseloh (CalTrout) – managed contract with CDFG and sub-contract with RTA, participated in site visits, and coordinated with NWPRR and Anderson-Penna.

Darren Mierau (CalTrout) – managed contract with CDFG and sub-contract with RTA and reviewed draft of final report.

Ian Anderson (AndersonPenna Partners – consultant for North Coast Railroad Authority) - provided information regarding railroad infrastructure, assisted with site access at various locations, and reviewed draft of final report.

David Anderson (AndersonPenna Partners – consultant for NCRA) – reviewed draft of final report.

Doug Albin (CDFG) – was the project's contract manager, attended pre-assessment meeting to develop site list, and reviewed draft of final report.

Scott Downie (CDFG) - attended pre-assessment meeting to develop site list, assisted with site access in southern Humboldt area, provided logs of railroad infrastructure, provided fisheries and habitat information for Woodman and Bridge creeks, and reviewed draft of final report.

Scott Harris (CDFG) - attended pre-assessment meeting to develop site list, assisted with site access in Willits area, and provided fisheries and habitat information for Outlet Creek tributaries.

George Edwards and Gary Flosi (CDFG) – attended pre-assessment meeting to develop site list.

Margaret Lang (Humboldt State University) – provided information regarding NWPRR crossings adjacent to Highway 101 sites previously surveyed and assessed by HSU.

Rubicon Rafting – guided RTA, CalTrout and AndersonPenna Partners personnel on a four-day float on the Eel River from Dos Rios to Alderpoint.

INTRODUCTION

The inventory and fish passage evaluation of stream crossings within the Eel River basin of California on NWPRR's railroad line was conducted between January of 2010 and December of 2011. The primary objective was to assess passage of juvenile and adult coastal rainbow trout/steelhead (*Oncorhynchus mykiss*), coho salmon (*O. kisutch*) and Chinook salmon (*O. tshawytscha*) and develop a project-scheduling document to prioritize corrective treatments to provide unimpeded fish passage at railroad/stream intersections.

In an upstream-to-downstream direction, the section of railroad evaluated started south of the town of Willits, where the railroad is located within the Outlet Creek and Haehl Creek watersheds, and proceeded north to the City of Fortuna, (near the mouth of the Eel River). A majority of the evaluated railroad was located along the Eel River mainstem. The evaluated section of railroad ran from railroad post-mile 135.0 to 268.0.

For this report the term **stream crossing** is defined as any human-made structure that crosses over or through a stream channel and lies on NWPRR property. Stream crossings identified in this report included mostly culverts and bridges, however at a couple of sites the natural stream channels were filled-in and flows were re-routed. For the purpose of assessing fish passage, the distinction between types of stream crossings is not as important as the effect the structure has on the form and function of the streamflow. A stream crossing encompasses the structure employed to pass stream flow as well as associated fill material within the crossing prism.

The inventory and assessment process included:

1. Developing a list of approximately 60 crossings to assess.
2. At selected sites, collecting information regarding crossing specifications and surveying a longitudinal profile.
3. Assessing fish passage using crossing specifications and passage criteria for juvenile and adult salmonids (state and federal criteria) by employing a first-phase evaluation filter and then using a computer software program (FishXing) on a subset of sites defined as partial/temporal barriers by the filter.
4. Assessing quality and quantity of stream habitat above and below each crossing.

The prioritization process ranked crossing sites by assigning numerical scores for the following criteria:

1. Presumed species diversity within stream reach of interest (and federal listing status).
2. Extent of barrier for each species and age-class over the range of estimated migration flows.
3. Quality and quantity of potential upstream habitat gains.
4. Hydraulic capacity of current stream crossing (risk of fill failure).
5. Condition of current crossing (life expectancy).

The initial ranking was not intended to provide an exact order of priority, but rather produce a first-cut rank in which sites could be grouped as high, medium, or low priority. Professional judgment was a vital component of the ranking process. On a site-specific basis, some or all of these factors were considered in developing the final ranked list:

1. Tributaries that currently support runs of coho salmon, steelhead, and/or Chinook salmon. Treating migration barriers in these sections of the watershed should result in a high probability of immediate utilization of re-opened habitat.

2. Physical stress or danger to migrating salmonids at crossings where migration attempts were observed. Recent studies have revealed numerous sites in California where concentrations of migrating salmonids were subjected to decades of predation by birds and mammals or poaching by humans (Taylor 2000 and 2001). Observations of adult coho salmon injuring themselves on failed leap attempts have also been made (Taylor 2000 and 2001). Inability to enter cool-water tributaries to escape stressful/lethal mainstem water temperatures during summer months has also been observed. These factors should weigh heavily in priority ranking.

3. Amount of fill material. At stream crossings that were hydraulically undersized and/or in poor condition, we assessed the volume of fill material within the crossing prism potentially deliverable to the stream channel if the crossing were to fail. Large, sudden contributions of sediment from crossing failures are often detrimental to salmonid spawning and rearing habitat.

4. Presence or absence of other stream crossings and other types of barriers. In some cases, a single stream was crossed by multiple roads under a variety of management or ownership. In these situations, close communication with other road managers, private property owners, and watershed coordinators is important. When multiple stream crossings were identified as migration barriers, a coordinated effort will be required to identify and treat them in a logical manner – generally in an upstream direction starting with the lowermost barrier or impediment.

5. Remediation project cost. The range of treatment options and associated costs should be considered when determining the order in which to proceed and what types of treatments should be implemented at specific sites. Long-term maintenance should be considered when estimating costs associated with retrofits. In cases where federal or state listed fish species are present, costs must also be weighed against the consequences of failing to comply with Endangered Species Acts by not providing unimpeded passage.

6. Scheduling of other railroad maintenance and repair projects. Railroad managers should consider upgrading all migration barriers during other possible activities they may perform.

7. Other factors impacting salmon and steelhead. In many cases, other limiting factors besides migration barriers exist that impair salmonid productivity. On a watershed or sub-basin level, restoration decisions must be made after carefully reviewing potential limiting factors, the source of the impacts, and the range of restoration options available, and what restoration activities are actually feasible.

Additional physical, operational, social, and/or economic factors exist that may influence the final order of sites; but evaluating these are beyond the scope of this project.

Final Product of Stream Crossing Inventory

This final report includes:

1. A count and location of all stream crossings with culverts and other manmade structures located within fish-bearing stream reaches. Stream crossing locations were identified by stream name; railroad mile post; USGS Quad name; Township, Range and Section; and latitude and longitude coordinates (NAD27 datum). All location data were entered into a spreadsheet for potential database uses.

2. For each fully-assessed site, crossing specifications were collected, including: length, dimensions, type, construction material, inlet and outlet configurations, position relative to flow and stream gradient, amount of fill material, depth of jump pool below crossing, height of leap required to enter crossing, and previous modifications (if any) to improve fish passage. All site-specific data were entered into a spreadsheet for potential database uses.

3. Information regarding crossing age, wear, and performance was collected, including: overall condition of the crossing (and associated road fill) and rust line height (applicable only to metal culverts). All crossing specifications were entered into a spreadsheet for potential database uses.

4. An evaluation of fish passage at each crossing location. Fish passage was evaluated by two methods. Initially, fish passage was assessed by employing a first-phase evaluation filter that was developed for Part IX of CDFG's *Salmonid Stream Habitat Restoration Manual* (Taylor and Love, 2003). The filter quickly determined if a crossing either met fish passage criteria for all species and age classes as defined by CDFG for the range of migration flows (**GREEN**); failed to meet passage criteria for all species and age classes (**RED**); or was a partial and/or temporal barrier (**GRAY**). Then FishXing (a computer software program) was used to conduct in-depth passage evaluations on the **GRAY** sites by modeling culvert hydraulics over the range of migration flows and comparing these values with leaping and swimming abilities of the species and age classes of interest. In some instances, FishXing was also utilized on crossings initially screened as **RED**.

5. Digital photo documentation of all crossings visited was taken to provide visual information regarding inlet and outlet configurations; as well as insertion in future reports, proposals, or presentations.

6. An evaluation of the quantity and quality of fish habitat above and below each crossing location. When available, information was obtained from habitat typing and fisheries surveys previously conducted by various federal and state agencies, as well as watershed groups and private consultants. Where feasible, a first-hand inspection and evaluation of stream habitat occurred. Lengths of potential anadromous habitat were also estimated from USGS topographic maps. In situations where formal habitat typing surveys were not conducted, professional judgment of biologists and/or watershed coordinators familiar with watershed conditions was utilized.

7. A ranked list of stream crossings that require treatment to provide unimpeded fish passage to spawning and rearing habitat. On a site-by-site basis, general recommendations for providing unimpeded fish passage were provided.

Project Justification

Migration Barrier Impacts to Salmonids

Fish passage through crossings (especially culverts) and over dams is an important factor in the recovery of depleted salmonid populations throughout the Pacific Northwest. Although most fish-bearing streams with culverts at stream crossings tend to be relatively small in size with only a couple of miles or less of upstream habitat, thousands of these exist and the cumulative effect of blocked habitat is probably quite significant. Recent research regarding watershed restoration considers the identification, prioritization, and treatment of migration barriers to restore ecological connectivity for salmonids a vital step towards recovering depressed populations (Roni et al. 2002).

Culverts often create temporal, partial or complete barriers for anadromous salmonids on their spawning migrations (Table 1) (adapted from Robison et al. 2000).

Typical passage problems created by culverts are:

- Excessive drop at outlet (too high of entry leap required);
- Excessive velocities within culvert;
- Lack of depth within culvert;
- Excessive velocity and/or turbulence at culvert inlet; and
- Debris accumulation at culvert inlet and/or within culvert.

Table 1. Definitions of barrier types and their potential impacts.

Barrier Category	Definition	Potential Impacts
Temporal	Impassable to all fish some of the time	Delay in movement beyond the barrier for some period of time
Partial	Impassable to some fish at all times	Exclusion of certain species and life stages from portions of a watershed
Total	Impassable to all fish at all times	Exclusion of all species from portions of a watershed

Even if culverts are eventually negotiated, excess energy expended by fish may result in their death prior to spawning or reductions in viability of eggs and offspring. Migrating fish concentrated in pools and stream reaches below stream crossings are also more vulnerable to predation by a variety of avian and mammalian species, as well as poaching by humans. Culverts which impede adult passage limit the distribution of spawning, often resulting in under seeded headwaters and superimposition of redds in lower stream reaches.

Current guidelines for new culvert installation aim to provide unimpeded passage for both adult and juvenile salmonids (CDFG 2002, NOAA 2001). However many existing culverts on federal, state, county, city, and private roads are barriers to anadromous adults, and more so to resident and juvenile salmonids whose smaller sizes significantly limit their leaping and swimming abilities to negotiate culverts. For decades, "legacy" culverts on established roads have effectively disrupted the spawning and rearing behavior of all four species of anadromous salmonids in California: Chinook salmon, coho salmon, coastal rainbow trout (steelhead are anadromous coastal rainbow trout), and coastal cutthroat trout (*O. clarki clarki*).

In recent years, there has been a growing awareness of the disruption of in-stream migrations of resident and juvenile salmonids caused at road/stream intersections. In-stream movements of juvenile and resident salmonids are highly variable and still poorly understood by biologists. Juvenile coho salmon spend approximately one year in freshwater before migrating to the ocean, and juvenile steelhead may rear in freshwater for up to four years prior to out-migration (one to two years is most common in California). Thus, juveniles of both species are highly dependent on stream habitat. Many studies indicate that a common strategy for over-wintering juvenile coho salmon is to migrate out of larger river systems into smaller streams during late-fall and early-winter storms to seek refuge from possibly higher flows and potentially higher turbidity levels in mainstem channels (Skeesick 1970; Cederholm and Scarlett 1981; Tripp and McCart 1983; Tschaplinski and Hartman 1983; Scarlett and Cederholm 1984; Sandercock 1991; Nickelson et al. 1992). Recent research conducted in Pacific Northwest watersheds suggests that juvenile salmonids migrate into smaller tributaries in the fall and winter to feed on eggs deposited by spawning adults as well as flesh of spawned-out adults (Wipfli et al. 2003). This important source of protein leads to significant increases in growth and potentially higher survival rates of coho salmon smolts (Wipfli et al. 2003; Giannico et al. 2007). Direct observation at numerous culverts in northern California confirmed similar upstream movements of three year-classes of juvenile steelhead (young-of-year, 1-year old and 2-year old) (Taylor 2000; Taylor 2001).

The variable life history of resident coastal rainbow trout is exhibited by seasonal movements in and out of one or more tributaries within a watershed. These smaller tributaries are where most culverts are still located since larger channels tend to be spanned by bridges.

Undersized and poorly constructed stream crossings affect more than just the migrations of salmonids. Stream crossings disrupt the movements of other native fish species, such as scuplins, lampreys, and suckers. Many amphibian and mammal species also utilize the stream and riparian corridor for movement. Undersized and infrequently maintained crossings can also interrupt the movement of bedload and LWD during high flow events, exacerbate flooding, and cause damage to other infra-structure.

Planning Efforts to Address Migration Barriers

Anadromous and resident salmonids will benefit from this planning effort because the final document provides the NWPRR with a prioritized list of stream crossing locations to fix that will provide unimpeded passage for all species (and age classes) of salmonids. Report information will assist in proposal development to seek State and Federal money to implement treatments. The inventory will also provide NWPRR managers with a comprehensive status evaluation of the overall condition and storm-flow capacities of crossings on fish-bearing stream reaches within their jurisdictions. Finally, this report provides the NWPRR with a better understanding of the potential costs and workload required to restore fish passage at railroad crossings throughout the Eel River watershed.

METHODS AND MATERIALS

Methods for conducting the stream crossing inventory and fish passage evaluation included seven tasks; accomplished generally in the following order:

1. Location of stream crossings.
2. Initial site visits and data collection.
3. Estimation of tributary-specific hydrology and design flows for presumed migration period.
4. Data entry and passage analyses. Passage was first evaluated with a first-phase evaluation filter referred to as the "Green-Gray-Red" filter. Sites determined to be "Gray" and/or "Red" then required an in-depth evaluation with FishXing – a computer modeling software.
5. Collection and interpretation of existing habitat information.
6. Prioritization of sites for corrective treatment.
7. Development of site-specific recommendations for unimpeded passage of both juvenile and adult salmonids.

These methods were fairly consistent with the protocol recently developed for Part IX of the CDFG *California Salmonid Stream Habitat Restoration Manual* (Taylor and Love, 2003). These methods were developed to be consistent with current state and federal fish passage criteria for anadromous salmonids (CDFG 2002, NMFS 2001).

Two modifications to the original CDFG protocol were made during the NWPRR fish passage assessment project:

- Use of more rigorous criteria (decreased minimum water depths and increased swimming abilities) for assessing passage of adult salmonids (see page 18).
- A reduction of the weight of crossing sizing and condition in the ranking score (see page 23).

These two modifications to the original CDFG protocol were initiated in response to results generated by following the original methods during assessments completed prior to 2003. All protocol changes were discussed with CDFG and NOAA personnel prior to their use in assessment projects conducted by RTA since 2003. In-depth explanations to the rationale of modifying the methodology are provided at appropriate places within the Methods and Materials Section.

Location of Stream Crossings

At the start of the project, RTA met with several CDFG biologists and CalTrout personnel to develop a list of potential sites to inspect in the field and potentially survey for full fish passage assessment. At this meeting, we reviewed the results of a 1998 assessment of the railroad crossings and selected 10 sites for field inspection. In addition, RTA reviewed topographic maps and railroad inventory and inspection log books and composed a list of an additional 40 sites to inspect. These sites were selected by type and size of crossing from the inspection logs, and by watershed drainage area and channel slope from topographic maps. Where feasible, these sites were visited in the field to determine if they are in fact fish bearing. We performed full fish passage assessments on crossings located on streams that appeared to be fish-bearing. An additional five sites were added when they were encountered during field visits.

Access Permission

Most crossings were located in remote regions of the Eel River canyon which required accessing them by rafting the river, crossing the river with a canoe or walking long stretches of unmaintained railroad tracks. Historically, many private property owners along the railroad corridor have constructed and maintained roads to access the railroad and the Eel River. Many of these roads have restricted access and permission from private landowners was necessary. We obtained private landowners names and contact information from CDFG, Anderson-Penna and the Humboldt County Assessors office.

Initial Site Visits

The objective of the initial site visits was to determine if pre-selected stream crossings were located on fish-bearing streams, and, if so, to collect physical measurements to utilize with the first-phase evaluation filter and with the FishXing passage evaluation software. Notes describing the type and condition of each crossing, as well as qualitative comments describing stream habitat immediately above and below each crossing were also included. Site photographs taken included: upstream and downstream sides of the crossing, locations of cross-section tape, stream channel conditions, and/or crossing condition such as damage or unique features.

Stream Crossing Type

Crossings were classified as culverts, bridges, paved channels or fords. Each crossing, and section within a continuous crossing, was identified by the type of culvert, number of pipes or bays, and the construction material.

Crossing Location

The location of each stream crossing within a fish-bearing stream reach was described by: stream name; railroad post mile; name of USGS quad map; Township, Range, and Section; and latitude and longitude. Lat/long coordinates were determined using Terrain Navigator (Version 3.01 by MapTech™), a geo-referenced mapping software program; or in the field with a handheld GPS unit. For data entry and analyses purposes, all lat/long coordinates were provided in the NAD27 datum.

Longitudinal Survey

A longitudinal survey was shot at each fully-assessed crossing to provide accurate elevation data for FishXing passage analyses. We utilized a total station (Topcon™ GTS-230W), a flat-head surveyor’s tripod, and an 8.5’ prism rod with a tilt single prism unit. The total station’s data logger was used to store survey coordinates and all survey data were measured in feet to an accuracy of $1/100^{th}$ of a foot. Survey notes and site information were written on water-proof data sheets and in a bound field notebook with a pencil. Data sheets and field notes were photocopied to provide back-ups in case of loss or destruction of originals.

Bright orange vests were worn by the survey crew to increase visibility to private land owners. To start the survey, the total station was set in a location to eliminate or minimize the number of re-sections required to complete the survey. The person on the prism rod then selected locations along the thalweg (deepest point of channel cross-section at any given point along the center tape) at various locations along the channel, generally capturing visually noticeable breaks in slope along the stream channel. Longitudinal surveys were typically conducted in an upstream to downstream direction. Left-bank measurements were associated to the channel bank on one's left when facing in a downstream direction. Extreme caution was used when wading through or climbing over the crossings. At several locations, full surveys were not performed due to dangerous conditions that prevented full access to the stream crossing. A hardhat and flashlight were standard items used during the surveys when we entered culverts.

At all sites, the minimum points required to run FishXing were measured (Figure 1):

1. crossing inlet (if culvert) or upstream edge of dam/weir,
2. crossing outlet (if culvert) or downstream edge of dam/weir,
3. maximum pool depth within five feet of the outlet,
4. outlet pool tail-water control,
5. at least one point downstream of the tail-water control, and
6. a cross-section at the tail-water control.

Each cross-section was comprised of approximately eight to 15 elevations from approximately the left bank-full channel margin to the right bank-full margin. A tape was typically stretched across the cross-section to assist the rod person in accurately selecting points along the cross-section (Figure 2). These cross sections allowed for more accurate modeling of changes in tail-water elevations over varying stream discharges with the FishXing software.

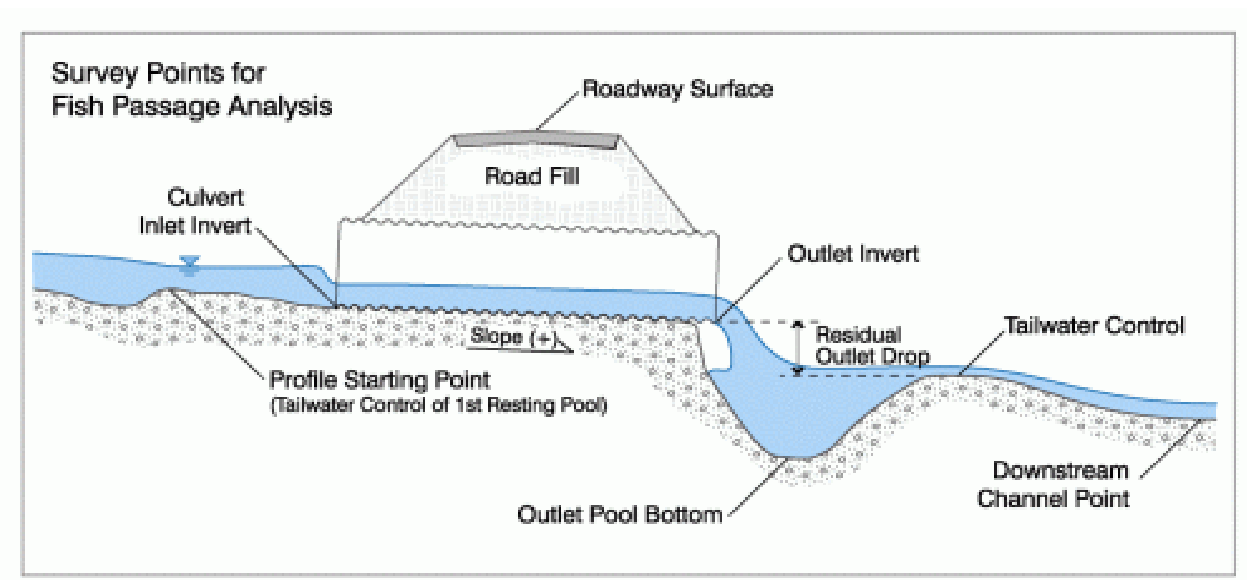


Figure 1. Diagram of required survey points though a culvert at a typical stream crossing.

Figure 2. Example of tape location for measuring the tail-water cross-section.

On a site-specific basis, the following additional survey points provided useful information for evaluating fish passage with FishXing:

- Apparent breaks-in-slope within the crossing. Older culverts often sag when road fills slump, creating steeper sections within a culvert. If only inlet and outlet elevations were measured, the overall slope will predict average velocities less than actual velocities within steeper sections. These breaks-in-slope may act as velocity barriers, which are masked if only the overall slope of the culvert was measured. The total station was set within the culvert or channel to measure breaks-in-slope.

- Steep drops in the stream channel profile immediately upstream of the culvert inlet. The elevation at the tail-water control of the first upstream holding water was measured to estimate the channel slope leading into the culvert. In some cases, a fish may negotiate the culvert only to fail at passing through a velocity chute upstream of the inlet entrance. Inlet drops often create highly turbulent conditions during elevated flows.

- Aprons are typically concrete structures extending upstream or downstream from a culvert at the channel-culvert interface that control the flow transition into or out of the culvert. Aprons often have a different slope than the culvert itself. If the apron was much steeper than the culvert, then it may be the factor preventing fish passage.

Channel widths

Where feasible, at least five measurements of the active channel width above the crossing (visually beyond any influence the crossing may have on channel width) were taken. Active channel is defined as the portion of channel commonly wetted during and above winter base flows and is often identified by a break in rooted vegetation or moss growth on rocks along stream margins. Some stream crossing design guidelines utilize active channel widths in determining the appropriate widths of new culvert installations (CDFG 2002; NMFS 2001; Robison et al 2000; Bates et al. 1999).

Fill Estimate

The site survey data were also used to obtain an estimate of the fill volume. This rough estimate of fill volume was used in prioritization of site replacement or remediation and has two purposes. First, the replacement cost of a migration barrier is highly influenced by the fill volume that must be moved and replaced to access the culvert. Second, the fill volume can also be an indication of potential consequences should a stream crossing fail due to plugging or being undersized. The fill volume represents the potential volume of sediment delivered to the downstream channel if a crossing were to fail. Fill elevation can also be used to estimate the culvert flood capacity or the flow rate through the culvert when the culvert is submerged with an upstream water depth approaching the top of the fill. These uses of fill volume and elevation are most appropriate for small to moderate fill volumes (less than 10,000 cubic yards). Finally, because these fill volume estimates are made with minimal survey points, they may contain significant error and should not be used for design or construction purposes (Taylor and Love 2003).

At minimum, 10 survey points were used to estimate the fill volume. The five points, FB_1, FB_2, FT_1, FT_2, and FT_3 (Figure 3) were measured on both the upstream and downstream fill slope. These ten points were then used to calculate the lengths (L_d, L_u, W_r, W_f, and W_c) and slopes (S_d and S_u) indicated in Figure 3. The fill volume was calculated using these values and equations 1 through 4 as outlined on page 12 of the *California Salmonid Stream Habitat Restoration Manual* (Taylor and Love, 2003). The fill displaced by the culvert volume was then subtracted from the fill volume estimate.

Fill volume estimates were not performed at each surveyed railroad crossing. Crossings that were bridges or concrete channels did not have fills and thus have no fill volume values associated with them.

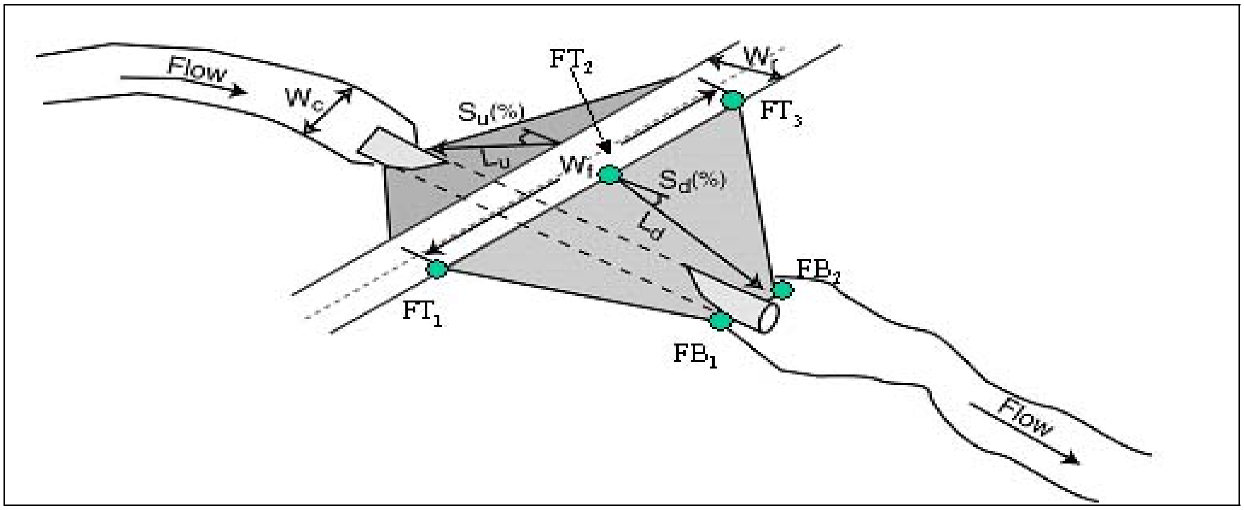


Figure 3. Road fill measurements (modified from Taylor and Love 2003).

For each crossing, the following specifications were collected:

1. Length (to nearest 1/10 of foot);
2. Dimensions: diameter (circular), or height and width (box culverts), or span and rise (pipe arches and open-bottom arches);
3. Type: corrugated metal pipe (CSP), structural steel plate (SSP), concrete pipe, concrete box, open-bottom pipe arch, squashed pipe-arch, or a composite of materials;
4. Overall condition of pipe (good, fair, poor, extremely poor);
5. Height and width of rust-line (if present);
6. Position relative to flow and stream gradient;
7. Depth of pool below culvert;
8. Height of jump required to enter culvert;
9. Previous modifications (if any) to improve fish passage; and
10. Condition of previous modifications.

Qualitative notes describing stream habitat immediately upstream and downstream of each crossing were taken. Where feasible, variable lengths of the stream channel above and below crossings were walked to detect presence of salmonids, other fish species, and provide additional information regarding habitat conditions.

Data Entry and Passage Analyses

After returning from the field, the total station files were downloaded to a computer. Each site was given a unique site identification number with the preface NWPRR (North Western Pacific Railroad) followed by the corresponding railroad post mile. The downloaded survey data were then processed in Excel to calculate the physical characteristics needed to perform a fish passage assessment using the CDFG ranking filter and, if needed, hydraulic analysis with FishXing. All site characteristic data and information that were recorded on waterproof data sheets were also entered into an Excel spreadsheet.

First-phase Passage Evaluation Filter: GREEN-GRAY-RED

In collaboration with NOAA Fisheries, CDFG developed a ranking filter to quickly assess fish passage at stream crossings (Taylor and Love, 2003). The filtering process was used to assist in identifying sites which either met, or failed to meet, state and federal fish passage criteria for all fish species and age classes (CDFG 2002; NMFS 2001). Using the field inventory data, the following values were calculated: average active channel width, crossing slope, residual inlet depth and drop at outlet (Figure 4). The first-phase passage evaluation filter was employed to reduce the number of crossings which required an in-depth passage evaluation with FishXing. The filter criteria were designed to quickly classify crossings into one of three categories:

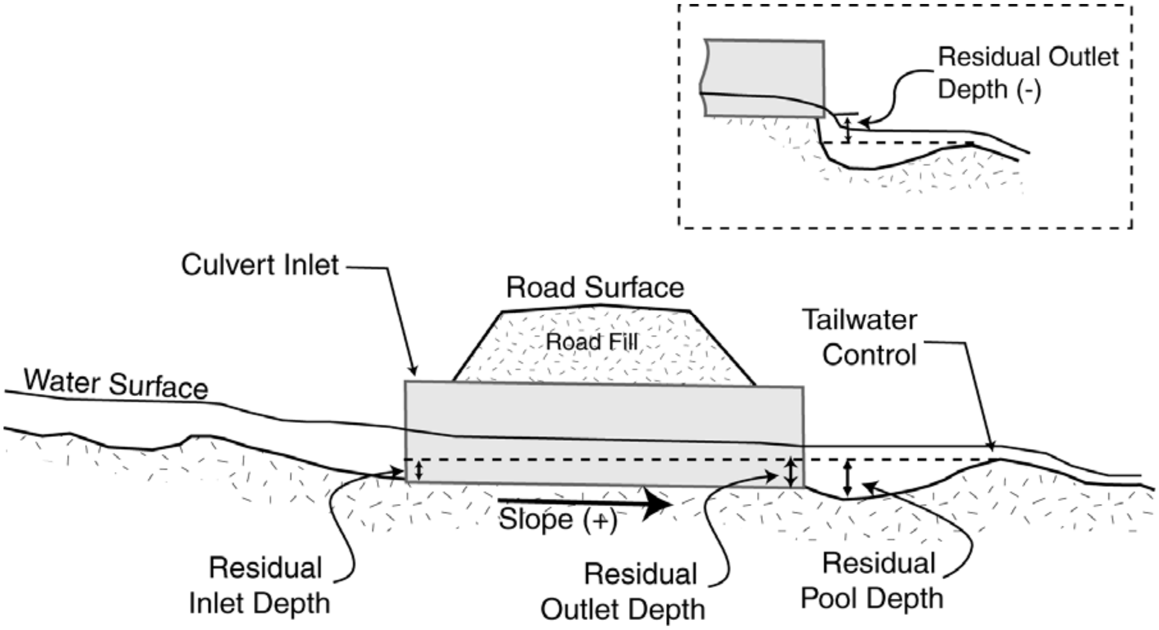
- **GREEN**: Conditions assumed adequate for passage of all salmonids, including the weakest swimming age class.

- **GRAY**: Conditions may not be adequate for all salmonid species or age classes presumed present. Additional analyses required to determine extent of barrier for each species and age class.

- **RED**: Conditions do not meet passage criteria at any flows for strongest swimming species presumed present. In some instances, assume "no passage" and move to analysis of habitat quantity and quality upstream of the barrier. However, some **RED** sites were evaluated further with FishXing.

A spreadsheet macro was utilized that followed the CDFG flowchart to determine a stream crossing's status as **GREEN**, **GRAY**, or **RED** (Figure 5). Depending on geographic location within California, species of interest will vary. Within anadromous-bearing watersheds, CDFG has determined that crossings classified as **GREEN** must meet upstream passage criteria for both adult and over-wintering juvenile salmonids at all expected migration flows.

Many stream crossings have unique characteristics which may hinder fish passage, yet they are not recognized in the filtering process. For crossings meeting the **GREEN** criteria, a review of the inventory data and field notes was necessary to ensure no unique passage problems existed before classifying the stream crossings as "100% passable".



Residual Pool Depth = ($\text{Elev}_{\text{Tailwater Control}}$ – $\text{Elev}_{\text{Pool Bottom}}$)

Outlet Depth = ($\text{Elev}_{\text{Tailwater Control}}$ – $\text{Elev}_{\text{Culvert Outlet}}$) *(No outlet drop if Outlet Depth $\geq$ 0)*

Residual Inlet Depth = ($\text{Elev}_{\text{Tailwater Control}}$ – $\text{Elev}_{\text{Culvert Inlet}}$)

Figure 4. Measurements used in **GREEN**-**GRAY**-**RED** filtering criteria.

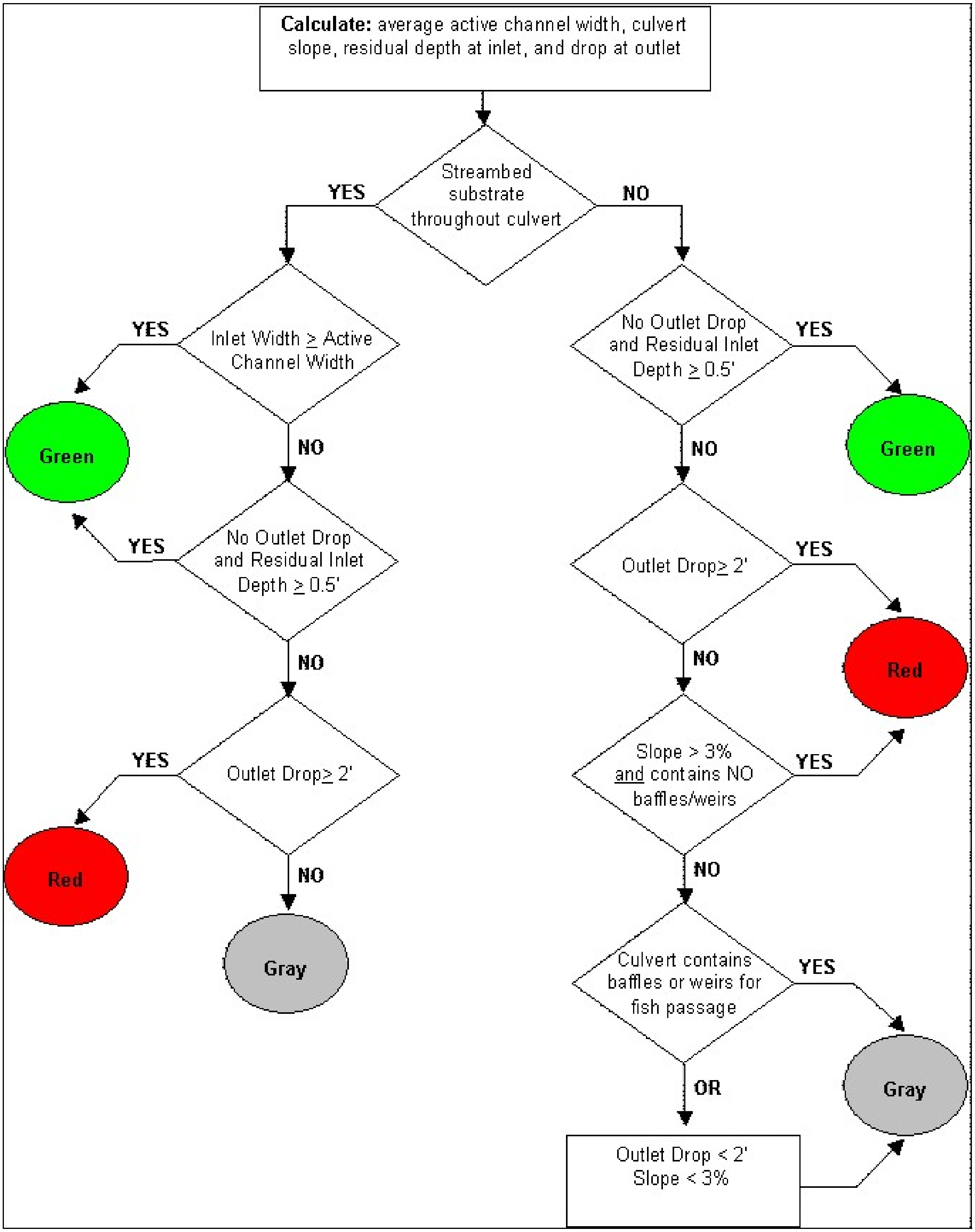


Figure 5. GREEN-GRAY-RED first-phase passage evaluation filter.

FishXing Overview

FishXing is a computer software program developed by Six Rivers National Forest's Watershed Interactions Team - a group of scientists with diverse backgrounds in engineering, hydrology, geomorphology, geology, and fisheries biology. Mike Furniss, a Forest Service hydrologist for Six Rivers, managed program development. The initial version of FishXing was released in March, 2000. FishXing has since undergone two revisions, with version 3.0 being the most current. In-depth information regarding FishXing (or a copy of the most-recent version) may be obtained at the FishXing homepage on the internet at www.stream.fs.fed.us/fishxing/ .

FishXing is an interactive software package that integrates a culvert design and assessment model for fish passage nested within a multimedia educational setting. Culvert hydraulics are well understood and model output closely resembles reality. FishXing successfully models (predicts) hydraulic conditions throughout the culvert over a wide range of flows for numerous culvert shapes and sizes. The model incorporates fisheries inputs including fish species, age classes, body lengths, and leaping and swimming abilities. FishXing uses the swimming abilities to determine whether the culvert installation (current or proposed) will accommodate fish passage over a desired range of migration flows, and identify specific locations within the culvert that impede or prevent passage. Software outputs include water surface profiles and hydraulic variables such as water depths and average velocities displayed in both tabular and graphical formats.

Fish Passage Criteria – First Deviation from CDFG Passage Assessment Protocol

FishXing utilized survey elevation and crossing specifications to evaluate passage at sites defined as **GRAY** by the first-phase evaluation filter for each species and age class of salmonids known to currently or historically reside in coastal watersheds. The swimming abilities and passage criteria recommended in the original CDFG fish-passage protocol and the alternate values used by RTA in the NWPRR project (in bold font) for each species and age class are listed in Table 2.

The CDFG fish passage protocol recommended using conservative values for assessment under the assumption that although many individual fish will have swimming abilities surpassing those listed, swim speeds and minimum water depths were selected to ensure stream crossings accommodated passage of weaker individuals within each age class. This assumption is better suited for the *design* of new crossings where being conservative hopefully allows for the passage of all fish. However, for *assessment* purposes, the use of conservative swimming values and minimum water depths generated many **RED** sites that, in fact, were allowing the passage of adult salmonids. This discrepancy was first noticed during RTA's Marin County assessment project (in 2002) where extensive spawning survey data confirmed adult coho salmon and steelhead consistently spawning upstream of crossings initially assessed as **RED**.

If the objective of the passage assessment is to identify crossings that are truly barriers to adult migration, as well as, accurately estimate the percentage of temporal passage to allow a gradation in the scoring matrix; then using conservative values is not appropriate. The use of more rigorous passage criteria should reduce the number of **RED** sites and generate a wider range of "extent of barrier" scores for the **GRAY** sites.

Table 2. Fish species and age classes used in the fish passage along with associated swimming abilities and passage criteria. Values in parentheses are the conservative values recommended in the CDFG protocol. Passage flows are based on current adult salmonid criteria combined with observational data from northern California coastal streams.

Fish Species/Age Class	**Adult Steelhead and Coho**	**Resident Trout**	**Juvenile Salmonids**
Fish Length	500 mm	200 mm	80 mm
Prolonged Mode Swim Speed Time to Exhaustion	(6 ft/sec) **8 ft/sec** 30 min	4 ft/s 30 min	1.5 ft/s 30 min
Burst Mode Swim Speed Time to Exhaustion	(10 ft/sec) **16 ft/sec** 5 sec	5.0 ft/s 5 s	3.0 ft/s 5 s
Maximum Leaping Speed	(12.0 ft/sec) **16 ft/sec**	6.0ft/s	3.0 ft/s
Velocity Reduction Factors for Corrugated Metal Culverts **	Inlet = 1.0 Barrel = 1.0 Outlet = 1.0	Inlet = 0.8 Barrel = 0.6 Outlet = 0.8	Inlet = 0.8 Barrel = 0.6 Outlet = 0.8
Minimum Required Water Depth	(0.8 ft) **0.5 ft**	0.5 ft	0.3 ft
Minimum Passage Flow *(Use the larger of the two flows)*	50% exceedence flow or 3 cfs	90% exceedence flow or 2 cfs	95% exceedence flow or 1 cfs
Maximum Passage Flow	50% of Q2	30% of Q2	10% of Q2

** Velocity reduction factors only apply to culverts with corrugated walls, baffles, or natural substrate. All other culverts had reduction factors of 1.0 for all fish.

FishXing and other hydraulic models report the average cross-sectional water velocity, often failing to account for spatial variations. Culverts embedded with natural substrate or with large corrugations will have regions of reduced velocities that can be utilized by migrating fish. These areas are often too small for larger fish to use, but can enhance juvenile passage success. FishXing allows the use of reduction factors that decrease the calculated water velocities proportionally. As shown in Table 2, velocity reduction factors were used in the passage analysis of resident fish and juveniles with specific types of stream crossing structures.

Using FishXing, the range of flows that met the depth, velocity, and leaping criteria for each age class were identified. The range of flows meeting the passage requirements were then compared to the entire range of fish passage flows to determine “percent passable”.

<u>Hydrology and Design Flow</u>

When examining stream crossings that required fish passage, three specific flows were considered: peak flow capacity of the stream crossing, the upper fish passage flow, and the lower fish passage flow. Because flow is not gauged on most small streams, it must be estimated using techniques that required hydrologic information about the stream crossing's contributing watershed, including:

- Drainage area;
- Mean annual precipitation;
- Mean annual potential evapotranspiration; and
- Average basin elevation.

Drainage area and basin elevations were calculated from a 1:24,000 USGS topographic map. For most projects, mean annual precipitation (MAP) and potential evapotranspiration (PET) were estimated from regional maps produced by Rantz (1968).

Peak Flow Capacity

Peak flows are typically defined in terms of a recurrence interval, but reported as a quantity; often as cubic feet per second (c.f.s.). Current guidelines recommend all stream crossings pass the flow associated with the 100-year flood without damage to the stream crossing (NOAA, 2001). Additionally, infrequently maintained crossings with culverts should accommodate the 100-year flood without overtopping the culvert's inlet.

Determination of a crossing's flood capacity assisted in ranking sites for remediation. Undersized crossings have a higher risk of catastrophic failure, which often results in the immediate delivery of sediment from the railroad-fill into the downstream channel. Depending on the amount of railroad-fill, this pulse of sediment may have a minor-to-catastrophic impact on downstream rearing and spawning habitat. Undersized crossings can also adversely affect sediment transport and downstream channel stability, creating conditions that hinder fish passage, degrade habitat, and may cause damage to other stream crossings or infrastructure..

The first step was to estimate hydraulic capacity of each inventoried stream crossing. Capacity is generally a function of the shape and cross-sectional area of the inlet. Capacity was calculated for two different headwater elevations: water ponded to the top of the culvert inlet (HW/D = 1) and water ponded to top of the railroad/fill prism (HW/F = 1). Nomograph equations developed by Piehl et. al (1988) were used to calculate capacity of circular culverts. Federal Highways nomographs presented in Norman et al (1995) were used for pipe-arches, open bottom arches, oval pipes and box culverts. The FishXing program was also used to determine when backwatered culverts were flowing full due to outlet-controlled situations.

The second step was to estimate peak flows at each crossing. This required estimating the 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year peak flows. Regional flood estimation equations developed by Waananen and Crippen (1977) were used to estimate peak flows for the various recurrence intervals (Figure 6). The equations incorporate drainage area, MAP, and mean basin elevation as variables to predict peak flow in North Coast region California streams.

The third step was to compare the stream crossing capacity to peak flow estimates. Risk of failure was assessed by comparing a stream crossing's hydraulic capacity with the estimated peak flow for each recurrence interval. Each crossing was placed into one of six "sizing" categories:

1. equal to or greater than the 100-year flow,
2. between the 50-year and 100-year flows,
3. between the 25-year and 50-year flows,
4. between the 10-year and 25-year flows,
5. between the 10-year and 5-year flows,
6. less than the 5-year storm flow.

These six categories were utilized in the stream crossing ranking matrix.

Fish Passage Flows

It is widely agreed that designing stream crossings to pass fish at all flows is impractical (CDFG 2002; NOAA 2001; Robison et al. 2000; SSHEAR 1998). Although anadromous salmonids typically migrate upstream during higher flows triggered by hydrologic events, it is presumed that migration is naturally delayed during larger flood events. Conversely, during low flow periods on many smaller streams, water depths within the channel are often impassable for both adult and juvenile salmonids. To identify the range of flows that stream crossings should accommodate for fish passage, lower and upper flow limits have been defined specifically for streams within California (CDFG 2002; NOAA 2001).

To evaluate the extent to which a crossing is a barrier, passage was assessed between the lower and upper passage flows for each fish species and age class of concern. Typically, passage flows were determined by calculating the exceedence flows with average daily stream flow data from gauged streams available from the USGS. The methods for calculating exceedence flows were fully described in Section IX of the CDFG Restoration manual (Taylor and Love 2003).

However; for the NWPRR project we found that small drainage areas above many crossings lead to extremely small values for adult high-passage flows when using the exceedence flow methodology. Thus, we utilized 50% of the two-year recurrence interval discharge as the alternate means to determine adult high-passage flow as recommended by CDFG since this method results in higher flows and a wider range of migration flows for passage assessment (CDFG 2002). For assessing resident trout/2+ juvenile high-passage we used 30% of the two-year flow and for 1+/young-of-year juveniles we used 10% of the two-year flow (CDFG 2002). The two-year recurrence interval was estimated using regional flood estimation regression equations by the USGS for the North Coast (Waananen and Crippen, 1977).

When analyzing fish passage with FishXing, these flows were used to determine the extent to which the crossing was failing to meet passage criteria. The stream crossing must meet water velocity, leap height and depth criteria between Q_{lp} and Q_{hp} to be considered 100% passable (NOAA 2001). For the ranking matrix, at each stream crossing, the extent of the migration barrier was determined for each salmonid species and age class presumed present.

Habitat Information

Because the NWPRR's railroad line within the Eel River basin was located primarily in extremely remote areas and many of the streams crossed by culverts were relatively small and unnamed, habitat information was not equally available. Visual, in-the-field, professional assessments were always made at each site and included walking at least several hundred feet of channel upstream of each assessed crossing. However, this was sometimes the only habitat information available. When available, previously completed surveys and reports, as well as the professional judgment of biologists, and restoration groups familiar with the watersheds were used. Additional CDFG reports and memos also provided information on past, present, and future land uses within watersheds where stream crossings were located.

<u>Habitat Quantity</u>

Lengths of potential anadromous salmonid habitat upstream of each crossing were estimated by two methods:

1. Lengths measured in the field during previously conducted habitat typing or fisheries surveys. If access was permitted, these surveys were terminated where the field crews thought the limit of anadromy was located. The surveys were often terminated at obvious features such as natural waterfalls, extremely steep-sloped boulder cascades, or at permanent human-made structures such as dams.

2. Measured off of digitized USGS 7.5 Minute Series topographic maps (Terrain Navigator, Version 3.01by MapTech). The upper limit of anadromous habitat was considered when the channel exceeded an eight to ten percent slope for at least a 300-foot channel reach.

The habitat quantity value used in the ranking matrix varied, but usually if a habitat typing survey identified an obvious feature where anadromy was terminated – this was the value used. In other instances, the eight-to-ten percent slope was used only if on-the-ground survey information was unavailable.

The presence of previously assessed stream crossings above and below each site included in this project was also considered when evaluating potential habitat gains. The location (and status) of these previously assessed crossings were considered when developing the final ranking matrix for the purpose of selecting sites for treatment scheduling.

Initial Ranking of Stream Crossings for Treatment

The ranking objective was to arrange the sites in an order from high to low priority using a suite of site-specific information. However, the scores generated were not intended to be absolute in deciding the exact order of scheduling treatments. Once the first-cut ranking was completed, professional judgment played an important part in deciding the order of treatment. As noted by Robison et al. (2000), numerous social and economic factors influenced the exact order of treated sites.

This report also acknowledges (but makes no attempt to quantify or prioritize) that other potentially high-priority restoration projects exist throughout California, and these must all be considered when deciding where and how to best spend limited restoration funds. However, recent research regarding watershed restoration considers the identification, prioritization, and treatment of human-made migration barriers to restore ecological connectivity for salmonids a vital (and often initial) step towards recovering depressed populations (Roni et al. 2002).

Ranking Criteria

The criteria and scoring for ranking stream crossings were relatively consistent with those developed for Part IX of CDFG's *Salmonid Stream Habitat Restoration Manual* (Taylor and Love, 2003), except for two aspects. The second deviation from the CDFG protocol entailed reducing the weight of the current crossing's sizing and condition scores on the site's total score. Again, this modification to the CDFG protocol resulted from carefully analyzing data sets from previously completed assessment projects. The ranking matrix developed for the *Restoration Manual* can generate a maximum possible score of 41 points, with a maximum of 10 points (24.4%) associated with crossing condition and sizing. In some instances, crossings with very little upstream habitat (<1,000') and/or met the adult passage criteria on 70-100% of the range of migration flows were ranking near the top due primarily to poor condition and under-sizing.

Undersized crossings that are in poor condition should be of concern. However, if the primary purpose of the ranking matrix is to identify sites to treat with fisheries restoration funding, then more weight should be put on the biological-related criteria so that crossings which are serious impediments to migration with significant reaches of potential upstream habitat rank higher than crossings in need of replacement due to poor condition and flow capacity issues.

The weight of the sizing and condition criteria score was reduced by utilizing the average of the two values. This resulted in a maximum possible total score of 36 points, with sizing and condition criteria comprising no more than 13.8% of the maximum total score. This adjustment in scoring crossing capacity and condition has already occurred on the following projects completed by RTA: Corte Madera Creek watershed, San Mateo County, Marin County, Russian River, Santa Cruz County, the Morro Bay watershed, Hopland Band of Pomo Indians, Mendocino District of California State Parks, North Coast Redwoods District of California State Parks, and the City of Arcata fish passage assessment projects.

The method utilized for the NWPRR assessment assigned a score or value for the following criteria at each crossing location. The total score was the sum of four criteria: species diversity, extent of barrier, average value of crossing sizing and current condition, and total habitat score.

1. **Species diversity:** number of salmonid species known to occur (or historically occurred) within the stream reach at the crossing location. **Score:** CA. ESA listing status as endangered: Coho salmon = **4** points; Federal ESA listing status as endangered south of the Klamath River: Steelhead = **2** points; Federal ESA listing status as threatened south of the Klamath River: Chinook Salmon = **2** points. **Maximum score = 8 points.**

2. **Extent of barrier:** for three age classes of salmonids (adults, resident trout/2+ and 1+/young-of-year), over the range of estimated migration flows, assign one of the following values. **Score: 0** = 80-100% passable; **1** = 60-80% passable; **2** = 40-60% passable; **3** = 20-

40% passable; **4** = less than 20% passable; **5** = 0% passable (RED by first-phase evaluation filter). For a total score, sum scores given for adults and each year-class of juveniles. **Maximum score = 15 points.**

3. **Sizing (risk of failure):** for each crossing, assign one of the following values as related to flow capacity. **Score: 0 =** sized to NMFS standards of passing 100-year flow at less than inlet height. **1** = sized for at least a 50-year flow, low risk. **2** = sized for at least a 25-year flow, moderate risk. **3** = sized for less than a 25-year flow, moderate to high risk of failure. **4** = sized for less than a 10-year event, high risk of failure. **5** = sized for less than a five-year event, high risk of failure.

4. **Current condition:** for each crossing, assign one of the following values. **Score: 0** = good condition. **1** = fair, showing signs of wear. **3** = poor, floor rusting through, crushed by road-base, etc. **5** = extremely poor, floor rotted-out, severely crushed, damaged inlets, collapsing wing-walls, slumping road-base, etc.

5. **Crossing Score:** for each crossing, combine the sizing and condition values and compute the average value. **Maximum score = 5 points.**

6. **Habitat quantity:** above each crossing, length in feet to sustained 8-10% gradient. **Score:** Starting at a 500’ minimum; 0.5 points for each 500’ length class (**example**: **0** points for <500’; **1** point for 1,000’; **2** points for 2,000’; **3.5** points for 3,500’; and so on). **Maximum score = 10 points.**

7. **Habitat quality:** for each stream reach within the vicinity of the crossing, assign a “multiplier” of quality (relative to other streams and stream-reaches in inventory) after reviewing available habitat information

- **Score: 1.0 = Excellent-** Relatively undeveloped, “pristine” watershed conditions. Habitat features include dense riparian zones with mix of mature native species, frequent pools, high-quality spawning areas, cool summer water temperatures, complex in-channel habitat, and/or channel floodplain relatively intact. High likelihood of no future human development. Presence of migration barrier(s) is obviously the watershed’s limiting factor.

- **0.75 = Good-** Habitat is fairly intact, but human activities have altered the watershed with likelihood of continued activities. Habitat still includes dense riparian zones of native species, frequent pools, spawning gravels, cool summer water temperatures, complex in-channel habitat, and/or channel floodplain relatively intact. Presence of migration barrier(s) is most likely one of the watershed’s primary limiting factors.

- **0.5 = Fair-** Human activities have altered the watershed with likelihood of continued (or increased) activities, with apparent effects to watershed processes and features. Habitat impacts include riparian zone present but lack of mature conifers and/or presence of non-native species, infrequent pools, sedimentation evident in spawning areas (pool tails and riffle crests), summer water temperatures periodically exceed stressful levels for salmonids, sparse in-channel complex habitat, floodplain intact or slightly modified). Presence of migration barrier(s) may be one of the watershed’s limiting factors (out of several factors).

- **0.25 = Poor-** Human activities have drastically altered the watershed with high likelihood of continued (or increased) activities, with apparent effects to watershed processes. Habitat impacts include riparian zones absent or severely degraded, little or no pool formations, excessive sedimentation evident in spawning areas (pool tails and riffle crests), stressful to lethal summer water temperatures common, lack of in-channel habitat, floodplain severely modified with levees, riprap, and/or residential or commercial development. Other limiting factors within watershed are most likely of a higher priority for restoration than remediation of migration barriers. NOTE: a "poor" habitat rating was also assigned to stream reaches that were either too small and/or too steep immediately upstream of the crossing to provide adequate habitat for anadromous salmonids even though the stream reach was potentially available for fish utilization.

- **Total habitat score:** Multiply #5 by #6 for habitat "score". A multiplier assigned for habitat quality, weighs the final score more on quality than sheer quantity of upstream habitat. **Maximum score = 10 points.**

For each culvert, the five ranking criteria were entered into a spreadsheet and total scores computed. Then the list was sorted by "Total Score" in a descending order to determine an initial ranking. On closer review of the rank, some professional judgment was used to slightly adjust the rank of several sites. The list was then divided subjectively into groups defined as "high", "medium", or "low" priority.

The high-priority sites were generally characterized as serious impediments to migration with significant amounts of upstream spawning and rearing habitat for salmon and steelhead. Medium-priority sites were characterized as limited in upstream habitat gains and/or were only significant impediments to juvenile migration. Low-priority sites were either limited in upstream habitat, habitat condition was poor, and/or the site allowed passage of adults and most juveniles.

Remediation of crossings identified as "high-priority" should be accomplished by submitting proposals to various fisheries restoration funding sources. The information provided in this report should be used to document the logical process employed to identify, evaluate, and rank these migration barriers.

<u>Additional Considerations for Final Ranking</u>

On a site-specific basis, some or all of these factors were considered in rearranging the first-cut ranking to develop a final list for project scheduling:

1. Fish observations at crossings. Sites where fish were observed during migration periods were given higher priority in the final ranking. The species of salmonids observed, the number of fish, frequency of attempts, and the number of failed versus successful passage attempts were important variables considered. Sites with fish present are areas where immediate re-colonization of upstream habitat is likely to occur. Many streams in northern California have experienced immediate re-colonization after migration barriers were treated.

2. Stocks of fish presumed present. Streams currently supporting runs of anadromous fish were given a higher priority over streams that historically supported anadromous fish populations.

3. Amount of railroad fill. At stream crossings that were undersized and/or in poor condition, we examined the volume of fill material within the railroad prism potentially deliverable to the stream channel if the crossing were to fail.

4. Presence, location, and barrier status of other stream crossings. In some cases, an individual stream was crossed by multiple roads under a variety of management or ownership. In these situations, close communication amongst road managers will be important in project selection and implementation. If multiple crossings are migration barriers, a coordinated effort is required to identify and treat them in a logical manner – generally in an upstream direction starting with the lowermost crossing.

5. Remediation project cost. In some cases, sites were raised in priority if cost-effective retrofits were feasible treatment options. Conversely, some sites were lowered in priority because the only feasible treatments were full replacements of culverts underneath large amounts of fill.

RESULTS

Site Visits

Sixty-six crossings were identified by CDFG and RTA personnel to be inventoried, of which 22 received full fish passage assessments (Table 3). The reasons for excluding 44 crossings from full assessments included: stream channel was too steep for fish, crossing was a bridge with natural channel underneath, or we were unable to safely access the site (Table 3). Organizationally, sites were ordered by increasing railroad post mile, which occurred from south-to-north and upstream-to-downstream (Table 3). The 22 evaluated stream crossings were each given a unique ID number starting with the prefix NWPRR (North Western Pacific Railroad), followed by their railroad post mile (Table 4). A table of the 22 fully-assessed stream crossings and their location information and characteristics is provided in Appendix A. More detailed summaries of location information, site-specific characteristics, FishXing results, site photographs, and habitat descriptions for the stream crossings were assembled in a separate document titled *Site Catalog of Stream Crossings Located on Fish-bearing Stream Reaches on the North Western Pacific Railroad within the Eel River Basin.*

The following list is an overview of the crossings inventoried:

1. During the initial site visits a limited type of materials and culvert types were discovered. 68%, or 15 out of 22, of the culverts were concrete arch culverts with concrete floors. The rest of the sites were a mix of circular pipes, bridges, concrete channels, hardened floors and one SSP pipe arch (Table 4).

2. Eight of the 22 fully-assessed crossings were in extremely poor condition (36% of the sites, about one third). These extremely poor sites are currently introducing road fill material to the channel in addition to having compromised structural integrity. Five sites (23%) were listed as being in poor condition and should be repaired or replaced so they do not deteriorate further. The extremely poor and poor condition sites comprised close to 60% of the sites surveyed. It should be noted that numerous crossings on non-fish bearing streams observed by RTA had a similar trend in conditions; while these smaller/steeper drainages do not provide fish habitat they should be considered potential sediment sources if, and when, crossing failures occur. Within many of the concrete structures, the floors were worn down to rebar or worn completely through; also many of the crossings had fractures in the walls that appeared to compromise structural integrity. Most of the concrete structures had the dates "1911" or "1912" stamped on the headwalls.

3. Four crossings, Bloyd Creek (233.93) and Allen Creek (240.28), which received full or partial surveys, and Pipeline Creek (235.27) and Bridge Creek (243.38), which were not fully surveyed, all had completely buried inlets due to channel aggradation. The buried inlets at these sites blocked fish passage at all flows and only passed flows through seepage or a stand pipe. All four of these sites were included in the ranking matrix.

4. Fourteen of the crossings (64%), which included two bridges, are properly sized for flow conveyance greater than a 100-year storm flow at less than 100% of inlet height (Table 4). Five crossings are considered severely undersized because they were estimated to pass less than a 5-year storm flow at 100% of inlet height (Table 4).

Table 3. Status of initial site visits for the NWPRR stream crossing inventory and fish passage evaluation project.

RR MILE	STREAM NAME	LAT	LONG	STATUS OF INITIAL SITE VISIT
135.78	Haehl Creek	39.36577	123.31681	**Survey Completed**
136.73	Haehl Creek	39.37683	123.32892	**Survey Completed**
138.23	Haehl Creek	39.39629	123.34060	**Survey Completed**
141.78	Wild Oat Can	39.44521	123.35105	Bridge
145.23	Unnamed tributary	39.56954	123.39604	Channel too steep for fish
153.99	Unnamed tributary	39.56954	123.39604	Channel too steep for fish
155.24	Unnamed tributary	39.58385	123.38580	**Survey Completed**
158.61	Bloody Run Creek	39.61553	123.35932	Bridge
161.07	Unnamed tributary	39.64567	123.34489	Channel too steep for fish
161.82	Tatu Creek	39.65670	123.34520	Channel too steep for fish
162.62	Unnamed tributary	39.66701	123.34813	**Survey Completed**
164.80	Brad Turner Creek	39.68508	123.35843	**Survey Completed**
165.50	Dean Creek	39.69436	123.36079	**Survey Completed**
167.39	Burger Creek	39.72325	123.36639	Bridge
168.28	Gamache Creek	39.73457	123.37074	Channel too steep for fish
169.05	Stoney Creek	39.75075	123.38039	Channel too steep for fish
171.49	Woodman Creek	39.77652	123.39177	**Survey Completed**

Table 3. (continued) Status of initial site visits for the NWPRR stream crossing inventory and fish passage evaluation project.

RR MILE	STREAM NAME	LAT	LONG	STATUS OF INITIAL SITE VISIT
174.21	Barn Creek	39.81050	123.40836	**Survey Completed**
174.31	Unnamed tributary	39.81091	123.41112	Channel too steep for fish
174.53	Black Oak Creek	39.81198	123.41470	**Survey Completed**
174.92	Corbet Creek	39.81711	123.41782	**Survey Completed**
176.04	Unnamed tributary	39.83117	123.41793	**Survey Completed**
178.29	Shell Rock Creek	39.85597	123.43478	Bridge
179.32	Unnamed tributary	39.86905	123.44057	Channel too steep for fish
182.90	Blue Rock Creek	39.90506	123.47352	Bridge
185.01	Bell Springs Creek	39.93413	123.47607	Bridge
187.49	Buck Creek	39.95100	123.44532	Bridge
185.13	Cinch Creek	39.93506	123.47481	Did not appear fish-bearing
192.03	Raff Creek	39.99765	123.48299	Channel too steep for fish
199.20	Kekawaka Creek	40.09341	123.51663	Bridge
204.31	Haman Creek	40.12488	123.57575	Channel too steep for fish
204.65	Ticknor Creek	40.12961	123.57826	Channel too steep for fish
207.05	Mill Creek	40.15243	123.60153	**Survey Completed**
211.68	Steelhead Creek	40.17080	123.64750	Bridge
214.42	Soda Creek	40.19885	123.65341	Channel too steep for fish

Table 3. (continued) Status of initial site visits for the NWPRR stream crossing inventory and fish passage evaluation project.

RR MILE	STREAM NAME	LAT	LONG	STATUS OF INITIAL SITE VISIT
214.42	Jackass Creek	40.20149	123.65103	Channel too steep for fish
217.95	UNT Old Car Ck	40.23050	123.66603	Channel too steep for fish
219.04	Willow Draw Creek	40.23846	123.68268	Channel too steep for fish
220.04	Ort Creek	40.23875	123.70025	Outlet is perched approximately 100 ft above Eel River.
221.73	Brock Creek	40.24717	123.71868	Bridge
222.49	Unnamed tributary	40.25614	123.72422	Not fish bearing – channel too steep.
223.47	Unnamed tributary	40.26777	123.73116	**Survey Completed**
223.88	Constantine Creek	40.27018	123.73781	**Survey Completed**
224.48	Unnamed tributary	40.27865	123.73532	Not fish bearing
227.43	Unnamed tributary	40.30680	123.75851	No access to site – very steep on topographic map.
230.25	Sonoma Creek	40.31370	123.80303	Bridge
231.62	Devil's Elbow Ck	40.32212	123.83280	Channel too steep for fish
232.71	McCann Creek	40.32857	123.84300	**Survey Completed**
233.22	Bell Creek	40.33442	123.84779	Bridge, upstream abandoned road crossing is a barrier.
233.93	Bloyd Creek	40.33605	123.85726	**Survey Completed**
234.29	Bluff Creek	40.33929	123.86627	Channel too steep for fish
235.27	Pipeline Creek	40.34017	123.88932	Not surveyed, culvert was buried under gravel, used UNT to Pipeline Creek as fish passage crossing.

Table 3. (continued) Status of initial site visits for the NWPRR stream crossing inventory and fish passage evaluation project.

RR MILE	STREAM NAME	LAT	LONG	STATUS OF INITIAL SITE VISIT
235.64	UNT to Pipeline Ck	40.33915	123.89564	**Survey Completed**
236.08	Poison Oak Ck	40.33819	123.89976	**Survey Completed**
236.27	UNT to Poison Oak Creek	40.33744	123.90208	**Survey Completed**
238.21	Perrot Creek	40.35852	123.91601	**Survey Completed**
239.55	Weber Creek	40.37711	123.91868	Bridge
240.28	Allen Creek	40.38725	123.92317	**Partial Survey - Took fill & upstream channel meas.**
242.00	Larabee Creek	40.41047	123.92845	Bridge
243.38	Bridge Creek	40.42557	123.93606	Not surveyed, difficult site to safely access. DFG had developed treatment plans in the mid-1990s.
245.90	Shively Creek	40.43530	123.96904	Bridge
247.36	Panther Creek	4044180	123.97808	Bridge
248.08	Darnell Creek	40.45177	123.98697	Unable to obtain access from private landowner. NWPRR inspection log identified this crossing as a bridge.
267.27	Palmer Creek	40.60434	124.17852	Already treated with corner baffles and downstream weirs. Site was inspected by RTA on 4/27/11.
267.35	Little Palmer Creek	40.60498	124.17985	Perched 10-ft, difficult access. M. Lang skipped in CalTrans assessment on DFG recommendation.
268.15	Finch Creek	40.61160	124.19174	Appeared not fish bearing. M. Lang skipped in CalTrans assessment on DFG recommendation.

In reviewing the railroad inspection logs and the USGS topographic maps, RTA also noted that the NWPRR tracks crossed Outlet Creek (and five of its larger tributaries - Baechtel, Broaddus, Mill, Upp, and Ryan creeks) 18 times between post-miles 138.86 and 159.60. RTA visually inspected the lower eight bridges on Outlet Creek and these did not appear to impede fish passage. The other 10 crossings on Outlet Creek were not considered migration barriers by the local CDFG fisheries biologist (Harris, pers. comm.).

Table 4. Site ID, crossing type and hydraulic capacity for the 22 stream crossings fully assessed for the NWPRR. Hydraulic capacity is expressed as both a discharge (cfs) and a recurrence-interval (RI) for flows overtopping the culvert inlet (HW/D=1).

SITE ID	STREAM NAME	CROSSING TYPE	CAPACITY (cfs) at HW/D = 1	CAPACITY RI (years)
NWPRR-135.78	Haehl Creek	CMP Circular	77	5
NWPRR-136.73	Haehl Creek	Concrete Arch Culvert	440	>250
NWPRR-138.23	Haehl Creek	Bridge with hardened floor	NA	NA
NWPRR-155.24	Unnamed Tributary	Concrete Arch Culvert	680	>250
NWPRR-162.62	Unnamed Tributary	SSP Pipe Arch	1,500	>250
NWPRR-164.80	Brad Turner Creek	Concrete Arch Culvert	680	243
NWPRR-165.50	Dean Creek	Concrete Arch Culvert	800	77
NWPRR-171.49	Woodman Creek	Bridge	NA	NA
NWPRR-174.21	Barn Creek	Concrete Arch Culvert	740	>250
NWPRR-174.53	Black Oak Creek	Concrete Arch Culvert	1,116	>250
NWPRR-174.92	Corbet Creek	Concrete Arch Culvert	2,880	>250
NWPRR-176.04	Unnamed Tributary	Concrete Arch Culvert	1,116	>250
NWPRR-207.05	Mill Creek	Concrete Arch Culvert	1,159	>250
NWPRR-223.47	Unnamed Tributary	Concrete Arch Culvert	758	>250
NWPRR-223.88	Constantine Creek	Concrete Arch Culvert	440	41
NWPRR-232.71	McCann Creek	Concrete Arch Culvert	384	217
NWPRR-233.93	Bloyd Creek	CSP Circular	20	1
NWPRR-235.64	UNT to Pipeline Creek	Concrete Arch Culvert	76	2
NWPRR-236.08	Poison Oak Creek	Concrete Arch Culvert	550	3*
NWPRR-236.27	UNT to Poison Oak Creek	Concrete Channel	NA	NA
NWPRR-238.21	Perrott Creek	Concrete Arch Culvert	198	19
NWPRR-240.28	Allen Creek	Concrete Circular	62	1

* sized in its severely aggraded condition during RTA site visit, as-built was designed for approximately 50-year RI.

Passage Analyses

The **GREEN**-**GRAY**-**RED** first-phase evaluation filter greatly reduced the number of sites requiring in-depth analyses with FishXing. The initial use of the first-phase filter determined six sites were GRAY and fifteen sites were **RED**. However, one **GRAY** site (NWPRR-233.93) was changed to **RED** because the inlet was completely embedded and one **RED** site (NWPRR-138.23) was changed to **GRAY** because the outlet riprap was configured to form step pools. Passage evaluations with FishXing were also run on the six **GRAY** sites (
Table **5**). Passage for adult anadromous salmonids was assessed with the more rigorous swimming abilities of 8ft/sec for prolonged swimming mode, 16 ft/sec for burst speed swimming mode and exit velocity, and a minimum water depth of 0.5 feet.

Crossings which failed to meet the more rigorous criteria may still actually provide partial or temporal passage during certain flow conditions. The values used for the passage evaluations were more rigorous than CDFG's recommended criteria, yet were still less than the maximum values recorded for adult coho salmon and steelhead. Some passage probably also occurs at sites where FishXing identified the only violation of the passage criteria as a lack-of-depth. However, **RED** sites were given a "total barrier" score in the ranking matrix unless a FishXing assessment confirmed some passage for adults.

Table 5. **GREEN**-**GRAY**-**RED** first-phase evaluation filter results for the 22 fully-assessed stream crossings.

SITE ID #	STREAM NAME	FILTER RESULT
NWPRR-135.78	Haehl Creek	**RED**
NWPRR-136.73	Haehl Creek	**RED**
NWPRR-138.23	Haehl Creek	**GRAY**
NWPRR-155.24	Unnamed Tributary	**RED**
NWPRR-162.62	Unnamed Tributary	**RED**
NWPRR-164.80	Brad Turner Creek	**RED**
NWPRR-165.50	Dean Creek	**RED**
NWPRR-171.49	Woodman Creek	**GRAY**
NWPRR-174.21	Barn Creek	**RED**
NWPRR-174.53	Black Oak Creek	**RED**
NWPRR-174.92	Corbet Creek	**RED**
NWPRR-176.04	Unnamed Tributary	**GRAY**
NWPRR-207.05	Mill Creek	**RED**

Table 5 (continued). **GREEN-GRAY-RED** first-phase evaluation filter results for the 22 fully-assessed stream crossings.

SITE ID #	STREAM NAME	FILTER RESULT
NWPRR-223.47	Unnamed Tributary	**RED**
NWPRR-223.88	Constantine Creek	**RED**
NWPRR-232.71	McCann Creek	**GRAY**
NWPRR-233.93	Bloyd Creek	**RED**
NWPRR-235.64	UNT to Pipeline Creek	**GRAY**
NWPRR-236.08	Poison Oak Creek	**GREEN**
NWPRR-236.27	UNT to Poison Oak Creek	**RED**
NWPRR-238.21	Perrott Creek	**GRAY**
NWPRR-240.28	Allen Creek	**RED**

For the NWPRR fish passage assessment project, the FishXing software proved to be a useful tool in estimating the extent of passage at the six **GRAY** crossings and identifying the probable causes of blockages. Most problems associated with fish passage were easily identified due to steep terrain and actively eroding geology associated with the Eel River Canyon. FishXing was not needed on 15 or 68% of the sites which were flagged as **RED** due to the characteristics of the sites, primarily extremely perched outlets. Thirteen of the crossings were perched more than three feet, ten crossings were perched more than four feet and seven crossings were perched more than six feet. Eight of the crossings had slopes greater than 3%, creating excessive velocities and lack-of-depth conditions due to the predominately concrete construction. Four crossings had their inlets completely buried and were considered impassable.

Biological considerations are probably more difficult to account for than the physical attributes of the stream crossings in interpreting FishXing results. Over the past 12 winters, repeated visits to numerous crossings with culverts in northern California during migration flows revealed some confounding results generated by FishXing:

1. Adult salmonids having great difficulties entering perched culverts which FishXing suggested were easily within the species' leaping and swimming capabilities.

2. Adult salmonids successfully migrating through water depths defined as "too shallow" by current fish passage assessment and design criteria.

The behavior and abilities of fish are too varied and complex to be summed up with an equation or a number taken from a published article. Even a single fishes' leaping and swimming abilities at a culvert may change as numerous attempts are made. During extensive winter-time observations at culverts in northern California fisheries biologists and fish passage engineers have documented individual fish becoming fatigued over repetitive attempts, and conversely documented other fish gaining access to culverts after numerous failed attempts (Taylor 2000-03; Love pers. comm.).

Due to these factors, passage evaluation results generated by FishXing were used conservatively in the ranking matrix by lumping "percent passable" into large (20%) categories. Adult steelhead and salmon were grouped in the "adult" run, resident coastal rainbow trout and two-year old (2+) steelhead were grouped as the "resident trout" run, and one-year old (1+) and young-of-the-year (y-o-y) steelhead and salmon were grouped as the "juvenile" run (Table 6).

For each site, by age-class, FishXing evaluation results are provided in Table 6. Hydrologic data and information utilized to calculate peak flows and range of fish passage flows at each crossing are provided in Appendix B. The detailed FishXing results are also located in Appendix B.

Table 6. FishXing results for six crossings maintained by the NWPRR. Q_{lp} = low fish passage flow; Q_{hp} = high fish passage flow.

Site ID #	Stream Name	Age Class Evaluated	Range of Migration Flows (cfs)	Percent Passable	Barriers at Qlp	Barriers at Qhp
NWPRR-138.23	Haehl Creek	Adult steelhead/salmon	3 - 208.1	72%	Depth	V
NWPRR-138.23	Haehl Creek	Resident trout/2+ juveniles	2 - 124.8	0%	Leap, Depth, Pool	Leap, V
NWPRR-138.23	Haehl Creek	1+/y-o-y juvenile salmonids	1 - 41.6	0%	Leap, Depth, Pool	Leap, V
NWPRR-171.49	Woodman Creek	Adult steelhead/salmon	3 - 1,224.6	0%	Leap	Leap
NWPRR-171.49	Woodman Creek	Resident trout/2+ juveniles	2 - 734.8	0%	Leap	Leap
NWPRR-171.49	Woodman Creek	1+/y-o-y juvenile salmonids	1 - 244.9	0%	Leap	Leap
NWPRR-176.04	Unnamed Trib	Adult steelhead/salmon	3 - 63.5	0%	Depth	Depth, EB
NWPRR-176.04	Unnamed Trib	Resident trout/2+ juveniles	2 - 38.1	0%	Depth	Depth, V
NWPRR-176.04	Unnamed Trib	1+/y-o-y juvenile salmonids	1 - 12.7	0%	Leap, Depth, EB	Leap, Depth, V
NWPRR-232.71	McCann Creek	Adult steelhead/salmon	3 - 41.2	38%	Depth	NONE
NWPRR-232.71	McCann Creek	Resident trout/2+ juveniles	2 - 24.7	0%	Depth	Depth, V
NWPRR-232.71	McCann Creek	1+/y-o-y juvenile salmonids	1 - 8.2	0%	Depth	Depth, V
NWPRR-235.64	UNT to Pipeline Creek	Adult steelhead/salmon	3 - 42.2	88%	Depth	NONE
NWPRR-235.64	UNT to Pipeline Creek	Resident trout/2+ juveniles	2 - 25.3	0%	Depth	V

Barrier Code Key: Leap = too high; Pool = outlet pool too shallow; Depth = culvert too shallow; V = excessive velocities within culvert; EB = fish swims to exhaustion in burst mode.

Table 6 (continued). FishXing results for six crossings maintained by the NWPRR. Q_{lp} = low fish passage flow; Q_{hp} = high fish passage flow.

Site ID #	Stream Name	Age Class Evaluated	Range of Migration Flows (cfs)	Percent Passable	Barriers at Qlp	Barriers at Qhp
NWPRR-235.64	UNT to Pipeline Creek	1+/y-o-y juvenile salmonids	1 - 8.4	0%	Depth, EB	Depth, V
NWPRR-238.21	Perrott Creek	Adult steelhead/salmon	3 - 39.3	53%	Depth	NONE
NWPRR-238.21	Perrott Creek	Resident trout/2+ juveniles	2 - 117.1	0%	Depth	V
NWPRR-238.21	Perrott Creek	1+/y-o-y juvenile salmonids	1 - 7.9	0%	Depth	V

Ranking Matrix

The 24 (the 22 surveyed and 2 visited sites) evaluated stream crossing locations were sorted by "Total Score", the sum of the four ranking criteria (Appendix C). The right-hand column of the final ranking matrix provides information on the passage analyses, general recommendations for treatment and suggested changes in treatment order due to professional judgment and other factors (Table 7).

As previously mentioned in the Methods section, the primary purpose of the ranking matrix developed for the CDFG protocol was to roughly sort the sites into a descending order of scores where sites could be grouped as high, medium, or low priority. There are many other factors to consider when selecting sites to treat that were not feasible to capture in a discrete scoring matrix. On a site-specific basis, one or more of the following factors were considered when recommending that a site be either raised or lowered in the ranking for project scheduling:

- Site photos and field notes confirmed adequate depths and low velocities at backwatered sites that FishXing had flagged as failing to meet criteria – lower in ranking.
- Additional migration barriers above or below a site that would limit the amount of re-opened habitat by treating just this crossing – lower in ranking.
- Criteria other than "extent of barrier" accounting for large percentage of a site's final score – lower in ranking.
- FishXing flagged "lack-of-depth" as the only passage criteria violation – lower in ranking.
- Expensive replacement is only feasible treatment option – lower in rank.
- Cost-effective retrofit versus expensive replacement – raise in ranking.
- Limited upstream habitat benefit, but high likelihood of crossing failure and potential for significant sediment release to good-quality downstream habitat – raise in ranking.
- In streams with multiple crossings, re-arranging sites so that treatment proceeds in an upstream direction – either raise or lower in ranking.

Adjustments to the suggested order of treatment scheduling in this final report were made after drafts of the ranking matrix and of Table 7 were circulated for review by CDFG, AndersonPenna Partners, and the CalTrout contract manager.

Table 7. Ranked list (high, medium, low) of 24 crossings located in anadromous-bearing stream reaches within the Eel River watershed on Northwestern Pacific Railroad land.

Rank	Site ID#	Stream Name	Barrier Score (15 pts max)	Length Upstream Habitat (ft)	TOTAL SCORE	Comments Regarding Site and any Adjustments made to Final Rank
High	**NWPRR-171.49**	Woodman Creek	15	34,000	30.5	**High-Priority due to:** severity of barrier and significant reach of potential spawning and rearing habitat located upstream of the barrier. The watershed area of Woodman Creek is approximately 24.5 square miles with approximately 14 miles of potential anadromous habitat within several sub-drainages. CDFG habitat typed the lower 4.3 miles of channel in 1998, as well as 4,200 feet of channel within two tributaries. The report indicated conditions were suitable for anadromous salmonid spawning and rearing. CDFG electro-fished one reach and captured y-o-y and age-1+ coastal rainbow trout, yet it is unknown if these were progeny of resident fish or of steelhead. The barrier at the mouth of Woodman Creek was formed when the NWPRR filled-in the creek's channel with the railroad prism and re-routed the channel over a bedrock drop. A Denil-style weir was installed on the bedrock drop by CDFG in the mid-1980s. The 1998 fish passage report said the weir was in good condition; however it was rusted, partially crushed and filled with bedload during RTA's May 2010 site survey. Treatment of the Woodman Creek barrier should consider several options, including: 1) partial removal of railroad fill and re-establishing the natural creek channel; 2) construction of a properly designed concrete fishway at the location of the bedrock drop; or 3) partial blasting and/or re-working of the bedrock drop to form step-pools.
High	**NWPRR-136.73**	Haehl Creek	15	7,800	29.4	**High-Priority due to:** severity of barrier and significant reach of potential spawning and rearing habitat located upstream. The drop at the outlet of this perched culvert was approximately six feet and stream flow dropped onto a jumble of woody debris and broken sections of concrete (possibly from a retaining wall or previous crossing). The downstream channel lacked a well-defined outlet pool with adequate depth for leap attempts. The downstream channel also appeared to be severely incised, possibly from channel straightening or other land use practices. Upstream there is nearly 1.5 miles of potential fish-bearing habitat. Both Chinook salmon and steelhead have been observed in the downstream channel and coho are present within the Haehl Creek, with one relatively strong year-class (Harris, pers. comm.). The best long-term treatment option would be to either 1) temporarily remove the railroad crossing and pull-back the fill to re-establish a natural channel or 2) replace the culvert with a fully-spanning bridge and re-establish the creek's natural channel location and slope. Either option would require grade-control structures to account for the removal of the large drop at the culvert's outlet.

Table 7. (continued) Ranked list (high, medium, low) of 24 crossings located in anadromous-bearing stream reaches within the Eel River watershed on Northwestern Pacific Railroad land.

Rank	**Site ID#**	**Stream Name**	**Barrier Score (15 pts max)**	**Length Upstream Habitat (ft)**	**TOTAL SCORE**	**Comments Regarding Site and any Adjustments made to Final Rank**
High	**NWPRR-243.38**	Bridge Creek	15	8,100	29.1	**High-Priority due to:** severity of barrier and significant reach of potential spawning and rearing habitat located upstream. The culvert outlet has a two-stage drop of approximately five feet and the inlet is clogged with bedload and woody debris. The inlet has also been modified with a snorkel-like standpipe that would be impassable to fish regardless if it was clogged with debris, or not. The watershed area of Bridge Creek is approximately 2.2 square miles with about 1.5 miles of potential anadromous habitat. CDFG habitat typed the lower 450 feet of channel in 1992 and commented that the railroad culvert was the top priority treatment for this watershed. During the RTA site survey, the upstream channel appeared severely aggraded with sediment for several hundred feet above the culvert's inlet. RTA did not observe any fish in the upstream channel. The best long-term treatment option would be to either 1) temporarily remove the railroad crossing and pull-back the fill to re-establish a natural channel or 2) replace the culvert with a fully-spanning bridge and re-establish the creek's natural channel location and slope.
Med.	**NWPRR-135.78**	Haehl Creek	15	1,700	28.4	**Medium-Priority due to:** although this crossing is a complete barrier due to the extremely perched outlet, there is a limited reach of suitable fish-bearing habitat upstream (<2,000 ft). The outlet was perched at least eight to ten feet and any replacement or temporary removal of the current crossing would require extensive use of grade-control structures to minimize channel head-cutting. Above the railroad crossing, the channel splits into several smaller channels. Both Chinook salmon and steelhead have been observed in the downstream channel and coho are present within the Haehl Creek, with one relatively strong year-class (Harris, pers. comm.). The current culvert is in extremely poor condition and is undersized for storm flow conveyance with the inlet at 100% capacity on a flow with a five-year recurrence interval. The best long-term treatment option would be to either 1) temporarily remove the railroad crossing and pull-back the fill to re-establish a natural channel or 2) replace the culvert with a properly sized embedded culvert or open-bottom arch set on footings. Because this crossing is adjacent to the CalTrans Willits Bypass project, there may be opportunities for funding through mitigation.

Table 7. (continued) Ranked list (high, medium, low) of 24 crossings located in anadromous-bearing stream reaches within the Eel River watershed on Northwestern Pacific Railroad land.

Rank	Site ID#	Stream Name	Barrier Score (15 pts max)	Length Upstream Habitat (ft)	TOTAL SCORE	Comments Regarding Site and any Adjustments made to Final Rank
Med.	**NWPRR-138.23**	Haehl Creek	11	26,600	27.0	**Medium-Priority due to:** although there is a significant reach of good-quality habitat located upstream, the crossing provides good passage for adult anadromous salmonids. FishXing estimated that passage criteria for adult salmon and steelhead were met on 72% of the range of estimated passage flows, with lack-of-depth as the only violation. Excessive velocities, lack-of-depth on the concrete sill, and drops over riprap were passage issues for resident trout and juvenile salmonids. Passage conditions could be improved by partial removal of the concrete flooring, clearing of brush and accumulated debris on the concrete sill, and re-working of riprap placed at the downstream end of the concrete sill. During the 2011 site visit, there was a large pool downstream of the railroad crossing whose tailwater control also controlled the height of the drop over the riprap. The tailwater control consisted of willow root masses and accumulated woody debris. If (or when) this tailwater control fails and the channel head-cuts, the severity of the migration barrier at the railroad crossing would increase due to a larger drop at the downstream end. Recommend periodic site inspection to monitor the condition of the tailwater condition previously described.
Low	**NWPRR-235.27**	Pipeline Creek	15	1,600	26.8	**Low-Priority due to:** although the crossing is a complete migration barrier due to excessive sedimentation that has buried the culvert inlet, the limited amount of upstream habitat was rated as "fair" for anadromous salmonid spawning and rearing. RTA also had concerns about the quality of the downstream habitat which was inaccessible to inspect due to posted private property. The completely plugged inlet of this culvert has caused stream flow to pond on the upstream side of the crossing. RTA also observed the remnants of a recent marijuana grow at the railroad crossing with approximately 50 plant/soil bags on the tracks and equipment for pumping water out of the creek immediately upstream of the crossing. Some stream flow appears to seep through the railroad prism and some appears to be diverted north along the upstream side of the railroad tracks to the railroad crossing at milepost 235.64. No treatment is recommended for fish passage due to the relatively insignificant reach of fish-bearing habitat upstream of the railroad crossing; however we suspect that this crossing would need to be replaced for structural and drainage reasons if the NWPRR was going to re-open the railroad. If replaced by NWPRR, then fish passage should be addressed.

Table 7. (continued) Ranked list (high, medium, low) of 24 crossings located in anadromous-bearing stream reaches within the Eel River watershed on Northwestern Pacific Railroad land.

Rank	Site ID#	Stream Name	Barrier Score (15 pts max)	Length Upstream Habitat (ft)	TOTAL SCORE	Comments Regarding Site and any Adjustments made to Final Rank
Low	**NWPRR-165.50**	Dean Creek	15	2,050	25.0	**Low-Priority due to:** although the first-phase evaluation filter determined this crossing was "RED" due to the 8.5 foot drop at the outlet, there was a relatively low amount of suitable fish-bearing habitat located upstream. From the topographic maps RTA measured 2,050 ft of channel up to a sustained slope >8-10%; however during the site survey we observed that the upstream channel slope increased quickly with a 5-foot drop over boulders located approximately 50 ft upstream of the railroad crossing and a >10 foot cascade located approximately 150 ft upstream. The concrete arch culvert was in extremely poor condition due to the worn-down and comprised floor, and cracks in the arch section of the culvert. No treatment is recommended for fish passage due to the relatively insignificant reach of fish-bearing habitat upstream of the railroad crossing; however we suspect that this crossing would need to be replaced for structural reasons if the NWPRR was going to re-open the railroad. If replaced by NWPRR, then fish passage should be addressed.
Low	**NWPRR-207.05**	Mill Creek	15	1,200	24.1	**Low-Priority due to:** although the first-phase evaluation filter determined this crossing was "RED" due to the nearly 5% slope through the culvert; there was a relatively low amount of suitable fish-bearing habitat located upstream. From the topographic maps we measured 1,200 ft of channel up to a sustained slope >8-10%. The concrete arch culvert was in extremely poor condition due to the worn-down and comprised floor. No treatment is recommended for fish passage due to the relatively insignificant reach of fish-bearing habitat upstream of the railroad crossing; however we suspect that this crossing would need to be replaced for structural reasons if the NWPRR was going to re-open the railroad. If replaced by NWPRR, then fish passage should be addressed.
Low	**NWPRR-236.27**	Unnamed Tributary to Poison Oak Creek	15	1,300	22.2	**Low-Priority due to:** although the first-phase evaluation filter determined this crossing was "RED" due to the 3.1% slope of the concrete channel, there was a relatively low amount of suitable fish-bearing habitat located upstream. The upstream channel steepened quickly and when examined during the site survey, the actual amount of fish-bearing habitat was probably <1,000 ft of channel with very little suitable spawning habitat present. No treatment is recommended for fish passage due to the relatively insignificant reach of fish-bearing habitat upstream of the railroad crossing.

Table 7. (continued) Ranked list (high, medium, low) of 24 crossings located in anadromous-bearing stream reaches within the Eel River watershed on Northwestern Pacific Railroad land.

Rank	Site ID#	Stream Name	Barrier Score (15 pts max)	Length Upstream Habitat (ft)	TOTAL SCORE	Comments Regarding Site and any Adjustments made to Final Rank
Low	**NWPRR-233.93**	Bloyd Creek	15	700	22.4	**Low-Priority due to:** although the culvert at this crossing had a completely plugged and damaged inlet, there was a relatively low amount of suitable fish-bearing habitat located upstream. Approximately 550 ft upstream from the NWPRR crossing was a culvert on an unpaved road owned by Humboldt Redwoods Company that was slightly perched and had a relatively steep slope. No treatment is recommended for fish passage due to lack of significant fish-bearing habitat upstream of the railroad crossing; however we suspect that this crossing would need to be replaced for structural reasons if the NWPRR was going to re-open the railroad. If replaced by NWPRR, then fish passage should be addressed.
Low	**NWPRR-240.28**	Allen Creek	15	1,100	22.3	**Low-Priority due to:** although this culvert has a perched outlet with a drop greater than 10 feet, there was a relatively low amount of suitable fish-bearing habitat located upstream. RTA was unable to complete a survey at this crossing because of safety issues with the actively failing, and nearly vertical, fill slope on the downstream side. We were also unable to safely access the culvert inlet. RTA walked approximately 300 ft of the upstream channel which was low-gradient; however channel slope then quickly increased. Extensive ponding of storm flow occurs at this site, as evident by a "mud line" on trees upstream of the crossing. In places, this "mud line" was approximately eight to 10 feet above the summer low-flow channel. No treatment is recommended for fish passage due to lack of significant fish-bearing habitat upstream of the railroad crossing; however we suspect that this crossing would need to be replaced for structural reasons if the NWPRR was going to re-open the railroad.
Low	**NWPRR-235.64**	Unnamed Tributary to Pipeline Creek	10	1,600	19.4	**Low-Priority due to:** the channel immediately upstream of this crossing was not fish-bearing; however stream flow diverted from the plugged culvert on Pipeline Creek (site NWPRR 235.27) run through this crossing. The habitat in Pipeline Creek proper was considered "poor" for anadromous salmonid spawning and rearing. No treatment is recommended for fish passage due to lack of significant fish-bearing habitat upstream of the railroad crossing; however the current culvert was extremely undersized for storm flow conveyance.

Table 7. (continued) Ranked list (high, medium, low) of 24 crossings located in anadromous-bearing stream reaches within the Eel River watershed on Northwestern Pacific Railroad land.

Rank	Site ID#	Stream Name	Barrier Score (15 pts max)	Length Upstream Habitat (ft)	TOTAL SCORE	Comments Regarding Site and any Adjustments made to Final Rank
Low	**NWPRR-164.80**	Brad Turner Creek	15	<500	19.6	**Low-Priority due to:** although the first-phase evaluation filter determined this crossing was "RED" due to the nearly 10-foot drop at the outlet, there was a relatively low amount of suitable fish-bearing habitat located upstream. The upstream channel steepened to >10% slope in less than 500 feet. The concrete arch culvert was in extremely poor condition due to the worn-down and comprised floor. No treatment is recommended for fish passage due to lack of fish-bearing habitat upstream of the railroad crossing; however we suspect that this crossing would need to be replaced for structural reasons if the NWPRR was going to re-open the railroad.
Low	**NWPRR-174.21**	Barn Creek	15	2,400	19.1	**Low-Priority due to:** although the first-phase evaluation filter determined this crossing was "RED" due to the nearly four foot drop at the outlet and the 7.7% slope culvert, the upstream channel appeared to support poor habitat conditions for anadromous salmonids. RTA conducted the site survey in May 2010 during a very wet spring, yet the creek was barely flowing with wetted channel widths of less than three feet. The concrete arch culvert was in poor condition due to the worn-down and comprised floor. No treatment is recommended for fish passage due to lack of significant fish-bearing habitat upstream of the railroad crossing; however we suspect that this crossing would need to be replaced for structural reasons if the NWPRR was going to re-open the railroad. If replaced by NWPRR, then fish passage should be addressed.
Low	**NWPRR-176.04**	Unnamed Tributary	15	1,200	19.1	**Low-Priority due to:** although FishXing determined that this crossing failed to meet fish passage criteria for all age-classes of salmonids, there was a limited amount of fair-to-poor quality fish-bearing habitat upstream of the railroad crossing. The current crossing was properly sized for storm flow conveyance; however it was in poor condition due to worn floor and fractures in the walls and ceiling of the arch culvert. No treatment is recommended for fish passage due to lack of significant fish-bearing habitat upstream of the railroad crossing; however we suspect that this crossing would need to be replaced for structural reasons if the NWPRR was going to re-open the railroad. If replaced by NWPRR, then fish passage should be addressed.

Table 7. (continued) Ranked list (high, medium, low) of 24 crossings located in anadromous-bearing stream reaches within the Eel River watershed on Northwestern Pacific Railroad land.

Rank	Site ID#	Stream Name	Barrier Score (15 pts max)	Length Upstream Habitat (ft)	TOTAL SCORE	Comments Regarding Site and any Adjustments made to Final Rank
Low	**NWPRR-174.53**	Black Oak Creek	15	800	18.9	**Low-Priority due to:** although the first-phase evaluation filter determined this crossing was "RED" due to the nearly four foot drop at the outlet and the 3.9% slope culvert, the limited reach of upstream channel appeared to support fair habitat conditions for anadromous salmonids. RTA talked to a landowner during the site survey who said in most years the creek was dry in the summertime, but he had occasionally observed juvenile steelhead in the pools just upstream of the railroad crossing. The current crossing was properly sized for storm flow conveyance; however it was in poor condition due to worn floor and fractures in the walls and ceiling of the arch culvert. No treatment is recommended for fish passage due to lack of significant fish-bearing habitat upstream of the railroad crossing; however we suspect that this crossing would need to be replaced for structural reasons if the NWPRR was going to re-open the railroad. If replaced by NWPRR, then fish passage should be addressed.
Low	**NWPRR-223.88**	Constantine Creek	15	<500	18.8	**Low-Priority due to:** although the first-phase evaluation filter determined this crossing was "RED" due to the nearly seven foot drop at the outlet, the upstream reach of potential fish-bearing channel was less than 500 feet. The current concrete arch culvert was in fair condition and passes approximately a storm flow with a recurrence interval of 40-years at 100% on the inlet height. No treatment is recommended for fish passage due to lack of significant fish-bearing habitat upstream of the railroad crossing.
Low	**NWPRR-223.47**	Unnamed Tributary	15	<500	18.6	**Low-Priority due to:** although the first-phase evaluation filter determined this crossing was "RED" due to the 11 foot drop at the outlet, the upstream reach of potential fish-bearing channel was only about 200 feet. According to the RTA field notes, at 200 feet upstream there was a steep bedrock constriction and above that the channel slope easily exceeded 10%. The current concrete arch culvert is properly sized for storm flow conveyance; however it was in poor condition due to extensive fractures in the culvert floor and walls. No treatment is recommended for fish passage due to lack of significant fish-bearing habitat upstream of the railroad crossing; however we suspect that this crossing would need to be replaced for structural reasons if the NWPRR was going to re-open the railroad.

Table 7. (continued) Ranked list (high, medium, low) of 24 crossings located in anadromous-bearing stream reaches within the Eel River watershed on Northwestern Pacific Railroad land.

Rank	Site ID#	Stream Name	Barrier Score (15 pts max)	Length Upstream Habitat (ft)	TOTAL SCORE	Comments Regarding Site and any Adjustments made to Final Rank
Low	**NWPRR-174.92**	Corbet Creek	15	2,000	18.5	**Low-Priority due to:** although the first-phase evaluation filter determined this crossing was "RED" due to the >4% slope through the culvert, some passage of adult salmonids could probably occur due to irregularities in the culvert floor. Within the culvert there were several pools formed by scouring of the floor, creating depth and resting areas for fish. RTA walked approximately 700 feet of channel above the railroad crossing and rated the habitat as "fair". The habitat appeared more suitable for rearing than spawning due to a lack of suitable sized spawning substrate. The current concrete arch culvert was properly sized for storm flow conveyance and was rated as being in fair condition. No treatment is recommended for fish passage due to lack of significant fish-bearing habitat upstream of the railroad crossing; however we suspect that this crossing would need to be replaced for structural reasons if the NWPRR was going to re-open the railroad. If replaced by NWPRR, then fish passage should be addressed.
Low	**NWPRR-155.24**	Unnamed Tributary	15	1,200	18.1	**Low-Priority due to:** although the first-phase evaluation filter determined this crossing was "RED" due to the 3.8 foot drop at the outlet, there was a relatively small amount of suitable fish-bearing habitat located upstream. From the topographic map RTA measured 1,200 ft of channel up to a sustained slope >8-10%; however during the site survey we observed that the upstream channel slope increased quickly with a 5-foot drop over boulders approximately 200 ft upstream of the railroad crossing. The concrete arch culvert was in fair condition with some cracks observed in the culvert's floor. No treatment is recommended for fish passage due to the relative lack of fish-bearing habitat upstream of the railroad crossing; however we suspect that this crossing would need to be replaced for structural reasons if the NWPRR was going to re-open the railroad.
Low	**NWPRR-162.62**	Unnamed Tributary	15	1,300	17.8	**Low-Priority due to:** although the first-phase evaluation filter determined this crossing was "RED" due to the 18.5 foot drop at the outlet, the upstream reach of potential fish-bearing channel was relatively short. According to the RTA field notes, at 200 feet upstream there was a bedrock constriction with several large drops and above that the channel slope steepened quickly. The 1,300 feet of channel pulled from the topographic maps most likely over-estimated the amount of channel that should be considered fish-bearing. The current SSP pipe-arch was properly sized for storm flow conveyance and was in fair condition. No treatment is recommended for fish passage due to lack of significant fish-bearing habitat upstream of the railroad crossing.

Table 7. (continued) Ranked list (high, medium, low) of 24 crossings located in anadromous-bearing stream reaches within the Eel River watershed on Northwestern Pacific Railroad land.

Rank	Site ID#	Stream Name	Barrier Score (15 pts max)	Length Upstream Habitat (ft)	TOTAL SCORE	Comments Regarding Site and any Adjustments made to Final Rank
Low	**NWPRR-238.21**	Perrot Creek	12	1,400	15.9	**Low-Priority due to:** FishXing estimated that this crossing met adult anadromous salmonid passage criteria on 53% of the range of migration flows and the limited amount of upstream habitat was rated as "poor". Lack-of-depth was the only passage criteria violation for adults, so actual passage could be higher. The downstream channel was cut through recently deposited sediment; it appeared that on high flows the mainstem Eel River may backwater up Perrot Creek to the railroad crossing. No treatment is recommended for fish passage due to the relatively insignificant reach of fish-bearing habitat upstream of the railroad crossing.
Low	**NWPRR-232.71**	McCann Creek	13	<500	15.3	**Low-Priority due to:** minimal reach of potential spawning and rearing habitat located upstream of the barrier. The current NWPRR crossing was in good condition and was adequately sized for storm flow conveyance. No treatment is recommended for fish passage due to the relative lack of fish-bearing habitat upstream of the railroad crossing.
Low	**NWPRR-236.08**	Poison Oak Creek	0	2,800	11.1	**Low-Priority due to:** current crossing provides unimpeded passage for all age-classes of salmonids. RTA observed juvenile salmonids upstream and downstream of the crossing during the site survey. The NWPRR culvert was fully embedded with substrate and was back-watered with adequate depths during summer flows. The Dyerville Loop Road (Humboldt County maintained) culvert was located immediately downstream of the railroad crossing and also appeared back-watered with adequate depth. Recommend periodic inspection to keep the inlet free of storm debris.

Scheduling of Site-Specific Treatments

<u>Woodman Creek - NWPRR-171.49</u>

The NWPRR crossing at Woodman Creek was easily the highest priority site for treatment due to the severity of the migration barrier and the large amount of potential upstream spawning and rearing habitat for salmon and steelhead. The watershed area of Woodman Creek encompasses approximately 24.5 square miles with nearly 14 miles of potential anadromous habitat within several sub-drainages. RTA calculated the upper fish passage flows using two methods; 1) the Q-average method as determined by calculating the exceedence flows with average daily stream flow data from gauged streams available from the USGS and 2) 50% of the two-year recurrence interval flow (Waananen and Crippen 1977). These two methods resulted in upper fish passage migration flows of 777 cfs and 1,225 cfs, respectively. Regardless of the high passage flow calculated, it appears that the upper range of migrations flows within Woodman Creek are substantial enough to attract migrating adult salmon, as well as steelhead, into the watershed from the mainstem Eel River. The information collected during the CDFG habitat typing survey also suggests that suitable over-summering rearing conditions exist within Woodman Creek. However; a more thorough examination of instream habitat and summer flow levels is recommended prior to addressing the NWPRR's migration barrier.

The barrier at the mouth of Woodman Creek was formed when the NWPRR filled-in the creek's channel with the railroad prism and re-routed the channel over a bedrock drop (Figure 6). The extensive railroad fill prism was apparently needed to maintain a relatively continuous grade as the railroad exited a tunnel just south (or upstream) of Woodman Creek's confluence with the Eel River. The longitudinal profile surveyed by RTA on May 23, 2010 depicts the two-stage character of this bedrock drop (Figure 7). Starting at the downstream end of the longitudinal profile, the small pool at the base of the bedrock drop had a depth of 2.9 feet and the first drop was 12.3 feet high (Figure 7). As measured on 5/23/10, the uppermost drop was 7.2 feet over a 52.7-foot reach of channel (Figure 7). The maximum pool depth below the upper drop was 4.3 feet (Figure 7).

A steep-pass style weir was installed on the lower bedrock drop with CDFG funding in the mid-1980s. Part of the installation process included chipping the bedrock face to accommodate the weir; no additional rock work was done due to NWPRR's concerns with compromising the integrity of the trestle and tunnel (Grass, pers. comm.). Over the next 20 years, the weir was visited approximately once annually for maintenance by Alan Grass (CDFG biologist) who would walk nearly five miles down the tracks from Dos Rios to clean bedload and woody debris out of the baffles. The overall performance of the steep-pass weir was poor, because the weir easily plugged and was difficult to effectively clear during elevated flows when fish movement was expected (Grass, pers. comm.). At the time of installation, the downstream end of the steep-pass weir was submerged in the lower pool; however channel adjustments at the confluence have resulted in exposing the lower end of the weir (Grass, pers. comm.). During the 20 year-period when the weir was maintained no spawner surveys were conducted to determine if salmon or steelhead were successfully accessing Woodman Creek; however landowners within the watershed periodically observed adult steelhead (Grass, pers. comm.). The 1997 Eel Basin Railway Fish Passage report described the steep-pass weir as in good condition (HCRRD, 1997). However; the weir was rusted, filled with bedload, and some baffles were crushed during RTA's 5/23/10 site survey.

Figure 6. Bedrock drop at mouth of Woodman Creek on May 23, 2010.

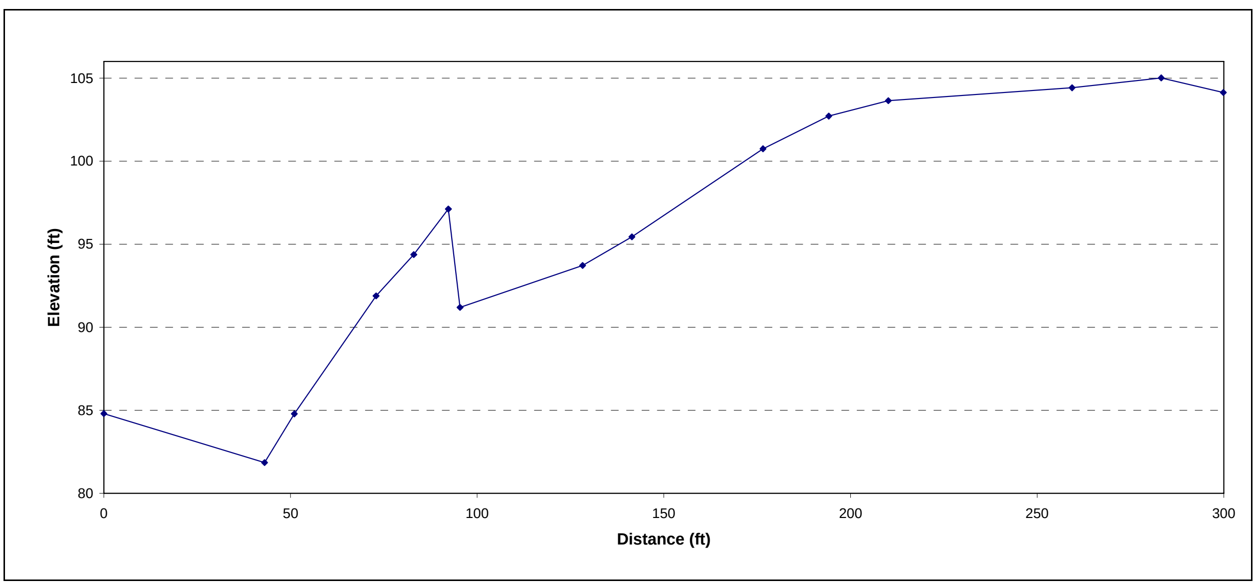


Figure 7. Longitudinal profile of the bedrock drop and immediate upstream channel on Woodman Creek, tributary to the Eel River, surveyed on 5/23/10.

Treatment of the Woodman Creek barrier should consider several options, including 1) partial removal of railroad fill and re-establishing the natural creek channel; 2) construction of a properly designed concrete fishway at the location of the bedrock drop; or 3) partial blasting and/or re-working of the bedrock drop to form step-pools. Each alternative has benefits and trade-offs; however RTA recommends #1 as the best for long-term restoration of fish passage that would also be relatively low-maintenance (Table 8). Fill volume dimensions and estimates for the railroad fill prism and the elevated bench located on the west side of the tracks (and north of Woodman Creek) are located in Appendix A. As mentioned in the Methods section, these volume estimates should be considered "order of magnitude" accurate and could provide a cursory estimate of fill removal required to re-establish Woodman Creek's lower channel. RTA recommends that a more thorough topographic survey is completed at Woodman Creek for development of any treatment design plans and detailed budgeting of heavy equipment costs.

Besides a more thorough topographic survey, additional steps in developing a proposal to treat Woodman Creek should include: project support from NWPRR, communication and access agreements with private landowners, geotechnical investigation of the bedrock under the existing bridge, the railroad fill prism and location of original channel/confluence; more thorough habitat typing survey; evaluation of summer-time flow and water temperature conditions; and evaluation of additional migration barriers at private road crossings. RTA also recommends that pre and post project monitoring are conducted; including biological monitoring (juvenile fish presence/distribution and adult spawner counts).

Table 8. The pros and cons of three alternatives to treat NWPRR's Woodman Creek barrier.

Alternative	Pros	Cons	Additional Comments
1) Partial removal of railroad fill and restoration of a natural channel connection between lower Woodman Creek and the Eel River.	Restore passage for all age classes of anadromous salmonids and other native species; low-maintenance; longevity of treatment.	Cost; need permission from NWPRR to remove fill; requires installation of new bridge by NWPRR if railroad is re-opened.	Need to determine feasibility of heavy equipment access to the site; need to identify locations to store excavated fill.
2) Construction of a properly designed concrete fishway at the location of the bedrock drop.	No need to disturb existing railroad fill or bridge; no excavated fill to deal with.	Cost, may not allow for juvenile migration; long-term maintenance required; could be damaged in extremely high-flow events.	How extensive manipulation of bedrock would be required? Could this affect the integrity of the existing trestle and bridge?
3) Partial blasting and re-working of bedrock drop to form step-pools for fish passage.	Relatively low cost, no need to disturb existing railroad fill or bridge; no excavated fill to deal with; does not require heavy equipment on-site.	May not allow for juvenile migration; long-term maintenance probably required; NWPRR may not allow alteration of bedrock.	How extensive manipulation of bedrock would be required? Could this affect the integrity of the existing trestle and bridge?

Bridge Creek – NWPRR-243.38

The NWPRR crossing at Bridge Creek was the second-highest priority site for treatment due to the severity of the migration barrier and the large amount of potential upstream spawning and rearing habitat for salmon and steelhead. The 2.2 square mile watershed has approximately 1.5 miles of potential fish-bearing habitat upstream of the NWPRR crossing, located primarily on private timberlands managed by the Humboldt Redwood Company. The mouth of Bridge Creek is located at the upstream end of a large, deep pool on the mainstem Eel River near Holmes Flat. CDFG habitat typed the lower 450 feet of Bridge Creek in 1992 and identified the railroad culvert as the top priority treatment for the watershed. RTA visited this crossing on 8/17/11 and was unable to complete a survey with the total station due to unsafe conditions accessing the steep and actively-failing fill prism. The culvert's outlet has a two-stage drop of approximately five feet (Figure 8) and the inlet is clogged with bedload and woody debris. The inlet has also been modified with a snorkel-like standpipe that would be impassable to fish regardless if it was clogged with debris, or not (Figure 9). During the site visit, we observed that some of the stream flow was bypassing the clogged standpipe and was percolating into the railroad fill prism.

In the mid-1990s, CDFG worked with Pacific Watershed Associates (PWA), Pacific Lumber Company, and the NWPRR to develop a treatment of the migration barrier at the mouth of Bridge Creek (Downie, pers. comm.). CDFG's concept was to remove the railroad culvert and associated fill, and realign the Bridge Creek channel to its original location. CDFG had committed to funding the planning, design and excavation costs. Pacific Lumber Company would excavate the fill and remove the culvert with PWA oversight, and the NWPRR had agreed to transport the fill spoils to disposal sites. The NWPRR had also agreed to the culvert removal concept and to construct with their own funds a new crossing when (or if) the railroad line re-opened. The costs of the project quickly escalated from the $300K range to $500K and the project concept was dropped by CDFG (Downie, pers. comm.).

RTA recommends that removal of the railroad culvert and re-establishment of the natural channel is the best long-term solution to providing unimpeded passage into Bridge Creek. During the RTA site visit, the existing culvert and associated fill prism appeared to be in poor condition and would most likely require replacement if rail service was re-established. As in the earlier project concept, a new railroad crossing such as a bridge or trestle could then be installed when (or if) the NWPRR re-opens the rail line.

As with any large restoration project, successful implementation would require: the support of NWPPR, the upstream landowner (now Humboldt Redwoods Company), careful planning, and adequate funds from preferably several funding sources. Pre and post project monitoring would track the functionality of the re-established channel and any re-establishment of salmon and steelhead utilization within Bridge Creek.

Figure 8. Two-stage drop at the outlet of site #NWPRR-243.38, photo taken on 8/17/11.

Figure 9. Debris on inlet standpipe of site #NWPRR-243.38, photo taken on 8/17/11.

Haehl Creek Sites – NWPRR-135.78, 136.73, 138.23

Haehl Creek is a tributary to upper Outlet Creek, which is a large tributary to the mainstem Eel River. Haehl Creek flows through the town of Willits, has a drainage area of approximately 34 square miles (including the drainage area within its tributaries of Baechtel, Broaddus and Mill creeks), and the NWPRR stream crossings are the uppermost crossings they have in the Eel River watershed. During wetter winters, Chinook salmon and steelhead spawn throughout Haehl Creek, and coho salmon are sporadically observed (Harris, pers. comm.).

RTA visited three railroad stream crossings in Haehl Creek and site #NWPRR-136.73 was the highest ranked of the three, followed by site NWPRR-135.78, and then NWPRR-138.23. The first two crossings were culverts and the third is a trestle-bridge with a fully-spanning concrete apron.

At site #NWPRR-136.73, the drop at the outlet was approximately six feet and stream flow dropped onto a jumble of woody debris and broken sections of concrete (possibly from a retaining wall or previous crossing). The downstream channel lacked a well-defined outlet pool with adequate depth for leap attempts. The downstream channel also appeared to be severely incised, possibly from channel straightening or other land use practices. Upstream there is nearly 1.5 miles of potential fish-bearing habitat. The best long-term treatment option would be to either 1) temporarily remove the railroad crossing and pull-back the fill to re-establish a natural channel or 2) replace the culvert with a fully-spanning bridge and re-establish the creek's natural channel location and slope. Either option would require grade-control structures to account for the removal of the large drop at the culvert's outlet.

At site NWPRR-135.78, the outlet was perched at least eight to ten feet and any replacement or decommissioning of the current crossing would require extensive use of grade-control structures to minimize channel head-cutting. Above the railroad crossing, the channel splits into several smaller channels. The current culvert is in extremely poor condition and is undersized for storm flow conveyance with the inlet at 100% capacity on a flow with a five-year recurrence interval. The best long-term treatment option would be to either 1) temporarily remove the railroad crossing and pull-back the fill to re-establish a natural channel or 2) replace the culvert with a properly sized embedded culvert or open-bottom arch set on footings.

At site NWPRR-138.23, passage conditions could be improved by partial removal of the concrete apron, clearing of brush and accumulated debris on the concrete sill, and re-working of riprap placed at the downstream end of the concrete sill. If tail-water conditions of the large pool immediately downstream of this crossing were to degrade, the concrete apron could become perched, creating more troublesome passage conditions for adult salmon and steelhead.

Because all three of the Haehl Creek railroad crossings assessed by RTA are adjacent or close to the CalTrans Willits Bypass project, there may be opportunities for treating these sites with mitigation funds. RTA recommends that CalTrout work closely with CDFG and NWPRR to investigate the nexus of railroad barrier treatment with CalTrans' Willits Bypass project.

Design Options for Improving Fish Passage

All stream crossing replacement projects should follow recently developed state criteria and federal guidelines for facilitating adult and juvenile fish passage (CDFG 2002; NMFS 2001). However, site-specific characteristics of the crossing's location should always be carefully reviewed prior to selecting the type of crossing to install. These characteristics include local geology, slope of natural channel, channel confinement, and extent of channel incision likely from removal of a perched culvert. For additional information, Bates et al. (1999) is recommended as an excellent reference to use when considering fish-friendly culvert installation options and Robinson et al. (2000) provides a comprehensive review of the advantages and disadvantages of the various treatment alternatives as related to site-specific conditions.

CDFG Allowable Design Options

Active Channel Design Option is a simplified design method that is intended to size a crossing sufficiently large and embedded deep enough into the channel to allow the natural movement of bed load and formation of a stable bed inside the culvert. Determination of the high and low fish passage design flows, water velocity, and water depth is not required for this option since the stream hydraulic characteristics within the culvert are intended to mimic the stream conditions upstream and downstream of the crossing.

The Active Channel Design Option is suitable for the following conditions:

- New and replacement culvert installations
- Simple installations with channel slopes of less than 3%.
- Short culvert lengths (less than 100 feet).
- Passage is required for all fish species and life-stages.

Culvert Setting and Dimensions

Culvert Width – the minimum culvert width shall be equal to, or greater than, 1.5 times the active channel width.

Culvert Slope – the culvert shall be placed level (0% slope).

Embedment – the bottom of the culvert shall be buried into the streambed not less than 20% of the culvert height at the outlet and not more than 40% of the culvert height at the inlet. Embedment does not apply to bottomless culverts.

Stream Simulation Design Option

The Stream Simulation Design Option is a design process that is intended to mimic the natural stream processes within a culvert. Fish passage, sediment transport, flood and debris conveyance within the crossing are intended to function as they would in a natural channel. Determination of the high and low fish passage flows, water velocity, and water depth is not required for this option since the stream hydraulic characteristics within the culvert are designed to mimic the stream conditions upstream and downstream of the culvert.

Stream simulation crossings are sized as wide, or wider than, the bankfull channel and the bed inside the culvert is sloped at a gradient similar to that of the adjacent stream reach. These crossings are filled with a streambed mixture that is resistant to erosion and is unlikely to change grade, unless specifically designed to do so. Stream simulation crossings require a greater level of information on hydrology and topography and a higher level of engineering expertise than the Active Channel Design Option.

The Stream Simulation Design Option is suitable for the following conditions:

- New and replacement culvert installations.
- Complex installations with channel slopes less than 6%.
- Moderate to long culvert length (greater than 100 feet).
- Passage required for all fish species and lifestages.
- Ecological connectivity is required.

Culvert Setting and Dimensions

Culvert Width – the minimum culvert width shall be equal to, or greater than, the bankfull channel width. The minimum culvert width shall not be less than six feet.

Culvert Slope - the culvert slope shall approximate the slope of the stream through the reach in which it is being placed. The maximum slope shall not exceed 6%.

Embedment – the bottom of the culvert shall be buried into the streambed, not less than 30% and not more than 50% of the culvert height. Embedment does not apply to bottomless culverts.

Substrate Configuration and Stability

- Culverts with slopes greater than 3% shall have the bed inside the culvert arranged into a series of step-pools with the drop at each step not exceeding 0.5 feet for juvenile salmonids.

- Smooth walled culverts with slopes greater than 3% may require bed retention sills within the culvert to maintain the bed stability under elevated flows.

- The gradation of the native streambed material or engineered fill within the culvert shall address stability at high flows and shall be well graded to minimize interstitial flow through it.

Hydraulic Design Option

The Hydraulic Design Option is a design process that matches the hydraulic performance of a culvert with the swimming abilities of a target species and age class of fish. The method targets specific species of fish and therefore does not account for ecosystem requirements of non-target species. There can be significant errors associated with estimation of hydrology and fish swimming speeds that are mitigated by making conservative assumptions in the design process. Determination of the high and low fish passage design flows, water velocity, and water depth are required for this option.

The Hydraulic Design Option requires hydrologic data analysis, open channel flow hydraulic calculations and information on the swimming ability and behavior of the target group of fish. This design option can be applied to the design of new and replacement culverts, and can be used to evaluate the effectiveness of retrofits for existing culverts.

The Hydraulic Design option is suitable for the following conditions:

- New, replacement, and retrofit culvert installations.
- Low to moderate channel slopes (less than 3%).
- Situation where either Active Channel Design or Stream Simulation Options are not physically feasible.
- Swimming ability and behavior of target fish species is known.
- Ecological connectivity is not required.
- Evaluation of proposed improvements to existing culverts.

For more information regarding the Hydraulic Design, obtain the most recent copy of the CDFG *Culvert Criteria for Fish Passage*, available on the Department's website. Also available on the CDFG website is Section XII of the Restoration manual, titled *Fish Passage Design and Implementation*. Section XII was released in April of 2009 and provides detailed information regarding fish passage design approaches and techniques.

NMFS Order of Preferred Alternatives

1. *No crossing* - relocate or decommission the road.
2. *Bridge* - spanning the stream to allow for long-term dynamic channel stability.
3. *Streambed simulation strategies* – bottomless arch, embedded culvert design, or ford.
4. *Non-embedded culvert* – this often referred to as a hydraulic design, associated with more traditional culvert design approaches limited to low slopes for fish passage.
5. *Baffled culvert or structure designed with a fish way* – for steeper slopes.

For more information, or to obtain a copy of the NMFS *Guidelines for Salmonid Passage at Stream Crossings* go to the Southwest Region website at: http://swr.nmfs.noaa.gov

LITERATURE CITED

Bates, K; B. Barnard; B. Heiner; P. Klavas; and P. Powers. 1999. Fish passage design at road culverts: a design manual for fish passage at road crossings. WA Department of Fish and Wildlife. Olympia, Washington. 44 p.

CDFG. 2002. Culvert criteria for fish passage. California Department of Fish and Game, Sacramento, CA. 15 p.

Cederholm, C.J. and W.J. Scarlett. 1981. Seasonal immigrations of juvenile salmonids into four small tributaries of the Clearwater River, Washington, 1977-1981, p. 98-110. *In* E.L. Brannon and E.O. Salo, editors. Proceedings of the Salmon and Trout Migratory Behavior Symposium. School of Fisheries, University of Washington, Seattle, WA.

Flannigan, S.A.; T.S. Ledwith; J. Ory; and M.J. Furniss. 1997. Risk assessment of culvert installations of forest roads. Water-roads Interactions Project, Six Rivers National Forest. 28 p.

Flosi, G. and F.L. Reynolds. 1994. California salmonid stream habitat restoration manual. Inland Fisheries Division, CDFG, Sacramento, California.

Giannico, G.R. and S.G. Hinch. 2007. Juvenile coho salmon (*Oncorhynchus kisutch*) responses to salmon carcasses and in-stream wood manipulations during winter and spring. Can. J. Aquat. Sci. 64: 324-335.

HCRRD. 1997. Eel Basin railway fish passage assessment. Final report for CDFG, Fortuna Office. CDFG Agreement #FG8070. 30 p.

Lang, M.M. 2005. California Department of Transportation (CalTrans) District 1 pilot fish passage assessment study: volume 1 – overall results. Final report for project #F 2001 EN 10. Environmental Resources Engineering, Humboldt State University. 56 p.

Nickelson, T.E., J.D. Rogers, S.L. Johnson, and M.F. Solazzi. 1992. Seasonal changes in habitat use by juvenile coho salmon (*Oncorhynchus kisutch*) in Oregon coastal streams. Can. J. Aquat. Sci. 49: 783-789.

NMFS. 2001. Guidelines for salmonid passage at stream crossings. NOAA Fisheries, Southwest Region, Santa Rosa, CA. 11 p.

Normann, J. L., R. J. Houghtalen, and W. J. Johnston. 1985. Hydraulic Design of Highway Culverts. U.S. Department of Transportation, Federal Highway Administration, Hydraulic Design Series No. 5, 272 pp.

Piehl, B. T., M. R. Pyles, and R. L. Beschta. 1988. Flow Capacity of Culverts on Oregon Coast Range Forest Roads. Water Resources Bulletin. Vol. 24, No. 3. pp 631- 637.

Rantz, S.E. 1968. Average annual precipitation and runoff in North Coastal California. USGS, Menlo Park, CA. 3 accompanying maps. 4 p.

Robison, E.G.; A. Mirati; and M. Allen. 1999. Oregon road/stream crossing restoration guide: spring 1999. Advanced Fish Passage Training Version. 75 p.

Roni, P., T.J.Beechie, R.E. Bilby, F.E. Leonetti, M.M. Pollack, and G.R. Pess. 2002. A review of stream restoration techniques and a hierarchical strategy for prioritizing restoration in Pacific Northwest watersheds. N. Am. J. Fish. Man. 22 (1): 1-20.

Scarlett, W.J. and C.J. Cederholm. 1984. Juvenile coho salmon fall-winter utilization of two small tributaries of the Clearwater River, Jefferson County, Washington, p. 227-242. *In* J.M. Walton and D.B. Houston, editors. Proceedings of the Olympic Wild Fish Conference, March 23-25, 1983. Fisheries Technology Program, Peninsula College, Port Angeles, WA.

SSHEAR. 1998. Fish passage barrier assessment and prioritization manual. Washington Department of Fish and Wildlife, Salmonid Screening, Habitat Enhancement, and Restoration (SSHEAR) Division. 57 p.

Skeesick, D.B. 1970. The fall immigration of juvenile coho salmon into a small tributary. Res. Rep. Fish Comm. Oregon 2: 90-95.

Taylor, R.N. 2000. Humboldt County culvert inventory and fish passage evaluation. Final Report, CDFG Agreement #FG 7068 IF. 39 p and appendices.

Taylor, R.N. 2001. Del Norte County culvert inventory and fish passage evaluation. Final Report, CDFG Agreement #FG 8094 WR. 50 p and appendices.

Taylor, R.N. 2003. Marin County stream crossing inventory and fish passage evaluation. Final Report, Marin County Department of Public Works. 73 p and appendices.

Taylor, R.N. and M. Love. 2003. Fish passage evaluation at stream crossings. Section IX of the California Salmonid Stream Habitat Restoration Manual, CDFG Agreement #P9985035.

Tripp, D. and P. McCart. 1983. Effects of different coho stocking strategies on coho and cutthroat trout production in isolated headwater streams. Can. Tech. Rep. Fish. Aquat. Sci. 40: 452-461.

Tschaplinski, P.J. and G.F. Hartman. 1983. Winter distribution of juvenile coho salmon (*Oncorhynchus kisutch*) before and after logging in Carnation Creek, British Columbia, and some implications for over-wintering survival. Can J. Fish Aquat. Sci. 40: 452-461.

Waananen, A.O. and J.R. Crippen. 1977. Magnitude and frequency of floods in California. U.S. Geological Survey, Water Resources Investigation 77-21, Menlo Park, CA. 96 p.

Wipfli, M.S., J.P. Huson, and J.P. Caquette. 2003. Marine subsidies in freshwater ecosystems: salmon carcasses increase the growth rates of stream-resident salmonids. Trans. Am. Fish. Soc. 132: 371-381.

PERSONAL COMMUNICATIONS

Downie, Scott. CDFG, Senior Biologist Supervisor, Fortuna, CA. (707)-725-1070.

Grass, Alan. Retired CDFG biologist/habitat specialist. (707)-743-1565.

Harris, Scott. CDFG, Environmental Scientist. (707)-459-2238.

Love, Michael. Fish Passage Engineer, Michael Love and Associates, Eureka, CA. (707)-476-8938.

Taylor, Ross. Consulting Fisheries Biologist, Ross Taylor and Associates, McKinleyville, CA. (707)-839-5022.

APPENDIX A:

STREAM CROSSING LOCATION INFORMATION AND SURVEY DATA

Site ID #	Stream Name	Railroad Mile Post	USGS Quad	Township, Range, Section	Latitude and Longitude Coordinates	Type of Crossing	Construction Material	Corrugation Dimensions	Crossing Length (ft)	Culvert Dimensions: Diameter, height/width, or rise/span (ft)	% Slope thru Crossing	Rustline Height (ft)	Inlet Type	Inlet Alignment to Channel
NWPRR-135.78	Haehl Creek	135.78	Willits	T18N, R13W, S32	39.365772 N 123.31681 W	Circular	CMP	2-2/3" x 1/2"	NA	4.0	NA		Headwall	>45°
NWPRR-136.73	Haehl Creek	136.73	Willits	T18N, R13W, S32	39.37689 N 123.32912 W	Concrete Arch Culvert	Concrete	NA	50.4	7.0 x 8.0	1.14%	NA	Wingwall	>45°
NWPRR-138.23	Haehl Creek - Left Side	138.23	Willits	T18N, R13W, S19	39.39651 N 123.34075 W	Bridge with hardened floor	Concrete	NA	24.5	Width = 27.0	-0.61%	NA	NA	30° - 45°
NWPRR-138.23	Haehl Creek - Right Side	138.23	Willits	T18N, R13W, S19	39.39651 N 123.34075 W	Bridge with hardened floor	Concrete	NA	26.2	Width = 27.0	-2.59%	NA	NA	30° - 45°
NWPRR-155.24	Unnamed Trib	155.24	Longvale	T20N, R14W, S14	39.58398 N 123.38470 W	Concrete Arch Culvert	Concrete	NA	46.1	8.0 x 10.0	4.12%	NA	Wingwall	<30°
NWPRR-162.62	Unnamed Trib	162.62	Dos Rios	T21N, R13W, S19	39.66701 N 123.34813 W	Pipe Arch	SSP	6" x 2"	84.3	11.5 x 18.5	5.75%	1.2	Wingwall	30° - 45°
NWPRR-164.80	Brad Turner Creek	164.80	Dos Rios	T21N, R13W, S18	39.68525 N 123.35843 W	Concrete Arch Culvert	Concrete	NA	61.7	8.0 x 10.0	2.16%	NA	Wingwall	30° - 45°
NWPRR-165.50	Dean Creek	165.50	Dos Rios	T21N, R13W, S7	39.69436 N 123.36079 W	Concrete Arch Culvert	Concrete	NA	54.6	9.0 x 10.0	10.99%	NA	Wingwall	30° - 45°
NWPRR-171.49	Woodman Creek	171.49	Iron Peak	T22N, R14W, S11	39.7766620 N 123.3907345 W	Bridge	NA	NA	NA	NA	NA	NA	NA	<30°
NWPRR-174.21	Barn Creek	174.21	Iron Peak	T23N, R14W, S34	39.81032 N 123.40925 W	Concrete Arch Culvert	Concrete	NA	66.2	8.5 x 10.0	7.70%	NA	Wingwall	>45°
NWPRR-174.53	Black Oak Creek	174.53	Iron Peak	T23N, R14W, S34	39.81208 N 123.41471 W	Concrete Arch Culvert	Concrete	NA	96.8	10.0 x 12.0	3.91%	NA	Wingwall	<30°
NWPRR-174.92	Corbet Creek	174.92	Iron Peak	T23N, R14W, S33	39.81723 N 123.41760 W	Concrete Arch Culvert	Concrete	NA	53.5	18.0 x 16.0	4.26%	NA	Wingwall	<30°
NWPRR-176.04	Unnamed Trib	176.04	Iron Peak	T23N, R14W, S28	39.83123 N 123.41793 W	Concrete Arch Culvert	Concrete	NA	79.2	10.0 x 12.0	2.80%	NA	Wingwall	<30°
NWPRR-207.05	Mill Creek	207.05	Alderpoint	T3S, R5E, S34	40.15243 N 123.60153 W	Concrete Arch Culvert	Concrete	NA	156.5	10.2x 12.2	4.98%	NA	Wingwall	<30°

Site ID #	Inlet Apron	Outlet Configuration	Outlet Apron	Culvert Embedded?	Crossing-Culvert Condition	Average Active Channel Width (ft)	Estimated Road fill (cubic yards)	Previous Fish Passage Modifications to Crossing	Additional Comments from Initial Site Visit
NWPRR-135.78	No	Freefall into pool	No	No	Extremely Poor	NA	NA	None	Site observed on 4/25/11. A complete survey was not performed on this pipe. Access was not safe and the pipe was an obvious barrier due to it being perched about 10 feet and the pipe is in extremely poor condition. The bottom of the pipe is completely rusted through, water flow below the culvert and exits about 2-ft below the culvert at the outlet. The habitat is poor, creek is small and there is very limited amount of habitat. Channel splits about 100-ft upstream to two channels.
NWPRR-136.73	Yes	Freefall into pool	Yes	No	Extremely Poor	9.0	983	None	Site surveyed on 4/25/11. Habitat appears fair. Upstream several pools with cobble and gravel tailouts. Riparian is brush and small deciduous trees. Maybe dry channel in summertime.
NWPRR-138.23	No	Cascade over Riprap	No	No	Fair	NA	NA	None	Site surveyed on 4/25/11. Good rearing habitat with deep pools and dense riparian cover of willows and alders. Fish observed in downstream pool. Several YOY salmonid and 10-20 species unknown (roach/suckers?). Thick growth on channel divider has caught storm debris, recommend removal for clearer flow path.
NWPRR-138.23	No	Cascade over Riprap	No	No	Fair	NA	NA	None	
NWPRR-155.24	Yes	Freefall into pool	Yes	No	Fair	19.6	1,296	None	Site surveyed on 4/26/11. Upstream habitat is fair, channel gets steep, may also be dry in summer. Most cobbles & boulders covered in moss, even in current wetted channel. 4 to 5 foot Waterfall over boulders approximately 200-ft upstream. No fish observed in large pool. Culvert has some cracks present on the floor.
NWPRR-162.62	Yes	Freefall into pool	No	No	Fair	16.0	2,094	None	Site surveyed on 6/23/10 at 14:10. Culvert appears to be sitting on bedrock, not really fish habitat upstream. Bedrock drops and chutes upstream.
NWPRR-164.80	Yes	Cascade over Riprap	Yes	No	Extremely Poor	11.4	2,648	None	Site surveyed on 6/23/10 at 11:55. Steep, bouldery channel upstream with large angular substrate. Culvert is extremely worn on the inside and worn through in spots. Very perched with no real outlet pool.
NWPRR-165.50	No	Cascade over Riprap	No	No	Extremely Poor	20.0	4,399	None	Site surveyed on 6/23/10 at 10:00. Crossing in very poor condition, channel is fairly steep with a 6-8 ft falls just upstream of the inlet and 150-ft upstream is a 10-15 ft high cascade. Dean Creek is cooler than the Eel River.
NWPRR-171.49	NA	NA	NA	NA	NA	NA	NA	Yes - Denil Fish Ladder	Site surveyed on 5/24/10. Water temp=11.5 C at 17:45. Discussed crossing with Marcin Whitman and Doug Albin. Surveyed a long profile to get grade of bedrock where fish ladder is located. Surveyed RR fill to the downstream side of woodman ck confluence. There is also a lower terrace of fill where the woodman ck channel used to go.
NWPRR-174.21	Yes	Freefall into pool	Yes	No	Poor	9.0	1,912	None	Site surveyed on 5/25/10 at 08:30, water temp =56F. Poor habitat, no pools upstream, appears like it would go dry in the summer. Large sediment deposit upstream of inlet. Culvert has several cracks in walls, floor is completely worn through in numerous locations.
NWPRR-174.53	Yes	Freefall into pool	Yes	No	Poor	10.9	5,030	None	Site surveyed on 5/25/10 at 10:30, water temp=56F. Walked ~550 upstream of Xing. Fair habitat with bedrock chutes, several pools, moderately dense riparian. Talked to friendly land owner who said creek is mostly dry in summer and has observed steelhead in some years. Fractures in inlet headwall and arch walls. Floor has numerous fractures and is worn through in two locations.
NWPRR-174.92	No	Freefall into pool	No	No	Fair	27.8	2,887	None	Site surveyed on 5/25/10 at 12:30, water temp=56F air temp=60F. Eel R is at 52F. Floor of culvert is partially natural and paved, appear to have worn through concrete bottom. Large outlet pool. Walked 700-ft upstream of crossing. Fair fish habitat should be better assessed for quality.
NWPRR-176.04	Yes	Freefall into pool	Yes	No	Poor	21.0	3,417	None	Site surveyed on 5/25/10, water temp =55F. Fair habitat, moderate slope, dense riparian, large substrate with not much spawning sized material, several small pools. Culvert has several large fractures that go the entire circumference of the arch and floor.
NWPRR-207.05	Yes	Stream Grade	No	No	Extremely Poor	18.3	11,498	None	Site surveyed on 5/27/10. Extensive cracks and holes in culvert floor with exposed rebar and flow below the crossing.

Site ID #	Stream Name	Railroad Mile Post	USGS Quad	Township, Range, Section	Latitude and Longitude Coordinates	Type of Crossing	Construction Material	Corrugation Dimensions	Crossing Length (ft)	Culvert Dimensions: Diameter, height/width, or rise/span (ft)	% Slope thru Crossing	Rustline Height (ft)	Inlet Type	Inlet Alignment to Channel
NWPRR-223.47	Unnamed Trib	223.47	Blocksburg	T2S, R4E, S21	40.2679174 N 123.7300901 W	Concrete Arch Culvert	Concrete	NA	212.5	8.7 x 10.1	0.84%	NA	Wingwall	<30°
NWPRR-223.88	Constantine Creek	223.88	Blocksburg	T2S, R4E, S21	40.2703089 N 123.7366255 W	Concrete Arch Culvert	Concrete	NA	125.7	7.0 x 8.0	1.55%	NA	Wingwall	<30°
NWPRR-232.71	McCann Creek	232.71	Myers Flat	T1S, R3E, S33	40.32857 N 123.84300 W	Concrete Arch Culvert	Concrete	NA	50.3	7.0 x 8.0	1.12%	NA	Headwall	<30°
NWPRR-233.93	Bloyd Creek	233.93	Myers Flat	T1S, R3E, S32	40.3382 N 123.8553 W	Circular	CSP	2-2/3" x 1/2"	23.6	2.5	-0.64%	---	Projecting	>45°
NWPRR-235.64	UNT to Pipeline Creek	235.64	Weott	T1S, R3E, S31	40.3391486 N 123.8956415 W	Concrete Arch Culvert	Concrete	NA	33.2	3.5 x 4.0	0.56%	NA	Wingwall	>45°
NWPRR-236.08	Poison Oak Creek	236.08	Weott	T1S, R2E, S36	40.33850 N 123.89862 W	Concrete Arch Culvert	Concrete	NA	43.4	7.0 x 10.0	-1.75%	NA	Wingwall	<30°
NWPRR-236.27	UNT to Poison Oak Creek	236.27	Weott	T1S, R2E, S36	40.3374424 N 123.9020793 W	Concrete Channel	Concrete	NA	67.1	No Defined Dimensions	3.11%	NA	Wingwall	<30°
NWPRR-238.21	Perrott Creek	238.21	Weott	T1S, R2E, S23	40.3588235 N 123.9148439 W	Concrete Arch Culvert	Concrete	NA	95.6	5.0 x 6.0	1.18%	NA	Wingwall	>45°

Site ID #	Inlet Apron	Outlet Configuration	Outlet Apron	Culvert Embedded?	Crossing-Culvert Condition	Average Active Channel Width (ft)	Estimated Road fill (cubic yards)	Previous Fish Passage Modifications to Crossing	Additional Comments from Initial Site Visit
NWPRR-223.47	Yes	Cascade over Riprap	Yes - Broken	Yes	Poor	18.3	30,711	None	Site surveyed on 8/29/11. Water temp = 17C at 15:30. Very limited habitat~200 ft. of low gradient. Then a steep bedrock constriction. Above that channel is greater than 10%. The flat reached is just aggraded cobbles due to the RR culvert. Water is cooler than the mainstem Eel. Floor of culvert is partially broken but is completely natural bed material.
NWPRR-223.88	Yes	Cascade over Riprap	Yes	No	Fair	13.6	9,940	None	Site surveyed on 8/29/11. Water temp = 15C at 11:00. Fair fisheries habitat. Channel is steep, large cobbles & boulders, dense mixed riparian, several pools. Perched culvert on private road, about 400' upstream, is also 'red'. Could be good non-natal rearing but lacks suitable spawning habitat.
NWPRR-232.71	Yes	Freefall into pool	Yes	Yes	Good	12.0	429	None	Site surveyed on 4/27/11. Site is partially embedded with cobble, boulders and two large boulders. Habitat good for rearing, not much spawning sized substrate. Pools and riffles, dense alder and redwood riparian. Channel appears moderately sloped. County pipe is a complete barrier to juvenile/resident fish. Walked 300 feet upstream of road, looks passable for all age classes.
NWPRR-233.93	No	Stream Grade	No	Yes	Extremely Poor	6.1	67	None	Site surveyed on 6/2/11. Culvert is completely plugged with inlet buried and is blocking fish passage. Water is either entering from seepage or going through a rust hole and then exiting the pipe through the outlet. Fill around the tracks at the inlet is failing and actively eroding between RR ties. US is highly aggraded with fine sediment. Habitat is fair. Small channel, highly aggraded with gravel and fines, several small pools. Dense riparian mixed canopy. Observed several frogs and pacific giant salamanders in channel up and down stream. Entire crossing is in poor condition.
NWPRR-235.64	Yes	Stream Grade	Yes	No	Fair	NA	183	None	Poor fish habitat, dry channel 3 days after 3" of rain. No defined pools and no real channel. Appears to be drainage ditch which might receive diverted flow from mainstem Pipeline Ck. Mainstem of pipeline creek was not surveyed since the crossing was completely embedded with gravel up to the base of the railroad on the upstream side. Two circular metal pipes were used to try and relieve the embedded pipe. Mainstem pipeline has fair to good quality fish habitat with spawning gravels, pools and riffles. Water upstream but none downstream.
NWPRR-236.08	No	Stream Grade	No	Yes	Fair	13.7	611	None	x 10' CAC. Moisture seeping through crack which runs along ceiling. Upstream habitat is good. Walked 200 feet, several pool/riffle sequences with good spawning sized substrate. Dense riparian redwood/hardwood/brush canopy. Low gradient channel. Close to downstream county crossing which is embedded and does not appear to be a barrier (assessed by RTA and ranked 30 out of 31).
NWPRR-236.27	No	Freefall into pool	No	No	Fair	7.6	NA	None	Site surveyed on 6/2/11. Crossing is a concrete channel which is below a RR bridge and next to a county road. The channel was probably put in by the county. The crossing is essentially a box culvert without a top on it. Habitat is fair. Small channel mostly riffles with several pools US of crossing. Slope increases quickly. DS is low gradient through a closed, private campground, about 300 ft to confluence with Poison Oak Creek. Open bottom arch (6x4) about 100 ft downstream.
NWPRR-238.21	No	Freefall into pool	Yes	Yes	Fair	10.8	4,808	None	Site surveyed on 6/2/11. Culvert not fully embedded, the right side of the culvert is concrete about a foot wide almost all the way through. Embedding starts about 20-ft from the outlet. Poor fish habitat, few pools, creek is already going dry after a wet spring/winter. Incised channel cut through some major aggradation maybe from Eel R backwatering on peak flows. Small angular material downstream.

Site ID #	Stream Name	Railroad Mile Post	USGS Quad	Township, Range, Section	Latitude and Longitude Coordinates	Type of Crossing	Construction Material	Corrugation Dimensions	Crossing Length (ft)	Culvert Dimensions: Diameter, height/width, or rise/span (ft)	% Slope thru Crossing	Rustline Height (ft)	Inlet Type	Inlet Alignment to Channel
NWPRR-240.28	Allen Creek	240.28	Red Crest	T1S, R2E, S11	40.3873997 N 123.9220368 W	2 Circular	Concrete	NA	NA	3.0	NA	NA	NA	$<30^{o}$

Site ID #	Inlet Apron	Outlet Configuration	Outlet Apron	Culvert Embedded?	Crossing-Culvert Condition	Average Active Channel Width (ft)	Estimated Road fill (cubic yards)	Previous Fish Passage Modifications to Crossing	Additional Comments from Initial Site Visit
NWPRR-240.28	No	Freefall into pool	No	No	Extremely Poor	9.0	2,018	None	Site surveyed on 6/2/11. Crossing in extremely poor condition. Outlet is blown out with pieces of the culvert laying in the channel, the banks are highly eroded from being over topped. Railroad ties and track at outlet used for erosion control are scoured out and ready to fall into creek. No survey conducted due to conditions at the crossing. Obvious red site. Inlet is completely plugged and aggraded over the top of the pipes, can not even see the inlet of the pipes. Outlet is severely perched. Poor fish habitat downstream, channel ~15% downstream. Upstream has signs that it ponds up each winter. The channel is highly aggraded, trees have silt lines at 7 to 8 feet up their trunks. Large amount of scour at inlet. 150 ft to the Eel River.

NWPRR-136.73 HAEHL CREEK #2

Longitudinal Profile Raw Data

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
2	24.235	1.28	99.395	USCH1	I=1.3' pool US of apron	0.00	99.40
3	10.04	-0.115	100.515	INLAPUS	d=0.1'	14.26	100.52
4	-0.465	-7.465	99.91	INLINV	at worn thalweg	27.08	99.91
6	-30.245	-48.08	99.335	OUTINV	d=0.2'	77.45	99.34
7	-32.8	-51.795	99.065	OUTAPDS		81.96	99.07
8	-34.09	-52.66	94.465	POOLD	Pool on rap rap	83.51	94.47
9	-36.72	-48.105	93.025	POOLD	use at TWC	88.77	93.03

Tailwater Cross Section Raw Data

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
						0.00	0.00
						0.00	0.00

Fill Survey Points

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
3	10.04	-0.115	100.515	FILINBOT1		0.00	100.52
3	10.04	-0.115	100.515	FILINBOT2		0.00	100.52
				FILINTOP1		0.00	0.00
10	-9.67	-15.86	116.145	FILINTOP2	sythetic point	18.58	116.15
				FILINTOP3		37.15	0.00
				FILOUTTOP1		0.00	0.00
	-28.37	-38.16	116.145	FILOUTTOP2		47.55	116.15
				FILOUTTOP3		95.10	0.00
9	-36.72	-48.105	93.025	FILOUTBOT1		0.00	93.03
9	-36.72	-48.105	93.025	FILOUTBOT2		0.00	93.03

Calculations for R-G-G Filter

us channel slope =	-0.0785
inlet apron slope =	0.0472
inlet apron length(ft) =	12.8
culvert slope =	0.0114
non-embedded segment length (ft)=	N/A
embedded segment length (ft)=	N/A
outlet apron slope =	0.0599
outlet apron length(ft) =	4.51
total culvert length(ft) =	50.4
ds channel slope =	#DIV/0!
residual inlet depth(ft) =	-6.88
residual outlet depth(ft) =	-6.31
residual pool depth(ft) =	N/A

scope and field notes:	TDG
rod:	RNT
spreadsheet:	TDG

Culvert shape = 7x8 CAC
Culvert xs area (ft^2) = 49.0

Fill Volume Calculation

16.24

Lu(ft)	Ou (%)	Ld(ft)	Od (%)	Wr(ft)	Wtopu(ft)	Wtopd(ft)	Wbotu(ft)	Wbotd(ft)	Hu(ft)	Hd(ft)	Vu	Vd	Vr	Fill + Culvert V yd^3	Culvert V yd^3	Fill V yd^3
29.7	62.0	26.5	178.0	29.1	37.2	59.0	10.0	10.0	15.6	23.1	4648	5179	19193	1,075	91	**983**

NWPRR-138.23 HAEHL CREEK

Longitudinal Profile Raw Data - Left Side

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
2	-76.215	-74.4	103	INLINV	Left side	0.00	103.00
3	-68.24	-68.525	102.88	INLINV	Left side	9.91	102.88
4	-65.08	-64.82	103.11	INLINV	Left side	14.77	103.11
5	-58.62	-57.495	103.15	OUTINV	Left side	24.54	103.15
6	-57.975	-56.735	101.02	RIPRAP	Left side	25.54	101.02
7	-56.215	-53.075	100.845	RIPRAP	Left side	29.60	100.85
8	-52.955	-49.495	101.38	RIPRAP	Left side	34.44	101.38
9	-50.945	-48.005	100.285	RIPRAP	Left side	36.94	100.29
10	-47.65	-45.795	99.675	RIPRAP	Left side	40.91	99.68
11	-44.805	-45.175	99.68	RIPRAP	Left side	43.82	99.68
12	-40.95	-43.7	99.52	RIPRAP	Left side	47.95	99.52
13	-39.99	-41.91	99.065	RIPRAP	Left side	49.98	99.07
14	-38.58	-40.655	98.69	RIPRAP	Left side	51.87	98.69
28	-24.265	-33.11	96.93	POOLD	d=2.9'	68.05	96.93
29	-13.145	-16.72	96.67	POOLD	d=3.3'	87.86	96.67
30	-2.74	-6.4	98.41	POOLD	d=1.5'	102.51	98.41
35	9.29	-10.995	99.24	TWXS1	d=0.6'	115.39	99.24
46	22.125	3.545	94.765	DSCH1	d=4.6'	134.78	94.77

Longitudinal Profile Raw Data - Right Side

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
15	-93.725	-66.985	101.245	USCH1	Right side	0.00	101.25
16	-87.8	-64.735	102.605	INLINV	Right side	6.34	102.61
17	-85.41	-63.195	103.21	INLINV	Right side	9.18	103.21
18	-73.38	-53.04	103.31	INLINV	Right side	24.92	103.31
19	-68.065	-47.58	103.285	OUTINV	Right side	32.54	103.29
20	-66.89	-47.165	101.42	RIPRAP	Right side	33.79	101.42
21	-63.01	-44.83	100.865	RIPRAP	Right side	38.32	100.87
22	-60.075	-44.16	100.495	RIPRAP	Right side	41.33	100.50
23	-53.085	-42.03	100.975	RIPRAP	Right side	48.64	100.98
24	-50.115	-39.815	100.57	RIPRAP	Right side	52.34	100.57
25	-46.915	-38.595	100.525	RIPRAP	Right side	55.77	100.53
26	-44.465	-38.145	99.32	RIPRAP	Right side	58.26	99.32
27	-41.91	-37.02	99.095	RIPRAP	Right side	61.05	99.10
28	-24.265	-33.11	96.93	POOLD	d=2.9'	79.12	96.93
29	-13.145	-16.72	96.67	POOLD	d=3.3'	98.93	96.67
30	-2.74	-6.4	98.41	POOLD	d=1.5'	113.58	98.41
35	9.29	-10.995	99.24	TWXS1	d=0.6'	126.46	99.24
46	22.125	3.545	94.765	DSCH1	d=4.6'	145.86	94.77

Tailwater Cross Section Raw Data

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
31	14.785	-16.225	102.405	TWXS1	LB	0.00	102.41
32	14.4	-15.78	101.575	TWXS1		0.59	101.58
33	12.65	-14.145	100.555	TWXS1		2.98	100.56
34	10.86	-12.505	99.98	TWXS1	LEW	5.41	99.98
35	9.29	-10.995	99.24	TWXS1	d=0.6'	7.59	99.24
36	7.82	-8.12	99.455	TWXS1	d=0.5'	10.82	99.46
37	7.02	-6.575	99.65	TWXS1	d=0.3'	12.56	99.65
38	5.92	-4.95	99.38	TWXS1	d=0.5'	14.52	99.38
39	5.455	-3.86	99.34	TWXS1	d=0.6'	15.71	99.34
40	4.6	-2.275	99.62	TWXS1	d=0.3'	17.51	99.62
41	4.145	-1.34	99.86	TWXS1	REW	18.55	99.86
42	2.88	1.71	100.445	TWXS1		21.85	100.45
43	2.495	3.735	100.55	TWXS1		23.91	100.55
44	2.34	4.57	99.915	TWXS1		24.76	99.92
45	2.225	5.575	103.425	TWXS1	Top RB	25.77	103.43

Fill Survey Points

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
				FILINBOT1		0.00	0.00
				FILINBOT2		0.00	0.00
				FILINTOP1		0.00	0.00
				FILINTOP2		0.00	0.00
				FILINTOP3		0.00	0.00
				FILOUTTOP1		0.00	0.00
				FILOUTTOP2		0.00	0.00
				FILOUTTOP3		0.00	0.00
				FILOUTBOT1		0.00	0.00
				FILOUTBOT2		0.00	0.00

Calculations for R-G-G Filter - Left Side

us channel slope =	N/A
inlet apron slope =	N/A
inlet apron length(ft) =	N/A
culvert slope =	-0.0061
non-embedded segment length (ft)=	N/A
embedded segment length (ft)=	N/A
outlet rip rap slope =	0.0885
outlet rip rap length(ft) =	26.33
total culvert length(ft) =	24.5
ds channel slope =	0.2307
residual inlet depth(ft) =	-3.76
residual outlet depth(ft) =	-3.91
residual pool depth(ft) =	2.31

Calculations for R-G-G Filter - Right Side

us channel slope =	N/A
inlet apron slope =	N/A
inlet apron length(ft) =	N/A
culvert slope =	-0.0259
non-embedded segment length (ft)=	N/A
embedded segment length (ft)=	N/A
outlet rip rap slope =	0.0853
outlet rip rap length(ft) =	27.26
total culvert length(ft) =	26.2
ds channel slope =	0.2307
residual inlet depth(ft) =	-3.37
residual outlet depth(ft) =	-4.05
residual pool depth(ft) =	2.31

scope and field notes:	TDG
rod:	RNT
spreadsheet:	TDG

Culvert shape =

Culvert xs area (ft^2) =

Fill Volume Calculation

Lu(ft)	Ou (%)	Ld(ft)	Od (%)	Wr(ft)	Wtopu(ft)	Wtopd(ft)	Wbotu(ft)	Wbotd(ft)	Hu(ft)	Hd(ft)	Vu	Vd	Vr	Fill + Culvert V yd^3	Culvert V yd^3	Fill V yd^3
0.0	#DIV/0!	0.0	#DIV/0!	0.0	0.0	0.0	0.0	0.0	0.0	0.0	#DIV/0!	#DIV/0!	0	#DIV/0!	0	**#DIV/0!**

NWPRR-155.24 UNNAMED TRIB

Longitudinal Profile Raw Data

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
2	-31.555	-140.465	104.54	USCH1	d=0.4'	0.00	104.54
3	-27.355	-124.76	103.985	USCH1	d=0.55'	16.26	103.99
4	-21.73	-112	103.295	USCH1	d=0.9'	30.20	103.30
5	-19.35	-109.89	104	INLAPUS	use for fill length, d=0.15'	33.38	104.00
6	-17.645	-99.02	103.555	INLINV	d=0.05'	44.39	103.56
7	-14.58	-53.025	101.655	OUTINV		90.48	101.66
9	-14.97	-41.92	101.08	OUTAPDS		101.59	101.08
10	-6.935	-37.755	96.88	POOLD	d=1.5'	110.64	96.88
13	-12.305	-30.32	96.775	POOLD	d=1.6'	119.82	96.78
24	-11	-22.705	97.89	TWXS1	d=0.45'	127.54	97.89
30	-8.85	-15.78	97.58	DSCH1	d=0.3'	134.79	97.58
31	-12.375	-8.535	96.585	DSCH1	d=0.3'	142.85	96.59
32	-17.585	-2.355	96.035	DSCH1	d=0.3'	150.93	96.04
33	-17.55	6.475	95.55	DSCH1	d=0.3'	159.76	95.55
34	-24.83	13.175	96.06	DSCH1	d=0.9'	169.66	96.06
35	-51.51	19.22	95.345	DSCH1	d=0.3'	197.01	95.35
36	-65.31	14.625	95.315	DSCH1	d=0.15'	211.56	95.32
37	-104.23	20.585	93.95	DSCH1	at outlet creek d=0.3'	250.93	93.95

Calculations for R-G-G Filter

us channel slope =	0.0162
inlet apron slope =	0.0404
inlet apron length(ft) =	11.0
culvert slope =	0.0412
non-embedded segment length (ft)=	N/A
embedded segment length (ft)=	N/A
outlet apron slope =	0.0517
outlet apron length(ft) =	11.11
total culvert length(ft) =	46.1
ds channel slope =	0.0272
residual inlet depth(ft) =	-5.67
residual outlet depth(ft) =	-3.77
residual pool depth(ft) =	1.01

scope and field notes:	TDG
rod:	RNT
spreadsheet:	TDG

Tailwater Cross Section Raw Data

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
14	14.48	-24.13	101.95	TWXS1	LB	0.00	101.95
15	7.22	-23.755	100.145	TWXS1		7.27	100.15
16	-3.62	-23.235	98.73	TWXS1		18.12	98.73
17	-6.625	-23.025	98.295	TWXS1	LEW	21.13	98.30
18	-7.37	-22.985	99.135	TWXS1	on rock	21.88	99.14
19	-7.94	-22.915	99.215	TWXS1	on rock	22.45	99.22
20	-8.5	-22.815	97.95	TWXS1	d=0.35'	23.02	97.95
21	-9.575	-22.845	97.945	TWXS1	d=0.35'	24.10	97.95
22	-9.905	-22.77	98.59	TWXS1	on rock	24.44	98.59
23	-10.645	-22.75	98.72	TWXS1	on rock	25.18	98.72
24	-11	-22.705	97.89	TWXS1	d=0.45'	25.54	97.89
25	-11.725	-22.795	98.885	TWXS1	on rock	26.27	98.89
26	-12.935	-22.815	98.61	TWXS1	on rock	27.48	98.61
27	-15.375	-22.575	98.275	TWXS1	REW	29.93	98.28
28	-18.62	-22.33	98.575	TWXS1	RB Gravel Bar	33.18	98.58
29	-20.19	-22.225	100.185	TWXS1	RB on Rock	34.76	100.19

Fill Survey Points

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
5	-19.35	-109.89	104	FILINBOT1	INLAPUS	0.00	104.00
8	-24.08	-109.87	103.77	FILINBOT2			103.77
41	28.08	-83.815	121.82	FILINTOP1		0.00	121.82
42	-16.44	-80.235	121.635	FILINTOP2		44.66	121.64
43	-40.99	-78.16	121.955	FILINTOP3		69.30	121.96
38	31.44	-70.53	121.275	FILOUTTOP1		0.00	121.28
39	-15.635	-68.055	121.255	FILOUTTOP2		47.14	121.26
40	-38.335	-64.86	121.135	FILOUTTOP3		70.06	121.14
11	-2.145	-41.765	98.015	FILOUTBOT1		0.00	98.02
12	-20.67	-38.73	98.055	FILOUTBOT2		18.77	98.06

Culvert shape = 8X10 CAC
Culvert xs area (ft^2) = 70.0

Fill Volume Calculation

									18.08					Fill + Culvert V	Culvert V	Fill V
Lu(ft)	Ou (%)	Ld(ft)	Od (%)	Wr(ft)	Wtopu(ft)	Wtopd(ft)	Wbotu(ft)	Wbotd(ft)	Hu(ft)	Hd(ft)	Vu	Vd	Vr	yd^3	yd^3	yd^3
35.0	58.8	37.7	78.3	12.2	69.3	70.1	10.0	18.8	17.8	23.2	10628	15291	12309	1,416	120	**1,296**

NWPRR-162.62 UNNAMED TRIB

Longitudinal Profile Raw Data

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
27	34.54	-152.95	109.01	USCH1	d=0.1	0.00	109.01
26	20.77	-125.04	108.805	INLINV		31.12	108.81
25	12.235	-41.195	103.96	OUTINV	d=0.1	115.40	103.96
19	10.275	-32.4	83.5	POOLD	d=2.75	124.41	83.50
12	14.56	-17.485	85.39	TWXS1	d=0.5	139.93	85.39
4	18.2	-13.915	84.405	DSCH1	d=0.5	145.03	84.41
3	23.95	2.23	82.785	DSCH1	d=0.4	162.17	82.79
2	38.865	24.06	81.565	DSCH1	d=0.3	188.60	81.57

Calculations for R-G-G Filter

us channel slope =	0.0066
inlet apron slope =	N/A
inlet apron length(ft) =	N/A
culvert slope =	0.0575
non-embedded segment length (ft)=	N/A
embedded segment length (ft)=	N/A
outlet apron slope =	N/A
outlet apron length(ft) =	N/A
total culvert length(ft) =	84.3
ds channel slope =	0.0749
residual inlet depth(ft) =	-23.42
residual outlet depth(ft) =	-18.57
residual pool depth(ft) =	1.89

scope and field notes:	TDG
rod:	RNT
spreadsheet:	TDG

Tailwater Cross Section Raw Data

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
5	21.34	-22.325	89.555	TWXS1	LB	0.00	89.56
6	19.88	-21.69	87.385	TWXS1		1.59	87.39
7	19.065	-21.175	85.755	TWXS1	LEW d=0.4	2.56	85.76
8	18.515	-20.845	85.75	TWXS1	d=0.5	3.20	85.75
9	16.715	-19.105	86.12	TWXS1	d=0.1	5.70	86.12
10	15.715	-18.57	87.01	TWXS1		6.84	87.01
11	14.85	-17.75	86.955	TWXS1		8.03	86.96
12	14.56	-17.485	85.39	TWXS1	d=0.5	8.42	85.39
13	14.26	-17.33	87.535	TWXS1		8.76	87.54
14	12.42	-16.16	87.67	TWXS1		10.94	87.67
15	9.75	-14.3	89.355	TWXS1		14.19	89.36
16	9.2	-13.495	87	TWXS1		15.17	87.00
17	2.985	-8.74	87.96	TWXS1		22.99	87.96
18	2.68	-8.53	91.505	TWXS1		23.36	91.51

Fill Survey Points

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
28	28.63	-127.045	109.585	FILINBOT1		0.00	109.59
29	16.465	-129.365	109.21	FILINBOT2		12.38	109.21
	47.834	-108.409	122.01	FILINTOP1	Synthetic Point	0.00	122.01
	19.559	-110.959	122.615	FILINTOP2	Synthetic Point	28.39	122.62
	-9.531	-113.679	122.31	FILINTOP3	Synthetic Point	57.61	122.31
24	44.115	-65.16	122.01	FILOUTTOP1		0.00	122.01
23	15.84	-67.71	122.615	FILOUTTOP2		28.39	122.62
22	-13.25	-70.43	122.31	FILOUTTOP3		57.61	122.31
20	16.58	-34.97	85.67	FILOUTBOT1		0.00	85.67
21	3.64	-34.04	86.7	FILOUTBOT2		12.97	86.70

Culvert shape = 11.5 x 18.5 pipe arch
Culvert xs area (ft^2) = 172.0

Fill Volume Calculation

Lu(ft)	Ou (%)	Ld(ft)	Od (%)	Wr(ft)	Wtopu(ft)	Wtopd(ft)	Wbotu(ft)	Wbotd(ft)	Hu(ft)	Hd(ft)	Vu	Vd	Vr	Fill + Culvert V yd^3	Culvert V yd^3	Fill V yd^3
									13.81							
22.8	71.2	50.0	106.3	43.4	57.6	57.6	12.4	13.0	13.2	36.4	4294	22036	44700	2,631	537	**2,094**

NWPRR-164.80 BRAD TURNER CREEK

Longitudinal Profile Raw Data

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
23	-76.645	-64.51	105.125	USCH1	d=0.3	0.00	105.13
22	-54.125	-47.59	101.41	INLAPUS	d=0.2	28.17	101.41
21	-47.555	-35.71	101.16	INLINV	d=0.2	41.74	101.16
20	2.455	0.42	99.825	OUTINV	d=0.2	103.44	99.83
19	7.44	3.5	99.77	OUTAPDS	d=0.2	109.30	99.77
18	10.425	3.275	94.91	OUTDROP	d=0.3	112.29	94.91
17	16.045	5.625	91.335	OUTAPMID	d=0.3	118.38	91.34
16	22.775	7.61	89.91	POOLD	bottom of rip rap d=0.6	125.40	89.91
10	22.39	14.06	89.56	TWXS1	Thalweg, d=0.8	131.86	89.56
5	22.465	17.925	89.43	DSCH1	d=0.3	135.73	89.43
4	30.895	25.89	86.63	DSCH1	d=1.8	147.33	86.63
3	37.035	29.24	87.84	DSCH1	d=0.3	154.32	87.84
2	59.57	47.03	87.01	DSCH1	d=0.3	183.03	87.01

Calculations for R-G-G Filter

us channel slope =	0.1319
inlet apron slope =	0.0184
inlet apron length(ft) =	13.6
culvert slope =	0.0216
non-embedded segment length (ft)=	N/A
embedded segment length (ft)=	N/A
outlet apron slope =	0.0094
outlet apron length(ft) =	5.86
total culvert length(ft) =	61.7
ds channel slope =	0.0477
residual inlet depth(ft) =	-11.60
residual outlet depth(ft) =	-10.27
residual pool depth(ft) =	-0.35

Tailwater Cross Section Raw Data

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
6	34.21	8.915	93.99	TWXS1	LB	0.00	93.99
7	29.45	10.905	91.255	TWXS1		5.16	91.26
8	24.925	13.075	91.145	TWXS1		10.18	91.15
9	24.145	13.505	89.94	TWXS1	LEW d=0.4	11.07	89.94
10	22.39	14.06	89.56	TWXS1	Thalweg, d=0.8	12.91	89.56
11	20.6	14.905	90.03	TWXS1	d=0.3	14.89	90.03
12	19.15	16.045	89.97	TWXS1	REW	16.73	89.97
13	16.92	16.725	91.155	TWXS1		19.06	91.16
14	13.04	19.265	90.84	TWXS1		23.70	90.84
15	12.445	19.585	95.345	TWXS1		24.38	95.35

scope and field notes:	TDG
rod:	RNT
spreadsheet:	TDG

Fill Survey Points

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
				FILINBOT1		0.00	0.00
				FILINBOT2		0.00	0.00
				FILINTOP1		0.00	0.00
				FILINTOP2		0.00	0.00
				FILINTOP3		0.00	0.00
				FILOUTTOP1		0.00	0.00
				FILOUTTOP2		0.00	0.00
				FILOUTTOP3		0.00	0.00
				FILOUTBOT1		0.00	0.00
				FILOUTBOT2		0.00	0.00

Culvert shape = 8 x 10 CAC
Culvert xs area (ft^2) = 70.0

Fill Volume Calculation

Lu(ft)	Ou (%)	Ld(ft)	Od (%)	Wr(ft)	Wtopu(ft)	Wtopd(ft)	Wbotu(ft)	Wbotd(ft)	Hu(ft)	Hd(ft)	Vu	Vd	Vr	Fill + Culvert V yd^3	Culvert V yd^3	Fill V yd^3
41.0	85.0	60.0	90.0	18.0	68.0	68.0	11.4	11.4	26.6	40.1	16466	35533	23829	2,808	160	**2,648**

NWPRR-165.50 DEAN CREEK

Longitudinal Profile Raw Data

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
36	-35.97	-63.655	111.47	FALLSTOP	d=1.0	0.00	111.47
35	-33.345	-57.79	103.12	FALLSBOT	d=1.8	6.43	103.12
34	-30.57	-53.095	101.385	INLPOOL	d=3.5	11.88	101.39
33	-27.56	-42.75	105.465	INLINV	Center	22.65	105.47
31	-21.905	-38.56	104.475	CLVBOT1	d=0.3	29.69	104.48
30	-13.765	-27.475	102.835	CLVBOT1	d=0.3	43.44	102.84
29	-12.365	-26.345	101.105	CLVBOT1	d=0.7	45.24	101.11
28	-10.14	-21.8	100.15	CLVBOT1	d=1.5	50.30	100.15
27	-7.37	-17.99	100.425	CLVBOT1	d=0.5	55.01	100.43
26	-3.47	-11.29	99.61	CLVBOT1	d=1.2	62.77	99.61
25	-3.39	-11.03	100.49	CLVBOT1	d=0.3	63.04	100.49
24	3.38	1.52	99.245	OUTINV		77.30	99.25
23	3.145	3.68	96.54	RIPRAP	Middle	79.47	96.54
22	4.67	7.305	90.57	RIPRAP	Bottom, d=0.5	83.40	90.57
21	7.675	10.885	89.465	POOLD	d=1.9	88.08	89.47
20	9.655	12.63	88.975	POOLD	d=2.2	90.72	88.98
12	12.705	16.63	90.735	TWXS1	d=0.5	95.75	90.74
5	18.795	20.59	90.545	DSCH4	d=0.4, US	103.01	90.55
4	27.235	34.435	89.38	DSCH2	d=0.5	119.23	89.38
3	25.91	37.205	87.25	DSCH2	d=1.1	122.30	87.25
2	27.19	40.99	87.845	DSCH1	d=0.5, DS	126.29	87.85

Calculations for R-G-G Filter

us channel slope =	0.2651
inlet apron slope =	N/A
inlet apron length(ft) =	N/A
culvert slope =	0.1099
non-embedded segment length (ft)=	N/A
embedded segment length (ft)=	N/A
outlet apron slope =	N/A
outlet apron length(ft) =	N/A
total culvert length(ft) =	54.6
ds channel slope =	0.1071
residual inlet depth(ft) =	-14.73
residual outlet depth(ft) =	-8.51
residual pool depth(ft) =	1.76

scope and field notes:	TDG
rod:	RNT
spreadsheet:	TDG

Tailwater Cross Section Raw Data

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
6	27.27	15.855	94.51	TWXS1	LB	0.00	94.51
7	24.395	16.095	92.36	TWXS1		2.89	92.36
8	19.345	16.245	91.16	TWXS1	LEW	7.94	91.16
9	15.39	16.4	90.97	TWXS1	d=0.2	11.90	90.97
10	15.105	16.415	91.425	TWXS1	on rock	12.18	91.43
11	14.41	16.495	90.835	TWXS1	d=0.3	12.88	90.84
12	12.705	16.63	90.735	TWXS1	d=0.5	14.59	90.74
13	11.305	16.75	90.95	TWXS1	REW d=0.3	16.00	90.95
14	10.47	16.67	92.675	TWXS1		16.83	92.68
15	9.53	16.845	93.35	TWXS1		17.79	93.35
16	7.11	17.01	93.67	TWXS1		20.22	93.67
17	5.56	17.205	93.685	TWXS1		21.78	93.69
18	4.26	17.37	92.7	TWXS1		23.09	92.70
19	2.49	17.325	94.21	TWXS1		24.86	94.21

Fill Survey Points

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
				FILINBOT1		0.00	0.00
				FILINBOT2		0.00	0.00
				FILINTOP1	synthesized pts	0.00	0.00
				FILINTOP2	synthesized pts	0.00	0.00
				FILINTOP3	synthesized pts	0.00	0.00
				FILOUTTOP1		0.00	0.00
				FILOUTTOP2		0.00	0.00
				FILOUTTOP3		0.00	0.00
				FILOUTBOT1		0.00	0.00
				FILOUTBOT2		0.00	0.00

Culvert shape = 9 X 10.0 CAC
Culvert xs area (ft^2) = 76.0

Fill Volume Calculation

Lu(ft)	Ou (%)	Ld(ft)	Od (%)	Wr(ft)	Wtopu(ft)	Wtopd(ft)	Wbotu(ft)	Wbotd(ft)	Hu(ft)	Hd(ft)	Vu	Vd	Vr	Fill + Culvert V yd^3	Culvert V yd^3	Fill V yd^3
41.0	85.0	75.0	120.0	26.0	65.0	65.0	20.0	20.0	26.6	57.6	17627	58786	46504	4,552	154	**4,399**

NWPRR-171.49 WOODMAN CREEK

Longitudinal Profile Raw Data

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
2	72.205	50.155	84.8	THALWEG	water to be used with fills for old mouth of creek	0.00	84.80
3	29.915	42.05	81.85	THALWEG	at bottom/pool below ladder	43.06	81.85
4	25.92	35.15	84.785	THALWEG	bottom of cascade	51.03	84.79
5	9.23	20.97	91.89	THALWEG		72.93	91.89
6	0.97	15.16	94.375	THALWEG		83.03	94.38
7	-7.545	11.56	97.115	THALWEG	d=0.9 top of cascade	92.28	97.12
8	-9.595	9.19	91.19	POOLD		95.41	91.19
9	-22.935	-20.8	93.72	POOLD		128.23	93.72
10	-29.945	-32.005	95.445	POOLD	bottom of falls	141.45	95.45
11	-45.555	-63.425	100.75	THALWEG		176.53	100.75
12	-43.71	-80.975	102.71	THALWEG		194.18	102.71
13	-58.25	-87.48	103.645	THALWEG		210.11	103.65
14	-95.825	-119.34	104.42	THALWEG		259.37	104.42
15	-112.525	-136.395	105.01	THALWEG		283.24	105.01
16	-127.155	-144.24	104.135	THALWEG		299.84	104.14

Calculations for R-G-G Filter

us channel slope =	N/A
inlet apron slope =	N/A
inlet apron length(ft) =	N/A
culvert slope =	0.0685
non-embedded segment length (ft)=	N/A
embedded segment length (ft)=	N/A
outlet apron slope =	N/A
outlet apron length(ft) =	N/A
total culvert length(ft) =	43.1
ds channel slope =	-0.3244
residual inlet depth(ft) =	N/A
residual outlet depth(ft) =	N/A
residual pool depth(ft) =	N/A

scope and field notes:	TDG
rod:	RNT
spreadsheet:	TDG

Distance from most downstream point to upstream TWC of pool

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
synthetic	350.000	-150.000	84.8		FILOUTBOT1	0	84.80
15	-112.525	-136.395	105.01	THALWEG		462.73	105.01
						462.73	20.21
					Slope=	4.37	

Fill Data

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
101	6.32	-132.66	123.96	FILL	downstream corner, front of flat	0.00	123.96
102	-58.98	-185.13	122.73	FILL	back, upstream corner	83.77	122.73
103	47.21	-263.95	123.99	FILL	middle of back flat	216.01	123.99
104	178.445	-246.025	123.48	FILL	front bottom flat/RR fill	348.47	123.48
105	252.67	-233.46	152.34	FILL	FILINTOP1	423.75	152.34
106	269.08	-227.02	152.405	FILL	FILOUTTOP1	441.38	152.41
107	24.28	-56.77	152.7	FILL	FILOUTTOP3	739.56	152.70
108	11.78	-73.925	152.77	FILL	FILINTOP3	760.78	152.77

Fill Survey Points

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
104	178.445	-246.025	123.48	FILINBOT1		0.00	123.48
101	6.32	-132.66	123.96	FILINBOT2		206.10	123.96
105	252.67	-233.46	152.34	FILINTOP1		0.00	152.34
	132.225	-153.6925	152.5	FILINTOP2		144.46	152.50
108	11.78	-73.925	152.77	FILINTOP3		288.93	152.77
106	269.08	-227.02	152.405	FILOUTTOP1		0.00	152.41
	146.68	-141.895	152.5	FILOUTTOP2		149.09	152.50
107	24.28	-56.77	152.7	FILOUTTOP3		298.18	152.70
	350	-150	84.8	FILOUTBOT1		0.00	84.80
	110	0	84.8	FILOUTBOT2		283.02	84.80

Culvert shape =
Culvert xs area (ft^2) =

Fill Volume Calculation

Lu(ft)	Ou (%)	Ld(ft)	Od (%)	Wr(ft)	Wtopu(ft)	Wtopd(ft)	Wbotu(ft)	Wbotd(ft)	Hu(ft)	Hd(ft)	Vu	Vd	Vr	RR Fill yd^3	Lower fill yd^3	Fill V yd^3
119.0	24.9	187.7	38.7	18.7	288.9	298.2	206.1	283.0	28.8	67.7	411212	1721644	352233	92,040	12,429	**104,469**

Fill Volume of flat below RR Terrace
trapezoid using 2 trinagles

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)	
101	6.32	-132.66	123.96	FILL	downstream corner, front of flat	0.00	123.96	b1
102	-58.98	-185.13	122.73	FILL	back, upstream corner	83.77	122.73	b2
103	47.21	-263.95	123.99	FILL	middle of back flat	216.01	123.99	b2
104	178.445	-246.025	123.48	FILL	front bottom flat/RR fill	348.47	123.48	b1

104	178.445	-246.025	123.48	FILL	front bottom flat/RR fill	0.00		b1
	92.3825	-189.3425						
101	6.32	-132.66	123.96	FILL	downstream corner, front of flat	206.10		b1

102	-58.98	-185.13	122.73	FILL	back, upstream corner	0.00	122.73	b2
	-5.885	-224.54						
103	47.21	-263.95	123.99	FILL	middle of back flat	132.25	123.99	b2

Two computed points used to determine h

	92.383	-189.343				0.00		
	-5.885	-224.540				104.38		h

Area of trapezoid = 1/2(b1+b2)*h

Area=	**17662**	**sq ft**
height =	**19**	**ft**
Volume=	**335,576**	**ft^3**
	12,429	**yd^3**

NWPRR-174.21 BARN CREEK

Longitudinal Profile Raw Data

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
2	-155.115	-68.825	113.59	USCH1	d=0.2	0.00	113.59
4	-133.995	-59.215	111.38	INLAPUS		23.20	111.38
6	-121.415	-57.115	110.61	INLINV	d=0.1	35.96	110.61
7	-62.75	-26.445	105.51	OUTINV		102.16	105.51
9	-50.345	-23.355	104.565	OUTAPDS		114.94	104.57
11	-50.455	-20.1	101.54	DROP	d=0.3	118.20	101.54
16	-48.905	-15.715	101.115	TWXS1	Thalweg	122.85	101.12
21	-45.09	-13.24	99.91	DSCH1	d=0.3	127.40	99.91
22	-10.21	7.9	97.025	DSCH1		168.18	97.03

Tailwater Cross Section Raw Data

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
12	-42.565	-28.765	104.57	TWXS1		0.00	104.57
13	-43.83	-26.29	103.025	TWXS1		2.78	103.03
14	-47.24	-18.895	101.96	TWXS1		10.92	101.96
15	-47.645	-17.965	101.565	TWXS1		11.94	101.57
16	-48.905	-15.715	101.115	TWXS1	Thalweg	14.52	101.12
17	-49.13	-14.98	101.305	TWXS1		15.28	101.31
18	-49.36	-14.51	101.885	TWXS1		15.81	101.89
19	-51.055	-11.315	102.82	TWXS1		19.42	102.82
20	-51.565	-10.005	104.49	TWXS1		20.83	104.49

Fill Survey Points

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
3	-132.11	-64	111.745	FILINBOT1		0.00	111.75
5	-135.095	-55.39	111.78	FILINBOT2		9.11	111.78
	-94.055	-86.895	134.205	FILINTOP1	synthesized pts	0.00	134.21
	-110.56	-52.1	133.7	FILINTOP2	synthesized pts	38.51	133.70
	-121.19	-30.525	134.355	FILINTOP3	synthesized pts	62.56	134.36
23	-72.335	-76.795	134.205	FILOUTTOP1		0.00	134.21
24	-88.84	-42	133.7	FILOUTTOP2		38.51	133.70
25	-99.47	-20.425	134.355	FILOUTTOP3		62.56	134.36
8	-47.355	-29.925	104.85	FILOUTBOT1		0.00	104.85
10	-52.78	-16.67	104.79	FILOUTBOT2		14.32	104.79

Calculations for R-G-G Filter

us channel slope =	0.0952
inlet apron slope =	0.0604
inlet apron length(ft) =	12.8
culvert slope =	0.0770
non-embedded segment length (ft)=	N/A
embedded segment length (ft)=	N/A
outlet apron slope =	0.0739
outlet apron length(ft) =	12.78
total culvert length(ft) =	66.2
ds channel slope =	0.0825
residual inlet depth(ft) =	-9.50
residual outlet depth(ft) =	-4.40
residual pool depth(ft) =	N/A

scope and field notes:	TDG
rod:	RNT
spreadsheet:	TDG

Culvert shape = 8.5 X 10.0 CAC
Culvert xs area (ft^2) = 74.0

Fill Volume Calculation

Lu(ft)	Ou (%)	Ld(ft)	Od (%)	Wr(ft)	Wtopu(ft)	Wtopd(ft)	Wbotu(ft)	Wbotd(ft)	Hu(ft) (23.09)	Hd(ft)	Vu	Vd	Vr	Fill + Culvert V yd^3	Culvert V yd^3	Fill V yd^3
33.0	88.9	52.3	66.2	24.0	62.6	62.6	9.1	14.3	21.9	28.9	9704	24223	22604	2,094	181	**1,912**

NWPRR-174.53 BLACK OAK CREEK

Longitudinal Profile Raw Data

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
2	-194.01	-98.465	109.89	USCH1	d=0.3	0.00	109.89
4	-183.92	-90.77	108.765	INLAPUS		12.69	108.77
6	-171.485	-82.91	108.45	INLINV	d=0.25	27.40	108.45
7	-84.435	-40.46	104.66	OUTINV	d=0.1	124.25	104.66
8	-71.74	-32.905	104.45	OUTAPDS		139.02	104.45
9	-70.39	-31.72	100.25	POOLD	d=0.75	140.82	100.25
18	-61.35	-27.705	100.73	TWXS1	d=0.3	150.71	100.73
23	-11.65	-15.28	97.66	DSCH1		201.94	97.66

Tailwater Cross Section Raw Data

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
12	-55.02	-40.99	103.73	TWXS1	LB	0.00	103.73
13	-56.44	-37.975	102.325	TWXS1		3.33	102.33
14	-57.48	-35.56	102.115	TWXS1		5.96	102.12
15	-57.605	-35.08	101.38	TWXS1		6.46	101.38
16	-58.455	-33.44	101.815	TWXS1		8.31	101.82
17	-60.73	-29.375	101.035	TWXS1	LEW	12.96	101.04
18	-61.35	-27.705	100.73	TWXS1	d=0.3	14.74	100.73
19	-62.935	-24.64	100.955	TWXS1	REW	18.20	100.96
20	-63.925	-22.51	101.57	TWXS1		20.54	101.57
21	-64.425	-21.715	102.35	TWXS1		21.48	102.35
22	-65.765	-19.11	103.255	TWXS1	RB	24.41	103.26

Fill Survey Points

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
3	-182.325	-94.675	108.78	FILINBOT1		0.00	108.78
5	-181.935	-81.005	109.945	FILINBOT2		13.68	109.95
	-114.955	-119.155	141.445	FILINTOP1	synthesized pts	0.00	141.45
	-138.335	-73.615	141.315	FILINTOP2	synthesized pts	51.19	141.32
	-155.665	-39.525	141.35	FILINTOP3	synthesized pts	89.43	141.35
24	-91.855	-112.655	141.445	FILOUTTOP1		0.00	141.45
25	-115.235	-67.115	141.315	FILOUTTOP2		51.19	141.32
26	-132.565	-33.025	141.35	FILOUTTOP3		89.43	141.35
10	-65.205	-42.45	102.47	FILOUTBOT1		0.00	102.47
11	-72.23	-23.94	101.855	FILOUTBOT2		19.80	101.86

Calculations for R-G-G Filter

us channel slope =	0.0887
inlet apron slope =	0.0214
inlet apron length(ft) =	14.7
culvert slope =	0.0391
non-embedded segment length (ft)=	N/A
embedded segment length (ft)=	N/A
outlet apron slope =	0.0142
outlet apron length(ft) =	14.77
total culvert length(ft) =	96.8
ds channel slope =	0.0599
residual inlet depth(ft) =	-7.72
residual outlet depth(ft) =	-3.93
residual pool depth(ft) =	0.48

scope and field notes:	TDG
rod:	RNT
spreadsheet:	TDG

Culvert shape = 10.0 X 12.0 CAC
Culvert xs area (ft^2) = 105.0

Fill Volume Calculation

32.87

Lu(ft)	Ou (%)	Ld(ft)	Od (%)	Wr(ft)	Wtopu(ft)	Wtopd(ft)	Wbotu(ft)	Wbotd(ft)	Hu(ft)	Hd(ft)	Vu	Vd	Vr	Fill + Culvert V yd^3	Culvert V yd^3	Fill V yd^3
56.4	68.7	70.3	67.1	24.0	89.4	89.4	13.7	19.8	32.0	39.2	38297	62396	45290	5,407	377	**5,030**

NWPRR-174.92 CORBET CREEK

Longitudinal Profile Raw Data

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
2	-40.57	-175.7	97.945	USCH1	d=0.7	0.00	97.95
3	-17.765	-107.705	93.04	INLINV	d=0.4	71.72	93.04
6	-12.82	-98.795	89.875	CLVBOT1	d=2.35	81.91	89.88
7	-14.16	-79.965	91.665	CLVBOT1	d=0.5	100.79	91.67
8	-11.625	-73.08	90.705	CLVBOT1	d=1.3	108.12	90.71
9	0.08	-60.57	90.76	OUTINV	d=0.3	125.25	90.76
10	-0.655	-54.855	85.29	POOL	d=4.4	131.02	85.29
15	2.43	-52.745	83.995	POOL	max pool - changed rod height	134.75	84.00
19	13.285	-33.57	88.925	TWXS1	thalweg d=0.5	156.79	88.93
28	44.58	50.57	83.37	DSCH1	d=0.4	246.56	83.37

Calculations for R-G-G Filter

us channel slope =	0.0684
inlet apron slope =	N/A
inlet apron length(ft) =	N/A
culvert slope =	0.0426
non-embedded segment length (ft)=	N/A
embedded segment length (ft)=	N/A
outlet apron slope =	N/A
outlet apron length(ft) =	N/A
total culvert length(ft) =	53.5
ds channel slope =	0.0619
residual inlet depth(ft) =	-4.12
residual outlet depth(ft) =	-1.84
residual pool depth(ft) =	4.93

scope and field notes:	TDG
rod:	RNT
spreadsheet:	TDG

Tailwater Cross Section Raw Data

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
14	21.94	-49.01	91.255	TWXS1	also filoutbot1	0.00	91.26
16	19.21	-43.75	90.79	TWXS1		5.93	90.79
17	17.2	-40.145	89.82	TWXS1		10.05	89.82
18	15.04	-36.44	89.355	TWXS1	LEW	14.34	89.36
19	13.285	-33.57	88.925	TWXS1	thalweg d=0.5	17.71	88.93
20	13.07	-32.45	89.655	TWXS1		18.85	89.66
21	11.495	-29.83	89.37	TWXS1		21.90	89.37
22	10.615	-28.66	88.915	TWXS1		23.37	88.92
23	9.315	-26.67	89.18	TWXS1	d=0.4	25.74	89.18
24	9.235	-26.245	90.465	TWXS1	REW	26.18	90.47
25	7.365	-22.93	91.61	TWXS1		29.98	91.61
26	4.46	-19.32	90.18	TWXS1		34.62	90.18
27	2.82	-17.245	91.5	TWXS1		37.26	91.50

Fill Survey Points

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
4	-14.35	-118.955	94.15	FILINBOT1		0.00	94.15
5	-26.62	-114.175	94.465	FILINBOT2		13.17	94.47
	39.541	-106.475	124.125	FILINTOP1	synthetic points	0.00	124.13
	-14.204	-93.955	124.305	FILINTOP2	synthetic points	55.18	124.31
	-43.759	-84.165	124.79	FILINTOP3	synthetic points	86.32	124.79
11	45.56	-83.235	124.125	FILOUTTOP1		0.00	124.13
12	-8.185	-70.715	124.305	FILOUTTOP2		55.18	124.31
13	-37.74	-60.925	124.79	FILOUTTOP3		86.32	124.79
14	21.94	-49.01	91.255	FILOUTBOT1		0.00	91.26
29	-6.505	-38.365	90.33	FILOUTBOT2		30.37	90.33

Culvert shape = 18X16 CAC
Culvert xs area (ft^2) = 288.0

Fill Volume Calculation

31.27

Lu(ft)	Ou (%)	Ld(ft)	Od (%)	Wr(ft)	Wtopu(ft)	Wtopd(ft)	Wbotu(ft)	Wbotd(ft)	Hu(ft)	Hd(ft)	Vu	Vd	Vr	Fill + Culvert V yd^3	Culvert V yd^3	Fill V yd^3
38.6	123.1	48.3	96.4	24.0	86.3	86.3	13.2	30.4	30.0	33.5	18178	33985	41200	3,458	571	**2,887**

NWPRR-176.04 UNNAMED TRIB

Longitudinal Profile Raw Data

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
2	-159.62	-117.245	102.635	USCH1	1st US resting pool d=0.2'	0.00	102.64
3	-142.12	-102.995	100.455	INLAPUS		22.57	100.46
6	-131.06	-94.035	100.335	INLINV	d=0.15	36.80	100.34
7	-67.92	-46.17	98.12	OUTINV		116.03	98.12
8	-56.53	-38.85	97.745	OUTAPDS		129.57	97.75
9	-55.02	-37.905	96.29	POOLD	d=1.1	131.35	96.29
21	-45.85	-27.755	97.03	TWXS1	Thalweg d=0.4	145.03	97.03
26	24.915	-41.91	92.965	DSCH1	d=0.35	217.20	92.97

Calculations for R-G-G Filter

us channel slope =	0.0966
inlet apron slope =	0.0084
inlet apron length(ft) =	14.2
culvert slope =	0.0280
non-embedded segment length (ft)=	N/A
embedded segment length (ft)=	N/A
outlet apron slope =	0.0277
outlet apron length(ft) =	13.54
total culvert length(ft) =	79.2
ds channel slope =	0.0563
residual inlet depth(ft) =	-3.30
residual outlet depth(ft) =	-1.09
residual pool depth(ft) =	0.74

scope and field notes:	TDG
rod:	RNT
spreadsheet:	TDG

Tailwater Cross Section Raw Data

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
12	-34.26	-48.1	99.59	TWXS1		0.00	99.59
13	-36.445	-44.6	98.48	TWXS1		4.13	98.48
14	-37.535	-41.895	97.99	TWXS1		7.04	97.99
15	-39.69	-37.89	97.39	TWXS1	LEW	11.59	97.39
16	-42.34	-33.875	97.15	TWXS1		16.40	97.15
17	-42.375	-33.675	97.7	TWXS1		16.60	97.70
18	-44.335	-30.495	97.525	TWXS1		20.34	97.53
19	-44.51	-30.045	98.125	TWXS1		20.82	98.13
20	-44.885	-29.195	97.245	TWXS1		21.75	97.25
21	-45.85	-27.755	97.03	TWXS1	Thalweg d=0.4	23.48	97.03
22	-46.855	-26.23	97.3	TWXS1	REW	25.31	97.30
23	-48.32	-23.735	97.96	TWXS1		28.20	97.96
24	-50.425	-20.545	98.545	TWXS1		32.03	98.55
25	-51.665	-18.385	99.81	TWXS1		34.52	99.81

Fill Survey Points

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
4	-138.43	-108.38	100.23	FILINBOT1		0.00	100.23
5	-145.17	-98.295	100.565	FILINBOT2		12.13	100.57
	-86.856	-108.323	129.2	FILINTOP1	synthetic points	0.00	129.20
	-104.721	-85.628	129.115	FILINTOP2	synthetic points	28.88	129.12
	-134.401	-54.158	129.545	FILINTOP3	synthetic points	72.14	129.55
27	-67.525	-94.115	129.2	FILOUTTOP1		0.00	129.20
28	-85.39	-71.42	129.115	FILOUTTOP2		28.88	129.12
29	-115.07	-39.95	129.545	FILOUTTOP3		72.14	129.55
10	-46.89	-48.395	97.07	FILOUTBOT1		0.00	97.07
11	-59.855	-30.06	97.115	FILOUTBOT2		22.46	97.12

Culvert shape = 10 x 12 CAC
Culvert xs area (ft^2) = 90.0

Fill Volume Calculation

28.78

Lu(ft)	Ou (%)	Ld(ft)	Od (%)	Wr(ft)	Wtopu(ft)	Wtopd(ft)	Wbotu(ft)	Wbotd(ft)	Hu(ft)	Hd(ft)	Vu	Vd	Vr	Fill + Culvert V yd^3	Culvert V yd^3	Fill V yd^3
50.5	69.2	56.7	68.5	24.0	72.1	72.1	12.1	22.5	28.7	32.0	25125	35392	38880	3,681	264	**3,417**

NWPRR-207.05 MILL CREEK

Longitudinal Profile Raw Data

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
2	1.69	-247.925	112.75	USCH1	d=0.3	0.00	112.75
4	-1.43	-199.865	108.97	INLAPUS		48.16	108.97
6	-5.64	-185.03	107.96	INLINV	d=0.2	63.58	107.96
7	-3.385	-28.565	100.16	OUTINV	d=0.3	220.06	100.16
8	-2.21	-20.5	99.835	POOLD	d=0.6	228.21	99.84
22	-7.445	-5.02	99.825	TWXS1	Thalweg d=0.4	244.55	99.83
26	-5.465	9.665	98.28	DSCH1	at river d=1.3	259.37	98.28

Calculations for R-G-G Filter

us channel slope =	0.0785
inlet apron slope =	0.0655
inlet apron length(ft) =	15.4
culvert slope =	0.0498
non-embedded segment length (ft)=	N/A
embedded segment length (ft)=	N/A
outlet apron slope =	N/A
outlet apron length(ft) =	N/A
total culvert length(ft) =	156.5
ds channel slope =	0.1043
residual inlet depth(ft) =	-8.13
residual outlet depth(ft) =	-0.33
residual pool depth(ft) =	-0.01

Tailwater Cross Section Raw Data

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
11	15.375	-16.505	102.895	TWXS1		0.00	102.90
12	11.32	-14.495	101.735	TWXS1		4.53	101.74
13	4.43	-10.9	100.81	TWXS1		12.30	100.81
14	3.305	-10.515	101.49	TWXS1		13.49	101.49
15	2.86	-10.215	101.09	TWXS1		14.02	101.09
16	2.15	-9.835	100.675	TWXS1		14.83	100.68
17	1.95	-9.695	101.005	TWXS1		15.07	101.01
18	1.355	-9.38	100.895	TWXS1		15.75	100.90
19	1.38	-9.33	100.205	TWXS1	LEW	15.80	100.21
20	-2.28	-7.605	99.955	TWXS1		19.85	99.96
21	-4.99	-6.205	100.085	TWXS1		22.90	100.09
22	-7.445	-5.02	99.825	TWXS1	Thalweg d=0.4	25.62	99.83
23	-10.72	-3.445	100.17	TWXS1	REW	29.26	100.17
24	-17	-0.245	101.325	TWXS1		36.31	101.33
25	-20.12	1.425	101.79	TWXS1		39.85	101.79

scope and field notes:	TDG
rod:	RNT
spreadsheet:	TDG

Fill Survey Points

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
3	2.365	-202.76	109.105	FILINBOT1		0.00	109.11
5	-9.39	-199.26	109.105	FILINBOT2		12.26	109.11
	38.44	-91.615	159.605	FILINTOP1	Sythetic Point	0.00	159.61
	-0.06	-91.615	159.605	FILINTOP2	Sythetic Point	38.50	159.61
	-38.56	-91.615	159.605	FILINTOP3	Sythetic Point	77.00	159.61
27	38.44	-114.615	159.605	FILOUTTOP1		0.00	159.61
	-0.06	-114.615	159.605	FILOUTTOP2	Sythetic Point	38.50	159.61
	-38.56	-114.615	159.605	FILOUTTOP3	Sythetic Point	77.00	159.61
9	3.645	-19.005	100.275	FILOUTBOT1		0.00	100.28
10	-12.88	-17.295	100.045	FILOUTBOT2		16.61	100.05

Culvert shape = 10.2 x 12.2 CAC
Culvert xs area (ft^2) = 95.0

Fill Volume Calculation

Lu(ft)	Ou (%)	Ld(ft)	Od (%)	Wr(ft)	Wtopu(ft)	Wtopd(ft)	Wbotu(ft)	Wbotd(ft)	Hu(ft)	Hd(ft)	Vu	Vd	Vr	Fill + Culvert V yd^3	Culvert V yd^3	Fill V yd^3
									51.65							
120.7	46.1	113.7	61.3	23.0	77.0	77.0	12.3	16.6	50.5	59.4	123527	134838	66934	12,048	551	**11,498**

Used the road width of 23 feet and fill width of 77 feet to compute the distance from the measured road fills to the sythesized points and copied the elevations for the measured fill points.

NWPRR-223-47 UNNAMED TRIB

Longitudinal Profile Raw Data

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
20	-167.08	216.235	103.76	USCH1		0.00	103.76
17	-132.83	178.94	101.71	INLAPUS		50.64	101.71
16	-126.45	172.215	101.74	INLINV		59.91	101.74
15	-0.645	0.915	99.95	OUTINV		272.44	99.95
14	1.85	3.375	98.785	BDRK	top of bedrock	275.94	98.79
11	6.825	-2.995	94.98	BDRK		284.03	94.98
10	8.585	-5.515	94.43	BDRK		287.10	94.43
9	8.545	-5.65	93.25	BDRK		287.24	93.25
8	10.085	-6.385	92.99	BDRK		288.95	92.99
7	10.82	-8.445	90.63	BDRK		291.13	90.63
6	11.23	-10.35	90.58	BDRK		293.08	90.58
5	11.665	-12.315	88.905	DSCH1	at bottom of bedrock, edge of Eel R gravels	295.10	88.91
4	16.225	-17.795	89.19	DSCH1		302.22	89.19
3	22.16	-23.95	88.445	DSCH1		310.77	88.45
2	31.215	-35.635	84.19	DSCH1	at confluence with Eel	325.56	84.19

Calculations for R-G-G Filter

us channel slope =	0.0405
inlet apron slope =	-0.0032
inlet apron length(ft) =	9.3
culvert slope =	0.0084
non-embedded segment length (ft)=	N/A
embedded segment length (ft)=	N/A
outlet apron slope =	N/A
outlet apron length(ft) =	N/A
total culvert length(ft) =	212.5
ds channel slope =	0.1624
residual inlet depth(ft) =	-12.84
residual outlet depth(ft) =	-11.05
residual pool depth(ft) =	N/A

scope and field notes:	TDG
rod:	RNT
spreadsheet:	TDG

Tailwater Cross Section Raw Data

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)

No tailwater cross section data recorded

Fill Survey Points

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
18	-137.315	173.92	102.47	FILINBOT1		0.00	102.47
19	-130.925	179.89	101.98	FILINBOT2		8.74	101.98
	-92	-35	150.835	FILINTOP1	moved point, not accurate from field	0.00	150.84
	-44	64	149.695	FILINTOP2	moved point, not accurate from field	110.02	149.70
103	22.58	191.39	150.585	FILINTOP3		253.76	150.59
	-81	-40	151.63	FILOUTTOP1	moved point, not accurate from field	0.00	151.63
	-34	51	151.45	FILOUTTOP2	moved point, not accurate from field	102.42	151.45
104	36.055	185.37	151.855	FILOUTTOP3		253.96	151.86
12	5.915	-12.01	93.565	FILOUTBOT1		0.00	93.57
13	11.84	-7.35	93.39	FILOUTBOT2		7.54	93.39

Original Fill Top Points

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
101	-29.28	90.035	150.835	FILINTOP1		0.00	150.84
102	-11.125	129.705	149.695	FILINTOP2		43.63	149.70
103	22.58	191.39	150.585	FILINTOP3		113.92	150.59
106	-23.265	70.96	151.63	FILOUTTOP1		0.00	151.63
105	1.565	119.875	151.45	FILOUTTOP2		54.86	151.45
104	36.055	185.37	151.855	FILOUTTOP3		128.88	151.86

Culvert shape = CAC 8.7x10.1
Culvert xs area (ft^2) = 93.1

Fill Volume Calculation

Lu(ft)	Ou (%)	Ld(ft)	Od (%)	Wr(ft)	Wtopu(ft)	Wtopd(ft)	Wbotu(ft)	Wbotd(ft)	Hu(ft)	Hd(ft)	Vu	Vd	Vr	Fill + Culvert V yd^3	Culvert V yd^3	Fill V yd^3
152.1	32.8	94.3	77.9	16.4	253.8	254.0	8.7	7.5	47.5	58.0	450247	281950	116795	31,444	733	**30,711**

NWPRR-223.88 CONSTANTINE CREEK

Longitudinal Profile Raw Data

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
2	-111.415	-102.205	102.46	USCH1	d=0.25	0.00	102.46
3	-105.08	-93.405	101.96	INLAPUS		10.84	101.96
4	-97.875	-88.445	101.72	INLINV	d=0.1	19.59	101.72
5	-3.105	-5.915	99.775	OUTINV		145.26	99.78
6	4.15	-1.4	99.675	OUTAPDS	d=0.05	153.80	99.68
7	5.455	-0.905	95.725	RIPRAP	d=0.4	155.20	95.73
8	11.785	3.22	93.66	RIPRAP	d=1.0	162.76	93.66
9	20.5	2.735	92.94	POOLD	d=0.6	171.48	92.94
10	25.425	6.715	92.95	POOLD	d=0.4	177.82	92.95
18	29.435	5.955	93.09	TWXS1	d=0.25	181.90	93.09
101	47.545	19.185	91.685	DSCH1	d=0.2	204.32	91.69
102	49.2	25.545	89.38	DSCH1	d=0.5	210.90	89.38
103	51.655	25.185	89.635	DSCH1	d=0.2	213.38	89.64
104	53.965	25.105	85.815	DSCH1	d=0.8	215.69	85.82
105	57.26	23.66	85.65	DSCH1	d=1.0	219.29	85.65
106	62.265	27.755	86.505	DSCH1	d=0.1	225.75	86.51
107	75.16	24.575	84.11	DSCH1	d=0.3, base of boulders	239.04	84.11
108	108.625	35.67	82.97	DSCH1	d=0.1	274.29	82.97
109	109.735	41.725	81.785	DSCH1	d=0.1	280.45	81.79
110	104.725	55.78	80.11	DSCH1	d=0.3, at edge of Eel R	295.37	80.11

Calculations for R-G-G Filter

us channel slope =	0.0461
inlet apron slope =	0.0274
inlet apron length(ft) =	8.7
culvert slope =	0.0155
non-embedded segment length (ft)=	N/A
embedded segment length (ft)=	N/A
outlet apron slope =	0.0117
outlet apron length(ft) =	8.55
total culvert length(ft) =	125.7
ds channel slope =	0.1076
residual inlet depth(ft) =	-8.63
residual outlet depth(ft) =	-6.69
residual pool depth(ft) =	0.15

scope and field notes:	TDG
rod:	RNT
spreadsheet:	TDG

Tailwater Cross Section Raw Data

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
11	31.715	-4.83	96.82	TWXS1	LB	0.00	96.82
12	31.625	-4.14	95.8	TWXS1		0.70	95.80
13	30.775	-0.605	94.13	TWXS1		4.33	94.13
14	31.06	1.265	96.695	TWXS1	On Rock	6.22	96.70
15	31.235	2.735	97.185	TWXS1	On Rock	7.70	97.19
16	31.095	4.845	95.695	TWXS1	On Rock	9.82	95.70
17	29.895	5.135	93.24	TWXS1	LEW d=0.1	11.05	93.24
18	29.435	5.955	93.09	TWXS1	d=0.25	11.99	93.09
19	29.23	6.52	93.495	TWXS1		12.59	93.50
20	29.01	7.285	93.305	TWXS1	REW	13.39	93.31
21	27.885	9.74	94.65	TWXS1		16.09	94.65
22	27.43	10.265	99.43	TWXS1	On Rock	16.79	99.43

Fill Survey Points

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
				FILINBOT1		0.00	0.00
				FILINBOT2		0.00	0.00
				FILINTOP1		0.00	0.00
				FILINTOP2		0.00	0.00
				FILINTOP3		0.00	0.00
				FILOUTTOP1		0.00	0.00
				FILOUTTOP2		0.00	0.00
				FILOUTTOP3		0.00	0.00
				FILOUTBOT1		0.00	0.00
				FILOUTBOT2		0.00	0.00

Culvert shape = CAC 7x8
Culvert xs area (ft^2) = 56.0

Fill Volume Calculation

Lu(ft)	Ou (%)	Ld(ft)	Od (%)	Wr(ft)	Wtopu(ft)	Wtopd(ft)	Wbotu(ft)	Wbotd(ft)	Hu(ft)	Hd(ft)	Vu	Vd	Vr	Fill + Culvert V yd^3	Culvert V yd^3	Fill V yd^3
70.0	70.0	92.0	57.0	27.0	116.0	116.0	13.6	13.6	40.1	45.6	74585	117981	82839	10,200	261	**9,940**

NWPRR-232.71 McCANN CREEK

Longitudinal Profile Raw Data

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
112	-55.535	-42.375	92.89	TWXS2	d=0.8'	0.00	92.89
105	-55.16	-34.47	92.24	USCH1	d=0.4'	7.91	92.24
104	-54.4	-29.84	92.08	USCH1	d=0.3'	12.61	92.08
102	-55.55	-23.285	89.5	INLAPUS	use as FILBOT1	19.26	89.50
101	-60.675	-14.265	89.56	INLINV	d=1.0'	29.64	89.56
27	-18.61	13.395	88.995	OUTINV	d=0.3'	79.98	89.00
26	-11.22	18.295	88.885	OUTAPDS	d=0.5'	88.85	88.89
25	-5.89	17.095	87.105	POOLD	d=0.7'	94.31	87.11
16	-1.355	19.765	87.105	TWXS1	LEW d=0.5'	99.57	87.11
9	-1.585	22.305	86.725	DSCH1	d=0.4'	102.12	86.73
8	4.385	24.905	85.995	DSCH1	d=1.2'	108.63	86.00
7	11.19	24.16	86.715	DSCH1	d=0.5'	115.48	86.72
6	20.435	17.715	85.61	DSCH1	d=0.5'	126.75	85.61
5	31.82	20.81	85.325	DSCH1	d=0.4', use for DS slope	138.55	85.33
4	33.305	22.89	84.62	DSCH1	d=0.5'	141.10	84.62
3	39.67	22.645	83.045	DSCH1	d=0.3'	147.47	83.05
2	45.905	25.09	82.025	DSCH1	d=1.4'	154.17	82.03

Calculations for R-G-G Filter

us channel slope =	0.1760
inlet apron slope =	-0.0058
inlet apron length(ft) =	10.4
culvert slope =	0.0112
non-embedded segment length (ft)=	N/A
embedded segment length (ft)=	N/A
outlet apron slope =	0.0124
outlet apron length(ft) =	8.87
total culvert length(ft) =	50.3
ds channel slope =	0.0780
residual inlet depth(ft) =	-2.46
residual outlet depth(ft) =	-1.89
residual pool depth(ft) =	0.00

scope and field notes:	TDG
rod:	RNT
spreadsheet:	TDG

Tailwater Cross Section Raw Data

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
10	2.12	12.995	90.895	TWXS1	LB	0.00	90.90
11	1.285	14.545	88.96	TWXS1		1.76	88.96
12	-0.285	17.485	88.1	TWXS1		5.09	88.10
13	-0.39	17.915	88.46	TWXS1	On Boulder	5.54	88.46
14	-0.86	19.09	88.76	TWXS1	On Boulder	6.80	88.76
15	-1.245	19.78	87.815	TWXS1	On Boulder	7.59	87.82
16	-1.355	19.765	87.105	TWXS1	LEW d=0.5'	7.70	87.11
17	-1.97	21.11	87.28	TWXS1	d=0.4'	9.18	87.28
18	-2.49	21.945	87.295	TWXS1	REW d=0.3'	10.17	87.30
19	-2.635	22.21	87.92	TWXS1	On Boulder	10.47	87.92
20	-3.42	23.34	87.61	TWXS1	On Boulder	11.84	87.61
21	-3.68	24.15	88.535	TWXS1	On Boulder	12.69	88.54
22	-4.57	25.755	88.805	TWXS1	On Boulder	14.53	88.81
23	-5.72	28.385	89.395	TWXS1	on RB	17.40	89.40
24	-6.38	29.155	90.015	TWXS1	on RB	18.41	90.02

Fill Survey Points

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
102	-55.55	-23.285	89.5	FILINBOT1		0.00	89.50
103	-62.12	-21.195	89.775	FILINBOT2		6.89	89.78
33	-17.24	-19.89	103.58	FILINTOP1		0.00	103.58
34	-33.86	-1.595	103.6	FILINTOP2		24.72	103.60
35	-44.35	8.525	103.62	FILINTOP3		39.29	103.62
30	-8.285	-13.415	103.215	FILOUTTOP1		0.00	103.22
31	-24.96	4.925	103.17	FILOUTTOP2		24.79	103.17
32	-33.94	15.71	103.19	FILOUTTOP3		38.82	103.19
28	-6.135	13.935	87.46	FILOUTBOT1		0.00	87.46
29	-13.85	22.39	87.465	FILOUTBOT2		11.45	87.47

Culvert shape = 7x8 CAC
Culvert xs area (ft^2) = 49.0

Fill Volume Calculation

Lu(ft)	Ou (%)	Ld(ft)	Od (%)	Wr(ft)	Wtopu(ft)	Wtopd(ft)	Wbotu(ft)	Wbotd(ft)	Hu(ft)	Hd(ft)	Vu	Vd	Vr	Fill + Culvert V yd^3	Culvert V yd^3	Fill V yd^3
									14.04							
35.4	42.9	26.1	75.6	11.0	39.3	38.8	6.9	11.4	14.0	15.7	5245	4103	4697	520	91	**429**

NWPRR-233.93 BLOYD CREEK

Longitudinal Profile Raw Data

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
2	-68.65	21.625	99.11	USCH1	d=0.1'	0.00	99.11
3	-34.74	-6.095	98.05	USCH1	d=0.2'	43.80	98.05
4	-31.86	-5.975	97.595	USCH1	d=0.6'	46.68	97.60
5	-22.585	-3.18	98.005	USCH1	d=0.1'	56.37	98.01
6	-14.685	-0.35	97.55	USCH1	Top of debris jam d=0.1'	64.76	97.55
7	-14.285	-0.335	95.725	USCH1	Bottom of debris	65.16	95.73
8	-11.155	4.26	97.06	INLINV	on top of culvert	70.72	97.06
19	12.005	0.63	95.36	OUTINV	Bottom, natural channel	94.16	95.36
20	11.93	0.735	97.21	OUTINV	on top of culvert	94.29	97.21
21	12.97	0.485	95.41	POOLD	d=0.4'	95.36	95.41
27	17.715	-0.35	95.655	TWXS1		100.18	95.66
33	48.8	-4	95.18	DSCH1		131.48	95.18

Calculations for R-G-G Filter

us channel slope =	0.0196
inlet apron slope =	N/A
inlet apron length(ft) =	N/A
culvert slope =	-0.0064
non-embedded segment length (ft)=	N/A
embedded segment length (ft)=	N/A
outlet apron slope =	N/A
outlet apron length(ft) =	N/A
total culvert length(ft) =	23.6
ds channel slope =	0.0152
residual inlet depth(ft) =	N/A
residual outlet depth(ft) =	0.30
residual pool depth(ft) =	0.25

Tailwater Cross Section Raw Data

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
22	19.425	-14.345	97.305	TWXS1	LB	0.00	97.31
23	18.87	-9.945	96.4	TWXS1		4.43	96.40
24	18.245	-5.075	96.335	TWXS1	clear gravels	9.34	96.34
25	17.905	-2.41	95.9	TWXS1	LEW	12.03	95.90
26	17.625	-0.915	95.795	TWXS1	d=0.2'	13.55	95.80
27	17.715	-0.35	95.655	TWXS1		14.12	95.66
28	17.435	1.17	95.76	TWXS1	REW	15.67	95.76
29	17.17	2.87	95.825	TWXS1	Terrace	17.39	95.83
30	16.95	4.89	96.655	TWXS1	Terrace	19.42	96.66
31	16.595	7.875	96.97	TWXS1		22.43	96.97
32	16.455	10.02	98.66	TWXS1	RB Top	24.58	98.66

scope and field notes:	TDG
rod:	RNT
spreadsheet:	TDG

Fill Survey Points

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
9	-13.68	-1.94	95.925	FILINBOT1		0.00	95.93
10	-11.11	9.49	96.54	FILINBOT2		11.72	96.54
11	-11.565	-11.65	100.53	FILINTOP1		0.00	100.53
12	-8.735	3.77	100.37	FILINTOP2		15.68	100.37
13	-7.755	14.475	100.615	FILINTOP3		26.43	100.62
14	7.38	-9.135	100.33	FILOUTTOP1		0.00	100.33
15	8.95	2.2	100.1	FILOUTTOP2		11.44	100.10
16	10.905	11.445	100.245	FILOUTTOP3		20.89	100.25
17	13.425	-1.73	95.48	FILOUTBOT1		0.00	95.48
18	13.36	2.055	95.515	FILOUTBOT2		3.79	95.52

Culvert shape = Circular 30" diameter
Culvert xs area (ft^2) = 4.9

Fill Volume Calculation

3.31

Lu(ft)	Ou (%)	Ld(ft)	Od (%)	Wr(ft)	Wtopu(ft)	Wtopd(ft)	Wbotu(ft)	Wbotd(ft)	Hu(ft)	Hd(ft)	Vu	Vd	Vr	Fill + Culvert V yd^3	Culvert V yd^3	Fill V yd^3
8.0	60.2	6.9	88.8	17.8	26.4	20.9	11.7	3.8	4.1	4.6	271	147	1519	72	4	**67**

NWPRR-236.08 POISON OAK CREEK

Longitudinal Profile Raw Data

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
105	-107.115	90.93	95.365	USCH1	d=0.5'	0.00	95.37
102	-57.735	37.87	92.855	INLINV	Thalweg d=1.5'	72.48	92.86
13	-22.78	12.145	93.615	OUTINV	Thalweg d=0.5'	115.88	93.62
7	-16.36	11.55	93.685	TWXS1	d=0.3'	122.33	93.69
2	-9.105	9.13	92.41	DSCH1	1.2' County Culvert Inlet	129.98	92.41

Calculations for R-G-G Filter

us channel slope =	0.0346
inlet apron slope =	N/A
inlet apron length(ft) =	N/A
culvert slope =	-0.0175
non-embedded segment length (ft)=	N/A
embedded segment length (ft)=	N/A
outlet apron slope =	N/A
outlet apron length(ft) =	N/A
total culvert length(ft) =	43.4
ds channel slope =	0.1667
residual inlet depth(ft) =	0.83
residual outlet depth(ft) =	0.07
residual pool depth(ft) =	N/A

scope and field notes:	TDG
rod:	RNT
spreadsheet:	TDG

Tailwater Cross Section Raw Data

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
3	-21.06	1.465	96.9	TWXS1	LB	0.00	96.90
4	-19.72	4.46	94.81	TWXS1		3.28	94.81
5	-19.52	4.845	94.305	TWXS1		3.71	94.31
6	-18.38	7.22	94.015	TWXS1	LEW	6.35	94.02
7	-16.36	11.55	93.685	TWXS1	d=0.3'	11.13	93.69
8	-14.615	15.205	93.79	TWXS1	d=0.2'	15.18	93.79
9	-13.46	17.385	93.925	TWXS1	REW	17.64	93.93
10	-13.08	18.195	95.455	TWXS1	RB	18.54	95.46
11	-12.485	19.23	96.885	TWXS1		19.73	96.89

Fill Survey Points

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
103	-69.89	30.725	93.05	FILINBOT1		0.00	93.05
104	-61.52	46.505	93.095	FILINBOT2		17.86	93.10
19	-56.905	3.9	107.745	FILINTOP1		0.00	107.75
20	-42.23	30.225	107.66	FILINTOP2		30.14	107.66
21	-30.865	50.15	107.605	FILINTOP3		53.08	107.61
16	-49.22	-0.45	107.465	FILOUTTOP1		0.00	107.47
17	-36.64	21.94	107.215	FILOUTTOP2		25.68	107.22
18	-23.89	45.405	107.115	FILOUTTOP3		52.39	107.12
14	-20.34	7.34	94.11	FILOUTBOT1		0.00	94.11
15	-14.105	16.98	93.77	FILOUTBOT2		11.48	93.77

Culvert shape = 7X10 CAC, Embedded to a 4 ft ris
Culvert xs area (ft^2) = 19.0

Fill Volume Calculation

									14.81					Fill + Culvert V	Culvert V	Fill V
Lu(ft)	Ou (%)	Ld(ft)	Od (%)	Wr(ft)	Wtopu(ft)	Wtopd(ft)	Wbotu(ft)	Wbotd(ft)	Hu(ft)	Hd(ft)	Vu	Vd	Vr	yd^3	yd^3	yd^3
30.2	55.1	26.1	59.1	10.0	53.1	52.4	17.9	11.5	14.6	13.3	6844	4765	5714	642	31	**611**

NWPRR-236.27 UNT TO POISON OAK CREEK

Longitudinal Profile Raw Data

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
2	-119.18	14.035	102.155	USCH1	d=0.3'	0.00	102.16
3	-75.04	2.74	101.885	INLINV	d=0.1'	45.56	101.89
4	-51.005	0.31	101.285	CLVBOT1	1st segment	69.72	101.29
5	-37.645	-9.09	100.71	CLVBOT2	end segment 2	86.06	100.71
6	-18.245	-27.335	99.8	OUTINV		112.69	99.80
7	-15.425	-27.665	97.575	POOLD	d=1.0'	115.53	97.58
11	-13.56	-30.16	98.365	TWXS1	d=0.2'	118.64	98.37
14	-3.835	-46.135	97.18	DSCH1	d=0.3'	137.34	97.18

Tailwater Cross Section Raw Data

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
8	-21.6	-36.72	100.09	TWXS1		0.00	100.09
9	-17.685	-33.755	99.31	TWXS1		4.91	99.31
10	-15.405	-31.775	98.465	TWXS1	LEW	7.93	98.47
11	-13.56	-30.16	98.365	TWXS1	d=0.2'	10.38	98.37
12	-10.14	-27.48	98.47	TWXS1	REW	14.73	98.47
13	-7.115	-25.255	98.325	TWXS1	at vertical wall	18.48	98.33
					synthetic pt	18.50	101.00

Fill Survey Points

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
				FILINBOT1		0.00	0.00
				FILINBOT2		0.00	0.00
				FILINTOP1		0.00	0.00
				FILINTOP2		0.00	0.00
				FILINTOP3		0.00	0.00
				FILOUTTOP1		0.00	0.00
				FILOUTTOP2		0.00	0.00
				FILOUTTOP3		0.00	0.00
				FILOUTBOT1		0.00	0.00
				FILOUTBOT2		0.00	0.00

No fill, crossing is a trapezoidal channel

Calculations for R-G-G Filter

us channel slope =	0.0059
inlet apron slope =	N/A
inlet apron length(ft) =	N/A
culvert slope =	0.0311
segment 1 slope =	0.0248
segment 1 length (ft)=	24.2
segment 2 slope =	0.0352
segment 2 length (ft)=	16.3
segment 3 slope =	0.0342
segment 3 length (ft)=	26.6
total culvert length(ft) =	67.1
ds channel slope =	0.0634
residual inlet depth(ft) =	-3.52
residual outlet depth(ft) =	-1.44
residual pool depth(ft) =	0.79

scope and field notes:	TDG
rod:	RNT
spreadsheet:	TDG

Culvert shape =
Culvert xs area (ft^2) =

Fill Volume Calculation

Lu(ft)	Ou (%)	Ld(ft)	Od (%)	Wr(ft)	Wtopu(ft)	Wtopd(ft)	Wbotu(ft)	Wbotd(ft)	Hu(ft)	Hd(ft)	Vu	Vd	Vr	Fill + Culvert V yd^3	Culvert V yd^3	Fill V yd^3
0.0	#DIV/0!	0.0	#DIV/0!	0.0	0.0	0.0	0.0	0.0	0.0	0.0	#DIV/0!	#DIV/0!	0	#DIV/0!	0	**#DIV/0!**

NWPRR-238.21 PERROTT CREEK

Longitudinal Profile Raw Data

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
16	39.03	123.99	104.06	INLINV		0.00	104.06
15	11.22	32.475	102.935	OUTINV		95.65	102.94
14	9.41	27.14	103.01	OUTAPDS		101.28	103.01
13	10.06	25.61	100.385	POOLD	d=1.2'	102.94	100.39
7	8.46	20.995	101.46	TWXS1		107.83	101.46
2	6.05	-21.14	99.545	DSCH1	d=0.2'	150.03	99.55

Calculations for R-G-G Filter

us channel slope =	N/A
inlet apron slope =	N/A
inlet apron length(ft) =	N/A
culvert slope =	0.0118
non-embedded segment length (ft)=	N/A
embedded segment length (ft)=	N/A
outlet apron slope =	-0.0133
outlet apron length(ft) =	5.63
total culvert length(ft) =	95.6
ds channel slope =	0.0454
residual inlet depth(ft) =	-2.60
residual outlet depth(ft) =	-1.48
residual pool depth(ft) =	1.07

scope and field notes:	TDG
rod:	RNT
spreadsheet:	TDG

Tailwater Cross Section Raw Data

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
3	-0.105	23.48	104.31	TWXS1	LB	0.00	104.31
4	0.57	23.14	101.84	TWXS1		0.76	101.84
5	3.69	22.28	101.515	TWXS1	LEW	3.99	101.52
6	4.515	22.215	101.49	TWXS1		4.82	101.49
7	8.46	20.995	101.46	TWXS1		8.95	101.46
8	9.83	20.575	101.55	TWXS1	REW	10.38	101.55
9	13.44	19.775	101.545	TWXS1		14.08	101.55
10	14.23	19.65	104.77	TWXS1	Top RB	14.88	104.77

Fill Survey Points

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
17	39.665	129.07	103.845	FILINBOT1		0.00	103.85
18	42.17	128.255	103.685	FILINBOT2		2.63	103.69
			133.21	FILINTOP1	synthetic points	0.00	133.21
	27.15	91.38	132.885	FILINTOP2	synthetic points	95.33	132.89
			132.665	FILINTOP3	synthetic points	190.66	132.67
19	-8.02	71.625	133.21	FILOUTTOP1		0.00	133.21
20	17.92	66	132.885	FILOUTTOP2		26.54	132.89
21	41.215	58.755	132.665	FILOUTTOP3		50.94	132.67
11	3.325	26.75	101.07	FILOUTBOT1		0.00	101.07
12	14.42	23.29	100.965	FILOUTBOT2		11.62	100.97

Culvert shape = 5 X 6 CAC
Culvert xs area (ft^2) = 30.0

Fill Volume Calculation

Lu(ft)	Ou (%)	Ld(ft)	Od (%)	Wr(ft)	Wtopu(ft)	Wtopd(ft)	Wbotu(ft)	Wbotd(ft)	Hu(ft)	Hd(ft)	Vu	Vd	Vr	Fill + Culvert V yd^3	Culvert V yd^3	Fill V yd^3
49.3	73.2	53.0	75.2	27.0	190.7	50.9	2.6	11.6	29.1	31.9	55956	21115	55610	4,914	106	**4,808**

NWPRR-240.28 ALLEN CREEK

No Survey ConductedFill Meaasurements Reported

Longitudinal Profile Raw Data

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
						0.00	0.00
						0.00	0.00
						0.00	0.00
						0.00	0.00

Tailwater Cross Section Raw Data

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
						0.00	0.00
						0.00	0.00

Fill Survey Points

Pt #	N(ft)	E(ft)	Z(ft)	pcode	notes	Dist (ft)	Elev (ft)
				FILINBOT1		0.00	0.00
				FILINBOT2		0.00	0.00
				FILINTOP1		0.00	0.00
				FILINTOP2		0.00	0.00
				FILINTOP3		0.00	0.00
				FILOUTTOP1		0.00	0.00
				FILOUTTOP2		0.00	0.00
				FILOUTTOP3		0.00	0.00
				FILOUTBOT1		0.00	0.00
				FILOUTBOT2		0.00	0.00

Calculations for R-G-G Filter

us channel slope =	NA
inlet apron slope =	NA
inlet apron length(ft) =	NA
culvert slope =	NA
non-embedded segment length (ft)=	NA
embedded segment length (ft)=	NA
outlet apron slope =	NA
outlet apron length(ft) =	NA
total culvert length(ft) =	50.0
ds channel slope =	NA
residual inlet depth(ft) =	NA
residual outlet depth(ft) =	NA
residual pool depth(ft) =	NA

scope and field notes:	TDG
rod:	RNT
spreadsheet:	TDG

Culvert shape = 2 Circular 36" diameter
Culvert xs area (ft^2) = 14.1

Fill Volume Calculation

Lu(ft)	Ou (%)	Ld(ft)	Od (%)	Wr(ft)	Wtopu(ft)	Wtopd(ft)	Wbotu(ft)	Wbotd(ft)	Hu(ft)	Hd(ft)	Vu	Vd	Vr	Fill + Culvert V yd^3	Culvert V yd^3	Fill V yd^3
20.0	100.0	40.0	140.0	25.0	90.0	90.0	9.0	9.0	14	33	4950	18730	31517	2,044	26	**2,018**

APPENDIX B:

HYDROLOGY, FISHXING RESULTS, AND SUMMARY

NORTH WESTERN PACIFIC RAILROAD HYDROLOGY AND DESIGN FLOWS FOR FISHXING

Site Characteristics					Waananen and Crippen - Regression Equations						Design Flows		
Site ID #	Stream Name	Drainage Area ($mi.^2$)	Mean Annual Precipitation (in/yr)	H Altitude Index (1000 ft)	2-year Recurrence Interval (cfs)	5-year Recurrence Interval (cfs)	10-year Recurrence Interval (cfs)	25-year Recurrence Interval (cfs)	50-year Recurrence Interval (cfs)	100-year Recurrence Interval (cfs)	Adult High Passage Flow 50% 2yr (cfs)	Resident High Passage Flow 30% 2yr (cfs)	Juvenile High Passage Flow 10% 2yr (cfs)
NWPRR-135.78	Haehl Creek	0.50	52	1.7	49	82	115	157	200	233	24.7	14.8	4.9
NWPRR-136.73	Haehl Creek	0.82	52	1.6	79	131	181	243	308	359	39.7	23.8	7.9
NWPRR-138.23	Haehl Creek	5.16	52	1.6	416	671	914	1,206	1,528	1,777	208.1	124.8	41.6
NWPRR-155.24	Unnamed Trib	1.02	58	1.6	107	175	243	326	414	482	53.3	32.0	10.7
NWPRR-162.62	Unnamed Trib	1.61	68	2.0	167	281	396	543	705	837	83.4	50.0	16.7
NWPRR-164.80	Brad Turner Creek	1.02	68	2.2	106	181	258	359	470	563	52.9	31.7	10.6
NWPRR-165.50	Dean Creek	1.65	68	2.1	167	282	400	550	717	855	83.3	50.0	16.7
NWPRR-171.49	Woodman Creek	25.00	72	1.4	2,449	3,851	5,142	6,612	8,328	9,617	1,224.6	734.8	244.9
NWPRR-174.21	Barn Creek	0.53	53	1.5	56	92	128	171	216	250	28.1	16.9	5.6
NWPRR-174.53	Black Oak Creek	1.25	68	1.7	143	237	331	447	573	672	71.7	43.0	14.3
NWPRR-174.92	Corbet Creek	3.10	70	2.3	289	492	698	963	1,267	1,522	144.5	86.7	28.9
NWPRR-176.04	Unnamed Trib	1.24	58	1.6	127	208	289	387	491	571	63.5	38.1	12.7
NWPRR-207.05	Mill Creek	1.82	56	1.5	179	290	398	528	666	771	89.7	53.8	17.9
NWPRR-223.47	Unnamed Trib	1.44	56	1.2	161	255	344	447	553	629	80.7	48.4	16.1
NWPRR-223.88	Constantine Creek	1.18	56	1.1	140	220	296	382	468	529	70.2	42.1	14.0
NWPRR-232.71	McCann Creek	0.66	58	1.2	82	131	179	235	290	330	41.2	24.7	8.2
NWPRR-233.93	Bloyd Creek	0.29	55	1.0	41	64	87	113	137	153	20.4	12.3	4.1
NWPRR-235.64	UNT to Pipeline Creek	0.66	54	1.0	84	131	176	226	275	308	42.2	25.3	8.4
NWPRR-236.08	Poison Oak Creek	1.52	54	1.0	179	276	367	467	568	637	89.3	53.6	17.9
NWPRR-236.27	UNT to Poison Oak Ck	0.49	54	1.0	64	101	135	175	212	238	32.2	19.3	6.4
NWPRR-238.21	Perrott Creek	0.61	54	1.0	79	122	164	211	257	288	39.3	23.6	7.9
NWPRR-240.28	Allen Creek	0.86	54	1.0	107	166	222	285	346	388	53.5	32.1	10.7

NWPRR - Fish Passage Analysis
Results of Existing Passage Conditions

Culvert Location Information			Hydrology Information			Adult Salmon and Steelhead Barriers Passage Flows (cfs)			Leap		Depth	Velocity
Site ID	Stream Name	RR Mile Post	Length of Anadromy (ft)	Drainage Area (mi.^{2})	Conclusion from Filter Output	Lower (cfs)	Upper (cfs)	%Passable	Lower Limit barrier<Q (cfs)	Upper Limit barrier>Q (cfs)	Lower Limit barrier<Q (cfs)	Upper Limit barrier>Q (cfs)
NWPRR-135.78	Haehl Creek	135.78	1,700	0.50	RED	3.0	24.7	**0%**	---	---	---	---
NWPRR-136.73	Haehl Creek	136.73	7,800	0.82	RED	3.0	39.7	**0%**	---	---	---	---
NWPRR-138.23	Haehl Creek - Left Side	138.23	26,600	5.16	GRAY	3.0	208.1	**72%**	0.0	---	60.0	---
NWPRR-138.23	Haehl Creek - Right Side	138.23	26,600	5.16	GRAY	3.0	208.1	**72%**	0.0	---	60.0	---
NWPRR-155.24	Unnamed Trib	155.24	1,200	1.02	RED	3.0	53.3	**0%**	---	---	---	---
NWPRR-162.62	Unnamed Trib	162.62	1,300	1.61	RED	3.0	83.4	**0%**	---	---	---	---
NWPRR-164.80	Brad Turner Creek	164.8	<500	1.02	RED	3.0	52.9	**0%**	---	---	---	---
NWPRR-165.50	Dean Creek	165.5	2,050	1.65	RED	3.0	83.3	**0%**	---	---	---	---
NWPRR-171.49	Woodman Creek	171.49	>10,000	25.00	GRAY	3.0	1224.6	**0%**	---	---	---	---
NWPRR-174.21	Barn Creek	174.21	2,400	0.53	RED	3.0	28.1	**0%**	---	---	---	---
NWPRR-174.53	Black Oak Creek	174.53	800	1.25	RED	3.0	71.7	**0%**	---	---	---	---
NWPRR-174.92	Corbet Creek	174.92	2,000	3.10	RED	3.0	144.5	**0%**	---	---	---	---
NWPRR-176.04	Unnamed Trib	176.04	1,200	1.24	GRAY	3.0	63.5	**0%**	---	---	65.0	30.1
NWPRR-207.05	Mill Creek	207.05	1,200	1.82	RED	3.0	89.7	**0%**	---	---	---	---
NWPRR-223.47	Unnamed Trib	223.47	200	1.44	RED	3.0	80.7	**0%**	---	---	---	---
NWPRR-223.88	Constantine Creek	223.88	<500	1.18	RED	3.0	70.2	**0%**	---	---	---	---
NWPRR-232.71	McCann Creek	232.71	<500	0.66	GRAY	3.0	41.2	**38%**	---	---	26.8	---
NWPRR-233.93	Bloyd Creek	233.93	700	0.29	RED	3.0	20.4	**0%**	---	---	---	---
NWPRR-235.64	UNT to Pipeline Creek	235.64	1,600	0.66	GRAY	3.0	42.2	**88%**	0.0	None	7.9	---
NWPRR-236.08	Poison Oak Creek	236.08	2,800	1.52	GREEN	3.0	89.3	**100%**	---	---	---	---
NWPRR-236.27	UNT to Poison Oak Ck	236.27	1,300	0.49	RED	3.0	32.2	**0%**	---	---	---	---
NWPRR-238.21	Perrott Creek	238.21	1,400	0.61	GRAY	3.0	39.3	**53%**	0.0	None	20.0	---
NWPRR-240.28	Allen Creek	240.28	1,100	0.86	RED	3.0	53.5	**0%**	---	---	---	---

NWPRR - Fish Passage Analysis
Results of Existing Passage Conditions

Culvert Location Information				Hydrology Information		Resident Trout Barriers Passage Flows (cfs)			Leap		Depth	Velocity
Site ID	Stream Name	RR Mile Post	Length of Anadromy (ft)	Drainage Area (mi.^{2})	Conclusion from Filter Output	Lower (cfs)	Upper (cfs)	%Passable	Lower Limit barrier<Q (cfs)	Upper Limit barrier>Q (cfs)	Lower Limit barrier<Q (cfs)	Upper Limit barrier>Q (cfs)
NWPRR-135.78	Haehl Creek	135.78	1,700	0.50	RED	2.0	14.8	**0%**	---	---	---	---
NWPRR-136.73	Haehl Creek	136.73	7,800	0.82	RED	2.0	23.8	**0%**	---	---	---	---
NWPRR-138.23	Haehl Creek - Left Side	138.23	26,600	5.16	GRAY	2.0	124.8	**0%**	0.0	2.0	60.0	42.7
NWPRR-138.23	Haehl Creek - Right Side	138.23	26,600	5.16	GRAY	2.0	124.8	**0%**	0.0	2.0	60.0	42.7
NWPRR-155.24	Unnamed Trib	155.24	1,200	1.02	RED	2.0	32.0	**0%**	---	---	---	---
NWPRR-162.62	Unnamed Trib	162.62	1,300	1.61	RED	2.0	50.0	**0%**	---	---	---	---
NWPRR-164.80	Brad Turner Creek	164.8	<500	1.02	RED	2.0	31.7	**0%**	---	---	---	---
NWPRR-165.50	Dean Creek	165.5	2,050	1.65	RED	2.0	50.0	**0%**	---	---	---	---
NWPRR-171.49	Woodman Creek	171.49	>10,000	25.00	GRAY	2.0	734.8	**0%**	---	---	---	---
NWPRR-174.21	Barn Creek	174.21	2,400	0.53	RED	2.0	16.9	**0%**	---	---	---	---
NWPRR-174.53	Black Oak Creek	174.53	800	1.25	RED	2.0	43.0	**0%**	---	---	---	---
NWPRR-174.92	Corbet Creek	174.92	2,000	3.10	RED	2.0	86.7	**0%**	---	---	---	---
NWPRR-176.04	Unnamed Trib	176.04	1,200	1.24	GRAY	2.0	38.1	**0%**	---	---	65.0	4.5
NWPRR-207.05	Mill Creek	207.05	1,200	1.82	RED	2.0	53.8	**0%**	---	---	---	---
NWPRR-223.47	Unnamed Trib	223.47	200	1.44	RED	2.0	48.4	**0%**	---	---	---	---
NWPRR-223.88	Constantine Creek	223.88	<500	1.18	RED	2.0	41.2	**0%**	---	---	---	---
NWPRR-232.71	McCann Creek	232.71	<500	0.66	GRAY	2.0	24.7	**0%**	---	---	26.8	11.1
NWPRR-233.93	Bloyd Creek	233.93	700	0.29	RED	2.0	12.3	**0%**	---	---	---	---
NWPRR-235.64	UNT to Pipeline Creek	235.64	1,600	0.66	GRAY	2.0	25.3	**0%**	0.0	None	7.9	5.6
NWPRR-236.08	Poison Oak Creek	236.08	2,800	1.52	**GREEN**	2.0	53.6	**100%**	---	---	---	---
NWPRR-236.27	UNT to Poison Oak Ck	236.27	1,300	0.49	RED	2.0	19.3	**0%**	---	---	---	---
NWPRR-238.21	Perrott Creek	238.21	1,400	0.61	GRAY	2.0	23.6	**0%**	0.0	---	20.0	8.4
NWPRR-240.28	Allen Creek	240.28	1,100	0.86	RED	2.0	32.1	**0%**	---	---	---	---

NWPRR - Fish Passage Analysis
Results of Existing Passage Conditions

Culvert Location Information			Hydrology Information			Young of the Year Barriers Passage Flows (cfs)			Leap		Depth	Velocity
Site ID	Stream Name	RR Mile Post	Length of Anadromy (ft)	Drainage Area (mi.^{2})	Conclusion from Filter Output	Lower (cfs)	Upper (cfs)	%Passable	Lower Limit barrier<Q (cfs)	Upper Limit barrier>Q (cfs)	Lower Limit barrier<Q (cfs)	Upper Limit barrier>Q (cfs)
NWPRR-135.78	Haehl Creek	135.78	1,700	0.50	RED	1.0	4.9	**0%**	---	---	---	---
NWPRR-136.73	Haehl Creek	136.73	7,800	0.82	RED	1.0	7.9	**0%**	---	---	---	---
NWPRR-138.23	Haehl Creek - Left Side	138.23	26,600	5.16	GRAY	1.0	41.6	**0%**	0.0	1.0	25.0	8.0
NWPRR-138.23	Haehl Creek - Right Side	138.23	26,600	5.16	GRAY	1.0	41.6	**0%**	0.0	1.0	25.0	8.0
NWPRR-155.24	Unnamed Trib	155.24	1,200	1.02	RED	1.0	10.7	**0%**	---	---	---	---
NWPRR-162.62	Unnamed Trib	162.62	1,300	1.61	RED	1.0	16.7	**0%**	---	---	---	---
NWPRR-164.80	Brad Turner Creek	164.8	<500	1.02	RED	1.0	10.6	**0%**	---	---	---	---
NWPRR-165.50	Dean Creek	165.5	2,050	1.65	RED	1.0	16.7	**0%**	---	---	---	---
NWPRR-171.49	Woodman Creek	171.49	>10,000	25.00	GRAY	1.0	244.9	**0%**	---	---	---	---
NWPRR-174.21	Barn Creek	174.21	2,400	0.53	RED	1.0	5.6	**0%**	---	---	---	---
NWPRR-174.53	Black Oak Creek	174.53	800	1.25	RED	1.0	14.3	**0%**	---	---	---	---
NWPRR-174.92	Corbet Creek	174.92	2,000	3.10	RED	1.0	28.9	**0%**	---	---	---	---
NWPRR-176.04	Unnamed Trib	176.04	1,200	1.24	GRAY	1.0	12.7	**0%**	---	1.0	30.0	1.0
NWPRR-207.05	Mill Creek	207.05	1,200	1.82	RED	1.0	17.9	**0%**	---	---	---	---
NWPRR-223.47	Unnamed Trib	223.47	200	1.44	RED	1.0	16.1	**0%**	---	---	---	---
NWPRR-223.88	Constantine Creek	223.88	<500	1.18	RED	1.0	14.0	**0%**	---	---	---	---
NWPRR-232.71	McCann Creek	232.71	<500	0.66	GRAY	1.0	8.2	**0%**	---	---	11.0	2.4
NWPRR-233.93	Bloyd Creek	233.93	700	0.29	RED	1.0	4.1	**0%**	---	---	---	---
NWPRR-235.64	UNT to Pipeline Creek	235.64	1,600	0.66	GRAY	1.0	8.4	**0%**	0.0	None	3.6	1.0
NWPRR-236.08	Poison Oak Creek	236.08	2,800	1.52	**GREEN**	1.0	17.9	**100%**	---	---	---	---
NWPRR-236.27	UNT to Poison Oak Ck	236.27	1,300	0.49	RED	1.0	6.4	**0%**	---	---	---	---
NWPRR-238.21	Perrott Creek	238.21	1,400	0.61	GRAY	1.0	7.9	**0%**	0.0	---	3.2	1.8
NWPRR-240.28	Allen Creek	240.28	1,100	0.86	RED	1.0	10.7	**0%**	---	---	---	---

NORTHWEST PACIFIC RAILROAD - EEL RIVER BASIN - Summary of Fish Passage Analysis for Existing Passage Conditions

Culvert Location Information			Adult Salmon & Steelhead Fish Passage Criteria Flows (cfs)			Resident Trout Fish Passage Criteria Flows (cfs)			Juvenile Salmonids - Young of the Year Fish Passage Criteria Flows (cfs)		
Site ID	Stream Name	RR Mile Post	Lower Q50% or 3 cfs	Upper Q1%	%Passable	Lower Q90% or 2 cfs	Upper Q5%	%Passable	Lower Q95% or 1 cfs	Upper Q10%	%Passable
NWPRR-135.78	Haehl Creek	135.78	3.0	24.7	0%	2.0	14.8	0%	1.0	4.9	0%
NWPRR-136.73	Haehl Creek	136.73	3.0	39.7	0%	2.0	23.8	0%	1.0	7.9	0%
NWPRR-138.23	Haehl Creek - Left Side	138.23	3.0	208.1	72%	2.0	124.8	0%	1.0	41.6	0%
NWPRR-138.23	Haehl Creek - Right Side	138.23	3.0	208.1	72%	2.0	124.8	0%	1.0	41.6	0%
NWPRR-155.24	Unnamed Trib	155.24	3.0	53.3	0%	2.0	32.0	0%	1.0	10.7	0%
NWPRR-162.62	Unnamed Trib	162.62	3.0	83.4	0%	2.0	50.0	0%	1.0	16.7	0%
NWPRR-164.80	Brad Turner Creek	164.8	3.0	52.9	0%	2.0	31.7	0%	1.0	10.6	0%
NWPRR-165.50	Dean Creek	165.5	3.0	83.3	0%	2.0	50.0	0%	1.0	16.7	0%
NWPRR-171.49	Woodman Creek	171.49	3.0	1224.6	0%	2.0	734.8	0%	1.0	244.9	0%
NWPRR-174.21	Barn Creek	174.21	3.0	28.1	0%	2.0	16.9	0%	1.0	5.6	0%
NWPRR-174.53	Black Oak Creek	174.53	3.0	71.7	0%	2.0	43.0	0%	1.0	14.3	0%
NWPRR-174.92	Corbet Creek	174.92	3.0	144.5	0%	2.0	86.7	0%	1.0	28.9	0%
NWPRR-176.04	Unnamed Trib	176.04	3.0	63.5	0%	2.0	38.1	0%	1.0	12.7	0%
NWPRR-207.05	Mill Creek	207.05	3.0	89.7	0%	2.0	53.8	0%	1.0	17.9	0%
NWPRR-223.47	Unnamed Trib	223.47	3.0	80.7	0%	2.0	48.4	0%	1.0	16.1	0%
NWPRR-223.88	Constantine Creek	223.88	3.0	70.2	0%	2.0	41.2	0%	1.0	14.0	0%
NWPRR-232.71	McCann Creek	232.71	3.0	41.2	38%	2.0	24.7	0%	1.0	8.2	0%
NWPRR-233.93	Bloyd Creek	233.93	3.0	20.4	0%	2.0	12.3	0%	1.0	4.1	0%
NWPRR-235.64	UNT to Pipeline Creek	235.64	3.0	42.2	88%	2.0	25.3	0%	1.0	8.4	0%
NWPRR-236.08	Poison Oak Creek	236.08	3.0	89.3	100%	2.0	53.6	100%	1.0	17.9	100%
NWPRR-236.27	UNT to Poison Oak Ck	236.27	3.0	32.2	0%	2.0	19.3	0%	1.0	6.4	0%
NWPRR-238.21	Perrott Creek	238.21	3.0	39.3	53%	2.0	23.6	0%	1.0	7.9	0%
NWPRR-240.28	Allen Creek	240.28	3.0	53.5	0%	2.0	32.1	0%	1.0	10.7	0%

APPENDIX C:

STREAM CROSSING RANKING MATRIX

INITIAL RANK	SITE ID #	Stream Name	Presumed Species Diversity	Species Diversity Score	Extent of Barrier Score	Current Sizing Score	Current Condition Score	Culvert Score (ave of sizing and condition scores)	Length of habitat for scoring (ft)	Habitat Length score	Habitat Quality Modifier	Total Habitat Score	TOTAL SCORE	Comments and/or Considerations for the Final Ranking
#1	NWPRR-171.49	Woodman Creek	Coho?, Steelhead, Chinook	8	15	0	0	0.0	>10,000	10.0	0.75	7.50	30.5	Original stream channel was buried in RR fill and the stream was re-routed to flow over bedrock drop.
#2	NWPRR-136.73	Haehl Creek	Coho, Steelhead, Chinook	8	15	0	5	2.5	7,800	7.8	0.50	3.90	29.4	Extremely perched outlet, appears that major channel incision has occurred in the upper reaches of Haehl Creek.
#3	NWPRR-243.38	Bridge Creek	Coho, Steelhead	6	15	5	3	4.0	8,100	8.1	0.50	4.05	29.1	Inlet completely buried and has a "snorkel top". Channel appears to have been re-routed during RR construction.
#4	NWPRR-135.78	Haehl Creek	Coho, Steelhead, Chinook	8	15	5	5	5.0	1,700	1.7	0.25	0.43	28.4	Severely incised downstream channel and upstream channel splits into several small channels.
#5	NWPRR-138.23	Haehl Creek - two sides	Coho, Steelhead, Chinook	8	11	0	1	0.5	26,600	10.0	0.75	7.50	27.0	Crossing is a bridge with a hardened floor. Treatment is relatively inexpensive.
#6	NWPRR-235.27	Pipeline Creek	Coho, Steelhead	6	15	5	5	5.0	1,600	1.6	0.50	0.80	26.8	Inlet completely buried. Evidence of past grow operation that pumped water from the creek.
#7	NWPRR-165.50	Dean Creek	Coho, Steelhead	6	15	1	5	3.0	2,050	2.0	0.50	1.00	25.0	
#8	NWPRR-207.05	Mill Creek	Coho, Steelhead	6	15	0	5	2.5	1,200	1.2	0.50	0.60	24.1	Crossing appears to be back-watered by the Eel River during elevated flows.
#9	NWPRR-233.93	Bloyd Creek	Steelhead	2	15	5	5	5.0	1,500	1.5	0.50	0.75	22.8	Inlet completely buried. RR xing actively failing.
#10	NWPRR-240.28	Allen Creek	Steelhead	2	15	5	5	5.0	1,100	1.1	0.25	0.28	22.3	Inlet completely buried.
#11	NWPRR-236.27	UNT to Poison Oak Creek	Coho, Steelhead	6	15	0	1	0.5	1,300	1.3	0.50	0.65	22.2	
#12	NWPRR-164.80	Brad Turner Creek	Steelhead	2	15	0	5	2.5	<500	0.5	0.25	0.13	19.6	
#13	NWPRR-235.64	UNT to Pipeline Creek	Coho, Steelhead	6	10	5	1	3.0	1,600	1.6	0.25	0.40	19.4	Habitat length taken from mainstem Pipeline Creek due to this crossing receiving diverted flow from the mainstem.

INITIAL RANK	SITE ID #	Stream Name	Presumed Species Diversity	Species Diversity Score	Extent of Barrier Score	Current Sizing Score	Current Condition Score	Culvert Score (ave of sizing and condition scores)	Length of habitat for scoring (ft)	Habitat Length score	Habitat Quality Modifier	Total Habitat Score	TOTAL SCORE	Comments and/or Considerations for the Final Ranking
#14	NWPRR-174.21	Barn Creek	Steelhead	2	15	0	3	1.5	2,400	2.4	0.25	0.60	19.1	
#14	NWPRR-176.04	Unnamed Tributary	Steelhead	2	15	0	3	1.5	1,200	1.2	0.50	0.60	19.1	
#15	NWPRR-174.53	Black Oak Creek	Steelhead	2	15	0	3	1.5	800	0.8	0.50	0.40	18.9	
#16	NWPRR-223.88	Constantine Creek	Steelhead	2	15	2	1	1.5	<500	0.5	0.50	0.25	18.8	Private crossing located just upstream. Not much available fish habitat due to steep channel slope.
#17	NWPRR-223.47	Unnamed Trib	Steelhead	2	15	0	3	1.5	500	0.5	0.25	0.13	18.6	
#18	NWPRR-174.92	Corbet Creek	Steelhead	2	15	0	1	0.5	2,000	2.0	0.50	1.00	18.5	
#19	NWPRR-155.24	Unnamed Tributary	Steelhead	2	15	0	1	0.5	1,200	1.2	0.50	0.60	18.1	
#20	NWPRR-162.62	Unnamed Tributary	Steelhead	2	15	0	1	0.5	1,300	1.3	0.25	0.33	17.8	
#21	NWPRR-238.21	Perrott Creek	Steelhead	2	12	2	1	1.5	1,400	1.4	0.25	0.35	15.9	
#22	NWPRR-232.71	McCann Creek	Steelhead	2	13	0	0	0.0	<500	0.5	0.50	0.25	15.3	County road crossing just upstream was assessed by RTA in 2003 as a complete barrier.
#23	NWPRR-236.08	Poison Oak Creek	Coho, Steelhead	6	0	5	1	3.0	3,200	3.2	0.75	2.40	11.4	This arch culvert was highly embedded with substrate.